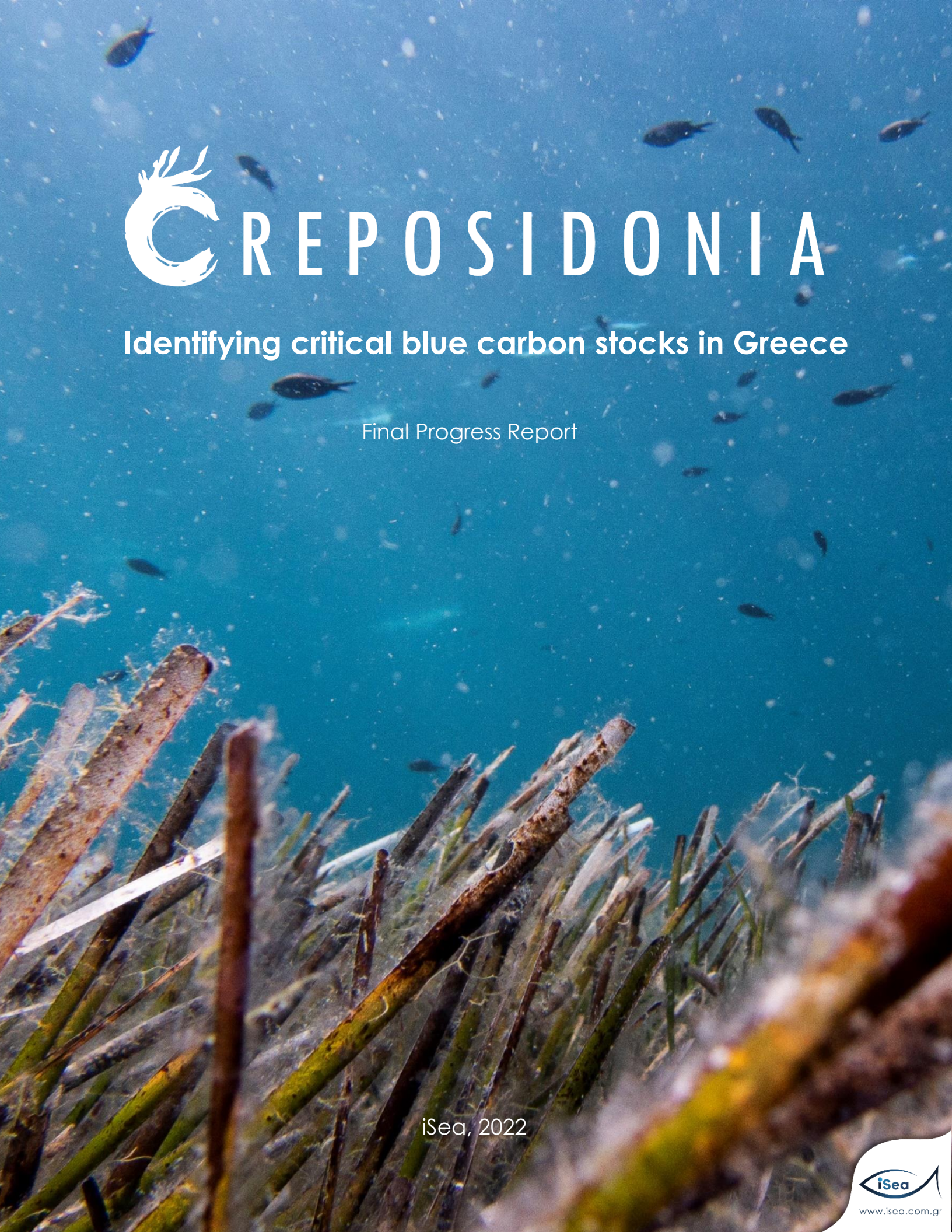


CREPOSIDONIA

Identifying critical blue carbon stocks in Greece

Final Progress Report

iSea, 2022

www.isea.com.gr

Suggested citation:

Naasan Aga Spyridopoulou, R., Gkikas, R., Adamopoulou, L., Poursanidis D., REPOSIDONIA

Final Report Identifying Critical Blue Carbon stocks in Greece, iSea Thessaloniki, Greece 2023, 55pp.

Declaration of conflict of interest:

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.

Funded by: BLUE MARINE FOUNDATION

In collaboration with: terra SOLUTIONS, Mer

Table of contents

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 area 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 has identified three main regions of importance for *P. oceanica* habitat: Formicula island (Inner Ionian Archipelago); Lemnos Island and Nisyros, Gyali and surrounding islands. These areas belong to the Natura2000 network designated as Sites of Community Interest (SCI) and Special Areas for Conservation (SAC). The drivers in pinpointing these areas derive from their similarities as the data of the habitat 1120 (Posidonia beds) is listed as "Poor" in the Standard Data Forms (SDFs), indicating that more research is needed, while the threats they receive are not sufficiently assessed or monitored (i.e. tourism, coastal development, pollution etc.). All the objectives of the project are included in the detailed description of activities for each region.

Progress report on Formicula Island

Description of the area

Formicula is a small uninhabited island in the inner Ionian Archipelago located west of Kastos, southeast of Kalamos (Map 1). The island is located within the Natura2000 site Esoteriko Archipelagos Ioniou (Meganisi, Arkoudi, Atokos, Vromonas) (Sitecode: GR2220003). The site was proposed to be designated as a Site of Community Interest in 1996 and was designated in 2006 while it was also designated in 2011 as a Special Areas for Conservation (SAC). Due to its "recent" designation as a Natura2000 site, the seabed habitats of the site were never mapped. Nevertheless, the SDF form indicates that the 1120 habitat (*P. oceanica*) covers in total of 8,895.16 ha. We consider the whole site of great importance due to the presence of many marine megafauna species the presence of *P. oceanica*, and the distinct biomorphology of the whole marine and coastal area. The site is also an Important Mammal Area (IMMAs) due to the presence of Cuviers' beak dolphin *Ziphius cavirostris*, the fin whale *Balaenoptera physalus* and the bottlenose dolphin *Tursiops truncatus*. In addition, the Inner Ionian Archipelago has been known to host populations of the Endangered common dolphins *Delphinus delphis* (Bearzi et al., 2005) and for its importance for the Mediterranean Monk Seal *Monachus monachus* (Panou et al., 1993; Mpougas et al., 2019). The latter has been documented due to the presence of many submerged or partially submerged sea caves (8330) that are mentioned in the Standard Data Form (SDF) of the Natura2000 site. Formicula has at

least two caves that monk seals use as birthing sites (Per. Comm. Ionian Dolphin project). The area is potentially important for seabirds due to its proximity to the marine Important Bird Area (IBA) site code: GR084, (LIFE07 NAT/GR/000285) for pelagic species. Allegedly, according to the Standard Data Form (SDF), *Chelonia mydas* is present in the area however no recent references prove this. While for *C. caretta* indeed has a confirmed presence in the whole area.

Formicula is uninhabited, yet it suffers from intense boat traffic since the early 90s during the summer months by recreational boats (i.e., sailing boats, yachts, etc.) and the uncontrolled anchorage that comes with it. Additionally, it is an area that illegal, Unregulated Unreported fishing (IUU) takes place the last few years by beach seines, that are currently banned in Greece. Meanwhile, it is pressured due to recreational fishing as well, as it's a known spot for rod and line targeting pelagic species. iSea in support of the Monk Seal Alliance (MSA) who consolidates management and conservation activities aimed at reducing harmful impacts of tourism on seals in the Ionian Sea, had co-signed a letter urging the Greek government to implement temporary emergency measures before the summer of 2022 to regulate access to the area.

iSea to further strengthen the argument of the need for protection, provided data concerning the protection of *P. oceanica* as a habitat highlighting the obligation to protect these meadows by showcasing their spatial distribution and evidence of destruction by uncontrolled anchorage around the island.

The actions taken are described below in the context of each activity.

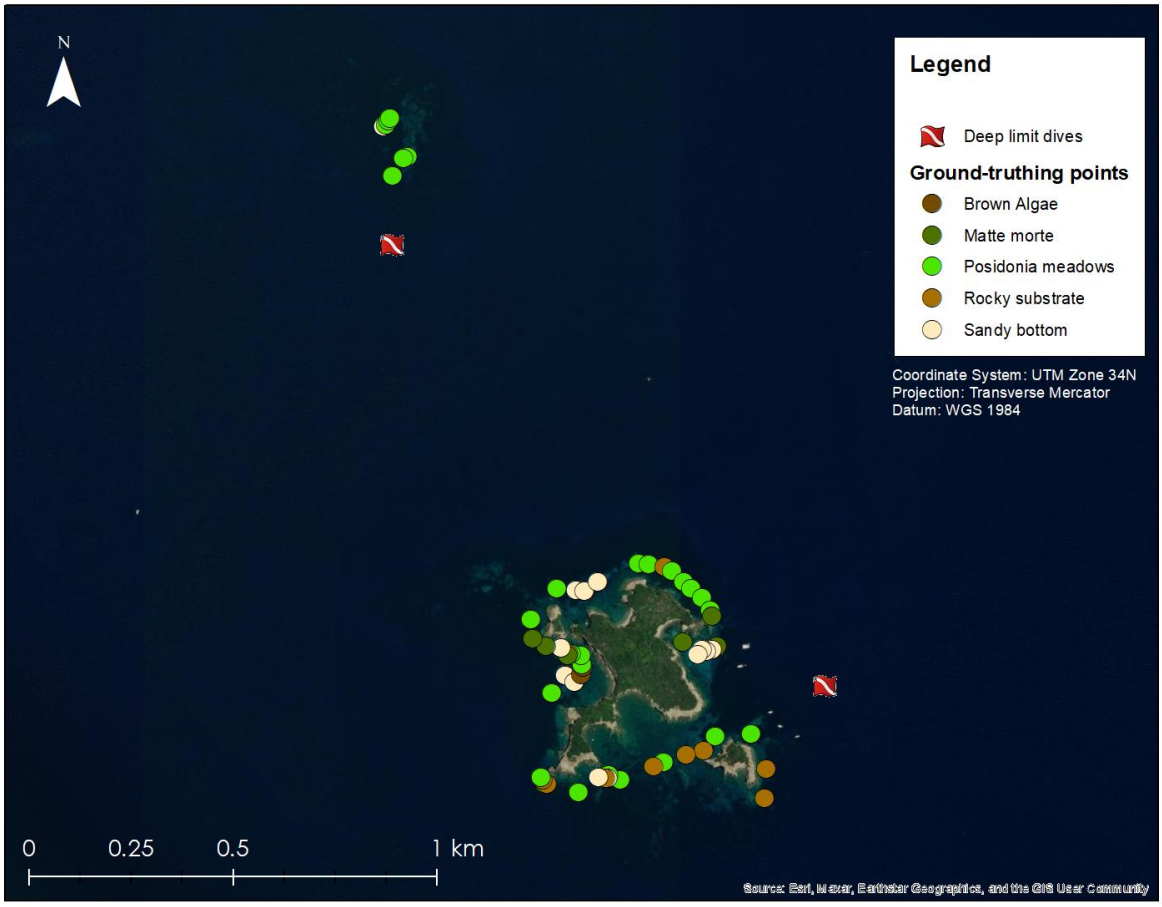
Activities progress

A.1. Mapping the meadows

According to the methodology proposed, the mapping was conducted via analysing high-resolution satellite image to effectively cover a broader area of Formicula island and Formicula's shoals, in a cost-effective and accurate way. This action foreseen four dives for the collection of ground truthing points and definition of the deep margin. The project team scheduled the fieldwork on late April (28/04/2022 - 31/04/2022). In total, 64 ground-truthing points were collected, of which 58 were used for mapping analysis (Table 1; Map 1). Due to poor bathymetric data along with the depth of the habitat type it was recorded using the Garmin Echomap, provided by the Tethys Research Institute. The coordinates were obtained using a porTable GPS device (Garmin 22x) with a maximum accuracy of 3m. The team made sure to record each point, in habitats covering about 10 m^2 to avoid a decrease in the accuracy of the classification of habitats due to the accuracy of the GPS. All points were then transferred to a text file, along with the date received, coordinates and associated habitat. The text file was then converted to a shapefile using ArcGIS (Version 10.4).

Table 1. The ground-truthing points that were collected during the fieldwork along with the assigned habitat.

Substrate type	N	%
Brown algae	2	3.45%
Matte morte	6	10.34%
Posidonia meadows	27	46.55%
Rocky substrate	10	17.24%
Sandy bottom	13	22.41%
Total	**58**	**100.00%**



Map 1: The sampling effort conducted in Formicula island and Formicula's shoals for the ground truthing points and the definition of the deep limits.

To define the deep limit of the meadows iSea divers performed two deep dives (Map 1), in the sites that the deep end of the meadow was not visible through the satellite image (Figure 1). In these two locations the meadow continued well below 35m, with a progressive limit, whereas in the other areas it had a sTable limit (Figure 1).

