The ADRIREEF database: a comprehensive collection of natural/artificial reefs and wrecks in the Adriatic Sea

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Abstract. The paper presents a database of information on wrecks, natural and artificial reefs located in the Adriatic Sea, collected within the framework of the Interreg Italy-Croatia project ADRIREEF - Innovative exploitation of Adriatic Reefs in order to strengthen Blue Economy. The data collection lasted more than one year and comprehended three surveys and a wide literature review. After being collected, data were harmonized and, where possible, made machine-readable. Moreover, data were widely metadated, published in a webGIS (https://adrireef.github.io/sandbox3/) and shared as Open Data in EMODnet (European Marine Observation Data network) Data Ingestion Portal through the SEANOE repository (Ferrà et al., 2020; http://doi.org/10.17882/74880). The database is composed of 285 three-dimensional records, each one described by 51 attributes. Parameters are clustered in four main groups: identification, reef and site description, management/exploitation information. Available literature (scientific and/or grey) was also included in the database and linked to the corresponding site.

1 Introduction

In the Blue Innovation concept, the attractiveness and possible use of existing marine resources which are not yet properly exploited is relevant to promote sustainable economic development (Vogt, 1998; Orams, 2002; Cater and Cater, 2007; Kiper, 2013; Sakellariadou and Kostopoulou, 2015; Nurhayati et al., 2019) and redefine marine fisheries (Pauly, 2018; Stead, 2018). In this context, the recognition of less known and appreciated natural reefs (NRs), existing artificial structures (e.g. artificial reefs, rig-to-reefs; ARs) and wrecks could also be a successful way to pursue Blue Growth as all these sites might be suitable places for developing or improving sustainable activities such as fishing (both recreational and professional), nautical tourism, diving and aquaculture (Wilhelmsson et al., 1998; Stolk et al., 2007; Uyarra et al., 2009; Needham, 2010; Edney, 2011; Spalding et al., 2017; Alempijević and Kovačić, 2019). Therefore, qualitative and quantitative information about the heritage presence and already existing human activities is fundamental to pursue an ecosystem-based sea use management according to the Maritime Spatial Planning (MSP) Directive (EU Directive 2014/89/EU, 2014; Douvere, 2008; Gilliland and Laffoley, 2008). As MSP is based on the three pillars for sustainable development – social, economic and environmental – its implementation will facilitate in turn the enforcement of the Marine Strategy Framework Directive (MSFD, European Commission, 2008) and the achievement of Good Environmental Status (GES).

~~Basing on the above considerations, this paper presents a comprehensive collection of 285 natural reefs, artificial reefs and wrecks located in the Adriatic Sea resulting from~~This work represents the joint effort of Italian and Croatian partners participating in the Interreg Italy-Croatia project ADRIREEF (Innovative exploitation of Adriatic Reefs in order to strengthen blue economy, https://www.italy-croatia.eu/web/adrireef) aimed at assessing the potentiality of reefs in the Adriatic Sea ~~in order to strengthen the Blue Economy.~~, in order to strengthen the Blue Economy. Within the framework of the project, natural reefs are defined as either biogenic or geogenic formations protruding from the solid or soft seabed with distinctive living marine resources. An artificial reef is a submerged natural or manmade structure deliberately constructed or placed on the seabed to emulate some functions of a natural reef such as protecting, regenerating, concentrating, and/or enhancing populations of living marine resources, while doing "no harm". Accidentally sunken ships and planes are instead defined as wrecks.

Based on the above considerations, this paper presents a comprehensive collection of 285 natural reefs, artificial reefs and wrecks located in the Adriatic Sea within Italian, Croatian and International waters.

An analogous attempt of inventory was made on intentionally sunk shipwrecks to serve as ARs over six continents (Ilieva et al., 2019). Anyway, no structures of this type were signalled in the Adriatic Sea, whereas available literature (Pivetta and Spazzapan, 2012) and our search highlighted the occurrence of several accidentally sunken ships which, anyway, act as artificial habitats. Similar attempts to geolocalize ARs and wrecks were made along the national coasts and offshore waters of Florida and Alabama (U.S.A.), by querying municipalities about the deployment of the reefs (U.S. Fish and Wildlife Service, Wildlife & Sport Fish Restoration Program, https://www.fws.gov/wsfrprograms/), as well as in the Gulf of Mexico (Alabama Marine Resources Division, https://www.outdooralabama.com/saltwater-fishing/artificial-reefs). The latter dataset reports all

67 the submerged structures (including ARs, rig-to-reefs and wrecks) in the Gulf of Mexico, but only name, type of reef and

68 coordinates are publicly available. Lastly, some efforts were done concerning NRs within the Reefbase project

69 (http://www.reefbase.org/projects_partners/projects.aspx), which helped localize and concisely qualify ~10,000 reefs on a

70 global scale (Oliver et al., 2002).

71 Another attempt made to identify aquaculture zones in the Adriatic Sea, also through a ~~webGis~~webGIS application

72 (http://www.caps2.eu/caps2/), reports zones of production, harvesting and farms (~~Tara~~Tora et al., 2017), but it does not include

73 a few Italian reefs dedicated to this practice.

74 The collection work presented here is thus an ambitious attempt to gather in a single dataset the location, geometries, history

75 and detailed characteristics of natural reefs, artificial reefs and wrecks existing in the Adriatic Sea. It required a deep knowledge

76 on the overall status of the sites, their history, past and ongoing research and monitoring programs carried out to characterize

77 their ecological features, as well as on their current exploitation level. In this perspective, a key exercise in the ADRIREEF

78 project was to obtain a classification of NRs, ARs and wrecks occurring in the cooperation area and to provide a map of these

79 sites from different perspectives: from the environmental to the economic point of view.

80 The result is an interactive map and an Open Access detailed dataset (Ferrà et al, 2020) published on ~~EMODnet~~SEANOE

81 whose contents are available for any user and purpose.

82 **2 Data mining**

83 Starting from an existing own database, established in 2009 within the Italian Artificial Habitat Group of the Italian Society of

84 Marine Biology (Fabi et al., 2011; Fabi et al., 2015; ~~of the Adriatic artificial reefs, CNR-~~

85 ~~IRBIM~~http://www.habitatartificiali.irbim.cnr.it/wp) carrying basic information about location and description of the artificial

86 reefs, the National Research Council – Institute of Marine Biological Resources and Biotechnologies (CNR-IRBIM,

87 http://www.irbim.cnr.it/it/index.php) coordinated the data collection activity to improve it by developing and sharing among

88 the ADRIREEF partners three online questionnaires on NRs, ARs and wrecks (Appendix A, B and C, respectively). An initial

89 review of available literature and data was carried out to identify the necessary information on NRs/ARs and wrecks to be

90 required. The questionnaires were structured in such a way to obtain a unique database for the two reef typologies and wrecks,

91 including physical, ecological and economic aspects and allowing to classify elements according to their characteristics. Given

92 the importance of collecting answers quickly and having a structured and homogeneous database, it became essential to use

93 easy online tools and to limit the possibility of free answers by proposing multiple-response questions (e.g. Google Forms

94 application; https://www.google.com/forms/about/).

95 The collected information was used to create the final ADRIREEF database which fed, in turn, a ~~webGis~~webGIS application

96 allowing the visualization of reefs and wrecks on an interactive map and their selection basing on running queries.

97 .Projects' partners (PPs) were surveyed and answers were harmonized to obtain a consistent database. New features were

98 defined and used as categories for the elements' classification and/or for the ~~webGis~~webGIS application. Finally, all data

99 properly checked and harmonized were assembled and used to populate the database.

2.1 Literature and ~~available~~ data review

101 The review of existing literature took into account European environmental databases (https://www.eea.europa.eu/data-and-

102 maps, https://ec.europa.eu/environment/nature/natura2000/data/index_en.htm), research projects carried out by CNR-IRBIM

103 and other entities, scientific publications and grey literature. Based on the results of the review and expert knowledge, existing

104 gaps in the information of already known reef sites ~~ad~~and wrecks were identified.

