Anthropogenic underwater noise sources information database

Final Version of 19/09/2019

Deliverable Number D.3.1.1.

Project Acronym	SOUNDSCAPE
Project ID Number	10043643
Project Title	Soundscapes in the north Adriatic Sea and their impact on marine biological resources
Priority Axis	3
Specific Objective	3.2
Work Package Number	3
Work Package Title	Soundscape assessment
Activity Number	3.1
Activity Title	Review and analysis of the sources of anthropogenic underwater noise in the Northern Adriatic Sea
Partner in Charge	CNR
Partners Involved	CNR; BWI; IOF, ARPA-FVG
Authors	Michol Ghezzo (CNR-ISMAR), Fantina Madricardo (CNR-ISMAR), Giulio Farella (CNR-ISMAR), Stefano Menegon (CNR_ISMAR), Iole Lenori (CNR-IRBIM), Francesco Filiciotto.
Status	Final
Distribution	Public
Citation	Ghezzo M., Madricardo M., Farella G., Menegon S., Lenori I., Filiciotto F. Vukadin P. Anthropogenic underwater noise sources information database SOUNDSCAPE project, WP3, 32 pp, 2019.

Summary

List of figures

List of tables

Abstract

Document describes the main sources of underwater noise in the North Adriatic Sea.

1 Introduction

The SOUNDSCAPE project is funded by the 2014 - 2020 Interreg V-A Italy - Croatia CBC Programme funded by the European Union within the 'Call for proposal 2017 Standard, Priority Axis:Environment and cultural heritage within the specific call objective 3.2 - Contribute to protect and restore biodiversity.

The main objective of the project is to create a cross-border technical, scientific and institutional cooperation to face together the challenge of assessing the impact of underwater environmental noise on the marine fauna and in general on the Northern Adriatic Sea (NAS) ecosystem. This cooperation aims to ensure an efficient protection of marine biodiversity and to develop a sustainable use of marine and coastal ecosystems and resources. Marine Strategy Framework Directive (MSFD) Descriptor 11(D11) points out to the need to monitor and manage underwater noise to achieve Good Environmental Status (GES) of EU marine waters by 2020.

According to a recent report about the Blue Growth Trends in the Adriatic Sea of the MEDTRENDS project, though, there is a high risk that the GES related to underwater noise (D11) will not be achieved in the NAS by 2020. At this stage, in fact, there are no extensive data on underwater noise in the area and our knowledge on noise pollution and its impact on biodiversity is very limited. To date Maritime Spatial Planning (MSP) initiatives in this region (e.g. SHAPE, ADRIPLAN, ADRIATIC +) have not fully explored the underwater noise issue. SOUNDSCAPE aims to fill this knowledge gap by implementing a substantial technological upgrade in noise measurements and modeling in the area and informing MSP in the region. The project will make possible the transition from an almost "no-data-available" situation to a modern network of continuous noise measurements and an advanced sound modeling in the full NAS area taking into account the seasonality, the spatial distribution of noise and its impact on biodiversity and on marine fauna including endangered species (e.g. bottlenose dolphins, sea turtles).

The objectives of the SOUNDSCAPE project are to be pursued in three ways:

- Implementing a shared monitoring network for a coordinated regional and transnational assessment of the underwater noise in the NAS in accordance with the MSFD, specific to the soundscape ecology of the EUSAIR region;
- Evaluating the noise impact on marine biological resources to protect biodiversity through the assessment of acoustic diversity index and noise enhanced habitat suitability in the NAS and raising of public awareness regarding the impact of underwater noise;
- Developing and implementing a planning tool for straightforward management of underwater noise in accordance with the MSF and MSP Directives. Identifying feasible measures agreed upon with stakeholders to mitigate impacts of noise pollution on biodiversity while allowing sustainable development of maritime uses.

Within the project, the Work package 3 aims at the assessment of underwater soundscape, which includes underwater noise sources review and analysis, planning and implementation of the monitoring network, continuous underwater noise level collection.

In particular the Activity 3.1 is dedicated to the Review and analysis of the sources of anthropogenic underwater noise in the Northern Adriatic Sea. This activity aims to gather and structure in a unique database all available information and data on different anthropogenic sources of underwater noise from existing databases and other available sources.

The noise in the ocean is the result of the propagation and interactions of anthropogenic and natural sources.

Anthropogenic sound sources have a broad range of characteristics, including source level (sound level 1 metre from the source), frequency content (expressed in Hertz [Hz] or kiloHertz [kHz]), duty cycle (pattern of occurrence) and movement (i.e., stationary or mobile). Sound sources can also vary between coastal and open ocean regions (Van der Graaf et al. 2012, Tasker ML et al, 2010). Schematically we can associate typical noise sources with typical frequency bands for a general description of noise source contribution.

The low-frequency band (peak around 10-500 Hz but) is dominated by anthropogenic sources overall commercial shipping followed by seismic exploration. They contribute to the noise across the basin because low frequency have little attenuation and long range propagation. Shipping noise contribution increased in the last 10 years by 12 dB, correlated with the increase in number and size of vessels in the word (Hildebrand et al. 2009). In the same time oil exploitation and construction are moving from continental margins into the deep sea, so seismic signals are increased the range of propagation.

The medium frequency (peak around 500-25000 Hz) are propagating on local or regional range (10s of km) around the sources, so their contribution on ambient noise is spatially more limited. The noise in this frequency range is due to sea-surface agitation (breaking waves, bubbles, rainfall). Sonar and small vessels contribute as anthropogenic sources in medium frequency.

The high frequency (over 25000 Hz) is characterized by very high acoustic attenuation so the effect is only local close the source.

Anthropogenic noise sources vary in space and time, but may be grouped into general categories following TG noise recommendations (Van der Graaf et al. 2012):

a) maritime traffic,

b) oil & gas exploration (airguns and other seismic exploration devices),

c) underwater warfare exercises (including military sonars),

d) offshore construction,

e) fossil fuel extraction,

g) offshore drilling implements,

h) offshore wind-power construction and operations,

i) research sound sources,

j) ship-mounted sonars

k) small ships or recreational boats.

A useful review of sources of anthropogenic sound in the ocean was presented ten years ago by Hildebrand (2009).

However, with the exception of data regarding large ships, which can be deduced collecting and analysing the Automatic Information System (AIS) data transmitted by them, it is very difficult to gather data about oil & gas exploration, military activity, and other marine activities because they are either not collected or are difficult to obtain and analyse because they are maintained by separate organizations.

Some attempts to collect information about seismic exploration and oil&gas exploration have been done during the QuiteMED project that designed an International impulsive noise register for the Mediterranean basin that ideally would collect all the information about these activities, such as dates, location, frequencies used, source levels, etc. (http://80.73.144.60/CTN_Geoportal/home/). A national register for impulsive noise was created within the Italian monitoring activities of the Marine Strategy Framework Directive for the descriptor 11 (Pavan et al., 2017) where few data were gathered concerning the seismic surveys in the Adriatic Sea mainly analysing the reports of the Italian Coast Guard. Direct inquiry did brought almost no information (Pavan, *private communication*). The register was not updated in the following years. Croatia has not established national register for impulsive noise yet.

Information about the anthropogenic sources will be the gather from indirect sources, such as the areas of the active exploration licences for the seismic explorations, or the areas assigned for the military exercises.

More data was available concerning the oil&gas extraction since the location of the oil&gas platform in Italy and Croatia are available from the Edmonet portal about Human Activities (www.emodnet.eu)

2 Geoportal

The Tools4MSP Geoplatform (former ADRIPLAN Portal) is a community-based, open source portal based on GeoNode, a web-based Content Management System (CMS) for developing geospatial information systems (GIS) and for deploying spatial data infrastructure (SDI). It includes over 600 geospatial datasets, organised in the following categories: coastal defence and sand extraction, energy, environmental protection, environment and ecosystem, fisheries and aquaculture, maritime transport and tourism, miscellanea. The Geoplatform capitalizes data from other projects (e.g. Shape, CocoNet) and enables access to standard services from other geoportals (e.g. EMODnet, EU Sea Atlas). Moreover the Geoplatform provides a set of MSP-oriented web-tools such as Cumulative Effects Assessment (CEA), Marine Use Conflict Analysis and a Marine Ecosystem Services Threat (MES-Threat) Analysis. The Tools4MSP Geoplatform is regularly updated by the Tools4MSP Development Team. The original version was developed in the context of the ADRIPLAN Project and has been consolidated within the Italian RITMARE Flagship Project and by ongoing projects such as SUPREME. Core functionalities of CEA/MUC have been supported by an MSP pilot study in sea areas of Emilia-Romagna Region (Italy), and incorporated as case studies analyses within the SUPREME (Supporting maritime spatial Planning in the Eastern Mediterranean) and SIMWESTMED (Supporting Maritime Spatial Planning in the Western Mediterranean region) projects. Currently the web-tools are providing core functionalities within PORTODIMARE (geoPortal of Tools & Data for sustainable Management of coAstal and maRine Environment; 2018-2020) Project.

2.1 Guidelines to support a Geoportal Data Policy

One of the main aims of the SOUNDSCAPE project is to allow partners to collect, process, access and share underwater noise relevant data on regional level trough an interoperable and accessible geoportal.

With this goal in mind, some rules have to be set up to allow a secure and profitable exchange of information among partners and with stakeholders.

