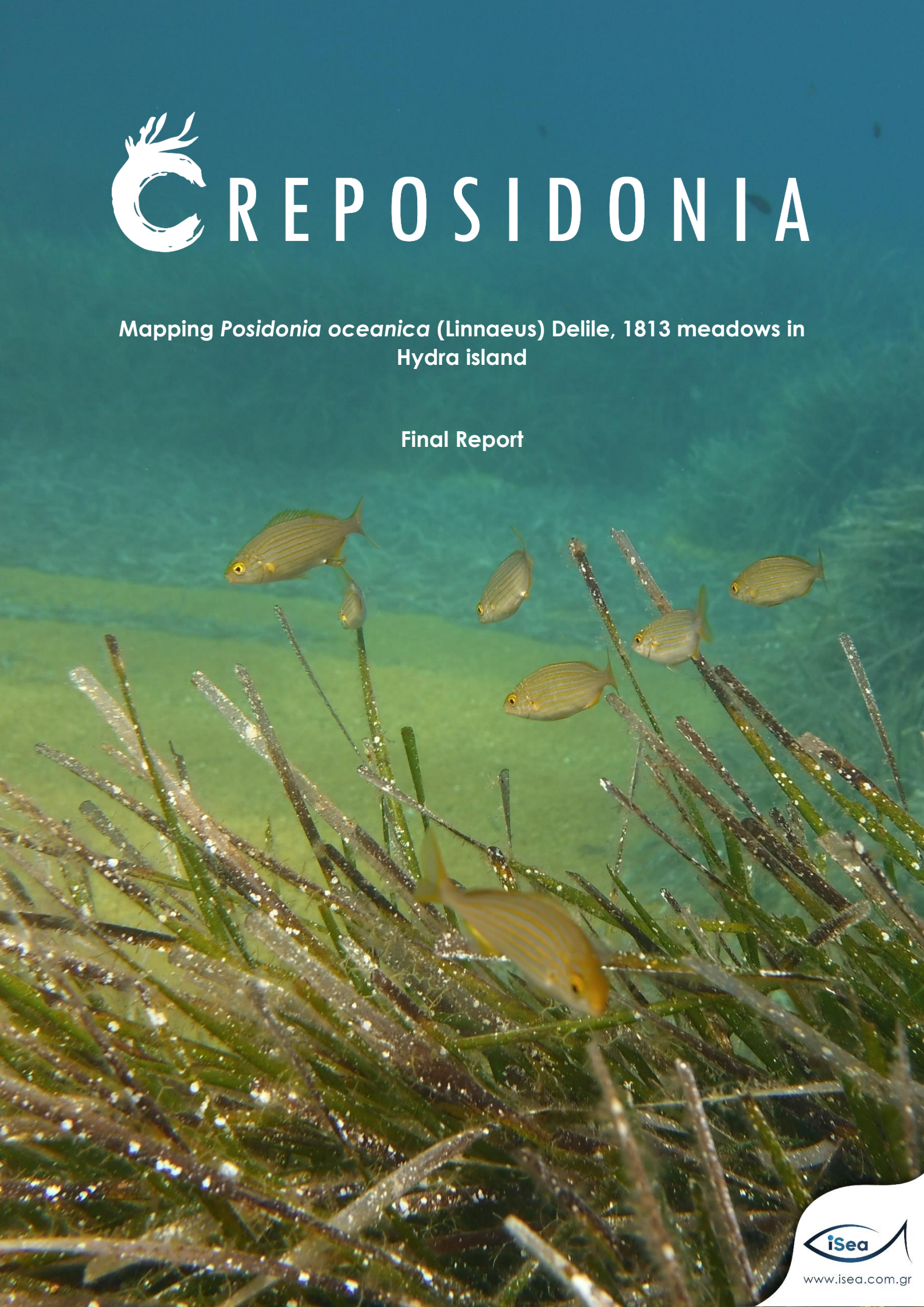
REPOSIDONIA

Mapping *Posidonia oceanica* (Linnaeus) Delile, 1813 meadows in Hydra island

Final Report



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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this report.

