Instituto Português do Mar e da Atmosfera

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Terms of reference for geophysical, geotechnical and environmental characterization of proposed areas for offshore renewable energy installations

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1. Executive Summary

1.1. Geophysical and Geotechnical Study

This document identifies the generic requirements that should be followed in a geophysical and geotechnical study required for the characterization of proposed areas for the installation of offshore wind energy generation infrastructure.

The study to be carried out should 1) meet or exceed the minimum requirements imposed by the licensing entity, to ensure the continuation of the licensing process, 2) produce relevant information for the development of the wind farm project and for the characterization of the baseline situation in future environmental impact studies.

The geophysical and geotechnical study to be developed should consider 4 main phases, which should include the following datasets and/or information:

1. Previous studies;
    a. Geological characterization;
    b. Characterization of cultural heritage;
2. Geophysical survey;
    a. Multibeam sonar, including bathymetry and backscatter (MBES);
    b. Magnetic (MAG);
    c. Side-scan sonar (SSS);
    d. Sub-bottom profiler (SBP);
    e. Ultra-high resolution seismic reflection (UHRS);
    f. Sampling and analysis of surface sediments (SED);
3. Geotechnical survey;
    a. Complement to SED sampling and analysis;
    b. Collection and analysis of 6m long vibrocores;
    c. Cone penetration tests (CPT);
4. Production of an integrated ground model;
    a. Data calibration and review of its integrated reinterpretation;
    b. Generation of an integrated terrain model (IGM);
5. Delivery of the products obtained as a coherent and integrated data package with clear documentation.

The study to be developed for the characterization of each area (or block) should follow the best practices adopted by the international industry, be adapted to the specificities of the area under study (*e.g.* depth and morphology of the seabed, nature and structure of the soil) and respect environmental protection regulations, namely with regard to marine mammals, and safeguard cultural heritage. The study should also be developed by phases, and the planning of the work in each phase should be based on the results of the preceding phases. The minimum requirements identified in this document should, therefore, be understood as generic indicative requirements of the type and main characteristics of the data that will be necessary to gather. The planning and development of the studies should be carried out in coordination between the promoting and licensing entities to ensure that the necessary requirements are met to ensure the continuation of the licensing process for the installation of the intended structures.

All data acquired and information generated, whether in offshore work or in office studies (previous studies), must be properly documented and delivered to the licensing entity, which should proceed with its validation and archiving.

Each phase of the study should produce a set of deliverables, which should constitute a coherent and integrated data package with clear documentation, including metadata, listing and location in the folder structure of each file. Metadata must comply with European standards, namely the INSPIRE directive.

1.2. Environmental Characterization Study

This document aims to identify the minimum requirements that should be followed in the study for the environmental characterization of proposed areas for installing offshore wind energy generation infrastructure. The studies to be carried out are intended to support the following objectives:

- Produce relevant information for the development of the offshore wind farm project, namely concerning location, pre-dimensioning of structures and constraints of the construction techniques to be adopted;
- Produce relevant baseline information to characterize the reference situation in future environmental impact studies.

The studies to be developed will initially consider the compilation and analysis of existing data at IPMA (*e.g.* research campaigns, biological sampling, numerical models), information published in scientific journals and data made available by DGRM (*e.g.* VMS and landing data) on the broader area. The collection of new data will, whenever possible, also be carried out during the regular monitoring campaigns conducted by IPMA, namely in campaigns of the PNAB-DCF program, and it will be necessary to intensify or expand the sampling, especially offshore, to cover areas proposed for wind farm installation. The collection of physicochemical data, abiotic samples (water and sediment), and benthic organisms is expected to be compatible with the planned geotechnical campaigns. Samples of plankton and nekton will also be collected, as well as the observation of birds, reptiles and marine mammals.

The terms of reference to be adopted are listed below:

1. Chemical characterization of the water column, including quantification of nutrients, metallic contaminants, Persistent Organic Pollutants (POPs), and microplastics in the sediment surface layer;
2. Characterization of circulation patterns: identification of upwelling and downwelling zones and mesoscale structures, such as eddies and filaments;
3. Determination of primary and secondary productivity in the water column, characterization of phytoplankton and zooplankton communities;
4. Determination of plankton dispersion patterns, namely eggs and larval stages of species with high ecological and commercial importance;
5. Physico-chemical characterization of the sediment, including grain-size, sedimentation rates, quantification of metallic elements, POPs;
6. Assessment of the health of marine organisms for human consumption through the quantification of metallic contaminants, POPs and microplastics in biological tissues and histopathological analyses in indicator species;
7. Characterization of benthic fauna communities associated with sedimentary and rocky bottoms by determining the number and abundance of taxa, identification of sensitive and structuring taxa, detection of non-indigenous species, diversity indices and multimetric indices for assessing the ecological quality status;
8. Identification and assessment of the conservation status of Vulnerable Marine Ecosystems (VMEs);
9. Characterization of demersal species communities through the joint analysis of indicators of taxonomic and functional structure/composition, dominance, and spatiotemporal patterns of abundance/biomass of indicator groups/species;
10. Characterization of pelagic species communities by determining global density, taxonomic diversity and mapping of the preferred spawning areas of the main species in the community; assessment of the abundance and spatial distribution of sardine, anchovy and mackerel;
11. Characterization of the distribution, abundance and migration patterns of large pelagic migrants, focusing on the most abundant and representative species of the Portuguese coast, namely tunas;
12. Characterization of seabird communities through the assessment of abundance, spatial distribution and migratory fluxes;
13. Characterization of marine mammal and reptile communities through the assessment of abundance, population demographic structure and spatial distribution of the main species potentially affected by wind farm operation;
14. Description of the food web, including information on the relative trophic level of critical species;

15. Assessment of the relative importance of fishing activities in the areas for wind farm installation through the analysis of the proportion of use of these areas, the location of preferred/recurrent fishing zones (fishing grounds) and the volume and commercial value of catches, as well as the gears used;
16. Synthesis of spatial and temporal patterns of environmental parameters and characteristics through spatiotemporal statistical modelling, storage and management of data and model estimates on the 'somosatlântico' platform.

2. Technical Annex for Geophysical and Geotechnical Studies

2.1. Introduction

This document aims to identify the minimum requirements that should be followed in the study for geophysical and geotechnical characterization of proposed areas for installing offshore wind energy generation infrastructure. The survey to be carried out is intended to support the following objectives:

- Meet or exceed the requirements imposed by the licensing entity to ensure the continuation of the licensing process;
- Produce relevant information for the development of the offshore wind farm project, namely concerning location, pre-dimensioning of structures and constraints of the construction techniques to be adopted;
- Produce relevant information for characterizing the reference situation in future environmental impact studies.

The studies to be developed to characterise areas (or blocks) where structures for offshore renewable energy production are intended to be installed should be adapted to the specificities of the area under study (e.g. depth and morphology of the seabed, nature and structure of the soil). These studies should be developed in a phased manner, and the planning of the work in each phase should be based on the results of the preceding phases. Therefore, the minimum requirements identified in this document should be understood as generic indicative requirements of the type and main characteristics of the data that will be necessary to gather. The planning and development of the studies to be carried out in each area (or block) should be performed in coordination between the promoting and licensing entities to ensure that the requirements are met to continue the licensing process for the installation of the intended structures.

2.2. Requirements

2.2.1. Work Phases

The study to be carried out should consider 4 main phases, namely:

1. Previous studies;
2. Geophysical survey;
3. Geotechnical survey;
4. Production of an integrated ground model.

Without prejudice to the possibility of some overlapping in the planning and execution times of the various phases, the results of each of the initial 3 phases should inform the planning and execution of the subsequent phases.