2.1.1 Open data and Public Sector Information

The European legislation strongly encourages the publishing of publicly-funded scientific research results as Open Access and Open data.

The definition of Open Data is commonly expressed as “data that anyone can access, use and share” (http://opendefinition.org/).

Open data becomes usable when made available in a common, machine-readable format.

Open data must be licensed. Its license must permit people to use the data in any way they want, including transforming, combining and sharing it with others, even commercially.

Starting from 2011, the European Commission has launched an Open Data Strategy for Europe, with the aim to boost economy. The Open Data Strategy led to a revision of the Directive 2003/98/EC on reuse of public sector information (PSI Directive).

The PSI Directive focuses on the economic aspects of the re-use of information rather than on access to information by citizens. It encourages the Member States to make as much information available for re-use as possible. It addresses material held by public sector bodies in the Member States, at national, regional and local levels, such as ministries, state agencies and municipalities, as well as organizations funded mostly by or under the control of public authorities.

Data collected within SOUNDSCAPE project falls also in the scope of application of Directive 2007/2/EC (INSPIRE) that contains the rules about data and services sharing about environmental informations inside the framework of an interoperable Spatial Infrastructure at a national and European level.

In addition to these legal framework requirements, the choice to release scientific data as reusable products gives advantages to the data producer itself:

data will be licensed only once and there's no need to evaluate every single request of access and reuse to data (which requires a great amount of time and effort in legal contracts);

licensed data can reach a wider audience and will contain always proper attribution;

data quality can be checked and improved by advanced users.

2.1.2 Definitions

In order to clarify the various contexts and places where data will be used in the project, we need first to define some terms that will be used in the following chapters:

- data: a structured series of numbers, values, text, geometries that represents scientific information and can be accessed in different forms (e.g. the series of sea levels measured by one station in a year, the coordinates of all stations, the coastline). A single data can include a content with their own license (e.g. images inside a database with authors from the database copyright holder).
- content: a product that represents scientific information in a fixed form (e.g. a map, an image, a document with descriptive text).
- raw data: data as collected from sensors or surveyors in their original format (e.g. TXT, CSV,), without validation processes or gap-filling.
- validated data: data in original or standard format after a validation process (e.g. outline removal, sensor registration) usually contains the same amount of information of raw data and optionally the reconstruction of data gaps.
- aggregated data: data in original or standard format but with less amount of information than the original raw data.
- derived products: data or content products created by styling, modifying, meshing up, remixing, merging, data from different origin (e.g. a map with different layers).

2.1.3 License types

1. CC0: Creative commons Zero, applies to content and data on public domain; corresponds to a waiver of all rights including those of attribution.
2. PDDL: Open Data Commons Public Domain Dedication and License , same rights as CC0 but applies to data only.
3. CC-BY: Creative Commons Attributions, applies to content and data; gives to users the rights to copy and redistribute the material in any medium or format and remix, transform and build upon the material for any purpose, even commercially and the obligation to give proper attribution to the copyright holder.
4. ODC-BY: Open Data Commons Attribution License, refers to same rights and obligation as CC-BY but applies to data only.
5. CC-BY-SA: Creative Commons Attribution Share Alike, applies to content and data and, compared to CC-BY, requires that users share the derived products with a compatible license.
6. OdbL: Open Data Commons Open Database License, refers to the same rights and obligations as CC-BY-SA but applies to data only.

(Source: http://opendefinition.org/licenses/)

2.1.4 Types of data

We can define different types of data:

- measurement data (which can be raw, validated, aggregated) from monitoring network;
- derived models;
- georefenceddatat from other sources (e.g.EMODNet, regional and national authorities, etc.).

Depending on the policies of the partners, this data can have different levels of detail for different levels of sharing.

2.1.5 License and sharing

Data sharing is an essential need of SOUNDSCAPE project and data must be reusable at least by the project partners. To share data doesn't mean that the owners shall give up to the intellectual property on their data but, on the contrary, that their data are protected, giving other users some precise rights and obligations.

The rights on the data provided refers to actions like access, view, download, modify, republish, reuse, remix and produce derived products; the obligations imply that the user must give attribution, use the data with spatial/temporal limitations or just for explicitly permitted purposes.

The simplest way to give rights and obligations is to give data an open license like those listed in point 1.2.

A Data Policy Agreement will be defined in order to give partners and contributors the ability to share data according to their internal regulations, choosing different levels of openness and the correct license.

The recommended level of contribution is a license that gives to anyone the rights to download, publish, redistribute, reuse data without limitations, giving proper attribution (e.g CC-BY license)

The minimum level of contribution is a license that gives to project partners the rights to access, download, publish, extract and derive data for the project purposes and duration.

2.1.6 Users

Different categories of users can have different levels of accessibility to data:

project partners need to access all shared data for the duration and for the purposes of the project;members of the network can access to a subset of relevant data and/or to aggregated data as a reward to share their data into the geoportal;

scientific community or other stakeholders can have a privileged access to some data through specific requests.

2.1.7 Data sharing infrastructure

SOUNDSCAPE partners will share and have access to data only for the purposes of the project. An community-based Geoportal will make available to project partners in order to share and reuse the collected and modeled noise data layers.

2.2 Guidelines to access the SOUNDSCAPE DATA map

Geoportal GUIs (Graphical User Interfaces) will visualize integrated maps (Map 1) which, by default, will be visible but non downloadable.

Instructions for accessing the GeoPortale Tools4MSP:

1) register your user at: http://www.tools4msp.eu/account/signup

2) send an email to tools4msp@ismar.cnr.it from the registered address, specifying your partnership in SOUNDSCAPE project

3) once the communication of the user authorization has been received by e-mail, the map link will be provided;

4) users can then view the georeferenced layers by selecting them from the left column.

For support contact tools4msp@ismar.cnr.it.

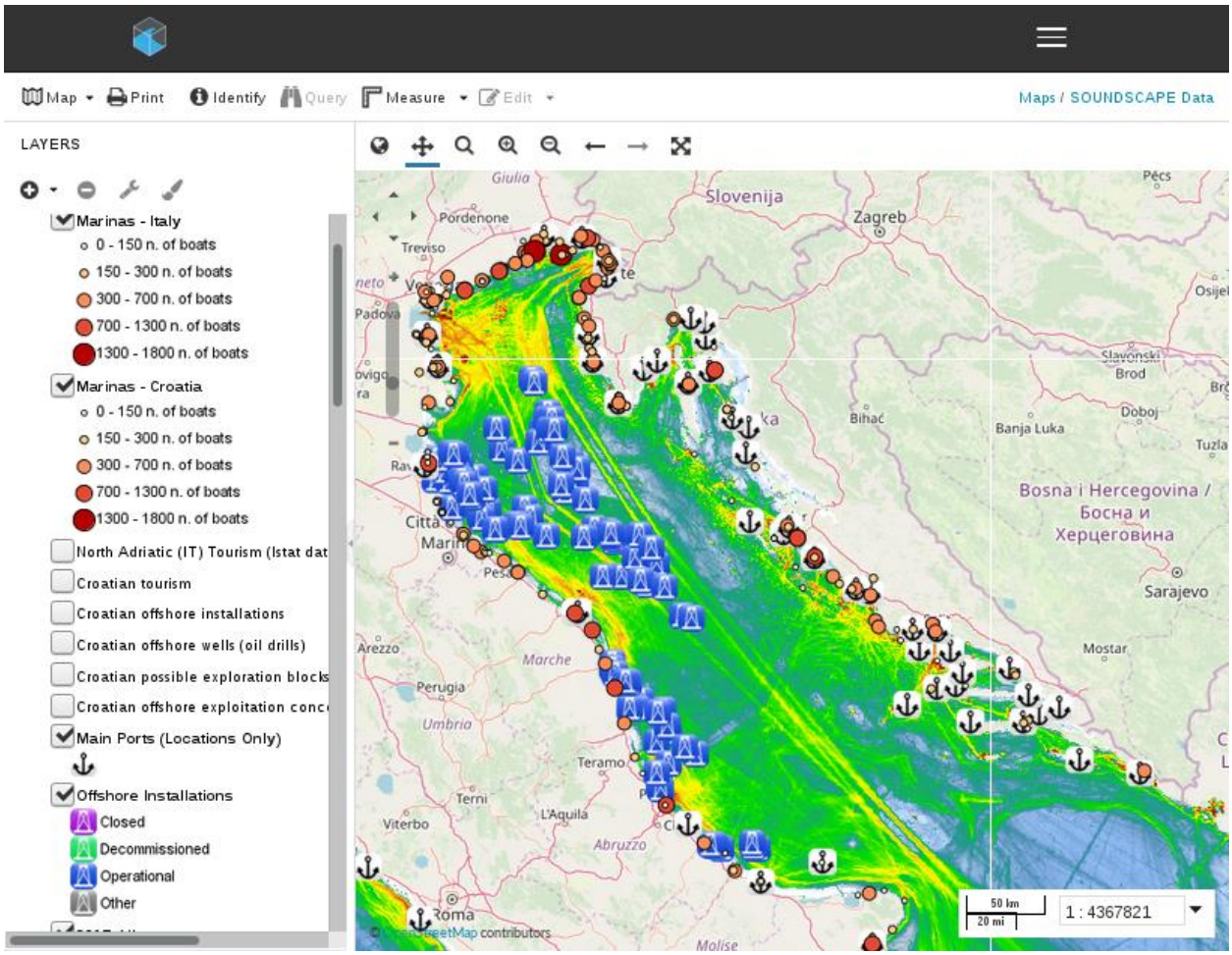

Figure 1SOUNDSCAPE DATA map on Tools4MSP Geoportal

3 Domain area

The project area showed in Figure 1 includes the north part of the Adriatic Sea and a small part of the central Adriatic Sea. The entire area covers about 30000 km2 and borders three countries: Italy (IT), Slovenia (SL), Croatia (HR).

