



# 1 The ADRIREEF database: a comprehensive collection of 2 natural/artificial reefs and wrecks in the Adriatic Sea

3

4 Annalisa Minelli<sup>1</sup>, Carmen Ferrà<sup>1\*</sup>, Alessandra Spagnolo<sup>1</sup>, Martina Scanu<sup>1</sup>, Anna Nora Tassetti<sup>1</sup>, Carla  
5 Rita Ferrari<sup>2</sup>, Cristina Mazziotti<sup>2</sup>, Silvia Pigozzi<sup>2</sup>, Zrinka Jakl<sup>3</sup>, Tena Šarčević<sup>3</sup>, Miranda Šimac<sup>3</sup>, Claudia  
6 Kruschel<sup>4</sup>, Dubravko Pejdo<sup>4</sup>, Enrico Barbone<sup>5</sup>, Michele De Gioia<sup>5</sup>, Diego Borme<sup>6</sup>, Emiliano Gordini<sup>6</sup>,  
7 Rocco Auriemma<sup>6</sup>, Ivo Benzon<sup>7</sup>, Đeni Vuković-Stanišić<sup>7</sup>, Sandi Orlić<sup>8</sup>, Vlado Frančić<sup>9</sup>, Damir Zec<sup>9</sup>,  
8 Ivana Orlić Kapović<sup>9</sup>, Michela Soldati<sup>10</sup>, Silvia Ulazzi<sup>10</sup>, Gianna Fabi<sup>1</sup>

9

10 <sup>1</sup>CNR-IRBIM, Largo Fiera della Pesca 1, 60125 Ancona (Italy)

11 <sup>2</sup>ARPAE (Regional Agency for Prevention, Environment And Energy In Emilia Romagna), Via Po 5, 40139 Bologna (Italy)

12 <sup>3</sup>SUNCE (Association for Nature, Environment and Sustainable Development), Obala Hrvatskog Narodnog Preporoda 7/III,  
13 21000, Split (Croatia)

14 <sup>4</sup>University of Zadar, Mihovila Pavlinovica 1, 23000 Zadar (Croatia)

15 <sup>5</sup>ARPA Puglia (Regional Agency for Environmental Prevention and Protection of the Puglia Region), Corso Trieste 27,  
16 70126 Bari (Italy)

17 <sup>6</sup>National Institute of Oceanography and Applied Geophysics - OGS, Borgo Grotta Gigante 42/C, 34010 Sgonico (Italy)

18 <sup>7</sup>RERA (Public Institution RERA SD for Coordination and Development of Split Dalmatia County), Domovinskog Rata 2,  
19 21000 Split (Croatia)

20 <sup>8</sup>Ruder Bošković Institute, Bijenicka 54, 10000 Zagreb (Croatia)

21 <sup>9</sup>University of Rijeka, Faculty of Maritime Studies, Studentska 2, 51000 Rijeka (Croatia)

22 <sup>10</sup>Municipality of Ravenna, Piazza del Popolo 1, 48121, Ravenna (Italy)

23 *Correspondence to:* Carmen Ferrà (carmen.ferravega@cnr.it)

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



## 33 1 Introduction

34 In the Blue Innovation concept, the attractiveness and possible use of existing marine resources which are not yet fully  
35 exploited is relevant to promote sustainable economic development (Vogt, 1998; Orams, 2002; Cater and Cater, 2007; Kiper,  
36 2013; Sakellariadou and Kostopoulou, 2015; Nurhayati et al., 2019) and redefine marine fisheries (Pauly, 2018; Stead, 2018).  
37 In this context, the recognition of less known and appreciated natural reefs (NRs), existing artificial structures (e.g. artificial  
38 reefs, rig-to-reefs; ARs) and wrecks could also be a successful way to pursue Blue Growth as all these sites might be suitable  
39 places for developing or improving sustainable activities such as fishing (both recreational and professional), nautical tourism,  
40 diving and aquaculture (Wilhelmsson et al., 1998; Stolk et al., 2007; Uyarra et al., 2009; Needham, 2010; Edney, 2011;  
41 Spalding et al., 2017; Alempijević and Kovačić, 2019). Therefore, qualitative and quantitative information about the heritage  
42 presence and already existing human activities are fundamental to pursue an ecosystem-based sea use management according  
43 to the Marine Spatial Planning Directive (EU Directive 2014/89/UE; Douvère, 2008; Gilliland and Laffoley, 2008). As MSP  
44 is based on the three pillars for sustainable development – social, economic and environmental – its implementation will  
45 facilitate in turn the enforcement of the Marine Strategy Framework Directive (MSFD, European Commission, 2008) and the  
46 achievement of Good Environmental Status (GES).

47 Basing on the above considerations, this paper presents a comprehensive collection of 285 natural reefs, artificial reefs and  
48 wrecks located in the Adriatic Sea resulting from the joint effort of Italian and Croatian partners participating in the Interreg  
49 Italy-Croatia project ADRIREEF (Innovative exploitation of Adriatic Reefs in order to strengthen blue economy,  
50 <https://www.italy-croatia.eu/web/adrireef>) aimed at assessing the potentiality of reefs in the Adriatic Sea in order to strengthen  
51 the Blue Economy.

52 An analogous attempt of inventory was made on intentionally sunk shipwrecks to serve as ARs over six continents (Ilieva et  
53 al., 2019). Anyway, no wreck was signalled in the Adriatic Sea, whereas available literature (Pivetta et al., 2012) and our  
54 search highlighted the occurrence of several accidentally sunken ships which, anyway, act as artificial habitats. Similar  
55 attempts to geolocalize ARs and wrecks were made along the national coasts and offshore waters of Florida and Alabama  
56 (U.S.A.), by querying municipalities about the deployment of the reefs (U.S. Fish and Wildlife Service, Wildlife & Sport Fish  
57 Restoration Program, <https://www.fws.gov/wsfrprograms/>) as well as in the Gulf of Mexico (Alabama Marine Resources  
58 Division, <https://www.outdooralabama.com/saltwater-fishing/artificial-reefs>). The latter dataset reports all the submerged  
59 structures (including ARs, rig-to-reefs and wrecks) relying on the Gulf of Mexico area, but only name, type of reef and  
60 coordinates are publicly available. Lastly, some efforts were done concerning NRs within the Reefbase project which helped  
61 localize and concisely qualify ~10000 reefs on a global scale (Oliver et al., 2002).

62 Another attempt made to identify aquaculture zones in the Adriatic Sea, also through a webGis application  
63 (<http://www.caps2.eu/caps2/>), enhances zones of production, harvesting and farms (Tara et al., 2017), but does not include  
64 some Italian reefs dedicated to this practice which are present in our database.



65 The collection work presented here is thus an ambitious attempt to gather in a single dataset location, geometries, history and  
66 detailed characteristics of natural reefs, artificial reefs and wrecks existing in the Adriatic Sea. It required a deep knowledge  
67 on the overall status of the sites, their history, past and ongoing research and monitoring programs carried out to characterize  
68 their ecological features as well as on their current exploitation level. In this perspective, the key exercise in Activity 1 of  
69 Work Package 3 of the ADRIREEF project was to obtain a classification of NRs, ARs and wrecks occurring in the cooperation  
70 area and provide a map of these sites from different perspectives.

71 The result is an interactive map and an Open Access detailed dataset (Ferrà et al, 2020) published on EMODnet whose contents  
72 are available for any user and purpose.

## 73 **2 Data mining**

74 Starting from an existing own database of the Adriatic artificial reefs, CNR-IRBIM coordinated the data collection activity to  
75 improve it by developing and sharing among the ADRIREEF partners three online questionnaires on NRs, ARs and wrecks  
76 (Appendix A, B and C, respectively). An initial review of available literature and data was carried out to identify the necessary  
77 information on NRs/ARs and wrecks to be required. Questionnaires were structured in such a way to obtain a unique database  
78 for the two reef typologies and wrecks, including physical, ecological and economic aspects and allowing to classify elements  
79 according to their characteristics. Given the importance of collecting answers quickly and having a structured and  
80 homogeneous database, it became essential to use easy online tools and limit the possibility of free answers by proposing  
81 multiple-response questions (i. e. Google Forms application; <https://www.google.com/forms/about/>).

82 Wrecks were included as a specific category and deserved a dedicated set of questions since they were defined within the  
83 project as accidentally-sunken artificial structures which are attractive for some economic activities (i.e., diving and  
84 recreational fishing).

