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Baseline

Mind the gap in data poor Natura 2000 sites and how to tackle them using Earth Observation and scientific diving surveys

Dimitris Poursanidis [a,d,*], Kostas Mylonakis [a], Spyros Christofilakos [b], Antonios Barnias [c]

[a] *terraSolutions marine environment research, Arximidous 63, PO 71601, Heraklion, Crete, Greece*
[b] *German Aerospace Center (DLR), Remote Sensing Technology Institute (IMF), Department of Photogrammetry and image Analysis, Rutherford 2, 12489 Berlin, Germany*
[c] *Management Unit of Samaria National Park and the Protected Areas of Western Crete, Old National Road Chanion-Kissamou, Agioi Apostoloi, opposite to the supermarket Lidl, P.O. Box 73100, Chania, Greece*
[d] *Remote Sensing Lab, Institute of Applied and Computational Mathematics, Foundation for Research and Technology Hellas, 100 N. Plastira Str., Vassilika Vouton, Heraklion 70013, Greece*

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ABSTRACT

Charismatic species drives decisions for the conservation of marine areas in the view of the coverage of the Natura 2000 sites in the European Union and other forms of Marine Protected Areas in Europe. However, when used solely, critical seascapes and habitats are systematically ignored and practically it can take decades to fulfill baseline needs on habitats distributions, habitats conservation status and species distributions and biodiversity assessments. Luckily, in the last decade, the use of new technologies in conjunction with scientific diving and budget friendly hydroacoustic tools and applications, has allowed to fill the gap in knowledge in such situations and seascapes. The current work demonstrates the use of Earth Observation and Science Dive to fill the gap of knowledge in a newly established Natura 2000 area in Crete, Greece, East Mediterranean, paving the road for replicable approaches in similar situations.

European Union, with the Habitats Directive (European Commission, 1992 - HD) and the Birds Directive (European Commission, 1979 - BD) established its network of Protected Areas, under the umbrella of Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) for species/habitats and birds respectively. The overall conservation objective of the network is to "*…maintain or restore, at favorable conservation status, natural habitats and species of wild fauna and flora of Community interest*" (Article 2, HD). Given the working definition of "*favorable conservation status*" this means protecting and conserving at least 60 % of the populations (Anonymous, 1997). The N2000 (N2k) is one of the World's most extensive networks of protected areas, which currently includes over 27,500 terrestrial and marine sites, covering almost 19 % of the territorial waters of EU member states but <4 % of their Exclusive Economic Zones (Agnesi et al., 2017). When evaluating the need for the designation of marine N2k sites for species listed in Annex II of the HD and identifying Sites of Community Importance (SCI), which are the first step for SACs designation, national administrations must follow the framework laid out in Article 4 and Annex III. Stage 1 must consider the overarching objective to set up "*a coherent European ecological network of special areas of conservation*" that will enable "*the species' habitats concerned to be maintained or […] restored at a favorable conservation status in their natural range*" (HD Article 3). Thus, the only two key factors that need to be considered to achieve this objective are the species and its habitat. Once an SCI has been adopted and published in the Union list by the European Commission, it becomes part of the N2k network, and the relevant Member State (MS) shall designate it as a SAC "*within 6 years at most*". It is only at this point those aspects related to threats become important, as priorities for designation of a SCI into a SAC are formally established "in the light of the threats of degradation or destruction to which those sites are exposed" (HD Article 4.4) (Fortuna et al., 2018).

However, in several cases due to the need for the use of charismatic species for the declaration of such areas (Gruber et al., 2012) like the loggerhead turtle *Caretta caretta*, several ecological and seascape aspects of the site are ignored in the initial stages of declaration. These include the occurrence of important habitats and species of community

* Corresponding author at: Remote Sensing Lab, Institute of Applied and Computational Mathematics, Foundation for Research and Technology Hellas, 100 N. Plastira Str., Vassilika Vouton, Heraklion 70013, Greece.
E-mail address: dpoursanidis@iacm.forth.gr (D. Poursanidis).

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importance such as seagrass meadows (habitat 1120*), coralligenous/ biogenic formations (habitat 1170), noble shell populations (*Pinna nobilis* Linnaeus, 1758), etc. By that, and since the emphasis is given in the nesting areas of the marine turtles which are located in the sandy beaches, no actions for the establishment of the baseline for the seascape of the area is performed by the national authorities.

The Mediterranean Sea hosts elusive and important coastal marine biodiversity - biota and seascapes wise. Extensive seagrass meadows (habitat 1120*) and rocky reefs in the sunny and dark parts of the systems occur and extend in thousands of kilometers (Traganos et al., 2018a, 2018b, Ponti et al., 2021).