The work planning, activities, and results should be documented appropriately. The documentation to be delivered to the licensing entity should include at least the following elements for each phase of the study:

- Work planning;
- Interim reports;
- Final report;
- Properly documented integrated data package.

2.2.2. Previous Studies

Previous studies (desktop studies) should be carried out, and all pre-existing available information which is relevant to the topic under analysis should be compiled and synthesised. These preliminary studies will inform the scope definition and planning of subsequent study phases.

As a minimum, preliminary studies should be conducted covering the following topics:

- Marine geology, covering at least the following subtopics:
    - Compilation and synthesis of information provided by geophysical data available for the area, in the graphic form of maps and/or images, namely of areas of natural hazard for infrastructure installation;
    - Compilation and synthesis of information provided by sedimentary sampling and geotechnical data available for the area, in the graphic form of maps and/or images, namely of areas of natural hazard for infrastructure installation;
    - Bibliographic review and synthesis of current geological knowledge of the area;

- Cultural Heritage, covering at least the following subtopics:
    - Compilation of information related to shipwrecks, aircraft accidents, isolated finds or other anthropogenic remains recorded in the area;
    - Compilation of information related to references to shipwrecks, aircraft accidents, isolated finds or other anthropogenic remains whose location is not known but which can be framed within the study area;
    - Compilation of information related to the geological characterisation of the seabed that may contain archaeological remains;
    - Inventory of war activities that may have historically occurred in the area and characterisation of possible weapons and ammunition used in each event.

2.2.3. Impulsive Noise Generation

The operation of all equipment that generates impulsive noise in the acoustic frequency range between 10 Hz and 10 kHz should follow procedures that minimize possible impacts on marine life communities. In particular, marine mammals, fish, and invertebrates use sound in their activities. These procedures should, at a minimum, include:

- Monitoring the presence of sensitive animals in the vicinity of the vessel should be ensured during all offshore work, 24 hours a day, by a team of certified Marine Mammal Observers (MMOs);
- During nigh time or low visibility periods (e.g., fog), monitoring should be supported by a Passive Acoustic Monitoring (PAM) system;
- A soft start or ramp-up of the equipment that generates impulsive noise in the referred frequency range should be performed;
- If sensitive animals are detected within the defined exclusion zone, the equipment that generates impulsive noise in the referred frequency range should be temporarily suspended.
- The monitoring of the presence of sensitive animals in the vicinity of the ship shall be ensured during all seagoing work 24 hours a day, by a team of certified observers (*Marine Mammal Observers* - MMOs);
- During periods of night or poor visibility (e.g. fog) monitoring should be supported by a passive acoustic monitoring system (*PAM*);
- A soft start or ramp-up should be made of equipment that generates impulsive noise in the referred frequency range;
- If the presence of sensitive animals is detected within the defined exclusion zone, the operation of equipment that generates impulsive noise in the frequency range should be temporarily suspended.

The necessary information should be prepared to report the generated impulsive noise according to the parameters and procedures described in the manual published by the Directorate-General for Natural Resources, Safety, and Maritime Services (DGRM).[1]

Although not mandatory, using an Acoustic Deterrent Device (ADD), such as a "Pinger" or similar, may be considered.

2.2.4. Geophysical Survey

The objective of marine surface and subsurface geophysical investigations is to contribute to the knowledge of the area's bathymetric, morphological, geological, environmental, and cultural characterization. During the geophysical survey phase, the aim is to acquire, process, and interpret a set of data that provides information about the surface and subsurface of the seabed, which should be suitable for:

[1] https://www.dgrm.mm.gov.pt/documents/20143/532604/Formul%C3%A1rio+Ru%C3%ADdo+Impulsivo_Manual+do+utilizador+2023.pdf/2f818050-95cb-d4d7-d687-7ee40793a657

1. Satisfying the requirements requested by the licensing entity regarding this area of the territory to ensure the continuation of the licensing processes and design of the infrastructures to be installed;
2. Satisfying the requirements for planning and preparing subsequent geotechnical investigations;
3. Satisfying the requirements for the production of a preliminary geological model of the area;
4. Contributing to the identification, mapping, and characterization of habitats and cultural heritage.

The geophysical campaign should consider the acquisition of data using the following types of equipment:

- Multibeam Echosounder (MBES), with data on:
  - Bathymetry;
  - Backscatter;
- Side-Scan Sonar (SSS);
- Magnetometer (MAG);
- Reflection seismic, with data from:
  - Sub-Bottom Profiler, with penetration up to 5 m below the seabed (SBP);
  - Ultra-High Resolution Seismic, either multi-channel only or multi-channel and single-channel, with penetration up to 100 m below the seabed (UHRS);
  - Grab sampler for collecting surface sediment samples.

2.2.4.1. Data Acquisition Grid

A grid of lines should be defined along which geophysical data will be acquired. This grid should consist of parallel main lines (ML) and a second set of parallel cross lines (XL) intersecting the MLs.

The orientation and spacing of the MLs and XLs should be established according to the characteristics of the study area to obtain the required data coverage and respect the following general rules:

- The spacing of the MLs should ensure complete coverage of the seabed with the MBES and SSS systems, ensuring a swath overlap of 30% between adjacent lines. Ideally, the spacing of the MLs should be constant throughout the study area and as close as possible to perpendicular to the orientations of the main known or expected geological structures, such as faults, slides, and preferred structural orientation;
- The spacing of the MLs should not exceed 200 m;
- The spacing of the XLs should not exceed 3 times the spacing of the MLs and should not exceed the maximum value of 600 m;

- The direction of the XLs should not deviate more than 10° from perpendicular to the MLs;
- Each line should have at least 2 intersections with other lines.

The grid lines defined for data acquisition should be identified with a nomenclature that includes the line type and a unique numeric identifier for each line type (e.g., line ML001 or Line CL002). Data acquired along a line with the various equipment should include the line and equipment reference (e.g., line: ML001_MAG, or line: ML001_UHRS). In case data acquisition is repeated along the entire line (rerun) or part of the line (infill), this information should be included in the line nomenclature, using, for example, a suffix with a sequential number for complete lines and a sequential letter for line segments (e.g., line ML001_1_MAG, or line: ML001_B_UHRS). The line nomenclature criteria adopted should be clearly described in the documents delivered with the data.

Data should be acquired with the MBES, SSS, MAG, SBP, and UHRS systems along all lines of the defined grid.

Before the start of the offshore work, the following two subsets of lines should be defined by agreement between the promoter and the licensing entity:

- **Priority lines.** A subset of lines that should not exceed 20% of the total length of the established general line network. Data acquisition should start with the priority lines, and the processing and interpretation of these data should begin immediately after their acquisition.
- **Lines with mobile sediments.** A subset of 2 to 4 lines is located where the bottom sediments are expected to be more mobile. MBES surveys on these lines should be carried out at least twice with the greatest possible temporal spacing between consecutive surveys (ideally at the beginning and end of the survey of each area, with a minimum time interval of 15 days) to evaluate the sedimentary dynamics of the mobile sediments.

2.2.4.2. Positioning

The acquisition, processing, and interpretation of data should preferably be made using the official horizontal reference system adopted in Portugal, with PT-TM06/ETR89 coordinates (EPSG code: 3763). Alternatively, the World Geodetic System 84 (WGS84) with the Universal Transverse Mercator (UTM) Zone 29N projection system (WGS84/UTM-29N, EPSG code: 32629) may be used. If this alternative coordinate system (WGS84/UTM-29N) is used, versions of the final study maps referenced in both coordinate systems (PT-TM06/ETR89 and WGS84/UTM-29N) should be delivered.