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In collaboration with:

Introduction

REPOSIDONIA, is one of the main projects, that falls under the scope of the Vulnerable Species pillar of iSea. It is an umbrella project that aims at the protection and the preservation of the priority habitat that *P. oceanica* constitutes to the point it fulfils its ecological role in a healthy marine ecosystem through various ecosystem functions and services. Through the REPOSIDONIA project, iSea aims to contribute to the management and protection of the *P. oceanica* seabeds in Greece, as it is one of the most important coastal habitats in the Mediterranean, providing nursery and hunting grounds for many species (Pergent et al., 2016), among other services. To achieve this, the project has four main thematic units of activities (i) increase the scientific knowledge about the distribution and coverage of *P. oceanica* meadows in the Greek Seas (ii) conduct biodiversity surveys and health assessments for the meadows (iii) estimate the mapped meadows' Blue Carbon potential to propose science-based management measures, and finally, (iv) educate and sensitise key stakeholders to propose target management actions for these habitats, highlight the important ecosystem services offered by the meadows. In this context, iSea uptook the mapping of *Posidonia oceanica* in the Argolic Gulf, specifically in Spetses, Velopoula and Hydra island, with the support of the Argolic Environment Foundation and in collaboration with terraSolutions.

Importance of *P. oceanica*

Posidonia oceanica, is an endemic phanerogam plant of the Mediterranean Sea (Boudouresque et al., 2006). Also known as Neptune Grass, it is one of the most common species of seagrass in the Mediterranean, along with *Cymodocea nodosa*, and *Zostera marina*. *P. oceanica* has the largest size among Mediterranean phanerogams (Traganos et al., 2022). The plants consist of plagiotropic or erect stems, usually buried in the sediment, called rhizomes. Rhizomes also have roots that can grow to 70 cm beneath the surface of sediment. Its leaves form all year around and live between 5 and 8 months. The length of its leaves reaches up to 1.2 meters and their density can reach up to 1,000 per square meter (Díaz-Almela & Duarte, 2008). In Greece, Neptune's Grass is present along the majority of the mainland coasts and the islands, mostly to the protected sites from the dominant northwest winds. In the Northern Aegean Sea, its meadows can extend down to 25 meters, while in the South Aegean Sea to 35 meters (Gerakaris et al., 2014, Poursanidis et al., 2018), depending on many factors but primarily water clarity and local oceanographic conditions. In the Ionian Sea, a highly oligotrophic area, the meadow can reach depths up to 45 m depth (Gerakaris et al., 2014, Traganos et al., 2018).

Posidonia oceanica along with the Coralligenous/Biogenic habitats is the most important Mediterranean marine ecosystem (Giakoumi et al., 2013). The role of *Posidonia oceanica* meadows in marine coastal environments is often correctly compared to that of the forest ecosystems in terrestrial environments, as they constitute the basis of the richness of coastal waters in the Mediterranean Sea. By producing enormous quantities of vegetal biomass, the meadows form the basis of many food webs (McRoy & McMillan, 1977). This primary production is comparable to or greater than that of other high production environments, whether terrestrial or oceanic (Fergusson et al., 1980). In addition, *P. oceanica* meadows constitute a spawning ground, a nursery or a permanent habitat for a lot of species (over 400 different plant species and several thousand animal species populate the meadows of which many commercially important species; Pergent et al., 2016), making these underwater meadows a unique biodiversity hotspot (Boudouresque et al., 2012). Furthermore, *P. oceanica* is considered an "ecosystem engineer" as it stabilises the sediment with its roots and changes the hydrodynamic status of the sublittoral zone and protects from erosion (Pergent et al., 2012). Besides, it serves as a purifier as it improves the water quality by reducing particle loads (Hemminga & Duarte, 2000). Moreover, the plants produce large amounts of atmospheric oxygen, while also removing atmospheric CO_2. Through this process, the meadows can store large amounts of organic carbon, serving as long-term carbon storages (Pergent et al., 2012). Finally, their rhizomes concentrate radioactive substances, synthetic chemicals and heavy metals, reducing the levels of such persistent contaminants in the water column. Hence, *Posidonia oceanica* is also used as a 'biological quality element' in the long-term monitoring programmes of the Water Framework Directive (WFD 2000/60/EC) and also according to the Marine Strategy Framework Directive (MSFD, 2008/56/EC) as an indicator for assessing the "Good environmental status" of coastal water bodies.

Background of the project

Despite the benefits and services that these ecosystems offer, they are some of the most threatened ecosystems globally. In 2022, AEF funded the project of REPOSIDONIA in Spetses. Through this project, the mapping of the Posidonia meadows around Spetses and the islet of Parapola (Velopoula) was conducted. The high-resolution map produced as a result, together with other data gathered by iSea divers during their field visits provided an unprecedented look at the extent and key threats of seagrass meadows in these waters. The report (GR, ENG) notes that these are fragmented in many areas due to anthropogenic factors, with anchor tracks visible in many locations. Meanwhile, Velopoula was found to have over 10 times more extensive seagrass meadows than the estimated coverage in the relevant NATURA 2000 standard data form (SDF). Findings such as the above highlight the value of the mapping for future conservation efforts.

