SCIENCE AND TECHNOLOGY ORGANIZATION

CENTRE FOR MARITIME RESEARCH AND EXPERIMENTATION

Technical Progress Report

Environmental Characterization of Test Site

(ESTCP UXO Testbed Project, Subtask 1.2, Due Date 29 October, 2021)

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ABSTRACT

This report describes a study performed by the Centre for Maritime Research & Experimentation (CMRE), in the area nearby its facilities in the Gulf of La Spezia (Italy). The main objective has been to collect environmental and morphological data to characterize their proposed test site, with the aim of providing these datasets to inform potential end users. The test site and its characterization have been made within the framework of the project for evaluating unexploded ordnance (UXO) detection technologies and equipment funded by the Environmental Security Technology Certification Program (ESTCP).

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1 ABSTRACT

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The approach followed to address this task has been to select and deploy a set of instruments and sensors that can provide the widest set of characteristics of the area. Data collection ranges from atmospheric parameters, through the water column, reaching the seabed properties.

Regarding the meteorological parameters, a weather station was installed on top of a laboratory container placed on one edge of the test area. This weather station has been collecting data such as wind speed and direction, atmospheric pressure and precipitation rate.

For the water column characterization, several instruments were placed in the area. There was a vertical thermistor chain with ten elements with 1 metre spacing, two Sound Velocity Probes (SVP), one upwards looking Acoustic Doppler Current Profiler (ADCP), and one underwater camera. Moreover, during the period of observation, a CTD cast was performed twice a day.

Regarding the bottom characterization, several grabs were collected along the area, and the gathered sediments were analyzed in the laboratory to characterize their composition. In 2022, additional seven grabs were collected and analyzed. CMRE is currently attempting to have three cores performed in the area. Bathymetry has also been retrieved with different sensors (Side Scan Sonar and Multi-Beam) on different autonomous platforms (Remus-100 and Bluefin-BP21) to account for wide coverage as well as detailed information where needed. The clutter present in the area has been checked and catalogued for future use.

During this initial phase of environmental characterization, CMRE has also started to establish contacts with several military Agencies (“Balipedio Cottrau”, the Italian Navy experimental artillery shooting range, and “Agenzia Industrie Difesa”, the military establishment for munition retrieval at Noceto, Parma) to obtain information on the most commonly used munition and also to obtain a representative sample set of such projectiles and other assets to seed the test site.

Permits and approvals are required to operate in the area, since the test site lies within a military zone. Nevertheless, CMRE has already a MoU in place with the “Centro di Supporto e Sperimentazione Navale” (CSSN), since both entities already use the area as a testbed for other purposes (autonomous vehicles testing, underwater communications, etc). Within the framework of UXO/ESTCP Project, the permission to use the area has been granted by ITA-N (CSSN) and reported.

The methodology to seed the site is already under study to ascertain a safe deployment and recovery, proper geolocation of targets, and procedures for maintenance of equipment.

In summary, the test site proposed by CMRE provides technology developers with an adequate facility for testing their equipment to detect classify and/or identify UXO targets. CMRE provides a convenient access to sea from within its facilities, equipped with a crane, pier for docking, mechanical and electronic workshops, etc. and the test area is immediately accessible in front of its facilities.

2 ACKNOWLEDGMENTS

We would like to thank Commander Stifani and Commander Fusco from ITA-N/CSSN for their availability and kindness in coordinating the operations in the test site, and in providing contacts with other ITN commands potentially involved in the future Testbed design, implementation and operation.

We thank the CMRE LOON Research Team, Joao Alves, Roberto Petroccia and Costas Pelekanakis, for supporting and funding the cabled observatory, as well as the CMRE Engineering and Information Technology Team (Richard Stoner, Marina Ampolo-Rella, Alberto Grati, Giovanni Zappa and Giampaolo Cimino), which have provided invaluable support and information on the equipment and environmental datasets used in this report.

We thank John Redmayne (CMRE MCM Section Leader), who has dedicated his time in the planning phase of the Project and contributed with suggestions and corrections to this manuscript.

This Project has been funded by the Environmental Security Technology Certification Program (ESTCP) via the Strategic Environmental Research and Development Program (SERDP) as a response to the Statement of Need: MRSON-17-02, Preliminary Design Study for Munitions Response Underwater Test Site.

3 ACRONYMS AND ABBREVIATIONS

ADCP	Acoustic Doppler Current Profiler
AUV	Autonomous Underwater Vehicle
°C	Degrees Celsius
CMRE	Centre for Maritime Research & Experimentation
CSSN	Centro di Supporto e Sperimentazione Navale
CTD	Conductivity/Temperature/Depth Sensor
EITD	Engineering and Information Technology Department
ESTCP	Environmental Security Technology Certification Program
GPS	Global Positioning System
ha	Hectare
ITA-N	ITAlian Navy
LOON	Littoral Ocean Observatory Network (cabled observatory)
MB	Multi Beam
MBES	Multi Beam Echo Sounder
MCM	Mine Counter Measures
PSU	Practical Salinity Unit
RHIB	Rigid Hulled Inflatable Boat
SERDP	Strategic Environmental Research and Development Program
SSS	Side Scan Sonar
SWL	Safe Working Load
SVP	Sound Velocity Probe
UXO	Unexploded Ordnance

4 INTRODUCTION

The Centre for Maritime Research and Experimentation (CMRE) has been working for several years in the development of technology and equipment to detect, classify and/or identify unexploded ordnances (UXO) in the framework of the scientific programme of work of Mine Counter Measures (MCM) projects.

During the development of such equipment and instruments, the need for controlled testing conditions has become evident, to evaluate their performance based on the characteristics of the site, whether environmental, morphological or any other aspect possibly affecting the instrumentation under test. Furthermore, the test site should be properly documented as accurately as possible regarding the seeding of targets, their position and orientation, as well as the existing clutter.

It would be therefore desirable for technology developers to access different test sites, to evaluate their equipment under different challenging conditions, and to be able to characterize their own instrument performance within various scenarios. From another point of view, it would also be desirable for a test site characterized by a certain set of conditions to be inspected by different technological solutions, in order to assess which one of them is more suitable within such a scenario. Overall, the crossover of test sites and technology developments would be extremely beneficial for all participants to speed up their progression in the field of UXO remediation, maximizing the operational time available for their tests, and avoiding the preparation time of the required facilities.

5 OBJECTIVES

The main objective of this report is to describe the environmental characterization of the proposed operational area at CMRE / CSSN, in preparation for the construction of a UXO test site, and provide potential users with the necessary information ahead of future experimentation. A historical background of the area and a resume of ongoing activities is also reported, to provide insights on the logistical and operational implications.

6 TECHNICAL APPROACH AND SETUP

6.1 PURPOSE

The purpose of this Task was to provide a full environmental description of the site and an accurate location and description of existing objects (clutter). According to the reference Project Plan [as described in ESTCP proposal MR21-B4-5243], the environmental assessment initial plan was to contain:

- Currents
- Waves
- Tides
- Bathymetry
- Sediment Characterization
- Water Column Surveys
- Biological Activity
- Environmental clutter

To achieve these objectives, a network of instruments have been deployed in the operational area. The most of the equipment was installed in a network of CMRE developed platforms (deployed in the framework of LOON Project), namely:

- A forward looking ADCP, to measure water current profile and wave/tide height;
- Two SVPs, to provide real time sound velocity, at two different depths.
- A vertical thermistor chain with ten temperature sensors (spacing 1m), to provide real time measurement of water temperature.

In addition to this:

- A CTD cast was performed twice per day, in order to obtain profiles of water temperature, conductivity and turbidity.
- An underwater camera, pointing at a surrogate target, to estimate bio-fouling progression.

Figure 1. The ADCP and SVPs used within the LOON platforms

6.2 Current and Wave Height Measurements

The deployment of the WaveRider buoy in the testbed area was considered impractical and difficult, mostly due to the limited depth and the heavy traffic of leisure boats in the immediate proximity.

Instead, a bottom deployed, upward looking ADCP (installed as part of the LOON Network, and configured to measure wave height as well) was preferred, to avoid interference with surface activities.

ADCP data have been recorded at the beginning of the observation period. Unfortunately, the communication with the unit stopped after about two weeks, preventing further data acquisition. The available dataset has been extracted from the instrument, allowing a preliminary characterization of the currents present in the area. The instrument has been repaired and redeployed at the end of October, and current measurements will be acquired until the start of the Demonstration phase.

6.3 Tide measurements

The CMRE tide-gauge was sent to the Manufacturer for repair in May. Initially, the troubleshooting of the unit was delayed due to COVID-19 related workforce issues. Later (and well into the planned measurement period), the Manufacturer stated that the gauge was no longer serviceable, and no immediate replacement unit was available.

Despite the lack of measured data, it is confirmed that the testbed area is characterized by a low tidal energy. Tidal model outputs, available online, show maximum tidal amplitudes ranging between 0.2m and 0.3m. To validate the above assumption, the historical model outputs will be tentatively cross-checked with the relevant data from the ADCP (surface lock) and SVPs (pressure gauges) sensors.

Furthermore, the Italian "Istituto Superiore per la Protezione e la Ricerca Ambientale" also operates a tide gauge, deployed at less than 400 metres distance from the CMRE meteo-station. Data from this unit are available on-line (ISPRA-06, Reference (9)).

6.4 BATHYMETRY

Bathymetry data have been obtained by combining historical data sets (collected by CMRE, and covering approximately the 80% of the testbed area) with complementary measurements resulting from dedicated surveys.