105 With regard to ARs, a large part of inputs came from the above mentioned CNR-IRBIM database on artificial habitats in Italy,

106 ~~established in 2009 within the Italian Artificial Habitat Group of the Italian Society of Marine Biology (Fabi et al., 2011; Fabi~~

107 ~~et al., 2015; http://www.habitatartificiali.irbim.cnr.it) and~~ containing more than 500 bibliographic references and information

108 on 80 Italian artificial habitats. ~~Bibliographic references included scientific publications and grey literature on artificial habitats~~

109 such as harbours, breakwaters, ~~fish aggregating devices~~Fish Aggregating Devices (FADs), offshore platforms and ARs since

110 1967. By checking this database, it was possible to obtain a list of 150 studies regarding the Adriatic ARs published between

111 1977 and 2017. Conversely, a similar literature heritage was not present for NRs and wrecks.

2.2 Questionnaire design

113 The analysis of the collected information highlighted the need of improving existing data especially on NRs and wrecks.

114 As ARs and NRs have completely different features, it was decided to develop two distinct questionnaires. A third

115 questionnaire was developed for wrecks as they have peculiar characteristics. All questionnaires were built in a systematic

116 way with the aims of (i) investigating the reefs' and wrecks' suitability for Blue Economy purposes and identifying those

117 answers that would help to achieve this target; (ii) facilitating experts' participation in the poll by ordering questions into a

118 logical structure.

119 The identification of the person/s filling in the questionnaires was considered relevant to collect consistent information and

120 have a contact person in case of missing data. Moreover, numerical information (distances, measures, coordinates) were asked

121 in specific measurement units to add collected data directly to the database avoiding transformations.

2.2.1 Identification of required information

Natural and artificial reefs

124 ~~Interrogations~~Questions about reefs' characteristics that could influence their suitability for sustainable exploitation were

125 ~~posed~~divided in four main groups:

126   1. Which is the reef and where is it located?

4

As a baseline, data regarding the identification of a reef are needed, therefore name and location (in WGS84 Coordinate Reference System and Decimal Degrees) of the reef were required.

2. Which are the main characteristics of the area where the reef is located?

The environmental characteristics of the area where a reef is located may influence its possible exploitation as well as its attractiveness to perform some activities, hence the following features were considered: minimum distance to the coast (km); typology of the surrounding seabed; ~~the~~ presence of meadows; important biocoenoses, alien and protected species (in case of NRs); possible protection level applied to the area (in case of NRs).

3. Which are the physical features of the reef?

The reef's physical features may also influence its potential use, especially for ARs, which are handmade constructed and designed for specific scopes. To answer this fundamental question, multiple information are needed: the typology of the reef; reef bottom depth (m); reef edge (in meters, for NRs); spatial extension of the reef (m^2); the origin of the reef (for NRs, if biogenic or geogenic); the material used for the reef construction (for ARs); structural design of the reef (for ARs, where it is necessary to know the type and number of modules/structures put in place and their layout).

4. Is the reef already managed and/or exploited and/or could it be ~~site for~~seat of new activities?

The actual use of a reef and/or the scope for which it was built, in the case of ARs, can limit the development of further activities, thus such information is crucial to identify possible synergies and conflicts with additional potential users. At the same time, the original purpose of an artificial reef turns out to be a key information for better understanding monitoring and surveillance programs, management plans and possible grants taking place in the area, as those could also limit or benefit future uses. Therefore, the following information were requested: scope/s for which an AR was built; if the reef is managed (for both NRs and ARs) and, if yes, who is the management entity; if a monitoring program is already in place (for both NRs and ARs) and, if yes, its duration and the investigations carried out; if the reef area is subjected to grant or surveillance service (only for ARs). Furthermore, questions regarding available data (scientific publications, grey literature, monitoring data) were added to the questionnaires, as they could help for future research purposes.

Wrecks

The questionnaire related to the category of wrecks required some information shared with reefs and some extra information about the physical features of the structure.

Shared information concern (i) wreck identification (location and name), (ii) characterization of the surrounding area (distance from the coast, type of surrounding seabed, presence of meadows), (iii) physical features of the wreck (material, bottom depth and wreck edge), (iv) exploitation and protection of the wreck (exploitation, protection and management of the site, if existing). Extra information asked to the partners were: weight of the wreck (tons), total area of the footprint (m^2), total volume of the shipwreck (m^3) and known dimensions (length, width, height in meters).

2.3 Harmonisation and construction of the database

Firstly, all data collected from ~~270~~ questionnaires were screened to delete duplicates and identify incomplete entries and missing information, ~~thus making~~in order to make possible an evaluation of a reef/wreck for Blue Economy purposes ~~impossible~~. For these missing records, a data integration was asked to the contact person.

Data collected from questionnaires were then assembled together with those already contained in the CNR-IRBIM database and harmonized, as some answers were not in line with the requirements. Moreover, geolocations of reefs were inspected in a GIS environment and, when those were inconsistent, clarifications were asked.

Once data control and harmonization were completed, a preliminary analysis and classification of the Adriatic reefs/wrecks was performed and query filters of the ~~webGis~~webGIS application were identified. Once criteria for reef/wreck classification and filters to be applied in the ~~webGis~~webGIS application were definitely agreed with PPs, the ADRIREEF database was finalized.

The final database counted 51 columns, 48 of them derived by the questionnaires and 3 created by the database manager (Type of reef, Country, Region). Of these fields, 10 were used as filters in the ~~webGis~~webGIS application and/or for the reefs' classification while the remaining 41 as part of technical information sheets.

3 Database structure and geographical coverage

The database counts 285 three-dimensional elements (Latitude/Longitude coordinate and bottom depth), described by 51 parameters and divided into 129 natural reefs, 47 artificial reefs and 109 wrecks located in the Adriatic Sea falling into Italian, Croatian and International waters (Table 1).

All artificial reefs and most of wrecks fell within the Italian territorial waters, while the majority (79%) of natural reefs was located within the Croatian ones. The presence of almost all the natural reefs on the eastern side of the studied area is mainly due to the geological morphology of the Adriatic basin (Stefanon, 1972), while the complete absence of artificial reefs on the same side is currently due to Croatian legal constraints. It is worth noting that the number of wrecks reported in the Croatian waters is somewhat underestimated. This fact is due to the lack of basic information about several wrecks (e.g. lack of exact position of the shipwreck, which did not allow to place it in the map), so it was decided to keep into the database only those with adequately detailed information. It is also worthy to note that, given the great occurrence of rocky substrates along the Croatian coast, it was agreed within the ADRIREEF Consortium to identify homogeneous areas and map each of them as a single natural reef (Zec et al., 2019).

	Croatian waters	Italian waters	International waters	Total
Artificial Reefs	-	47	-	47
Natural Reefs	102	27	-	129

Wrecks	9	87	13	109
Total	111	161	13	285

Table 1: Adriatic reefs and wrecks by typology and country.

The geographical bounding box delimiting the studied area is individuated by the coordinates: (N, S, E, W) = (46.0546, 39.4115, 20.0239, 11.7390),Location of reefs and wrecks is expressed in decimal degrees and Coordinates Reference System WGS84. The database is available inas a unique Comma Separated Values (CSV) file.

Table 2 summarizes the structure of the ADRIREEF database specifying the parameters required for each new element: currentparameter name, relative column namedescription, unit of measure, origin of the data (if they come directly from questionnaires or have been created by the database manager) and possible applicability restrictions. Table 2 also reports, for each parameter, the group it belongs to. As mentioned in paragraph 2.2.1, Group no. 1 corresponds to reef identification and geolocation information, Group no. 2 contains parameters summarizing the characteristics of the area hosting the reef or wreck, Group no. 3 concerns aspects of the reefs/wrecksreef/wreck that may also have an effect on its usage, Group no. 4 includes parameters about the present and/or possible future reef or wreck exploitation.