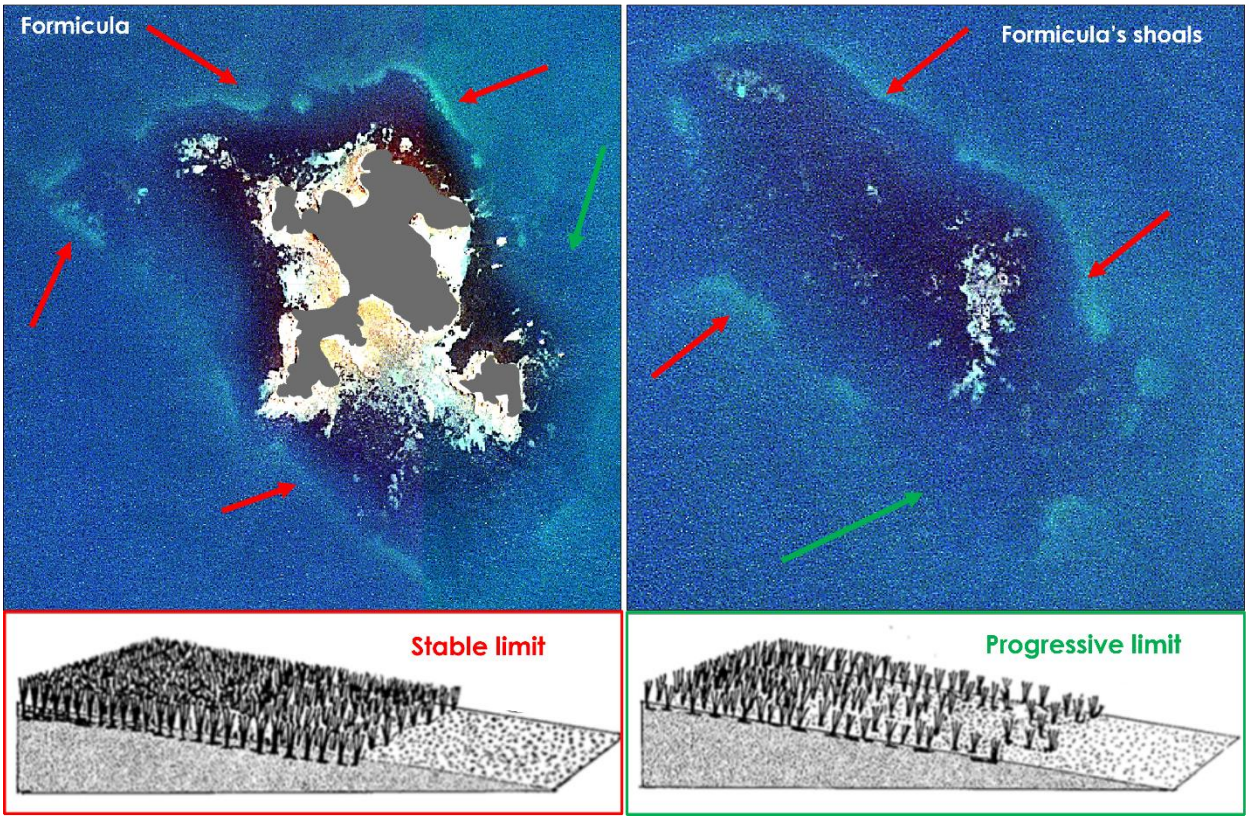
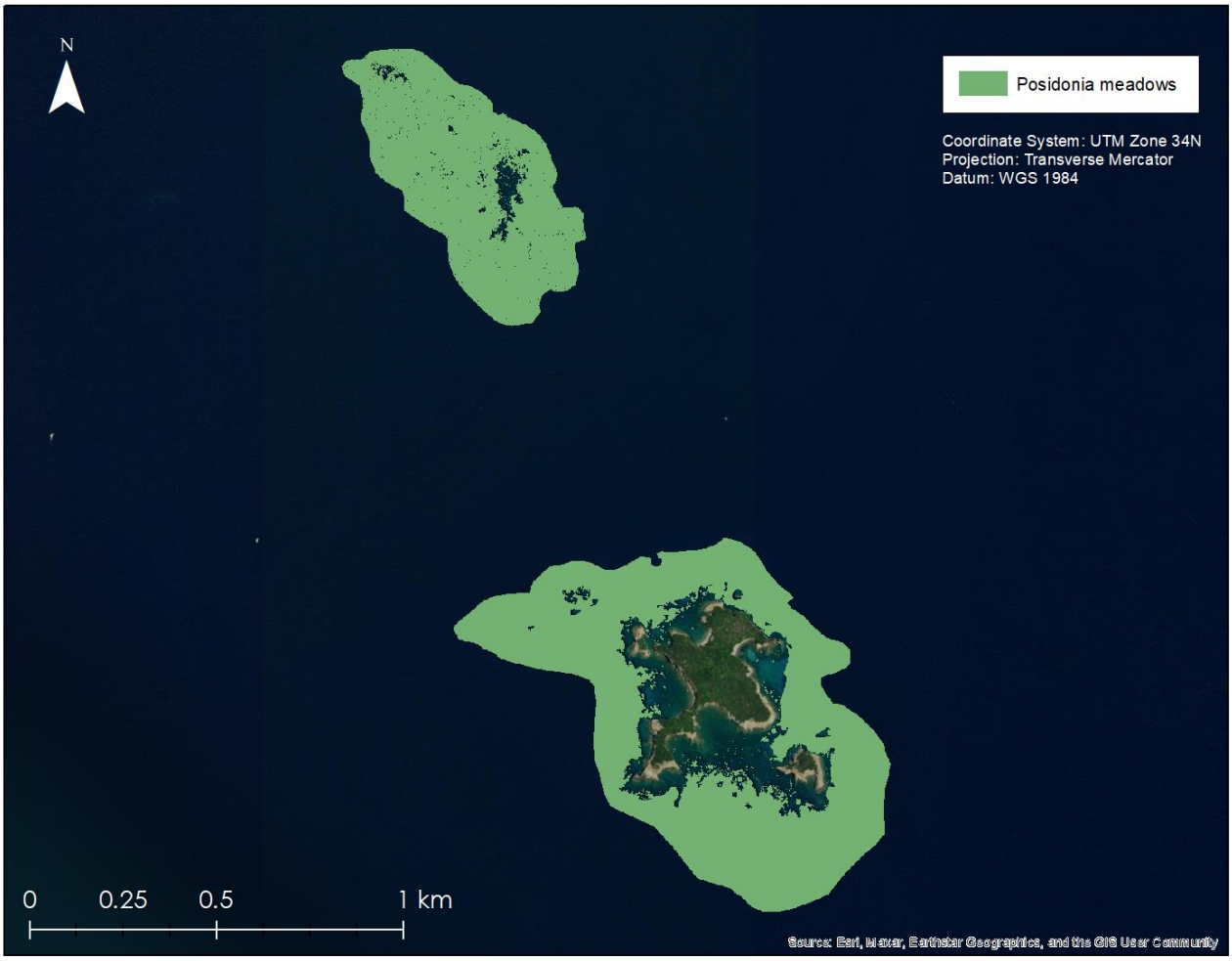


Figure 1. Satellite image after atmospheric correction; red arrows indicating the deep limit of Posidonia meadows that was visible and has a sTable typology, green arrows pointing at the locations where the meadow has a progressive limit (lower density) and extend well beyond 35m deep. Types of deep limit adjusted by Pergent et al., (1995).

The first step of the mapping was to harvest a satellite image satisfying the criteria for the mapping analysis (i.e., Minimum cloud coverage; Minimum sand glint and wave glint; minimum angle; high spatial resolution; multispectral). After research on various platforms, the project's team resulted in an image sensed by WorldView 3 of Maxar on 23/07/2021, that offers 8 multispectral band imagery with a mean resolution of 1.31 m per pixel. Afterwards, an Atmospheric correction was performed using the aquatic processor ACOLITE (version 20220222.0). The default parameters for the retrieval of bottom reflectance have been used (Vanhellemont & Ruddick, 2018). A mask was applied to remove the terrestrial part of the imagery using the Near-IR1 band (wavelength: 770 - 895 nm). The study area was further reduced by applying a manual mask, via manual delineation, close to the deep limits of the meadows, as these were clearly visible from the imagery and the fieldwork data. Then a series of supervised classifications were performed using different algorithms. First the algorithms Random Forests (RF) (Breiman, 2001) and Support Vector Machines (SVM) (Vapnik 1995) in EnMAP 10 toolbox, QGIS, were performed. Finally, a Maximum Likelihood algorithm (Haynes, 2013) was performed in ENVI software (version 5.6.2.). The classification with the highest accuracy derived from the Maximum Likelihood algorithm (Table 2).

Table 2. The overall accuracy achieved by the classification of Posidonia meadows.

Classification Algorithms	Accuracy
Random Forests	83%
Maximum Likelihood	**95%**
Support Vector Machines	85%



Map 2. The final map of Posidonia meadows deriving from the Maximum Likelihood algorithm with overall accuracy 95%.

The final step of the analysis, consist of two parts; 1) a low pass filter to remove the "salt n' pepper" effect over the homogeneous areas of the seascape, using a small kernel window of 3x3 pixels, 2) the editing of seagrass polygons due to misclassified pixels as seagrass in deep water (remove pixels over the open sea that behave spectrally similar with the seagrass class due to sun angle and phytoplankton pigments). The accuracy assessment was conducted with the use of the ground truthing points collected during

the field activities using a binary approach (Seagrass/no seagrass). The final map deriving from the best performing algorithm shows that Posidonia meadows cover a total 0.67 Km^2 including the meadows in Formicula's shoals (Map 2). To further explore the distribution of *P. oceanica* below 35m depth where remote sensing using satellite data was not applicable. iSea conducted anther field visit during September 2022, which allowed the conduction of visual survey transects between the island's defined northern deep limit and the northern deep limit of Formicula. Indeed, Posidonia meadows cover the sea bottom in the defined area with a distribution similar to the progressive limit exhibited in figure 1; with limited patches of Posidonia meadows covering the sandy to muddy bottom (Figure 2). Hence the patchiness, although the meadow is connected the extend of the meadow between Formicula and the shoals was not considered for the final map and A.3.

Figure 2: The typology of the meadows below 35m depth between Formicula and Formicula's shoals. In this picture this P. oceanica patch has plagiotropic rhizomes.

A.2. Ichthyofauna biomass, biodiversity, and health assessment

This action includes the documentation of the local biodiversity, the estimation of ichthyofaunal biomass and the health assessment of the meadows using non-invasive techniques. For this action, six dives were conducted: five in Formicula and one in Formicula's shoals. All the equipment that was used was ordered and purchased

(slades; quadrates; diving equipment) the week before the fieldwork. The samplings were conducted on 28/04/2022 - 31/04/2022 and 28/09/2022 - 03/10/2022.

A.2.1 Ichthyofauna biomass

For this action iSea used a visual census technique documenting the ichthyofauna (species/no of individuals/average size (TL)), while swimming in 25m transects in different bathymetric contours on top of the meadows, based on a on a variation of the visual census method of Harmelin-Vivien et al. (1985). In total, 4 transects were conducted in the first sampling visit and 9 transects were conducted in the second sampling visit. The abundance of species, the average depth, and the estimated biomass for each transect are presented in Table 2 for each visit. In the first visit 12 fish species were recorded in total of which 7 are recognized as commercial. Overall, the fish fauna hosted in the meadows is significant in terms of abundance and biomass, however seasonality plays an important role, and this is evident as during the second field visit in October 2022, a total of 23 fish species were recorded of which 1 is not indigenous; the Dusky spinefoot, *Siganus luridus* and 10 were recognized as commercial. The biomass was estimated for every individual observation per species per transect using. The length-weight equation $W = a L^b$ was used to estimate the relationship between the Weight (g) of the fish and its total Length (cm). Parameters "a" and "b" were obtained from published bibliography for each species using the online database Fishbase (Version 6/2022).

Table 2: Summary of the biomass surveys conducted in Formicula. Transect code; Average Depth (m), number of unique species and their estimated biomass (g) is noted.

Transects	Date	Average depth (m)	Number of Species	Estimated Biomass (g) per transect
T1	28/04/2022	5	4	74.69
T2	28/04/2022	10	4	15.90
T3	29/04/2022	15	4	59.46
T4	29/04/2022	20	4	157.53
T1	01/10/2022		7	5,730.28
T2		25	11	9,117.10
T3			8	1,362.90
T1			5	920.73
T2	03/10/2022	10	6	406.91
T3			8	2,177.07
T1			9	294.46
T2	03/10/2022	5	5	124.66
T3			8	370.76
Total				**41,323.21**

The biomass and density were estimated for each sampling and were extrapolated to the mapped meadows area coverage using the bootstrap method while their level of confidence was also estimated. Seasonality plays an important role as can be seen in Figure 3 where S1(First sampling) is far less than S2(Second sampling) both in terms of ichthyofaunal density (A)) and (B)) biomass.

