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KM3NeT INFRADEV – H2020 – 739560

An environmental impact study for KM3NeT-Gr

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Abstract

The necessity of a formal Environmental Impact Assessment (EIA) has been investigated for the scenario of an ARCA block at the KM3NeT-GR site offshore Pylos, connected to a shore station at Methoni.

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I. DELIVERY SLIP

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III. APPLICATION AREA

This document is a formal deliverable for the GA of the project, applicable to all members of the KM3NeT INFRADEV project, beneficiaries and third parties, as well as its collaborating projects.

IV. TERMINOLOGY

A complete project glossary is provided:

ARCA: Astroparticle Research with Cosmics in the Abyss

PMB: Project Management Board
WP: Work Package
EIA: Environmental Impact Assessment
EUA: Ephorate of Underwater Antiquities
EOC: Electro-Optical Cable
HCMR: Hellenic Centre for Marine Research
ACCOBAMS: Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area
FAD: Fish Aggregation Device
SEC: Standard Environmental Commitment
CSA: Coordination and Support Actions

V. LIST OF FIGURES

VI. LIST OF TABLES

None

VII. PROJECT SUMMARY

KM3NeT is a large Research Infrastructure that will consist of a network of deep-sea neutrino detectors in the Mediterranean Sea with user ports for Earth and Sea sciences. Following the appearance of KM3NeT 2.0 on the ESFRI roadmap 2016 and in line with the recommendations of the Assessment Expert Group in 2013, the KM3NeT-INFRADEV project addresses the Coordination and Support Actions (CSA) to prepare a legal entity and appropriate services for KM3NeT, thereby providing a sustainable solution for the operation of the research infrastructure during ten (or more) years. The KM3NeT-INFRADEV is funded by the European Commission's Horizon 2020 framework and its objectives comprise, amongst others, environmental impact studies for all existent and potential installation sites (work package 5).

VIII. EXECUTIVE SUMMARY

The location of the KM3NeT infrastructure in the abysses of the Mediterranean Sea requires assessment of the impact of KM3NeT on the environment of the deep sea at the installation sites for official governmental permission for construction. For this, the KM3NeT collaboration needs to present environmental studies taking into account regulations and procedures defined at the European and national level. This report shows the study performed to find out which study has to be completed and how.

We report on all the steps taken to reach a conclusion, which is that such a study should initially concentrate on the impact of an ARCA block offshore Pylos and its connection to shore at Methoni via a submerged cable. In particular, defining the route of the cable in the shallow waters is of importance to allow for minimal interference with fishing, anchoring and especially in view of the fact that the area is under the strict jurisdiction of the National Archaeological Agency. During the infrastructure deployment, best practice procedures must be employed for safety and for minimal interference with general shipping in the area, such as prior notifications to the appropriate authorities. Within the framework of this WP any possible interference of the detector's operation, in terms of mechanics and noise emission, with deep diving creatures must be studied and minimized. The responsibility for the delivery of the environmental studies will be in the hands of the KM3NeT-GR installation manager.

We also list all the contacts that have been established and procedures that have been found, so no work has to be repeated and no time will be lost. All relevant environmental constraints are analysed and, whenever necessary, the appropriate actions needed for receiving authorisations from the associated regulatory authorities are listed. This report describes the actions that need to be taken for answering the question of whether a formal EIA is necessary for a Greek ARCA scenario. In particular, all environmental constraints have been collected, the corresponding regulatory authorities have been consulted for the environmental legal framework of the project and finally, the necessary preceding legal actions have been identified. It should also be noted that past experience with cable and detector deployments by the "NESTOR" Institute and consultation with the HCMR (Hellenic Institute of Marine Research), who also perform sea operations in the area regularly, were useful for conducting the environmental impact study for the KM3NeT-GR site.

IX. Table of Contents

1. Introduction

KM3NeT is a large Research Infrastructure (RI) currently under construction. When completed, it will consist of a network of deep-sea detectors with user ports for Earth and Sea sciences, deployed at various locations in the Mediterranean Sea. This network will comprise two ARCA blocks and one ORCA block, to be deployed offshore Capo Passero (Italy) and Toulon (France), respectively. Each block is formed by 115 interconnected detection units and is powered from and communicates with a shore station via a submerged electro-optical cable (EOC). The main science objectives, a description of the technology and a summary of the costs are presented in the KM3NeT 2.0 Letter of Intent (1).

