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Integrated Methodological Approach for the Documentation of Marine Priority Habitats and Submerged Antiquities: Examples from the Saronic Gulf, Greece

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Abstract: The rising human activities and resource exploitation have increased pressure in the coastal zone and the marine environment, risking the very existence of Marine Priority Habitats (MPH) and Underwater Cultural Heritage (UCH). The delimitation of these two priority areas in a time- and cost-effective way is essential for the sustainable management and exploitation of sea resources and natural-cultural heritage preservation. We propose an Integrated Methodological Approach for the Detection and Mapping of MPH and UCH. To achieve this, we used a downscale methodological approach of increasing spatial resolution based on three main methodological axes: (i) desk-based research, (ii) marine geophysics/seafloor classification, and (iii) in-depth visual inspection/3D mapping. This methodological scheme was implemented at the Saronic Gulf and focused on Aegina island. The methodology proposed, which combines existing and new techniques, proved successful in detecting and mapping the MPH and UCH in detail, while it compiled the information necessary for the establishment of Marine Spatial Planning (MSP) maps. Finally, the MSP map constructed for the Saronic Gulf demonstrated the lack of holistic coastal zone management plans due to impacts on UCH linked to anthropogenic intervention and the sparsity of marine habitats owing to marine pollution.

Keywords: marine geophysics; marine spatial planning; Aegina; Salamis; seafloor classification; 3D seismic profiles; photogrammetry; *Posidonia oceanica*; downscaling

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Citation: Georgiou, N.; Dimas, X.; Papatheodorou, G. Integrated Methodological Approach for the Documentation of Marine Priority Habitats and Submerged Antiquities: Examples from the Saronic Gulf, Greece. *Sustainability* **2021**, *13*, 12327. https://doi.org/10.3390/su132112327

Academic Editors: Tiziana Luisetti and Clement Garcia

Received: 15 September 2021
Accepted: 1 November 2021
Published: 8 November 2021

1. Introduction

The vision for sustainable coastal development lies within the balanced economy-, environment-, and society-related actions [1]. However, the increasing population, especially in coastal areas, led to urban development, land reclamation, resource over-exploitation, and pollution. The human-induced pressure, together with climatic change effects (i.e., sea-level rise, sea surface temperature rise), poses a significant threat to marine biodiversity and underwater cultural heritage [2–9]. Therefore, detection and detailed mapping of the cultural and biological wealth of our seas is essential for their protection and inclusion in integrated coastal management plans [10–12].The European Union is following specific policies and directives regarding the protection, preservation, and sustainable development of the cultural and biological wealth (Valetta, 1992; ICOMOS Sofia, 1996; UNESCO, 2001; Barcelona, 1970-Directive: 92/43/EEC-21/05/1992; NATURA, 2000), while all European countries are obliged to fully map the extent of their marine bio-habitats and base any action in the marine environment on its ecological significance (Marine Strategy Framework Directive-Descriptors of Good Environmental Status). These directives constitute the main pillars regarding the capabilities and limitations of the marine environment, intending to enact Integrated Coastal Zone Management (ICZM) and Marine Spatial Planning (MSP) strategies. The ultimate objective of these strategies is to protect the marine environment but also support the European economy through maritime development (Blue Growth). It should be mentioned that the value of coastal UCH is mentioned in ICZM; however, it is usually neglected in coastal management plans even though it can be a highly beneficial resource [10].

According to MESH (Development of a framework for "Mapping European Seabed Habitats"), habitats can be defined as "both the physical and environmental conditions that support a particular biological community together with the community itself". The Mediterranean Sea is the birthplace of many unique habitats [6,13–15]. At the Saronic Gulf, two of the most important marine habitats, *P. oceanica* meadows [15,16] and coralligenous formations [15,17], are flourishing. *P. oceanica* is a marine angiosperm, endemic to the Mediterranean Sea shallow habitat (0–40 m), and presents multi-aspect benefits to the marine environment. Posidonia meadows cover 23% of the sea bottom between 0 and 50 m water depth [18], and through photosynthesis, they are one of the key contributors to the oxygenation of the sea. In addition, the canopy created by the Posidonia leaves act as a natural wave barrier and prevent coastal erosion, while high amounts of sediment are retained inside its high-density rhizome [19,20]. Lastly, the Posidonia beds are one of the habitats with the highest biodiversity as they constitute the feeding and nursing ground for a plethora of other marine species [21–23]. Coralligenous formations are found in the whole of the Mediterranean Sea in many different forms [14,24], and their ecological value is also highly valuable [25]. These unique formations of the eastern Mediterranean, especially those of the Cyclades Plateau and the Saronic Gulf, are only stated as part of the ecological dynamics of these areas [13,14,25], and so far, only one article is dedicated to mapping and studying their characteristics [26].

Since the Last Glacial Maximum (~19 ka Before Present-BP), the sea level has risen by almost 120 m due to eustatic and relative sea-level change processes [27,28]. Therefore, the coastal zone was flooded, and prehistoric and historic evidence was submerged under the sea [29–31]. The maritime tradition in the Mediterranean has offered a wealthy repository of archaeological remains, submerged port facilities, settlements, and shipwrecks [32–36], while the geographic location of Greece and its widespread submerged landscapes favor the existence of findings related to hominin migrations and evolution, early seafaring, colonization and seaborn trade [37,38]. The earliest archaeological findings to date in Greece revealed early human occupation during the Lower Paleolithic (0.5 ma BP) [38], when that of the earliest modern humans' dispersal out of Africa were dated 210 ka BP [39]. The first-ever recorded underwater archaeological survey was performed by the archaeologist C. Tsountas in 1884 A.D. [40], who attempted to find ruins from the historical Salamis naval battle using diving equipment and a long rod to validate the texture of the seabed's substrate. Unfortunately, the low visibility and the great extent of the survey area did not allow any findings, while he concluded that "maybe in the future more opportune moments will come for succeeding in such difficult tasks". Today, the advance in marine geophysical surveying makes it possible to simultaneously map a great area of the seafloor's surface and the substrate with an accuracy of a few centimeters and in minimum time, without the presence of humans underwater [8,41].