Crete is the 88th largest island in the world and the fifth largest island in the Mediterranean Sea, after Sicily, Sardinia, Cyprus, and Corsica. It bounds the southern border of the Aegean Sea. It lies approximately 160 km south of the Greek mainland. It has an area of 8336 km^2 and a coastline of 1046 km. It has 4 mountain massifs and more that 50 picks over 2000 m (Wikipedia, 2020). The coastal zone hosts rocky shores, mostly made by limestone, extended sandy bottoms and seagrass meadows with variable forms. Deep areas host coralligenous formations with coral gardens and other deep habitats like maerl beds and black coral assemblages while the South Crete host marine mammals like whales and dolphins.

Due to the elusive and important biodiversity originated mostly due to geographical isolation of the island, >53 Natura 2000 sites have been declared in Crete and designed covering a large proportion of the terrestrial and marine area of the island. However, the marine and coastal N2k sites, since these have been declared quite recently or cover marine mammals and marine turtles (Aliki, 2015) as target species for protection and conservation or are designated to protect endemic coastal terrestrial species and have been extended to cover the nearby coastal marine areas, few information on the habitats and the hosted biodiversity is available in the Standard Data Forms of each area. This scientific information gap extends also to relevant authorities obliged to manage these areas. The current study focuses on the site GR4340003 "*Chersonisos Rodopou – Paralia Maleme – Kolpos Chanion*". It includes Rodopos peninsula and the coastal area from Kolympari to Platanias. It is located at the NW part of Crete (about 20 km from Chania city, Fig. 1). The site is relatively close to the Chania city and is vastly affected by large number of visitors during the summertime. According to the Standard Data Form (SDF, 2022), the marine part of the site is delimited by the isodepth of 50 m with no available information on habitats and species. The terrestrial part is characterized by 1) Vegetated Sea cliffs, Aegean cliffs, chasms, screes and sink holes. 2) Phrygana affected by grazing. 3) Local *Pistacia lentiscus* thickets in a good condition. 4) Areas cultivated with vineyards. 5) Locally restricted intensive building activities. Habitat 5331 is used to describe thickets of *Euphorbia dendroides* of macaronisia origin. The coastal part of the site includes a sandy beach from Kolympari to Platanias, a heavily affected by tourism area and the marine area up to the isobath of 50 m.

The aim of the study is to setup the baseline for the marine part of the site using multiscale Earth Observation data from various data providers combined with scientific diving protocols and low-cost tools for the mapping of coastal habitats, the first biodiversity inventory and the estimation of the conservation status of the priority habitat 1120* which

Fig. 1. In dotted red polygon, the study area in Chania, Crete. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

is known to exist in the area without any other information (Traganos et al., 2018b; Topouzelis et al., 2018).

Bathymetry data have been collected using the inflatable boat of the Management Body of Samaria National Park–West Crete aiming at the use with satellite data towards a satellite-derived bathymetry product for the N2000 site. The boat is equipped with a Lowrance single beam echo sounder with the capability to collect and store bathymetry data using a Lowrance Dual Frequency Transom Mount Transducer that operates at the dual 50/200 kHz frequency with built-in temperature sensor (Fig. 1 in Supplemental file). For the operations and the usability of the data, these are collected with a speed of 2–3 knots, under very calm weather conditions. As such, data don't include any motion errors such as the yo, pitch and roll of the boat due to waves and currents which could require onboard expensive and dedicated equipment and post-processes to correct in the office. Data are stored in proprietary format of Lowrance. The collected data are analyzed using ReefMaster (https://reefmaster.com.au/) a unique software designed to open and extract bathymetry information from commercial low-cost tools such as the used one (Fig. 2 in Supplemental file). The application is one-of-its-kind and has available routines to process simultaneously a large amount of bathymetry data from such systems.

The classification scheme for the analysis of images, related to the coastal seascape, is challenging to be defined and usually is driven by the nature of the data that will be the primary base for the analysis. Since 2000, very high-resolution (VHR) imagery becomes available from the commercial sector allowing high resolution mapping products. For the current work, we use two sources of imagery. Firstly, we create an image composite from the time series of Copernicus Sentinel 2 within the Google Earth Engine platform, a planetary-scale platform for Earth science data & analysis. Instead of using single image for analysis, we use all available images and from that we create an image composite that allow the consolidation of clean of clouds, waves, sun glint and water sedimentation pixels for further use (Poursanidis et al., 2019a, 2019b, 2021; Traganos et al., 2018a, 2018b).

Furthermore, we use a single L3A Planet Cubesat image from the SuperDove sensor, carrying 8 bands from the coastal blue to the VNIR (431–850 nm). We obtain an image from the month May (Image ID: 20200505_082122_45_2259_3B_AnalyticMS) due to cloud absence, sun glint almost free and clear water conditions. These selections along with the use of basemaps from Google Earth Pro and Microsoft BING viewer support the creation of the training data used for the image analysis.