The initial KM3NeT planning foresaw an installation of an ARCA block at the Greek installation site offshore Pylos, however, the severe economic crisis that the country underwent recently has led to indefinitely postponing this project. As the possibility for an ARCA block at the Greek site has not yet been definitely excluded, it is meaningful to pose the question whether a formal Environmental Impact Assessment (EIA) for the aforementioned installation is necessary.

In what follows, the scenario of an ARCA block offshore Pylos connected with an electro-optical cable (EOC) to a shore station at Methoni is assumed. Despite the excellent physical characteristics of the area for the installation of scientific equipment, there are several environmental constraints that one should take into account. The entire area has been classified in the NATURA 2000 network, owing to the presence of large Posidonia submarine fields as well as endangered sea turtles and various sea mammals. Moreover, Methoni bay is a known site of archaeological interest, due to the existence of several ancient submerged settlements and shipwrecks. Cultural and natural heritage environmental constraints fall under different regulatory authorities and consequently, a separate permission from each of them should be granted before any activity is performed in the area.

This report describes the actions that need to be taken for answering the question of whether a formal EIA is necessary for a Greek ARCA scenario. In particular, all environmental constraints have been collected, the corresponding regulatory authorities have been consulted for the environmental legal framework of the project and finally, the necessary preceding legal actions have been identified. It should also be noted that past experience with cable and detector deployments by the "NESTOR" Institute and consultation with the HCMR (Hellenic Institute of Marine Research), who also perform sea operations in the area regularly, were useful for conducting the environmental impact study for the KM3NeT-GR site.

2 An EIA for KM3NeT-GR

The objective of this paragraph is to define from an environmental viewpoint the case study of a potential ARCA block offshore Pylos, connected via a submarine cable with the shore station in Methoni. In the following, all relevant environmental constraints are analysed and, whenever necessary, the appropriate actions needed for receiving authorisations from the associated regulatory authorities are listed.

2.1 History of KM3NeT-GR

The selection of the KM3NeT-GR installation area is far from accidental; the former NESTOR (Neutrino Experimental Submarine Telescope with Oceanographic Research) Institute, established in 1998 at Pylos in SW Peloponnese targeting to the construction, deployment and operation of a neutrino telescope, may be naturally considered as the ancestor of the Greek KM3NeT sector. NESTOR had already conducted extensive studies of the physical characteristics of the area, including water properties (2) (3), bathymetric mapping and interferences with known locations of archaeological interest. The result of these studies was the identification of a submarine plateau around the geographical location 36° 37.5' N, 21° 34.6' E, as an ideal candidate for the deployment of a neutrino telescope. This location meets all prerequisites for an underwater neutrino detector due to the excellent water transparency, large sea depth (~3,8 km), low sea currents, short distance to the shore and stable geophysical conditions. The picture below is a bathymetric map of the area. The location of the NESTOR telescope is indicated in pink (depth 3750 m) and the deepest point in the Mediterranean (5200m) in red; two additional installation locations of potential use are also indicated.