The condition for achieving sustainable coastal zone management and development is the deep knowledge of the foundations on which it will be based. The foundations are laid through the detection and detailed mapping of the areas of interest. Given the dangers that the marine environment confronts, the scientific community needs to develop an efficient methodology for locating and mapping areas that contain both marine priority habitats and submerged antiquities within a short period and in a cost-effective way. Usually, the existence of the two is interdependent since multiple archaeological sites are accompanied by the presence of seagrass. Seagrass has been proved to play a central role in the preservation of submerged archaeology, while its ability to accumulate sediment secures the site and preserves the sedimentary balance [42]. Artificial seagrass mats have been installed on submerged archaeological sites within the framework of the SASMAP project, aiming to protect them from erosion [11]. Existing methodologies for mapping UCH or MPH have been established on the basis of an unambiguous perspective aimed at locating and mapping only one of the two elements. In this paper, we propose a robust methodology that combines existing standard methodologies and merges them with new/developing practices on how to approach and document areas with a high presence of MPH accompanied by UCH. This is accomplished through collecting and interpreting data in three (3) levels of increasing spatial analysis constituting a "downscale approach" (Figure 1). The proposed methodological scheme was implemented in the Saronic Gulf, Greece, and was mainly focused on the coastal zone of Aegina city in Aegina island. The acquired information from the three (3) different data levels contributed to a first attempt for the development of a Marine Spatial Planning map of the Saronic Gulf.

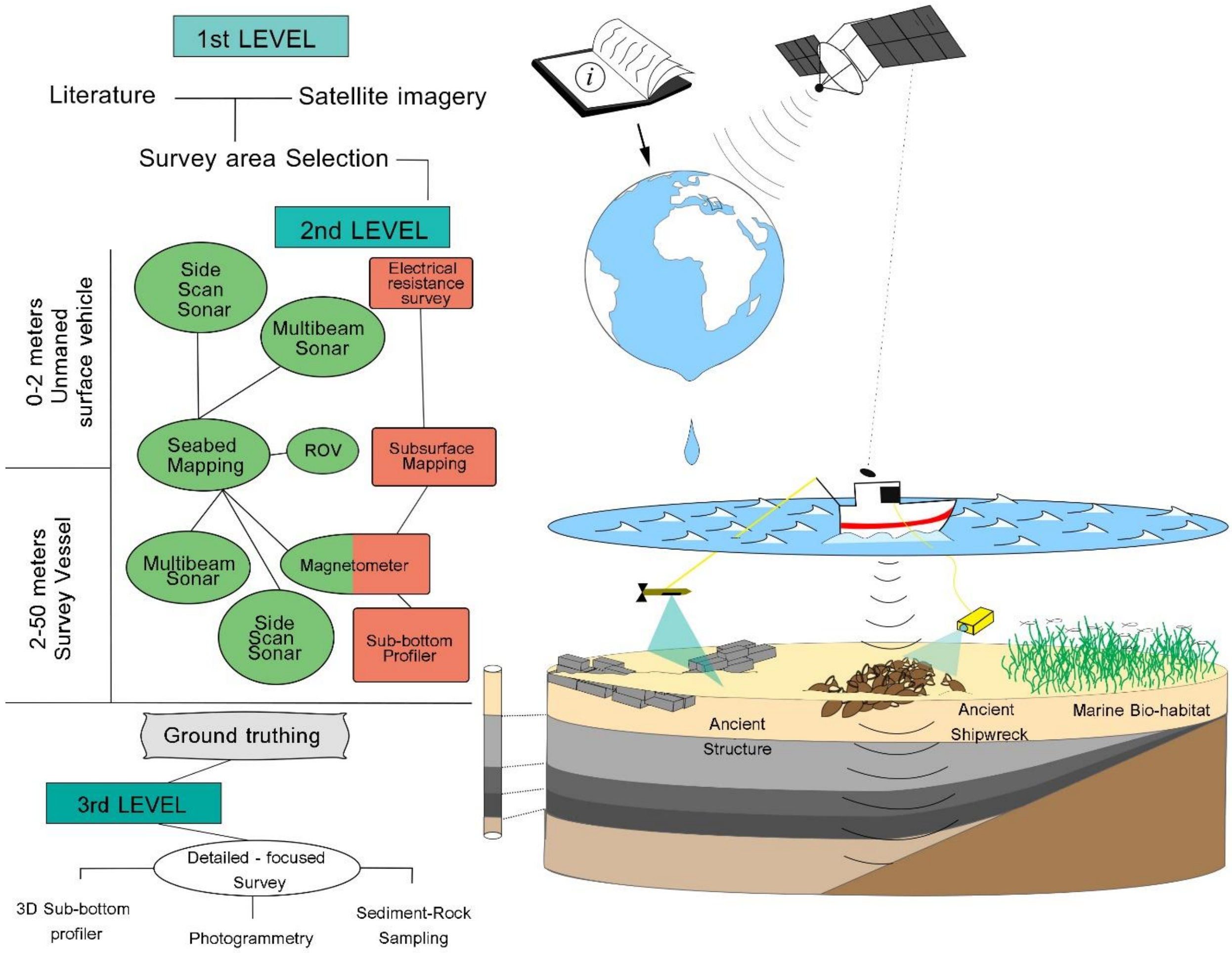

Figure 1. Methodological plan for the Detection and Mapping of Marine Priority Habitat Types and Submerged Antiquities.