Shallow depth from 0 to 50 m. characterize the northern and west part of the domain; the basin is deeper and more irregular only from half of the domain area toward the south part of the domain.

The west coast is sandy, gently sloping and making wide coast line, the east coast is rocky, heavy sloping and jagged. The domain is characterized by high riverine input overall on the west coast. The temperature across the water column is variable during the year in correspondence with the season. The salinity is also variable during the year and in correspondence of rain events and it influences the intensity of coastal currents, overall on the north and west side.

Numerous human activities take place in this area: maritime traffic, fishery, aquaculture are emerging sectors and their environmental impact is growing. Alsogas&oil survey and exploitation and military exercitations take place in the area also if the knowledge on their real activity is limited.

4 Database discussion

In literature the relevant sources of anthropogenic noise are identified, but not univocally defined. Sometimes the classification are prioritizing the human activities, sometime the action are considered on the basis of how many giving noise source level is produced. First step is to associate each human activity with the corresponding activity defined in Tools4msp data portal and in other noise source database (ACCOBAMS). This permits to verify the substantial meaning of the definitions and to associate correctly our data layer, if present in the portal, to a source of anthropogenic noise. In the project the database of the sources of anthropogenic noise represents the basic knowledge and collection of information useful as input to modelling the underwater noise in the domain area.

To be compliant with the modelling needs we describe shortly the QUONOPS model input needed to work in prevision mode, successively we will associate the corresponding layer in Tools4msp data portal and in ACCOBAMS definition.

4.1 ENVIRONMENTAL DATA AND NATURAL SOUND SOURCES

QUONOPS uses a reference database to provide automatically some information in the domain area, but of course more detailed data permits to have better results.

Environmental data in NetCDF4 following the Climate and Forecast convention are used in the model, specifically :

- Bathymetry data
- Surface roughness
- Sound speed profile across the water column
- Bottom Sediment

The bathymetry data represent a maps of the bottom depth provided as matrix on regular grid dividing the domain area in cells and defining the depth in each cell. The default data source is the EMODNET layers (2019).

Bottom sediment has the same format, but can be defined also layer by layer in order to better describe the sound interaction with the bottom. The attributes considered are speed of sound in the sediment, attenuation and density in the sediment. The default data considered in the model comes from the EMODNET seabed data layers (2019)

Surface roughness, meaning surface wave height, and sound speed profile in the water column are defined as maps varying in time on the surface or on several layer from top to bottom respectively. Default source for the model are COPERNICUS wave data and hydrodynamic modelling, but in the case

of the Adriatic Sea we can access to 3D finite element simulation in Adriatic Sea with high resolution on the coast by the operative forecast system, running in CNR-ISMAR (Ferrarin et al 2019)

4.2 ANTROPHOGENIC SOUND SOURCES

Several human activities produce underwater noise with different spatial and temporal variability and adopting different acoustic sources. Each activity is composed by different actions (i.e. hdrocarbon exploratin: shipping + seismic survey..) and each action generate a specific typology of underwater noise.

A first classification is based on the characteristics of noise generation by human action:

- shipping
- seismic survey
- sonars
- explosion
- industrial activity

The human activities having place in the sea combine several actions, but accounting the intentional/unintentional production of noise and the typology of noise source generated, human activities can be classified as:

- maritime traffic
- oil and gas – fossil fuel expoitation
- offshore construction
- underwater military actions

QUONOPS model follows a very similar classification of activity producing antropogenic noise:

- maritime traffic (Folegot et al. 2016a,b)
- oil exploitation (Shutton et al. 2013)
- fossil fuel extractions
- underwater warfare exercises
- offshore construction (Thomsen et al. 2015, Thomsen at el. 2013)
- offshore wind power construction and operation (Folegot et al. 2016c)
- drilling and blasting

Now we examine one-by-one the listed activity and define the main actions involved in each one and consequently the noise source level of the main actions. We check which information are needed in the QUONOPS model (if the action is modeled). Finally we will check which layer in Tools4msp portal database give us useful information to localize the actions related with the activity and to specify its source noise level.

Quonops definition		Accobams	Action	Tools4msp layer	units	Recomm. In the Project
Maritime traffic	Navigation menu	Maritime traffic	AIS Row data and recreational boats	Traffic density Traffic line Ports Marinas	[vessel for Km2] [line] [point,type] [n berths]	Evaluate AIS data provider, evaluate the availability of VMS data
Oil fossil-fuel exploitation	Offshore costruction menu	Seismic survey	Areas subjected to airgun action	Oil and gas maps Croatian offshore wells (oil drills) or testing	[polygons] [points]	
Underwater warfare	Offshore costruction menu	Military exercises	Areas devoted to sonar, explosion	Temporary military areas in Italy No activity in Croatia	[polygons]	
Offshore construction	Offshore costruction menu	Coastal and offshore works	Drilling Dredging, Explosion	Hydrocarbon extraction platform - Italy Hydrocarbon exploitation permits in Italy (active) Bridge construction on border of south Croatia	[points and polygons]	Try to measure noise close a platform
Offshore wind power	Marine Renewable Device menu	n.c.		Offshore Wind Farms in project in Italy No offshore Farms in project in Croatia	[points]	

Table1Typology of sources and classification

Maritime traffic It is the most relevant anthropogenic source of continuous underwater noise . Its definition includes all vessel and boat movement as cruises, commercial shipping, cargo vessels, container ship, tankers, gas carriers, passenger, fishing vessels and also recreational boats. Each vessel typology has its own characteristics and navigation line. The commercial shipping is the major contributor to noise at low frequencies (5-500 Hz). Ships generate noise by a) propeller action, b) hul vibration due to machinery action, c) hydraulic flow over the hull. Propeller noise is associated with cavitation and voids creating broadband noise and tonal sound modulated by blade-passage frequencies. This accounts for 80% of ship radiated noise power. Each vessel produces a specific unique acoustic signature. This can be discerned at short ranges and isolated environments but at distant ranges multiple ships contribute to the background and the sum of all contributes for each moving ship creates a broak spectral peaks of noise in 5-500 Hz band.

Recreational boats contributes significativly to the underwater noise pollution expecially close to the coast during the touristic season. The study of noise signature of recreational boats is difficult due to the high variability in engine and typology of boats and due to the difficulty to estimate the route and the recreational traffic density.

In QUONOPS the modeling of maritime traffic is based on Automatic Identification System AIS data (mandatory for vessels over 300 GRT and length greater than 15m) and employs a model (RANDI3) to simulate the source level of individual vessels, based on their length and speed. The ACCOBMAS definition of this source is the same. Tools4msp data portal makes available layers on Traffic density maps (averaged vessels for sqm), traffic line (line), harbours location (position), marinas (position, number of berth).

AIS row data are freely available on AIShub and QUONOPS model uses automatically this data. Other AIS row data an be buy in the site www.maritimetraffic.com. The coverace and the number of tracked vessels is quite different in this two provider especially in southern part of the domain.

Also if the data should cover the whole domain, the coverage on the Croatian side has surely some lack due to the shape of the coast.

It is important to note that the AIS system is mandatory for boat length greater than 15 m, fishermen boats with length greater than 12m have to use the vessel monitoring system (VMS,). In the future all the categories of fisherman boats will have on board the AIS system. This means that boats smaller than 15m and fisherman boat smaller than 12m are not included as noise sources in the AIS+VMS data, and consequently if we consider only AIS data we are severely underestimating the noise source overall in the Adriatic Sea, where fisherman and recreational boat are very relevant.

The AIS data collection and processing will be considered in the deliverable 5.1.3, whereas information about the noise generated by recreational boats will be gathered in the activity 3.4.

Hydrocarbons exploitation Once living matter decomposing in geological formations due to pressure, heat, and physical structure of the earth as been transformed in hydrocarbons in geological deposits. The exploitation implies the following steps:

1) Initial identification by way of likely geological features;

2) Seismic airgun surveys to define the deposit

3) Exploratory wells to determine the production potential of the deposit and the quality of the product. In deep water settings exploratory wells are drilled from large stabilized floating platforms.

4) Once a deposit is determined to be suitably productive the safety systems of the well will be replaced by a flow control system to prepare the well for production.

Fossil fuel deposits are not just oil; rather they contain many other substances in various concentrations depending on the nature of the deposit. It is not uncommon for liquids (oil and brine), solids (sand, coal, shale), and gas (methane, ethane, butane, CO2, nitrogen...) to all be part of the product extracted out of the deposit. So the product coming out of the well is called “multiphase” containing gas, liquids and solids.

Oil and fossil fuel exploitation includes actions of ’active exploration’ and of ’offshore construction’ as drilling, structure emplacement and removal and production included boat and helicopter supplies.