The existing data were acquired from a Kongsberg Maritime EM3002 Multibeam Echo Sounder (MBES). Additional bathymetric data for the area not covered by the existing data set has been surveyed with a REMUS 100 autonomous underwater vehicle (AUV) equipped with Side Scan Sonar (SSS). For redundancy, a second dataset, covering the whole area, has been built using a BlueView MBES installed on a Bluefin BP-21 AUV.

AUVs have been preferred over Vessels/Boats as operational platforms for the sensors, given the intrinsic constraints of the area (dimensions, depth, obstacles), which would have made a ship-based approach too complex if not impossible, for little or no gain in time and fidelity.

6.5 SEDIMENT CHARACTERIZATION

Given the dimensions of the area, seven grab-samples were performed from a rigid hulled inflatable boat (RHIB) and analyzed in the CMRE sediment laboratory during Q4 / 2021. Seven additional grabs were later collected and analyzed in Q1 / 2022. An external company has been contracted to perform a coring campaign (using vibrocores technology) and a Sub Bottom Profiling survey in the testbed area during Q1 / 2022. Results will be available on time for the Demonstration phase of the project.

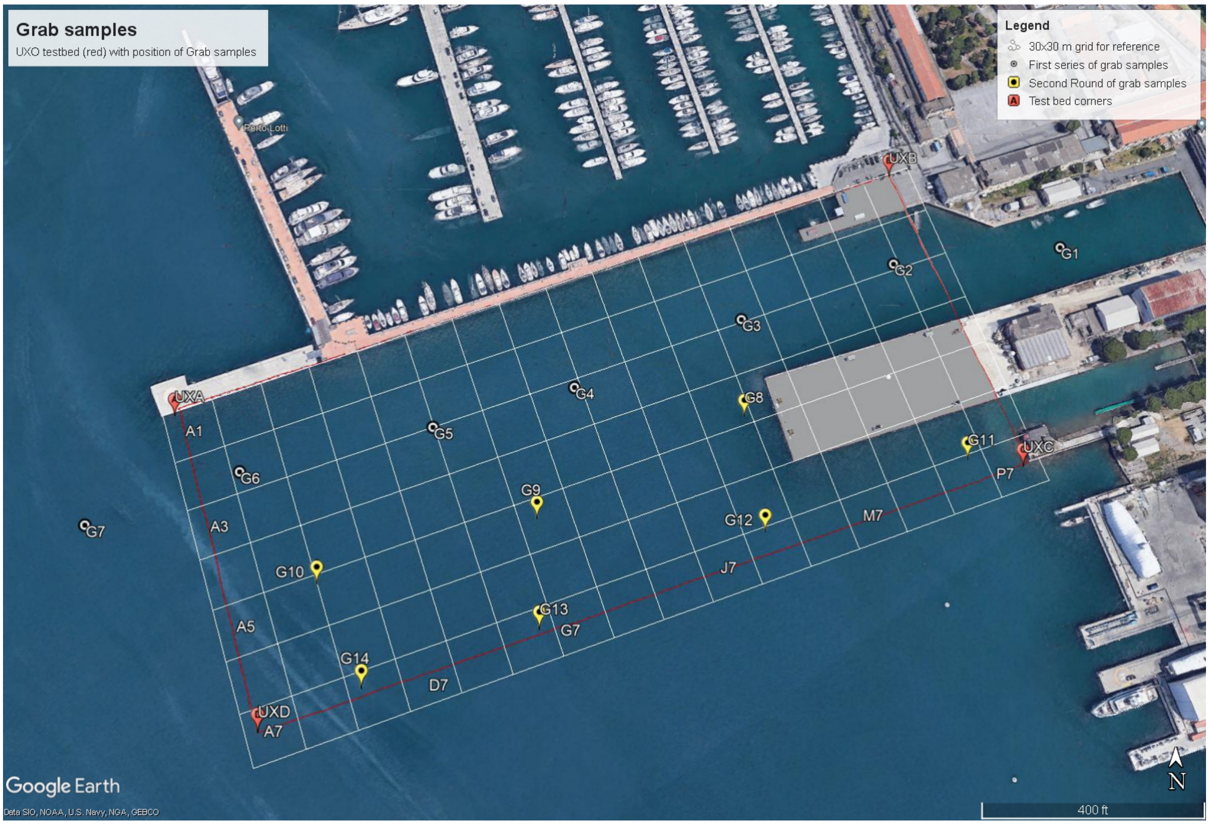


Figure 2. Google Earth images showing the position of fourteen grab samples taken in or near the area. The initial seven grabs (G1-7, white circle) was taken the summer 2021. The last seven (G8-14, yellow drop) in January 2022. The red line indicates the limit of the testbed whereas the white lines forms a 30x30m grid for reference. Each grid cell is named A to P in the West-East direction with a number 1-7 in the North-South direction.

6.6 Water Column Surveys

The water column has been thoroughly characterized by a combination of sensors: a vertical thermistor chain (installed in one of the LOON nodes), and a CTD profiler, deployed from shore by means of a ballast and a set of pulleys. The thermistor chain has provided a highly dense time-series characterization of the temperature field evolution, while the CTDs were able to provide an insight of how the temperature data relate to other parameters, such as salinity, density and turbidity.

6.7 Biological Activity

The bio-fouling progression has been estimated by deploying a tripod holding a target and an underwater camera (with additional lightning equipment), adequately focused on the target. The system has collected images of the target at regular time intervals over several months, in order to characterize the growing of biota over the target.

6.8 Environmental clutter

The SSS and bathymetric surveys have provided information on clutter and unknown objects found in the area. These objects have been catalogued, named (according to the grid cell they lie in) and geolocated for future use. To ensure fair comparison between system demonstrators the information on clutter objects (Appendix A – Clutter Catalogue) will not be made available to the users of the site.

7 RESULTS

7.1 INTRODUCTION: CMRE LOCATION AND FACILITIES

7.1.1 THE PORT OF LA SPEZIA: HISTORICAL BACKGROUND

CMRE is hosted within the Port of La Spezia, inside a natural Gulf closed on the Southern side by a breakwater defense.

La Spezia is the capital of the easternmost of the four provinces forming the Liguria region. It is the second largest city in Liguria, and is serviced by the nearby airports of Genova (111 km / 80 minutes), Pisa (83 km / 60 minutes) and Florence (141 km / 90 minutes). La Spezia lies in a node of the Italian highway system, at the intersection of the routes to Genoa, Livorno and Parma

The port of La Spezia is first mentioned in literature by Strabo, a Greek geographer (62 BC – 26 AD). Being mostly under control by Genova, La Spezia had a contorted development. Situated in the extreme south of Liguria it proved to be difficult to defend from attacks coming from other states. In 1416, a law was passed to prohibit offloading of merchant goods in ports other than Genoa.

After the fall of the Genoa republic in 1792, La Spezia grew, developed and changed as part of the newly constituted Italian State. The decision to build a large base ("Arsenale") for the Italian Navy, taken in the mid of the 19th Century, had been the most important passage for the development of the city. Construction works of the Arsenale began in 1862, and the base was officially opened in 1869. The Arsenale became one of the Italian Navy's most important bases. Due to the strategic importance, it sustained heavy allied bombing during WW2.

7.1.2 LA SPEZIA MAIN ACTIVITIES: SHIP BUILDING

The gulf of La Spezia and in particular the area around the UXO test site has hosted and is still hosting several small to medium size ship-yards, active in the construction and repair of merchant and military ships (Fincantieri, Intermarine) and yachts (Riva, Ferretti, Baglietto, Perini, Sanlorenzo, San Marco).

7.1.3 CMRE NEIGHBOURING RESEARCH CENTER: CSSN

The Centre for Naval Support and Experimentation (Centro di Supporto e Sperimentazione Navale, CSSN) was born in 2007 by the fusion of three experimental units: MariPerman (ship structures, machinery, and weapons), MariMissili (missiles) and MariTeleRadar (ship and shore radar systems), active since the beginning of 20th Century. CSSN is currently located together with CMRE in the San Bartolomeo compound. The CSSN is responsible for all test and verification activities on ships and submarines, spanning from munitions and weapons, to hulls and machinery, with a particular focus on acoustic and magnetic signatures. The CSSN has direct control on an active Italian Navy shooting range (“Balipedio”), located at the Southwestern entrance of the Gulf.