2. Study Area

To validate our methodological approach, an area that holds great potential of including both elements (MPH and UCH), and that is under rapid development and anthropogenic intervention, is needed. For this purpose, the area of the Saronic Gulf (Figure 2), Greece, was appointed. Since prehistoric times, the islands of the Saronic Gulf were connected through a dense maritime route network as witnessed by more than a dozen submerged ancient installations, scattered all around the Saronic shoreline (Kenchreai, Epidaurus, Aegina (Figure 2b), Salamis (Figure 2c), Zea, Sounio, etc.) [43–47]. Nowadays, the Saronic Gulf is one of the busiest marine areas in the country, in terms of industrial, shipyard, and shipping activities, while it is the receptor of the capital city Athens and Piraeus sewage discharge. Especially the northern part of the Gulf, called Elefsina Bay, is among the most polluted areas in the country, affecting the fauna assemblage on the seafloor [48–50]. In order to evaluate the human impact on this area, studies have focused on examining the induced pollution through its accumulation into several benthic communities [49,51], and specifically in *P. oceanica* [16], and applying new desk-based techniques to evaluate and combine previous [52]. The research was also focused on the water circulation patterns [53,54], on the detection of alien species invading the gulf area [55], and in the benthic litter that constitutes a serious threat to the benthic environment [56]. However, according to the General Directorate of Sustainable Fisheries, the east coast of the Saronic Gulf and part of Aegina island belong to the areas of maximum priority as the percentage of bottom cover from the habitat of *P. oceanica* is of the order >35% per sq. km.

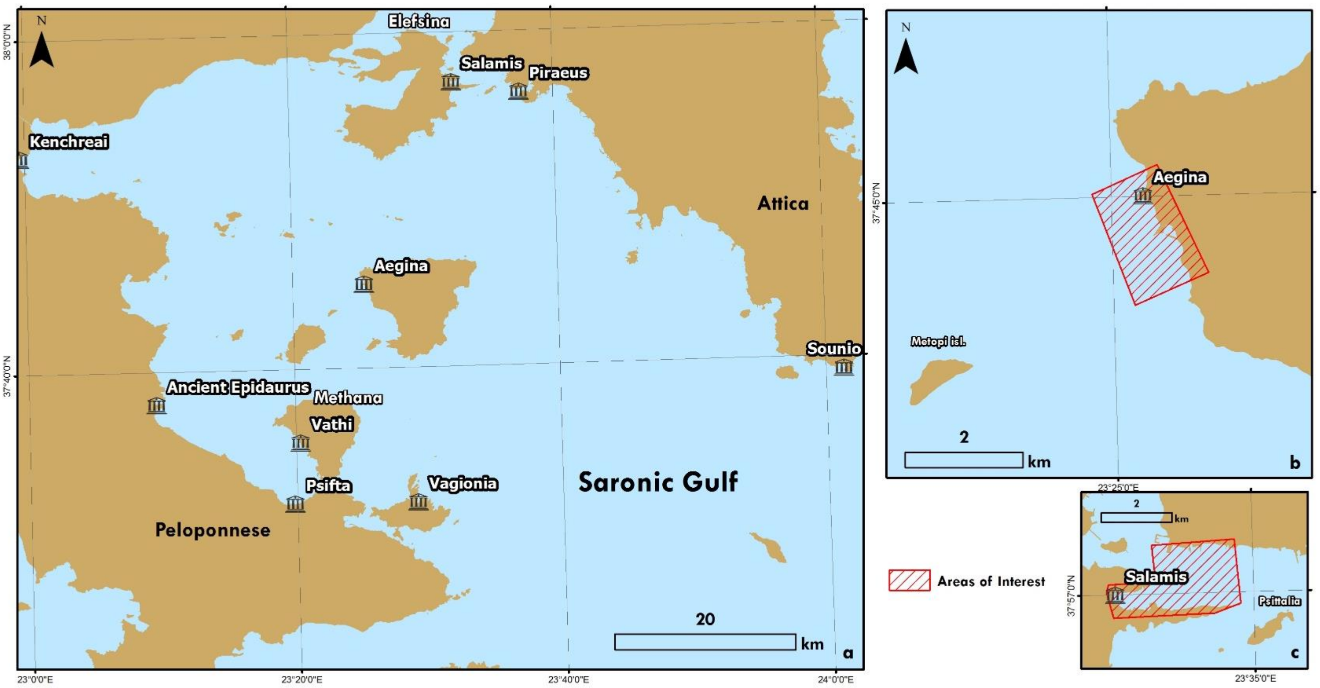

Figure 2. (**a**) Map showing the Saronic Gulf and the submerged archaeological findings around it and (**b**) the surveyed areas of Aegina and (**c**) Salamis.

3. Data and Methodological Approach

3.1. First Level of Information: Desk-Based Survey

The first step in the investigation of an area of great ecological or archaeological importance is the desk-based research, which aims in the collection of broad-scale data and information about the study area. This is achieved by studying previous scientific research and literature and collecting data from public access databases. The use of aerial photographs, satellite imagery and open access bathymetric data is also useful for the detection of shallow-water marine habitats and submerged antiquities [57,58].

Information regarding the geomorphological characteristics of the survey area (i.e., bathymetry, topography, landforms) can be acquired through the public access databases such as EMODnet, European Environment Agency, EU Science Hub, Copernicus, and GEBCO (Table 1). Geological information and tectonics can be acquired through the National Institutes of Geology since they are updated more often. An ongoing process of collecting data for marine habitats and submerged archaeological sites or landscapes have been performed by EMODnet lately, yet it is still in an early stage. Hence, for more detailed information, it is preferred to study the existing literature for the area of interest regarding the known submerged archaeological sites. Information for the location and extent of the marine habitats is usually supplied by each ministry responsible for their mapping and protection. Additionally, the first delimitation of shallow marine habitats (usually *P. oceanica* in the Mediterranean) can be performed by using satellite imagery [59–62] or aerial photos [18,63] (Table 1).

Through the manipulation of these data, a digital map can be created combining all the available information of different spatial resolutions. The evaluation of this multi-thematic map will result in mining areas of possible archaeological and also ecological interest, which will finally be selected for the implementation and accurate planning of the second and third levels of the proposed methodology.

Table 1. Instrumentation and means used for the establishment of the 1st level of the proposed methodological approach.