Column name	Description	Group	Unit of measure	Origin of the data	Applicability restriction
type	type of reef/wreck	1		DB manager	NRs, ARs, Wrecks
country		1		DB manager	NRs, ARs, Wrecks
region		1		DB manager	NRs, ARs, Wrecks
location	reference city or zone for the reef/wreck	1		DB manager	NRs, ARs, Wrecks
name	common name of the reef/wreck	1		Questionnaires	NRs, ARs, Wrecks
latitude		1	[decimal degrees]	Questionnaires	NRs, ARs, Wrecks
longitude		1	[decimal degrees]	Questionnaires	NRs, ARs, Wrecks
year_deployment	year of reef deployment/wreck sink	1		Questionnaires	for artificial reefs and wrecks onlyARs, Wrecks

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year_modification	year of eventual modification	1		Questionnaires	~~for artificial reefs only~~ARs
min_depth_m	bottom depth altitude	2	[m]	DB manager	NRs, ARs, Wrecks
depth_m	depth range covered by the structure	2	[m]	Questionnaires	NRs, ARs, Wrecks
reef_edge_m	height of the structure	2	[m]	Questionnaires	~~for natural reefs only~~NRs
min_dist_km	minimum distance from the coastline	2	[km]	Questionnaires	NRs, ARs, Wrecks
surrounding_seabed	surrounding seabed sedimentary composition	2		Questionnaires	NRs, ARs, Wrecks
meadows	presence of meadows	2		Questionnaires	NRs, ARs, Wrecks
reef_typology	reef typology	3		Questionnaires	~~for natural reefs only~~NRs
structure_wreck	type of wreck	3		Questionnaires	~~for wrecks only~~Wrecks
material	material composing the reef	3		Questionnaires	~~for artificial reefs only~~ARs
arrangement_modules	global arrangement of modules composing the reef	3		Questionnaires	~~for artificial reefs only~~ARs
origin_reef	origin of the reef	3		Questionnaires	~~for natural reefs only~~NRs
total_area_sqm	total footprint area of the reef	3	[sqm]	Questionnaires	~~for natural and artificial reefs only~~NRs, ARs
total_volume_cubm	total volume of the reef	3	[cubm]	Questionnaires	~~for artificial reefs only~~ARs
n_oases	number of oases, composed by structures	3		Questionnaires	~~for artificial reefs only~~ARs
dist_between_oases_m	linear distance between oases	3	[m]	Questionnaires	~~for artificial reefs only~~ARs
dimens_oases_sqm	footprint area of the oases	3	[sqm]	Questionnaires	~~for artificial reefs only~~ARs

Name	Description		Unit	Source	Applicability
type_structures	type of structures present in the reef, composed of modules	3		Questionnaires	~~for artificial reefs only~~ARs
n_structures	number of structures present in the reef	3		Questionnaires	~~for artificial reefs only~~ARs
dim_structures_m	relevant dimensions of the structures of the reef	3	[m]	Questionnaires	~~for artificial reefs only~~ARs
dist_between_structures_m	linear distance between structures of the reef	3	[m]	Questionnaires	~~for artificial reefs only~~ARs
modules_shape	shape of the modules composing the structures of the reef	3		Questionnaires	~~for artificial reefs only~~ARs
n_modules	number of modules composing the structures of the reef	3		Questionnaires	~~for artificial reefs only~~ARs
dist_between_modules_m	linear distance between modules composing the structures of the reef	3	[m]	Questionnaires	~~for artificial reefs only~~ARs
dimension_leng_width_heigh_m	dimensions L H W of the reef/wreck	3	[m, m, m]	Questionnaires	~~for artificial reefs and wrecks only~~ARs, Wrecks
weight_or_displacement_tons	weight or displacement of the wreck	3	[tons]	Questionnaires	~~for wrecks only~~Wrecks
experimental_professional	describes the type of exploitation, if professional or experimental, of the reef	4		Questionnaires	~~for artificial reefs only~~ARs
scope	describes original conception scopes of the reef	4		Questionnaires	~~for artificial reefs only~~ARs
exploitation	current exploitation of the reef/wreck	4		Questionnaires	NRs, ARs, Wrecks
possible_exploitation	potential exploitation of the reef/wreck	4		Questionnaires	NRs, ARs, Wrecks
observations	additional observations	3		Questionnaires	~~for wrecks only~~Wrecks
biocoenosis	presence (and types, if available) of biocoenosis	2		Questionnaires	~~for natural reefs only~~NRs
alien_species	presence (and names, if available) of alien species	2		Questionnaires	~~for natural reefs only~~NRs

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protected_species	presence (and names, if available) of protected species	2		Questionnaires	~~for natural reefs only~~NRs
protected_area	presence of a protected area where the reef is placed	2		Questionnaires	~~for natural reefs only~~NRs
management_prog_Y_N	existing of a management program insisting on the reef/wreck	2		Questionnaires	NRs, ARs, Wrecks
management_body	name of the management body of the reef/wreck (if applicable)	2		DB manager	NRs, ARs, Wrecks
concession_area_Y_N	presence of a concession area insisting on the reef/wreck	2		Questionnaires	~~for artificial reefs and wrecks only~~ARs, Wrecks
surveillance_service	presence (and name, if available) of a surveillance service on reef/wreck	2		Questionnaires	NRs, ARs, Wrecks
current_monitoring_program_Y_N	presence of a current monitoring program on reef/wreck	2		Questionnaires	NRs, ARs, Wrecks
monitoring_programs	present or past monitoring program insisting on the reef/wreck	2		Questionnaires	NRs, ARs, Wrecks
available_data	eventually available data related to the reef/wreck	-		Questionnaires	NRs, ARs, Wrecks
available_literature	available literature, scientific or grey	-		Questionnaires	NRs, ARs, Wrecks

199 **Table 2: Column name, the current name of the parameter, type of parameter, unit of measure, origin of the information and**
200 **eventual applicability restrictions.**

201 **4 Data interrogation and visualization**

202 With the purpose of easily exploiting, representing and filtering data, a ~~webGis~~webGIS was created enabling the contemporary
203 filtering (where applicable) of more than one of the following selected attributes:

204 ● Type of element;
205 ● Country;
206 ● Minimum depth of the reef/wreck;
207 ● Distance from the coastline;

10

208   ●   Usage of the reef/wreck;

209   ●   Reef typology (for natural reefs);

210   ●   Reef material (for artificial reefs)

211   The ~~webGis~~webGIS main page is reachable at the ~~address~~following URL: https://adrireef.github.io/sandbox3/ and it is

212   composed of two user-friendly windows (Fig. 1), one reporting all available data filters (left side) and the other one (right side)

213   showing the map where points, identifying elements, are divided by colour in NRs (green), ARs (blue) and Wrecks (red).

214   Hovering on an element with the mouse, its Name and Location appear in the left bottom corner of the map.

215
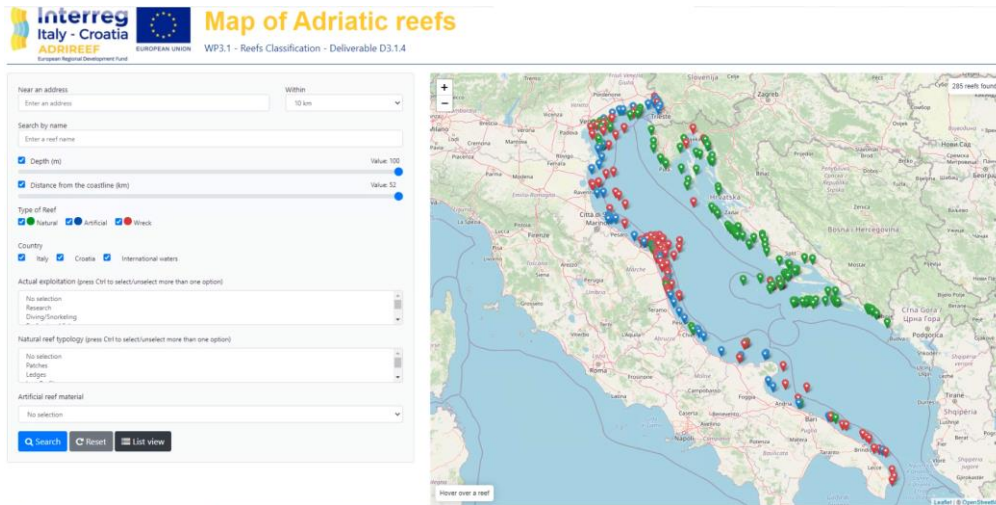
216   **Figure 1: The ~~webGis~~webGIS interface. On the left side: the filter window. On the right side: the map window with hover function**

217   **(bottom left) and the total number of identified elements (top right). Basemap credits: © OpenStreetMap contributors 2020.**

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219   The total number of currently visualized elements is reported at the top right of the map. Moreover, when an element is clicked,

220   a pop-up window appears showing the associated relevant information (Fig. 2). From this pop-up, it is possible to print out

221   information regarding the selected element in PDF format. From the main page, it is also possible to access to the "List view"

222   that shows, for the visualized elements, some common information throughout natural, artificial reefs and wrecks (Fig. 3). The

223   number of visualized elements, in the top right corner of the map view, is updated accordingly to the output of data filtering

224   operations.