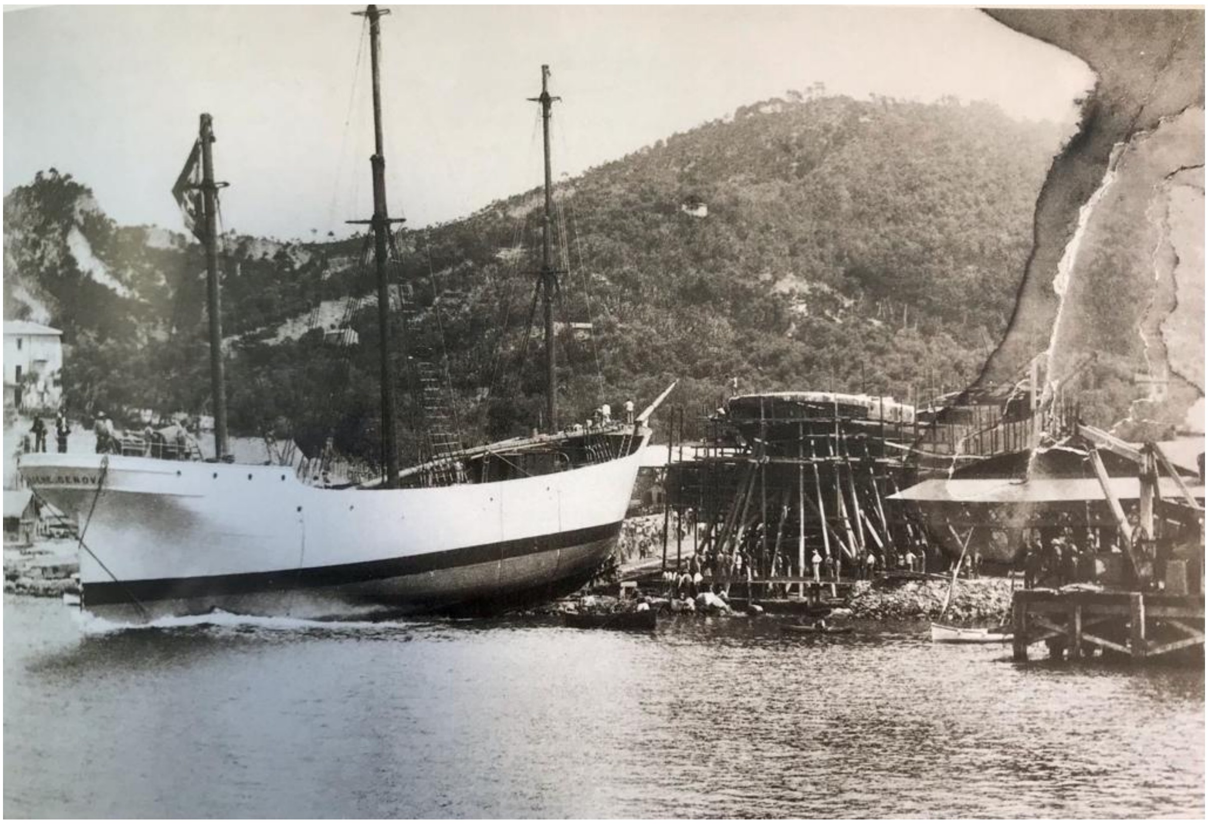


Figure 3. The gulf of La Spezia and in particular the area around the UXO test-bed has historically been a busy area for small and medium shipbuilding industry.

7.1.4 CURRENT USES OF THE TEST SITE

The UXO testbed is located immediately outside CMRE and CSSN facilities. This water space is used by CMRE and CSSN to test autonomous assets before deployment or trials at sea. Coordination between the two Authorities is maintained on a monthly basis, and resumed in a trials plan including requirements, timelines, type of equipment, need for acoustic transmissions, and mutual Points of Contact.

Small pleasure and working boats transit outside the western side of the area, on their way in and out of the gulf. Small boats operated by the Italian Navy, Coast Guard and Police occasionally enter the area for inspection, training or to load material.

7.1.5 Facilities at CMRE

CMRE, (previously known as SACLANTCEN, then NURC), was formally funded in May 1959 to conduct research and provide scientific and technical advice in the field of anti-submarine warfare. The Centre evolved along the years, extending its Programme of Work to a broad range of underwater and maritime research fields (antisubmarine warfare, mine countermeasures, military oceanography, and underwater communications).

Currently, CMRE offers engineering and logistic support to the experimental and scientific activities through a series of laboratories, workshops and facilities, the most notable being:

- A full mechanical workshop with lathes, mills and other auxiliary machines
- Three pressure chambers with 100m, 1000m and 6000m equivalent depth rating
- A fully equipped molding laboratory for underwater cables and connectors
- An electronic workshop
- One of the first installed CTD calibration laboratory in Europe
- An optical calibration laboratory
- A geophysics laboratory, for the analysis of cores and grab-samples
- A towed array construction and repair facility, with hosing and de-hosing capability
- Multiple storage facilities
- A 2T safe working load (SWL) shore crane, next to the main building, to serve the testbed area
- Conference rooms

7.2 Local Geology

The Gulf of La Spezia is located in the Southeastern extremity of the Ligurian region, between the promontory of Portovenere (further extending on the islands of Palmaria, Tino and Tinetto) and Punta Bianca.

The Gulf is surrounded on its land perimeter by hills, rising in the East towards the mountains of the “Alpi Apuane”, a detached chain of the Tuscan Appennines. The western and eastern promontories forming the Gulf consist of semi-parallel folds of Mesozoic and younger rock: an overturned anticline on the West and a normal anticline on the East. The Gulf is therefore a tectonic feature generated in response to deep-seated thrusting forces directed from southwest to northeast. This tectonic structure was subsequently flooded to form the actual gulf.

The Gulf is 7 km long and 4.5 km wide (maximum distance) and it is restricted by a breakwater, extending in the SW-NE direction between the villages of Le Grazie and Muggiano. The breakwater separates the inner harbour (average water depth 12 m), from the outer part of the Gulf (average depth 17-18 m).

The CMRE/CSSN facilities, including the UXO testbed site, are located in the inner Gulf. This area is characterized by shallow depths, with a recent sedimentation of fine texture (predominantly silt and clay fractions) resting on a thin layer of fine sediments, attributable to a deposition of the lagoon environment. Beneath these layers, there are sediments of continental origin (gravels and fine matrix sands) which lie on a rocky substrate.

The approximate stratigraphy of the harbour can be reconstructed using historical data, deriving from direct (3m/5m cores, collected during the "*Progetto preliminare di bonifica dell'area marina, inclusa nella perimetrazione del sito di bonifica di interesse nazionale di Pitelli"* performed by ICRAM) as well as from indirect surveys (sub-bottom profiles and seismic analysis performed by SACLANTCEN). This preliminary information allows the geological correlation between three sedimentary levels, and three associated acoustic facies. Moving from top to bottom layers, the area is characterized by:

Sedimentary Cover (B), with a variable thickness between 0m and 10-12m, characterized by clayey silts and silty clays (whose compactness progressively decreases when moving upwards), locally becoming gravelly and/or sandy. The most superficial layer (B) is made up of clayey silts and not very consistent silty clays. This level represents the most superficial clayey cover and is characterized by thicknesses ranging from 1m (along the coastline), to over 10m in the deepest areas of the gulf, consistent with the deepening of the first reflector. From the historical seismic data acquired by the SACLANTCEN (see Report: "The Gulf of La Spezia: a case History of Seismic-Sedimentology Correlation") this sedimentary facies can be associated with the acoustic facies called Shallow layer. This layer is a weak reflector and excellent transmitter of acoustic energy.

Intermediate Level (A) characterized by a greater abundance of coarse fractions consisting of sands, silty sands and silty-gravelly sands of medium thickness of about 2 m. Below the superficial clayey cover there is a level consisting of silty sands, sands, gravelly sands and sandy gravels often interspersed with clays silty (A). This level is found at modest depths of about 1-2m, along the coast while proceeding towards the centre of the gulf it deepens up to 10-13m. This sedimentary facies can be associated with the acoustic facies called Main Intermediate Layer. This layer is both a good reflector and a good transmitter of acoustic energy.

Deep Level (S), rarely reached by historical coring, consisting of very consistent sandy-clayey marl which probably represent the roof of the compact substrate. The lower level (S) probably represents the roof of the compact substrate, and it is presumably continuous throughout the area. The depth of this reflector increases progressively with distance from the shore. It is in fact found at cores collected close to the coast and it is no longer found in core samples carried out further out. This sedimentary facies can be associated with the acoustic facies called Deep Layer. This layer is a good reflector and poor transmitter of acoustic energy. It is the terminal reflector, and the deepest layer that has been reached with the particular seismic equipment used during the historical surveys.

From the interpretation of the historical SACLANTCEN, data it is possible to deduce the presence of sediments impregnated with gas (Gas charged sediments or Dark Patch) punctual gas rising (Plume or Light Dome). These are the due effects of the great abundance of organic substance. The presence of buried channels is also noted. This feature appears on the seismic record in the form of a trough-shaped depression in deep layer (see Figure 6).

7.3 BATHYMETRY

The UXO test site occupies an area of approximately 1Km^2, with the 90% being on water. The shape of the area is rectangular, with approximate dimensions of 200m by 500m. Depth distribution, as seen in Figure 5, indicates an average depth of approximately 10m and more than 50.000 m^2 provide depths greater than 9.5 metres.

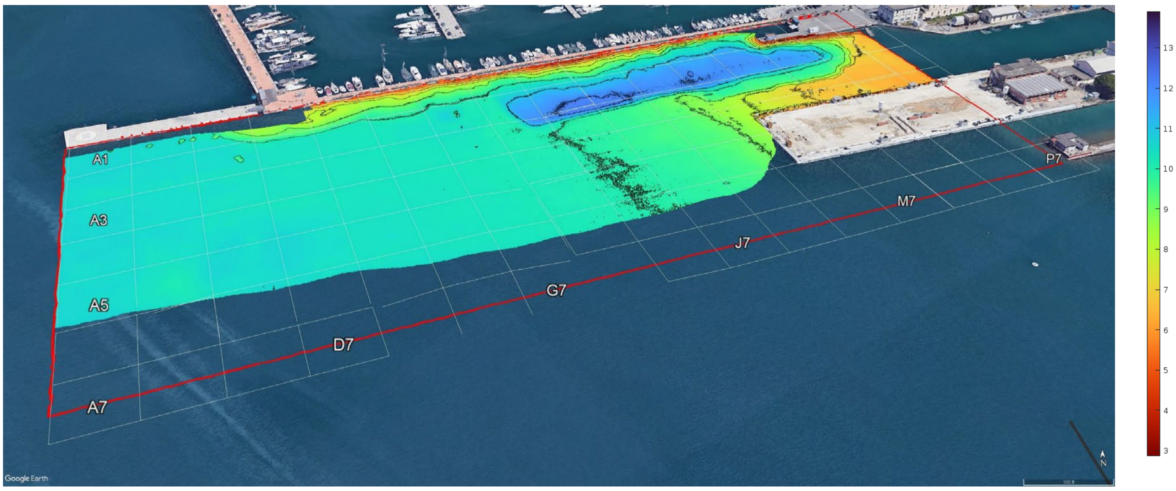


Figure 4. Bathymetry of the area from historical EM3002 MBES surveys with a 30x30m grid overlaid.