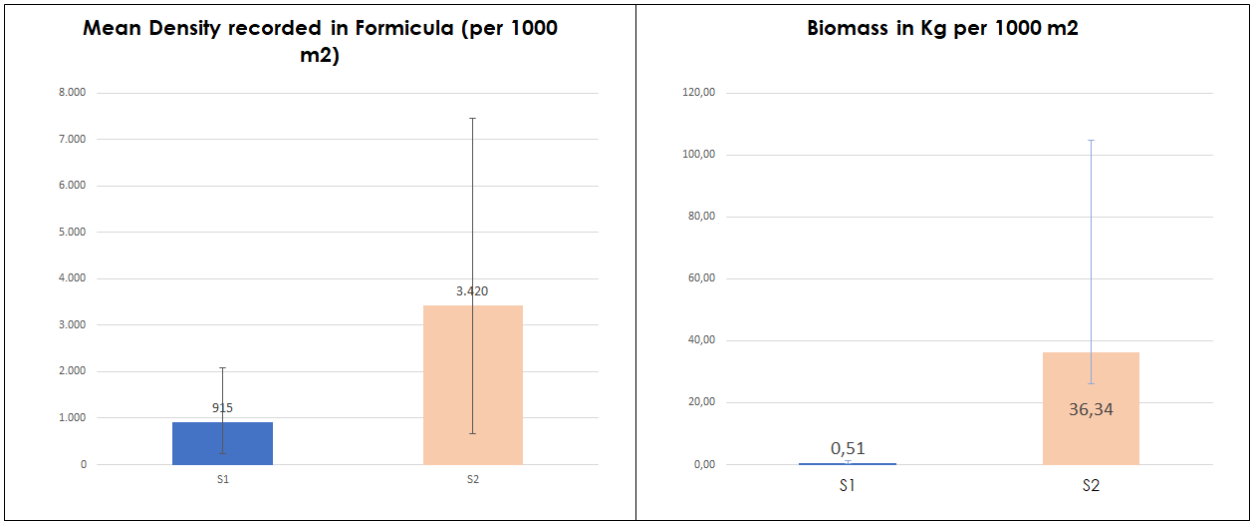


Figure 3: Comparison of the mean density and biomass per 1000 m² in two samplings in Formicula where S1(First sampling) is far less than S2(Second sampling) both in terms of ichthyofaunal density (A)) and (B)) biomass.

A.2.2 Biodiversity

During the surveys apart from fish, other species were recorded as well such as marine phanerogams (other than Posidonia), sea algae, sponges, echinoderms, mollusks, and mammals. The species were visually identified to the lower taxonomic level possible during fieldwork or by collaborating experts with pictures. Not Indigenous species of fish were recorded out of the transects as well and it's worth mentioning the recording of two individuals of the invasive lionfish and a school of spinefoot in the second visit. In total 80 different organisms were recorded and identified belonging in 20 different taxa of which 72 were identified in a species level. It is worth mentioning that the diversity in the class of Actinopterygii is biased because more effort was put into recording them due to ichthyofaunal biomass sampling. A table with the species recorded in Formicula is available in table 1, Annex 1.

A.2.3 Health Assessment

For the heath assessment iSea used a non-invasive technique of visual observations which includes i) calculating the shoot density with quadrates in different bathymetric contours and ii) recording the seagrass cover (sand, seagrass, matte morte) in 25m transects of the same bathymetric contours with one-meter intervals. The data collected were used for the estimation of Conservation Index (CI) (Moreno et al., 2001). The shoot density was obtained from one dive. A total of 15 quadrates were obtained in the depths of 10m, 15m and 25m. Table 4, provides the overview of the results on shoot density analysis linked with the health status associated with the meadows in each depth.

Table 4. The shoot density data per depth, the standard deviation (Std%) and the interpretation of the values into ecosystem status.

Depth	Average Shoot density per m^2	Std%	Status
10	175	28.57	Bad
15	170	25.3	Poor
25	180	26.93	Moderate

The meadow's upper limit was in 6m while the deep limit continued well below 35m with a progressive typology (Pergent et al., 1995) indicating that the water clarity is sufficient to allow the meadow to extend in the deep limits while it is important to note that in depths below 35m the meadows were patchier mostly with plagiotropic rhizomes. The CI for Formicula was estimated at 0.98, which classifies it in the "maximum state of conservation" or in the "very good state" category, indicating that the meadow does not suffer from fragmentation due to uncontrolled frequent anchorage or other human induced pressures at least in the depths below 10m. The shoot density analysis shows on the other hand that the meadow is a receiver of pressures from the wider marine system linked with eutrophication and other factors that cause the meadow to show a sparse shoot density behavior. It is worth noting that the team recorded disturbances linked with uncontrolled anchorage in depths less than 10m which is mostly attributed to recreational vessels anchors. More specifically, the team recorded numerous anchor tracks around the main bay of Formicula (Figure 4) while in deeper waters the meadows were undisturbed for the most part. However, in all the deep dives from the first and the second visit, the divers recorded abandoned fishing gears with a variety of nets and lines (Figure 6). The locations of the gears were recorded for future restoration actions.

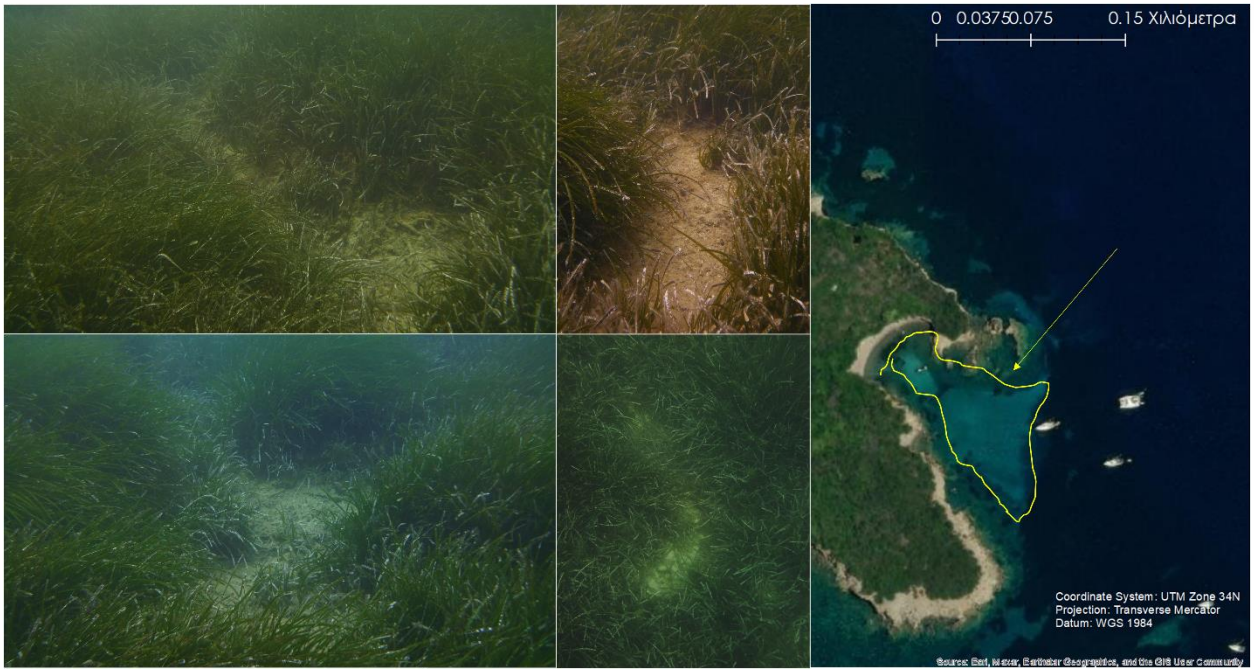


Figure 4. Anchor tracks in the main bay of Formicula island in the area indicated in yellow.

Figure 5: Abandoned fishing nets recorded over a rock surrounded by Posidonia meadows.

A.3. Estimation of the blue carbon stock of the meadows

A total of 4 core samples were extracted by iSea divers from within the study area using PVC handcrafted corers. The 4 corers had a length of 60cm and were driven into the sediment between the shoots using a sledgehammer. After each corer reached the maximum possible depth into the soil, the divers extracted the corer and secured the sample with a lid. The corers were taken from different depths (i.e., 6m, 20m, 25m, 30m). The height of the soil inside the corer was recorded to account for compression. The corers were kept in a dark and cool environment until they were refrigerated, in order to avoid decomposition. To prepare the samples for the analysis, the cores were subsampled and homogenized, then they were dried in an oven at 60°C, until a constant weight was reached. After 24 hours, samples were removed from the oven and kept in a room with low humidity to cool prior to weighing them. At first, iSea chose to utilise the Walkley-Black chromic acid wet oxidation method, however because the results were conflicting with the published bibliography, iSea chose to utilise another methodology which is also proposed by several blue carbon protocols and is within the budget limitations in the scope of this project. The methodology used is called Loss of Ignition (LOI)is one of the methods preferred for Carbon analysis in sedimentary organic matter after the Elemental Analyzer (Monier et al., 2022, Lavery et al., 2013). The analysis was performed by an external laboratory and the Total Organic Carbon (TOC) was calculated as a factor of the loss of ignition (LOI) (table 3).

Table 3: The total organic carbon estimated from each corer obtained, accompanied with extraction depth the sample length in each corer.

Core ID	Core length (cm)	Depth of extraction (m)	Total Organic Carbon (g/100g)	Total Organic Carbon in MgC/ha
FOR1	4	30	22.0	38.82
FOR2	20	25	17.9	32.28
FOR3	16	20	21.0	37.56
FOR4	30	6	29.3	50.87

The total blue carbon sequestered in *P. oceanica* meadows mapped in Formicula was estimated by extrapolating the mean value for all samples to the total coverage of the meadow resulting in 2,512.63 MgC. This value is the first estimate for Blue Carbon in the Inner Ionian Archipelago.

A.4. Stakeholders' involvement

This action foresees a round Table meeting discussion with all the key stakeholders of the area. During the field visit, iSea met with local stakeholders of the area (i.e., fishers and diving centers) and informed them about the project. Further mapping from neighboring areas was conducted to ensure maximum participation of different stakeholders. Specifically, iSea met with the mayor of Lefkada, who was happy to actively contribute to the project by facilitating the place for the round Table meeting and participating to the management actions. The workshop was set to be conducted on 29 September 2022 along with an event of Tethys Research Institute; namely "Supporting the Conservation of Endangered Marine Mammals in the Special Conservation Zone of the Inner Ionian Archipelago", to amplify the impact of both projects. More than 30 fishers were invited personally and by the local associations of Lefkada, Palairos, Meganisi and Astakos while only 5 attended; however, the competent fisheries bureau of Lefkada was present. The management unit of National Park of Zakynthos was also represented other NGOs were present namely, WWF Hellas, Kosamare, Blue Marine Foundation and Tethys who were co-hosting the event. Relevant tourism businesses were also invited and attended both including sailing and boat rental companies and diving centers. Finally, the event was conducted under the auspices of the Municipality of Lefkada, and the mayor was present along with the department of environment. In total the participation yielded to 25 individuals.

A.5. Management actions

This action foresees the drafting of a report that will encompass all the results of the research efforts conducted in the area. iSea seized the opportunity of a scheduled meeting with the vice-minister of Environment, Mr. Amyras and included in the agenda the topic of Formicula. The meeting was postponed initially but it was rescheduled and conducted for the 19th of May 2022. Formicula's case was discussed, and the vice-minister committed that he would contact the company that up took the SES for the Natura2000 site, for the inclusion of our proposed management measures in the SES. iSea, in collaboration with the Tethys Research Institute, the municipality of Lefkada and the Blue Marine Foundation agreed to draft a document with the proposed management measures for Formicula. The document was sent to the Ministry of Environment on the 8th of June and iSea is in close communication with them for the next steps ahead and during October they confirmed that the proposed management measures were included in the SES and iSea also got in contact with the company for clarifications on the layer of the mapped meadows. Also, as the SES for the Ionian Sea is in public consultation iSea has added comments concerning the actions and measures for Formicula, Atokos and Arkoudi which were submitted and co-singed by Tethys Research Institute, Ionian Environment foundation and Blue Marine Foundation.

Finally, the SDF of the Natura2000 site for Inner Ionian Archipelago was updated and will be sent along with a report to NECCA.

Progress report on Nisyros, Gyali and surrounding islands

Description of the area

The second area identified by iSea is the natura2000 site: Notia Nisyros kai Strongyli, Ifaistiko Pedio kai Paraktia Thalassia Zoni (GR4210007). The site is located in the southern Aegean Sea, and it includes the islands of Nisyros, Gyali, Stroggili, Pachia and Pergoussa. The total area of the site is 3,4430.7 ha. The area has a unique geological history, as two active volcanos exist in Nisyros and Stroggili islands (Map 3). According to the Natura2000 SDF, Posidonia beds cover 2,070 ha, accounting for 11% of the total area. The site used to be smaller in coverage, when first registered to the Natura2000 network in 1995, only including Nisyros and Strongyli. It has since been expanded through network updates, due to the unique habitat and species it contains. The marine species of interest reported are the green turtle *Chelonia mydas*, and the Mediterranean Fan Mussel, *Pinna nobilis*. The presence of marine turtles in the Dodecanese region is confirmed in existing literature, with reports on *Caretta caretta* and *Chelonia mydas* (Cattaneo, 2020). Furthermore, the general region is also included in the Important Marine Mammal Areas (IMMAs). Additionally, the area is proposed to be included in the Unesco Global Geoparks Network including the whole Natura2000 site and the small island of Kandelioussa, excluding Gyali due to the mining activities.

Finally, iSea through an ongoing project in Kos Island, has confirmed the presence of critically endangered rays (i.e., *Aetomylaeus bovinus, Gymnura altavela*) and more rarely the two species of Guitarfish while the area has recent records of angel sharks *Squatina spp*.. Nisyros is not among the most popular destination for tourists in the Dodecanese, with few hotels and two boat rental services. Yet it is a popular destination for daily cruises from Kos and the island is visited by Charters. Other anthropogenic pressures exist in the area with two mines operating in the island of Gyali one for perlite and one for pumice stone. A volcanic eruption took place approximately 10,000 years ago and creating one of the largest pumice deposits in Greece. Today according to the mining company mining in Gyali yields 1,000,000 tons of pumice annually. It is worth mentioning that the island belongs in "landscapes of special natural beauty," yet there are concerns on the rate of mining on the island. The impact of these activities on *P. oceanica* meadows has not been assessed, and no mapping effort has been reported for the island of Gyali. It is worth mentioning that no pressures associated with mining are reported in the SDF about the site. Finally, although in the island of Nisyros there is one professional fisher left, the whole island complex is an important fishing ground for the fishers of the Dodecanese islands, especially for Rhodes and Kos.