What concerns the offshore construction will be detailed in the next section. The exploration of oil and natural gas reserves occurs along continental margins and shelf seas generally and it employs mainly the seismic reflection profiling using high-intensity sound to define geologic structures down to depth of 10 km. Industries, Academic and government groups perform this action. The major operational elements in 3D seismic reflection survey are : 1) seismic vessel (100 m long 30 m wide) 1 or 2 air-gun arrays towed about 200 m behind the vessel 3) cables containing a large number 9few thousand0 of hydrophone sensors towed behind the vessel. In shallow water (< 4 m.) explosives buried in drilled holes substitute the air-guns.

Air-guns release a volume of air under high pressure and are composed by 12-18 individual guns, operating pressures of 2000 psi (around 13.8 million pascal) covers 20 m by 20 m region until 200 m under the vessel. The maximum pressure level and animal could experience from air-guns in use today will be in the range 235-240 dB 1 uPa (RMS) with the peak pressure in the 5-300 Hz range.

ACCOBAMS mentions this activity as ’seismic survey areas’ and collect data on licensing block area (large survey areas covering a great portion of maritime space of a country), real routes of data acquisition vessels (only for public research) and time frame of the licence survey.

Tools4msp database portal contains the layers:

- Oil and Gas maps = Oil and gas exploration sites and concessions.
- Hydrocarbon exploitation permits in Italy (active)

Concerning the whole Adriatic Sea the hydrocarbons exploration and extraction activity are related only to natural gas resource.

The layer offers the knowledge of wide areas for survey, but no additional information on time and power of airgun experiments. So probably this is not sufficient to implement the noise sources in the model.

Gas exploitation in Croatia is displayed in Map 9 (also the same in Map 10). There are currently no exploration of any kind on Croatian side. But there has been an extensive seismic exploration in 2013. and 2015. which resulted in possible exploration blocks as shown in Map 10.

Underwater warfare exercises are identified with military zone subjected to several military actions. It means military training of different war actions (mine defense, boat detection, explosions, test of new technologies)

Sonar and chemical explosion can be considered the main actions generating noise under this activity, while it is very difficult to know exactly the activity and the period of actions. Sonar create acoustic energy to explore water column content, bottom and sediment. It emits high acoustic energy and receives the reflected / scattered energy back. Several categories of sonar are employed. Military sonar covers a broad frequency range with also high source level. They are used for target detection , anti-submarine warfare, or intreplatform communication/activation. Military Training is the main contest when the action producing noise is performed.

In ACCOBAMS it corresponds to military exercises.

QUONOPS includes airgun as noise level source under the offshore construction menu.

In Tools4msp there are some information on permanent and temporary military areas but considering no information on the real actions performed in that areas we prefer to exclude the layers.

Offshore construction includes all the activities to build infrastructures in the ocean and along the coast.

Marine dredging take place along the coast to deepen channels, harbours , reclaim land and mine seabed. As noise source level it ranges from 160 to 180 dB 1 uPa (RMS)with peak intensity between 50-500 Hz.

Oil and gas construction includes drilling, structure emplacement/removal, explosion and oil production. The noise levels achieved by this activity are lower than in exploration phase. The main source levels are associated with drilling including drilling machinery and propeller, auxiliary support (boats and helicopters). A wide variety of equipment is used in drilling activity. In detail are:

1) platform rings permanently mounted on stationary production structures

2) semisubmersibles: mobile steel-decked structures, support do not rest on the seafloor

3) jack-ups: mobile steel-decked structures, support do rest on the seafloor

4) drill-ships: ship with drilling capabilities

The last category is the noisest with source pressure levels across the 10 Hz – 10 kHz band of about 190 dB re 1 uPA at 1m (RMS)

Offshore structures create unintentionally localized noise for relatively brief periods of time. The activity to transport the construction material lasts for few weeks, 8-10 times per year.

During oil production additional noise are generated. Impulsive hammering sounds created by pipe installation are calculated to be around 195 dB re 1uPa at 1 m with peak amplitudes around 40-100 Hz.

The production of oil and gas is moving from shallow to deep water (3000 m) generating greater noise.

ACCOBAMS under the definition of 'coastal and offshore work' includes harbor developments , wind farm construction and operation and oil&gas platform operations.

In QUONOPS the offshore construction menu includes a very large variety of offshore actions as airgun, clapping material, dredging, drilling, explosive, piling, rock breaker, trenching, cable burial, vibrodriving. The user has to know some characteristics in case of dirilling as drill diameter, explosion as eq kg of TNT and blast duration, piling, rock breaker and vibrodriving as diameters of pile and spear respectively.

In the Tools4msp data portal we selected the following layer useful to represent this noise sources : Hydrocarbon extraction platform Italy

In Croatian side the layer Croatian offshore wells produced by the Croatian Hydrocarbon Agency and Blue Word Institute can be useful as input for the noise source taking into account that it actually no exploration of any kind occurs on Croatian side and when perfomed are only for nautral gas. An extensive seismic exploration was in 2013 and 2015 on Croatian side, which resulted i possible exploration block in Map 10.

Offshore wind power

The installation phase is noisy as the offshore construction category. The pile-driving noise and vibration in some was measured in peak sound pressure levels and equivalent sound pressure levels in 1/3 octave bands in 110 m distance from a 1.5 MW turbine. The sound pressure levels depends from the pile diameter and wind intensity. In the Adriatic Sea no operatively wind farm are registered and in tools4MSP only Offshore Wind Farms in project layer exists and no Wind Farm are in project in Croatia side, so we exclude this source from our actual database.

4.3 SPECIFICATION OF SOURCE LEVELS IN THE DATABASE

The database on anthropogenic noise source has to define the position of each noise source and its noise signature. This is very hard challenge because, in example, identical ships category can produce very different noise spectra in reason of the vessel length, navigation state, maintenance, load and environmental interactions. What is feasible is to characterize each type of source with a sound source level descriptor detailed in reason of literature knowledge and/or field measurement.

For example; divide all vessels in categories (cargo, tankers, passenger..) and assign corresponding source level from literature. Another way is to have a model of noise level of the source in function of length and velocity as in RANDI3 model adopted in QUONOPS.

In general QUONOPS details the source level descriptor specifying the typology of the source and the vertical distribution of the energy across the water column. A source is represented as a series of point sources along the water column, each one contributing to the total energy emitted. The user has to specify how the energy is distributed along the water column. The source level profile is specified associating a list of pairs values representing frequency and corresponding source level.

In our anthropogenic source database no info except literature range are included at the moment.

5 Database description

Consistent with this context and with the objectives set, the activities of the SOUNDSCAPE project have foreseen the set up of a complete knowledge framework on the sea uses with specific focus on potential noise sources. Information about the anthropogenic sources will be the gather from direct and indirect sources, such as the areas of the active exploration licences for the seismic explorations, or the areas assigned for the military exercises, and will be constantly updated during the whole project duration. The following maps have been on-line extracted from SOUNDSCAPE data map on the Tools4msp geoportal. To explore the detail of layer info and metadata and to custom the visualization the reader should refer to the on-line tool.

5.1 Maritime traffic

The central and northern part of the Adriatic Sea provides one of the main maritime routes from Asia, via Suez, to Europe and the northern Adriatic ports of Koper, Rijeka, Trieste, Venice, Ravenna and Ancona are located in close proximity to each other. Due to their geographical characteristics they hold a special position in the European ports system, operating in a relatively closed system in which the market and customers are limited and therefore the ports are forced to co-operate (e.g. through NAPA) while at the same time competing with each other. The intensive maritime transport activity in the Adriatic-Ionian region implies a various array of pressures on the environment: ships and port emissions, risks of accidents, acute pollution events, underwater noise, and the introduction of alien species through ballast water discharges. For what concerns other types of pressures produced by maritime transport activities, underwater noise is recognized as an important form of pollution with relevant transboundary nature and of international concern and the main source of underwater noise is maritime transport (Codarin&Picciulin, 2015).

Within the European Marine Observation and Data Network (EMODnet, http://www.emodnet.eu) activities, the collection, harmonisation and publication of relevant, updated and georeferenced data on marine and maritime human activities is an ongoing activity. The EMODnet Human Activities portal (https://www.emodnet-humanactivities.eu/) provides free access to GIS data on European vessel

density. EMODnet Vessel Density Map was created by Cogea in 2019 in the framework of EMODnet Human Activities. The maps are based on AIS data purchased by CLS and show shipping density in 1km*1km cells of a grid covering all EU waters (and some neighbouring areas). Density is expressed as hours per square kilometre per month. The following ship types are available: 0 Other, 1 Fishing, 2 Service, 3 Dredging or underwater ops, 4 Sailing, 5 Pleasure Craft, 6 High speed craft, 7 Tug and towing, 8 Passenger, 9 Cargo, 10T anker, 11 Military and Law Enforcement, 12 Unknown and All ship types. Data are available by month of year. Yearly averages are also available (https://www.emodnet-humanactivities.eu/search-results.php?dataname=Vessel+Density+). The geodatabase on Main Portss was created in 2018 by CETMAR using the Ports 2013 data available in Eurostat and updated on an annual basis, including annual data from 2000 to 2018 (where available). The datasets have been included in the SOUNDSCAPE map within the Tool4MSP Geoportal via EMODnet web map services (WMS) (maps 2 to 8).