85 The collected information was used to create the final ADRIREEF database which fed, in turn, a webGis application allowing  
86 the visualization of reefs and wrecks on an interactive map and their selection basing on running queries.

87 . Projects' partners (PPs) were surveyed and answers were harmonized to obtain a consistent database. New features were  
88 defined and used as categories for the elements' classification and/or for the webGis application. Finally, all data properly  
89 checked and harmonized were assembled and used to populate the database.

### 90 **2.1 Literature and available data review**

91 The review of existing literature took into account European environmental databases ([https://www.eea.europa.eu/data-and-](https://www.eea.europa.eu/data-and-maps)  
92 [maps](https://ec.europa.eu/environment/nature/natura2000/data/index_en.htm), [https://ec.europa.eu/environment/nature/natura2000/data/index\\_en.htm](https://ec.europa.eu/environment/nature/natura2000/data/index_en.htm)), research projects carried out by CNR-IRBIM  
93 and other entities, scientific publications and grey literature. Based on the results of the review and expert knowledge, existing  
94 gaps in the information of already known reef sites ad wrecks were identified.



95 With regard to ARs, a large part of inputs came from the existing CNR-IRBIM database of artificial habitats in Italy,  
96 established in 2009 within the Italian Artificial Habitat Group of the Italian Society of Marine Biology (Fabi et al., 2011; Fabi  
97 et al., 2015; <http://www.habitatartificiali.irbim.cnr.it>) and containing more than 500 bibliographic references and information  
98 on 80 Italian artificial habitats. Bibliographic references included scientific publications and grey literature on artificial habitats  
99 such as harbours, breakwaters, fish aggregating devices (FADs), offshore platforms and ARs since 1967. By checking this  
100 database, it was possible to obtain a list of 150 studies regarding the Adriatic ARs published between 1977 and 2017.  
101 Conversely, a similar literature heritage was not present for NRs and wrecks.

## 102 **2.2 Questionnaire design**

103 The analysis of the collected information arose the need of improving existing data especially on NRs and wrecks.  
104 As ARs and NRs have completely different features it was decided to develop two distinct questionnaires. A third questionnaire  
105 was developed for wrecks as they have peculiar characteristics. All questionnaires were built in a systematic way with the aims  
106 of (i) investigating the reefs' and wrecks' suitability for Blue Economy purposes and identifying those answers that would  
107 help to achieve this target; (ii) facilitating experts' participation in the poll by ordering questions into a logical structure.  
108 The identification of the person/s filling in the questionnaires was considered relevant to collect consistent information and  
109 have a contact person in case of missing data. Moreover, numerical information (distances, measures, coordinates) were asked  
110 in specific measurement units to add collected data directly to the database avoiding transformations.

### 111 **2.2.1 Identification of required information**

#### 112 **Natural and artificial reefs**

113 Interrogations about reefs' characteristics that could influence their suitability for sustainable exploitation were posed:

- 114 ● Which is the reef and where is it located?  
115 As a baseline, data regarding the identification of a reef are needed, therefore name and location (in WGS84  
116 Coordinate Reference System and Decimal Degrees) of the reef were required.
- 117 ● Which are the main characteristics of the area where the reef is located?  
118 The environmental characteristics of the area where a reef is located may influence its possible exploitation as well  
119 as its attractiveness to perform some activities, hence the following features were considered: minimum distance to  
120 the coast (km); typology of the surrounding seabed; the presence of meadows; important biocoenoses, alien and  
121 protected species (in case of NRs); possible protection level applied to the area (in case of NRs).
- 122 ● Which are the physical features of the reef?  
123 The reefs' physical features themselves may also influence its potential use, especially for ARs which are handmade  
124 constructed and designed for specific scopes. To answer this fundamental question, multiple information are needed:  
125 the typology of the reef; reef bottom depth (m); reef edge (in meters, for NRs); spatial extension of the reef (m<sup>2</sup>); the



126 origin of the reef (for NRs); the material used for the reef construction (for ARs); structural design of the reef (for  
127 ARs, where it is necessary to know type and number of modules/structures put in place and their layout).

- 128 • Is the reef already managed and/or exploited and/or could it be site for new activities?

129 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  
130 further activities, thus such information is crucial to identify possible synergies and conflicts with additional potential  
131 users. At the same time, the original purpose of an artificial reef turns out to be a key information for better  
132 understanding monitoring and surveillance programs, management plans and possible grants taking place in the area,  
133 as those could also limit or benefit future uses. Therefore, the following information were requested: scope/s for  
134 which an AR was built; if the reef is managed (for both NRs and ARs) and, if yes, who is the management entity; if  
135 a monitoring program is already in place (for both NRs and ARs) and, if yes, its duration and the investigations carried  
136 out; if the reef area is subjected to grant or surveillance service (only for ARs). Furthermore, questions regarding  
137 available data (scientific publications, grey literature, monitoring data) were added to the questionnaires, as they could  
138 help for future research purposes.

### 139 **Wrecks**

140 Either accidentally or purposely sunken shipwrecks are full-fledged artificial structures even though they cannot be considered  
141 as actual artificial reefs. Therefore, they were included into a specific category sharing some information with the reefs and  
142 integrating some extra information about the physical features of wrecks.

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

### 148 **2.3 Harmonisation and construction of the database**

149 Firstly, all data collected from questionnaires were screened to delete duplicates and identify incomplete entries and missing  
150 information, thus making an evaluation of a reef for Blue Economy purposes impossible. For these missing records, a data  
151 integration was asked to the contact person.

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

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



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

### 161 3 Database structure and geographical coverage

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

165 All artificial reefs and most of wrecks fell within the Italian territorial waters, while the majority (79%) of natural reefs was  
166 located within the Croatian ones. The presence of almost all the natural reefs on the eastern side of the studied area is mainly  
167 due to the geological morphology of the Adriatic basin (Stefanon, 1972), while the complete absence of artificial reefs on the  
168 same side is currently due to Croatian legal constraints. It is worth noting that the number of wrecks reported in the Croatian  
169 waters is somewhat underestimated. This fact is due to the lack of basic information about several wrecks (e.g. lack of exact  
170 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  
171 with adequately detailed information. It is also worthy to note that, given the great occurrence of rocky substrates along the  
172 Croatian coast, it was agreed within the ADRIREEF Consortium to identify homogeneous areas and map each of them as a  
173 single natural reef (Zec et al., 2019).

174

	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

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

176

177 The geographical bounding box delimiting the studied area is individuated by the coordinates: (N, S, E, W) = (46.0546,  
178 39.4115, 20.0239, 11.7390), expressed in decimal degrees and Coordinates Reference System WGS84. The database is  
179 available in a unique Comma Separated Values (CSV) file.

180 Table 2 summarizes the structure of the ADRIREEF database specifying the parameters required for each new element: current  
181 name, relative column name, unit of measure, origin of the data (if they come directly from questionnaires or have been created  
182 by the database manager) and possible applicability restrictions. Table 2 also reports, for each parameter, the group it belongs  
183 to. As mentioned in paragraph 2.2.1, Group no. 1 corresponds to reef identification and geolocation information, Group no. 2



184 contains parameters summarizing the characteristics of the area hosting the reef or wreck, Group no. 3 concerns aspects of the  
 185 reefs/wrecks that may also have an effect on its usage, Group no. 4 includes parameters about the present and/or possible future  
 186 reef or wreck exploitation.