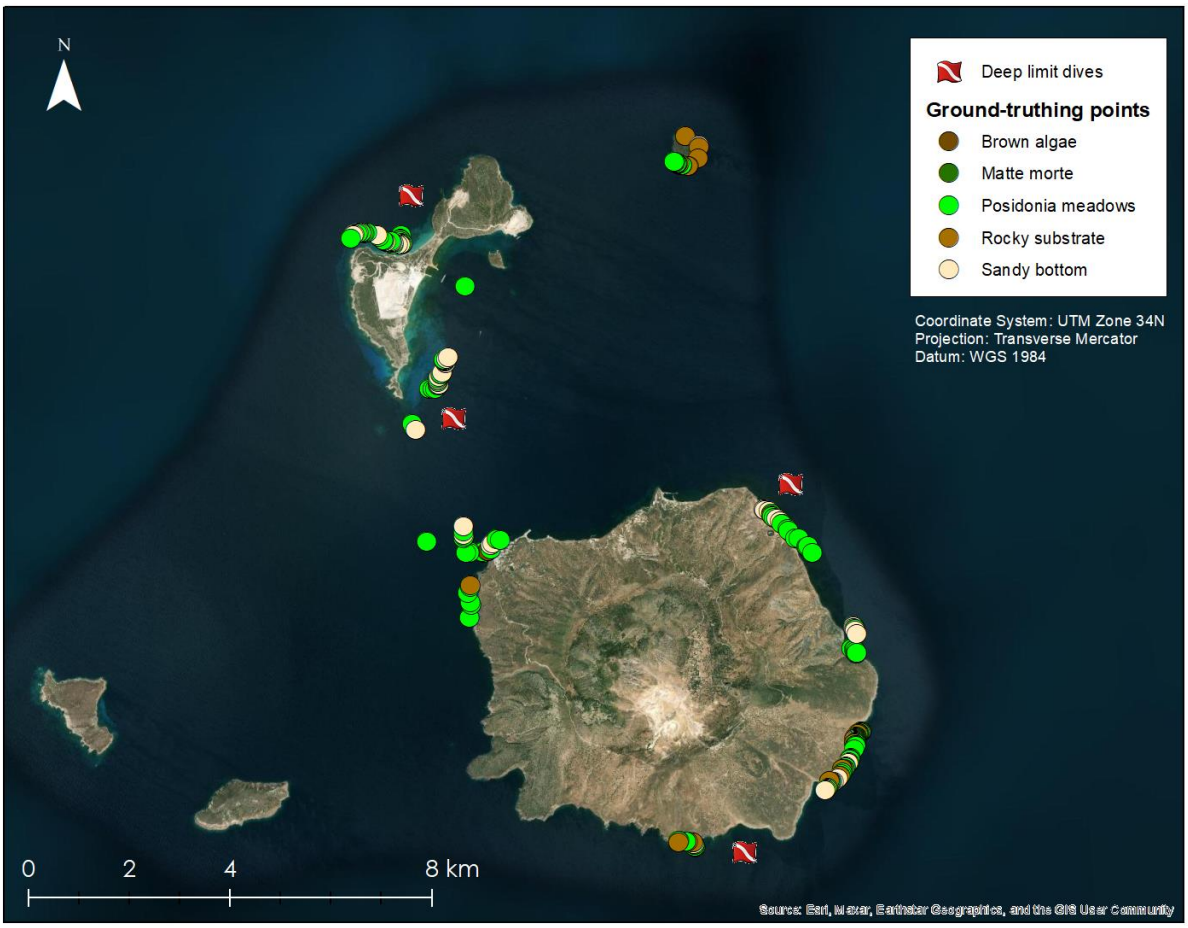
Activities progress

A.1. Mapping of the meadows

The mapping was conducted via analysing high-resolution satellite imagery to effectively cover the Natura2000 designated site in a cost-effective and accurate way. This action foreseen 5 dives for the collection of ground truthing points and definition of its deep margin. More specifically, 3 dives in Nisyros and 2 dives in Gyali. The project team scheduled the fieldwork in early May. More specifically, the fieldwork lasted from 08/05/2022 to 13/05/2022. In total, 212 ground- truthing points were collected, all of which were used as training and validation points in the mapping analysis (Table 6; Map 3). The coordinates for each specific point were listed along with the habitat type observed for each point. A GPS device (Garmin 22x) was used with a minimum accuracy of 3m. The team was careful to record each point, in habitats covering approximately 10 m^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 date taken, the coordinates and the affiliated habitat. The text file then was transformed into a shapefile using ArcGIS (Version 10.4).

Table 6. Ground-truthing points per type of Substrate for Nisyros and Gyali.

Substrate type	N	%
Brown algae	1	0.47%
Matte morte	5	2.36%
Posidonia meadows	119	56.13%
Rocky substrate	25	11.79%
Sandy bottom	62	29.25%
Grand Total	212	100.00%



Map 3. The sampling effort conducted in Nisyros, Gyali and Strongyli island for the ground truthing points and the definition of the deep limits.

To prepare for the mapping and have the results ready for the public consultation, the team requested different options on the available satellite images and their pricing to decide the best option as this is a crucial step in the mapping process. The images were requested by the INFOREST RESEARCH O.C. that can provide previews of satellite images. The team investigated images derived by WorldView3 and Pleiades, as the area of interest due to its size had not had available images that satisfy the quality required (No sun glint, Wave glint etc.). Thus, the team to avoid images from Sentinel II (10m resolution) which cover adequately the area, ordered Planet composites (i.e., images compiled by different images taken in daily basis). Through the available imagery from the archive (full access upon the previous day data), the selection was based on the 8-band data and the cloud cover to be less than 20% within the search area. Further, the filtered imagery was visually inspected prior to order for further analysis. The 8-band Planet Superdove has been used for coastal bathymetry and

habitat mapping with success at various water types (Schill et al., 2021, Poursanidis et al., 2019, Li et al., 2019, Asner et al., 2020). An imagery composed in 17/05/2022 in Top of Atmosphere Reflectance (TOAR) was selected and an atmospheric correction using ACOLITE (Vanhellemont et al., 2018) was performed. For the image classification towards seagrass mapping, a Random Forests Regression-based analysis workflow adapted from Poursanidis et al., 2021using the EnMAP toolbox (Van der Linden et al., 2015, Poursanidis et al., 2019) of QGIS software. For the analysis, a series of image-based training data that are evenly distributed in the area of work was created. A binary scheme has been designed aiming at the separation of the target habitat, here the seagrass meadows, from the other seabed habitats named sandy/soft bottoms, rocky surfaces/reefs, and optically deep waters, where the spectral data that are recorded by the satellite sensor can have both a bottom or mid water origin.

The analysis of the Planet SuperDove imagery for Nisyros using Random Forests classification shows that the spatial distribution of the seagrass meadows is restricted to a thin area at the coastal zone with an exemption in the south part of Gyali island (Map 2). The former occurs due to the steep slopes of the aquatic seascape that shows great depths at short distances from the coastline. By that, meadows are restricted to the zone where the seabed allows them to grow along with the local oceanographic conditions. In Gyali island, at the south part, which is protected by the north Etesian winds, meadows show a different spatial distribution. However, in locations where the depths are deeper than 30 meters were unable to be determined. The overall accuracy of the final product is 76.4%, based on 110 validation points collected during the fieldwork. According to the current work, the meadows cover an area of 578,5 hectares. According to the mapping conducted in this project meadows in Nisyros cover 3.55 km^2, whereas the data deriving from the habitat mapping conducted in 2001 suggest that the meadows cover 4.97 km^2. As mentioned in the proposal of the project there was no formal mapping prior to this study for Gyali, Strogyli and Pergousa showing that *P. oceanica* meadows exist and hence it is an important outcome that Posidonia meadows in cover 1.20 km^2, 0.035 km^2 and 0.56 km^2 accordingly.

Map 1: The final map of Posidonia meadows deriving from the Random Forests algorithm with overall accuracy 76.4%.

A.2. Ichthyofauna biomass, biodiversity, and health assessment

This action includes the documentation of the local biodiversity, the estimation of ichthyofaunal biomass and the health assessment of the meadows using non-invasive techniques. For this action two dives were conducted in Nisyros and three in Gyali. The field work for this action was conducted from 08/05/2022 to 13/05/2022.

A.2.1 Ichthyofauna biomass

For this action iSea used a visual census technique documenting the ichthyofauna (species/no of individuals/average size (TL)), while swimming in 25m transects in different bathymetric contours on top of the meadows, based on a on a variation of the visual census method of Harmelin-Vivien et al. (1985). For Gyali a total of 8 transects were performed, 5 for South Gyali and 3 for North Gyali. The abundance of species, the average depth, and the estimated biomass for each transect are presented in Table 7. In North Gyali, 13 fish species were recorded while in the South of Gyali 11 fish species were recorded.

Table 7. Summary of the biomass surveys conducted in Gyali. Transect code; Average Depth (m), number of unique species and their estimated biomass (g) is noted.

North Gyali			
Transect	**Average depth (m)**	**Number of Species**	**Estimated Biomass (g)**
T1	5	5	8.26
T2	10	7	404.40
T3	15	8	62.43
Total		**20**	**475.09**
South Gyali			
T1	10	3	393.20
T2	15	4	11.51
T3	25	4	21.87
T4	10	6	27.83
T5	5	6	18.93
Total		**23**	**473.35**

For Nisyros 5 transects were performed, 2 in Eastern Nisyros and 3 for Southern Nisyros. The abundance of species, the average depth, and the estimated biomass for each transect are presented in Table 8. In Eastern Nisyros, 9 fish species were recorded while in the Southern Nisyros 12 fish species were recorded. The length-weight equation $W = a\ L^b$ was used to estimate the relationship between the Weight (g) of the fish and its total Length (cm). Parameters "a" and "b" were obtained from published bibliography for each species using the online database Fishbase (Version 6/2022).

Table 8. Summary of the biomass surveys conducted in Nisyros. Transect code; Average Depth (m), number of unique species and their estimated biomass (g) is noted.

East Nisyros			
Transects	**Average depth (m)**	**Number of Species**	**Estimated Biomass (g)**
T1	5	5	20.98
T2	10	6	29.49
Total		**11**	**50.47**
South Nisyros			
T1	5	7	154.96
T2	10	8	222.07
T3	15	7	51.655
Total		**22**	**428.69**

The biomass and density were estimated for each sampling and were extrapolated to the mapped meadows area coverage using the bootstrap method while their level of confidence was also estimated.

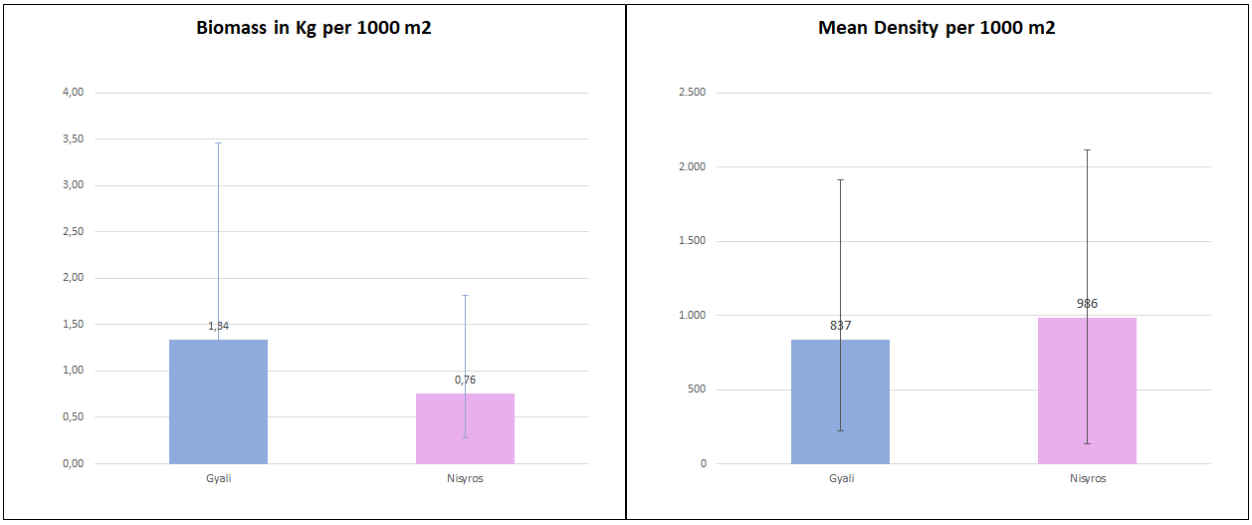


Figure 6.: Comparison of the mean density and biomass per 1000 m² in Nisyros and Gyali.

As shown in Figure 6, the biomass is higher in Gyali due to the larger fishes that were recorded while the mean density is slightly higher in Nisyros sites due to the presence of schools with juvenile fishes. In general, the seasonality plays an important role in such surveys and for more concrete conclusions more surveys need to be conducted.