Based on previous experience (Poursanidis et al., 2014, 2018, 2019a, 2019b) we firstly designed on the VHR basemap data for the corresponding habitats we aimed to map (here the classification scheme is i) seagrass meadows, ii) rocky reefs and iii) soft bottoms) and depending on the class and the homogeneity of it, we digitized in QGIS sufficient number of points or polygons to be used for the training/validation of the Earth Observation data. Emphasis has been given, during the designation of the data (i.e., expert data), to collect/design data from homogeneous areas that correspond to the pixel size of the satellite images (i.e., 10 m pixel size of Sentinel 2 and 3.7 m pixel size of Planet). Otherwise, the provided information in the analytical workflow would be false.

All data related to the calibration/validation have been validated either during the field campaign by means of snorkeling or SCUBA diving or by cross checking with VHR data from Google Earth Pro timeseries imagery or Microsoft BING aerial imagery and the aerial photos available by the Greek Cadaster Office. For the calculation of satellite-bathymetry we use Random Forests Regression using 80 % of the field data for training and 20 % for model validation. Random forests for nonlinear regression are formed by growing trees depending on a random vector such that the tree predictor takes on numerical values as opposed to class labels (Breiman, 2001). This nonlinear regression is a machine learning approach that belongs to the family of decision tree learning (Breiman, 2001). The goal of decision tree learning is to create a model that predicts the value of a target variable based on several input variables (Diesing et al., 2016). A drawback of the machine learning approaches against the statistical regression is that they do not allow generalization beyond the limits of the predictor (here the depth limit of 25 m). However, they show excellent performance in SDB problems (Manessa et al., 2016; Sagawa et al., 2019) in comparison to other methods. For estimating the water depth an in-house developed toolbox has been used; it is based on the SciKit learning package of Python. For the coastal habitat mapping, we limit the working depth at 25 m using the bathymetry product, due to optical deep waters that exist deeper and the high seascape slopes. We followed already developed workflows from previous work (i.e., Traganos et al., 2018a, 2018b, Poursanidis et al., 2021) within the Google Earth Engine (GEE) platform, adapted for the needs of the project. For the habitats classification we used two machine learning classifiers: Random Forests (RF) and Support Vector Machines (SVM). For the first (RF), we tuned the methods using various values of trees from 10 to 1000 while for the second (SVM) we tuned a Gaussian radial basis kernel function (RBF) with variable values in the cost and gamma parameters. These tunes allow better discriminating the desired classes while keeping the errors low. We chose the classification between the two, based on the higher overall accuracy. Fig. 2 provides an overview of the steps.

The characterization of the conservation status of *Posidonia oceanica* meadows (priority habitat 1120*) is usually based on univariate or multivariate descriptors (Pergent-Martini et al., 2005) that have been developed in the last two decades. Several biotic indices have been proposed to assess the ecological quality of coastal waters using *P. oceanica* (Romero et al., 2007, Fernández-Torquemada et al., 2008a, 2008b, Gobert et al., 2009, Montefalcone et al., 2007, 2009, Lopez y Royo et al., 2010, Personnic et al., 2014, Gobert et al., 2020, SPA/RAC, 2014). Almost all of them require laboratory work for analysis of tissues and samples (both plants, sediments, and water column) and knowledge of the coefficients of the intercalibration exercises, which are not public available.

The application is depending on the resources, the replicability, and the use by non-experts or by scientists that are not dedicated on the seagrass meadows monitoring, as is usually the case of the personnel of the Management bodies of Protected Areas or other management authorities. We follow the metrics that are used in several ecological descriptors (Boudouresque et al., 2012; UNEP/MAP, 2019); these were collected at three locations out of four since the northern site was an incidental discovery; a meadow where the upper limit starts at 21 m depth, and the dive was planned for reef biodiversity and not for seagrass work (Fig. 1). The collected metrics are a) shoot density at medium and deep depths depending on the meadow using a square frame of 20 × 20 cm and five replicate measurements, b) typology of the deep limit of the meadow, c) occurrence of marine litter, d) signs of scars by boat anchorage or other sources and e) occurrence of invasive alien species in and/or around the meadows.

The above metrics collected by means of scientific diving using air as breathing gas and 50 % Nitrox as deco gases. These can provide information on the status of the meadows that can further support management activities. The choice of the sites for the collection of the data was based on the previous steps that indicate the spatial extend of the meadows based on satellite image analysis. However, and given the limitations of satellite data to provide information deeper than 25 m, depending in the time, site, location and other oceanographic characteristics, local ecological knowledge has been also utilized by collecting information from local Scuba Diving clubs and social media forums asking if seagrass meadows occur at the site of work and if these are patchy or continues. Based on the assembly of the collected information but also the restrictions due to the Covid19 virus pandemic, a full survey of the peninsula was not possible; we focused on the east side of it due to the occurrence of meadows based on the above sources but also due to the weather conditions and the availability of time; we decided to work in places of known meadows but unknown distributions (depth limits) and ecological status rather that doing fully exploratory diving in the