Information	Source	Resolution	e-link
Satellite Imagery	Google Earth	15 m	earth.google.com
	IKONOS Satellite	4 m multispectral/1 m panchromatic	earth.esa.int
	Spot5 Satellite	10 m multispectral/2,5 m fused	
	Sentinel 2	10–60 m	sentinel.esa.int
Geomorphology (bathymetry, elevation, sediment thickness etc.)	EMODnet, Copernicus, European Environment Agency, EU Science Hub, GEBCO	25–500 m	emodnet.ec.europa.eu, www.copernicus.eu (accessed on 5 August 2021), ec.europa.eu, gebco.net
Geology, Tectonics	Literature, National Databases	-	-
Seabed Habitats, Archaeological Sites	Literature, National Databases	-	-

3.2. Second Level of Information: Remote Sensing Survey

When the areas of interest are defined through the first level of the methodology and the survey area limits are defined, a marine remote sensing survey follows. This step is about defining and prospecting the survey areas through non-intrusive marine remote sensing techniques. Marine geophysics is used for mapping extensive areas of the seafloor with a great vertical and spatial resolution that fits the needs of the survey's goals, whether it is for mapping marine habitats, underwater archaeological sites, or a combination of them both, in a time-efficient and cost-effective way.

For the marine remote sensing survey, a research vessel properly equipped with modern-day sensors is needed. The vessel must always be equipped with a Multi-Beam Echosounder (MBES) for high-resolution bathymetrical surveying of the seafloor or/and a Single Beam Echosounder (SBES) mostly for MBES data verification, a Side-Scan Sonar (SSS) for the detection and mapping of the morphological features of the seafloor and targets lying on top, and a Sub-Bottom Profiler (SBP) for the detection of the geological bedrock, the estimation of the sediment thickness deposited in the survey area, and the detection of targets buried below the seafloor. Those sensors are the core of every marine remote sensing survey. More specifically:

- Research vessel and Navigation

The first step for starting the remote sensing survey is choosing the appropriate vessel. Traditional research vessels are, in most cases, too big to fit the needs of a remote sensing survey in shallow waters. The vessel must be agile and big enough to accommodate all of the equipment that will be used for surveying. The high-precision geographical location through GPS and the monitoring of the vessel's motion in three axes is of crucial importance. These are used for data georeferencing, the vessel's navigation and marine geophysical data correction. Conventional GPS systems have a precision of about 1m, which is too low for the goal of accurately mapping the seafloor and especially archaeological areas. Thus, a Differential GPS with a precision of a few decimeters and even better RTK GPS connected to GNSS receivers with a precision of some centimeters can be utilized (Table 2).

Table 2. Instrumentation and means used for the establishment of the 2nd level of the proposed methodological approach.

Instrument	Use	Characteristics	Resolution
SSS	Morphology/Target detection	Frequency 100–1000 kHz/Swath 5–200 m	10 cm
MBES	Bathymetry/Morphology	Frequency 300–455 kHz	Depth accuracy~1 cm
SBP	Stratigraphy/Target detection	Frequency 1–12 kHz/	30 cm (Vertical Res.)
Positioning	Vessel positioning and Data Georeference	-	GPS~1 m/DGPS~0.1 m/RTK GPS~0.01 m

- Seafloor marine geophysical survey

The base for any marine survey that aims to map marine habitats or submerged antiquities is a bathymetric map of high detail. MBES is the instrument used to achieve this. MBES consists of an array of multiple transducers that emits a fan-shaped pulse through multiple narrow beams. The frequency range of MBES systems is between 70 and 700 kHz. Higher frequencies produce a more detailed bathymetric map at the cost of swath range and lower depth limit. A high-frequency MBES system in shallow water can achieve up to 1 bathymetric point per 5 cm^2. MBES systems are also used for mapping geomorphological features of the seafloor through backscatter analysis of the echoes. Mapping of underwater biological communities through MBES is considered one of the most effective techniques as it has been applied in many different cases [64–66], such as detecting *P. oceanica* meadows [67–69] and coralligenous formations [70]. In marine geoarchaeology, the MBES is now a basic tool for mapping submerged landscapes and delimiting ancient submerged structures or shipwrecks [71,72].

For the mapping of the seafloor's acoustic properties, the SSS is the most appropriate instrument [73]. SSS is an underwater acoustic sensor that creates 2D images of the sea surface and the objects lying on top of it. This is conducted by emitting acoustic pulses in high frequency and recording the reflected echo of it. The interpretation of the echo is based on: (a) the strength, where a higher backscatter intensity corresponds to a hard bottom or surface (i.e., geological outcrop or a wreck) and a lower backscatter intensity represents soft substrate (fine-grained sediments), and (b) the time difference between the emitted pulse and the recorded reflection of it (the bigger the delay the furthest the pulse has reached from the sonar) [74]. The frequency range of it is between 100 and 1000 kHz. SSS offers higher resolution with higher frequencies that are traded with a lower scanning range. For high-resolution general archaeological surveying, the standard range is 40 m and 10–15 m for site-specific surveying [11]. SSS is regarded as the most efficient tool for the detection and mapping of habitats. *P. oceanica* meadow is a habitat that has been thoroughly investigated through SSS [75–78] for mapping its extent or evaluating its ecological status. SSS is even more important for the mapping of coralligenous formation due to the depth that most of these formations are found [17,26,34,79–81]. Modern-day remote sensing surveying considers the simultaneous use of both MBES and SSS a must, and this is why integrated systems that are able to supply bathymetric and backscatter intensity data simultaneously have been developed. The technological advancements in the construction of these sensors make it possible to operate both, if not even more (SBP and magnetometer), simultaneously in USVs [80,82] and AUVs. With this, it is possible to reduce the survey time and cost to the bare minimum while maintaining high-resolution mapping. Similarly, the SSS offers marine geo-archaeologists the possibility to map great areas in minimum time and discover submerged archaeological sites, shipwreck remains of naval battles, or submerged landscapes regardless of visibility and environmental conditions [83,84].

- Substrate marine geophysical survey

Remote sensing surveying is not limited to the sea bottom surface. Using the SBP, information can be gathered for the sediment accumulation at the area of interest, the detection of the geological bedrock, and, most importantly, of objects buried inside the sediment. The SBP emits low-frequency vertical acoustic pulses of a conical shape, which penetrate the seafloor. The echo is reflected in the layers of the different sediment properties (acoustic impedance). The stronger the reflected echo, the more compact the sediment layer. The profile created through this is interpreted based on their continuity, sharpness, distinctiveness, and amplitude [85]. SBP is widely used in marine geo-archaeology for the reconstruction of paleogeography and the detection of buried features of archaeological interest [32,35,86]. SBP, while crucial to the detection of underwater antiquities, is not so widely used for mapping benthic habitats. This is mostly because most of these habitats are growing as a layer on top of the seabed with a great spatial extent. Recent studies have focused on the detection of different habitats through SBP sonograph analysis and for the evaluation of the substrate where the habitats are developed [34,70]. In addition, seismic profiles proved useful for calculating the *P. oceanica* seagrass matte height and estimating the carbon sink size in the Mediterranean [87,88].