225
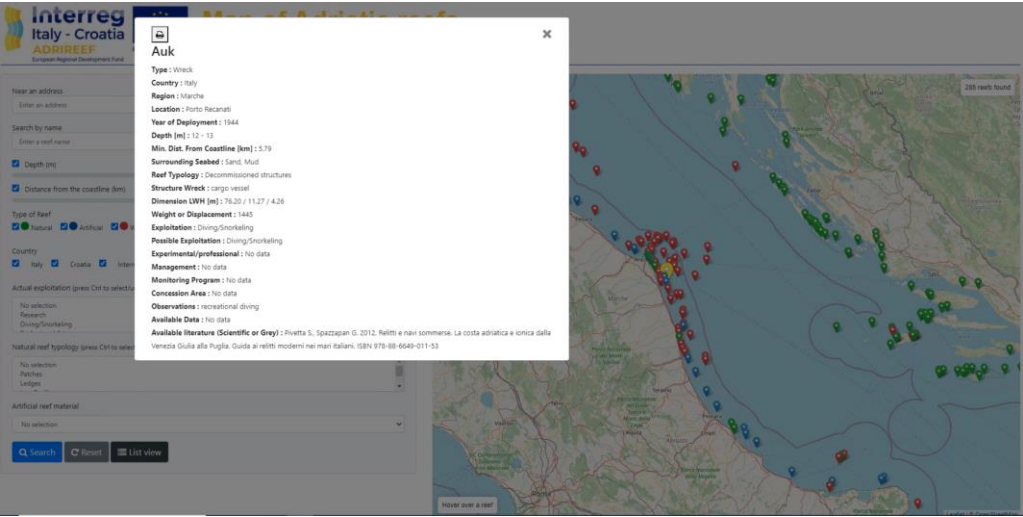
Figure 2: Example of the pop up that appears once an element is clicked. Basemap credits: © OpenStreetMap contributors 2020.

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Figure 3: List view. Once elements are selected, it is possible to obtain some common information by clicking the ~~appropriate button.~~ **"List view" button (that turns into "Map view" when the list is visualized, evidenced in red).**

234 From a technical point of view, data were entered in .csv format, then transformed in JSON objects as "Collection of Features"
235 class, with prototype (generic) and object (specific) capabilities. For each element, an integer and consecutive identification
236 number was assigned by default. The interactive map has been published using the GitHub Pages extension
237 (https://pages.github.com/), which represents an easy and rapid way to make information quickly available online. The base
238 map coming from the open-source cooperative geographical project ~~Open Street Map~~OpenStreetMap
239 (https://www.openstreetmap.org/) and the Nominatim package for geocoding operations
240 (https://nominatim.openstreetmap.org/) were used. The whole infrastructure is based on Searchable Map Template – CSV
241 project (https://github.com/datamade/searchable-map-template-csv).

242 **5 Data analysis**

243 Data contained in the database can be analysed in many different ways and for different purposes. For example, Figure 4,
244 representing the wrecks' sink and the artificial reefs' deployment on time (excluding missing information elements), shows
245 that until the end of 1990s the majority of artificial structures occurring on the seabed of the Adriatic Sea were represented by
246 wrecks, most of which accidentally sunken. Afterwards, almost all the manmade structures deployed on the seabed were
247 purposely-constructed artificial reefs.

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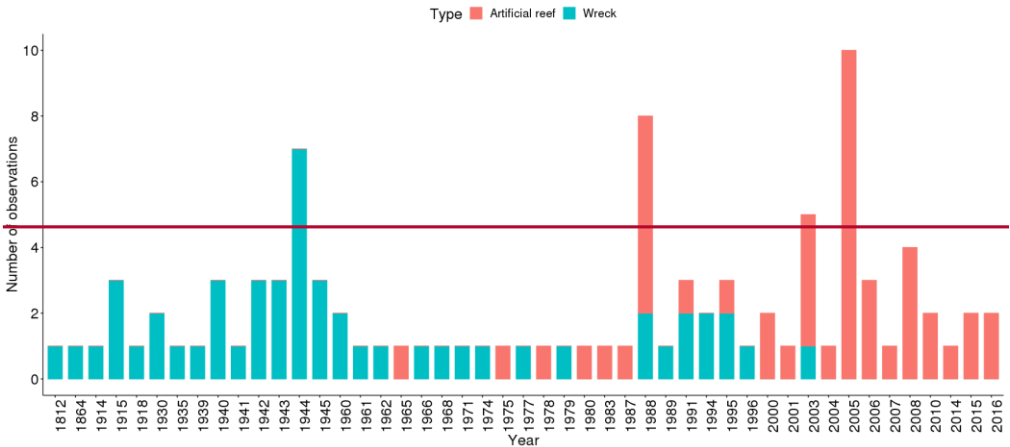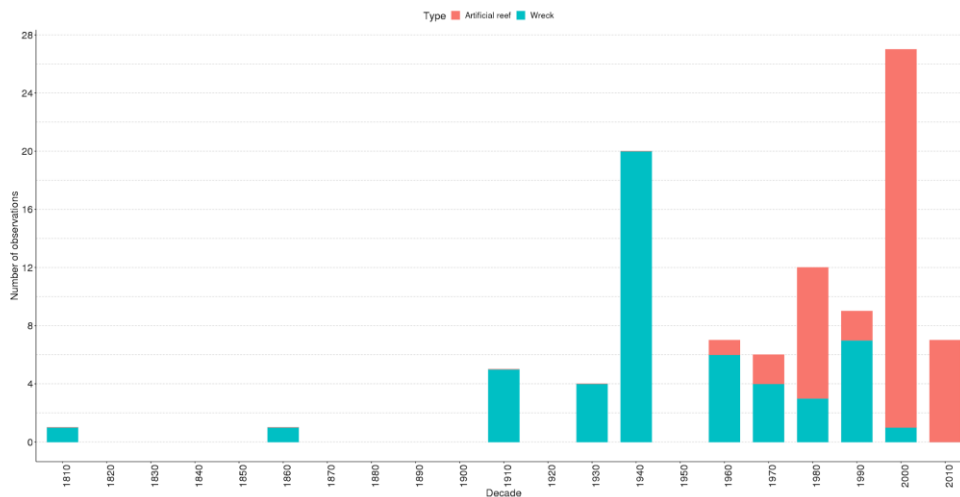
Figure 4. Artificial reefs and wrecks by year of deployment at decadal scale.

Another interesting example of analysis that can be performed on the data is the evaluation of the number of natural reefs subjected to any form of protection. Again, after deduction of "No data", it is possible to identify 31 Natura 2000 sites, 12 Protected areas, 4 Natural reserves and 11 National parks (Fig. 5) with an overlapping at some sites. Figure 5 also shows how NRs are distributed in these categories through Italian and Croatian waters. Coupling this graph with the information contained in Table 1, it results that almost the totality of the Italian natural reefs is subjected to some form of protection, while only half of the Croatian ones are under preservation constraints.

Also, the 3D representation of the sites can be useful for divulgationdissemination purposes. For example, in Figure 6 (A) all reefs and wrecks are reported over a bathymetric map of the Adriatic Sea. A section of the Tremiti Islands (Apulia, Italy), connecting three observations of the database is reported in the zoom (B).
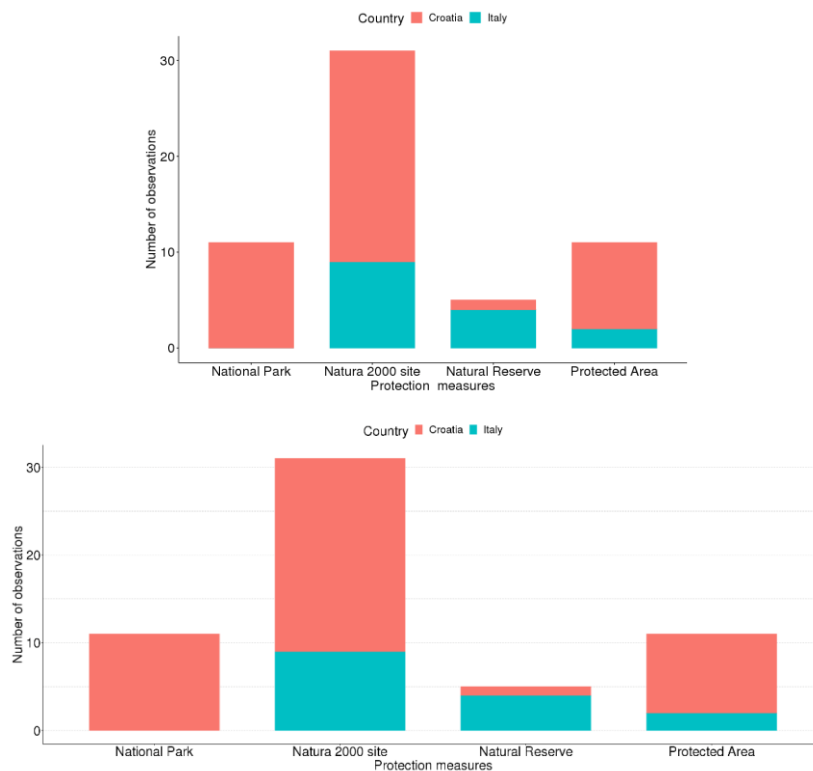
Figure 5. Protection measures applied to Natural Reefs in Croatia and in Italy.