The vertical reference for the surveys should be the Hydrographic Zero – Mainland Portugal. The official geoid model for Mainland Portugal (GeodPT08) should be used.

The positioning system to be used should be of the Differential GNSS type, using precision augmentation systems (EGNOS, RTK, Omnistar, Trimble, or other equivalent) to allow horizontal and vertical positioning accuracies of the data acquisition systems compatible with the survey requirements. The GNSS system should be complemented with an inertial vessel attitude measurement system ("Inertial Measurement Unit" – IMU) that allows the correction of the wave effect.

Surface-towed equipment should be positioned with DGPS correction systems or higher quality. Depth-towed equipment should be positioned with DGPS correction systems or higher quality and by underwater acoustic systems (e.g., USBL). The accuracy of the acoustic positioning systems should be better than 0.5% of the distance between the equipment to be positioned and the vessel (range).

The combined accuracy of the positioning system and the data post-processing methodology should be better than or equal to:

- Static accuracy:
  - Better than 0.1 m horizontally and vertically.
- For equipment fixed to the moving vessel:
  - Better than 1 m horizontally and 0.1 m vertically;

2.2.4.3. Multibeam echosounder

The bathymetric surveys, to be performed with a multibeam echo sounder (MBES) system suitable for the range of depths in each area, are intended to:

- Obtain a detailed map of the morphology (depths) of the seabed;
- Identification and mapping of static or potentially mobile bedforms;
- Identification and mapping of natural structures of geological or biological origin or artificial structures on the bottom;
- Contribute to the classification and mapping of the bottom type and sediments.

In addition to a detailed bathymetric model, the project aims to obtain an acoustic backscatter map from the MBES system.

Without prejudice to the possibility of requiring or proposing models with better resolution, depending on the specificities of each area to be surveyed (e.g., models with a resolution of 1 m may be required or proposed for depths up to 100 m), it is intended to obtain a digital terrain model (DTM) and an acoustic backscatter map (mosaic) produced from the processed MBES data with the following resolutions:

- For depths up to 100 m:
  - DTM with resolution (cell size) ≤1 m;
  - The depth value of each DTM cell was obtained using measurements of at least 4 valid measurements (depth);
  - Acoustic backscatter map with resolution (cell size) ≤1 m;

- For depths greater than 100 m:
    - DTM with resolution (cell size) ≤2% of depth;
    - The depth value of each DTM cell was obtained using measurements of at least 4 valid measurements (depth);
    - Acoustic backscatter map resolution (cell size) ≤2% of depth;
    - For depths greater than 200 m, the indicated values may be revised by agreement between the promoter and the licensing entity, considering the area's characteristics.

Without prejudice to the possibility of adjusting the MBES survey specifications by agreement between the promoters and the licensing entity, depending on the expected depths for each area to be surveyed, to maximize the quality of the final products, the MBES system and respective data should meet the following minimum specifications and ideally comply with the indicated preferred conditions:

- The MBES and SSS multibeam surveys should be performed simultaneously;
- Ensure coverage of the bottom surface is greater than 100%, with overlap between adjacent sounding swaths of 30%;
- It is recommended to use swath angles not exceeding 110° to minimize the effect of sound refraction on the outer beams;
- The sound velocity sensor (SV probe) installed near the multibeam transducers should have real-time data acquisition with better accuracy than ±0.15 m/s.
- During the surveys, sound velocity profiles (SVPs) should be performed with a periodicity not exceeding 6 hours (4 times a day) or preferably with a periodicity of 2 hours;
- SVPs should be performed using properly calibrated equipment that allows direct measurement of sound velocity (using an acoustic transducer) or by measuring temperature, salinity, and pressure;
- The identification of each SVP performed, as well as its date, time, and geographical position, must be recorded in the Sounding Log;
- MBES surveys should be corrected appropriately for tide, giving preference to the tide reduction methodology by GNSS (RTK, PPK, or similar);
- Depth values should be indicated in meters referred to as the Hydrographic Zero;
- Acoustic backscatter values should be expressed in decibels.

All object contacts identified in the MBES data (point cloud and DTM) should be cross-referenced with the contacts defined by SSS and MAG, to assist their interpretation and should be identified, listed, and classified according to the following standards:

- Identification and recording in a spreadsheet, along with a description and, whenever possible, an indication of length, width, height, and associated SSS and MAG contacts;
- Classification, at least, in the following categories:
  - Associated with anomalies, targets, and metallic masses with presumed heritage significance or wreck/shipwreck, known or not, and MAG and SSS object-contacts;
  - Associated with various debris, with correspondence to MAG and SSS object-contacts;
  - Pipeline (including indication of several segments belonging to the same set);
  - Cable (including indication of several segments belonging to the same set);
  - Localized elevation
  - Localized depression

2.2.4.4. Side-scan sonar

Side Scan Sonar *(SSS)* surveys will be carried out with the aim of contributing to the characterization of the seabed, namely:

- Identification and mapping of possible static or movable background shapes;
- Identification and mapping of natural or artificial structures in the background;
- Contribute to the classification and mapping of bottom and sediment type.

The SSS system adopted shall operate at two frequencies simultaneously, optimised so that the higher frequency allows an effective range for bottom coverage at the expected depths of the work area, with the best compromise between resolution and effective lateral range.

Full coverage of the seafloor of the study area is required, including coverage of the seafloor areas in the sensor vertical (*nadir*) of each SSS line. The survey should therefore provide for coverage where the scan of each borehole line covers the *nadir* and has an overlap in the data collected by the sensor from the opposite edge of the sensor from the adjacent lines. Alternative technical solutions may be considered using SSS equipped with sensors to ensure adequate coverage of the nadir of each line.

Without prejudice to the fact that models with better resolution may be required or proposed, depending on the specificities of each area to be surveyed, it is intended to obtain acoustic backscatter maps from SSS data with the following resolution (cell size):

- For depths up to 200 m, resolution ≤2 m;
- For depths greater than 200 m, resolution preferably ≤3 m, value to be agreed between the promoter and the licensing entity according to the characteristics of the area.

The SSS system and its data should comply with the following minimum specifications and ideally comply with the preferential conditions indicated:

- MBES and SSS withdrawals must be executed simultaneously;
- An acoustic positioning system (USBL) shall be used to determine the relative position of the SSS transducers relative to the ship;
- Towing of the SSS transducer at an altitude above the bottom ≥8 % and ≤ 15 % of the lateral reach. Changes to this rule, due to special characteristics of the fund, may be admissible by agreement with the licensing entity
- Minimum dimensions of objects to be identified in the background:
  - For depths up to 200 m ≤2 m
  - For depths greater than 200 m, preferably ≤ 3 m, to be agreed between the promoter and the licensing entity, according to the characteristics of the area.
- The processing of SSS data for the production of the backscatter map (tile) shall use bathymetry information (MBES) for topographic correction of the tile and include at least the following corrections:
  - Slant squeaks;
  - Attitude of transducers;
  - Acoustic signal absorption;
  - Geometric dispersion;
  - Towing speed;

All the contact objects identified in the SSS data must be cross-referenced with the contacts defined by MBES and MAG, in order to assist in their interpretation, and must be identified, listed and classified according to the following standards:

- Identification and registration in a spreadsheet, together with description and, where possible, indication of length, width, height and associated MBES and MAG contacts;
- Classification in at least the following categories:
  - Targets with presumed heritage significance or possible relation to shipwrecks/wrecks;
  - Isolated, linear or point objects;
  - Blocks or perimeters of block zones when the density is greater than 20 per 100 m²;
  - Localized depressions;
  - Cables;
  - Pipelines;
  - Gas plumes;
  - Drag marks and regions of concentration of drag marks.