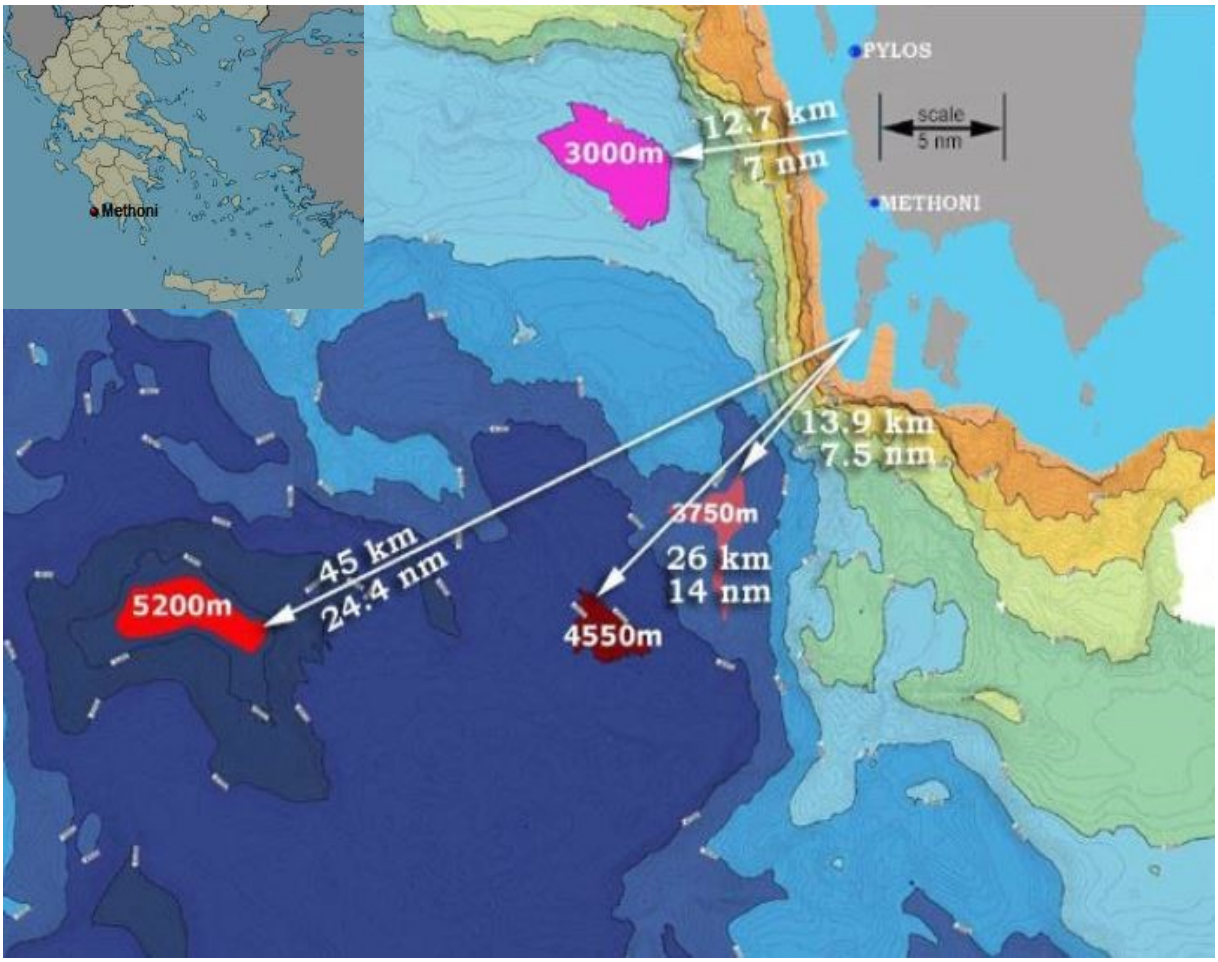

Figure 1: Bathymetric map of KM3NeT-GR.

An immersed ~30km long electro-optical cable (4) connects the installation site with a hub of the National Telecommunications Organisation in the nearby town of Methoni. The cable was deployed in 2000 and contains 18 single mode fibers for data transmission as well as a coper wire capable of providing a 6kW DC power to the detector. It should be noted that, although the cable suffered during the NESTOR equipment recovery process, the optical integrity of the cable has been verified recently by a group of French seismologists. The trace of the NESTOR cable is depicted in the two pictures below. On the left, a detailed view of the first part of the cable, close to the shore station in Methoni is shown. This part is a few kilometers long, lies in the bay of Methoni and is burried 2m beneath the sea bottom to avoid interference with anchoring and fishing lines. A special permission from the EUA had to be issued before the deployment, as this area is rich in underwater antiquities. However, no environmental impact study had been requested. The NESTOR cable is resurfaced to the seafloor after it reaches the north shore of the Sapienza island, and then it is routed to the deployment location in an almost straight configuration.