- Seabed Classification

The ultimate aim of the detection and mapping of submerged habitats and antiquities is to produce simple seafloor classification maps that will constitute the base of the Marine Spatial Planning maps. All of the maps produced in the second level of information can then be validated using both manual and automatic seafloor classification methods. Lately, a lot of classification software products have been developed for classifying acoustic or image data [34,67,89,90] through object-based image analysis, geostatistical analysis, and machine learning. The manual or "expert" classification contains the scientists' manual delimitation of areas based on the different backscatter intensity, the morphological characteristics, its validation through ground-truthing techniques, and their experience on their interpretation. The most trustworthy methodology so far is the combination of all the available means—the use of the existing automatic classification software and thereafter the manual validation of the results produced.

For the classification of the acquired data, we used: (i) the Benthic Terrain Modeler [89] software for the classification of the benthic environment based on the bathymetric position index, slope, and terrain ruggedness; (ii) the TargAn image segmentation software [90] was used for the delimitation of the archaeological targets. An image of the bathymetric slope was used as input where areas with specific characteristics, controlled by the user, were outlined. The results from these two methodologies were combined with the "expert" classification results, resulting in the delimitation of the areas covered by *P. oceanica* and those related to archaeological findings (Figure 5). The final classification map was validated using ground-truthing techniques, as described in the third level of information.

3.3. Third Level of Information: In-depth Inspection and 3D Mapping

The third level of the methodology aims to acquire data with maximum vertical and spatial resolutions from the areas of interest ("hotspots"). These "hotspots" were derived after the findings of the second level of the methodological scheme and the classification of the acoustic data using manual and automatic techniques. To acquire data of maximum resolution, a high-quality inspection of these sites should be performed via visual, acoustic, or sampling means. The means presented in this methodological part are dependent on the nature of each "hotspot". The two broad "hotspot" categories distinguished are those: (a) lying on the seafloor and (b) buried under the sediments.

The "hotspots" detected lying on the seafloor can be visually inspected through remotely operated vehicles (ROVs) that are equipped with HD and/or action cameras, laser scalers, small grabbers, and ultra-short baseline acoustic positioning system (USBL) [91,92]. With this equipment installed on the ROV, researchers can capture high-quality footage of the site at every possible angle, place measuring scales on site, measure targets, or perform a small sampling while knowing the position of the ROV underwater at all times. In the post-process, the visual data collected can be used to create accurate 3D models of the site through photogrammetry (structure from Motion (SfM) and MultiView Stereo

(MVS) techniques). SfM-MVS merges photogrammetric principles with advances in 3D computer vision algorithms [93]. A set of overlapping photographs of the study area is required as input data. The use of ROVs, especially in deep waters, decreased the operational risk since the presence of divers underwater is now optional for these tasks. By these visual means, the biological status of marine habitats, such as corals [94] can be assessed while regarding the submerged antiquities' level of preservation and possibly assessing their age [95]. Unmanned surface vehicles (USVs) have also been used for photogrammetric and bathymetric purposes in shallow areas that are not accessible by boat to map submerged antiquities [96], and they can also be used for bathymetric mapping in shallow waters. In the case that "hotspots" are detected in extremely shallow waters or they are a continuation from the land towards the sea (semi-submerged), a very detailed combined elevation and bathymetry can be acquired by using airborne remote sensing techniques, such as Laser Imaging Detection and Ranging (LiDAR) systems and UAVs, which are able to produce detailed bathymetric data of high quality [97]. Their application has been growing recently, using them for the detection of archaeological features [98,99] and seagrass mapping [60,100].

In the second category, the inspection of sites buried under the sediments cannot be achieved via visual means unless an excavation is preceded. The first non-intrusive approach to a buried site is to use a 3D sub-bottom profiler and acquire a dense grid of data [101]. This cutting-edge technology gives the researchers the ability to acquire seismic profiles from very shallow areas (<-0.5 m) and create a 3D cube of seismic data with a resolution of a few centimeters. By using sophisticated 3D software, researchers are able in post-process to "slice" the cube in all directions and reveal the information needed.

Another non-intrusive method to detect submerged (ferromagnetic) antiquities under the sediments is the magnetometer. Magnetometers can map the Earth's magnetic field and the magnetic anomalies created by the presence of ferromagnetic buried targets. It is usually used to detect metallic objects, yet, ancient anthropogenic constructions and habitation ruins can also be detected [102]. A less often used method is electromagnetic surveying which uses electromagnetic signals for the detection of conductive objects. Acquisition of magnetic and electromagnetic data is operated by towing the equipment behind a research vessel while performing a grid of track lines with spacing less than double the size of the selected target [103].

Apart from excavation, another intrusive and less destructive method of sampling a site is coring. Cores are natural archives of earth and human history. Coring can be performed via using a gravity, hammer, or piston corer to vertically sample a sedimentary sequence. Depending on the sediment texture and permeability, researchers can retrieve up to a maximum of 16 m of undisturbed sediment [104]. In this way, multiple sedimentary analyses can be performed to study the sedimentation rate of the area, paleo-climatology (via various proxies), sea-level change, and environmental biota changes. To unravel the information hidden inside the microcosm of the core, an extended series of analyses can be performed. Important core scanning non-destructive techniques include X-ray radiography and computerized tomography (CT), X-ray fluorescence analysis (XRF), etc. Using X-ray radiography and CT, it is possible to visualize core internal structures (that are visible due to the density difference and atomic composition), fractures, and general physical properties of the core in 3D [105,106]. Paleo-climatic variations can be reconstructed by studying the chemical composition of sediment archives. This can be achieved by using X-ray fluorescence (XRF) core scanning. XRF counts the major and trace elements, and by calculating the ratios of different elements, it is possible to understand the paleoclimatic factors that affected the environment over a great timescale [107].