187

Column name	Description	Group	Unit of measure	Origin of the data	Applicability restriction
type	type of reef/wreck	1		DB manager	
country		1		DB manager	
region		1		DB manager	
location	reference city or zone for the reef/wreck	1		DB manager	
name	common name of the reef/wreck	1		Questionnaires	
latitude		1	[decimal degrees]	Questionnaires	
longitude		1	[decimal degrees]	Questionnaires	
year_deployment	year of reef deployment/wreck sink	1		Questionnaires	for artificial reefs and wrecks only
year_modification	year of eventual modification	1		Questionnaires	for artificial reefs only
min_depth_m	bottom depth altitude	2	[m]	DB manager	
depth_m	depth range covered by the structure	2	[m]	Questionnaires	
reef_edge_m	height of the structure	2	[m]	Questionnaires	for natural reefs only
min_dist_km	minimum distance from the coastline	2	[km]	Questionnaires	
surrounding_seabed	surrounding seabed sedimentary composition	2		Questionnaires	
meadows	presence of meadows	2		Questionnaires	
reef_typology	reef typology	3		Questionnaires	for natural reefs only
structure_wreck	type of wreck	3		Questionnaires	for wrecks only
material	material composing the reef	3		Questionnaires	for artificial reefs only
arrangement_modules	global arrangement of modules composing the reef	3		Questionnaires	for artificial reefs only



origin_reef	origin of the reef	3		Questionnaires	for natural reefs only
total_area_sqm	total footprint area of the reef	3	[sqm]	Questionnaires	for natural and artificial reefs only
total_volume_cubm	total volume of the reef	3	[cubm]	Questionnaires	for artificial reefs only
n_oases	number of oases, composed by structures	3		Questionnaires	for artificial reefs only
dist_between_oases_m	linear distance between oases	3	[m]	Questionnaires	for artificial reefs only
dimens_oases_sqm	footprint area of the oases	3	[sqm]	Questionnaires	for artificial reefs only
type_structures	type of structures present in the reef, composed of modules	3		Questionnaires	for artificial reefs only
n_structures	number of structures present in the reef	3		Questionnaires	for artificial reefs only
dim_structures_m	relevant dimensions of the structures of the reef	3	[m]	Questionnaires	for artificial reefs only
dist_between_structures_m	linear distance between structures of the reef	3	[m]	Questionnaires	for artificial reefs only
modules_shape	shape of the modules composing the structures of the reef	3		Questionnaires	for artificial reefs only
n_modules	number of modules composing the structures of the reef	3		Questionnaires	for artificial reefs only
dist_between_modules_m	linear distance between modules composing the structures of the reef	3	[m]	Questionnaires	for artificial reefs only
dimension_leng_width_heigh_m	dimensions L H W of the reef/wreck	3	[m, m, m]	Questionnaires	for artificial reefs and wrecks only
weight_or_displacement_tons	weight or displacement of the wreck	3	[tons]	Questionnaires	for wrecks only
experimental_professional	describes the type of exploitation, if professional or experimental, of the reef	4		Questionnaires	for artificial reefs only
scope	describes original conception scopes of the reef	4		Questionnaires	for artificial reefs only
exploitation	current exploitation of the reef/wreck	4		Questionnaires	
possible_exploitation	potential exploitation of the reef/wreck	4		Questionnaires	
observations	additional observations	3		Questionnaires	for wrecks only
biocoenosis	presence (and types, if available) of	2		Questionnaires	for natural reefs





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

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

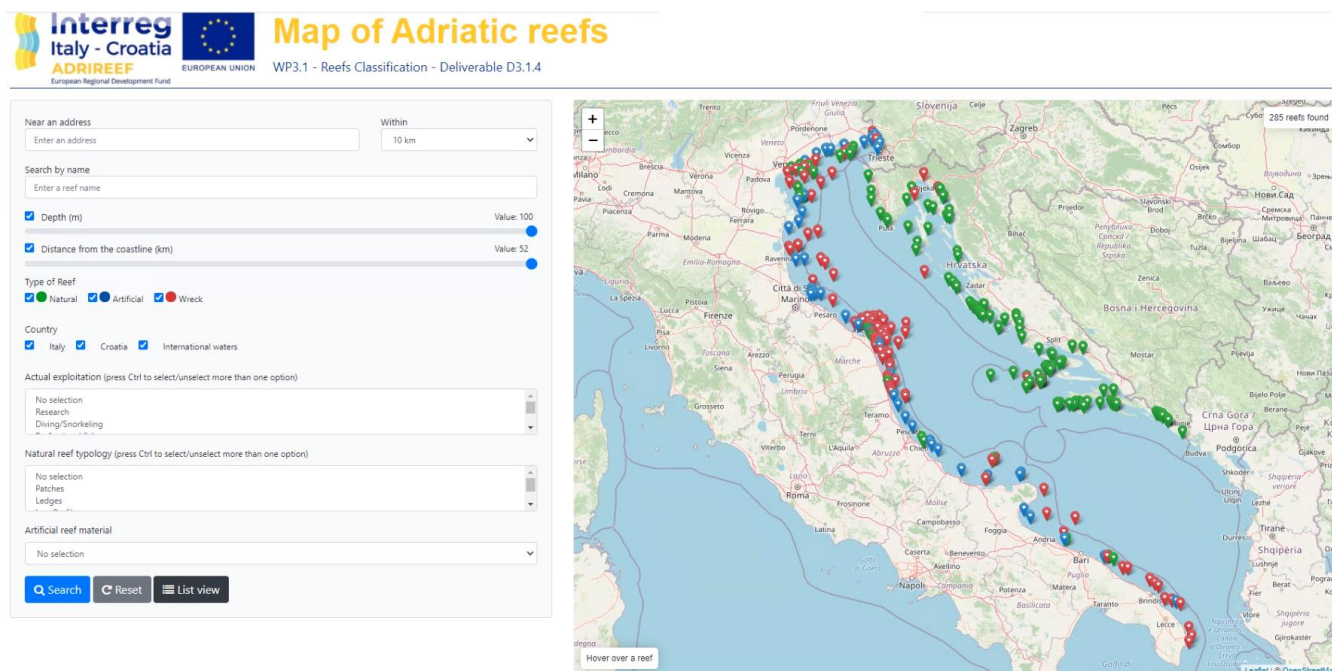
190 **4 Data interrogation and visualization**

191 With the purpose of better exploiting, representing and filtering data, a webGis was created enabling the contemporary filtering  
 192 (where applicable) of more than one of the following selected attributes:

- 193 ● Type of element;
- 194 ● Country;
- 195 ● Minimum depth of the reef/wreck;
- 196 ● Distance from the coastline;
- 197 ● Usage of the reef/wreck;
- 198 ● Reef typology (for natural reefs);
- 199 ● Reef material (for artificial reefs)

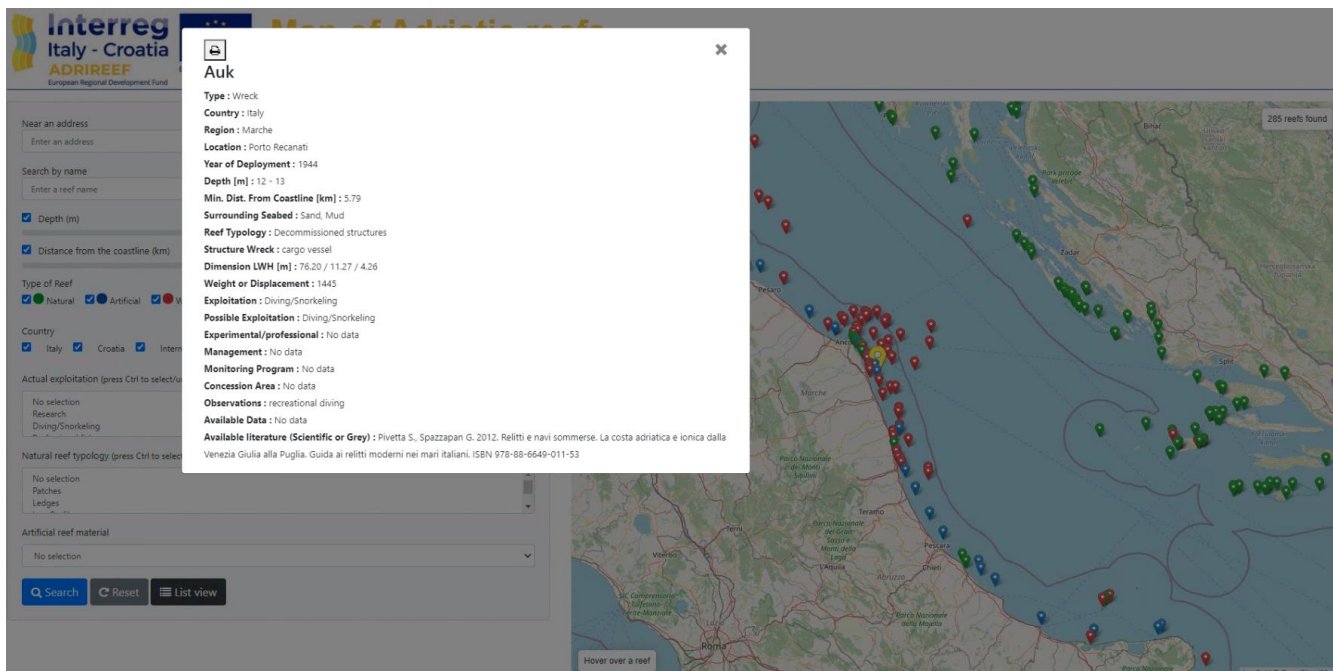


200 The webGis main page is reachable at the address: <https://adrireef.github.io/sandbox3/> and it is composed of two user-friendly  
201 windows (Fig. 1), one reporting all available data filters (left side) and the other one (right side) showing the map where points,  
202 identifying elements, are divided by colour in NRs (green), ARs (blue) and Wrecks (red). Hovering on an element with the  
203 mouse, its Name and Location appear in the left bottom corner of the map.