2.2.4.5. Magnetic anomalies

It is intended that the magnetic data acquired will allow the identification or confirmation of the positions of all anthropogenic structures causing magnetic anomalies in the work area (e.g. conduits, electrical and communication cables, wreckage of ships, aircraft, unexploded ordnance or other targets under the bottom or buried with presumed heritage significance) which are crossed by or in the immediate vicinity of the lines followed by the sensor and contain a volume of ferromagnetic materials greater than the limit volume defined by agreement between the promoter and the licensing authority, taking into account the information from the respective preliminary studies.

It is recommended that the target nominal altitude of the magnetometer on the seabed should be ≤5 m and not exceed 10 m. The value of the maximum nominal altitude may be revised according to the depth and morphology of the seabed in the area.

The MAG system and its data shall comply with the following minimum specifications and ideally comply with the preferential conditions indicated:

- Sensor sensitivity ≥ 0.01 nT/√Hz;
- Sensor sampling rate ≥ 10 Hz;
- Data with Total Magnetic Intensity (TMI) measured at each point, associated with the position and altitude of the magnetometer, calibrated and continuous, preferably with sensor positioning supported by a USBL (Ultra Short Baseline) system or similar;
- The spacing between consecutive TMI measurement points should be ≤ 0.5 m;
- Preferably with sensor trailer on individual cable (as opposed to joint trailer with SSS – *piggy-back*);
- Preferably, the adoption of a transverse gradiometer system, with 2 magnetometers mounted on a single frame;
- The processing of MAG data shall include:
    - Main Field Correction (IGRF);
    - External field correction with data from a nearby base station or magnetic observatory;
    - Removal of spikes;
    - Production of map(s) with corrected total magnetic anomaly data;
    - Production of map(s) with residual anomaly after removal of regional anomaly (if applicable);
    - Identification of anomalies considered notable along each line
    - List of notable anomalies, indicating position, depth, sensor altitude, width and amplitude of each anomaly

All magnetic anomalies identified in the MAG data shall be cross-referenced with the contacts defined by the MBES, SSS and, where appropriate, with the seismic data in order to assist their interpretation, and shall be identified and recorded in a spreadsheet, together with a description and, where possible, an indication of their length, amplitude and associated MBES and SSS contacts.

2.2.4.6. Reflection seismics

The reflection seismic survey shall include for the entire defined survey network data acquired with the following two systems:

- Low penetration seismic, using a *Sub Bottom Profiler* (SBP), preferably of the parametric probe type;
- *Ultra-High Resolution Seismic* (UHRS), using a high-bandwidth, consistent signature source (e.g. Sparker-type source).

The main objective of the SBP survey is to provide information about the upper 5 m of the sedimentary column. The SBP data are intended to provide detailed images of the Holocene formations, including the base of the mobile sediments.

The main objective of the UHRS survey is to allow the detection, interpretation and mapping of the different types of subsoils and significant discontinuities from the subsurface to a depth of 100 m below the seafloor in sedimentary substrate.

Multi-channel Ultra-High Resolution Seismic (MUHRS) data is required to model the speed of sound propagation, ideally up to 50 m below the seafloor. If MUHRS data is not acquired on all lines in the mesh, the remaining lines may be supplemented with single-channel *Ultra-High Resolution Seismic* (SUHRS) data. The MUHRS line spacing should be at least less than or equal to 4 times the line separation of the adopted data acquisition mesh.

The SBP system and its data shall comply with the following minimum specifications:

- Stroke spacing ≤1 m;
- Nominal penetration ≥ 3 m;
- Vertical resolution[2] ≤0.2 m;
- Full waveform recording at least 24-bit;
- The final processing flow of SBP data, while it may not be limited, should at least include the following key steps:
    - Quality control of positioning and failed shots;
    - Noise attenuation;
    - Correction of ripple effects (heave correction);

[2] The vertical resolution of the reflection seismic data is here defined as 1/4 of the dominant wavelength.

- Amplitude correction;
- Signal conditioning (e.g. bandpass filter, *top & bottom mute*, ...).

The MUHRS system and its data should comply with the following minimum specifications and ideally comply with the preferential conditions indicated:

- Hydrophone chain with channel spacing (groups) between 3,125 m and 1 m;
- Number of channels ≥ 48, 96 channels preferred.
- Hydrophone chain with active length between 75 m and 250 m, preferably greater than 90 m;
- Minimum offset ≤ to a quarter of the minimum depth
- Maximum offset ≥ to 80 m, preferably with a maximum angle of incidence at the depth of interest > 40°;
- CMP fold ≥ 24 real strokes (no interpolation);
- CMP spacing (stacked) < 1.57 m
- Vertical Resolution
    - Up to 40 m below the bottom < 0.5 m
    - From 40 m to 100 m below the bottom < 1 m
- The final processing flow of MUHRS data, while it may not be limited, should at least include the following key steps:
    - Quality control of positioning, geometry and missed shots;
    - Deconvolution and optimization of spectral content;
    - Noise attenuation;
    - Application of residual statics to correct the effects of ripple and optimize the continuity of reflectors;
    - Velocity analysis at interval ≤ 500 m;
    - Removal/attenuation of multiples;
    - Spherical divergence correction;
    - Normal Moveout (NMO) fix, and stack;
    - Migration;
    - Post-migration signal conditioning (e.g. time-varying bandpass filter, top & bottom mute and other relevant operators).

The SUHRS system and its data shall comply with the following minimum specifications:

- Hydrophone chain with 8 to 24 hydrophones;
- Hydrophone chain with active lengths between 2 m and 8 m;
- Offset ≥ 5 m and ≤ 150 m;

- Stroke spacing ≤ 1.5 m;
- Vertical Resolution:
    - Up to 40 m below the bottom <0.5 m;
    - From 40 m to 100 m below the bottom <1.5 m;
- The final processing flow of SUHRS data, while it may not be limited, should at least include the following key steps:
    - Quality control of positioning, geometry and missed shots;
    - Noise attenuation;
    - Correction of ripple effects (*swell filter*);
    - Removal/attenuation of multiples;
    - Spherical divergence correction;
    - Migration;
    - Post-migration signal conditioning (e.g. time-varying bandpass filter, *top & bottom mute* and other relevant operators).

2.2.4.7. Surface sediment sampling

The purpose of collecting sediment samples from the seafloor surface is to:

- Identify the nature, cohesion and particle size distribution of the sediments for calibration of the interpretation made from the acoustic methods (MBES and SSS);
- Determine levels of physicochemical contamination;
- Sample the existing benthic macrofauna.

The total number of seafloor sediment samples to be collected should be adjusted according to the expected variability of the nature and morphology of the bottom, and the average density of sampling points in each area (block) should not be less than 0.03 points per km2.

The sampling equipment shall be a Van Veen, Smith-McIntyre or other similar sampling device with a minimum sampling surface area of 0.1 m^2.

For all samples collected, at least the following minimum information shall be provided, ideally subject to the preferential conditions indicated:

- On-board data:
    - Location of the sampling point, with indication of the depth referred to the hydrographic zero (ZH). If applicable, indication of the MBES, SSS and MAG contact of the site;
    - Sampling form, with macroscopic description and photographic record of the sample;
    - Sampled and preserved material;
- Laboratory sedimentary analysis data:

- Particle size distribution, preferably with Udden/Wentworth classification with particle size curves, medians and sorting coefficients;
- Density (total wet and dry solid fraction);
- Organic Carbon (Corg) and Calcium Carbonate (CaCo3) content.