A.2.2 Biodiversity

During the surveys other species were recorded as well, such as other marine phanerogams and seaweeds, sponges, echinoderms, and mollusks. In total, 47 different organisms were recorded and identified belonging in 13 different taxa of which 43 were identified in a species level. Similarly, to Formicula, the species representing Actinopterygii are not representative as more effort was put in recording them due to the biomass surveys. A Table of the species recorded along with the transect number is provided in Annex 1 Table 2.

A.2.3 Health assessment

For the heath assessment iSea used a non-invasive technique of visual observations which includes i) calculating the shoot density with quadrates in different bathymetric contours and ii) recording the seagrass cover (sand, seagrass, matte morte) in 25m transects of the same bathymetric contours with one-meter intervals. The data collected were used for the estimation of Conservation Index (CI) (Moreno et al., 2001).

The shoot density was obtained from 4 distinct locations in Gyali and Nisyros. Table 9 provides the overview of the shoot density per m^2 and the interpreted habitat status.

Table 9. The shoot density data per depth, the std and the interpretation of the values into ecosystem status.

Area	Depth	Average Shoot density per m^2	Std%	Status
North Gyali	10	270	15.93	Poor
	15	215	21.57	Poor
	25	180	16.20	Moderate
South Gyali	5	365	38.16	Poor
	15	310	16.61	Moderate
	25	215	28.10	Good
East Nisyros	5	330	25.81	Bad
	15	345	12.47	Moderate
South Nisyros	10	280	22.16	Poor
	15	255	19.01	Moderate

As expected from the in-situ observations, North Gyali had poorer meadows density possibly due to the oceanographic conditions in combination with the hydrothermal activity of the seabed. It would be interesting to investigate the effects of the pumice sedimentation to the meadows as the canopies seemed to be covered with a thin layer of pumice and this is expected to effect the plant's ability to photosynthesize. The meadow in the southern sampled area had a shallower upper limit starting at 3m and the meadows were less disrupted by sand patches with the deep limit extending further than 32m with a progressive limit (Pergent et al., 1995), while the meadows in the Northern sampled area started in 7-10m of depth and reached the deep limit in 25-30m with a stable limit (Pergent et al., 1995).

In the East of Nisyros, a total of 10 quadrates were obtained in 5m and 15m of depth as the meadow had a deep limit in ~17m which was succeeded by a *Cymodocea nodosa* meadow that continued to down to 30m of depth. The upper limit for *P. oceanica* was up to 2m deep. The typology of the deep limit was regressive (Pergent et al., 1995). In the south of Nisyros, a total of 10 quadrates were obtained in 10 and 15m of depth as the meadows in this area had a patchier distribution with a maximum depth of 17m and a minimum of 6-7 m. The typology of the deep limit was regressive (Pergent et al., 1995). Table 10, provides the data for the CI index at the selected sites and depths.

Table 10. The CI index as calculated at different locations and depths around Nisyros and Gyali

	North Gyali			South Gyali			East Nisyros		South Nisyros	
	T1 - 10m	T2 - 15m	T3 - 25m	T1 - 5m	T2 - 15m	T3 - 25m	T1 - 5m	T2 - 15m	T1 - 10m	T2 - 15m
CI index	1.00	0.88	0.86	0.95	1.00	1.00	1.00	0.94	0.95	1.00

All sites exhibit a high value in the CI indices classify them in the "maximum state of conservation" or in the "very good state" category. Matte morte occurrence was a rare finding in the diving sites and hence the high CI values. However, the density of the meadow classifies it as of moderate to bad condition. Further investigation is required to unlock the pressures that drive the densities and if these are of the different oceanographic conditions or hydrothermal activities. Finally, it is worth noting, that the divers recorded several litter items in the North of Gyali including tires, bottles and numerous factory plastic bags, however further investigation is needed to determine if these are deriving from the pumice mine or oceanographic conditions concentrate them in North Gyali's bay. Finally, it is worth noting that although the divers did not record evidence of mechanic damage on the meadows such as anchor tracks or ghost gear, they noticed that in East Nisyros dives a damaged underwater cable.

A.3. Estimation of the blue carbon stock of the meadows

Initially, a total of 5 core samples were proposed to be extracted by iSea divers from within the study area using PVC handcrafted corers. Unfortunately, during the fieldwork one corer was dropped in the sea and sank before the team could retrieve it. The 4 corers retrieved were two from Nisyros and two from Gyali. The total length of the corers was 60cm and they were driven into the sediment between the shoots using a sledgehammer. After each corer reached the maximum possible depth into the soil, the divers extracted the corer and secured the sample with a lid. The corers were taken from different depths (i.e., 5m, 10m, 15m). The height of the soil inside the corer was recorded to account for compression. The corers were kept in a dark and cool environment until they were refrigerated, in order to avoid decomposition. At first, iSea chose to utilise the Walkley-Black chromic acid wet oxidation method, however because the results were conflicting with the published bibliography, iSea chose to utilise another methodology which is also proposed by several blue carbon protocols and is within the budget limitations in the scope of this project. The methodology used is called Loss of Ignition (LOI) is one of the methods preferred for Carbon analysis in sedimentary organic matter after the Elemental Analyzer (Monier et al., 2022, Lavery et al., 2013). The analysis was performed by an external laboratory and the Total Organic Carbon (TOC) was calculated as a factor of the loss of ignition (LOI).

Table 4:The total organic carbon estimated from each corer obtained, accompanied with extraction depth the sample length in each corer.

Core ID	Core length (cm)	Depth of extraction (m)	Total Organic Carbon (g/100g)	Total Organic Carbon in MgC/ha
GYA1	20	10	20.3	35.18
GYA2	4	5	28.6	44.25
NIS2	15	10	14.4	61.24
NIS3	3	10	19.7	7.66

The total blue carbon sequestered in *P. oceanica* meadows mapped in Nisyros and Gyali was estimated by extrapolating the mean value for the samples to the total coverage of the meadow resulting in 12,230.90 MgC and 4,772.48 MgC accordingly. These results are preliminary yet is the first indication of the Blue Carbon stock in the area using the most detailed mapping of Posidonia meadows.

A.4. Stakeholders' involvement

This action foreseen a round Table meeting discussion with all the key stakeholders of the area. When visited the islands, iSea tried to meet with as many stakeholders as possible, namely, iSea met with the mayor of Nisyros to present the project, the local fishers (one from Nisyros and president of fishers' association from Kos), the local diving center and finally the port authorities to discuss about the project's aims, and possible threats to the marine environment. iSea began discussions with the mayor of Nisyros during November to organise an online event under the auspices of the municipality. However non available dates were found to fit in the municipality's schedule and iSea until December and it was further postponed for 2023. The event finally took place on the 2nd of June 23, 2023, under the auspices of the Nisyros Geopark, where iSea was invited to present the project and its outcomes. A total of 35 attendants were present during the event including local businesses (diving centers, restaurants, tourist's shops, sailing companies), the Cultural Association of Nisyros "Diavatis", Dr. Evi Nomikou and Dr. Panagiotis Nastos from the National Kapodistrian University who co-presented the Geopark of Nisyros and the municipality of Nisyros with the mayor Dr. Christofis Koronaios who welcomed the event. The attendants were actively participating in the event, asking questions regarding the work presented for Posidonia meadows, the invasive species that were recorded and other queries regarding the marine environment. The results of the project will be shared with Nisyros Geopark to be included in the application that will be resubmitted for the inclusion of Nisyros Georpark in the Unesco Global Geoparks Network in September 2023.

A.5. Management actions

This action foresees the drafting of a report to be sent to the competent ministry including all the project's actions. Additionally, the action foresees sharing the results with NECCA that constitutes the management authority for the Natura2000 site. Finally, the action foresees the participation for the Special Environmental Study for the area by providing advice and ensuring that the benefit of the marine environment is well- preserved, and the feasibility of the proposed actions is met. These actions will take place in the foreseeable future as the SES has yet to be put under public consultation. While, there are other discussions to join the research efforts with the National Kapodistrian University to increase the knowledge regarding the biodiversity and habitats in the complex geomorphology of the marine environment in the area.

Progress report on Northeast Lemnos Island

Description of the area

The last area identified is located in the northeastern part of Lemnos Island namely: Limnos: Chortarolimni - Limni Alyki kai Thalassia periochi (GR4110001). The area extends beyond the island's coastline and well into the north Aegean Sea; namely the Truva Self. The site covers an area of 18,313.57 ha and contains one of the largest cohesive meadows of *Posidonia oceanica* in Greece (Topouzelis et al., 2018). The area attributed to habitat 1120 within the protected area is 11,792.24 ha. Previous mapping efforts in the general area indicate that the meadows expand outside the protected area surrounding the whole island and cover more than, 25000 ha (Traganos et al, 2018). Unique features of the site's coastal area are the presence of various sand dune habitats and three salt pans, one of which "Aliki" is the largest natural salt pan of Greece. The list of marine species of interest contained in the database is rather extensive compared to the rest of the areas. Specifically, 19 species are recorded in the region, however the area is estimated to have a higher biodiversity. Another unique aspect of this particular site is that tourism development and traffic in Limnos is rather limited, although has increased in the past few years. Only two boat rental businesses are located in the entire island, locale economy is more dependent on primary primary section in which fishing is an important source of income, with 220 professional fishing vessels being active (EU, fisheries database). The island is also a well-known location for recreational fishing activities, such as surf casting and spear fishing with fishing rallies organised regularly. Although more research has been conducted on this meadow there has not been any attempt to assess the blue carbon stock in it, considering it might be the greatest marine carbon sink of Greece. In contrast with the other areas, this site has no major threats as middle scale fisheries (vessels >17 meters) are not using the area of interest as a fishing ground, with almost "zero" fishing effort documented for the past ten years according to Global Fishing Watch. In this extended coastline, there is only a small port "Marina of Plaka" hosting ~40 small scale fishing boats who fish inside and outside the Natura2000 designated area however the pressure from small scale fisheries is not quantifiable as there is no such data available. The most significant potential threat for the meadow is the plans for an "Offshore Wind Farm of Electricity Production" with a total capacity 498.15 MW which is planned to be placed at the northern borders of the Natura2000 site. According to RAE the permit for the production on the site was issued, however in November 2022, the permit was withdrawn. There were 7 more applications for windmills both northern and southern of the Natura2000 site. Finally, after discussions with the local fishers illegal fishing could be taking place to the eastern most part of the Natura2000 site, yet this is hard to be confirmed, due to the remoteness of the area and lack of monitoring.

Activities progress

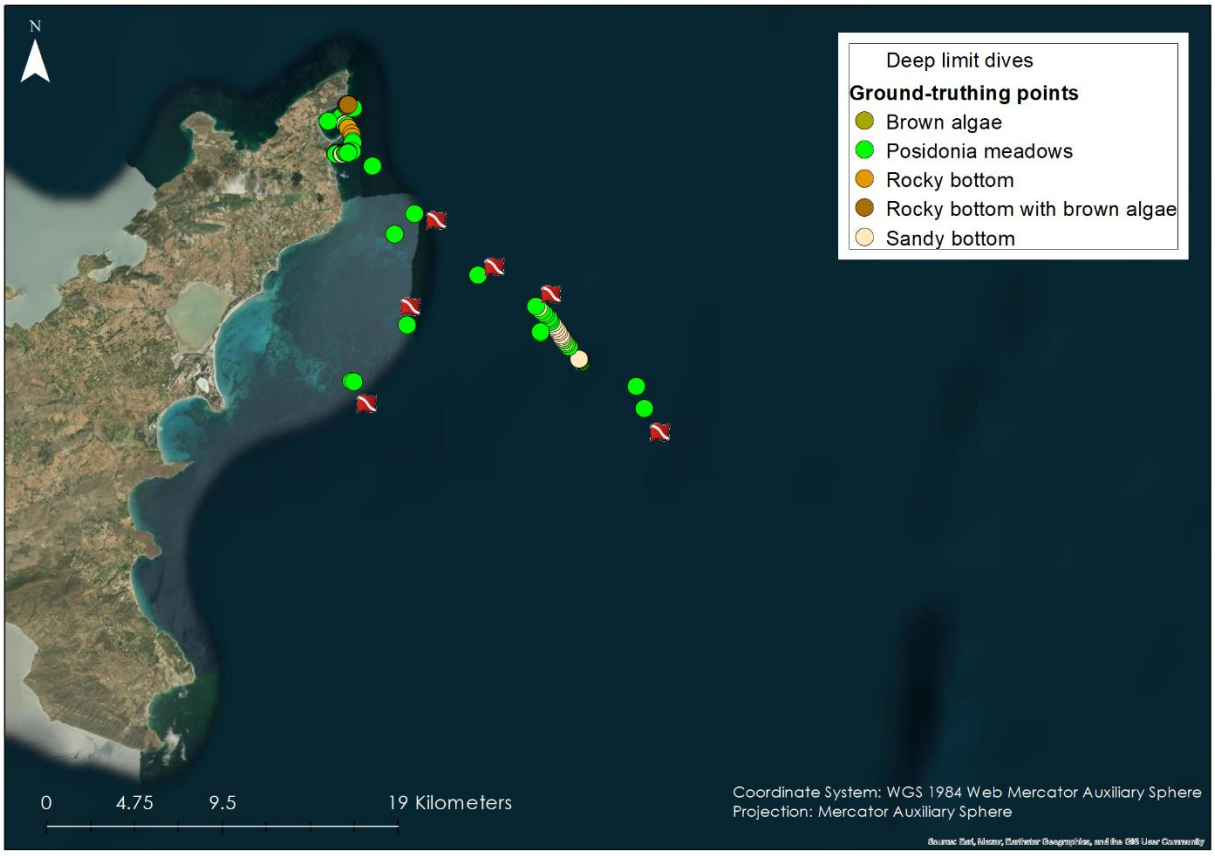
A.1. Mapping of the meadows

According to the methodology proposed, the mapping was conducted via analysing high-resolution satellite imagery to effectively cover a broader range than the Natura2000 designated site in a cost-effective and accurate way. This action foreseen 10 dives in the meadow for the collection of ground truthing points and definition of its deep margin. To prepare for the mapping and have the results ready for the consultation, the team requested different options on the available satellite images and their pricing to decide the best option as this is a crucial step in the mapping process. The images were requested by the INFOREST RESEARCH O.C. that can provide previews of satellite images. The team investigated images deriving by WorldView3, Pleiades and GAOFEN-1 as the area of interest due to its size had not had available images that satisfy the quality required (No sun glint, Wave glint etc.). Thus, the team to avoid images from Sentinel II (10m resolution) which cover adequately the area, ordered Planet composites (i.e., images compiled by different images taken in daily basis). These images have 3m resolution and are multispectral.