In regard to this, first steps would be to raise awareness at a local level and to preserve and protect this precious habitat by strengthening protection measures. Mapping of the distribution of the meadows in the Argolic Gulf will serve as a baseline for future management, protection and possibly restoration of this important habitat and can be used as a tool for future designations of Natura 2000 sites. Furthermore, the Argolic region is not well studied for its marine environment and thus studies as such can serve as a stepping stone for more concrete conservation.

In light of the above, iSea continued their work in the Argolic through the REPOSIDONIA project in Hydra Island. This project, funded by Argolic Environment Foundation and Blue Marine Foundation and undertaken by iSea, to expand the mapping of the Posidonia meadows in other areas of the Argolic region and continue raising awareness through informative materials at a local level.

Project aim: to improve the knowledge on the distribution and extend of *Posidonia oceanica* in the Argolic Gulf, and the threats they face, and finally raise awareness on the importance of *Posidonia oceanica* among the local community and stakeholders.

Study area

Location: Hydra and Spetses

The mapping of the Posidonia took place in Hydra. Hydra island receives hundreds of visitors during the summer months and is amongst the most popular destinations for boat tourism. As vehivle use on the island is limited, moving around the island is mainly done with seataxis and boats. This high boat activity gives rise to an array of threats for the marine environment. In Greece, there are no official maps for seagrass meadows, except in Natura2000 cosites which date back to the 00s, and the approximate maps made by the Ministry of Agriculture, to monitor large-scale fisheries. In the context of REPOSIDONIA, iSea aimed to map the Posidonia in Hydra Island with ~3m resolution. This effort will set the road for future management actions, as it will help identify priority meadows in a region that are heavily disturbed. The mapping has been utilised complementary with the mapping conducted in 2022, in Spetses, to create informative materials to sensitise key stakeholders.

Methodology & Results

A1. Mapping of *P. oceanica*

Mapping of the endemic phanerogam species of *Posidonia oceanica* was undertaken to better understand its coverage, distribution, and threats faced around the highly touristic island of Hydra.

1. Field activities

An important aspect of the mapping process was to obtain accurate ground truthing points, representing the different seabed habitats, which was used as training data for the classification of the pixels in habitat types as well as for validation. On the 28th of October till the 1st of November, iSea visited Hydra island to conduct the fieldwork activities. To obtain the ground truthing points iSea developed a plan for the samplings using free source satellite images from Google Earth, and consulting with the external collaborator. The team tried to cover as much area as possible from the two islands. The areas visited are apparent from the ground truthing points collected. Two sampling methods were developed: i) visual confirmation from circumnavigation with a boat and ii) snorkelling/apnea (Figure 1). No diving was performed as the meadows' deep limit did not exceed 20m in most cases.

The coordinates for each specific point were listed along with the habitat type observed for each point (see Table 1 for overview). A GPS device (Garmin 22x) was used with a minimum accuracy of 3m. The team was careful to record each point, of habitat covering approximately 10m^2 to avoid the reduction of the accuracy of the habitat classification due to the GPS's accuracy. All the points were then transferred in a text file, along with the coordinates and the affiliated habitat. The text file then was transformed into a shapefile using ArcGIS (Version 10.4) (attached with the report).

Figure 1: Data collection methodology using visual confirmation from circumnavigation with a boat to characterise groundtuthing points (left). View from the glass container used (right).

Table 1: The total number of ground truthing points collected and their resulting habitat type

Substrate type	Hydra island	Platonisi island	Total (N;%)
Posidonia meadows	344	5	349; 51.62%
Sandy bottom	83	-	83;12.28%
Rocky bottom	218	-	218; 32.25%
Matte morte	26	-	26; 3.8%
Total	671	5	676

1.2. Defining the deep limit of the meadows

To define the deep limit of the meadows two field methods were used i) visual confirmation from circumnavigation with a boat, using the on-vessel bathymetry equipment and ii) snorkelling/apnoea. No scuba dives were completed. In total, 7 deep-limit points were considered. From these, the deep limit was defined as **20.63m** (average), with a minimum of **17.9m** and a maximum of **24.7m**. Apart from the Eastern side of the island that patches were only found in shallow waters (<10m).

2. Analysis workflow

The analysis consisted of 6 main steps. The steps are briefly described in the workflow below (Figure 3), and then are briefly explained in the following paragraphs accompanied with the produced results.