- Analysis and characterization of any archaeological remains existing in the sampled material.

Up to one third of the total number of samples collected shall be selected for additional ecological characterisation analyses, which shall include:

- Identification of trace metal concentration (As, Cd, Cu, Cr, Hg, Pb, Ni, Zn);
- Identification of the concentration of persistent organic pollutants (PAHs, PCBs, HCBs);
- Determination of benthic macrofauna, with screening, identification down to genus level or higher and counting.

If the volume of sediment required for ecological characterisation is greater than that required for sedimentary characterisation, the additional volume of sediment shall be obtained by taking several collections at the same sampling station, using the same type of sampler or a sampler with a larger sampling capacity (e.g. boxcorer).

2.2.5. Geotechnical survey

The general objective of the geotechnical soil investigation is to acquire geotechnical data by *in situ* testing that allows the creation of an Interpretive Geotechnical Report and a Soil Model in order to improve the geological and geotechnical understanding of the investigation area and to satisfy the permitting requirements and project progress for offshore wind farms.

For this phase of the study, it is recommended the development of a low-penetration geotechnical investigation, which provides relevant information about the soils of the research area in terms of stratigraphic, lithological, chronological, geotechnical properties of the materials and their variability.

The geotechnical campaign should consider the following activities:

- Sampling of surface sediment;
- Collection of sedimentary cores using a Vibrocorer;
- Conducting cone penetration tests (CPTs).
- Laboratory analysis of the sampled materials.

2.2.5.1. *Surface sediment samples*

The objective of sampling surface sediment from the seabed at this stage is to densify the sampling network carried out during the geophysics campaign, taking advantage of the information resulting from the geophysics campaign to optimise the sampling network.

The location of the samples and the number of samples to be collected in the geotechnical campaign should be adjusted according to the information available at the time of the planning of the campaign and ensuring a total sampling density (including samples from the geophysical and geotechnical campaigns) per area (or block) of not less than 0.1 samples per km^2.

The procedures required for sampling and subsequent sedimentary and ecological analyses should be similar to those described for the geophysics campaign.

2.2.5.2. *Vibrocoring*

The objectives of the collection and analysis of sediments at depth using vibrocorers are the dating and compositional, mineralogical, grain size and petrophysical characterization of the different geological units up to a depth of 6 m below the seabed.

The sites for the collection of vibrocores should be chosen taking into account the information from the preliminary studies and the geophysics campaign, in order to ensure a sampling of all the expected geological units up to a target depth of 6m below the seabed. If applicable, the MBES, SSS and MAG contact object of the site shall be indicated. The total number of vibrocores to be collected should be adjusted according to the expected variability of the nature and morphology of the background, ensuring that the average sampling density per area (or block) is not less than 0.05 colours/km2.

The target depth for vibrocores is 6 m below the seabed, and the recovery should not be less than 3 m. The vibrocorer used should meet or exceed the following minimum characteristics and ideally comply with the preferential conditions indicated:

- Core barrel length ≥ 3m, preferably ≥ 6m;
- PVC liner with a diameter ≥ 100 mm;
- High-frequency vibration, preferably ≥ 28 Hz.

The analysis of the cores collected by vibrocore shall include at least the following activities:

- Opening of the cores by longitudinal division in order to ensure a constant and flat surface of the sediments;
- Photographic recording of open sections with adequate quality, focus, color and resolution to resolve features on a millimetre scale;

- Macroscopic description, describing at least the lithological composition, presence of sedimentary or biogenic structures and presence of anthropogenic elements (e.g. fragments of glass or plastic);
- Measurement of magnetic susceptibility (DM) along the split sections, with a minimum resolution (spacing of point measurements) of 10 mm;
- Measurement of the colour spectrophotometric properties of sediments, with a minimum resolution (spacing of point measurements) of 10 mm, providing complete spectral data in the visible wavebands (400-700 nm);
- Measurement of P-wave velocity (Vp) with a minimum resolution (point measurement spacing) of 10 mm;
- Radiographic recording, with radiographs of all sections using a system that allows the acquisition of high-resolution 2D X-ray transition images that make it possible to generate images of internal sedimentary structures, main variations in sedimentary composition, and identify disturbances and drilling anomalies;
- Subsampling of the core at intervals of no more than 50 cm or whenever there are visual or X-ray variations in the composition of the sediment, to determine particle size, density (dry and wet), organic carbon and calcium carbonate contents;
- Absolute dating of sediment samples, biological or anthropogenic materials, using dating methodologies appropriate to the sampled materials and expectation of their age (e.g. C-14, Pb-210, OSL), and construction of age models and determination of sedimentation rates. The number and choice of locations of each section to be dated should be made according to sedimentary variability and the suitability of the materials for dating, and it is suggested as an indication to carry out at least 0.33 dates per linear meter of core (i.e. one dating for every 3 m of core).

2.2.5.3. Cone Penetration Tests (CPTs)

By performing cone penetration tests (CPTs) it is intended to evaluate the nature and mechanical properties of the sub-surface geological structure up to a minimum target depth of 15 m below the seabed. The target depth may have to be greater if geophysical studies reveal the existence of potential geological hazards that require it. The acquired data should contribute to the calibration of previously acquired geophysical data, the generation of an integrated terrain model and the continuation of the project for offshore wind farms, namely with regard to the pre-dimensioning and identification of technical solutions for the installation of anchor structures and cables.

The promoter shall propose a test plan, including the type of equipment, locations and set of tests (e.g. CPT, PCPT, SCPT) to be carried out, which shall be determined in accordance with the characteristics of the subsoil expected according to the previous studies, the geophysical data acquired in order to meet the desired requirements.

The total number of CPTs to be carried out in the geotechnical campaign should be adjusted according to the expected variability of the nature and morphology of the bottom and ensuring that the average sampling density per area (block) should not be less than 0.02 CPTs/km^2.

Tasks to be carried out should include:

- Test plan;
- Performing seafloor CPTs with a target depth of 15 m using a standard piezocone penetrometer (PCPT) or a seismic cone (SCPT) as specified in the CPT plan. The seabed unit shall have sufficient length of CPT rods to physically achieve at least 15 m of corrected vertical penetration, including tolerance for rod deviation from the vertical. The use of equipment that allows the minimum target penetration limit of 15 m to be exceeded is encouraged;
- Sample sheet including sample reference, location, depth (relative to ZH), date and time of collection. If applicable, the MBES, SSS and MAG contact of the site shall be indicated;
- Report and data delivery.

2.2.6. Integrated terrain model

The objective of this phase of the study is the creation of an integrated terrain model (IGM) that should result from the integration and joint interpretation of all the information produced in the previous phases of the study. Ultimately, it is intended to obtain an integrated terrain model that incorporates industry best practices and represents the current state of knowledge of the geological structure up to a target depth of 100 m and the mechanical characteristics of the seabed and its subsurface up to a minimum depth of 15m below the seabed. According to the identified risks (e.g. slope instability, gas accumulations, etc.), the minimum depth recommended for the characterization of the mechanical characteristics of the terrain may have to be increased (e.g. until at least reaching a potential detachment surface that may be associated with slope instability risks).