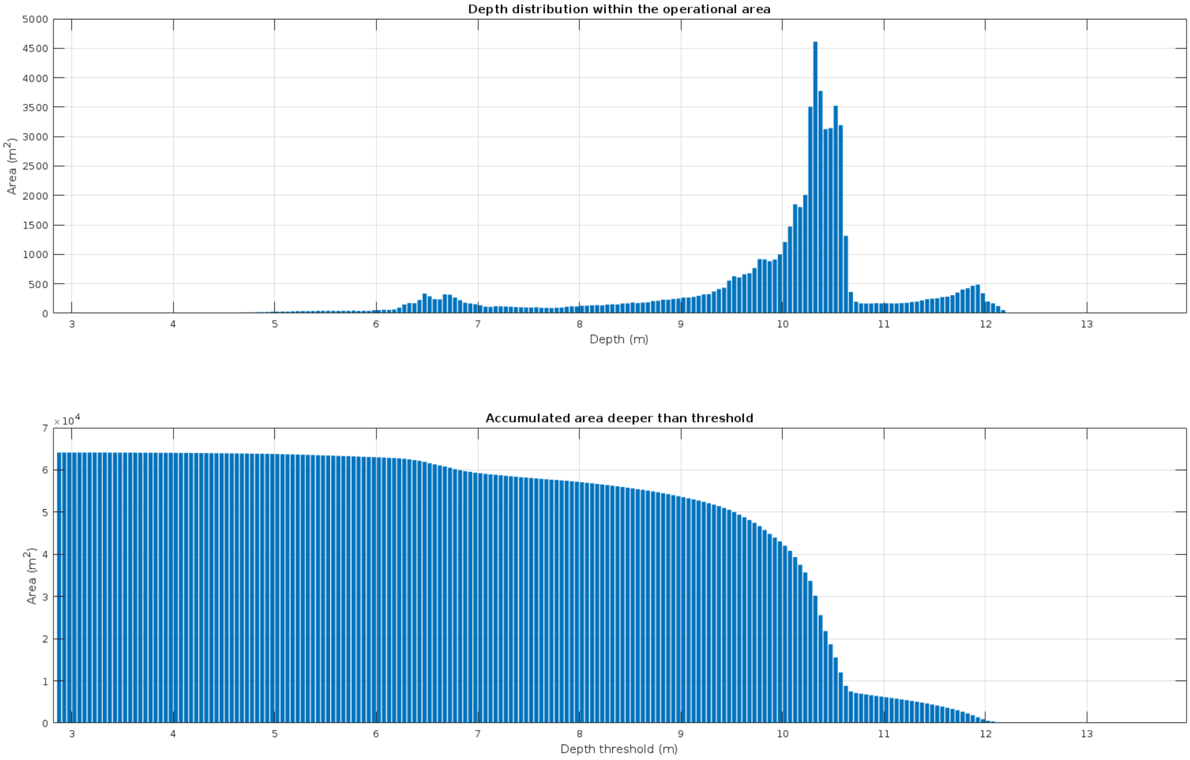


Figure 5. Depth distribution in the area based on multibeam-data surveys. The top image represents the histogram, while the bottom one shows the accumulated area deeper than any depth threshold

This area is limited by the Marina of Porto Lotti on the northern boundary, CMRE and CSSN facilities on the north-eastern and eastern sides, and a shipyard (Baglietto) on the south-eastern corner. The southern and south-western sides of the area are opened towards the centre of the Gulf. This geometry is shown in Figure 6.

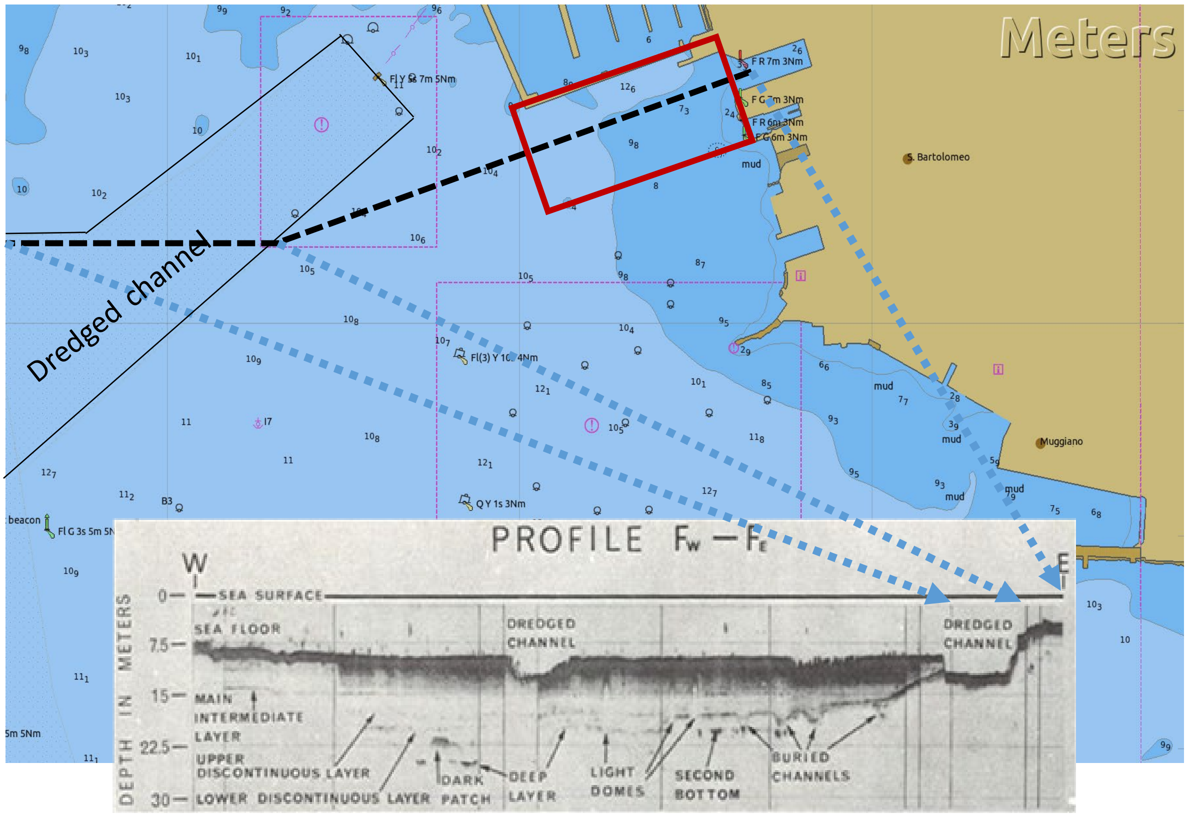
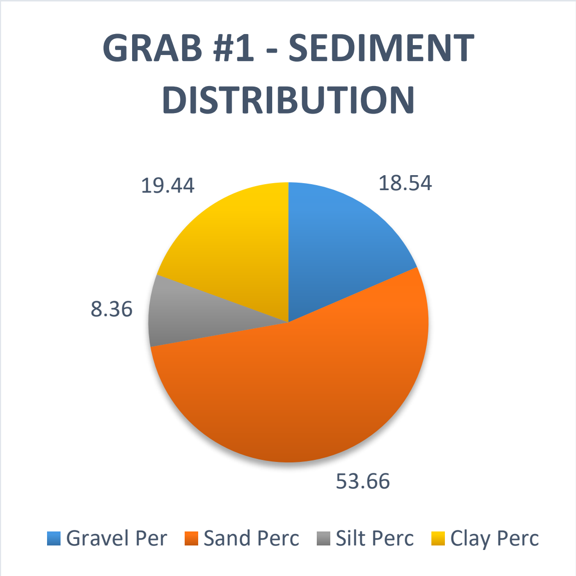


Figure 6. Map of the surrounding area of the test site. For reference, FL(3) 10s 4 Nm (44.091166 N, 9.856885 E) is located 450m from the Porto Lotti SW-most corner; Q Y 1s 3NM is at 700m from that same SW corner. A historical sub-bottom profile [1968 Breslau & Edgerton] is shown and the track of the survey is indicated (dotted-black). Blue arrows roughly indicate the map versus sub-bottom profile.