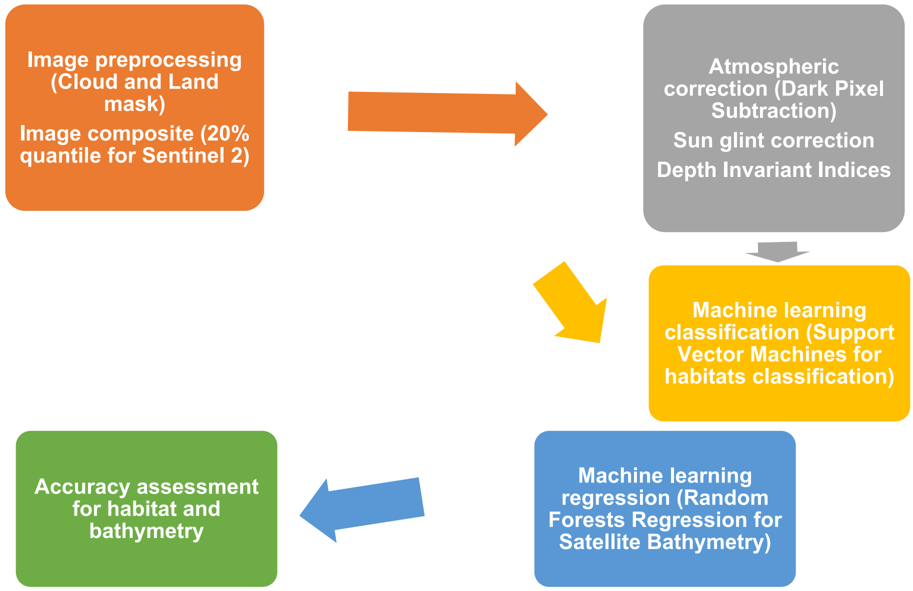


Fig. 2. The workflow for the analysis of the Earth Observation data.

west part.

In total, 222.5 km of travel with the inflatable boat of the Management Body, allowed the collection of 84.145 depth points covering the depth range between −1.1 and −59 m (Fig. 3). The data have been imported in ReefMaster software for postprocessing and export in the format of ESRI shapefile. There, the offset between the sensor and the recorder have been corrected as well as the offset between the GPS antenna and the recorder. Further, the data have been cleaned by artefacts such as zero or positive values or values that does not correspond to the neighborhoods caused by fast turns or dense bubbles from the propel and use in the next activities (i.e., estimation of bathymetry using satellite images and machine learning methods). Lastly, the data have been truncated within the limits of the N2000 which are defined by the official vector data by the Natura 2000 - General Viewer of European Environment Agency (https://www.eea.europa.eu/data-and-maps/data/natura-11/natura-2000-spatial-data) and a subset of them up to the depth of -25 m (Fig. 4) has been used in the analysis following internal test analysis. These data will be used for the extraction of continuous coastal bathymetry using Earth Observation data following previous experience (Poursanidis et al., 2019a, 2019b, 2019c, Pike et al., 1830, Traganos et al., 2018a, 2018b). For the coastal habitats (Fig. 3 Sup file), 82 homogeneous locations have been selected for the habitat 1120* (*Posidonia oceanica* meadows), 37 homogeneous areas for the habitat 1170 and 26 homogeneous areas for the habitat 1110. The data for the