The fieldwork was conducted from 02/08/2022 to 08/08/2022. In total, 83 ground- truthing points were collected, along with observation data from deeper parts of the meadows. All data collected were used as training and validation points in the mapping analysis (Table 5; Map 4). The coordinates for each specific point were listed along with the habitat type observed for each point and the depth. A GPS device (Garmin 22x) was used with a minimum accuracy of 3m. The team was careful to record each point, in habitats covering approximately 10 m2 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 date taken, the coordinates and the affiliated habitat. The text file then was transformed into a shapefile using ArcGIS (Version 10.4).

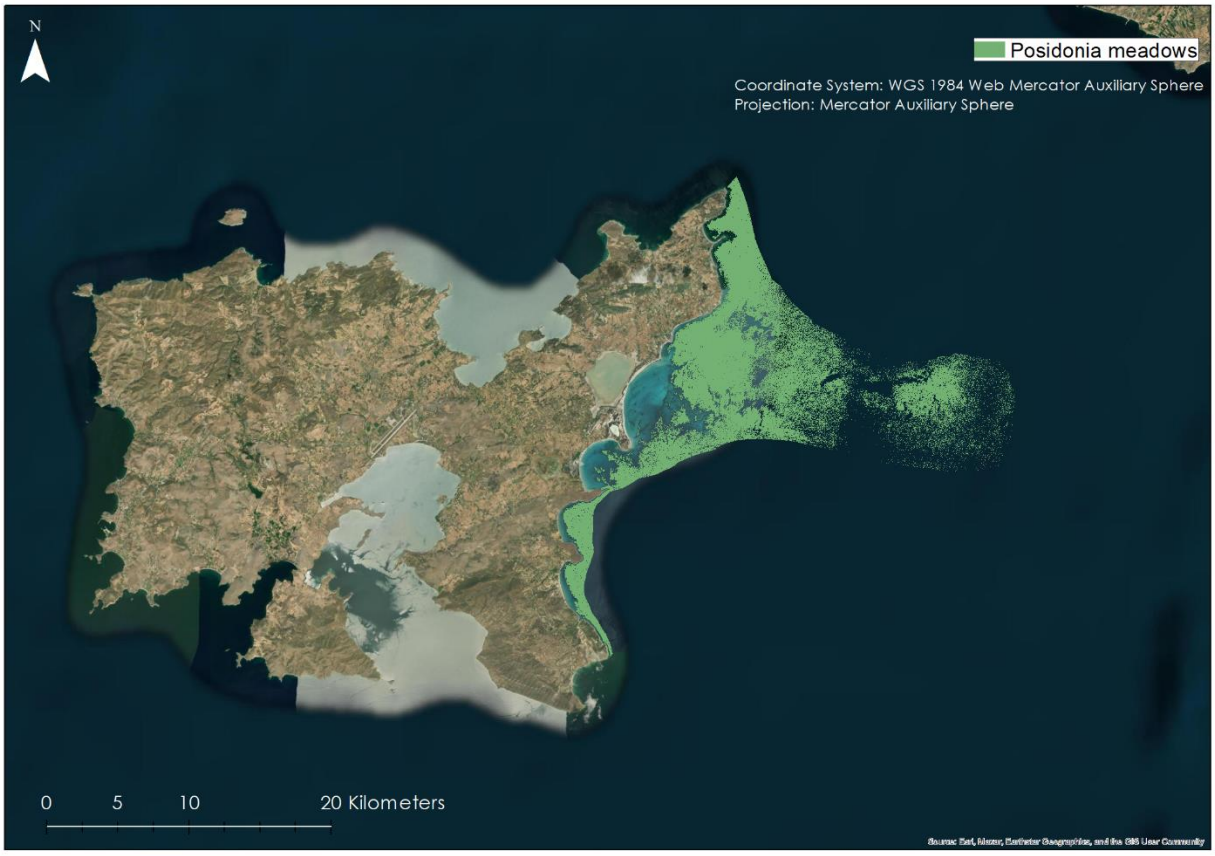
Table 5. Ground-truthing points per type of Substrate for Lemnos

Substrate type	N	%
Brown algae	2	2.40%
Posidonia meadows	51	61.45%
Rocky bottom	4	4.82%
Rocky bottom with brown algae	8	9.64%
Sandy bottom	18	21.69%
Grand Total	83	100.00%



Map 2. The sampling effort conducted in Lemnos Island for the ground truthing points and the definition of the deep limits.

The imagery used for the study area was based on the 8-band data with the cloud cover less than 20%. Further, the filtered imagery was visually inspected prior to order for further analysis. Similar to Nisyros, the 8-band Planet Superdove Top of Atmosphere Reflectance (TOAR) was selected. Then an atmospheric correction using ACOLITE (Vanhellemont et al., 2018) was performed. For the image classification towards seagrass mapping, a Random Forests Regression-based analysis workflow adapted from Poursanidis et al., 2021 using the EnMAP toolbox (Van der Linden et al., 2015, Poursanidis et al., 2019) of QGIS software was performed. For the analysis, a series of image-based training data that are evenly distributed in the area of work were created. A binary scheme has been designed aiming at the separation of the target habitat from the other seabed habitats named sandy/soft bottoms, rocky surfaces/reefs, and optically deep waters, where the spectral data that are recorded by the satellite sensor can have both a bottom and mid water origin.



Map 3.: The final map of Posidonia meadows deriving from the Random Forests algorithm with overall accuracy 86%.

The meadows cover larger areas than the designed Natura 2000 area, showing a continuous meadow, shaped over ancient ruins, and other geomorphological features (Map 4). The meadow is the largest continuous in the East Mediterranean Sea, in a distance that reach almost 20km far from the coastline. In the middle of the area, a valley exists that reaches depths down to 30 meters; it is shaped by the bottom currents and the hydrodynamics of the wider area. Challenges to map accurate such depths exist and there is low confidence for that area. The overall accuracy of the final product is 86%, based on 51 of the 83 validation points collected during the fieldwork. According to the current work, the meadow covers an almost continuous area of 67.35 Km^2 inside the Natura2000 site while the total area was estimated to cover 83.72 km^2. As this site is of particular interest in terms of the extend of the *Posidonia oceanica* meadow further analysis was performed to compare the current mapping effort to the previously conducted namely; Natura2000; Topouzelis et al., 2018; Traganos et al., 2018 and Panayotidis et al., 2022. The results of the analysis highlight the variance of the results due to the different methodologies and their "weaknesses", the need for standardization of a spatial scale for Posidonia meadows mapping and ultimately the need for collaboration among different entities to bring out the most of research to the service of conservation. The comparative analysis will be published in a peer reviewed journal.

A.2. Ichthyofauna biomass, biodiversity, and health assessment

This action includes the documentation of the local biodiversity, the estimation of ichthyofaunal biomass and the health assessment of the meadows using non-invasive techniques. For this action 14 dives were conducted in Lemnos. The field work for this action was conducted from 02/08/2022 to 08/08/2022.

A.2.1 Ichthyofauna biomass

For this action iSea used a visual census technique documenting the ichthyofauna (species/no of individuals/average size (TL)), while swimming in 25m transects in different bathymetric contours on top of the meadows.

Table 7. Summary of the biomass surveys conducted in Formicula. Transect code; Average Depth (m), number of unique species and their estimated biomass (g) is noted.

Transect	Average depth (m)	Number of Species	Estimated Biomass (g) per transect
L1_D 10m T2	10	15	9,970.14
L1_D 21m T1	21	11	18,440.93
L1_D 5m T3	5	13	320,324.45
L2_D 10m T2	10	19	141,326.55
L2_D 26m T1	26	8	47,298.26
L2_D 5m T3	5	25	36,950.90
L3_D 10m T1	10	18	38,573.39
L4_D 5m T2	5	17	107,792.00
L5_D 10m T2	10	16	12,850.26
L5_D 5m T1	5	19	16,892.58
L6_D 20m T1	20	9	4,070.89
L7_D 10m T1	10	27	33,462.35
L7_D 5m T1	5	27	66,033.81
L8_D 20 T1	20	16	5,063.78
L9_D 20 T1	20	16	7,770.97
Grand Total			**866,821.27**

The sampling methodology was based on a on a variation of the visual census method of Harmelin-Vivien et al. (1985). A total of 15 transects were performed. The abundance

of species, the average depth, and the estimated biomass for each transect are presented in Table 7. In total, 31 fish species were recorded. The biomass values for Lemnos were notably the highest recorded in comparison to the other sites along with the number of different species in one sampling unit and overall, as a site (Table 7). The biomass and mean density were estimated for the transects and were extrapolated to the mapped meadows area coverage using the bootstrap method while their level of confidence was also estimated. As expected, the values are considerably higher than all the other sites and whilst seasonality again is expected to have played a significant role; the values difference is astonishing.

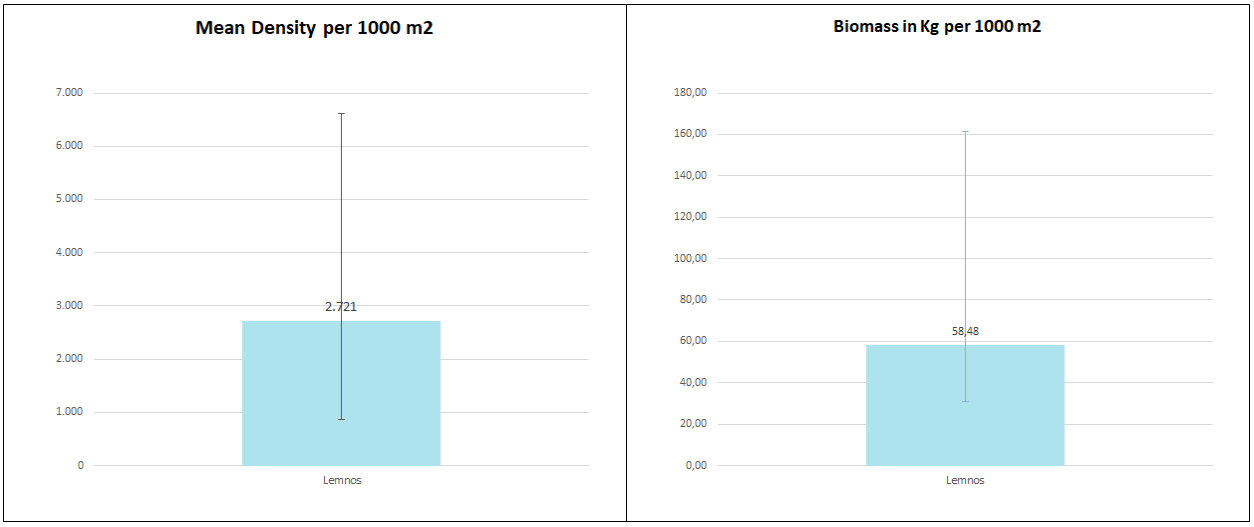


Figure 7: of the mean density and biomass per 1000 m² in Lemnos

A.2.2 Biodiversity

During the surveys, apart from fish, other species were recorded as well such as marine phanerogams (other than Posidonia), sea algae, sponges, echinoderms, and mollusks. In total, a list of 59 species were recorded, belonging to 13 genera. A Table of the species recorded along with the transect number is provided in Annex 1 Table 3.

A.2.3 Health assessment

For the heath assessment iSea used a non-invasive technique of visual observations which includes calculating the shoot density with quadrates in different bathymetric contours. Five measurements were obtained from each bathymetric contour from distinct stations comprising a total of 95 quadrates. Table 13 provides the overview of the shoot density per m² and the interpreted habitat status from each station and each bathymetric contour.

Table 13. The shoot density data per depth, the std and the interpretation of the values into ecosystem status.