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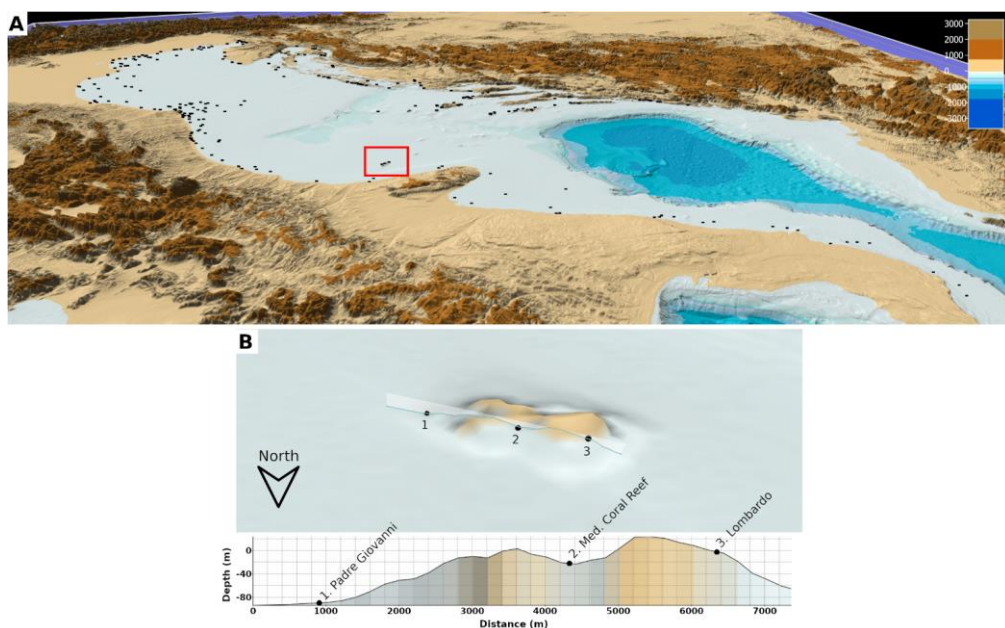
268 **Figure 6. A 3D visualization of the spatial distribution of natural reefs, artificial reefs and wrecks in the Adriatic Sea (A). In the red**
269 **square, the area concerning the zoom reported below. A view of Tremiti Islands and the vertical terrain section from left to right**
270 **side crossing three elements (B): Padre Giovanni and Lombardo wrecks (points no. 1 and 3) and Mediterranean Mesophotic Coral**
271 **Reef (point no. 2).**

272 **6 Data availability**

273 The database (Ferrà et al., 2020) is currently available for download ~~from EMODnet (European Marine Observation Data~~
274 ~~network, Novellino et al., 2015)~~ through the SEANOE (https://www.seanoe.org/) repository and it is reachable at the following
275 ~~address~~URL: https://doi.org/10.17882/74880. The dataset is also published in the EMODnet (European Marine Observation
276 Data network, Novellino et al., 2015) Data Ingestion Portal and it is currently undergoing the required procedure to be
277 published into the EMODnet catalogues. EMODnet was chosen for two main reasons: it ensures long-term data availability
278 and has increasingly become a reference point for all available European maritime data (Martín Míguez et al., 2019). In fact,
279 the platform was financed in the framework of EU's Integrated Maritime Policy definition (Commission of the European
280 Community, 2007) to unlock existing but fragmented and hidden marine data and make them freely accessible for a wide range
281 of users (Calewaert et al., 2016), while respecting FAIR data management principles (Findable, Accessible, Interoperable,
282 Reusable; Wilkinson et al., 2016). In this way, an invaluable heritage of marine data was collected and all data uploaded in

283 EMODnet are indexed in Web Of Science. The database was released under Creative Commons Attribution license (CC-BY,

284 v. 4.0, https://creativecommons.org/licenses/by/4.0/deed.it)

7 Conclusions

286 The data collection work and publication represent an unprecedented, consistent and robust recognition of the reefs and wrecks

287 in the Adriatic Sea. The database represents a comprehensive collection providing a well-detailed state of the art and some

288 hints on possible/future exploitation of reefs and wrecks in this geographical zone. and a tool to implement the EUSAIR

289 strategy (European Commission, 2014), aimed at promoting economic and social prosperity and growth in the Adriatic-Ionian

290 region by creating synergies and fostering coordination in some thematic pillars: sustainable tourism, environmental quality,

291 connecting the region and, in wider terms, the Blue Growth (European Commission, 2017).

292 Indeed, the collected information can be useful for different purposes, from spatial management, to the strengthening of some

293 economic activities and/or development of new ones taking into account the local environmental features.

294 Knowing the environmental status and current exploitation level of reefs/wrecks located in a specific geographical area is in

295 fact fundamental to identify potential additional ecosystem services they can provide and, consequently, develop sustainable

296 economic activities with subsequent positive impacts on the local communities (Costanza et al., 2014). In addition, from the

297 research point of view, a comprehensive database like the one presented here could be a starting point for the implementation

298 of ecological studies where the information is still scarce or lacking as well as of monitoring programmes aimed at evaluating

299 the impact of some economic activities (e.g., tourism, small-scale fisheries) on sensitive habitats.

300 Lastly, the interactive map represents a tool that allows, through the simultaneous usage of different filters, to highlight and

301 quantify particularly interesting situations in a user-friendly and quick manner, so to be also easily handled by the wide public.

302 It could be, for example, used by tourists to identify suitable and less known sites for recreational activities such as snorkelling,

303 diving and sailing.

304 In the overallOverall, the provided collection can be helpful to increase visibility and attractiveness of reefs and wrecks existing

305 in the Adriatic Sea while increasing awareness of both policy makers and citizens towards the need of managing and exploiting

306 these sites in a sustainable way in order to assure their preservation over time.

307 The general perception derived from an overall evaluation of the collected data is that, in the Adriatic context, reefs and wrecks

308 still represent an underestimated environmental heritage that, if adequately preserved and promoted, could provide in the near

309 future new opportunities for developing activities in line with the Blue Economy.

310

311 **Appendices**

Appendix A: Natural Reefs Questionnaire

313 1. Name and Surname: ....
314 2. Occupational qualification and workplace: ....
315 3. Name of the reef: ....
316 4. Location of the reef: ....
317 5. Geographical coordinates Latitude (WGS84 DD.DD. e.g. 43.023N): ....
318 6. Geographical coordinates Longitude (WGS84 DD.DD. e.g. 13.123N): ....
319 7. Reef bottom depth (m) (If it is in a range, please specify the max and min): ....
320 8. Reef edge (m): ....
321 9. Minimum distance from the coast (km): ....
322 10. Total area occupied by the Natural Reef (m^2): ....
323 11. Typology of the reef:
324   ☐ High profile reef (the reef protrudes more than 20 meters from the base substratum)
325   ☐ Low profile reef (the reef protrudes less than 20 meters from the base substratum)
326   ☐ Ledges (vertical reef face characterized by visible crevices)
327   ☐ Boulder reef (structure elevating from the flat seabed)
328   ☐ Patch reef (sand bottom with small reef structures protruding from the sediment)
329   ☐ I don't know
330 12. Origin of the reef:
331   ☐ Biogenic
332   ☐ Geogenic
333 13. Type of surrounding seabed:
334   ☐ Rocks
335   ☐ Sand
336   ☐ Mud
337   ☐ Detritic
338   ☐ Gravel
339   ☐ Other
340 14. Occurrence of meadows?
341   ☐ Yes, phanerogams
342   ☐ Yes, algae
343   ☐ no
344 15. Which are the most important biocenoses? ....
345 16. Any alien species?
346   ☐ Yes
347   ☐ No
348   ☐ Maybe
349 17. If "Yes", which alien species? ....
350 18. Any protected species? (e.g. IUCN Red List of Threatened Species, ASPIM Protocol, Berna Convention, etc.)
351   ☐ Yes
352   ☐ No
353   ☐ Maybe
354   ☐ If "Yes", which species?