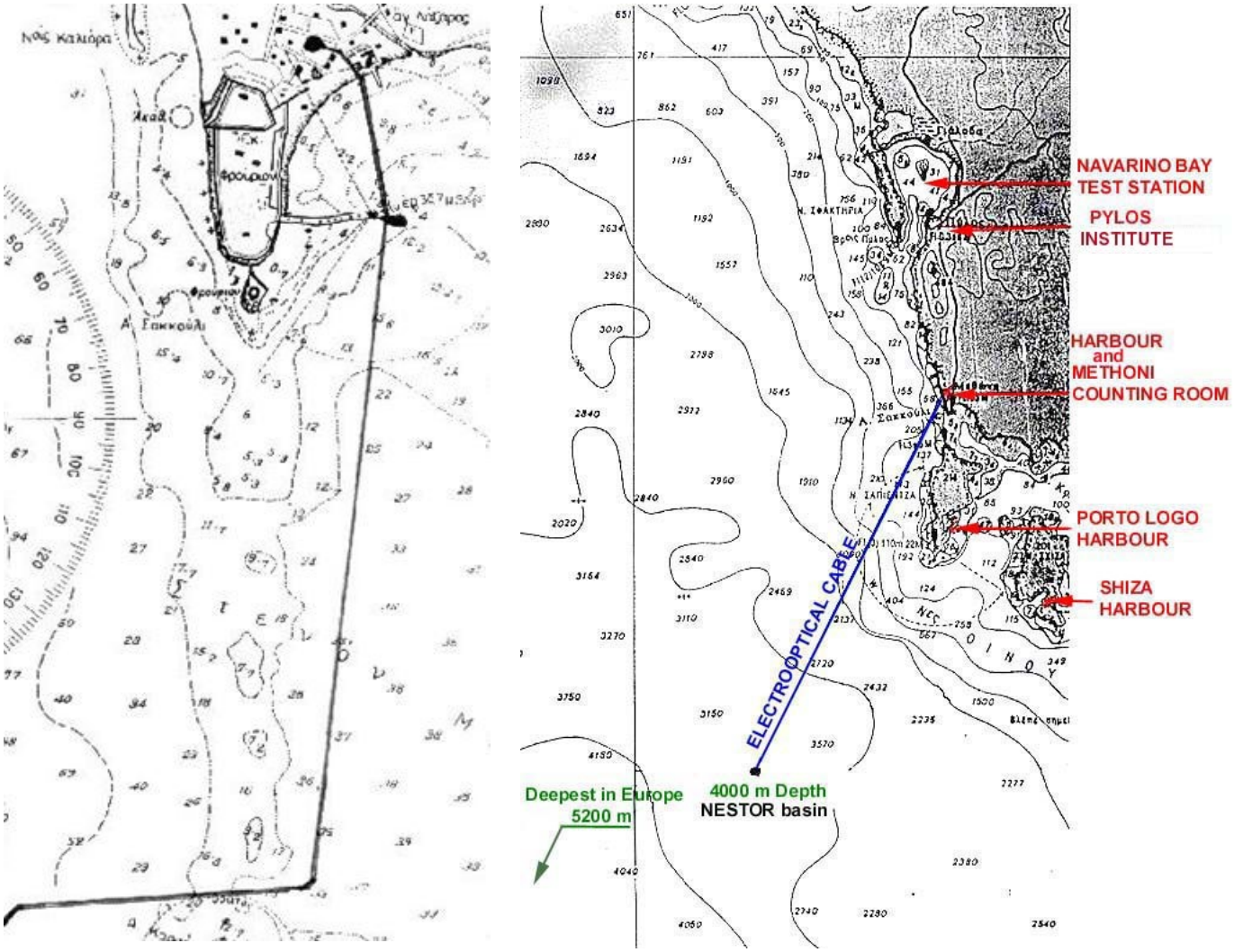

Figure 2: Footprints of the first part of the NESTOR cable (left) and the full cable (right)

In addition to the old NESTOR cable, HCMR has also deployed in the area a shorter (~15km) EOC, for supporting, in terms of power and data transmission to the shore, a submarine multi-parameter monitoring system. The initial part of the cable follows the same route with the NESTOR one; accordingly, only permission from the EUA was requested, although this deployment was performed several years after the deployment of the NESTOR cable. The observatory was deployed in 2018 at a depth of 1650m under the framework EMSO-ERIC (European Multidisciplinary Seafloor and water column Observatory) and the national infrastructure HIMIOFoTS. It provides real time information on several chemical and dynamical parameters of the sea water and contains a hydrophone focused on bio-acoustics.