Area	Depth (m)	Average Shoot density per m^2	Std%	Status
Station 1	5	290	22.21	Bad
	10	400	7.91	Moderate
	20	280	17.31	Good
Station 3	10	275	35.44	Poor
	20	190	22.94	Moderate
Station 4	5	555	14.91	Moderate
	10	515	9.00	Good
	20	300	9.13	Good
Station 6	10	585	7.45	Good
	20	255	13.01	Moderate
Station 7	5	465	24.19	Poor
	10	595	8.15	Good
	26	190	21.38	Moderate
Station 8	5	585	12.27	Moderate
	10	520	10.27	Good
	20	170	36.50	Poor
Station 12	5	320	16.73	Bad
	10	315	29.53	Poor
	21	250	27.69	Moderate

It is worth mentioning that the meadow exhibited the longest leaves in depths between 4 – 15 m reaching up to 1.2m in length and although the meadows exhibited more patchy distribution in some areas the meadows it could be attributed to the bottom morphology as the substrate was rocky in many different stations. In the case of Lemnos Conservation Index (CI) was not calculated as the fieldwork should have been organized better to accommodate the needs for such a large area. Nevertheless, these preliminary observations indicate that the meadows are flourishing in comparison to the other sites and more efforts to apply multiple indices will be conducted in the future provided the continuation of the project, while the sampling strategy will be more focused in areas that previous efforts were made in the past to facilitate comparisons.

A.3. Estimation of the blue carbon stock of the meadows

This action foreseen the estimation of the total Blue Carbon stock sequestered inside the meadow of Northeastern Lemnos. More specifically, the action foreseen the sampling and the analysis of at least 10 core sediment samples to be obtained from the meadow

randomly distributed. The carbon stock would be estimated and upscaled to the meadows' extent. The consumables for crafting the corers were purchased prior to the sampling. The sampling was conducted during early August similarly with the other actions. A total of 17 corers were sampled in several depths. The analysis for the estimation of total organic carbon (TOC) was performed by the external laboratory QLab. The method applied for the estimation of carbon was loss on ignition (LOI) the TOC was calculated as a factor of LOI. LOI is one of the methods preferred for Carbon analysis in sedimentary organic matter after the Elemental Analyzer (Monier et al., 2022, Lavery et al., 2013). The results are presented in table 14.

Table 14. The total organic carbon estimated from each corer obtained, accompanied with extraction depth the sample length in each corer.

Core ID	Core length (cm)	Depth of extraction (m)	Total Organic Carbon (g/100g)	Total Organic Carbon in MgC/ha
LEM4_0908_5m	21	5	16.7	57.59
LEM3_0208_10m	15	10.2	14	23.68
LEM1_0208_20m	7	20	19.3	23.75
LEM2_0208_22m	13	22	28.9	53.75
LEM7_0308_17m	6	17	19.4	19.23
LEM8_0308_21m	4	21	24.9	9.99
LEM6_0408_8m	26	8	16.2	66.43
LEM12_0408_10m	16	10	14.1	35.04
LEM12_0408_21m	15	21	18.7	36.90
LEM7_0508_6m	19	6	12.8	29.38
LEM7_0508_10m	20	10	10.5	36.78
LEM7_0508_26m	20	26	17.1	41.50
LEM1_0608_5m	7	5	16.6	25.65
LEM1_0608_10m	12	10	18.3	26.09
LEM4_0708_10m	13	10	11.8	20.35
LEM8_0708_10m	14	10	16	20.20
LEM8_0908_5m	12	5	20.6	31.83

The total blue carbon sequestered in *P. oceanica* meadows mapped in Northeastern Lemnos was estimated by extrapolating the mean value for the samples to the total coverage of the meadow resulting in 274,891.81 MgC. Although these values are preliminary, yet indicate the importance of the ecosystem services provided by the meadows in the area as a Blue Carbon Stock for the Aegean Sea. iSea aims to continue the research efforts and join forces with other research institutes and experts in the field

of Blue Carbon and ecosystem services to enhance the conservation efforts for this precious habitat.

A.4. Stakeholders' involvement

This action has foreseen the conduction of a meeting with all the key stakeholders of the area. To accomplish the maximum participation, iSea conducted a mapping with all relevant stakeholders and held two events to discuss the aims and actions of the project and the importance of seagrass meadow for the local marine environment as well as the actions of the project. The first event was organised under the auspices of the municipality of Myrina on 02/08/2022. The participation was less than anticipated with 12 people among which the majority were fishers, the port authority of Myrina was also represented by an officer, the chair of the community of Plaka, the president of the local fisher's association as well as a journalist representing LimnosXpress. After discussing the different threats that the meadow is facing locally, the fishers and the president of the Community of Plaka expressed their concern on the development plans for "Offshore Wind Farm of Electricity Production" just on the borders of the Natura 2000 site. Hence, another workshop was organised on 07/08/2022 in Plaka under the auspices of Plaka's community. More than 40 people attended the event, among which fishers, farmers, educators and other local business owners. The event was welcomed by the president of Plaka's community and president of the professional fishers' association Mr. Christos Tsalikis and Dr. Sotiris Orfanidis from Fisheries Research Institute talked about the importance of Posidonia meadows, the previous mapping efforts in the context of the designation of the Natura2000 site and the threats posed to this habitat. An open discussion followed with attendants posing questions about the project's expected outcomes, the habitat and the possible applications of the results to conservation. Most of the questions and concerns though, were concentrated to the potential threat an offshore windmill farm would pose to the meadows, the fishfauna and the scenery. The presenters also expressed their concern as the extent of the meadows outside the boundaries of the Natura2000 site was unknown. The team has an open communication with the local community following up with the president of the Plaka with the results of the project and discussed continuing working in the area in collaboration with local entities and the fisheries.

A.5. Management actions

This action foresees the drafting of a report to be sent to the competent ministry including all the project's actions and outputs. Additionally, the action foresees sharing the results with NECCA that constitutes the management authority for the Natura2000 site. Finally, the action foresees the participation for the Special Environmental Study for the area by providing advice and ensuring that the benefit of the marine environment is well-preserved, and the feasibility of the proposed actions is met. These actions will be

conducted in the upcoming months as the reports are completed. Specifically, about participating in the SES public consultation, we are in anticipation of it to be published.

Communication of the project

As in all the projects implemented by iSea, communication is a key part, as through it iSea aims to raise awareness among different stakeholder groups and the wide public. For this project, iSea developed a communication plan (attached with the report) for the project in which all the actions are described briefly. More specifically, these include the creation of a page dedicated to the project, communication on Social Media Platforms, in the Mass Media and a video for the project. Upon discussion with the Blue Marine Foundation communication milestones were set as communication goals of the project (Figure 2). During late April, a page was built specifically for this project to refer to the stakeholders involved and the public about the scope, the objectives, the specific regions, the foreseen activities and finally the consortium and the funding of the project. The page was uploaded in English and Greek.

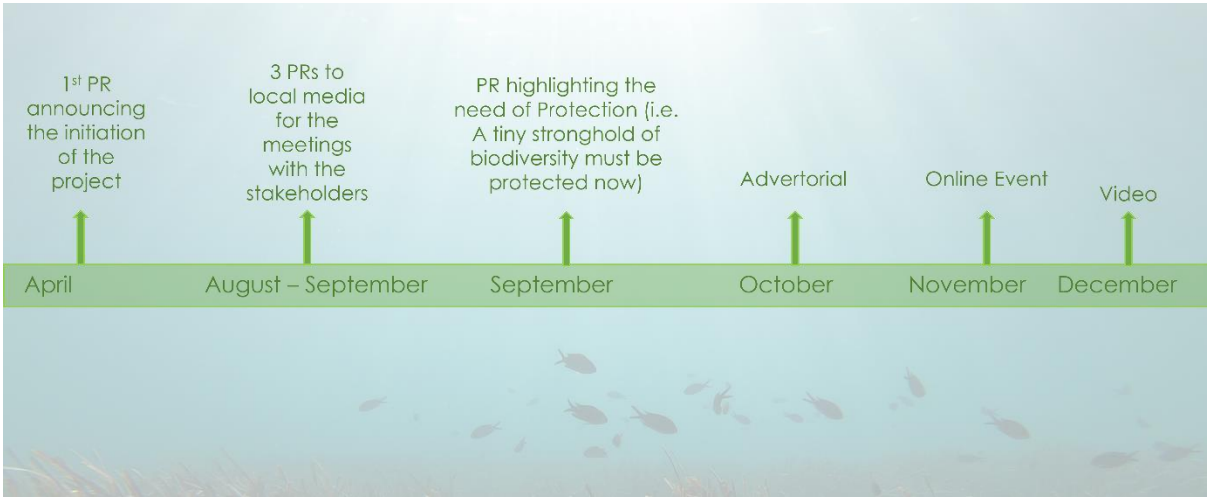


Figure 8. The communication milestones that were set for the project.

Social media

Regarding the communication on the social media to date, 22 posts were made on Facebook and Instagram (7 for Formicula, 2 for Nisyros 3 for Lemnos and 9 general posts on the project), 21 on Twitter (7 for Formicula, 2 for Nisyros 2 for Lemnos and 10 general posts on the project) and 11 on LinkedIn. The maximum reach for Facebook was 23.769 and 1330 on Instagram. The maximum impressions reached for Twitter were 1702, and 927 for LinkedIn. All the post made on social media of iSea are attached to the report along with their reach.

Mass media

For the communication on mass media, 4 Press Releases were foreseen; one for the initiation of the project (national level); three on the announcement of the round Table meetings (local level). Finally, another article on a prestigious mass media which will highlight the importance of a particular area of the project.

To date, a press release "REPOSIDONIA: Protecting the forests of the sea" announcing the initiation of the project and the partnership with the Blue Marine Foundation was sent to Greek media outlets on 28/04/2022. Another press release for the workshop in Lemnos was sent to local media outlets on 04/08/2022. For Nisyros there was no press release as the event took place as a part of the Nisyros Geopark event. Three articles in Mass Media were published regarding the project. The first one was published in Kathimerini after the official reply by Mr. Amyras concerning the proposed management measures for Formicula, as a strategic move to pressure the Ministry of Environment to abide by their written promise. The article "So that we don't see the seals as an attraction, Intervention by four entities to protect the marine mammal" was written by Giorgos Lialios, a

renowned journalist specializing in environmental issues and was published on 14/09/2022. The article narrates why Formicula is an important island and why it is in urgent need of protection, in the article Tethys Research Institute and Monk Seal Alliance participate as speakers along with the Director of iSea. The article was then disseminated through the social media accounts of iSea (see attachments of the report). During early 2023, iSea drafted the comments to be submitted to the public consultation of the SES regarding Formicula, the comments were co-singed by Tethys Research Institute, Ionian Environment Foundation and Blue Marine Foundation. In the meantime, iSea was in communication with other journalists to publish another article concerning Formicula along with the comments to the SES to pressure for a Ministerial Degree regarding the protection of Formicula during the tourism period for 2023. The article was published in "K magazine" by Olga Charami on 17/04/2025 with the title "An Ionian islet full of seals". In the article, the journalist narrates Formicula's importance, threats, and the research efforts by the different entities in the region, while highlighting the joint proposal, submitted to the Ministry of Environment and the management measures that were included in the SES yet identifies the urgent need for a Ministerial Degree. The journalist took an interview also from a fisher who is positive towards the protection of Formicula, which we consider very significant because it encompasses the positive attitude of a key stakeholder group. The article was then disseminated through the social media accounts of iSea in which it received high engagement (see attachments of the report). Finally, regarding the SES, as soon as the comments were submitted, iSea published an article in its webpage with the comments submitted and their highlights. The article was disseminated through the social media network of iSea receiving high engagement and reach(see attachments of the report).

iSea in parallel was working on publishing an advertorial for the project in Northeastern Lemnos, as the meadow there is the largest in extend in Greece and is the perfect example to showcase both the work conducted and the importance of this habitat and the ecosystem services it offers. For the advertorial iSea worked with News247 and a renowned journalist Kostas Koukoumakas while the videos and images were taken by the collaborating photographer and journalist Dimitris Tosidis. The advertorial video was published with the title "Posidonia: The unknown meadow at the bottom of the Aegean" on 09/04/2023. In the video the importance of the largest meadow in the Aegean is outlined and enhanced by the results of this effort. The video currently holds more than 8.9 thousand views on YouTube and similarly to the aforementioned articles was then disseminated to the social media outlets of iSea receiving even higher engagement than the previous articles (indicatively the post on Facebook received >34,000 impressions). Finally, it is worth mentioning that the advertorial caught the attention of the local community in Lemnos, where the video was reposted by the president of the community of Plaka, other researchers working in the area and other pages and websites working in tourism sector. Although the timeline of the foreseen communication plan was not followed strictly, we believe that the communication of the project was fruitful. Giving an

added value to the work conducted and raising awareness for the precious habitat *Posidonia oceanica* forms.

Miscellaneous

Throughout the project, iSea had the opportunity to present the project in various instances with the aim to highlight the importance and its impacts. To date, the project was presented in the Aegean Film Festival under the scope of Echoes Talks on 10/07/2022. While iSea was also invited to present the project in Tunisia in a SPA/RAC event, however due to tight timeline this was impossible.

Financial reporting

The final budget granted for the project sums to 47,500.00 euros. The detailed list of expenses along with the date of expense and the reference no of receipt/invoice are attached with the report. All the receipts and invoices are kept in iSea, and their copies are available to the funder upon request.