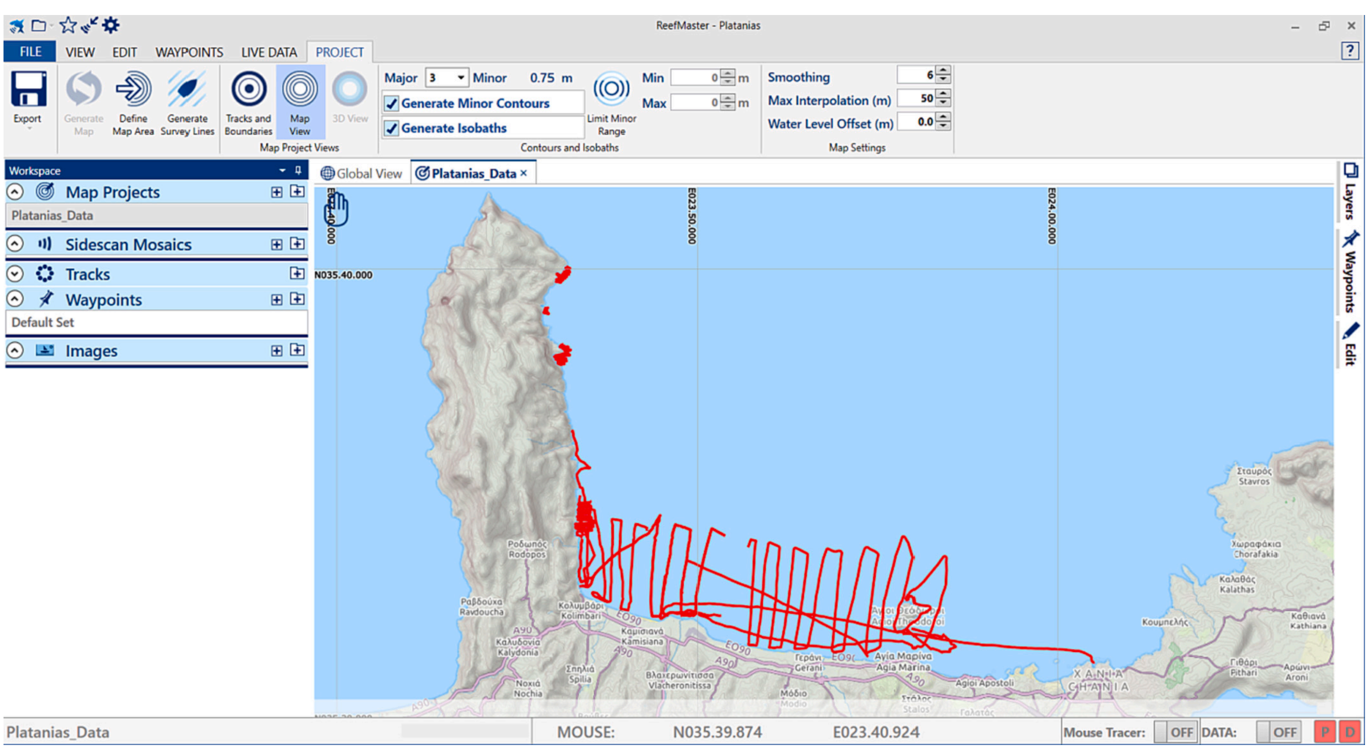


Fig. 3. The tracks of the fieldwork for the collection of bathymetry data.

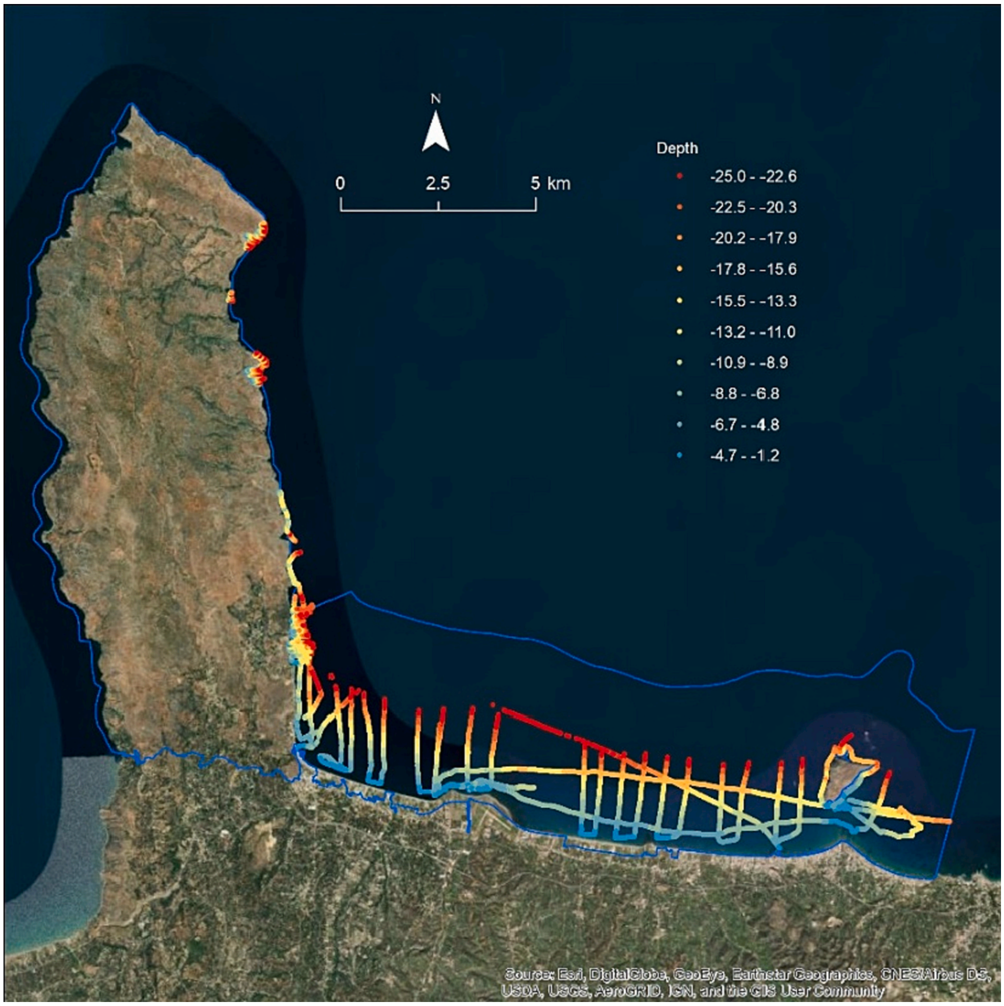
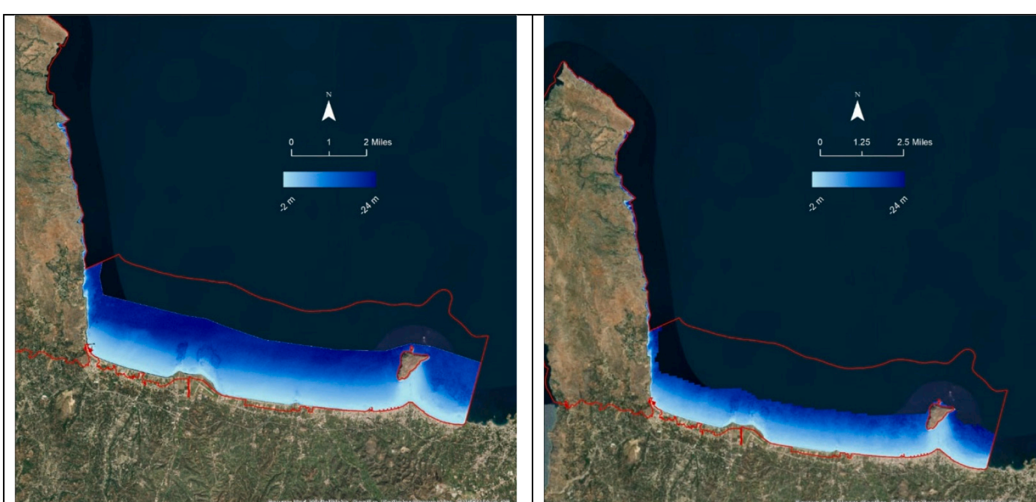