355	19. Is the natural reef within a protected area?
356	☐ Yes, MPA
357	☐ Yes, Natura 2000 site
358	☐ Yes, National park
359	☐ Yes, Natural park
360	☐ Yes, Marine reserve
361	☐ No
362	20. Is the reef managed?
363	☐ Yes
364	☐ No
365	☐ I don't know
366	21. If yes, which is the Managing Subject? (Please give a short summary of the management measures adopted)
367	22. Does exist a monitoring program?
368	☐ Yes
369	☐ No
370	23. If "Yes" please give a short summary of the program ....
371	24. Surveillance service?
372	☐ Yes
373	☐ No
374	25. Current use of the Reef:
375	☐ Diving
376	☐ Mariculture
377	☐ Research
378	☐ Professional fishery
379	☐ Recreation fishery
380	☐ Fishing tourism
381	☐ Nothing
382	☐ Other (please, specify) ....
383	26. Development perspectives of the Natural Reef:
384	☐ Diving
385	☐ Mariculture
386	☐ Research
387	☐ Professional fishery
388	☐ Recreation fishery
389	☐ Fishing tourism
390	☐ Nothing
391	☐ Other (please, specify) ....
392	27. Please list the available data (If "Other" please specify):
393	☐ Geophysical map
394	☐ Water column
395	☐ Sediments
396	☐ Benthic community
397	☐ Fish community
398	☐ Other (please, specify) ....
399	28. Available literature (Scientific or Grey):
400	(Please add as many papers/works you know about the reef using the scheme:
401	1 Title/ 2 Authors / 3 Year of publication / 4 Journal or project / 5 Pages / 6 Abstract / 7 Keywords)
402	

Appendix B: Artificial Reefs Questionnaire

1. Name and Surname: ....
2. Occupational qualification and workplace: ....
3. Name of the reef: ....
4. Location of the reef: ....
5. Geographical coordinates Latitude (WGS84 DD.DD. e.g. 43.023N): ....
6. Geographical coordinates Longitude (WGS84 DD.DD. e.g. 13.123N): ....
7. Year of deployment of the AR: ....
8. Year of modification of the AR: ....
9. Bottom depth (m) (If it is in a range, please specify the max and min): ....
10. Minimum distance from the coast (km): ....
11. Type of surrounding seabed:
    ☐ Rocks
    ☐ Sand
    ☐ Mud
    ☐ Detritic
    ☐ Gravel
    ☐ Other (please, specify) ....
12. Occurrence of meadows?
    ☐ Yes, phanerogams
    ☐ Yes, algae
    ☐ No

ARTIFICIAL REEF STRUCTURE

1. Reef typology:
    ☐ Specifically designed modules (basic module)
    ☐ Decommissioned structures
    ☐ Other (please, specify) ....

Specifically designed modules (basic module)

1. Material:
    ☐ Concrete
    ☐ Sea-friendly concrete (e.g., Tecnoreef)
    ☐ Coal Ash
    ☐ Rocks
    ☐ Fiberglass
    ☐ Other (please specify) ....
2. Shape of the single module:
    ☐ Cube
    ☐ Pole
    ☐ Plinth
    ☐ Other (please, specify) ....
3. Dimension of the single module (m): ....
4. Total volume of deployed material (m^3): ....
5. Arrangement of the modules:
    ☐ Geometrically assembled to form structures
    ☐ Scattered

448	☐ Other (please, specify) ....
449	<u>Artificial Reef geometrically assembled to form structures</u>
450	1. Typology (e.g., pyramid): ....
451	2. Number of deployed structures: ....
452	3. Height of the structures (m): ....
453	4. Distance among structures (m): ....
454	<u>Scattered Artificial Reef</u>
455	1. Number of deployed structures: ....
456	2. Distance between structures (m): ....
457	<u>If the Artificial Reef is composed by areas or oases, please indicate:</u>
458	1. Number of the oases: ....
459	2. Distance among oases: ....
460	3. Dimension of each oasis (m^2): ....
461	4. Total area occupied by the Artificial Reef (including the area covered by the bodies, the distance between the bodies
462	and the area of respect) (m^2): ....
463	**Decommissioned structures**
464	<u>Please specify the nature of the structure:</u>
465	☐ Offshore extraction platform
466	☐ Purposely sunk vessel/ship
467	☐ Other (please, specify) ....
468	<u>Offshore extraction platform:</u>
469	1. Type of the platform (e.g., one-leg platform): ....
470	2. Part of the platform used to realize the AR (e.g., jacket, deck): ....
471	3. Total area occupied by the Artificial Reef (m^2): ....
472	<u>Purposely sunk vessel/ship:</u>
473	1. Number of sunk vessels: ....
474	2. Vessel material:
475	☐ Wood
476	☐ Iron
477	☐ Fiberglass
478	☐ Other (please, specify) ....
479	3. Dimension of the sunk vessel/ship - LFT (m) and Weight (ton): ....
480	<u>Other Artificial Reefs:</u>
481	1. Number of bodies: ....
482	2. Material of bodies:
483	☐ Wood
484	☐ Iron
485	☐ Fiberglass
486	☐ Concrete
487	☐ Other (please, specify) ....
488	3. Dimension of each body - length (m) and Weight (ton): ....
489	**ARTIFICIAL REEF UTILIZATION**
490	1. Scope:
491	☐ Habitat protection
492	☐ Habitat restoration
493	☐ Finfish enhancement

494		☐ Diving
495		☐ Mariculture
496		☐ Research
497		☐ Professional fishery
498		☐ Recreational fishery
499		☐ Fishing tourism
500		☐ Other (please, specify) ....
501	2.	Type of Artificial Reef:
502		☐ Experimental
503		☐ Professional
504	3.	Is the Reef exploited at present?
505		☐ Yes
506		☐ No
507		☐ Maybe
508		If "Yes", by whom? ....
509	4.	Does exist a management program?
510		☐ Yes
511		☐ No
512		☐ Maybe
513		If "Yes", please specify the Managing Subject and give a short summary of the adopted management measures
514		....
515	5.	Concession area?
516		☐ Yes
517		☐ No
518	6.	Surveillance service?
519		☐ Yes
520		☐ No
521	7.	Does exist a monitoring program?
522		☐ Yes
523		☐ No
524		☐ Maybe
525		If "Yes", please give a short summary (Duration / Monitored aspects / Involved Institute or Agency /address, e-mail
526		address) ....
527	8.	Possible exploitation of the Artificial Reef:
528		☐ Diving
529		☐ Mariculture
530		☐ Research
531		☐ Professional fishery
532		☐ Recreational fishery
533		☐ Fishing tourism
534		☐ Nothing
535		☐ Other (please, specify) ....
536	9.	Please list the available data:
537		☐ Geophysical map
538		☐ Water column
539		☐ Sediments
540		☐ Benthic community
541		☐ Fish community
542		☐ Other (please, specify) ....