2.2 Definitions

The objective of this report is to summarize the actions that were taken to investigate the necessity of an EIA for a potential installation of an ARCA block offshore Pylos, connected via an EOC to the shore station at Methoni. Before analyzing the environmental aspects of the aforementioned scenario, it is meaningful to scrutinize first the corresponding definitions, as this, in turn, will help to identify the scope of the EIA as well as the relevant regulating authorities. An EIA is a procedure that ensures that the environmental implications of projects are taken into account prior to their approval or authorization. This guarantees that the implementation of the project may proceed flawlessly, without needing modifications related at least to legal environmental constraints. Every EIA essentially consists of the following sequenced steps

I. preparation of an environmental impact assessment report by the developer;
II. submission to and examination by the competent authority/ies;
III. reasoned conclusion by the competent authority along with recommendations for compliance to the legal framework;
IV. integration by the developer of the competent authority's reasoned conclusion and recommendations into any of the decisions.

Ideally all steps above should be done at the design phase of a project, so that it is ensured beforehand that environmental obstacles won't induce time delays or cost increase during the implementation phase. It should also be added that for certain projects, substantial understanding of the environment that the project will be placed in can only be beneficial for the project itself. For KM3NeT in particular, identifying parameters such as water current speed, temperature and sedimentation/bio-fouling development rate as well as studying the existence of large sea mammals or fishing activities in the neighborhood of the installation site are of severe importance for the mechanical as well as the functional integrity of the detector in the long run.

Depending on the project, the environmental constraints may vary. For underwater installations such as an ARCA block connected via an EOC to the shore, the following four large categories of environmental constraints do apply:

- Cultural heritage, e.g. presence of archaeological sites.
- Natural heritage: special areas of protection containing important wildlife habitats, endangered species or unique geological features; marine protected areas.
- Living resources, e.g. fishing.
- Water quality.

In the next paragraph, all these constraints mentioned will be analysed for the KM3NeT-GR site.

2.3 Environmental constraints applicable for KM3NeT-GR

2.3.1 Cultural heritage

As already implied above, one of the most severe environmental constraints for the area around the shore station of the KM3NeT-GR site is related to cultural heritage. The shore station for the Greek installation site is located at Methoni bay and the EOC will necessarily pass through it. Methoni bay and offshore the nearby Sapienza island are important underwater archaeological sites due to the excessive presence of underwater antiquities from the pre-historic to Medieval periods. The seafloor in between them contains, among others,

- a submerged middle Bronze age (2000-1600 BC) settlement;
- and ~ 20 shipwrecks, most notably the "Shipwreck of columns" (13th century AD), and the Shipwreck of "Sarcophagi" (3rd century AD).

Figure 3: Underwater antiquities in Methoni bay and offshore Sapienza island. From left to right: Prehistoric submerged settlement, the «Shipwreck of columns» and the «Shipwreck of Sarcophagi».

All sorts of activities in the area, from scuba diving to cable laying, are subject to prior authorization from the Ephorate of Underwater Antiquities (EUA). Despite the notoriously strict legal framework, past experience with the NESTOR and the HCMR cables indicate that granting permission for routing an EOC cable from the shore station up to the north edge of the Sapienza island is possible. It is also known from experience that it is a common practice of the EUA to appoint an onboard observer for sea operations to check compliance with regulations.

2.3.2 Natural heritage

The full area of the KM3NeT–GR site is classified in the NATURA 2000 network. As such, the ecology has been extensively studied and documented. On the maps below one can see the segmentation of the area of interest for the KM3NeT-GR site according to the NATURA 2000 conventions. The