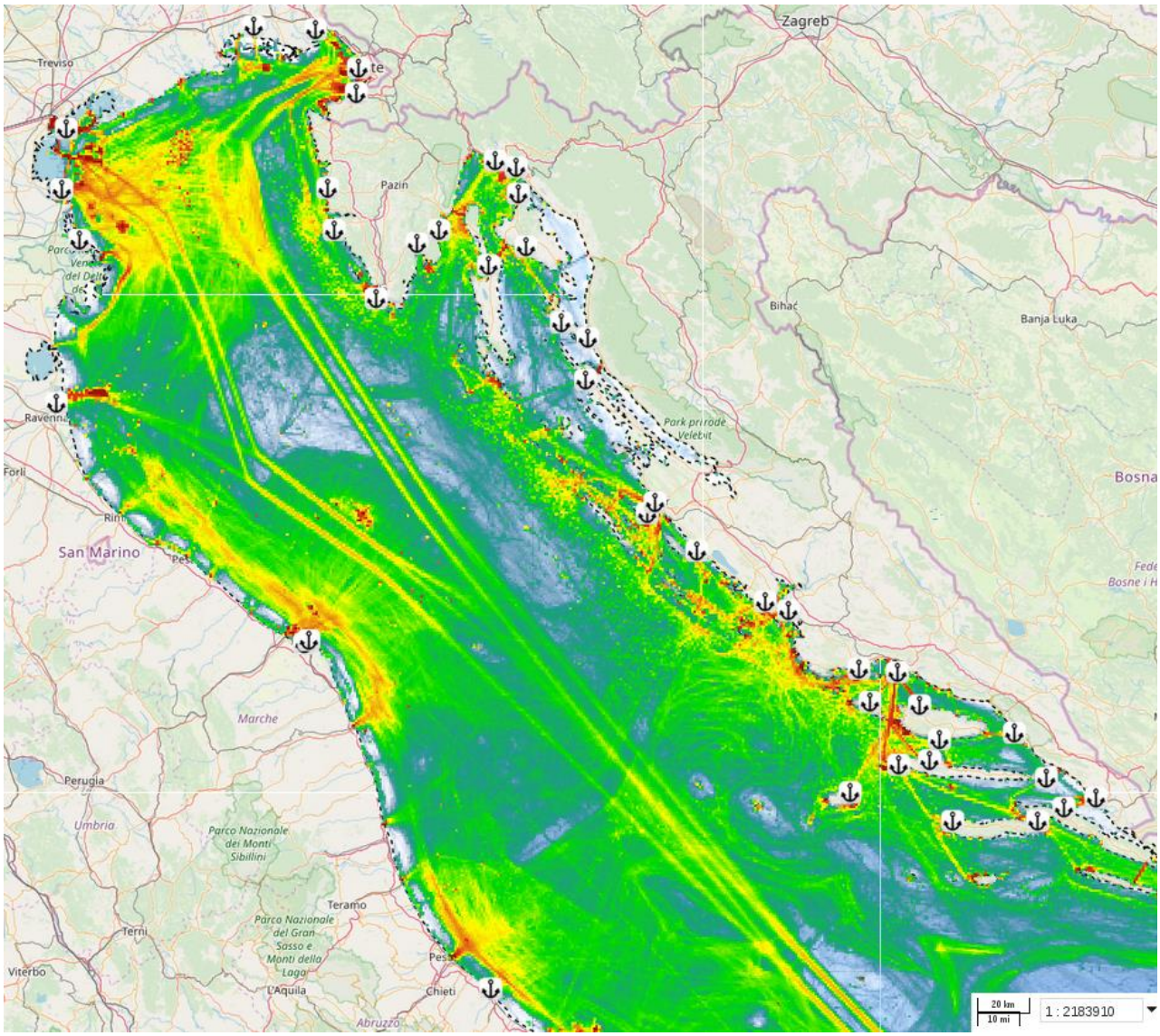

Figure 2All ship types traffic densities (2017 Yearly averages) and Main ports (Anchor). Vessel Density is expressed as hours per square kilometre per month. Bathymetry: EMODnet Digital Terrain Model (DTM) 2016 (http://www.emodnet-bathymetry.eu); Source: EMODnet.eu

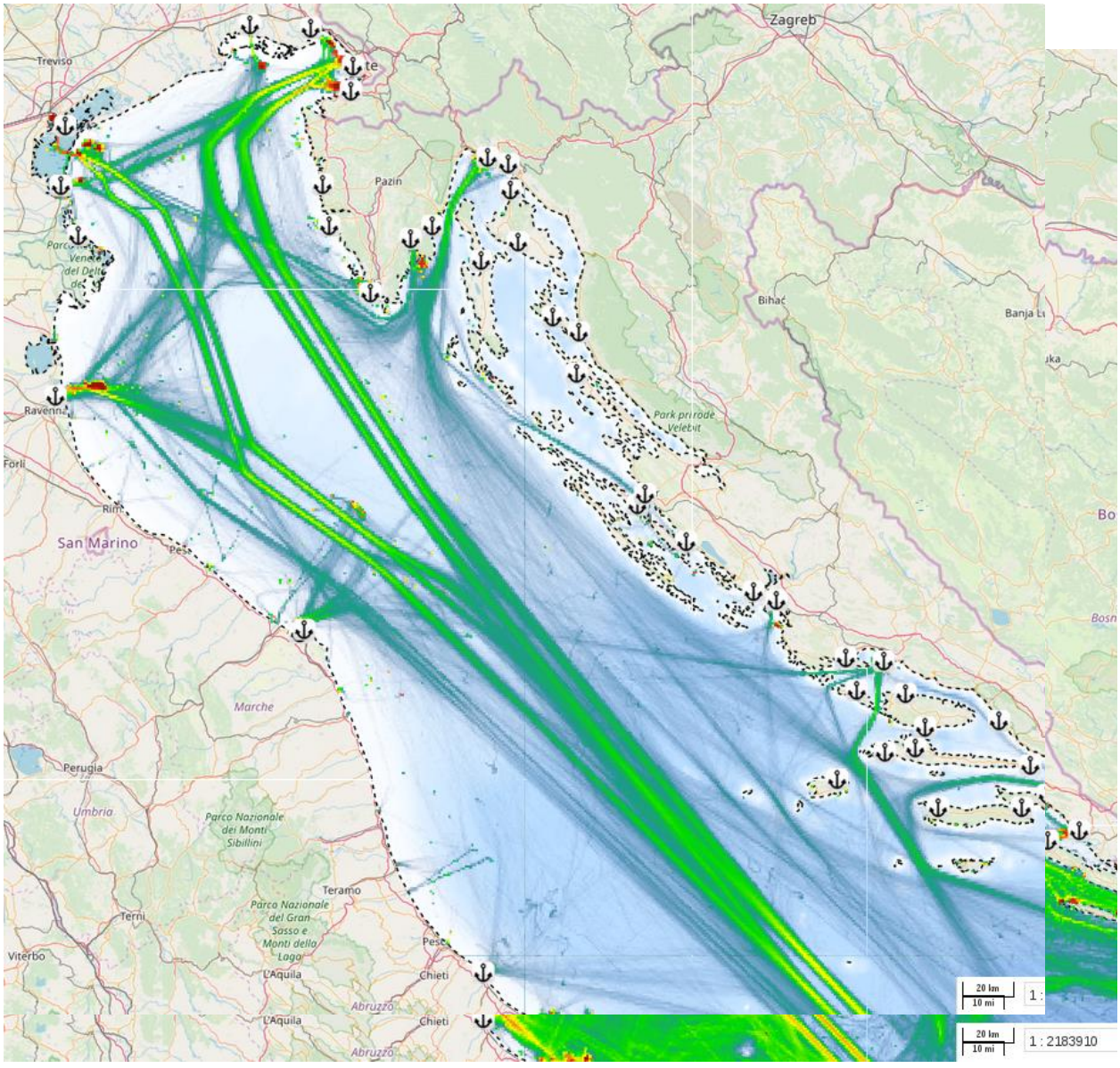

Figure 3Cargo traffic densities (2017 Yearly averages) and Main ports (Anchor). Vessel Density is expressedas hours per square kilometre per month. Bathymetry: EMODnet Digital Terrain Model (DTM) 2016 (http://www.emodnet-bathymetry.eu); Source: EMODnetH.A.