543   10. Available literature (Scientific or Grey):
544   (Please add as many papers/works you know about the reef using the scheme: 1 Title/ 2 Authors / 3 Year of
545   publication / 4 Journal or project / 5 Pages / 6 Abstract / 7 Keywords)
546

Appendix C: Wreck Questionnaire

1. Name and Surname: ....
2. Occupational qualification and workplace: ....
3. Name of the Wreck: ....
4. Location of the Wreck: ....
5. Geographical coordinates Latitude (WGS84 DD.DD. e.g. 43.023N): ....
6. Geographical coordinates Longitude (WGS84 DD.DD. e.g. 13.123N): ....
7. Year of accidental sinking of the Wreck: ....
8. Bottom depth (m) (If it is in a range, please specify the max and min): ....
9. Minimum distance from the coast (km): ....
10. Type of surrounding seabed:
    ☐ Rocks
    ☐ Sand
    ☐ Mud
    ☐ Detritic
    ☐ Gravel
    ☐ Other (please, specify) ....
11. Occurrence of meadows?
    ☐ Yes, phanerogams
    ☐ Yes, algae
    ☐ No
12. Vessel material:
    ☐ Wood
    ☐ Iron
    ☐ Fiberglass
    ☐ Other (please, specify) ....
13. Total area occupied by the Wreck (m²): ....
14. Total volume of the Wreck (m³): ....
15. Eventual fragments of the Wreck and their spatial configuration:...
16. Dimension of the sunk vessel/ship - LFT (m) and Weight (ton): ....
17. Is the Wreck exploited at present?
    ☐ Yes
    ☐ No
    ☐ Maybe
    If "Yes", by whom? ....
18. Does exist a management program?
    ☐ Yes
    ☐ No
    ☐ Maybe
    If "Yes", please specify the Managing Subject and give a short summary of the adopted management measures
    ....
19. Concession area?
    ☐ Yes
    ☐ No
20. Surveillance service?

592	☐ Yes
593	☐ No
594	21. Does exist a monitoring program?
595	☐ Yes
596	☐ No
597	☐ Maybe
598	If "Yes", please give a short summary (Duration / Monitored aspects / Involved Institute or Agency /address, e-mail
599	address) ....
600	22. Possible exploitation of the Wreck:
601	☐ Diving
602	☐ Mariculture
603	☐ Research
604	☐ Professional fishery
605	☐ Recreational fishery
606	☐ Fishing tourism
607	☐ Nothing
608	☐ Other (please, specify) ....
609	23. Please list the available data:
610	☐ Geophysical map
611	☐ Water column
612	☐ Sediments
613	☐ Benthic community
614	☐ Fish community
615	☐ Other (please, specify) ....
616	24. Available literature (Scientific or Grey):
617	(Please add as many papers/works you know about the reef using the scheme: 1 Title/ 2 Authors / 3 Year of
618	publication / 4 Journal or project / 5 Pages / 6 Abstract / 7 Keywords)
619	

References

Alempijević, A. and Kovačić, M.: Nautical Tourism and Small Shipbuilding as Significant part of Blue Economy Development, Pomorski zbornik, 57(1), 97-110, https://doi.org/10.18048/2019.57.07, 2019.

Calewaert, J.B., Weaver, P., Gunn, V., Gorringe, P. and Novellino, A.: The European Marine Data and Observation Network (EMODnet): Your Gateway to European Marine and Coastal Data. In: Zerr B. et al. (eds) Quantitative Monitoring of the Underwater Environment. Ocean Engineering & Oceanography, vol 6. Springer, Cham. https://doi.org/10.1007/978-3-319-32107-3_4, 2016.

Cater, C. and Cater, E.: Marine ecotourism: Between the devil and the deep blue sea (Vol. 6), Cab Intl, ISBN: 9781845932596, 2007.

Commission of the European Communities. Commission staff working document. Accompanying document to the communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions: An Integrated Maritime Policy for the European Union, SEC(2007) 1278, 2007.

647   Costanza, R., De Groot, R., Sutton, P., Van der Ploeg, S., Anderson, S. J., Kubiszewski, I., Farber, S. and Turner, R. K.:
648   Changes in the global value of ecosystem services. Global environmental change, 26, 152-158, doi:
649   10.1016/j.gloenvcha.2014.04.002, 2014.

650

651   Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 establishing a framework for maritime
652   spatial planning, Official Journal of the European Union L 257/135 L257, p. 135. https://eur-lex.europa.eu/legal-
653   content/EN/TXT/?uri=CELEX%3A32014L0089 (accessed on 05/02/2021), 2014.

654

655   Douvere, F.: The importance of marine spatial planning in advancing ecosystem-based sea use management. Marine Policy
656   32(5):762–71, https://doi.org/10.1016/j.marpol.2008.03.021, 2008.

657

658   Edney, J.: Understanding wreck divers: Case studies from Australia and Chuuk Lagoon, In Proceedings of the Asia-Pacific
659   Regional Conference on Underwater Cultural Heritage: 8–12 November (pp. 575-587), 2011.

660

661   European Commission: Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a
662   framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive), 164,
663   2008.

664

665   European Union: European Commission, Commission Staff Working Document: Action Plan Accompanying the document
666   COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE
667   EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS concerning the
668   European Union Strategy for the Adriatic and Ionian Region, 17 June 2014, SWD(2014) 190 final, available at:
669   https://www.adriatic-ionian.eu/wp-content/uploads/2018/04/EUSAIR-ACTION-PLAN-17-June-2014.pdf (accessed on
670   09/03/2021).

671

672   European Union: European Commission, COMMISSION STAFF WORKING DOCUMENT Report on the Blue Growth
673   Strategy Towards more sustainable growth and jobs in the blue economy, 31 March 2017, SWD(2017) 128 final, available at:
674   https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/swd-2017-128_en.pdf (accessed on 09/03/2021).

675

676   Fabi, G., Spagnolo, A., Bellan-Santini, D., Charbonnel, E., Çiçek, B. A., García, J. J. G., Jensen, A. C., Kallianiotis, A. and
677   Santos, M. N. D.: Overview on artificial reefs in Europe, Brazilian journal of oceanography, 59(SPE1), 155-166, doi:
678   10.1590/S1679-87592011000500017, 2011.

679

680　Fabi, G., Sarcella, G., Spagnolo, A., Bortone, S. A., Charbonnel, E., Goutayer, J. J., Naoufel, H., Lök, A. and Trommelen, M.:
681　Practical guidelines for the use of artificial reefs in the Mediterranean and the Black Sea. General Fisheries Commission for
682　the Mediterranean. Studies and Reviews, (96), I., ISSN: 1020-9549, 2015.
683

684　Ferrà, C., Minelli, A., Spagnolo, A., Scanu, M., Tassetti, A. N., Ferrari, C. R., Mazziotti, C., Pigozzi, S., Jakl, Z., Šarčević, T.,
685　Šimac, M., Kruschel, C., Pejdo, D., Barbone, E., De Gioia, M., Borme, D., Gordini, E., Auriemma, R., Benzon, I., Vuković-
686　Stanišić, Đ., Orlić, S., Frančić, V., Zec, D., Orlić Kapović, I., Soldati, M., Uliazzi, S. and Fabi, G.: The ADRIREEF database:
687　natural/artificial reefs and wrecks in the Adriatic Sea. SEANOE. https://doi.org/10.17882/74880, 2020.
688

689　Gilliland, P. M. and Laffoley, D.: Key elements and steps in the process of developing ecosystem-based marine spatial
690　planning. Marine Policy, 32(5), 787-796, doi: 10.1016/j.marpol.2008.03.022, 2008.
691

692　Ilieva, I., Jouvet, L., Seidelin, L., Best, B. D., Aldabet, S., da Silva, R. and Conde, D. A.: A global database of intentionally
693　deployed wrecks to serve as artificial reefs. Data in brief, 23, 103584, https://doi.org/10.1016/j.marpol.2008.03.021, 2019.
694

695　Kiper, T.: Role of ecotourism in sustainable development, InTech, 773-802, http://dx.doi.org/10.5772/55749, 2013.
696

697　Llewellyn, L. E., English, S. and Barnwell, S.: A roadmap to a sustainable Indian Ocean blue economy. Journal of the Indian
698　Ocean Region, 12(1), 52-66, doi: 10.1080/19480881.2016.1138713, 2016.
699

700　Martín Míguez, B., Novellino, A., Vinci, M., Claus, S., Calewaert, J.B., Vallius, H., Schmitt, T., Pititto, A., Giorgetti, A.,
701　Askew, N., Iona, S., Schaap, D., Pinardi, N., Harpham, Q., Kater, B.J., Populus, J., She, J., Palazov, A.V., McMeel, O., Oset,
702　P., Lear, D., Manzella, G.M.R., Gorringe, P., Simoncelli, S., Larkin, K., Holdsworth, N., Arvanitidis, C.D., Molina Jack, M.E.,
703　Chaves Montero, M.M., Herman, P.M.J. and Hernandez, F.: The European Marine Observation and Data Network
704　(EMODnet): Visions and Roles of the Gateway to Marine Data in Europe. Front. Mar. Sci. 6:313.
705　http://doi.org/10.3389/fmars.2019.00313, 2019.
706

707　Needham, M. D.: Value orientations toward coral reefs in recreation and tourism settings: a conceptual and measurement
708　approach, Journal of Sustainable Tourism, 18:6, 757-772, http://doi.org/10.1080/09669581003690486, 2010.
709

710　Novellino, A., D'Angelo, P., Benedetti, G., Manzella, G., Gorringe, P., Schaap, D., Pouliquen, S. and Rickards, L.: European
711　marine observation data network - EMODnet physics. In OCEANS 2015 - Genova (pp. 1-6). IEEE.
712　http://doi.org/10.1109/OCEANS-Genova.2015.7271548, 2015.
713

Nurhayati, A., Aisah, I. and Supriatna, A. K.: Model Development of A Synergistic Sustainable Marine Ecotourism - A Case Study in Pangandaran Region, West Java Province, Indonesia, Sustainability, 11(12), 3418, http://doi.org/10.3390/su11123418, 2019.