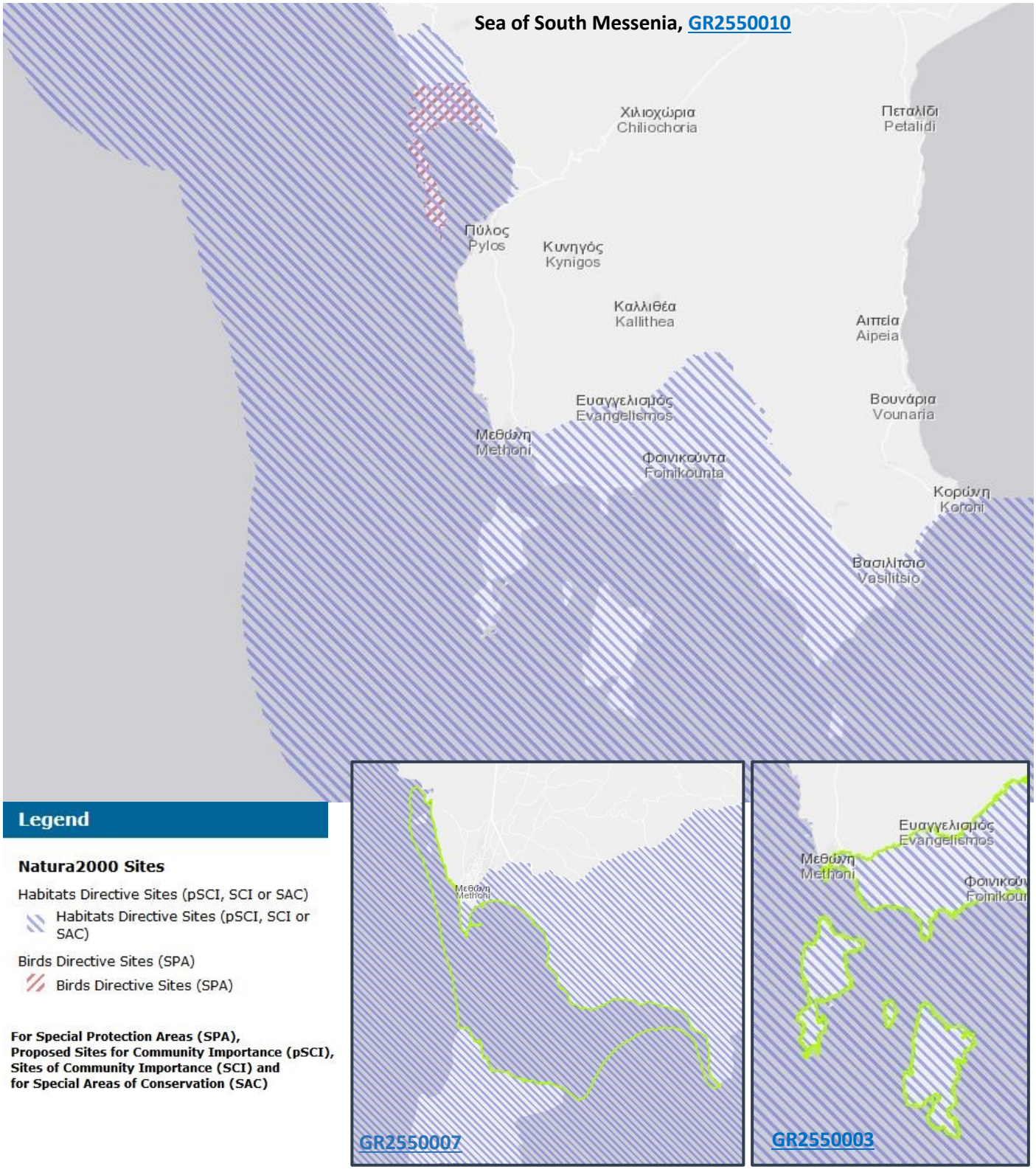

Figure 4: Segmentation of the KM3NeT-GR site according to the NATURA 2000 network conventions. For more information about the ecology of each area from the on-line NATURA 2000 database, click on the area codes.

corresponding online database (http://natura2000.eea.europa.eu) contains extensive information on the ecology of the concerned area; below, we restrict ourselves to endangered/protected species, whose presence might raise environmental concerns upon human interventions in the area:

- Extensive Posidonia plant beds (*Posidonion oceanicae*) up to depths of 40m. As it is well known, Posidonia is extremely sensitive to pollution and for this reason it is used as a bio-indicator of the ecological condition of the area. Posidonia is an inhabitant of small depth seabeds and therefore, its presence poses constraints only for the initial part of the EOC.
- Sea turtles (most notably *Caretta caretta*) use the beaches of the area for nesting and the surrounding marine area for mating and resting. Caretta Caretta is an endangered species, strictly protected by Greek law.
- Two species of endangered *Cetaceans* (marine mammals) are found in the area:
    - sperm whale (*Physeter macrocephalus*);
    - Cuvier's beaked whale (*Ziphius cavirostris*).

  The area around the KM3NeT-GR site is critical for both species for the entire Mediterranean populations, as it is being used for feeding and reproducing. For this reason, ACCOBAMS has proposed to include the sea of south Messenia into the list of *Marine Protected Areas* for deep diving mammals. The latter are known to be extremely sensitive to low frequency sounds and therefore, it should be investigated whether the sounds that the KM3NeT acoustic beacons produce for the positioning of the detector affect the sea mammals in any way. Moreover, as most sea mammals are deep divers, the possibility of reaching the detector's depth, and thus posing risks for its mechanical integrity should be investigated.
- Though not endangered, two species of dolphins are also included in this list for being deep divers and therefore, in principle capable to reach the detector depth:
    - striped dolphin (*Stenella coeruleoalba*);
    - bottlenose dolphin (*Tursiops truncatus*).