It is anticipated that this phase of the study should include the following activities, although it may not be limited to these only:

- Production of a work plan including the description and scheduling of tasks, methodologies to be applied and quality control plan to be implemented;
- Review of all data produced during the study and inclusion of the various relatable data packages in integrated interpretation project(s);
- Assessment of the need for reprocessing of geophysical data packets and, if necessary, a description of the reprocessing operations to be implemented and consultation with the licensing authority on future actions to be developed;
- Intercalibration of data and review of its integrated reinterpretation;

- Generation of an integrated terrain model (IGM), with express indication of geological hazard zones for the appropriate effects;
- Report describing the IGM, the procedures used for its production, assessment of the quality of the geophysical and geotechnical data used and its suitability for modelling the level of geological complexity of the study area, as well as indication of the remaining gaps and levels of uncertainty (structural and parametric);
- Delivery of the produced products as a coherent and integrated data package with clear documentation.

2.2.7. Deliverables

All data acquired, and information generated, whether in sea work or in desk studies, must be duly documented and delivered to the licensing entity, which must validate and archive it.

Each phase of the study should give rise to a set of deliverables, which should constitute a coherent and integrated data package with clear documentation, including metadata, listing and location in the folder structure of each file. Metadata must comply with European standards, such as the INSPIRE Directive.

In addition to the raw data, the processed data and the results of their interpretation for each data acquisition system, packages with the integration of the final data from the relatable systems should also be prepared and delivered. In particular, at least the following two projects should be prepared:

- Geographic information system (GIS, preferably in the form of a QGIS project, or compatible) project with all data that can be represented geographically;
- Geophysical data interpretation project (preferably in the form of a Kingdom or compatible project), with all related geophysical and geotechnical data integrated.

As an example, an example of what could be the list of all expected deliverables for the four phases of the study is provided in Annex 1.

2.2.7.1. Deliverables Listing Example Table

List of codes used in the deliverables listing example table:

Code listing	
Code	Description
Data packages	
EP	Previous studies
Gf	Geophysics campaign
GT	Geotechnics Campaign
Mt	Integrated terrain model
Systems	
PAS	Planning, monitoring and synthesis documents
MBES	Multibeam probe
SSS	Side scan sonar
MAG	Magnetometer
SBP	Sediment Profiler
UHRS	Ultra-high resolution seismic
ASS	Surface sediment sampling
stroke	Sampling with Vibrocore
CPT	Cone penetration tests
INT	Integrated data

Deliverables Listing Example Table:

Example of a general list of deliverables								
Data package	System	Group reference	Data type	Item No.	Description	Format	Uploaded to GIS	Relative delivery date
Previous studies (Ep)								
EP	PAS	Ep-PAS	Reports	1.001	Study execution plan	PDF	N	
				1.002	Previous study of geology	PDF	N	
				1.003	Previous study of marine archeology	PDF	N	
Geophysics Campaign (Gf)								
Gf	Planning, monitoring and synthesis (PAS) documents							
	PAS	Gf-PAS	Reports	2.001	Campaign plan, including quality control and safety plans	PDF	N	
				2.002	Mobilization report	PDF	N	
				2.003	Campaign Report	PDF	N	
	Bathymetry (MBES)							
	MBES	Gf-MBES	Reports	3.001	Report with identification and description of arms ("offsets") and angles associated with the GNSS/Inertial integrated positioning system, including drawings with inertial sensor positions and attitudes, phase centers of GNSS antennas, MBES transducers, other transducers mounted on the hull or on side supports and equipment towing points (MAG, SSS, UHRS). The main axes of the ship must appear on the drawings.	PDF	N	
			Raw data	3.002	Data acquisition log	Spreadsheet	N	
				3.003	Records of raw data from the GNSS/Inertial integrated positioning system required for post-processing	POSMV, Others	N	
				3.004	Raw data in native MBES sensor format	S7K, ALL, KMALL	N	
				3.005	Raw data recorded in the native format of the multibeam data acquisition software	S7K, GSF, PDS, ALL, KMALL	N	
				3.006	Raw data in native format from measurements performed with SVP profiler	Native, ASCII	N	
			Data processed	3.007	Total data processed in the native format of the multibeam data processing software, organized by lines	Native	N	
				3.008	Totality of processed data, exported by the multibeam data processing software to GSF format, organized by lines	GSF	N	
				3.009	Totality of x,y,z points corresponding to processed probes, free of artifacts, correctly positioned, organized by line	ASCII + prj	N	
				3.010	Totality of points x,y,z corresponding to acoustic backscatter, processed, cleaned of artefacts, correctly positioned, organized by lines	ASCII + prj	N	
				3.011	SVP profiles used in processing, including date/time and position	ASCII + prj, Spreadsheet	N	
				3.012	MBES navigation lines ("tracks") with line identification, "fix", date and time	shp (lines), Ascii + prj	N	
				3.013	Digital terrain model with regular bathymetry mesh, referred to ZH	ASCII + prj	N	
				3.014	Digital terrain model with regular bathymetry mesh, referred to the NMM	ASCII + prj	N	
				3.015	Digital terrain model with regular bathymetry mesh, referred to ZH	Geotiff	s	
				3.016	Digital terrain model with regular bathymetry mesh, referred to the NMM	Geotiff	s	
				3.017	Digital terrain model with regular bathymetry mesh, adjusted vertically, referred to the ZH	ASCII + prj	N	
				3.018	Digital terrain model with regular bathymetry mesh, adjusted vertically, referred to the ZH	Geotiff	s	
				3.019	Digital terrain model with regular bathymetry mesh, adjusted vertically, referred to the NMM	ASCII + prj	N	
				3.020	Digital terrain model with regular bathymetry mesh, adjusted vertically, referred to the NMM	Geotiff	s	
				3.021	Mosaic Index	shp (polygon)	s	
				3.022	Total Horizontal Uncertainty (THU), regular mesh, XYZ	ASCII + prj	N	
				3.023	Total Vertical Uncertainty (TVU), regular mesh, XYZ	ASCII + prj	N	
				3.024	Total Horizontal Uncertainty (THU), regular mesh, XYZ	Geotiff	s	
				3.025	Total Vertical Uncertainty (TVU), regular mesh, XYZ	Geotiff	s	
				3.026	Isobaths, 1 meter apart, referred to ZH	shp (lines)	s	
				3.027	Isobaths, 1 meter apart, referred to NMM	shp (lines)	s	
				3.028	Digital backscatter model with regular mesh, XYZ	ASCII + prj	N	
				3.029	Digital backscatter model with regular mesh, georeferenced "raster"	Geotiff	s	
				3.030	Slope map in degrees, regular mesh, XYZ	ASCII + prj	N	
				3.031	Slope map, regular mesh, georeferenced "raster"	Geotiff	s	
				3.032	File with tide corrections, indexed by date/time, 1 minute resolution	txt	N	
				3.033	Backscatter data in the water column, over debris/obstacles	Native	N	
			Interpreted data	3.034	MBES contact list	Spreadsheet	N	
				3.035	MBES contact list, points	shp (points)	s	
	Side Scanning Sonar (SSS)							
	SSS	Gf-SSS	Raw data	4.001	Data acquisition log	Spreadsheet	N	
				4.002	SSS raw data, navigation corrected (XTF, JSF), high frequency	xtf/jsf	N	
				4.003	SSS raw data, navigation corrected (XTF, JSF), low frequency	xtf/jsf	N	
			Data processed	4.004	Fixed SSS navigation lines, with points (x,y,z) with "fix", line ID, date and time as minimum attributes	shp (points)	s	
				4.005	Georeferenced mosaic of high-resolution SSS processed data	Geotiff	s	
				4.006	Georeferenced mosaic of low-resolution SSS processed data	Geotiff	s	
				4.007	Mosaic index	shp (polygons)	s	
			Interpreted data	4.008	SSS contact list	Spreadsheet	N	
				4.009	SSS contact list - points	shp (points)	s	
				4.010	SSS contact list - lines	shp(lines)	s	
				4.011	Limits of areas defined by the SSS (concentrations of drag marks, bottom shapes, etc.)	shp(polygons)	s	
				4.012	SSS contact report including images and description/interpretation	docx, PDF	N	
				4.013	Images of SSS contacts	Geotiff, png, tif	s	
	Magnetic (MAG)							
	MAG	Gf-MAG	Raw data	5.001	Data acquisition log	Spreadsheet	N	
				5.002	Raw MAG data in native sensor and ASCII format	ASCII, other	N	
			Data processed	5.003	Cleaned MAG data after applying positioning QC and layback correction (derived from USBL)	ASCII	N	
				5.004	MAG navigation data with fix points as minimum attributes	shp (points)	s	
				5.005	MAG navigation data including altitude, survey line ID included as minimum attribute	shp (lines)	s	
				5.006	Mag data processed for residual TMI anomaly	ASCII	Y	
				5.007	TMI residual anomaly maps	Geotiff/grid	Y	
			Interpreted data	5.008	Contact list/anomalies	Spreadsheet	N	
				5.009	List of central contact points/anomalies	shp (points)	Y	
				5.010	Report describing processing procedures, interpretation and synthesis of results	PDF	N	
	Sediment profiler (SBP)							
	SBP	Gf-SBP	Raw data	6.001	Data acquisition log	Spreadsheet	N	
				6.002	Raw seismic data in the native format of the acquisition system and in SEG-Y format with navigation	SEG-Y, other	N	
				6.003	SBP navigation data with trigger points, minimum attributes: FIX, FFID, line name, date, time	shp (points)	s	
				6.004	SBP navigation data with navigation lines, minimum attributes: line name, date, time	shp (lines)	s	
			Data processed	6.005	Quality control (QC) log, provided every 24 hours and final version	Spreadsheet	N	
				6.006	Line acceptance documents including data image	Several	N	
				6.007	SBP data processed and navigation applied	MON-Y	N	
				6.008	SBP data navigation	P190	N	
			Interpreted data	---	View integrated deliverables	---	---	
	High resolution seismic (UHRS)							
	UHRS	Gf-UHRS	Raw data	7.001	Data acquisition log	Spreadsheet	N	
				7.002	Raw seismic data in the native format of the acquisition system and in SEG-Y format with navigation	SEG-Y, other	N	
				7.003	UHRS navigation data, with trigger points, minimum attributes: FIX, FFID, line name, date, time	shp (points)	s	
				7.004	UHRS navigation data, with navigation lines, minimum attributes: line name, date, time	shp (lines)	s	
			Data processed	7.005	Quality control (QC) log, provided every 24 hours and final version	Excel	N	
				7.006	Line acceptance documents including brutestack in SEG-Y and image formats	Several	N	
				7.007	UHRS Data Navigation	P190	N	
				7.008	CMP gathers with multiple attenuation	MON-Y	N	
				7.009	Stack with multiple attenuation	MON-Y	N	
				7.010	Final stack with post-migration processing	MON-Y	N	
				7.011	Time-interval velocity model	MON-Y	N	
				7.012	Stack RMS Speed Model	ASCII	N	
			Interpreted data	---	View integrated deliverables	---	---	
	Surface sediment sampling (SED)							
	SED	Gf-SED	Raw data	8.001	Sampling log	Spreadsheet	N	
				8.002	Sampling sheets	Word, PDF	N	
				8.003	Preserved sampled material	---	N	
			Data processed	8.004	Location of samples and analysis results	shp (points)	s	
				8.005	Laboratory test results	ASCII	N	
				8.006	Lab Report	PDF	N	
				8.007	Sampling report with description of procedures and summary of results	PDF	N	
	Integrated Deliverables (INT)							
	INT	Gf-INT	MBES+SSS+MAG	9.001	List of correlated contacts for all sensors	Spreadsheet	N	
				9.002	List of correlated contacts for all sensors	shp (points)	s	
				9.003	Bottom sediment classification map	shp (polygons)	s	
				9.004	Map with background shape classification	shp (polygons)	s	
				9.005	Map with linear structures (sand waves, cliffs, cables, pipelines, …)	shp (lines)	s	
				9.006	Map with structures in area (boulder fields, drag marks, …)	shp (polygons)	s	
				9.007	Geohazard map with location (coordinates) of central points, type of risk/structure and dimensions	shp (points)	s	
				9.008	List of anthropic structures (wreckage, cables, pipelines, …) with vertex coordinates	shp (points)	s	
				9.009	Report describing integrated interpretation procedures, list of deliverables, metadata structure and synthesis of results	PDF	N	
			SBP+UHRS	9.010	Reflector data (interfaces) interpreted in double time (TWT): reflector name, time, CDP, x,y	ASCII	N	
				9.011	Reflector data (interfaces) interpreted in depth (reduced to ZH): reflector name, depth, CDP, x,y	ASCII	N	
				9.012	Double-time isobath (TWT) map of each reflector, with isolines	Geotiff/shape	Y	
				9.013	Double-time isopach (TWT) map of each seismic unit, with isolines	Geotiff/shape	Y	
				9.014	Elevation map (m) reduced to ZH of the surface of each reflector, with isolines (isobats)	Geotiff/shape	Y	
				9.015	Map of the elevation (m) below the seabed of the surface of each reflector, with isolines (isobats)	Geotiff/shape	Y	
				9.016	Thickness map (m) of each seismic unit, with isolines (isopaces)	Geotiff/shape	Y	
				9.017	Map of outcropping units	shp (polygons)	Y	
				9.018	Fault map with identification of neotectonic evidence	shp (lines, polygons)	Y	
				9.019	Map of geological structures (faults, fold axes, …)	shp (lines, polygons)	Y	
				9.020	Map of geohazards identified below the bottom with indication of type of risk/structure and minimum depth below the bottom	shp (in., line)	Y	
				9.021	Seismic interpretation project (preferably in Kingdon format) with all the information	tks, other	N	
			General	9.022	GIS project (preferably in QGIS format) with all geographic information	qgz, other	Y	
				9.023	Report describing processing procedures, interpretation and synthesis of results	PDF	N	
Geotechnics Campaign (Gt)								
GT	Planning, monitoring and synthesis (PAS) documents							
	PAS	Gt-PAS		10.001	Campaign plan, including quality control and safety plans	PDF	N	
				10.002	Mobilization report	PDF	N	
				10.003	Campaign Report	PDF	N	
	Surface sediment sampling (SED)							
	SED	Gt-SED	Raw data	11.001	Sampling log	Spreadsheet	N	
				11.002	Sampling sheets	Word, PDF	N	
				11.003	Preserved sampled material	---	N	
			Data processed	11.004	Location of samples and analysis results	shp (points)	s	
				11.005	Laboratory test results	ASCII	N	
				11.006	Lab Report	PDF	N	
				11.007	Sampling report with description of procedures and summary of results	PDF	N	
	Vibrocores (AVC)							
	stroke	Gt-AVC	Raw data	12.001	Sampling log	Spreadsheet	N	
				12.002	Sampling sheets	Word, PDF	N	
				12.003	Preserved sampled material	---	N	
			Data processed	12.004	Location of samples and analysis results	shp (points)	s	
				12.005	Laboratory test results	ASCII	N	
				12.006	Lab Report	PDF	N	
				12.007	Sampling report with description of procedures and summary of results	PDF	N	
	Cone Penetration Tests (CPT)							
	CPT	Gt-CPT	Raw data	13.001	Test log	Spreadsheet	N	
				13.002	Test sheets	PDF	N	
			Data processed	13.003	Location of trials	shp (points)	s	
				13.004	Test logs in a format that can be integrated into interpretation software (Log ASCII Standard)	LAS	N	
Integrated terrain model (Mt)								
Mt	PAS	Mt-PAS	Mr-PAS	14.001	Work plan	PDF	N	
	INT	Mt-INT	Interpreted data	14.002	Review and delivery of updated versions of deliverables 9.010 to 9.020	See deliverables 9,010 9,020		
				14.003	Seismic interpretation project (preferably in Kingdon format) with all the information	tks, other	N	
				14.004	GIS project (preferably in QGIS format) with all geographic information	qgz, other	Y	
				14.005	Report describing processing procedures, interpretation and synthesis of results	PDF	N	