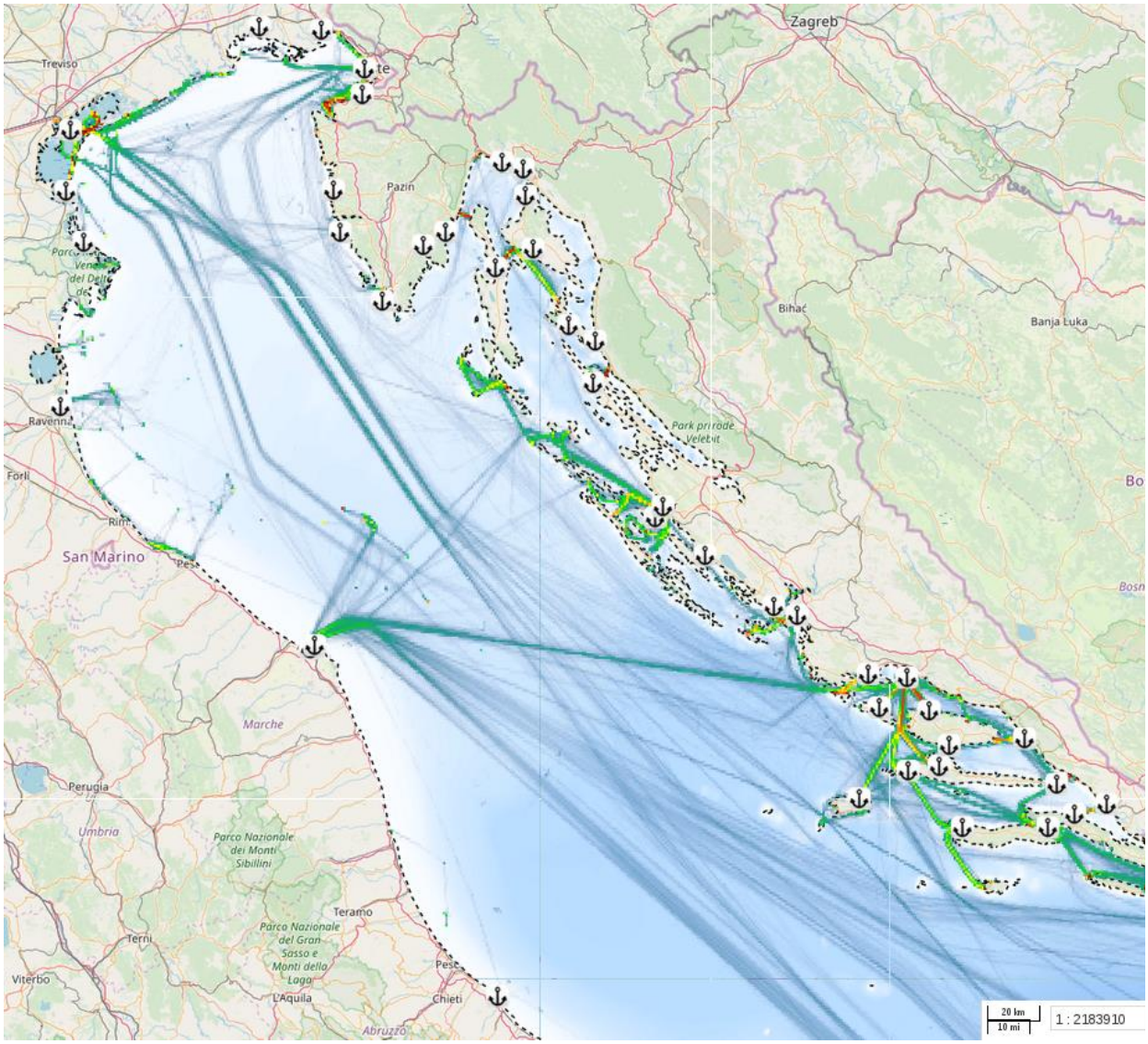

Figure 4. Passengershipstrafficdensities (2017 Yearly averages) and Main ports (Anchor). Vessel Densityisexpressedas hours per squarekilometre per month. Bathymetry: EMODnet Digital Terrain Model (DTM) 2016 (http://www.emodnet-bathymetry.eu); Source: EMODne

Figure 5 High speed vessels traffic densities (2017 Yearly averages) and Main ports (Anchor). Vessel Density is expressedas hours per square kilometre per month. Bathymetry: EMODnet Digital Terrain Model (DTM) 2016 (http://www.emodnet-bathymetry.eu); Source: EMODnet

Figure 6Pleasure crafts trafficdensities (2017 Yearly averages) and Main ports (Anchor). Vessel Density is expressedas hours per square kilometre per month. Bathymetry: EMODnet Digital Terrain Model (DTM) 2016 (http://www.emodnet-bathymetry.eu); Source: EMODnet

Figure 7Sailing traffic densities (2017 Yearly averages) and Main ports (Anchor). Vessel Density is expressedas hours per square kilometre per month. Bathymetry: EMODnet Digital Terrain Model (DTM) 2016 (http://www.emodnet-bathymetry.eu); Source: EMODnet Human Activities

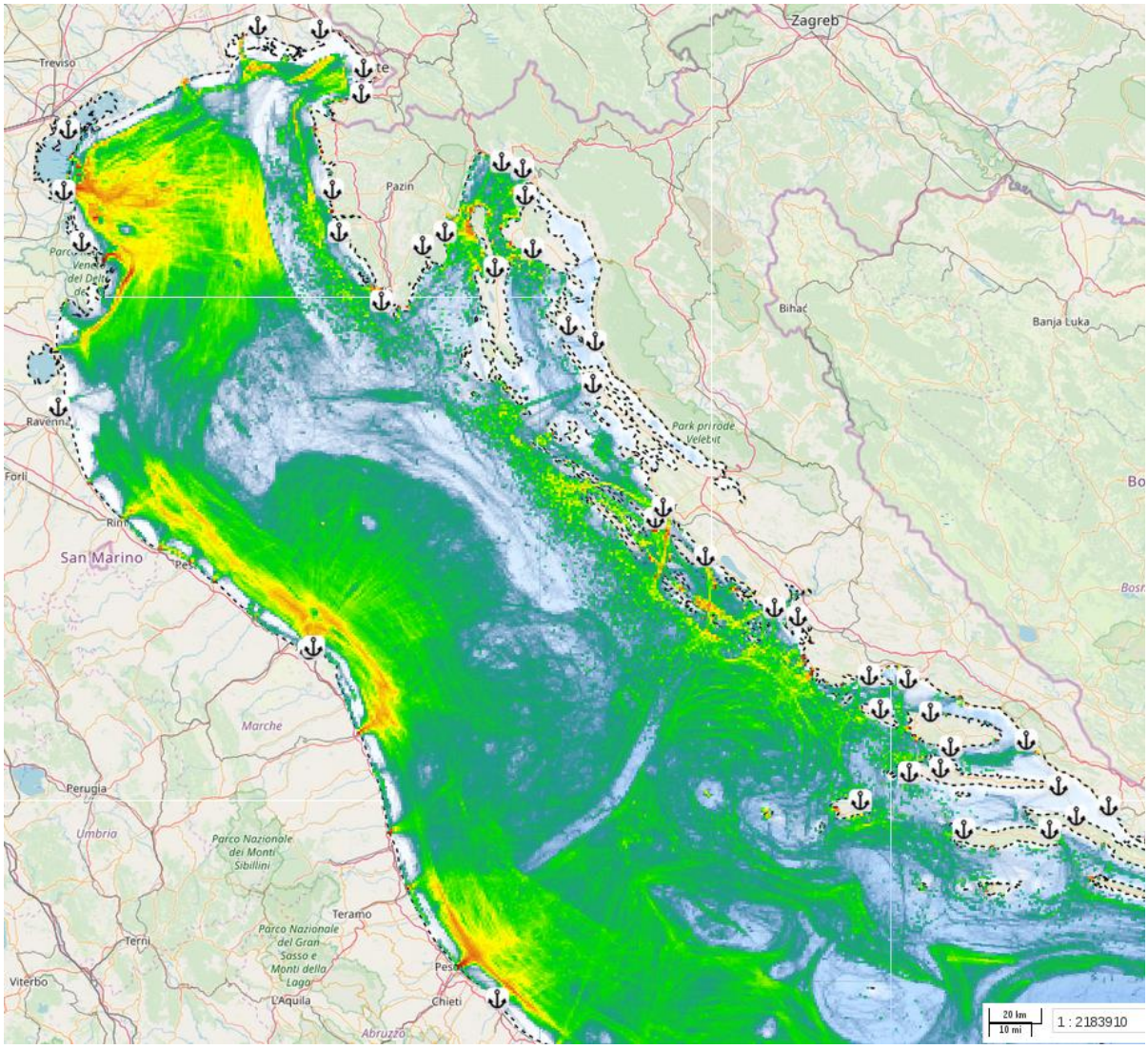

Figure 8Fishing vessels traffic densities (2017 Yearly averages) and Main ports (Anchor). Vessel Density is expressedas hours per square kilometre per month. Bathymetry: EMODnet Digital Terrain Model (DTM) 2016 (http://www.emodnet-bathymetry.eu); Source: EMODnet

5.2 Offshore installation

The EMODnet Human Activities database on offshore installations for hydrocarbon extraction was created in 2015 by Cogea. The dataset includes the name and ID number, location, operator, water depth, production start, current status, category and function of the installation. The datasets have been included in the SOUNDSCAPE map within the Tool4MSP Geoportal via EMODnet web map services (WMS) (map 9).

In addition, data on Italian offshore installations have been harmonized and verified (source: the Italian Ministry of Economic Development, https://unmig.mise.gov.it) and refined data from the Croatian Hydrocarbon Agency data on Croatian installations in the Adriatic Sea were uploaded on the Geoportal (map 10).

.