204  
205 **Figure 1: The webGIS interface. On the left side: the filters window. On the right side: the map window with hover function (bottom**  
206 **left) and the total number of identified elements (top right). Basemap credits: © OpenStreetMap contributors 2020. Distributed**  
207 **under a Creative Commons BY-SA License**

208 The total number of currently visualized elements is reported at the top right of the map. Moreover, when an element is clicked,  
209 a pop-up window appears showing the associated relevant information (Fig. 2). From this pop-up, it is possible to print out  
210 information regarding the selected element in PDF format. From the main page, it is also possible to access to the “List view”  
211 that shows, for the visualized elements, some common information through natural, artificial reefs and wrecks (Fig. 3). The  
212 number of visualized elements, in the top right corner of the map view, is updated accordingly to the output of data filtering  
213 operations.



214  
 215 **Figure 2: Example of a pop up that appears once an element is clicked. Basemap credits: © OpenStreetMap contributors 2020.**  
 216 **Distributed under a Creative Commons BY-SA License**

217



WP3.1 - Reefs Classification - Deliverable D3.1.4

Near an address  
 Enter an address Within 10 km

Search by name  
 Enter a reef name

Depth (m) Value: 56

Distance from the coastline (km) Value: 13

Type of Reef  
 Natural  Artificial  Wreck

Country  
 Italy  Croatia  International waters

Actual exploitation (press Ctrl to select/unselect more than one option)  
 No selection  
 Research  
 Diving/Snorkeling

Natural reef typology (press Ctrl to select/unselect more than one option)  
 No selection  
 Patches  
 Ledges

Artificial reef material  
 No selection

**Search results 206 reefs found**

Name	Type	Country	Region	Location	Depth [m]	Dist. from Coast [km]	Surrounding Seabed	Reef Typology	Exploitation
Eden V	Wreck	Italy	Apulia	Lesina	0 - 0.5	0	Sand	Decommissioned structures	Diving/Snorkeling
Scoglio di San Nicola	Natural reef	Italy	Marche	Grottammare	1.5 - 4.5	0	Sand	Patch reef (sand bottom with small reef structures protruding from the sediment)	Diving/Snorkeling
Rt Kaprije	Natural reef	Croatia	Sibenik-Knin County	Kaprije	45	0	Detritic	High profile reef (the reef protrudes more than 20 meters from the base substratum)	Diving/Snorkeling
Reef Rabac	Natural reef	Croatia	Istria	Prilog peninsula	30 - 50	0	Detritic	Ledges (vertical reef face characterized by visible crevices)	Professional fishery, Recreational fishery
Rt Peneda	Natural reef	Croatia	Istria	NP Brjuni	35	0	Detritic	High profile reef (the reef protrudes more than 20 meters from the base substratum)	Diving/Snorkeling
Marinida Rat	Natural reef	Croatia	Split-Dalmatia County	Šolta	40	0	Detritic	High profile reef (the reef protrudes more than 20 meters from the base substratum)	Diving/Snorkeling
Rt Kobila	Natural reef	Croatia	Split-Dalmatia County	Brač	40	0	Detritic	Ledges (vertical reef face characterized by visible crevices)	Diving/Snorkeling
Margini rat	Natural reef	Croatia	Split-Dalmatia County	Pakleni otoci	40	0	Detritic	High profile reef (the reef protrudes more than 20 meters from the base substratum)	Diving/Snorkeling

218  
 219 **Figure 3: List view. Once elements are selected, it is possible to obtain some common information by clicking the appropriate button.**



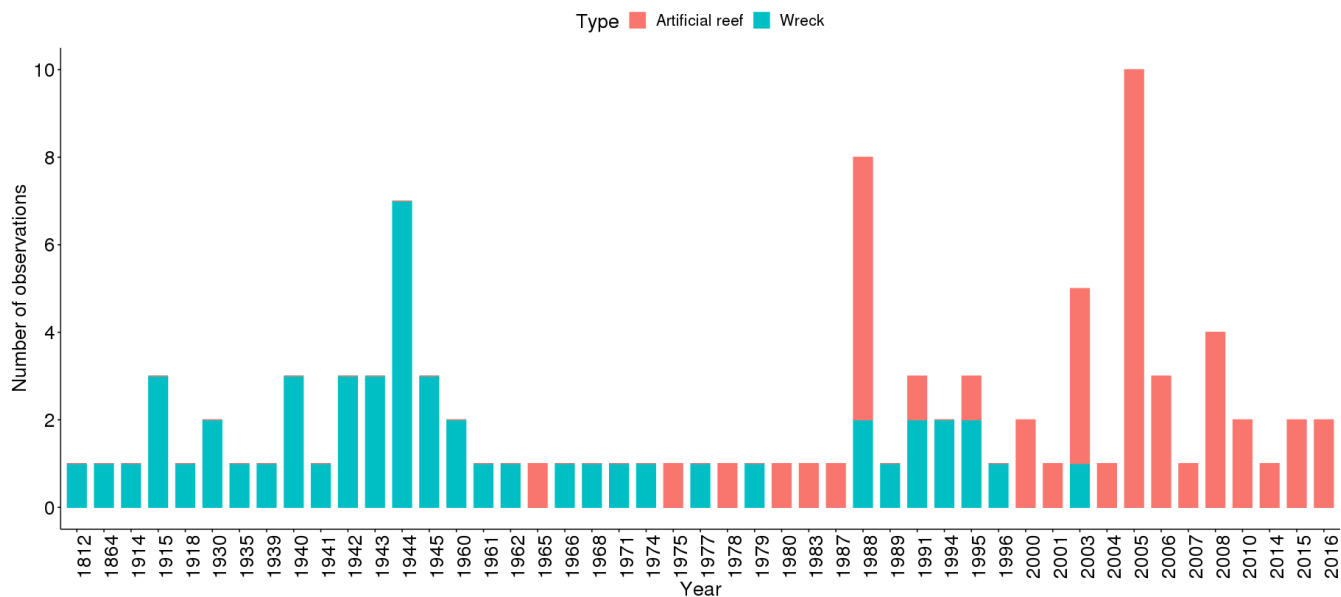
220

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

## 228 5 Data analysis

229 Data contained in the database can be analysed in many different ways and for different purposes. For example, Figure 4,  
230 representing the wrecks’ sink and the artificial reefs’ deployment on time (excluding missing information elements), shows  
231 that until the 2000s the majority of artificial structures existing in the Adriatic Sea were represented by wrecks, most of which  
232 accidentally sunken. Afterwards, almost all the manmade structures deployed on the seabed were purposely constructed  
233 artificial reefs.

234



235

236 **Figure 4. Artificial reefs and wrecks by year of deployment.**

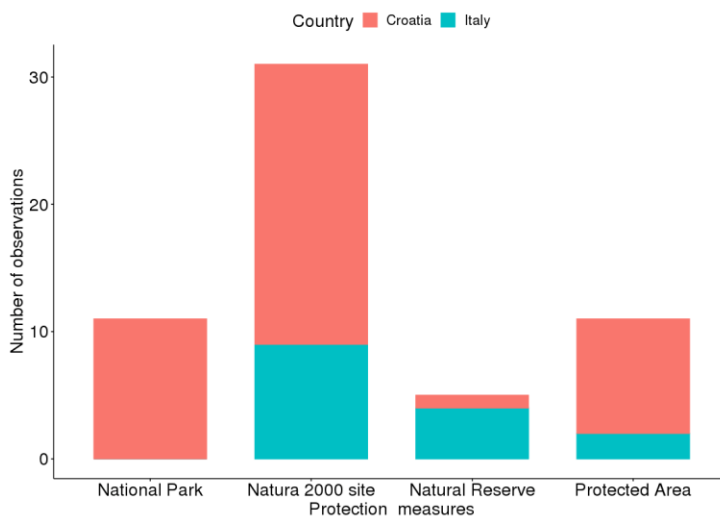
237



238 Another interesting example of analysis that can be performed on data is the evaluation of the number of natural reefs subjected  
239 to any form of protection. Again, after deduction of “No data”, it is possible to identify 31 Natura 2000 sites, 12 Protected  
240 areas, 4 Natural reserves and 11 National parks (Fig. 5) with an overlapping at some sites. Figure 5 also shows how NRs are  
241 distributed in these categories through Italian and Croatian waters. Coupling this graph with the information contained in Table  
242 1, it results that almost the totality of the Italian natural reefs is subjected to some form of protection, while only half of the  
243 Croatian ones are under preservation constraints.