Intrusive techniques include the most important dating techniques (^{137}Cs, ^{14}C, ^{210}Pb, Th^{230}, Optically Stimulated Luminescence (OSL)) that are essential for the establishment of the sedimentation rate, and they are powerful tools when combined with other analyses. More traditional techniques for paleo-climatic information include microfossil analysis (geochemical proxies, total organic carbon (TOC), total nitrogen (TN), lipid biomarkers, etc.), palynology, and isotopes ($\delta^{18}O$, $\delta^{13}C$) These techniques can supply scientists with important information for paleoenvironmental reconstruction. In addition, currently evolving techniques such as environmental-DNA (e-DNA) analysis can help scientists to record alterations in the environment and the organisms living in it. When combined with dating analysis it is feasible to reproduce paleo-environmental and paleo-biotic changes in time and, as a result, track the evolution and adaptation of organisms [108].

4. Results and Analysis

4.1. Implementation of the First Level: Desk-Based Survey

Data regarding the broader area of the Saronic Gulf were collected to build a map that summarizes all the available information for our survey area. The Saronic Gulf is the northwestern end of the South Aegean Active Volcanic Arc. The mountainous environment surrounding it is responsible for the formation of the central NS-oriented bathymetric plateau with a 90-meter maximum depth, which connects the island of Salamis with those of Aegina and Methana. Due to this plateau and the NS extensional back-arc tectonism, the Saronic Gulf is segmented into eastern and western parts that form four basins: Megara, Epidavros, Salamis, and Aegina basins with a maximum depth of 220 m, 421 m, 98 m, and 226 m, respectively (Figure 3). The enclosed Saronic Gulf bounded by the Attica and Peloponnese peninsulas offered protection from the extreme wave and wind conditions of the Aegean, while the spatial distribution of the islands offered an easy connection between them in antiquity. For these reasons, the gulf is surrounded by ancient submerged coastal facilities all along its shoreline. At least nine submerged archaeological sites are reported in the literature [43,45,47,101], which extend from the southwestern to the southeastern capes of the Saronic gulf (Vagionia, Vathi, Psifta, Ancient Epidaurus, Aegina, Kenchreai, Salamis, Piraeus-Zea-Mounichia, Sounio). The seafloor geomorphology and oceanographic setting favored the development of extended seagrass fields (*P. oceanica*) at the eastern part of the gulf and the island of Aegina. The data derived from the Hellenic Ministry of Agricultural Development and Food were disseminated as maps of tiles, with a dimension of 1×1 km, with each tile presenting the percentage of coverage of the seafloor with *P. oceanica* (red: over 35%; green: 25–35%; yellow: 5–25%). *P. oceanica* meadows in the Saronic gulf are only found to the north and west coast of Aegina island, and an even bigger extent is mapped at the west coast of the Attica Peninsula (Figure 3). The absence of *P. oceanica* at the western part of the gulf is probably linked to the geomorphological characteristics of the coast, such as the steep seafloor that prohibits the development of extended seagrass fields. In the northern part, at the area of Elefsina, the anthropogenic intervention that caused marine pollution is the main factor responsible for the sparse life on the seafloor [109–112].

By interpreting the final map, the two candidate areas fulfilling the criteria (existence of both ecological and archaeological features) for the implementation of the second and third levels (Figure 3) were those of the coastal zone of Aegina and that of Sounio in south Attica. The area of interest in Sounio has been extensively surveyed in the frameworks of the SASMAP project [11,47]. Thus, the main area used for the methodology implementation is that of the coastal zone of Aegina city, in Aegina island, where one of the biggest *P. oceanica* fields in the Saronic Gulf is apparent. The seafloor at the west coast of Aegina is covered by 35% per sq. km by the priority habitat *P. oceanica*. This seagrass field is accompanied by an ancient submerged archaeological harbor complex, which is of utmost archaeological importance since it contributed to the dominance of the Aegineans in the naval and trading field from ~1800 to 459 BC [113]. Aegina fulfills all the criteria needed for implementing both the second and third levels of our proposed integrated methodological plan. Finally, an additional area was used to present only new practices for the detection of buried features under the seabed. This area is the gulf of Ampelakia in Salamis island (north Saronic), where an ancient harbor, which is believed to have served as the Greek naval base before the crucial win against the Persians, was recently discovered [114]. Salamis island is a heavily affected area by human activities, as some of the largest shipyards in Greece have been functioning there in the last few decades; thus, the bay lacks the presence of marine habitats.

Even if the area does not fulfill both criteria needed for our methodological approach, both the second and third research levels were implemented, but only specific new practices were selected to be presented at the third level of the methodological approach (Section 4.3). The results from the second level of the methodology are presented extensively in the book *Salamis 480 B*.C (pp. 392–411) [101].