Coastal habitat mapping with emphasis on the seagrass meadows, the priority habitat 1120*, was performed using Maxar WorldView III 8-bands (here after WVIII), at 2m pixel size. The selection of the imagery was done using the public available Maxar Discover tool (https://discover.maxar.com/) through the available archive imagery. The selection was based on the 8-band data (https://worldview3.digitalglobe.com/) with less than a 20% cloud coverage within the search area. The filtered imagery was visually inspected prior to order for further analysis. The 8-band WorldView II/III has previously been used for coastal bathymetry and habitat mapping with success at various water types (Mederos-Barrera et al., 2022, Poursanidis et al., 2018, Coffer et al., 2023).

Two images (Figure 2), one WorldView III acquired on 07/01/2022 (North Hydra) & one WorldView II acquired on 06/03/2016 (South Hydra) with almost clear sky and wave free conditions were selected. Imagery was ordered in Top of Atmosphere Reflectance (TOAR) and the ACOLITE (Vanhellemont et al., 2018) was used as the proper atmospheric correction for aquatic environments. The final product is a bottom surface reflectance image composite. For the image classification towards seagrass mapping, a Random Forests Regression-based analysis workflow adapted from Poursanidis et al., 2021 was employed. The open source EnMAP toolbox (Van der Linden et al., 2015, Poursanidis et al., 2019) was used, where all necessary steps for proper creation of training data, image classification and product validation using the collected field data, can be found. The toolbox is a plugin in the open-source GIS software QGIS and can be used by any experienced user.

Figure 2: The footprints of the selected satellite images

For the analysis, a series of image-based training data was created, that were evenly distributed in each area of work. A binary scheme was designed aiming at the separation of the target habitat (seagrass meadows) from the other seabed habitats (sandy/soft bottoms, rocky surfaces/reefs and optically deep waters), where the spectral data recorded by the satellite sensor could have both a bottom and mid water origin. The areas with motion from speedboats were turned into wavy areas with no bottom reflectance information.

The product validation was based on the point-based dataset (groundtruthing points), collected by iSea during october 2023. A radius of 5m was used in order to compensate for the GPS accuracy.

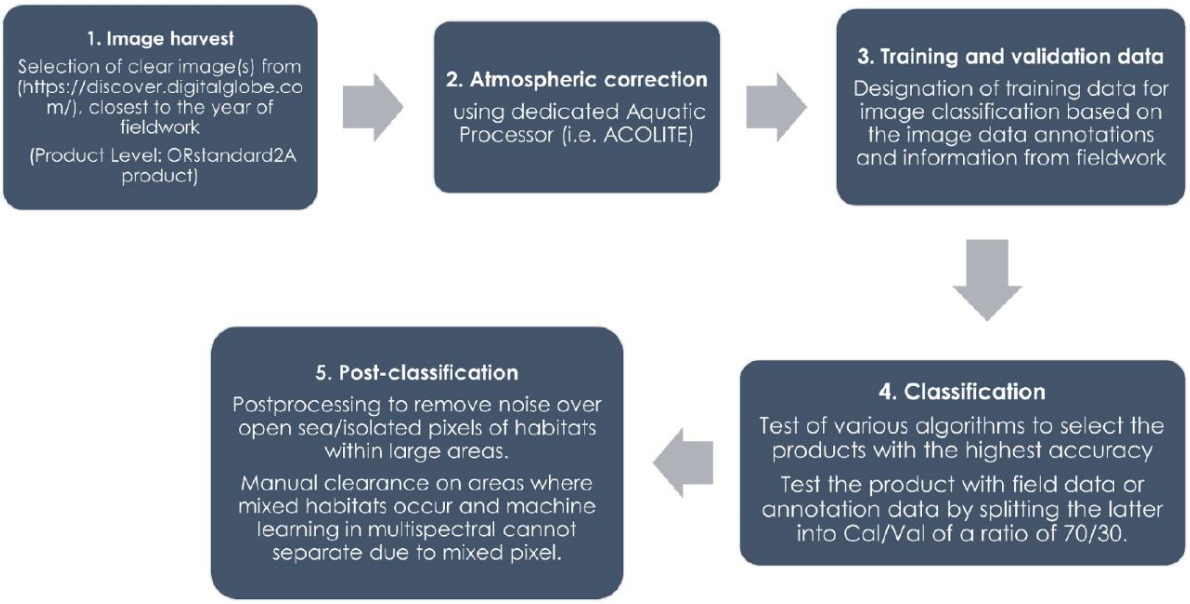

Figure 3: Workflow of the analysis followed for producing the final maps of *P. oceanica* meadows.