244 Also, the 3D representation of the sites can be useful for divulgation purposes. For example, in Figure 6 (A) all reefs and  
245 wrecks are reported over a bathymetric map of the Adriatic Sea. A section of the Tremiti Islands (Apulia, Italy), connecting  
246 three observations of the database is reported in the zoom (B).

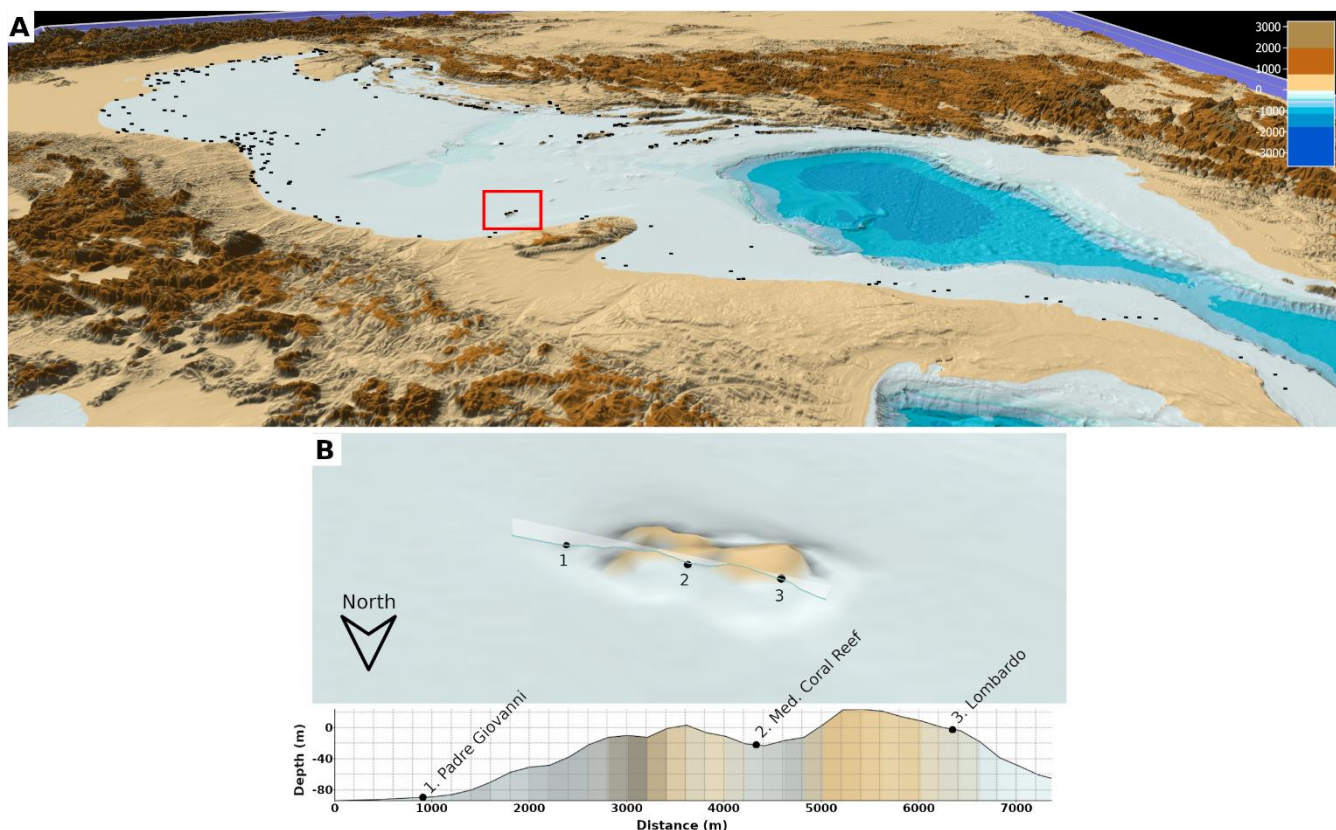
247



248

249 **Figure 5. Protection measures insisting on Natural Reefs both in Croatia and in Italy.**

250



251

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

## 256 6 Data availability

257 The database (Ferrà et al., 2020) is currently available for download from EMODnet (European Marine Observation Data  
258 network, Novellino et al., 2015) through the SEANOE (<https://www.seanoe.org/>) repository and it is reachable at the following  
259 address: <https://doi.org/10.17882/74880>. EMODnet was chosen for two main reasons: it ensures long-term data availability  
260 and has increasingly become a reference point for all available European marine data (Martín Míguez et al., 2019). In fact, the  
261 platform was financed in the framework of EU's Integrated Maritime Policy definition (Commission of the European  
262 Community, 2007) to unlock existing but fragmented and hidden marine data and make them freely accessible for a wide range  
263 of users (Calewaert et al., 2016), while respecting FAIR data management principles (Findable, Accessible, Interoperable,  
264 Reusable; Wilkinson et al., 2016). In this way, an invaluable heritage of marine data was collected and all data uploaded in  
265 EMODnet are indexed in Web Of Science. The database was released under Creative Commons Attribution license (CC-BY,  
266 v. 4.0, <https://creativecommons.org/licenses/by/4.0/deed.it>)



267 **7 Conclusions**

268 The data collection work and publication represent an unprecedented, consistent and robust recognition of the reefs and wrecks  
269 in the Adriatic Sea. The database fully accomplished the purposes for which it was developed as it represents a comprehensive  
270 collection providing a well-detailed state of the art and some hints on possible/future exploitation of reefs and wrecks in this  
271 geographical zone.

272 Indeed, the collected information can be useful for different purposes, from spatial management, to the strengthening of some  
273 economic activities and/or development of new ones taking into account the local environmental features.

274 Knowing the environmental status and current exploitation level of reefs located in a specific geographical area is in fact  
275 fundamental to identify potential additional ecosystem services that those reefs can provide and, consequently, develop  
276 sustainable economic activities with subsequent positive impacts on the local communities (Costanza et al., 2014). In addition,  
277 from the research point of view, a comprehensive database like the one presented here could be a starting point for the  
278 implementation of ecological studies where the information is still scarce or lacking as well as of monitoring programmes  
279 aimed at evaluating the impact of some economic activities (e.g., tourism) on sensitive habitats.

280 Lastly, the interactive map represents a tool that allows, through the simultaneous usage of different filters, to highlight and  
281 quantify particularly interesting situations in a user-friendly and quick manner, so to be also easily handled by the wide public.  
282 It could be, for example, used by tourists to identify suitable and less known sites for recreational activities such as snorkelling,  
283 diving and sailing.

284 In the overall, the provided collection can be helpful to increase visibility and attractiveness of reefs and wrecks existing in the  
285 Adriatic Sea while increasing awareness of both policy makers and citizens towards the need of managing and exploiting these  
286 sites in a sustainable way in order to assure their preservation over time.

287 The general perception derived from an overall evaluation of the collected data is that, in the Adriatic context, reefs and wrecks  
288 still represent an underestimated environmental heritage that, if adequately preserved and promoted, could provide in the near  
289 future new opportunities for developing activities in line with the Blue Economy.