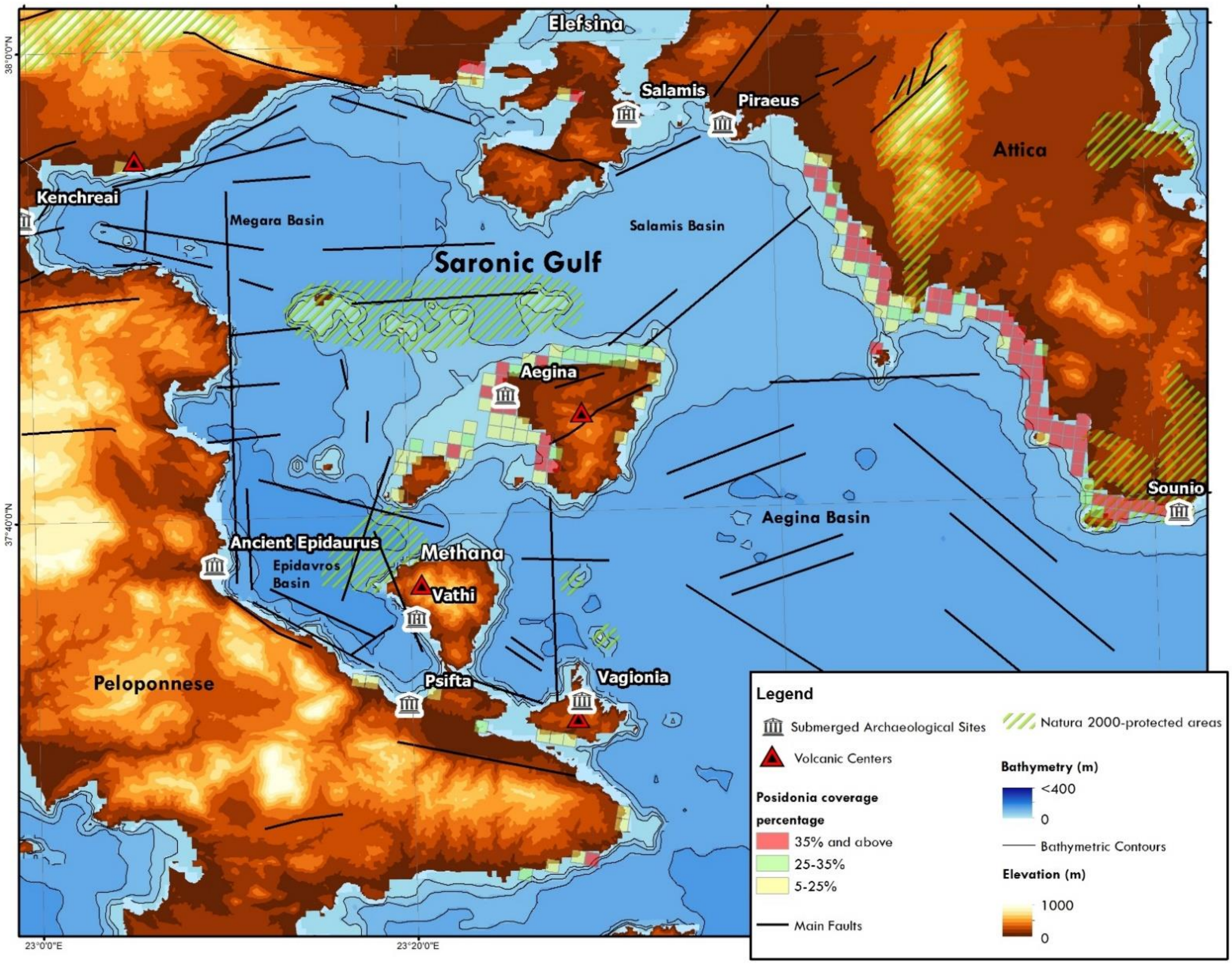

Figure 3. The final product of the 1st level of the methodological approach is a map summarizing all the available information.

4.2. Implementation of the Second Level: Remote Sensing Survey

For the implementation and testing of the second level of the downscale approach, the area of the Aegina harbor was selected (Figure 4a). The vessel used for the survey was modified to perform the survey and carry the whole of the instrument array (Table 3). The design of the survey lines was conducted through the Hypack 2014 navigation software. The line plan consisted of two parts: (a) one with lines parallel to the shoreline with a spacing of 40 m (Figure 4b) and, when needed, (b) one with lines perpendicular to the shoreline with a spacing of 80 m. These two track line plans, in conjunction with the swath range of the SSS being 100 m and MBES ground range of 150m, allowed full coverage of the area with sufficient overlap between 25 and 50%, with each successive line to achieve the best data resolution. The RTK GPS Emlid Reach was utilized for the vessel positioning and the IMU-108 Motion Sensor for recording its three-axis movement. For the bathymetric survey, the ITER Systems BathySwath1 interferometric MBES was deployed. The Edgetech 4200 SP SSS was used for the morphological survey and target detection, while for the stratigraphic evaluation, sediment thickness accumulation, and the detection of buried targets, the Kongsberg GeoPulse Plus SBP was operated.