Fig. 4. The distribution of the collected depth up to -25 m.



a. Bathymetry map from PlanetScope CubeSat imagery.	b. Bathymetry map from Sentinel 2 image composite.

Fig. 5. a. Bathymetry map from PlanetScope CubeSat imagery.
b. Bathymetry map from Sentinel 2 image composite.

habitat 1120* are in the form of point due to the spatial resolution of the used Earth Observation data (3.7 m of PlanetScope CubeSat and 10 m of Copernicus Sentinel 2, see Figs. 4 and 5 in the Sup file for the used imagery) and the fact that seagrass meadows is mixed with rocky bottoms in the depths that the image analysis will be performed. On the other side, the data for the habitat 1110 & 1170 have been designed in the form of polygon since >75 % of the area is composed (Fig. 5).

These data were transformed into points (i.e., the number of pixels that each polygon contains) and used in the classification process in the context of habitat mapping using Earth Observation data. Bathymetry estimations using Random Forests regression (RFR) show a variable behavior among the used satellite data. Table 1 summarize the findings among the three sensors while Fig. 6a and b provides an overview of the results.

The classification results for the delineation of the habitats based on the classification scheme of N2000 are presented in Table 2 while Fig. 6a and b provides an overview of the results.

Focusing on the seagrass meadows, the case study area is characterized by continuous seagrass meadows with high shoot densities per square meter (Table 3). This is the first time that data related to the ecology of meadows are collected from the area, aiming at the support of the conservation activities of the Management Body. Also, the data will be used as reference measurements against future monitoring schemes such as the Marine Strategy Framework Directive and the Water Frame Directive. The shoot density measurements are comparable with data collected under other projects by terraSolutions m.e.r. at the island of Crete (i.e., Ierapetra, Sfakia, Apokoronas) showing similar shoot density values at same or similar depths and substrates. *Halophila stipulace* and *Siganus luridus/rivulatus* where present in the three sites as well (Figs. 6 & 7 in Sup file).