2.4 EIA for KM3NeT-GR, case study

This paragraph summarizes all known modes of interference between an ARCA block at the Greek site connected with an EOC to the shore station, with the surrounding environment and in particular referring to the aspects mentioned above. In what follows we assume a scenario that is based on the design of the NESTOR neutrino detector, that is, a ~30 km EOC connected to the plateau that is closest to the shore at 3750m depth, where an ARCA block of 115 detection units will be deployed. Given the experience with the NESTOR cable and in particular the efforts that were made at that time to establish a route that avoids interference with known environmental constraints, it has been decided that there is no reason to attempt defining a new cable routing. Therefore, the EOC is assumed to be buried 2m beneath the seafloor for the part that lies in the area between Methoni bay and the north shore of the Sapienza island, after which the cable is routed to the installation plateau in an almost straight configuration.

The EOC is the component of the project that spans the larger area, extending from the shore to the installation site. Accordingly, one expects that the EOC's environmental footprint is basically the largest part of this work. In particular:

- Special effort had been made when routing the old NESTOR cable for avoiding safely all known archaeological sites. It should be noted that not only the trace of the EOC itself does not intercept with underwater antiquities but also special care had been taken to keep a safe distance from them for performing the cable deployment as well as possible repair operations.
- The deployment of the old NESTOR as well as the HCMR cables proved to be possible with little and restorable disturbance on the Posidonia beds.
- The materials used for the construction of the cable are the standard ones used internationally in underwater communications; it is therefore unlikely that any objections related to sea pollution are raised.
- Interference with anchoring and fishing lines is a common problem for underwater cables despite their mechanical robustness. In principle the problem should be solved by including the trace of the cables in the nautical maps. These, however, are not always respected especially by smaller scale/amateur fishing activities. For instance, illegal fish aggregation devices (FADs) have been proven to be a persistent problem for KM3NeT-IT, as their remnants get entangled with the detection units resulting in large declinations off their nominal shape. Luckily, FADs are not a common practise of the Greek fishermen and moreover, the strong presence of both the NESTOR and the HCMR Institutes in the area has led to an increased sensitivity towards scientific installations by the local fishing community. To deal with whatever human activities could interfere with the cable in the shallow area between Methoni and Sapienza, the EOC is buried 2m beneath the sea bottom. A latest development that should be mentioned is the extremely detailed (resolution ~5m) mapping of the sea bottom of a large (~500 km^2) area around the KM3NeT-GR site that emerged as the outcome of the 2018 SHELL/XPRIZE competition (5) (6). The latter was organized with the aid of INPP-Demokritos and the sea-bottom maps were kindly donated to INP for potential use within the framework of underwater neutrino detection. It is expected that these maps will allow further fine tuning for both EOC laying as well as for the ARCA block positioning.

Concerning the building block of the detector, that is, the set of 115 detection units to be deployed on a sea bottom plateau ~ 3.5 km deep and ~8 km offshore the south edge of Sapienza, no particular cultural or ecological constraints apply. The block as well as the seabed cable network are constructed by non-toxic, sea water resistant materials, whereas the overall intervention is planned to be restorable, as the decommissioning of the detector essentially constitutes of recovering all deployed parts. As mentioned before, FADs are not present in the area, extremely low sea currents (3) do not pose any significant risk for the mechanical integrity of the detector and the exceptional cleanliness of the waters (2) minimizes the blinding of the optical modules due to sedimentation. Deep diving mammals is a concern, as the detector might act as a mechanical obstacle in their navigation, in which case their large size might pose a risk for the detector itself. Luckily, the deepest dive ever observed is up to a depth of 1900m, leaving a safety margin of more than a kilometer between the deepest observed sea mammal and the upmost point of an ARCA detection unit. Time and position calibration of the detector are performed by exploiting optical and acoustic beacons, which emit pre-defined pulses during scheduled calibration runs. Although the light pulses are short and rare (5min/week) and thus unlikely to cause disturbance, the possibility of interference of the acoustic pulses with sea mammals should be further investigated. The acoustic beacons will initially emit signals between 20 and 40 kHz, Δt = 5ms, P=180 dB, once per minute. Despite the strong attenuation at this frequency range (P/10 after 10 km), and the fact that after commissioning, there will be a 10-fold decrease in the acoustic power and a 2-fold in the rate, it seems appropriate that

marine biologists should be consulted to re-assess the harmlessness of the ARCA position calibration system for the sea mammals by taking into account how critical the area is for their feeding and reproduction.