Oliver, J., Noordeloos, M., Yusuf, Y., Tan, M., Nayan, N., Foo, C. and Shahriyah, F.: ReefBase: a global information system on coral reefs. WorldFish Center, ReefBase Project., 2002.

Orams, M. B.: Marine ecotourism as a potential agent for sustainable development in Kaikoura, New Zealand, International Journal of Sustainable Development 5(3):338-352, http://doi.org/10.1504/IJSD.2002.003757, 2002.

Pauly, D.: A vision for marine fisheries in a global blue economy, Marine Policy, 87, 371-374., https://doi.org/10.1016/j.marpol.2017.11.010, 2018.

Pivetta, S. and Spazzapan, G.: Relitti e navi sommerse. La costa adriatica e ionica dalla Venezia Giulia alla Puglia. Guida ai relitti moderni nei mari italiani, Addictions-Manages Editoriale, ISBN: 9788866490111, 2012.

Sakellariadou, F. and Kostopoulou, E.: Marine ecotourism from the perspective of the blue growth, Conference 7th iCOnEc Conference Competitiveness and Stability in the Knowledge-based Economy, Craiova, Romania, https://www.researchgate.net/publication/317142241_Marine_ecotourism_from_the_perspective_of_blue_growth (accessed on 17/02/2020), 2015.

Spalding, M., Burke, L., Wood, S. A., Ashpole, J., Hutchison, J. and Zu Ermgassen, P.: Mapping the global value and distribution of coral reef tourism. Marine Policy, 82, 104-113, https://doi.org/10.1016/j.marpol.2017.05.014, 2017.

Stead, S. M.: Rethinking marine resource governance for the United Nations sustainable development goals, Current opinion in environmental sustainability, 34, 54-61, https://doi.org/10.1016/j.cosust.2018.12.001, 2018.

Stefanon A.: Beachrock and paleogeography in the North Adriatic Sea. Rapport et Procés Verbaux des Reunion Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée, 20(4), 605–608, 1972.

Stolk, P., Markwell, K. and Jenkins, J. M.: Artificial Reefs as Recreational Scuba Diving Resources: A Critical Review of Research, Journal of Sustainable Tourism, 15:4, 331-350, DOI: 10.2167/jost651.0, 2007.

747 Tora, S., Sacchini, S., Listeš, E., Bogdanović, T., Di Lorenzo, A., Smajlović, M., Filipović, J. V., Tahirović, V., Šuković, D.,
748 Beljkas, B., Xinxo, A., Maçi, R., Colangeli, P., Di Giacinto, F. and Conte, A.: A geographical information system for the
749 management of the aquaculture data in the Adriatic Sea–the Strengthening of Centres for Aquaculture Production and Safety
750 surveillance in the Adriatic countries experience: Present capabilities, tools and functions. Geospatial Health, doi:
751 10.4081/gh.2017.593, 2017.
752
753 Uyarra, M.C., Watkinson, A.R. and Côté, I.M.: Managing Dive Tourism for the Sustainable Use of Coral Reefs: Validating
754 Diver Perceptions of Attractive Site Features, Environmental Management 43, 1–16, doi: 10.1007/s00267-008-9198-z, 2009.
755
756 Vogt, H. P.: Economic benefits of tourism in the marine reserve of Apo Island, Philippines: Intercoast Network [Intercoast
757 Network], no. 31, pp. 13-14, 1998.
758
759 Wilhelmsson, D., Öhman, M. C., Ståhl, H. and Shlesinger, Y.: Artificial Reefs and Dive Tourism in Eilat, Israel, Ambio, Vol.
760 27, No. 8, Building Capacity for Coastal Management, pp. 764-766, https://www.jstor.org/stable/4314831 (accessed on
761 17/02/2020), 1998.
762
763 Wilkinson, M. D., Dumontier, M., Aalbersberg, I. J., Appleton, G., Axton, M., Baak, A., Blomberg, N., Boiten, J., Bonino da
764 Silva Santos, L., Bourne, P.E., Bouwman, J., Brookes, A.J., Clark, T., Crosas, M., Dillo, I., Dumon, O., Edmunds, S., Evelo,
765 C.T., Finkers, R., Gonzalez-Beltran, A., Gray, A.J.G., Groth, P., Goble, C., Grethe, J.S., Heringa, J., 't Hoen, P.A.C., Hooft,
766 R., Kuhn, T., Kok, R., Kok, J., Lusher, S.J., Martone, M.E., Mons, A., Packer, A.L., Persson, B., Rocca-Serra, P., Roos, M.,
767 van Schaik, R., Sansone, S., Schultes, E., Sengstag, T., Slater, T., Strawn, G., Swertz, M.A., Thompson., M., van der Lei, J.,
768 van Mulligen, E., Velterop, J., Waagmeester, A., Wittenburg, P., Wolstencroft, K., Zhao, J. and Mons, B.: The FAIR Guiding
769 Principles for scientific data management and stewardship, Scientific data, 3, http://dx.doi.org/10.1038/sdata.2016.18, 2016.
770
771 Zec, D., Fabi, G. and Soldati, M.: Deliverable 3.1.1. Definition of reefs' category. Work Package 3 – Mapping of Adriatic
772 Reefs from different perspectives. Activity 1 – Reefs' classification in the cooperation area. ADRIREEF project, 2019.
773
774 Map of Adriatic reefs: https://adrireef.github.io/sandbox3, last access: 03 November 2020.
775
776 ADRIREEF project page: https://www.italy-croatia.eu/web/adrireef, last access: 03 November 2020.
777
778 Wildlife & Sport Fish Restoration Program: https://www.fws.gov/wsfrprograms/, last access: 03 November 2020.
779
780 Outdoor Alabama Artificial Reefs: https://www.outdooralabama.com/saltwater-fishing/artificial-reefs, last access: 03
781 November 2020.

782

783   Refbase project: http://www.reefbase.org/projects_partners/projects.aspx, last access: 05 February 2021.

784

785   Habitat Artificiali group page: http://www.habitatartificiali.irbim.cnr.it, last access: 03 November 2020.

786

787   CNR-IRBIM website: http://www.irbim.cnr.it/it/index.php, last access: 25 February 2021.

788

789   CAPS2 project: http://www.caps2.eu/caps2/, last access: 03 November 2020.

790

791   Google Forms project: https://www.google.com/forms/about/, last access: 03 November 2020.

792

793   European Environment Agency data and maps: https://www.eea.europa.eu/data-and-maps, last access: 03 November 2020.

794

795   Natura 2000 data and maps: https://ec.europa.eu/environment/nature/natura2000/data/index_en.htm, last access: 03 November
796   2020.

797

798   Habitat Artificiali group page: http://www.habitatartificiali.irbim.cnr.it, last access: 03 November 2020.

799

800   GitHub Pages project: https://pages.github.com/, last access: 03 November 2020.

801

802   Open Street Map project: https://www.openstreetmap.org/, last access: 03 November 2020.

803

804   Searchable Map Template CSV: https://github.com/datamade/searchable-map-template-csv, last access: 03 November 2020.

805

806   SEANOE repository: https://www.seanoe.org/, last access: 03 November 2020.

807

808   Creative Commons Attribution license (v. 4.0): https://creativecommons.org/licenses/by/4.0/deed.it, last access: 03 November
809   2020.