Results and dicussion

The analysis of the WVII/III imagery for Hydra area using Random Forests classification shows that the spatial distribution of the seagrass meadows is restricted to the coastal zone, as is normal for the studied habitat (Figure 4). The overall accuracy of the final product is 72.00%, based on 266 validation points out of 676 (table 1) that were collected during the fieldwork in October 2023. According to the current work, the meadows cover an area of **0,77km²** (77,12 hectares).

It worth noting that the oceanographic conditions of the area along with the geographic orientation, as the sun azimuth is low during the image acquisition date of January 2022 and shadow cast is lower in the sea, this can limit the accuracy of the analysis of the satellite imagery regarding the lower limit of the meadows (deep limit) and for a more detailed investigation using hydroacoustics (side scan sonar) is recommended to supplement the analysis for a holistic approach.

Figure 4: The spacial distribution of *P. oceanica* meadows around the island of Hydra and associated islets

P. oceanica mapping around the island of Hydra was conducted resulting in a total area of **0,77 km²** of meadows. The distribution of seagrass appears scarce throughout the island, mainly found along the southwestern coastline, with more dense areas around Klimaki and the bay infront of Nisiza islet (37.314526N, 23.445693E), while the presence of seagrass on the northeastern part of the island was restricted in Limnioniza beach area and in Cape Zurva.

The observed limited distribution of Posidonia meadows is mainly attributed to the characteristics Hydra's coastline (steep continental shelf) and oceanographic conditions, which make it unsuitable for the settlement of a meadow.

However, where Posidonia meadows are present, they appear patchy and non-continuous. In the beaches of Agios Nikolaos and Agios Georgios (Bisti) this may be the result of uncontrolled anchoring as the areas are a popular spot for boats. Furthermore, in Molos beach the pier structure (37.325128N, 23.414461E) attracts a higher boat activity which may have resulted in the limited distribution of *P. oceanica* within the bay, while the Palamidas beach ship yard (37.331264N, 23.428826E) may act as a pollution point possibly leading to the degradation of the meadow in the area. Nevertheless, the limited distribution of *P. oceanica* around the island of Hydra stresses the need to protect and restore the remaining meadows.

A2. Infographic material creation for Hydra and Spetses

Informative materials (Posters, brochures) for Spetses were created in collaboration with the Argolic Environment Foundation and the local municipality, aiming to raise awareness for *Posidonia oceanica* among the local community and relevant stakeholders. An infographic similar to the one in Spetses was created for Hydra island (Annex I; ii) and iSea will communicate with the municipality of Hydra in the beginning of January 2024 to acquire a permission for the logo and discuss joint communications activities with the municipality and AEF. For Hydra, the poster will be released on SoMe platforms early next year after the aforementioned communications. See **Annex I** for the two infographic posters created and distributed for the project.

Project communication and materials' dissemination

For the communication of the project's results iSea attended an informative event organised by Argolic Environment Foundation(AEF), for Posidonia meadows in Spetses, under the auspices of Spetses municipality on the 19th of May 2023. The event was open to the public and and was attended by 20 people, among which municipality officials, port police and locals. During the event and after the meeting iSea kept an open dialogue with the municipality of Spetses and Argolic Environment Foundation to create a common communication for this important habitat in Spetses. Upon that discussion iSea, apart from the infographic that was foreseen in the project iSea created mini brochures for the municipality to have (Annex; iii)and disseminate in collaboration with AEF. Then for the materials another printed version was created similar to the one for Social Media to be printed and placed in the information kiosk of the municipality at the port. AEF informed iSea that the materials were printed and will be placed in beaches around the island. For Spetses infographic, a post was created on iSea social media platforms, on 30/08/2023, reaching over >7000 users. Once the final report is released the mapping will be shared with NECCA and HCMR to support better management of this priority habitat.

Coordination of the project

The project manager assigned to this project is responsible for closely monitoring its actions and ensuring their timely implementation by the project's team. During the implementation the project manager was in communication with Argolic Environment Foundation and Blue Marine Foundation for the overall timeline and the declinations from the original timeline were discussed and the timeline was readjusted.