7.4 Bottom Type / Sediment Characterization

The sediments collected during the grabbing activity performed within the current study (Q3 / 2021 and Q1 / 2022) are predominantly fine-grained, with a fair amount presence of a sandy fraction. Sediments from the stratigraphy of the cores are generally not very consistent in the superficial layers and more compact in the deeper layers. Additional vibrocores will be taken in Q2 / 2022. The position of the fourteen grabs shown in Figure 7 below are indicated on the map in Figure 2.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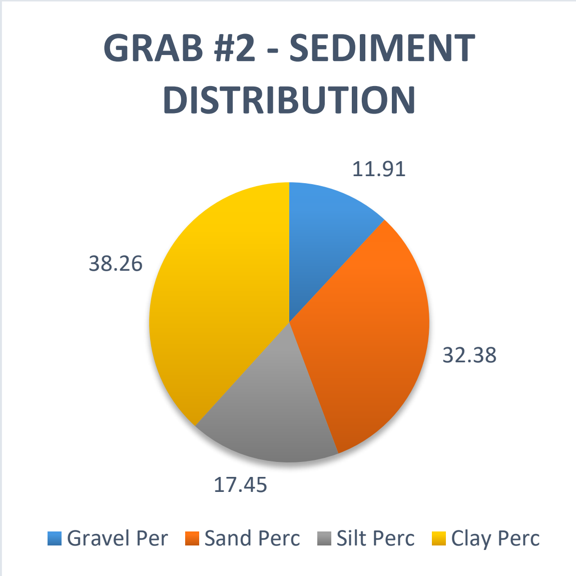
Clay Perc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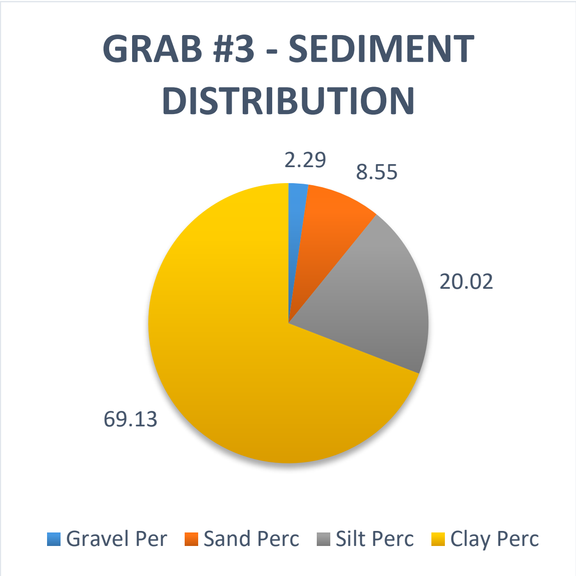
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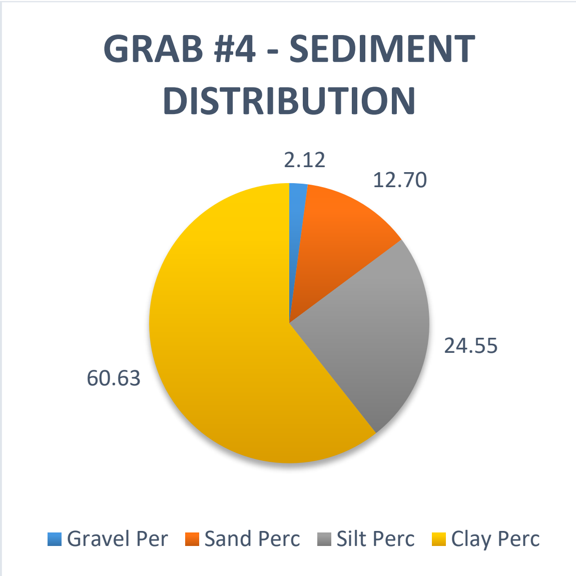
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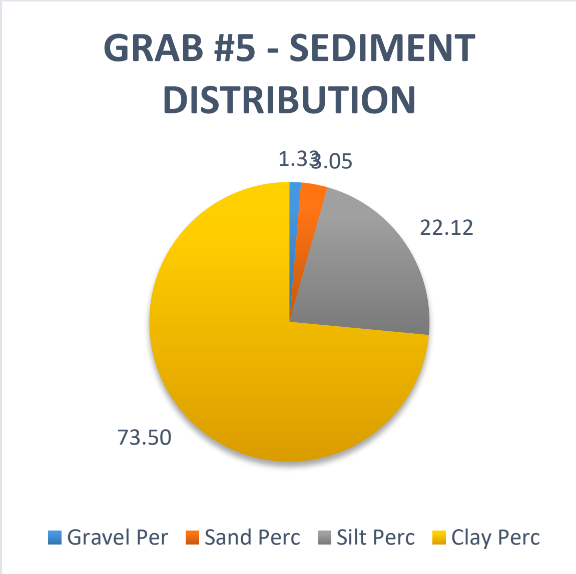
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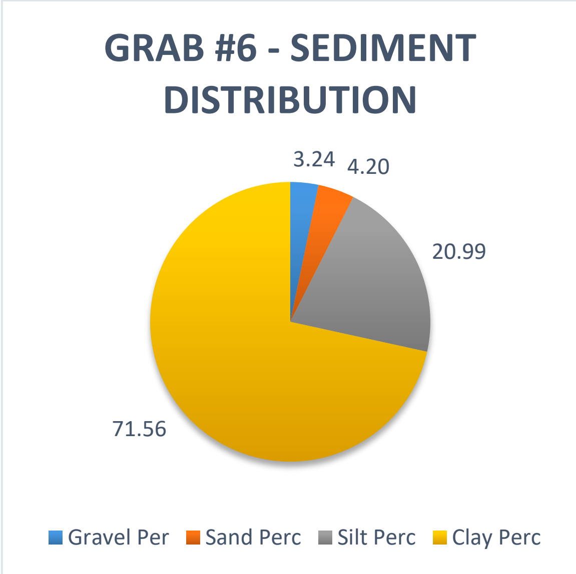
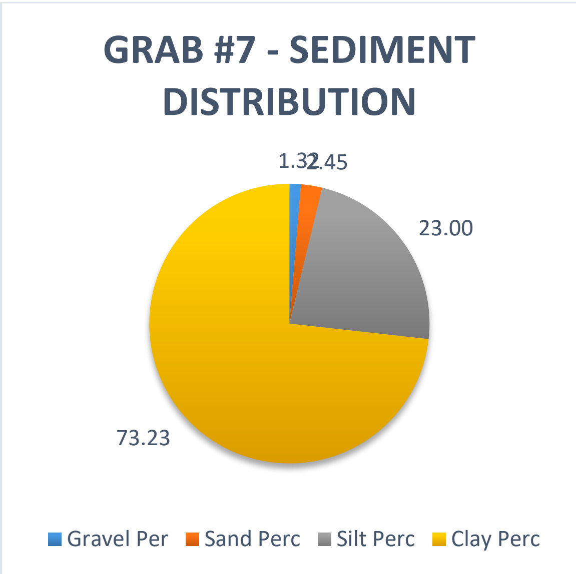
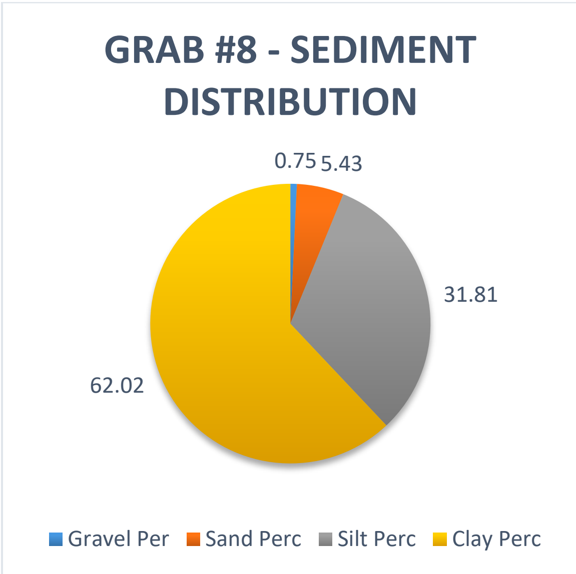
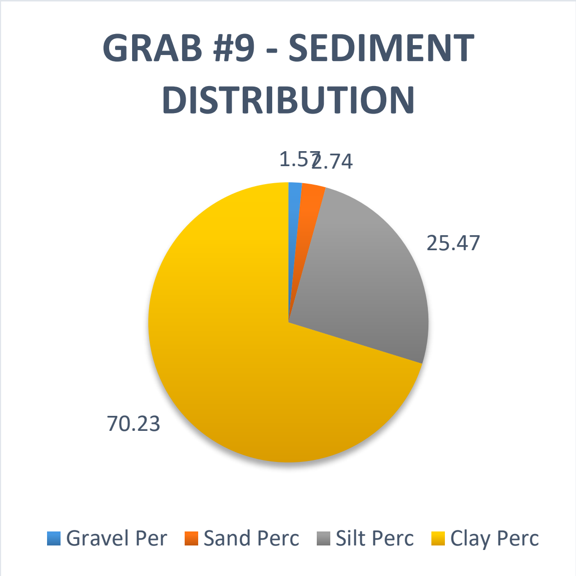
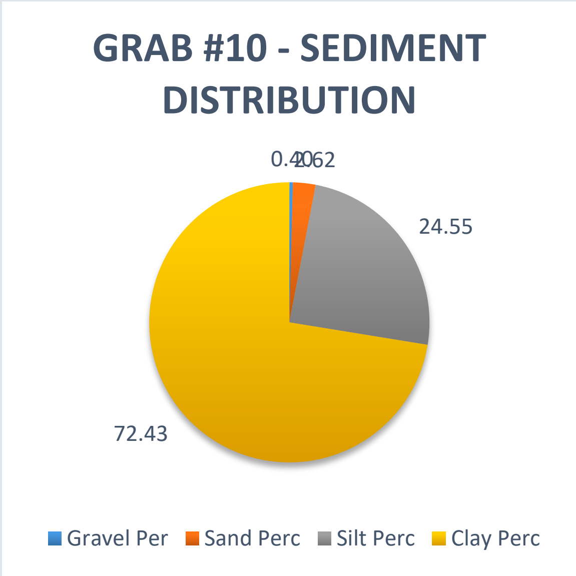
22.12
73.50
Gravel Per
Sand Perc
Silt Perc
Clay Perc