Figure 9 Offshore installations (Italy and Croatia) and Italian Active Licenses. Bathymetry: EMODnet Digital Terrain Model (DTM) 2016 (http://www.emodnet-bathymetry.eu); Source: EMODnet Human Activities; Basemap: OpenStreetMap; Map elaboration: data.Tools4msp.eu

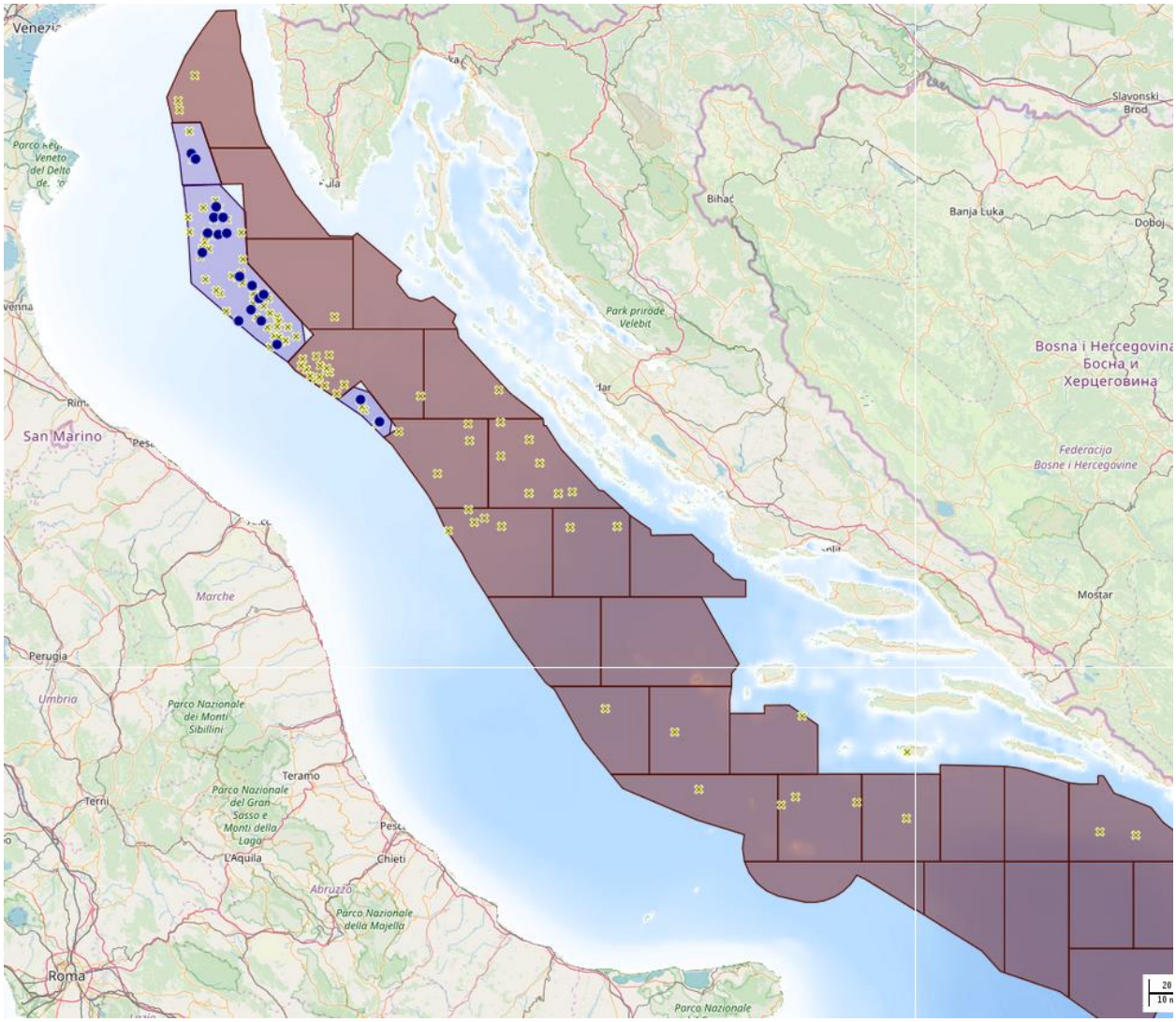

Figure 10 Croatian offshore installations (blue dots), offshore wells (test oil drills; yellow X), exploitation concessions (blue areas) and possible exploration blocks (red areas); Bathymetry: EMODnet Digital Terrain Model (DTM) 2016 (http://www.emodnet-bathymetry.eu

5.3 Coastal and Maritime Tourism

The North Adriatic Sea is an important coastal tourism destination in the Mediterranean.

Coastal and maritime tourism, which includes a variety of tourism typologies, represents one of the main socio-economic driver of the study area with great potential for the future. The nautical sector as well is highly developed, counting marinas distributed all along the coastline and around 20.000 leisure boat places.

In particular, seaside tourist flow is steadily increasing over the last 20 years. The tourism sector is characterized by highly positive dynamics at international level. Concerning the coastal tourism, data on the number of beds provided and arrivals at tourist accommodation for each Italian province of Friuli-Venezia Giulia, Veneto and Emilia -Romagna Regions in 2016 have been georeferenced from the Italian Statistics Institute (ISTAT). Updated data should be available during next months (map 11).

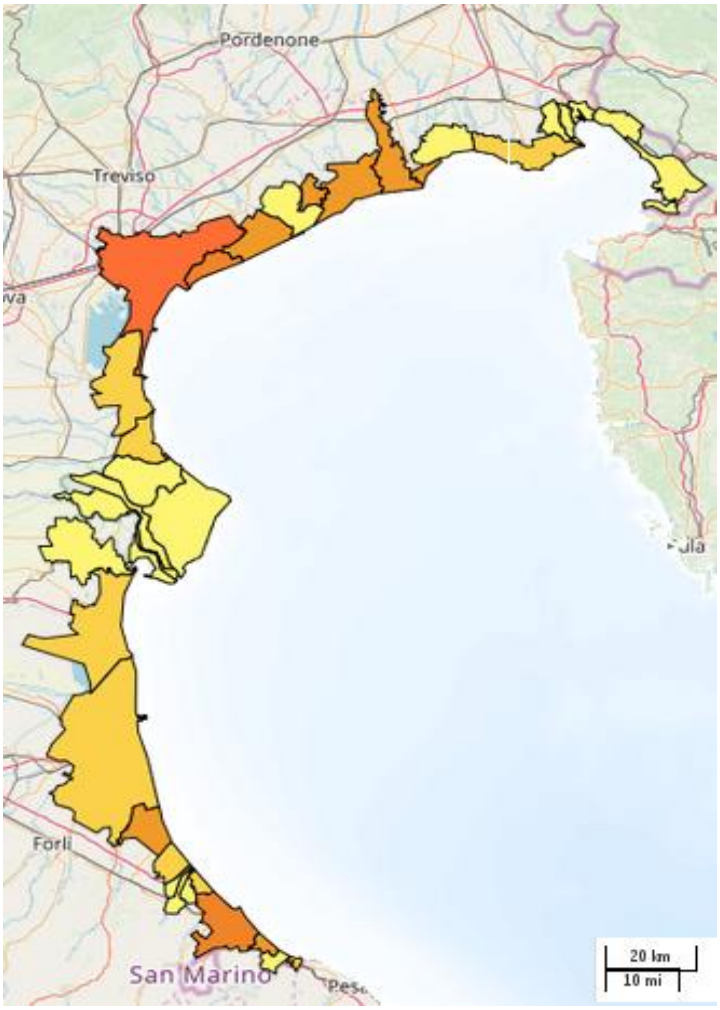

Figure 11TouristicArrivals in Italian Northern Adriaticmunicipalities (2016 - ISTAT data). Bathymetry: EMODnet Digital Terrain Model (DTM) 2016 (http://www.emodnet-bathymetry.eu); Source: ISTAT; Basemap: OpenStreetMap; Mapelaboration: data.Tools4msp.eu

Data on total, domestic and foreign touristic arrivals and overnight stays in Croatian counties (years 2016, 2017 and 2018) have been gathered from the Croatian Bureau of Statistics (https://www.dzs.hr/) and georeferenced (map 12).

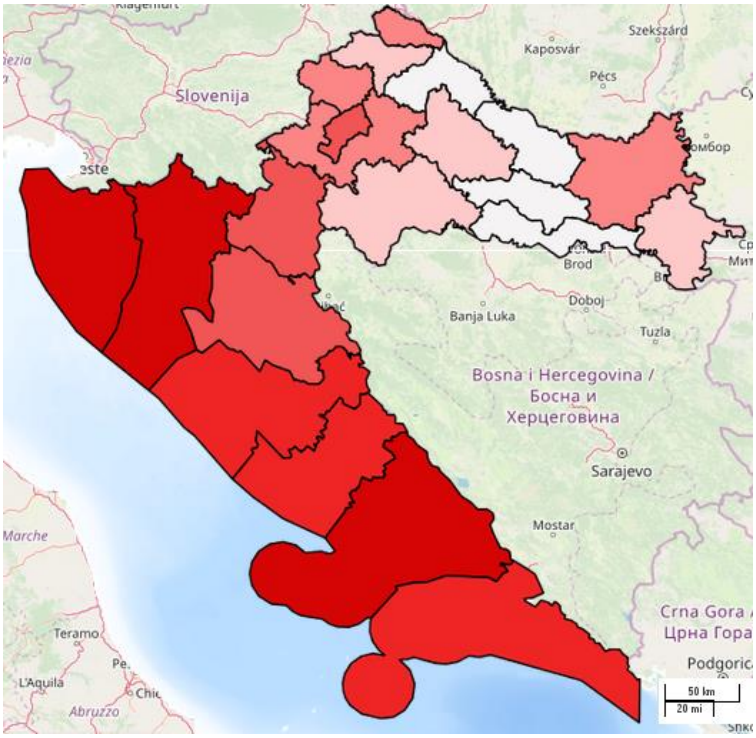

Figure 12: Touristicarrivals and overnight stays in Croatiancounties (2016, 2017, 2018; Total, Domestic, Foreign); Bathymetry: EMODnet Digital Terrain Model (DTM) 2016 (http://www.emodnet-bathymetry.eu); Source: Croatian Bureau of Statistics https://www.dzs.hr

The Adriatic Sea is one of the top nautical tourism destinations in the Mediterranean and therefore pressures from this sub-sector could be significant. Nautical tourism consists mostly of boating and yachting activities. Data on marinas along Italian, Slovenin and Istrian coasts, including the number of berths, have been georeferenced within the SUPREME project (http://www.msp-supreme.eu/). Within SUONDSCAPE the dataset has been extended to the whole Croatian area (map 13).