290



291 **Appendices**

292 **Appendix A: Natural Reefs Questionnaire**

- 293 1. Name and Surname: .....
- 294 2. Occupational qualification and workplace: .....
- 295 3. Name of the reef: .....
- 296 4. Location of the reef: .....
- 297 5. Geographical coordinates Latitude (WGS84 DD.DD. e.g. 43.023N): .....
- 298 6. Geographical coordinates Longitude (WGS84 DD.DD. e.g. 13.123N): .....
- 299 7. Reef bottom depth (m) (If it is in a range, please specify the max and min): .....
- 300 8. Reef edge (m): .....
- 301 9. Minimum distance from the coast (km): .....
- 302 10. Total area occupied by the Natural Reef (m<sup>2</sup>): .....
- 303 11. Typology of the reef:
- 304  High profile reef (the reef protrudes more than 20 meters from the base substratum)
- 305  Low profile reef (the reef protrudes less than 20 meters from the base substratum)
- 306  Ledges (vertical reef face characterized by visible crevices)
- 307  Boulder reef (structure elevating from the flat seabed)
- 308  Patch reef (sand bottom with small reef structures protruding from the sediment)
- 309  I don't know
- 310 12. Origin of the reef:
- 311  Biogenic
- 312  Geogenic
- 313 13. Type of surrounding seabed:
- 314  Rocks
- 315  Sand
- 316  Mud
- 317  Detritic
- 318  Gravel
- 319  Other
- 320 14. Occurrence of meadows?
- 321  Yes, phanerogams
- 322  Yes, algae
- 323  no
- 324 15. Which are the most important biocenoses? .....
- 325 16. Any alien species?
- 326  Yes
- 327  No
- 328  Maybe
- 329 17. If "Yes", which alien species? .....
- 330 18. Any protected species? (e.g. IUCN Red List of Threatened Species, ASPIM Protocol, Berna Convention, etc.)
- 331  Yes
- 332  No
- 333  Maybe
- 334  If "Yes", which species?





- 335 19. Is the natural reef within a protected area?  
336  Yes, MPA  
337  Yes, Natura 2000 site  
338  Yes, National park  
339  Yes, Natural park  
340  Yes, Marine reserve  
341  No
- 342 20. Is the reef managed?  
343  Yes  
344  No  
345  I don't know
- 346 21. If yes, which is the Managing Subject? (Please give a short summary of the management measures adopted)  
347 22. Does exist a monitoring program?  
348  Yes  
349  No
- 350 23. If "Yes" please give a short summary of the program .....  
351 24. Surveillance service?  
352  Yes  
353  No
- 354 25. Current use of the Reef:  
355  Diving  
356  Mariculture  
357  Research  
358  Professional fishery  
359  Recreation fishery  
360  Fishing tourism  
361  Nothing  
362  Other (please, specify) .....
- 363 26. Development perspectives of the Natural Reef:  
364  Diving  
365  Mariculture  
366  Research  
367  Professional fishery  
368  Recreation fishery  
369  Fishing tourism  
370  Nothing  
371  Other (please, specify) .....
- 372 27. Please list the available data (If "Other" please specify):  
373  Geophysical map  
374  Water column  
375  Sediments  
376  Benthic community  
377  Fish community  
378  Other (please, specify) .....
- 379 28. Available literature (Scientific or Grey):  
380 (Please add as many papers/works you know about the reef using the scheme:  
381 1 Title/ 2 Authors / 3 Year of publication / 4 Journal or project / 5 Pages / 6 Abstract / 7 Keywords)  
382



## 383 Appendix B: Artificial Reefs Questionnaire

- 384 1. Name and Surname: .....
- 385 2. Occupational qualification and workplace: .....
- 386 3. Name of the reef: .....
- 387 4. Location of the reef: .....
- 388 5. Geographical coordinates Latitude (WGS84 DD.DD. e.g. 43.023N): .....
- 389 6. Geographical coordinates Longitude (WGS84 DD.DD. e.g. 13.123N): .....
- 390 7. Year of deployment of the AR: .....
- 391 8. Year of modification of the AR: .....
- 392 9. Bottom depth (m) (If it is in a range, please specify the max and min): .....
- 393 10. Minimum distance from the coast (km): .....
- 394 11. Type of surrounding seabed:
- 395  Rocks
- 396  Sand
- 397  Mud
- 398  Detritic
- 399  Gravel
- 400  Other (please, specify) .....
- 401 12. Occurrence of meadows?
- 402  Yes, phanerogams
- 403  Yes, algae
- 404  No

### 405 ARTIFICIAL REEF STRUCTURE

- 406 1. Reef typology:
- 407  Specifically designed modules (basic module)
- 408  Decommissioned structures
- 409  Other (please, specify) .....

#### 410 Specifically designed modules (basic module)

- 411 1. Material:
- 412  Concrete
- 413  Sea-friendly concrete (e.g., Tecnoreef)
- 414  Coal Ash
- 415  Rocks
- 416  Fiberglass
- 417  Other (please specify) .....
- 418 2. Shape of the single module:
- 419  Cube
- 420  Pole
- 421  Plinth
- 422  Other (please, specify) .....
- 423 3. Dimension of the single module (m): .....
- 424 4. Total volume of deployed material (m<sup>3</sup>): .....
- 425 5. Arrangement of the modules:
- 426  Geometrically assembled to form structures
- 427  Scattered



- 428  Other (please, specify) .....
- 429 **Artificial Reef geometrically assembled to form structures**
- 430 1. Typology (e.g., pyramid): .....
- 431 2. Number of deployed structures: .....
- 432 3. Height of the structures (m): .....
- 433 4. Distance among structures (m): .....
- 434 **Scattered Artificial Reef**
- 435 1. Number of deployed structures: .....
- 436 2. Distance between structures (m): .....
- 437 **If the Artificial Reef is composed by areas or oases, please indicate:**
- 438 1. Number of the oases: .....
- 439 2. Distance among oases: .....
- 440 3. Dimension of each oasis (m<sup>2</sup>): .....
- 441 4. Total area occupied by the Artificial Reef (including the area covered by the bodies, the distance between the bodies
- 442 and the area of respect) (m<sup>2</sup>): .....
- 443 **Decommissioned structures**
- 444 **Please specify the nature of the structure:**
- 445  Offshore extraction platform
- 446  Purposely sunk vessel/ship
- 447  Other (please, specify) .....
- 448 **Offshore extraction platform:**
- 449 1. Type of the platform (e.g., one-leg platform): .....
- 450 2. Part of the platform used to realize the AR (e.g., jacket, deck): .....
- 451 3. Total area occupied by the Artificial Reef (m<sup>2</sup>): .....
- 452 **Purposely sunk vessel/ship:**
- 453 1. Number of sunk vessels: .....
- 454 2. Vessel material:
- 455  Wood
- 456  Iron
- 457  Fiberglass
- 458  Other (please, specify) .....
- 459 3. Dimension of the sunk vessel/ship - LFT (m) and Weight (ton): .....
- 460 **Other Artificial Reefs:**
- 461 1. Number of bodies: .....
- 462 2. Material of bodies:
- 463  Wood
- 464  Iron
- 465  Fiberglass
- 466  Concrete
- 467  Other (please, specify) .....
- 468 3. Dimension of each body - length (m) and Weight (ton): .....
- 469 **ARTIFICIAL REEF UTILIZATION**
- 470 1. Scope:
- 471  Habitat protection
- 472  Habitat restoration
- 473  Finfish enhancement



- 474  Diving  
475  Mariculture  
476  Research  
477  Professional fishery  
478  Recreational fishery  
479  Fishing tourism  
480  Other (please, specify) .....
- 481 2. Type of Artificial Reef:  
482  Experimental  
483  Professional
- 484 3. Is the Reef exploited at present?  
485  Yes  
486  No  
487  Maybe  
488 If “Yes”, by whom? .....
- 489 4. Does exist a management program?  
490  Yes  
491  No  
492  Maybe  
493 If “Yes”, please specify the Managing Subject and give a short summary of the adopted management measures  
494 .....
- 495 5. Concession area?  
496  Yes  
497  No
- 498 6. Surveillance service?  
499  Yes  
500  No
- 501 7. Does exist a monitoring program?  
502  Yes  
503  No  
504  Maybe  
505 If “Yes”, please give a short summary (Duration / Monitored aspects / Involved Institute or Agency /address, e-mail  
506 address) .....
- 507 8. Possible exploitation of the Artificial Reef:  
508  Diving  
509  Mariculture  
510  Research  
511  Professional fishery  
512  Recreational fishery  
513  Fishing tourism  
514  Nothing  
515  Other (please, specify) .....
- 516 9. Please list the available data:  
517  Geophysical map  
518  Water column  
519  Sediments  
520  Benthic community  
521  Fish community  
522  Other (please, specify) .....