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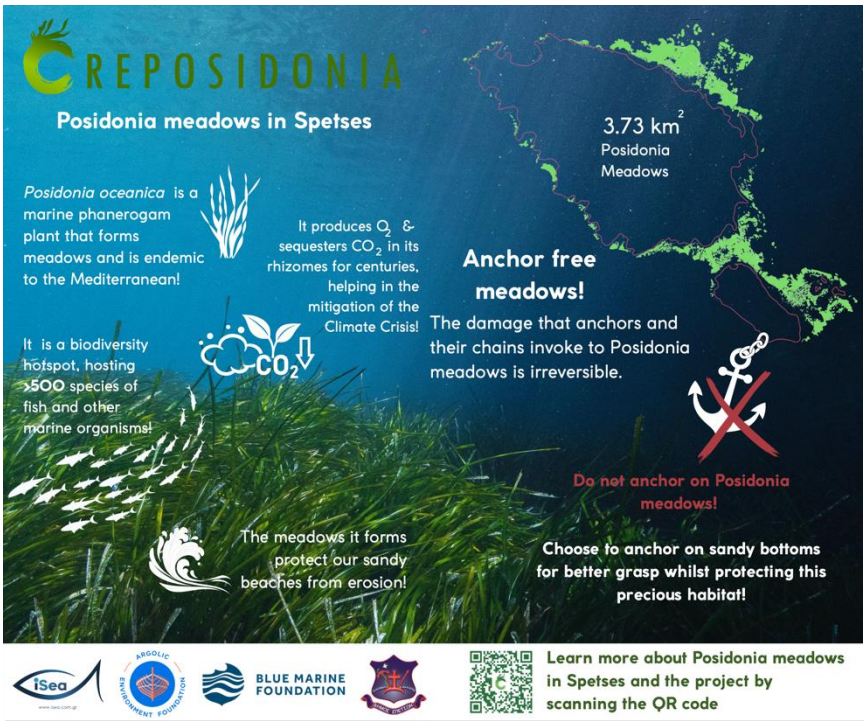
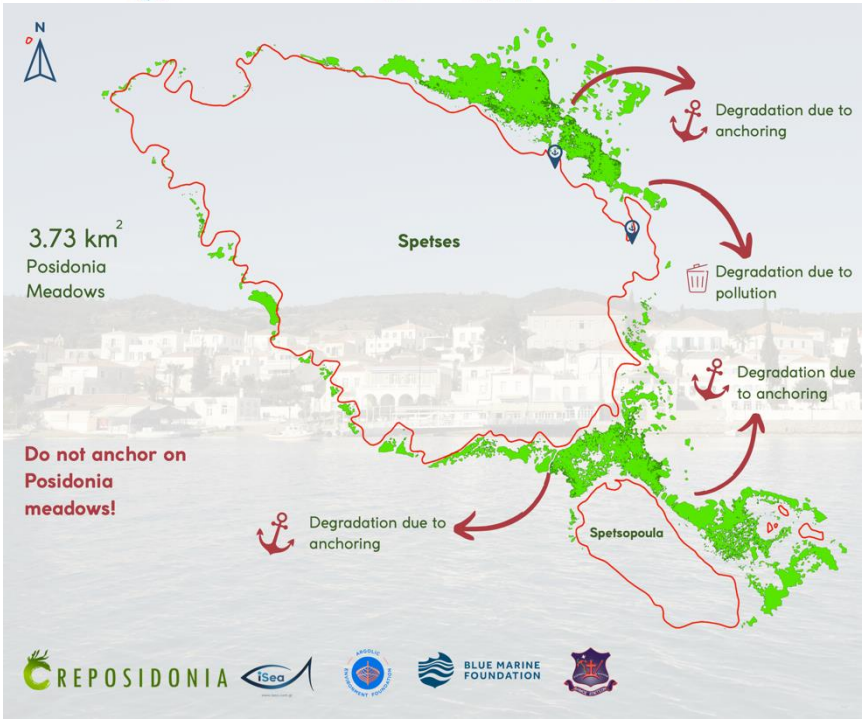
Annexes

ANNEX I. Informative material created for Spetses (i) and Hydra islands (ii) (ENG).

i)