References

- Bearzi, M. (2005). Dolphin sympatric ecology. *Marine Biology Research*, 1(3), 165-175.
- Breiman, L. (2001) Random forests. *Machine Learning*, 45, 5–32.
- Cattaneo, A., Cattaneo, C., & Grano, M. (2020). Update on the herpetofauna of the Dodecanese Archipelago (Greece). *Biodiversity Journal*, 11(1), 69-84.
- Harmelin-Vivien M.L., Harmelin J.G., Chauvet C., Duval C., Galzin R., Lejeune P., Barnabe G., Blanc F., and Chevalier R. (1985) The underwater observation of fish communities and fish populations: methods and problem. *Revue d'Ecologie* 40, 467–540.
- Haynes W. (2013) Maximum Likelihood Estimation. In: Dubitzky W., Wolkenhauer O., Cho KH., Yokota H. (eds) *Encyclopedia of Systems Biology*. *Springer*.
- Lavery, P. S., Mateo, M.-Á., Serrano, O., and Rozaimi, M. (2013). Variability in the carbon storage of seagrass habitats and its implications for global estimates of blue carbon ecosystem service. *PLoS ONE* 8:e73748. doi: 10.1371/journal.pone.0073748
- Monnier, B., Pergent, G., Mateo, M.Á ., Clabaut, P., and Pergent-Martini, C. (2022). Quantification of blue carbon stocks associated with Posidonia oceanica seagrass meadows in Corsica (NW Mediterranean). *Science of the Total Environment* 838, 155864. doi: 10.1016/j.scitotenv.2022.155864
- Moreno, D., Aguilera, P. A., & Castro, H. (2001). Assessment of the conservation status of seagrass (*Posidonia oceanica*) meadows: implications for monitoring strategy and the decision-making process. *Biological Conservation*, *102*(3), 325-332.
- Mpougas, E., Waggitt, J. J., Dendrinos, P., Adamantopoulou, S., & Karamanlidis, A. A. (2019). Mediterranean Monk Seal (Monachus monachus) Behavior at Sea and

Interactions with Boat Traffic: Implications for the Conservation of the Species in Greece. *Aquatic Mammals*, *45*(4), 419-424.

- Panou, A., Jacobs, J., & Panos, D. (1993). The endangered Mediterranean monk seal Monachus monachus in the Ionian Sea, Greece. *Biological Conservation*, *64*(2), 129-140.
- Pergent, G., Pergent-Martini, C., & Boudouresque, C.F., (1995), Utilisation de l'herbier a *Posidonia oceanica* comme indicateur biologique de la qualité du milieu littoral en Méditerranée: Etat des connaissances. *Mésogée*, 54, 3-29.
- Pergent, G., Gerakaris, V., Sghaier, Y.R., Zakhama-Sraier, R., Fernández Torquemada, Y., & Pergent-Martini, C. (2016). *Posidonia oceanica* (errata version published in 2018). *The IUCN Red List of Threatened Species 2016: e.T153534A135156882*.
- Traganos, D., Aggarwal, B., Poursanidis, D., Topouzelis, K., Chrysoulakis, N., & Reinartz, P. (2018). Towards global-scale seagrass mapping and monitoring using Sentinel-2 on Google Earth Engine: The case study of the aegean and ionian seas. *Remote Sensing*, 10(8), 12-27.
- Vanhellemont, Q., & Ruddick, K. (2018). Atmospheric correction of metre-scale optical satellite data for inland and coastal water applications. *Remote sensing of environment*, 216, 586-597.
- Vapnik, V. N. (1995). Conclusion: What is Important in Learning Theory? In The Nature of Statistical Learning Theory. *Springer*.
- Walkley, A., and I. A. Black. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.* 37, 29- 38.

Annex I

Table 1. The recorded biodiversity in all the sampling stations in Formicula island. Species indicated with (**) were not included in the biomass estimation as they were observed out of the transect and/or belonged in other taxa whose biomass could not be estimated with the methodology explained in A.2.1

Class	Species	F1_D10m_T2	F1_D15m_T3	F1_D20m_T4	F1_D5m_T1	F2_D25m_T1	F2_D25m_T2	F2_D25m_T3	F3_D10m_T1	F3_D10m_T2	F3_D10m_T3	F3_D5m_T1	F3_D5m_T2	F3_D5m_T3	Presence/ Absence
Actinopterygii	*Blennius sp*														x
	Boops boops		X		X	X	X	X	X		X				
	Centracanthus cirrus		X												
	Centrolabrus melanocercus													X	
	Chromis chromis	X			X	X	X	X	X	X	X	X	X	X	
	Coris julis				X	X	X	X	X	X	X	X	X	X	
	Dentex dentex			X			X								x
	Diplodus annularis		X		X		X	X		X	X	X	X	X	
	Diplodus sargus						X								x
	Diplodus vulgaris			X			X	X				X			
	*Epinephelus aeneus***				X										x
	Epinephelus costae														x
	Gobius sp														x

	Mullus surmuletus					X									
	Labrus merula														x
	Labrus viridis														x
	Oblada melanura											X	X	X	
	Parablenius sp														x
	Pterois miles														x
	Sarda sarda					X									
	Sarpa salpa												X		
	Serranus scriba						X			X	X				
	Siganus luridus											X		X	
	Siganus sp								X		X				
	Sparisoma cretense													X	
	Sparus aurata														x
	Spicara flexuosa			X											
	Spicara maena			X		X		X							
	Spicara smaris	X	X			X	X	X	X		X	X			
	Spondyliosoma cantharus							X				X			
	Symphodus mediterraneus	X													
	Symphodus melanocercus						X			X					
	Symphodus roissali						X								
	Symphodus rostratus										X			X	

	Symphodus tinca	X								X					
	Thalassoma pavo											X			x
	Uranoscopus scabe														x
Mammali	*Monachus monachus*														x
Ulvophyceae	*Codium fragile ssp.*														x
	Codium bursa														x
	Acetabularia acetabulum														x
	Acetabularia mediterranea														x
Phaeophyceae	*Cystoseira sp*														x
	Dictyota sp														x
	Padina pavonica														x
Florideophyceae	*Asparagopsis taxiformis*	-													x
	Asparagopsis armata														x
	Peysonelia sp														x
	Lithophylum sp														x
Anthozo	*Actinia mediterranea*														x
Ascidiac	*Halocynthia papillosa*														x

Demospongiae	*Axinella dacicornis*														x
	Axinella oculata														x
	Axinella polypoides														x
	Axinella cannabina														x
	Axinella verrucosa														x
	Petrosia ficiformis														x
	Sarcotragus spinosulus														x
	Crambe crambe														x
	Chondrilia nucula														x
	Chondrosia reniformis														x
	Aplysina aerophoba														x
Gastropoda	*Charonia variegata*														x
Bivalvia	*Lithophaga lithophaga*														x
	Pinna nobilis														x
	Pinna rudis														x
Cephalop	*Octupus vulgaris*														x

Polychaeta	*Sabella spallanzanii*														x
	Sabella pavonina														x
	Protula intestinum														x
	Hermodice carunculata														x
Gymnolae	*Adeonella calveti*														x
Magnoliop	*Cymodocea nodosa*														x
Scyphozo	*Pelagia noctiluca*														x
Asteroidea	*Echinaster sepositus*														x
	Asterina gibbosa														x
Ophiuroi	*Ophioderma longicauda*														x
Holothuri	*Holothuria foskalii*														x
Echinoid	*Arbacia lixula*														x
Crinoide	*Antedon mediterranea*														x

Table 2. The recorded biodiversity in all the sampling stations in Nisyros and Gyali. Species indicated with (**) were not included in the biomass estimation as they were observed out of the transect and/or belonged in other taxa whose biomass could not be estimated with the methodology explained in A.2.1

Class	Species	G1_D10mT2	G1_D15mT3	G1_D5mT1	G2_D10mT1	G2_D15mT2	G2_D25mT3	G3_D10mT2	G3_D5mT1	N1_D10mT2	N1_D5mT1	N2_D10mT2	N2_D15mT3	N2_D5mT1	Presence/ Absence
Actinopterygii	*Balistes capriscus*														X
	Boops boops			X	X							X	X	X	
	Chromis chromis		X		X	X	X	X	X	X	X	X	X	X	
	Coris julis			X		X	X	X	X		X	X	X	X	
	Diplodus annularis		X	X		X	X		X	X	X				
	Diplodus vulgaris													X	
	Enchelycore anatina													X	
	Epinephelus costae											X			
	Mullus barbatus												X		
	Oblada melanura									X		X	X		

Parupeneus forsskali								X			X	X		
*Pterois miles***											X			
Sarpa salpa														X
Serranus cabrilla	X	X												
Serranus scriba	X	X												
Siganus rivulatus							X			X				
Siganus spp.														
Solea solea									X					
Spicara smaris	X	X	X			X	X	X		X	X	X	X	
Sparisoma cretense	X													X
Spondyliosoma cantharus		X											X	
Symphodus mediterraneus	X				X		X				X			
Symphodus roissali							X							
Symphodus rostratus										X				

	Symphodus tinca	X	X								X				
	Synodus saurus			X	X										
	Torquigener flavimaculosus									X					
Cephalopoda	*Sepia officinalis*		X							X					
	*Loligo vulgaris (eggs) **														X
Chondrichthyes	*Dasyatis pastinaca*		X	X									X		
Holothuroidea	*Holothuria (Panningothuria) forskali **														X
	*Synaptula reciprocans**														X
Demospongiae	*Crambe crambe**														X
	*Petrosia (Petrosia) ficiformis**											X			
	*Sarcotragus spinosulus**										X				

Echinoidea	*Diadema setosum***														X
Gastropoda	*Flabellina affinis***										X				
Gymnolaem	*Electra posidoniae***														X
Hydrozoa	*Antennella sp.***														X
	*Bougainvilliidae***														X
Magnoliopsida	*Halophila stipulacea***		X								X				
	*Cymodocea nodosa***		X								X				
Mammalia	*Delphinus delphis***														X
Phaeophyceae	*Sargassum spp.***	X									X				
	*Cystoseira spp.***														X
Ulvoph	*Acetabularia acetabulum***														X

	*Caulerpa prolifera***														X

Table 3. The recorded biodiversity in all the sampling stations in Lemnos. Species indicated with (**) were not included in the biomass estimation as they were observed out of the transect and/or belonged in other taxa whose biomass could not be estimated with the methodology explained in A.2.

Class	Species	L1_D10mT2	L1_D21mT1	L1_D5mT3	L2_D10mT2	L2_D26mT1	L2_D5mT3	L3_D10mT1	L4_D5mT2	L5_D10mT2	L5_D5mT1	L6_D20mT1	L7_D10mT1	L7_D5mT1	L8_D20T1	L9_D20T1
Actinopterygii	*Atherina hepsetus*	X		X	X		X	X		X	X					
	Boops boops	X	X	X		X		X		X					X	
	Centrolabrus melanocercus		X				X		X	X						
	Chromis chromis	X	X	X	X		X	X	X	X	X		X	X	X	X
	Coris julis	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Dentex dentex			X									X			
	Diplodus annularis	X	X	X	X		X	X	X	X	X	X	X	X	X	X
	Diplodus puntazzo												X			
	Diplodus sargus										X	X	X	X		
	Diplodus vulgaris			X	X		X	X	X	X	X		X	X		X
	Epinephelus marginatus				X		X									
	Gobius sp						X							X		
	Labrus merula							X	X		X		X	X		
	Labrus viridis			X					X				X			
	Mullus barbatus						X									X
	Mullus surmuletus	X	X				X					X			X	
	Oblada melanura			X	X		X			X			X	X	X	X
	Salpa salpa			X					X		X					
	Sciaena umbra				X								X			
	Serranus cabrilla				X	X							X	X	X	
	Serranus scriba	X	X				X	X	X	X	X		X	X	X	X

	Sparisoma cretense				X											
	Sphyraena sphyraena				X											
	Spicara maena		X		X	X	X	X					X		X	
	Spicara smaris											X			X	X
	Spondyliosoma cantharus	X	X			X	X	X		X	X	X		X	X	X
	Symphodus cinereus						X						X			
	Symphodus mediterraneus				X		X			X			X	X		X
	Symphodus rostratus										X		X	X		
	Symphodus tinca	X	X		X	X	X	X	X	X	X		X	X	X	X
	Thalassoma pavo							X			X			X		
Ascidiacea	*Halocynthia papillosa* **															
Anthozoa	*Cladocora caespitosa* **															
Aves	*Phalacrocorax sp.* **								X							
Demospongiae	*Aplysina aerophoba* **															
	Axinella polypoides **															
	Axinella verrucosa **															
	Crambe crambe **															
	Petrosia (Petrosia) ficiformis **															
	Sarcotragus spinosulus **															
Echi	*Arbacia lixula* **															

	Paracentrotus lividus **															
	Echinaster (Echinaster) sepositus **															
Florideophyceae	*Asparagopsis sp.* **															
	Ellisolandia elongata **															
	Liagora viscida **															
	Lithophyllum spp. **															
Gymnolaemata	*Electra posidoniae* **															
Holothuroidea	*Holothuria (Panningothuria) forskali* **															
Hydrozoa	*Antennella sp.* **															
Mammalia	*Tursiops truncatus* **	4														
Phaeophyceae	*Cystoseira sp.* **															
	Padina pavonica **															
Polychaeta	*Hermodice carunculata* **															
	Protula intestinum **															
	Sabella spallanzanii **															

Ulvophyceae	*Caulerpa prolifera* **															
	Caulerpa taxifolia **															
	Flabellia petiolata **															


iSea,2023