Concerning the legal framework of the EIA, there are essentially three regulating authorities for issuing authorisations, depending on the action and the type of the environmental constraint under consideration. An important part of this work was to consult these authorities and identify the corresponding legal actions that have to be taken prior to proceeding with any implementation. Past experience with scientific operations performed by the NESTOR Institute and HCMR were particularly useful.

The competent authority in Greece for the evaluation of EIAs and licensing the environmental component of projects is the ministry of Environment and Energy. It should be noted that for projects that are expected to have a -however small-, non-reversible environmental impact, an approved environmental assessment is a substantial part of the permits that are required for their construction, installation or operation. According to the Greek legislation, projects are divided into two large categories, A and B and several subcategories. Although the former require a lengthy procedure for environmental licensing, which also includes the submission of detailed EAIs conducted by Environment engineers, class B projects are only subject to "Standard Environmental Commitments" - SECs («Πρότυπη περιβαλλοντική δέσμευση»), which commit the contractor of a project to comply with applicable rules for minimal environmental intervention. These rules generally vary according to the special environmental characteristics of the project but also of the installation site. In particular, if the latter happens to be classified in the NATURA-2000 network, the contractor is required to either follow what is prescribed for the area by presidential decrees or, if these are not available, to prepare and submit to the regional authorities a "Special Ecological Assessment", that is, a self-assessment report of the environmental implications of the concerned project. It should be noted that the process of a SEC does not relieve from the obligation to submit an area designation in accordance with forestry legislation and of course, all relevant approvals from the archaeological department. Project implementation permits that were received on the basis of the SEC procedure are valid for an indefinite period of time, provided that the capacity of the project does not change by more than 10%. SECs are submitted to and their enforcement is monitored by the regional governing authorities.

Luckily, consultation of HCMR and the relevant department of the Ministry of Environment and Energy revealed that a research project such as KM3NeT is de-facto a class B project. In accordance with the above, environmental licensing does not require a formal EIA but rather a SEC, which has to be submitted to the regional authorities. As the area concerned is classified in the NATURA-2000 network, a special ecological assessment of the project may be required. The overall time scale for receiving the permit is ~3 months. For the part of the EOC inside and close to the area between Methoni bay and Sapienza, an extra approval of its trace is required by EUA; the precedent endorsement of the old NESTOR cable suggests that a new EOC installation following the same route is most likely to be authorized too. It should also be noted that prior to each sea operation for whatever activity (inspection, testing, cable laying or components deployment), an authorization by a committee falling under the authority of Ministry of Foreign Affairs which includes representatives from the army, archaeology etc. must be acquired.

3. References

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4. Annex I: Legislation

1. Law: Environmental licensing is governed by the law **4014/2011** "Περιβαλλοντική αδειοδότηση έργων και δραστηριοτήτων, ρύθμιση αυθαιρέτων σε συνάρτηση με δημιουργία περιβαλλοντικού ισοζυγίου και άλλες διατάξεις αρμοδιότητας Υπουργείου Περιβάλλοντος" (Issue of government gazette A' 209/2011), as currently applicable. In particular, chapter Α' ("Περιβαλλοντική αδειοδότηση έργων και δραστηριοτήτων"), article 8 ("Περιβαλλοντική αδειοδότηση έργων και δραστηριοτήτων κατηγορίας Β").

2. Classification of projects: Ministerial decision nr. 1958/2012 ("Κατάταξη δημόσιων και ιδιωτικών έργων και δραστηριοτήτων σε κατηγορίες και υποκατηγορίες σύμφωνα με το άρθρο 1 παράγραφος 4 του ν.4014/2011) in Issue of government gazette B' 21/2012)

3. Standard Environmental Commitments (SEC): In the first table here, one can find what SEC is applicable for each project category, according to 1958/2012.