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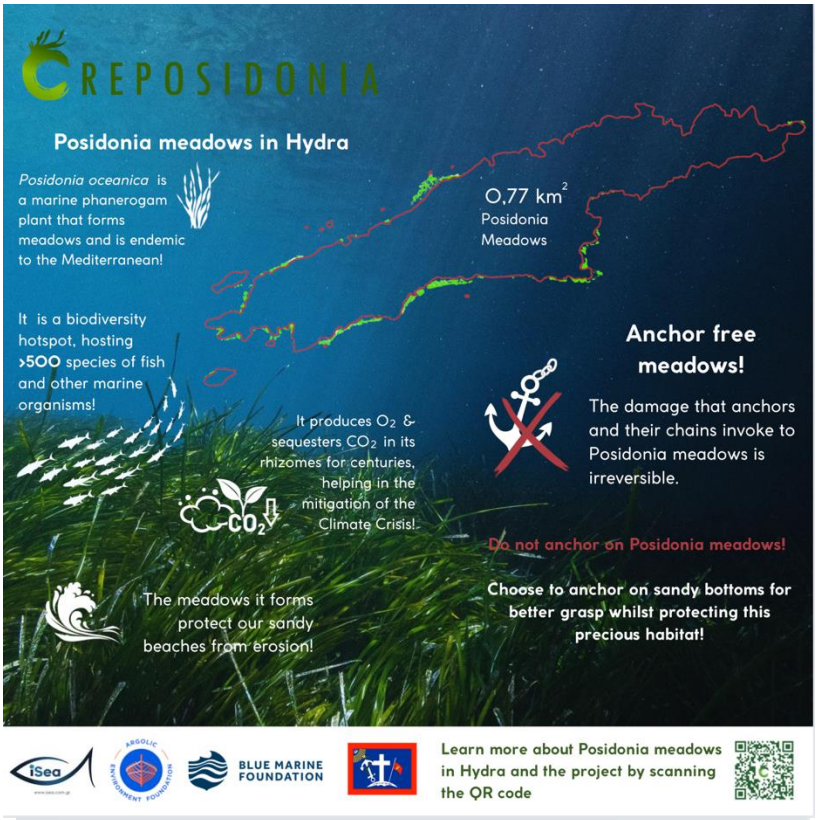
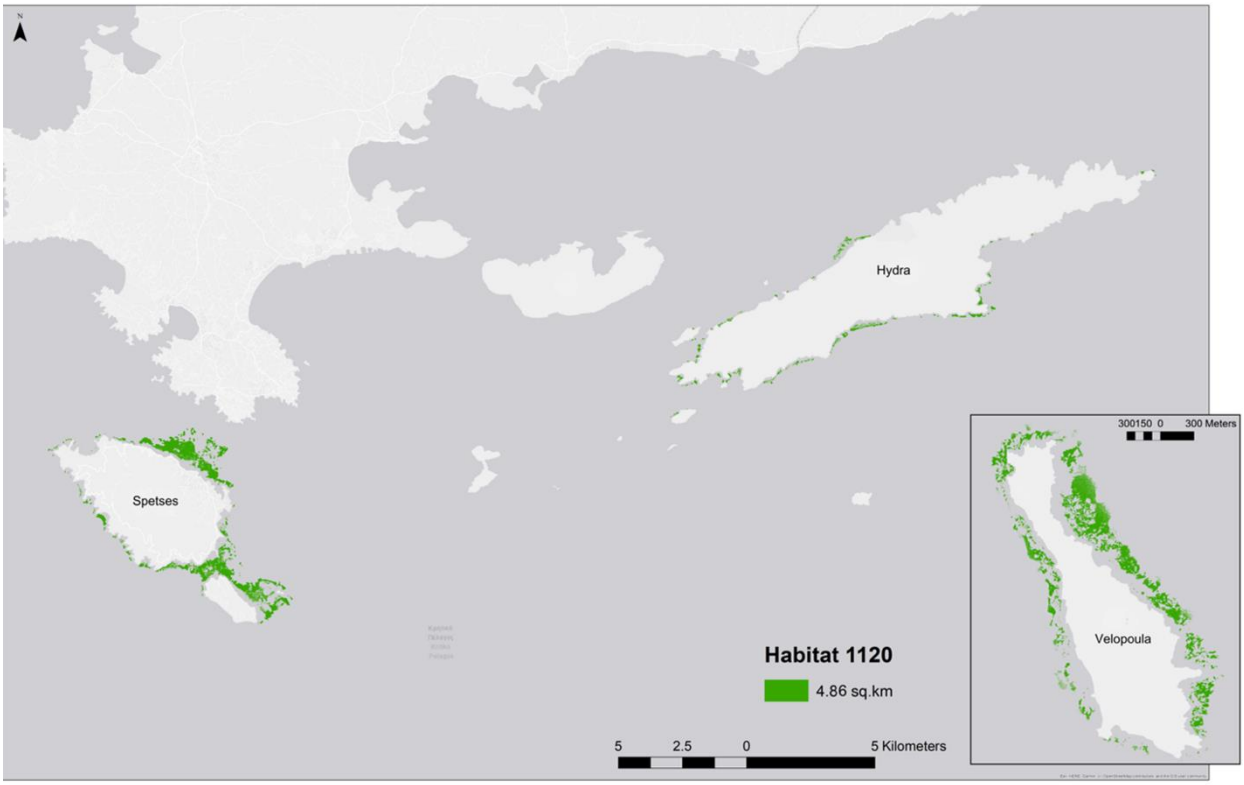
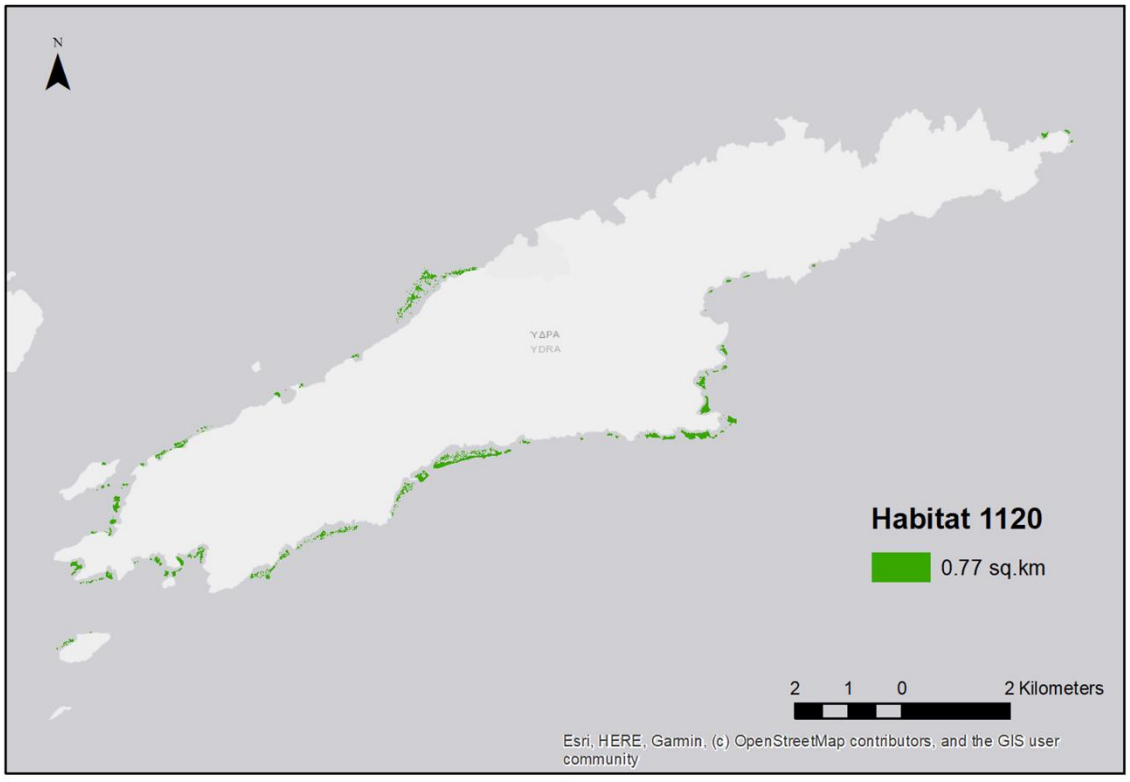

REPOSIDONIA
Posidonia meadows in Hydra
Posidonia oceanica is a marine phanerogam plant that forms meadows and is endemic to the Mediterranean!
0,77 km²
Posidonia Meadows
It is a biodiversity hotspot, hosting >500 species of fish and other marine organisms!
It produces O₂ & sequesters CO₂ in its rhizomes for centuries, helping in the mitigation of the Climate Crisis!
Anchor free meadows!
The damage that anchors and their chains invoke to Posidonia meadows is irreversible.
Do not anchor on Posidonia meadows!
Choose to anchor on sandy bottoms for better grasp whilst protecting this precious habitat!
The meadows it forms protect our sandy beaches from erosion!
BLUE MARINE FOUNDATION
Learn more about Posidonia meadows in Hydra and the project by scanning the QR code

N
0,77 km²
Posidonia Meadows
Hydra
Main Threats
Degradation due to anchoring
Degradation due to pollution
Do not anchor on Posidonia meadows!
REPOSIDONIA
BLUE MARINE FOUNDATION

iii) Brochures Spetses (left, GR) Hydra (right, ENG)

Annex II. The distribution of *P.oceanica* around the three assessed islands in the Argolic Gulf (top) and the distribution around Hydra island in detail (bottom)





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