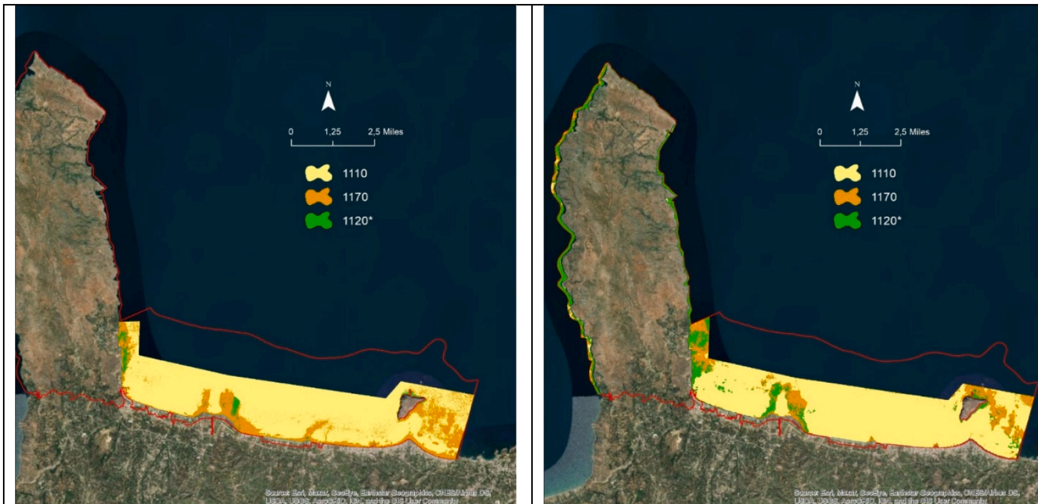
Setting the baseline on spatial distribution of coastal marine habitats and the conservation status of seagrass meadows in Natura 2000 sites using cost effective tools and methods is challenging. The use of Earth Observation in the estimation of coastal bathymetry and the mapping of the coastal marine habitats can be considered as a mature method in such conditions that within the last decade has gained space in the field of operational habitat mapping and monitoring. Especially within N2000 sites or other protected area schemes like Marine Protected Areas and Nature Reserves, can offer important information in cases where there is lack of it. Also, such tools can support the designation of data for use in conservation and planning in cases where there are limited funding sources to support hydroacoustic surveys (i.e., multibeam echo sounder and side scan sonar). For the case study area of the project, the estimation of bathymetry was within accuracy metrics that allow the use for activities like planning and management and follows the IHO CATZOC limits. For the bathymetry, the accuracy is higher than 2 m for two of the satellite sensors. Same for the MAE and R^2 where we have lower than 1.5 m and higher that 0.9 respectively. The availability of a large, updated dataset regarding the depths much deeper than the final product, allow the tuning of the algorithms at that level that provide results not often reported in the literature for such depth ranges from areas that have similar oceanographic characteristics (Poursanidis et al., 2018, Poursanidis et al., 2019a, 2019b, 2019c, Traganos et al., 2018a, 2018b). The satellites have different spatial resolutions allowing the use of the products in different mapping scales. For example, Sentinel 2 has pixel size of 10 m which turns into a mapping scale of 1:20,000 (Horning, 2004), PlanetScope has 3 m which turns into a mapping scale of 1:6000. As such, the use of the final bathymetric and habitats products must be done with caution and the sources of the products (i.e., the satellite data and the pixel size) must always be mentioned in order to avoid any misunderstanding regarding any missing element from any map. For the products of habitats and for all used satellite images, accuracies above 80 % which is an acceptable threshold were reached, following a rule of thumb but also other studies in the Mediterranean Sea. However, several misclassification issues occur mostly in shallow waters or in highly mixed habitats but also in waters beyond the capacity of the satellites to provide useful bottom (surface of the benthos) spectral information that can be translated from the machine learning methods into habitats.

Table 1
The results from the bathymetry estimations using RFR. RMSE = root mean square error, MAE = mean absolute error.

	Sentinel 2	PlanetScope
RMSE	1.37	1.75
MAE	0.92	1.15
R^2	0.93	0.91

Several factors affect the accuracy of the analysis. To name and describe some, we have situations of the occurrence of seagrass over deep waters or in cases of mixed habitats (Figs. 8, 9 in Sup file) as is the case in several locations at the shallow parts of the gulf. Several locations occur, where rocky reefs with pebbles, photophilic algae, sand pockets and small seagrass patches along with sparse meadows made by *Cymodocea nodosa* co-occur in scales of decimeters or meters and make any attempt to separate them by means of satellite image classifications of spatial resolutions beyond their co-occurrence a very challenging and doomed challenge. Other sources of errors are related to the topography of the seascape and the turbidity. Across the peninsula the topography is steep and the depth gradient change fast in terms of distance. This, in combination with the sun angle and sun azimuth during image acquisitions does not allow the return of reflectance from the bottom to the satellite sensor limiting the use of the images up to a certain depth, in this case around 25 m depth. Also, across the peninsula, the orientation in the north-south axis causes severe shadow contamination, especially in the west part which ends to a spectral confusion. This issue in combination with the optical deep waters resulted in the dominance of the seagrass class over the seascape. The habitat map based on the Sentinel 2 imagery and classification has some similarities with results from a work run in 2015 (Chintiroglou, 2015). More specifically, in pg. 44 of the technical report, Fig. 30 shows a bionomic map (sensu habitat map) which is based on field campaigns in several locations in a two-year period. There, the peninsula shows a mixed habitat behavior where seagrass can be found anywhere but mixed with rocky formations and outcrops. Therefore, the results of the present work from the analysis of the Sentinel 2 must be used with caution since further validation across the peninsula is needed.