Figure 13Touristicmarinas in Italy, Slovenia and Croatia (dot dimensionsaccording to the number of berths); Bathymetry: EMODnet Digital Terrain Model (DTM) 2016 (http://www.emodnet-bathymetry.eu); Source: Tools4Msp/BlueWord Institute; Basemap: OpenStreetMap;

5.4 Military operations

Extensive and integrated datasets on military operations, potentially generating underwater noise, are not publicly available. Information on Italian military restricted areas (both temporary or permanent) have been gathered and regularly updated in the Tools4MSP geoportal (map 14).

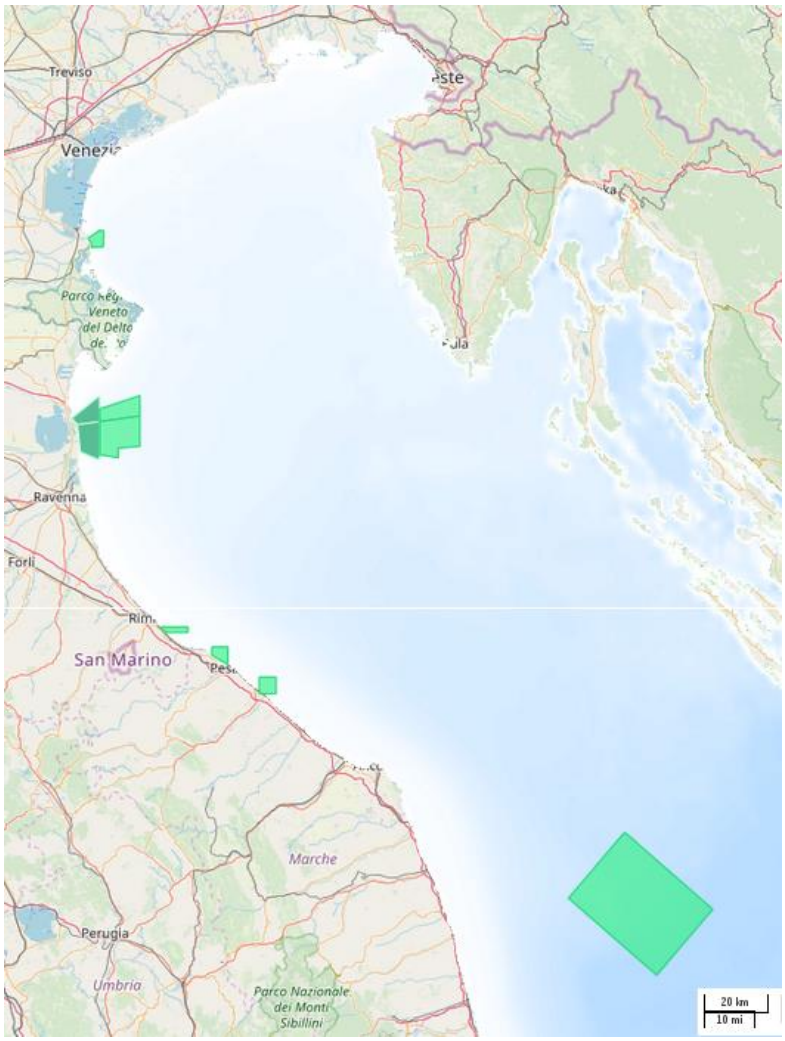

Figure 14Italianpermanent (dark green) and temporary (light green) military area. Bathymetry: EMODnet Digital Terrain Model (DTM) 2016 (http://www.emodnet-bathymetry.eu); Source: Tools4Msp; Basemap: OpenStreetMap; Mapelaboration: data.Tools4msp.eu

6 Conclusions and remarks

The geoportal with interactive SOUNDSCAPE map is ready and accessible to all the Project Partners. The actual database on anthropogenic noise sources is populated with the best resources actually available, nevertheless this should build a common baseline for the planned activities declared in the project. The data gathering should be improved and considered as work in progress.

Noise propagation models may constitute a solid base for managing underwater noise, in order to identify how the pressure and the environment interact and to determine potential hotspots. This information can be crucial to foster proper management and planning decisions. However the effectiveness of the results as always is dependent of the quality of the available data.

Therefore it is considered necessary for the purpose of the maritime space within the case study area to improve upon the quality of the data used.

The possible difficulties for the preparation of the initial assessment of local marine waters reflect the level of available knowledge where several activities, pressures and environmental components have been poorly surveyed as a whole, thus limiting the availability of accurate geo-referenced maps and detailed quantitative data.

7 Bibliography

Codarin, A., Picciulin, M. (2015). *Underwater noise assessment in the Gulf of Trieste (Northern Adriatic Sea, Italy) using an MSFD approach*. Marine pollution bulletin, 101(2), 694-700.

Committee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals, *Ocean noise and Marine Mammals* National Research Council ISBN: 0-309-50694-8, 204 pages, 6x9, (2003)

Drira A., Bouzidi, M., Maglio, A., Pavan, G., Salivas .*Modelling underwater sound fields from noise events contained in the ACCOBAMS impulsive noise register to address cumulative impact and acoustic pollution assessment,* CreteEuronoise 2018

Folegot. T, Clorennee D, Chavanne R, Gallou R *Mapping of ambient noise for BIAS.* (2016a) QuietOcean Technical report

Folegot T., D. Clorennec, A. Norro, A. Gill et F. Thomsen, (2016b), Modelling the risk of noise exposure to marine life during offshore wind farms construction and operation, 4th International Conference on the Effects of Noise on Aquatic Life, Dublin, Ireland, 2016.

Folegot T., D. Clorennec, A. Nikolopoulos, F. Fyhr, M. Andersson et P. Sigray (2016c), Regional management of underwater noise made possible: an achievement of the BIAS project, Internal Conference on Underwater Noise Racket in the Oceans, Paris, 2016.

Hildebrand, J.A., 2009. *Anthropogenic and natural sources of ambient noise in the ocean.*Marine Ecology Progress Series, 395, pp.5-20.

Maglio et al. *Overview of the noise hot spots in the ACCOBAMS area – Part I mediterranean Sea* (2016) Sixth Meeting of the Parties to ACCOBAMS (Monaco)

Pavan, G., Fossati, C., Maglio, A. and Filiciotto, F., 2013. I*L REGISTRO NAZIONALE DELLE SORGENTI DI RUMORE IMPULSIVO NELLA IMPLEMENTAZIONE DELLA MARINE STRATEGY*. Proceedings of the AssociazioneItaliana di Acustica, 44° Convegno Nazionale, Pavia, 7-9 giugno 2017

QuietMed D4.1 *International impulsive noise register for the Mediterranean basin*. December 2018

QuietMed D4.2. *User manual of the Impulsive Noise Register of the Mediterranean Sea Region* (INR-MED) 2018

Shutton G., ClorennecD.,Jesshop M. and Folegot T. (2013), Mapping the spatio-temporal distribution of underwater noise in Irish Waters, Editor: Environemental Protection Agency, Dublin, 2013.

Tasker, M. L., Amundin, M., Andre, M., Hawkins, A., Lang, W., Merck, T., ... &Zakharia, M. (2010). Marine Strategy Framework Directive Task Group 11 Report Underwater noise and other forms of energy. Report No. EUR, 24341

Thomsen T. (2013), Underwater sound in relation to dredging, CEDA Webinar Series, DHI Group.

Thomsen F., A. Gill, M. Kosecka, M. Andersson, M. Andre, S. Degraer, T. Folegot, J. Gabriel, A. Judd, T. Neumann, A. Norro, D. Risch, D. Wood et B. Wilson (2015), MaRVEN: Environmental Impacts of Noise, Vibrations and Electromagnetic Emissions from Marine Renewable Energy, Editor: European Commission, Brussels, 2015.

Van der Graaf AJ, Ainslie MA, André M, Brensing K, Dalen J, Dekeling RPA, Robinson S, Tasker ML, Thomsen F, Werner S (2012). European Marine Strategy Framework Directive – Good Environmental Status (MSFD GES): Report of the Technical Subgroup on Underwater noise and other forms of energy.

Consulted websites :

REMPEC 'MEDGIS-MAR' http://medgismar.rempec.org/

EMODNet http://www.emodnet.eu/

TOOLS4MSP http://data.adriplan.eu/tools4msp/

SINAYwww.sinay.fr

AIShub www.aishub.com

MaritimeTraffic https://www.marinetraffic.com/

QuietMED noise register http://80.73.144.60/CTN_Geoportal/home/

Marine Noise Registry service https://mnr.jncc.gov.uk/