- 523 10. Available literature (Scientific or Grey):  
524 (Please add as many papers/works you know about the reef using the scheme: 1 Title/ 2 Authors / 3 Year of  
525 publication / 4 Journal or project / 5 Pages / 6 Abstract / 7 Keywords)  
526



## 527 Appendix C: Wreck Questionnaire

- 528 1. Name and Surname: .....
- 529 2. Occupational qualification and workplace: .....
- 530 3. Name of the Wreck: .....
- 531 4. Location of the Wreck: .....
- 532 5. Geographical coordinates Latitude (WGS84 DD.DD. e.g. 43.023N): .....
- 533 6. Geographical coordinates Longitude (WGS84 DD.DD. e.g. 13.123N): .....
- 534 7. Year of accidental sinking of the Wreck: .....
- 535 8. Bottom depth (m) (If it is in a range, please specify the max and min): .....
- 536 9. Minimum distance from the coast (km): .....
- 537 10. Type of surrounding seabed:
- 538  Rocks
- 539  Sand
- 540  Mud
- 541  Detritic
- 542  Gravel
- 543  Other (please, specify) .....
- 544 11. Occurrence of meadows?
- 545  Yes, phanerogams
- 546  Yes, algae
- 547  No
- 548 12. Vessel material:
- 549  Wood
- 550  Iron
- 551  Fiberglass
- 552  Other (please, specify) .....
- 553 13. Total area occupied by the Wreck (m<sup>2</sup>): .....
- 554 14. Total volume of the Wreck (m<sup>3</sup>): .....
- 555 15. Eventual fragments of the Wreck and their spatial configuration:.....
- 556 16. Dimension of the sunk vessel/ship - LFT (m) and Weight (ton): .....
- 557 17. Is the Wreck exploited at present?
- 558  Yes
- 559  No
- 560  Maybe
- 561 If “Yes”, by whom? .....
- 562 18. Does exist a management program?
- 563  Yes
- 564  No
- 565  Maybe
- 566 If “Yes”, please specify the Managing Subject and give a short summary of the adopted management measures
- 567 .....
- 568 19. Concession area?
- 569  Yes
- 570  No
- 571 20. Surveillance service?



- 572  Yes  
573  No  
574 21. Does exist a monitoring program?  
575  Yes  
576  No  
577  Maybe  
578 If “Yes”, please give a short summary (Duration / Monitored aspects / Involved Institute or Agency /address, e-mail  
579 address) .....
- 580 22. Possible exploitation of the Wreck:  
581  Diving  
582  Mariculture  
583  Research  
584  Professional fishery  
585  Recreational fishery  
586  Fishing tourism  
587  Nothing  
588  Other (please, specify) .....
- 589 23. Please list the available data:  
590  Geophysical map  
591  Water column  
592  Sediments  
593  Benthic community  
594  Fish community  
595  Other (please, specify) .....
- 596 24. Available literature (Scientific or Grey):  
597 (Please add as many papers/works you know about the reef using the scheme: 1 Title/ 2 Authors / 3 Year of  
598 publication / 4 Journal or project / 5 Pages / 6 Abstract / 7 Keywords)  
599



600 **Author contribution**

601 AM, CF, GF and ANT worked to the conceptualization of the paper; AM and CF analysed the data and wrote the original  
602 draft; AM, ANT, GF, AS, MSc, MSo, DB reviewed and edited the manuscript; CF, AS, MSc, ANT, GF, CRF, CM, SP, ZJ,  
603 TŠ, MŠ, CK, DP, EB, MDG, DB, EG, RA, IB, ĐVS, SO, VF, DZ, IOK, MSo, SU contributed to the collection and curation  
604 of data described in this paper; AM worked at data visualization; GF supervised the whole work.

605 **Competing interests**

606 Authors declare that they have no conflict of interest.

607 **Funding**

608 The present work was funded by the European Regional Development Fund in the frame of the project ADRIREEF (Innovative  
609 exploitation of Adriatic Reefs in order to strengthen blue economy), project ID: 10045901. Interreg VA Italy Croatia Cross-  
610 border Cooperation Programme 2014-2020.

611 **References**

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

614

615 Calewaert, J.B., Weaver, P., Gunn, V., Gorringer, P. and Novellino, A.: The European Marine Data and Observation Network  
616 (EMODnet): Your Gateway to European Marine and Coastal Data. In: Zerr B. et al. (eds) *Quantitative Monitoring of the*  
617 *Underwater Environment. Ocean Engineering & Oceanography*, vol 6. Springer, Cham. [https://doi.org/10.1007/978-3-319-](https://doi.org/10.1007/978-3-319-32107-3_4)  
618 [32107-3\\_4](https://doi.org/10.1007/978-3-319-32107-3_4), 2016.

619

620 Cater, C. and Cater, E.: *Marine ecotourism: Between the devil and the deep blue sea (Vol. 6)*, Cab Intl, ISBN: 9781845932596,  
621 2007.

622

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

626





- 627 Costanza, R., De Groot, R., Sutton, P., Van der Ploeg, S., Anderson, S. J., Kubiszewski, I., Farber, S. and Turner, R. K.:  
628 Changes in the global value of ecosystem services. *Global environmental change*, 26, 152-158, doi:  
629 [10.1016/j.gloenvcha.2014.04.002](https://doi.org/10.1016/j.gloenvcha.2014.04.002), 2014.
- 630
- 631 Douvère, F.: The importance of marine spatial planning in advancing ecosystem-based sea use management. *Marine Policy*  
632 32(5):762–71, <https://doi.org/10.1016/j.marpol.2008.03.021>, 2008.
- 633
- 634 Edney, J.: Understanding wreck divers: Case studies from Australia and Chuuk Lagoon, In *Proceedings of the Asia-Pacific*  
635 *Regional Conference on Underwater Cultural Heritage: 8–12 November (pp. 575-587)*, 2011.
- 636
- 637 European Commission: Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a  
638 framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive), 164,  
639 2008.
- 640
- 641 Fabi, G., Spagnolo, A., Bellan-Santini, D., Charbonnel, E., Çiçek, B. A., García, J. J. G., Jensen, A. C., Kallianiotis, A. and  
642 Santos, M. N. D.: Overview on artificial reefs in Europe, *Brazilian journal of oceanography*, 59(SPE1), 155-166, doi:  
643 [10.1590/S1679-87592011000500017](https://doi.org/10.1590/S1679-87592011000500017), 2011.
- 644
- 645 Fabi, G., Sarcella, G., Spagnolo, A., Bortone, S. A., Charbonnel, E., Goutayer, J. J., Naoufel, H., Lök, A. and Trommelen, M.:  
646 Practical guidelines for the use of artificial reefs in the Mediterranean and the Black Sea. *General Fisheries Commission for*  
647 *the Mediterranean. Studies and Reviews*, (96), I., ISSN: 1020-9549, 2015.
- 648
- 649 Ferrà, C., Minelli, A., Spagnolo, A., Scanu, M., Tassetti, A. N., Ferrari, C. R., Mazziotti, C., Pigozzi, S., Jakl, Z., Šarčević, T.,  
650 Šimac, M., Kruschel, C., Pejdo, D., Barbone, E., De Gioia, M., Borme, D., Gordini, E., Auriemma, R., Benzon, I., Vuković-  
651 Stanišić, Đ., Orlić, S., Frančić, V., Zec, D., Orlić Kapović, I., Soldati, M., Uliazzi, S. and Fabi, G.: The ADRIREEF database:  
652 natural/artificial reefs and wrecks in the Adriatic Sea. *SEANOE*. <https://doi.org/10.17882/74880>, 2020.
- 653
- 654 Gilliland, P. M. and Laffoley, D.: Key elements and steps in the process of developing ecosystem-based marine spatial  
655 planning. *Marine Policy*, 32(5), 787-796, doi: [10.1016/j.marpol.2008.03.022](https://doi.org/10.1016/j.marpol.2008.03.022), 2008.
- 656
- 657 Ilieva, I., Jouvét, L., Seidelin, L., Best, B. D., Aldabet, S., da Silva, R. and Conde, D. A.: A global database of intentionally  
658 deployed wrecks to serve as artificial reefs. *Data in brief*, 23, 103584, <https://doi.org/10.1016/j.marpol.2008.03.021>, 2019.
- 659
- 660 Kiper, T.: Role of ecotourism in sustainable development, *InTech*, 773-802, <http://dx.doi.org/10.5772/55749>, 2013.