Regarding the conservation status of the seagrass meadows, following the interpretation tables by UNEP/MAP, 2019, all meadows are considered of good to high conservation status. This is not a surprising result for the given measured depths since the locations are far from direct anthropogenic activities that cause direct and indirect water pollution at such degree that can cause degradation. No agricultural activities occur in the nearby terrestrial areas that allow the entry of fertilizers and other agrochemicals during water runoff. At least, such evidence has not been recorded at the seagrass meadows (i.e., no high level of epiphytes growing on the leaves that can be linked with eutrophication). At two out of four locations, named Menies and Xoironisia, at waters shallower than 10-meter depth, signs of repeated anchorage have been recorded while medium to large parts of the meadows have been disappeared. At these sites the substitution of *Posidonia oceanica* by *Halophila stipulacea* in few parts was evident while on the dead matte, the seagrass *Cymodocea nodosa* has start to cover significant parts. This is a horizontally observed pattern across the Mediterranean Sea, as the matte morte of the meadow is a ready-to-use substrate for the growth of invasive alien species as is the case of *Halophila stipulacea*, a seagrass species of Indo-Pacific origin (Boudouresque et al., 2009, Apostolaki et al., 2019). It is worth noting that the species has also been recorded for the first time by the N2000 site (EASIN, 2020). No other invasive alien species such as the green algae *Caulerpa racemosa* or the *Caulerpa taxifolia* have been observed in the *matte morte* or elsewhere at shallow parts of the seagrass meadows. Since the damaged areas are of the scale



a. Habitat map from PlanetScope CubeSat imagery.	b. Habitat map from Sentinel 2 image composite.

Fig. 6. a. Habitat map from PlanetScope CubeSat imagery.
b. Habitat map from Sentinel 2 image composite.

Table 2
The results from the classification of the satellite images. The overall accuracy and the selected machine learning algorithm are presented per satellite.

	Overall accuracy	Algorithm	Parameters
Sentinel 2	0.87	RF	Number of trees = 1000
PlanetScope	0.88	SVM	Gamma = 1000, cost = 1000

Table 3
Results from the fieldwork at seagrass meadows.

	Menies	Xoironisia	Afrata
Mean density at 15 m at 1 m^2	420	545	590
Mean density at 20 m at 1m^2	450	450	390
Upper limit	8 m	5 m	12 m
Std 15 m	48	71	55
Std 20 m	68	68	45
Lower limit	25 m	23 m	25 m
Lower limit typology	Sharp/slight progressive	Sharp/slight progressive	Sharp/slight progressive
Invasive alien Species	Yes	Yes	Yes
Anchorage signs	Yes	Yes	No

of tenths of square meters concentrated at the shallow inner parts of the meadows, the regression can be halted with activities such as the ban of free anchorage, the installation of friendly mooring systems along with targeted replantation, following established approaches (RED, 2018) with donors from the nearby meadows to avoid genetic changes and also a concrete dissemination campaign to all relevant stakeholders that are active at the investigated locations. Other "holes" and "breaks" from anchorage of larger boats (>20 m) have been located in deeper parts but are few (<5 cases) and with proper activities, these can recover after the ban of anchorage and the transplantation of shoots from the plants around the hole. Siganids (*Siganus luridus* and *Siganus rivulatus*) have been observed in almost all locations. In most of the cases, they form mixed schools with the salema porgy (*Sarpa salpa*) while small individuals use *Posidonia oceanica* meadows for hiding and foraging.

For first time, data that provide information on spatial distribution of the seascape elements, named the bathymetry and habitats, along with the conservation status of the meadows based on the collected descriptors are collected from a newly established area of the Natura 2000 network. The meadows are of good conservation status; however, signs of degradation have been recorded. These are mainly due to activities that are related to the tourism industry that thrives in the wider area. The repeated temporary anchorage by the boats of various sizes have destroyed parts of the meadows, mostly at shallow waters. The seagrass meadows are distributed across the east side of the peninsula, based on the current work. During the current campaign, 4 locations have been visited for data collection, from them one was new site with the meadows to grow on extreme conditions. More locations are expected to occur with similar characteristics and larger projects are required for exploration and ecological relevant scientific diving also covering the west part of the peninsula. The presented approach to fill knowledge gap in Protected Areas using new technological advances along with careful designed scientific campaign is promising. In the era of accessible tools and budget friendly methods, the creation of spatial and ecological data is possible even by involving citizens for data collection and open accessible Earth Observation data for the mapping but also the monitoring of coastal habitats, here the priority habitat 1120*.

CRediT authorship contribution statement

DP: Conceptualization; Data curation; Formal analysis; Funding acquisition; Field work; Supervision; Writing - original draft; Writing - review & editing.
KM: Writing - original draft; Field data collection
SC: Data curation; Formal analysis; Methodology;
AB: Funding acquisition; Project administration; Writing - review & editing.

Declaration of competing 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 paper.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.marpolbul.2023.114595.

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