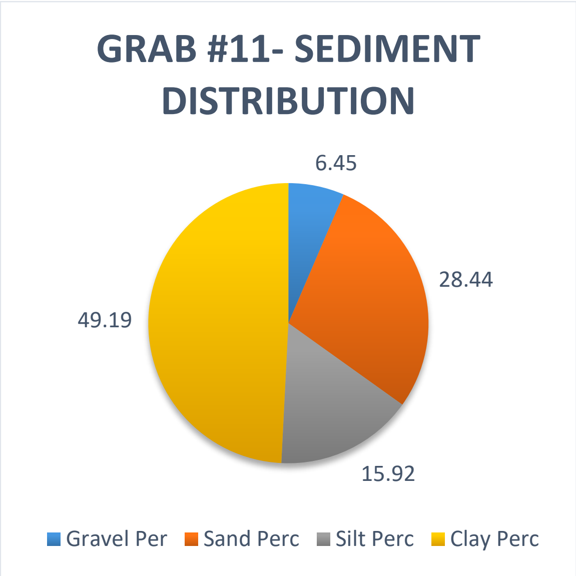

GRAB #6 - SEDIMENT DISTRIBUTION
3.24
4.20
20.99
71.56
Gravel Per
Sand Perc
Silt Perc
Clay Perc

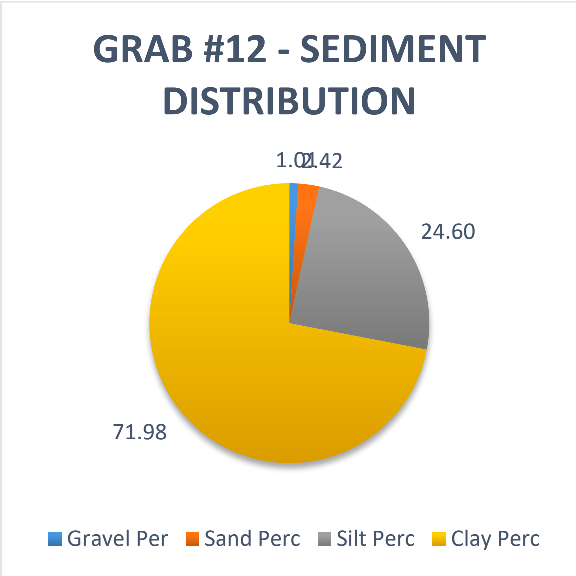

GRAB #7 - SEDIMENT DISTRIBUTION
1.32
2.45
23.00
73.23
Gravel Per
Sand Perc
Silt Perc
Clay Perc


GRAB #8 - SEDIMENT DISTRIBUTION
0.75
5.43
31.81
62.02
Gravel Per
Sand Perc
Silt Perc
Clay Perc


GRAB #9 - SEDIMENT DISTRIBUTION
1.57
2.74
25.47
70.23
Gravel Per
Sand Perc
Silt Perc
Clay Perc


GRAB #10 - SEDIMENT DISTRIBUTION
0.40
2.62
24.55
72.43
Gravel Per
Sand Perc
Silt Perc
Clay Perc


GRAB #11- SEDIMENT DISTRIBUTION
6.45
28.44
15.92
49.19
Gravel Per
Sand Perc
Silt Perc
Clay Perc


GRAB #12 - SEDIMENT DISTRIBUTION
1.0
2.42
24.60
71.98
Gravel Per
Sand Perc
Silt Perc
Clay Perc

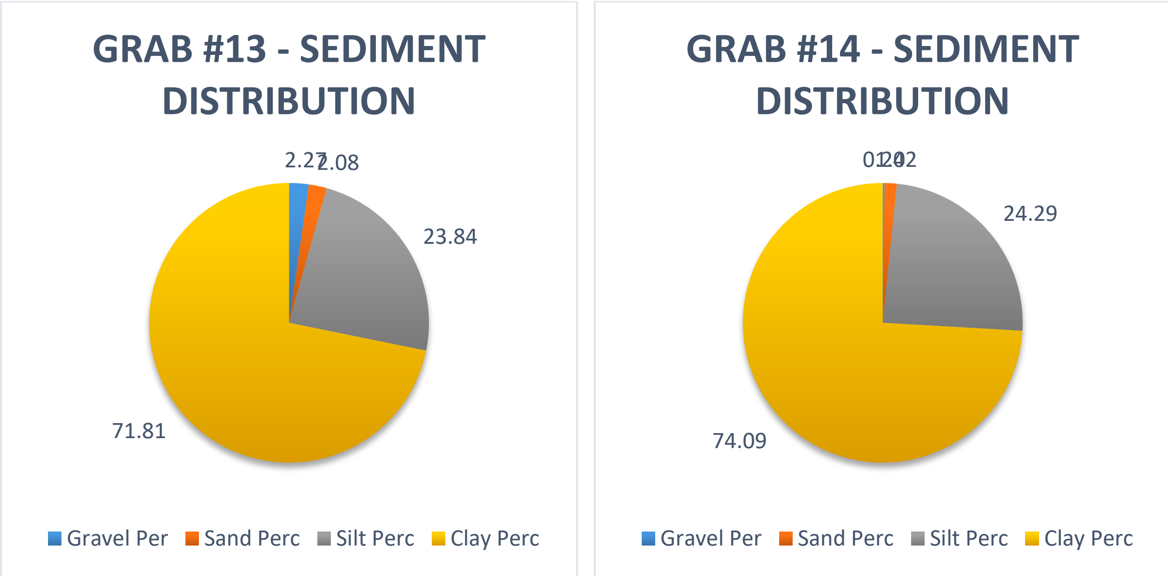


Figure 7. Illustration showing the percentage distribution of Gravel, Sand, Silt, and Clay in the 14 grab-samples taken in the area in 2021 and 2022. The outer grabs are mostly clay, whereas closer to the shore sand is predominant. The location of the individual grabs can be seen in Figure 2.

7.5 Environmental Assessment

The Gulf of La Spezia enjoys a mild climate, typical for a Mediterranean coastal zone.

7.5.1 Atmosphere and Meteorology

Air temperatures in the measurement period (May – October) have ranged between 10 and 30 degrees Celsius. Winds have been predominantly from two directions (North and Southeast) as shown in Figure 8, with wind speeds mostly lower than $4 ms^{-1}$.

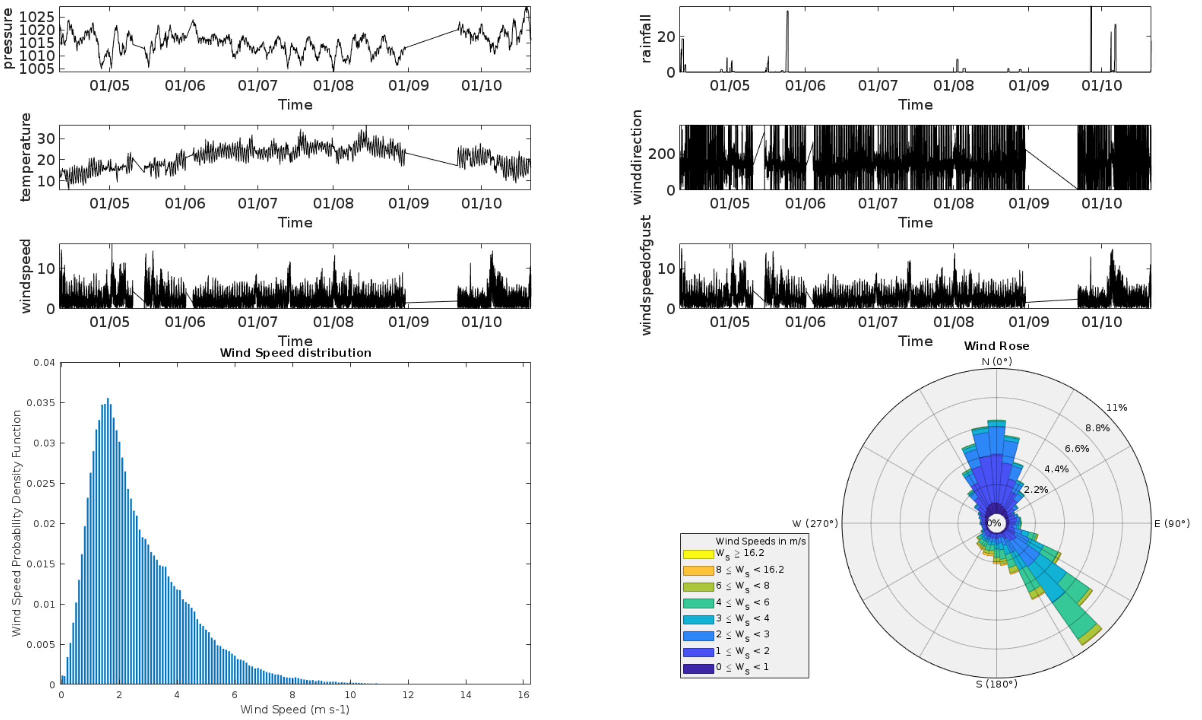


Figure 8. Time series of different parameters, wind speed histogram and wind rose showing prevalent directions and speed characterization.