- 661
- 662 Llewellyn, L. E., English, S. and Barnwell, S.: A roadmap to a sustainable Indian Ocean blue economy. *Journal of the Indian*
- 663 *Ocean Region*, 12(1), 52-66, doi: 10.1080/19480881.2016.1138713, 2016.
- 664
- 665 Martín Míguez, B., Novellino, A., Vinci, M., Claus, S., Calewaert, J.B., Vallius, H., Schmitt, T., Pititto, A., Giorgetti, A.,
- 666 Askew, N., Iona, S., Schaap, D., Pinardi, N., Harpham, Q., Kater, B.J., Populus, J., She, J., Palazov, A.V., McMeel, O., Oset,
- 667 P., Lear, D., Manzella, G.M.R., Gorringer, P., Simoncelli, S., Larkin, K., Holdsworth, N., Arvanitidis, C.D., Molina Jack, M.E.,
- 668 Chaves Montero, M.M., Herman, P.M.J. and Hernandez, F.: The European Marine Observation and Data Network
- 669 (EMODnet): Visions and Roles of the Gateway to Marine Data in Europe. *Front. Mar. Sci.* 6:313.
- 670 <http://doi.org/10.3389/fmars.2019.00313>, 2019.
- 671
- 672 Needham, M. D.: Value orientations toward coral reefs in recreation and tourism settings: a conceptual and measurement
- 673 approach, *Journal of Sustainable Tourism*, 18:6, 757-772, <http://doi.org/10.1080/09669581003690486>, 2010.
- 674
- 675 Novellino, A., D'Angelo, P., Benedetti, G., Manzella, G., Gorringer, P., Schaap, D., Pouliquen, S. and Rickards, L.: European
- 676 marine observation data network - EMODnet physics. In *OCEANS 2015 - Genova* (pp. 1-6). IEEE.
- 677 <http://doi.org/10.1109/OCEANS-Genova.2015.7271548>, 2015.
- 678
- 679 Nurhayati, A., Aisah, I. and Supriatna, A. K.: Model Development of A Synergistic Sustainable Marine Ecotourism - A Case
- 680 Study in Pangandaran Region, West Java Province, Indonesia, *Sustainability*, 11(12), 3418,
- 681 <http://doi.org/10.3390/su11123418>, 2019.
- 682
- 683 Oliver, J., Noordeloos, M., Yusuf, Y., Tan, M., Nayan, N., Foo, C. and Shahriyah, F.: ReefBase: a global information system
- 684 on coral reefs. WorldFish Center, ReefBase Project., 2002.
- 685
- 686 Orams, M. B.: Marine ecotourism as a potential agent for sustainable development in Kaikoura, New Zealand, *International*
- 687 *Journal of Sustainable Development* 5(3):338-352, <http://doi.org/10.1504/IJSD.2002.003757>, 2002.
- 688
- 689 Pauly, D.: A vision for marine fisheries in a global blue economy, *Marine Policy*, 87, 371-374.,
- 690 <https://doi.org/10.1016/j.marpol.2017.11.010>, 2018.
- 691
- 692 Sakellariadou, F. and Kostopoulou, E.: Marine ecotourism from the perspective of the blue growth, Conference 7th iConEc
- 693 Conference Competitiveness and Stability in the Knowledge-based Economy, Craiova, Romania,



694 [https://www.researchgate.net/publication/317142241\\_Marine\\_ecotourism\\_from\\_the\\_perspective\\_of\\_blue\\_growth](https://www.researchgate.net/publication/317142241_Marine_ecotourism_from_the_perspective_of_blue_growth) (accessed  
695 on 17/02/2020), 2015.

696

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

699

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

702

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

705

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

708

709 Tora, S., Sacchini, S., Listeš, E., Bogdanović, T., Di Lorenzo, A., Smajlović, M., Filipović, J. V., Tahirović, V., Šuković, D.,  
710 Beljkas, B., Xinxo, A., Maçi, R., Colangeli, P., Di Giacinto, F. and Conte, A.: A geographical information system for the  
711 management of the aquaculture data in the Adriatic Sea—the Strengthening of Centres for Aquaculture Production and Safety  
712 surveillance in the Adriatic countries experience: Present capabilities, tools and functions. *Geospatial Health*, doi:  
713 10.4081/gh.2017.593, 2017.

714

715 Uyarra, M.C., Watkinson, A.R. and Côté, I.M.: Managing Dive Tourism for the Sustainable Use of Coral Reefs: Validating  
716 Diver Perceptions of Attractive Site Features, *Environmental Management* 43, 1–16, doi: 10.1007/s00267-008-9198-z, 2009.

717

718 Vogt, H. P.: Economic benefits of tourism in the marine reserve of Apo Island, Philippines: Intercoast Network [Intercoast  
719 Network], no. 31, pp. 13-14, 1998.

720

721 Wilhelmsson, D., Öhman, M. C., Ståhl, H. and Shlesinger, Y.: Artificial Reefs and Dive Tourism in Eilat, Israel, *Ambio*, Vol.  
722 27, No. 8, *Building Capacity for Coastal Management*, pp. 764-766, <https://www.jstor.org/stable/4314831> (accessed on  
723 17/02/2020), 1998.

724

725 Wilkinson, M. D., Dumontier, M., Aalbersberg, I. J., Appleton, G., Axton, M., Baak, A., Blomberg, N., Boiten, J., Bonino da  
726 Silva Santos, L., Bourne, P.E., Bouwman, J., Brookes, A.J., Clark, T., Crosas, M., Dillo, I., Dumon, O., Edmunds, S., Evelo,  
727 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., Hooff,



- 728 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.,  
729 van Schaik, R., Sansone, S., Schultes, E., Sengstag, T., Slater, T., Strawn, G., Swertz, M.A., Thompson, M., van der Lei, J.,  
730 van Mulligen, E., Velterop, J., Waagmeester, A., Wittenburg, P., Wolstencroft, K., Zhao, J. and Mons, B.: The FAIR Guiding  
731 Principles for scientific data management and stewardship, *Scientific data*, 3, <http://dx.doi.org/10.1038/sdata.2016.18>, 2016.  
732
- 733 Zec, D., Fabi, G. and Soldati, M.: Deliverable 3.1.1. Definition of reefs' category. Work Package 3 – Mapping of Adriatic  
734 Reefs from different perspectives. Activity 1 – Reefs' classification in the cooperation area. ADRIREEF project, 2019.  
735
- 736 Map of Adriatic reefs: <https://adrireef.github.io/sandbox3>, last access: 03 November 2020.  
737
- 738 ADRIREEF project page: <https://www.italy-croatia.eu/web/adrireef>, last access: 03 November 2020.  
739
- 740 Wildlife & Sport Fish Restoration Program: <https://www.fws.gov/wsfrprograms/>, last access: 03 November 2020.  
741
- 742 Outdoor Alabama Artificial Reefs: <https://www.outdooralabama.com/saltwater-fishing/artificial-reefs>, last access: 03  
743 November 2020.  
744
- 745 CAPS2 project: <http://www.caps2.eu/caps2/>, last access: 03 November 2020.  
746
- 747 Google Forms project: <https://www.google.com/forms/about/>, last access: 03 November 2020.  
748
- 749 European Environment Agency data and maps: <https://www.eea.europa.eu/data-and-maps>, last access: 03 November 2020.  
750
- 751 Natura 2000 data and maps: [https://ec.europa.eu/environment/nature/natura2000/data/index\\_en.htm](https://ec.europa.eu/environment/nature/natura2000/data/index_en.htm), last access: 03 November  
752 2020.  
753
- 754 Habitat Artificiali group page: <http://www.habitatartificiali.irbim.cnr.it>, last access: 03 November 2020.  
755
- 756 GitHub Pages project: <https://pages.github.com/>, last access: 03 November 2020.  
757
- 758 Open Street Map project: <https://www.openstreetmap.org/>, last access: 03 November 2020.  
759
- 760 Searchable Map Template CSV: <https://github.com/datamade/searchable-map-template-csv>, last access: 03 November 2020.  
761
- 762 SEANOE repository: <https://www.seanoe.org/>, last access: 03 November 2020.

<https://doi.org/10.5194/essd-2020-384>  
Preprint. Discussion started: 29 December 2020  
© Author(s) 2020. CC BY 4.0 License.



763  
764 Creative Commons Attribution license (v. 4.0): <https://creativecommons.org/licenses/by/4.0/deed.it>, last access: 03 November  
765 2020.