Code listing	
Code	Description
Data packages	
EP	Previous studies
Gf	Geophysics campaign
GT	Geotechnics Campaign
Mt	Integrated terrain model
Systems	
PAS	Planning, monitoring and synthesis documents
MBES	Multibeam probe
SSS	Side scan sonar
MAG	Magnetometer
SBP	Sediment Profiler
UHRS	Ultra-high resolution seismic
ASS	Surface sediment sampling
stroke	Sampling with Vibrocore
CPT	Cone penetration tests
INT	Integrated data

3. Technical Annex of Environmental Characterization Studies

3.1. Water quality

The physicochemical characterization of the water column will be carried out, as well as the quantification of the concentrations of nutrients, metallic contaminants and POPs, namely:

- Temperature; Salinity; Dissolved oxygen; Matter in Suspension; Turbidity; Dissolved nutrients; Chlorophyll a and Pheopigments; ph; Colour;
- Metal contaminants (As, Cd, Cu, Cr, Hg, Pb, Ni, Zn)
- Persistent organic pollutant contaminants (POPs) listed in the environmental quality standard of Directive 2013/39/EU (e.g. PAHs, PCBs);
- Quantification of microplastics in the surface layer of seawater.

3.2. Circulation and upwelling patterns

3.2.1. Characterization of the horizontal structure of the wind field

The localized reduction of wind intensity in wind farm installation areas can alter the wind field and its rotational that can have an impact on upwelling patterns, local currents, water column stratification (temperature and salinity) and nutrient distribution. The characterization of the wind field at the wind farm sites will be based on the atmospheric reanalysis ERA5 (European ReAnalysis ERA5) and a simulation with the regional atmospheric model WRF.

3.2.2. High-resolution simulations with the CROCO regional ocean model

High-resolution simulations will be carried out with the CROCO ocean model, which will allow the evaluation of the effect of atmospheric forcing resolution on ocean processes. Simulations of larval dispersion with the Parcels model using as *input* the current fields obtained in the simulations with the regional ocean model CROCO.

3.3. Primary productivity and planktonic communities

3.3.1. Remote sensing (ocean color) and primary productivity (Chla)

This task will analyse the concentration of chlorophyll-a (Chl-a) as a proxy for phytoplankton biomass and yield. Chla-a data for the national waters of the continent via satellite will be extracted and validated by chlorophyll-a values measured *in situ* in the "Water quality" component.

3.3.2. Phytoplankton and zooplankton communities

Water samples will be collected in regular IPMA campaigns or in the campaigns related to the "Water Quality" component for taxonomic identification of phytoplankton and zooplankton. This characterization will allow the identification of functional groups, estimate abundances and, potentially, identify non-indigenous species.

3.3.3. Characterization and modelling of the planktonic environment

Based on a previous characterization of planktonic communities, Lagrangian simulations of plankton dispersal will be developed, using the biological information as reference conditions.

3.4. Habitats and tectonic communities

3.4.1. Sedimentary Structure and Contamination

The reference situation for sedimentary contaminants will be established, which should be used in the monitoring programs to be implemented in the exploration phase of the concession areas.

The following will be characterized:

- Sediment grain size;
- Organic matter, carbonates, moisture;
- Sedimentation rate,
- Major elements in the sedimentary substrate (Si, Ca, Mg, Mn);
- Metal contaminants (As, Cd, Cu, Cr, Hg, Pb, Ni, Zn);
- Persistent organic pollutants (POPs) listed in the environmental quality standard of Directive 2013/39/EU (e.g. PAHs, PCBs);

3.4.2. Reference of contamination in some species for human consumption

The accumulation of some metals, particularly mercury, cadmium, lead, and Persistent Organic Pollutants, namely PAHs and PCBs, in biological tissues of some indicator species and for human consumption will be determined. The benchmark for microplastics in some of these organisms will also be established.

3.4.3. Vulnerable Marine Ecosystems (VME)

The identification of Vulnerable Marine Ecosystems will be addressed through image analysis. The spatial distribution in the areas allocated for the implementation of wind farms will be determined and their conservation status will be assessed.

3.4.4. Diversity and spatial distribution of benthic fauna communities

For benthic fauna communities of sedimentary bottoms and rocky bottoms, the following shall be determined: i) number of taxa and abundance; (ii) sensitive rate numbers; iii) number of structuring fees; iv) diversity indexes; v) multimetric indices for assessing the state of ecological quality and vi) identification of non-indigenous species.

3.4.5. Diversity and spatial distribution of demersal fauna communities

The information collected in IPMA's research campaigns will allow us to characterize the abundance of demersal species and the taxonomic and functional diversity of their communities. This characterization will be carried out through the analysis of: i) taxonomic and functional structure/composition of the communities; ii) dominance and patterns of taxonomic and functional abundance/biomass of communities; iii) abundance/biomass of indicator groups/species. This characterization will include species of cartilaginous fishes that are frequent in the areas of implantation.

3.4.6. Diversity and spatial distribution of pelagic fish communities

Data from the historical series of IPMA's acoustic screening campaigns will be analysed to assess the natural variability in the overall density of pelagic fish and in the spatial distribution, abundance and biomass of sardines, anchovy and mackerel. The taxonomic and functional diversity of pelagic fish communities will be characterised and the preferred spawning areas of the main species will be mapped.

3.4.7. Distribution, abundance, and migration patterns of large migrators

The distribution, abundance and migration patterns of large pelagic migrators, namely tuna and some species of pelagic sharks, will be characterized. The abundance, spatial distribution and migratory flows of the main seabird species potentially affected by the installation and operation of wind farms will be studied, based on censuses obtained through on-board observations of research campaigns and coastal censuses. The abundance and spatial distribution of the main species of marine mammals and reptiles potentially affected by the installation and operation of wind farms will also be studied, based on visual monitoring (presence and number of individuals) in IPMA's research campaigns. In the case of marine reptiles, the occurrence and spatial distribution will be characterized using visual censuses.

3.5. Trophic relationships in benthic, demersal and pelagic communities

The trophic web will be evaluated through stable isotope analysis. Key species, belonging to each functional group, will be selected according to the biological and ecological characteristics of the species.

3.6. Fishing activity

Based on the data from Fishing Diaries, VMS/AIS and daily landings per vessel made available to IPMA by the DGRM, the fishing effort and catches in weight and value per unit effort for different target species and fleets will be characterized. The main fishing grounds, banks and gears will also be identified.

3.7. Georeferenced Data Analysis and Geographic Information System

3.7.1. Spatio-temporal modelling

Spatio-temporal models will be developed to predict parameters related to several components, in particular: i) distribution of nektonic species; ii) biodiversity indices; (iii) Parameters related to fishing activity

3.7.2. Data management and curation

The data collected will be stored on the 'SOMOSATLÂNTICO' platform, a platform that aims to facilitate the storage, access and interoperability of geographic data and spatial information of the marine environment.

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