7.5.2 Hydrography

The water column measurements during the observation period show a homogeneous distribution of the temperature in the vertical dimension, with a more obvious variation in the seasonal / time dimension, exhibiting changes from 20 to 27 degrees Celsius in the timeframe May - October. Some stratification can be observed, like in the month of June, during the transition from spring to summer.

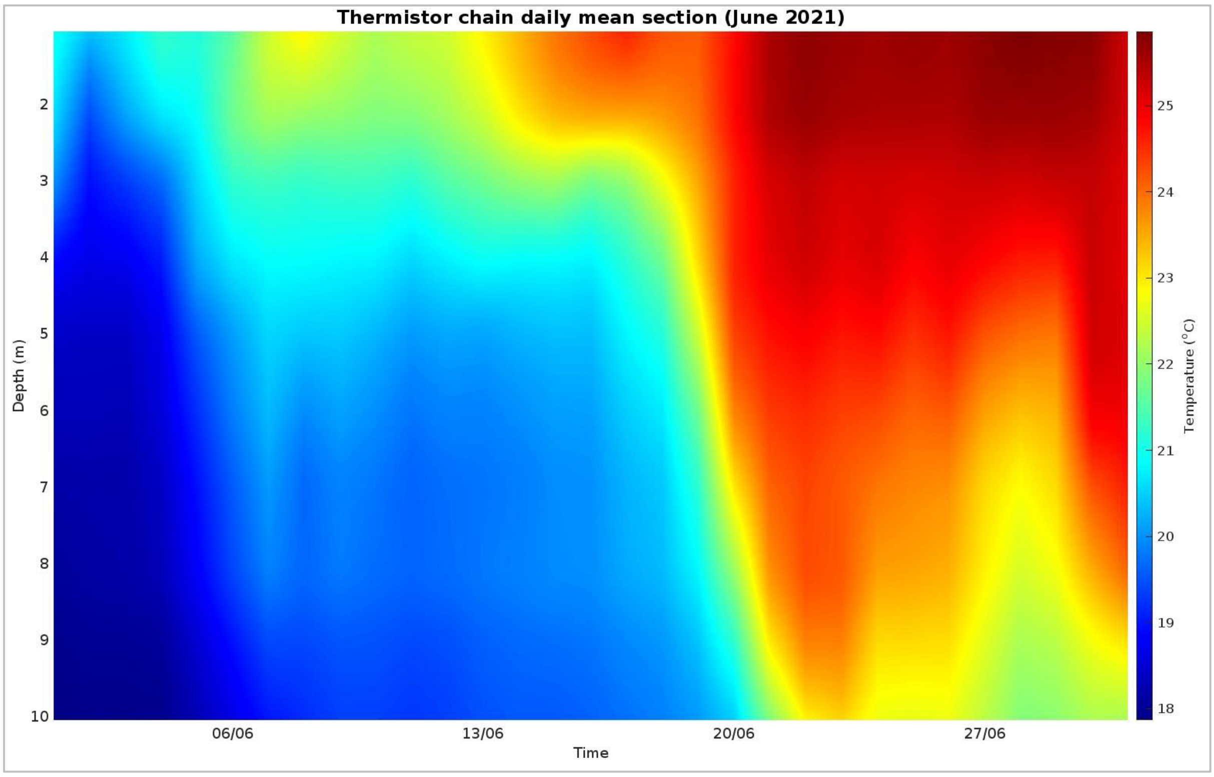


Figure 9. Thermistor chain results from June showing two weeks of stratification in between two homogeneous profiles.

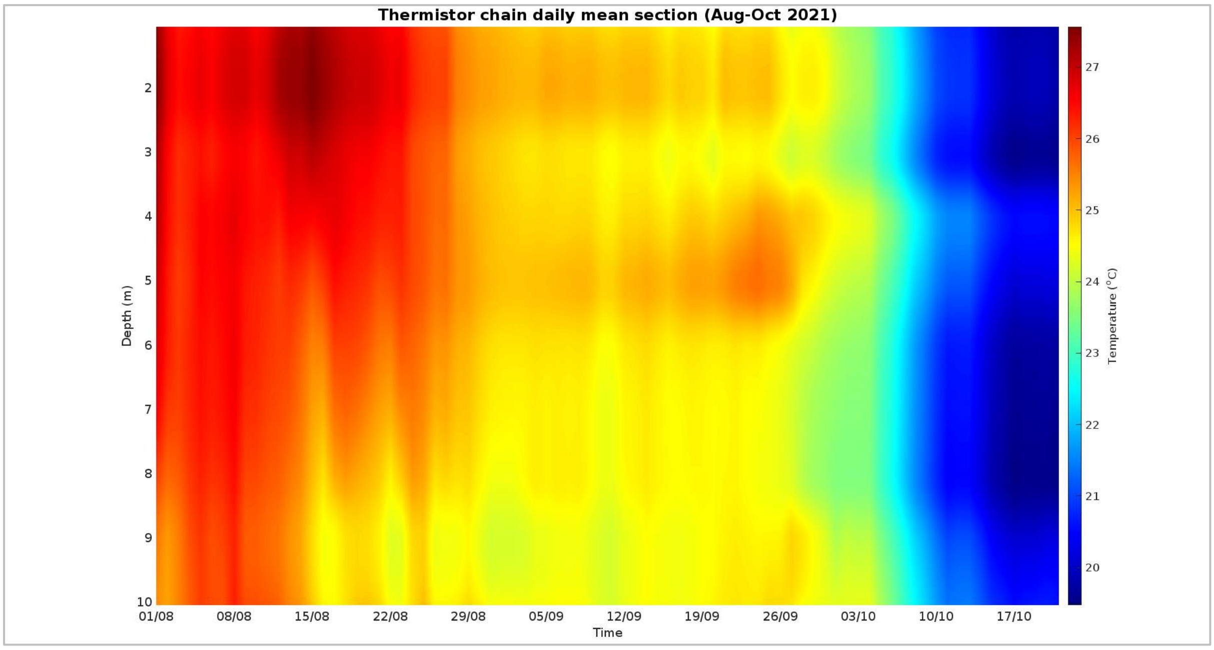


Figure 10. Thermistor chain results showing vertical homogeneity and seasonal variability.

The CTD casts show similar results in terms of the water column homogeneity. Turbidity (Figure 11) will require a more detailed analysis, but in general, the underwater visibility inside the bay is limited due to the presence of suspended particulates, sustained by the constant transit of large container ships towards the loading / unloading terminal, located in the innermost part of the Gulf.

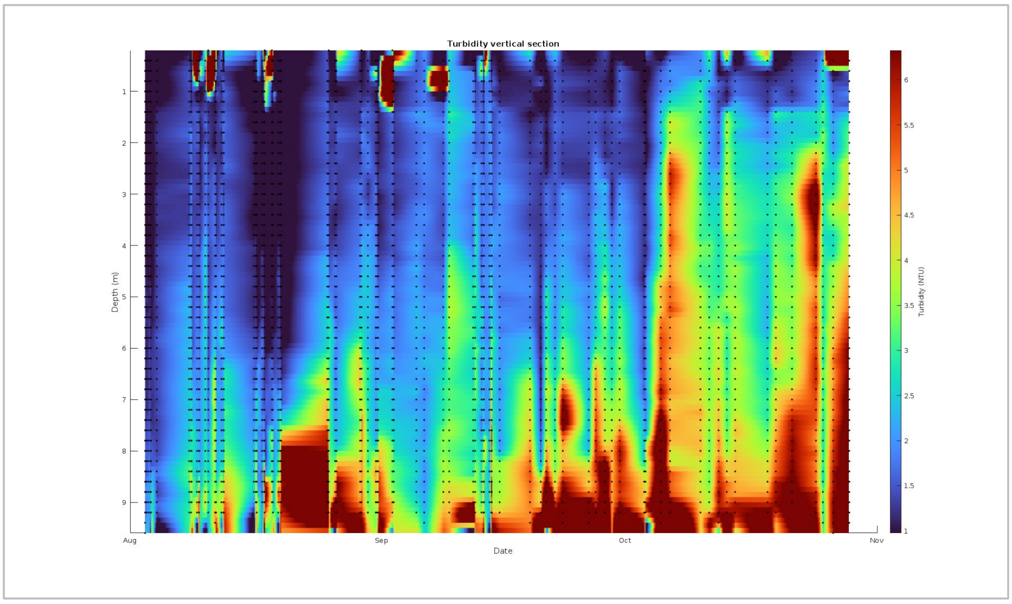


Figure 11. Vertical section of turbidity obtained from the CTD casts.

Some statistical analysis of the CTD profiles show some basic trends on the turbidity profile (Figure 12).

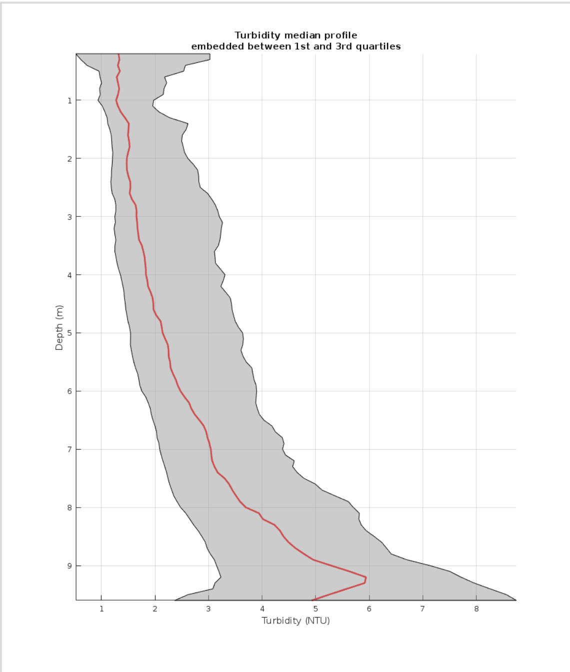


Figure 12. Turbidity profile statistics, grey area represent the portion between the first and third quartiles, while the red profile represents the median (second quartile)

The two SVP sensors recorded similar values, due to the homogeneity of the water column, ranging from 1500ms^{-1} in winter to 1540 ms^{-1} in summer.

7.5.3 Bio-Fouling

The images collected from the tripod with the underwater camera pointing at the target in Figure 13, show a considerable biofouling coverage after 45 days. After two months, the camera was overgrown and required the whole system to be recovered and cleaned, before again being redeployed.

Figure 13. Target showing biofouling progression after 45 days.

7.6 DATA CATALOGUE

The environmental data collected during the observation period, as well as the bathymetry, will be provided to the users on demand in network common data (netCDF) format, following the widely accepted Climate and Forecast (CF) conventions. The grid definition and the clutter and UXO catalog will also be provided in digital format.

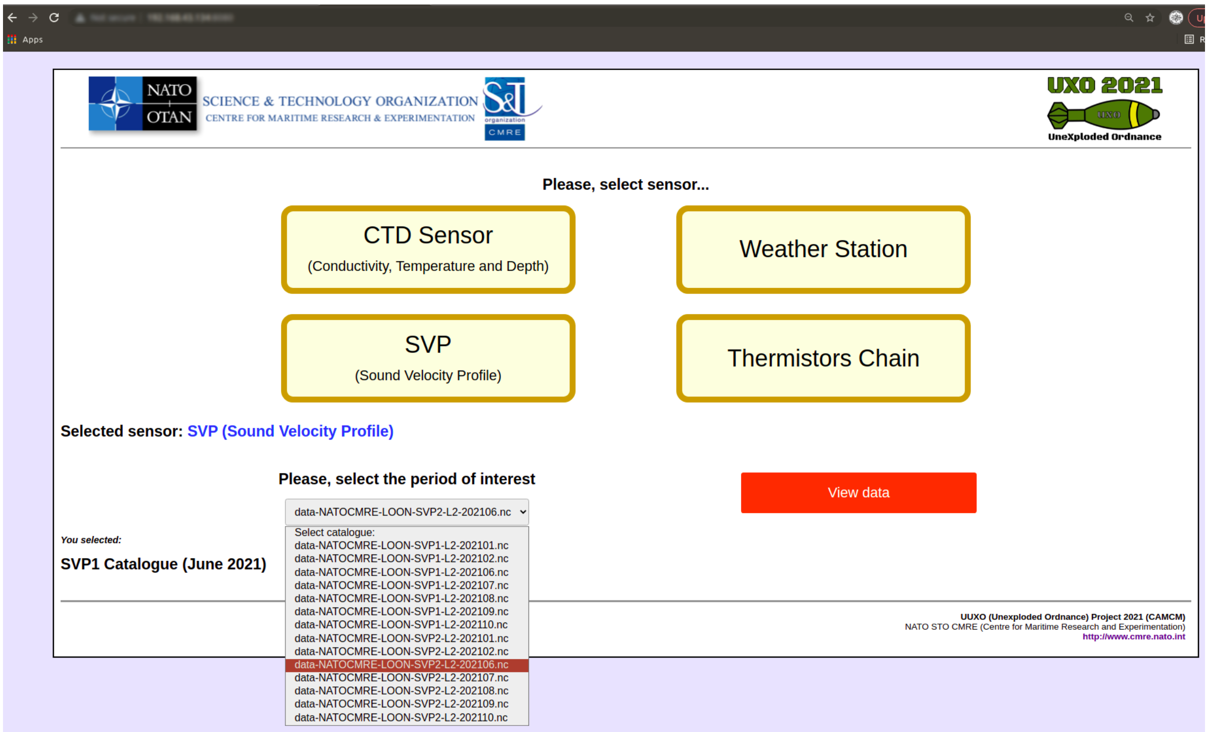


Figure 14. Example of data catalogue to be provided to users

8 CONCLUSIONS TO DATE

The environmental characterization has proven slightly more challenging than initially estimated. Indeed, it was observed that some sensors collected a highly dense dataset to be analyzed — maybe denser than needed, while the lack of redundancy has generated gaps in the data collection that complicate analysis. Future intentions are to observe which dynamic processes drive the largest changes, and try to adapt the sampling to characterize those processes adequately.

The area poses operational challenges, related to many features commonly found in commercial ports (presence of obstacles, limited depth, and low visibility). The clutter present in the area, along with the inert UXO that will be placed in the area, will provide an excellent test bench for technology developers. CMRE facilities at close distance should ease the workload for the trials, permitting the end users focus on the technology development.

9 REFERENCES

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D. https://www.marina.difesa.it/noi-siamo-la-marina/pilastro-logistico/scientifici/cssn/Pagine/default.aspx

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F. Istituto Superiore per la Protezione e la Ricerca Ambientale, Tide gauge ISPRA-06, https://webcritech.jrc.ec.europa.eu/TAD_server/Device/65

G. L.R. Breslau, H. Edgerton, "The sub-bottom structure of the gulf of La Spezia", SACLANT ASW Research Centre, December 1968, La Spezia, Italy.

10 Appendix A – Clutter Catalog

The existing clutter has been catalogued during surveys of the Area. The clutter catalogue is intentionally left out of this document to avoid giving advantages to system demonstrators.

The images and coordinates of clutter-objects will not be made available to users of the site.

11 Appendix B – Instrumentation and Methods

Product	Spatial Resolution / Location	Sampling Frequency	Collection Method	Data / Sensor Owner	Data Availability
Bathymetry	<1 m	N/A			
	< 4m	N/A			
	>=4 m	N/A	Blueview MBES on AUV	CMRE	CMRE
	>=8 m	N/A	Collated Historical Bathymetry Datasets / EM3002	CMRE	CMRE
Backscatter	<1 m	N/A			
	>=5 m	N/A	Blueview MBES on AUV & EM3002 (TBC)	CMRE	CMRE
LIDAR					

Product	**Spatial Resolution / Location**	**Sampling Frequency**	**Collection Method**	**Data / Sensor Owner**	**Data Availability**
Sediment	14 grab samples in area		Grab samples from RHIB	CMRE	
	Vibrocore	N/A	5 cores to be performed 2022 *	CMRE / COLMAR	CMRE
	Sub-bottom profile	N/A	profile planned in 2022 *	CMRE / COLMAR	CMRE
Bottom Type	N/A	N/A	Historical data set	CMRE	CMRE
Water Temp	Local in area	on request	CTD manually deployed during work-days	CMRE	CMRE
	Local in area	every 5 s	Thermistor chain, 10 sensors 1m depth spacing	CMRE	CMRE

Product	Spatial Resolution / Location	Sampling Frequency	Collection Method	Data / Sensor Owner	Data Availability
	Local close vicinity	every 15 s	ISPRA-06	ISPRA	https://webcritech.jrc.ec.europa.eu/TAD_server/Device/65
Tides	Local close vicinity		ISPRA-06	ISPRA	https://webcritech.jrc.ec.europa.eu/TAD_server/Device/65
	Local in area	N/A	sensor should arrive in February 2022 *	CMRE	CMRE
Salinity	Local in area	on request	CTD manually deployed during work-days	CMRE	CMRE
Waves	Local next to area	TBD	ADCP with Waves module *	CMRE	CMRE

Product	**Spatial Resolution / Location**	**Sampling Frequency**	**Collection Method**	**Data / Sensor Owner**	**Data Availability**
					https://www.ndbc.noaa.gov/station_page.php?station=51207
Wind	Local in area	every 60 s	Meteostation	CMRE	CMRE
	Local close vicinity	every 15 s	ISPRA-06	ISPRA	https://webcritech.jrc.ec.europa.eu/TAD_server/Device/65
Air Temp	Local close vicinity	every 15 s	ISPRA-06	ISPRA	https://webcritech.jrc.ec.europa.eu/TAD_server/Device/65
Barometric Pressure	Local in area	once a minute	Meteostation	CMRE	CMRE
	Local close vicinity	every 15 s	ISPRA-06	ISPRA	https://webcritech.jrc.ec.europa.eu/TAD_server/Device/65

Product	Spatial Resolution / Location	Sampling Frequency	Collection Method	Data / Sensor Owner	Data Availability
Total Rainfall	Local in area	once a minute	Meteostation	CMRE	CMRE
PAR Flux Density and Radiation	N/A	N/A	none	N/A	
Sound speed	Local close vicinity	every 60 s	Loon SVP	CMRE	CMRE
Turbidity	Local in area	on request	CTD w/turbidity manually deployed during work-days	CMRE	CMRE
Humidity	Local in area	every 60 s	Meteostation	CMRE	CMRE
	Local close vicinity	every 15 s	ISPRA-06	ISPRA	https://webcritech.jrc.ec.europa.eu/TAD_server/Device/65
Currents	Local next to area	TBD	ADCP with Waves module *	CMRE	* notes product to be performed in

Product	Spatial Resolution / Location	Sampling Frequency	Collection Method	Data / Sensor Owner	Data Availability
					2022, some partly started in 2021