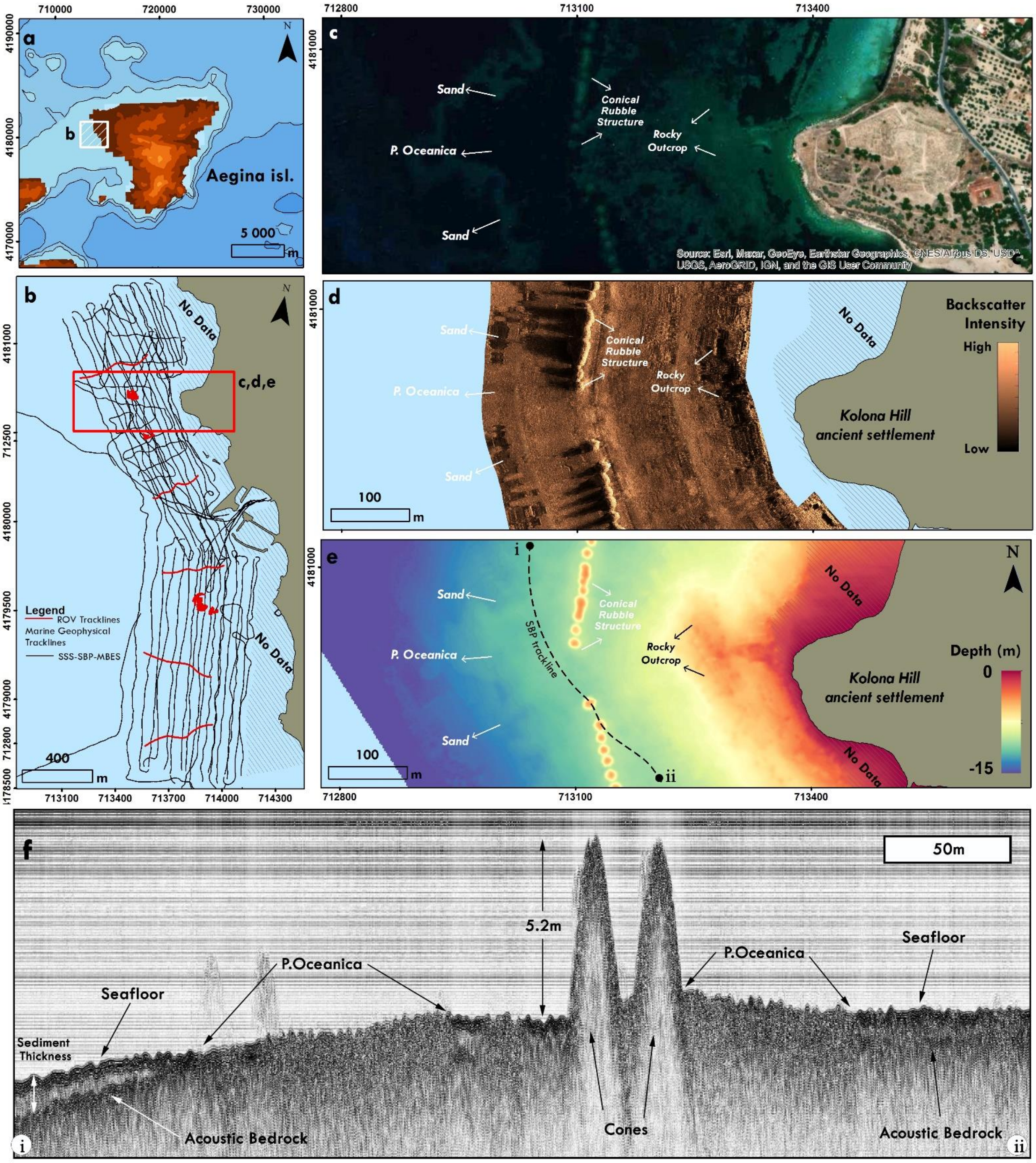

Figure 4. (**a**) Area of interest: Aegina island; (**b**) surveyed area using marine geophysical equipment (Aegina city coastal zone); (**c**) example from the satellite imagery showing the two criteria needed for the proposed methodology: marine habitat (*P. oceanica*) and submerged archaeological findings (conical rubble structures); (**d**) example of the SSS backscatter intensity from the same area; (**e**) MBES bathymetry and location of the seismic profile in (**f**); (**f**) seismic profile as derived from the SBP.

Table 3. The marine remote sensing techniques applied and their specifications.

Instrument	Type	Deployment	Specs	Resolution
ITER Systems BathySwath1	MBES	Over the Side	Depth Range 50 m/ Beams 126/Beam width 1.5°/Frequency 234 kHz	Depth accuracy of ~2 cm
Edgetech 4200 SP	SSS	Towed	Frequency 100 and 400 kHz (Simultaneously operated with Chirp Technology)/Swath Range 25–500 m/Depth Rating 2000 m/Beam Width 1.5° @100 kHz and 0.4° @ 400 khz	Across track resolution of 8 cm @100 kHz and 2 cm at 400 kHz
Kongsberg GeoPulse Plus	SBP	Over the Side	Transducers 4/Frequency 1.5–18 kHz (Chirp technology)/Pulse Length down 1 mS- Penetration 80 m@ Clay, 6 m @ Coarse Sand	Penetration 80 m @ Clay, 6 m @ Coarse Sand/Vertical down to 6 cm

The marine remote sensing survey in the Aegina coastal zone yielded several new pieces of information about the submerged antiquities and the extent of the *P. oceanica* fields. The bathymetry of the coastal area is characterized by smooth inclination, and the deepest surveyed depth was 15 m (Figure 4e) at a distance of 800 m from the coast. The seabed is mostly covered by *P. Oceanica* seagrass and sandy sediments, while rocky outcrops are especially apparent close to the shore (Figure 4d,e). The extent of the *P. Oceanica* field is between 1 m and 15 m water depth. The densest field was recorded at the northern part of the area, where its deep limit was not recorded as the field extends in greater depths. This seagrass is observed in the backscatter mosaic (Figure 4d) as areas of medium to high backscatter intensity, while the sandy parts of the seafloor are of low backscatter intensity. *P. oceanica* appears in the seismic profile as areas of chaotic reflections that acoustically mask the subsurface (Figure 4f). The sediment thickness of the area is derived by the digitization of the seafloor and the acoustic bedrock (Figure 4f).

Through the SSS survey, the submerged antiquities of the area were mapped in high detail. The archaeological findings consist of conical rubble structures, part of which is shown in Figure 4d. These structures are constructed parallel to the shoreline in depths ranging between 8.5 and 10.1 m. The whole site is about 1.6 km in length and extends up to 250 m from the coast. The sediment thickness of the area is between 0–5 m, and the thickest part is located in the southern area, while the area close to the shoreline is the one with the least accumulated sediment. While no buried targets of archaeological value were found in the area, several pieces of new information, such as the morphometric characteristics, were extracted for the conical rubble structures [115]

- Seafloor Classification

The Benthic Terrain Modeler [89] (BTM) software was used to classify the benthic environment based on the bathymetric data and the seafloor geomorphic derivatives (i.e., bathymetric position index, slope, aspect, and ruggedness) (Figure 5a). BTM contributed to the broader delimitation of the seagrass *P. oceanica*, the rocky outcrops, and the archaeological remains. The detailed delimitation of the archaeological remains was performed through seafloor segmentation. The bathymetric slope was converted to a greyscale image and was processed in the TargAn software for segmentation. The software segmented the image into areas by detecting the image's strong and weak edges. TargAn proved highly efficient in their detection (Figure 5b) and was also used for the extraction of the seafloor parameters. However, areas that were affected by anthropogenic activities (i.e., dredging) complexed the seafloor segmentation process and resulted in their inclusion in the possible archaeological areas. To avoid this biased result, these two methodologies were combined and were evaluated based on the "expert" classification (manual), where the *P. oceanica* seagrass, the rocky and sandy seafloor, and submerged antiquities were classified based on the acoustic data interpretation (i.e., backscatter intensity, bathymetry, seismic profiling). The combined classification techniques resulted in the creation of a detailed classification map where the submerged antiquities, the seagrass *P. Oceanica*, and the seafloor texture were defined (Figure 5c).

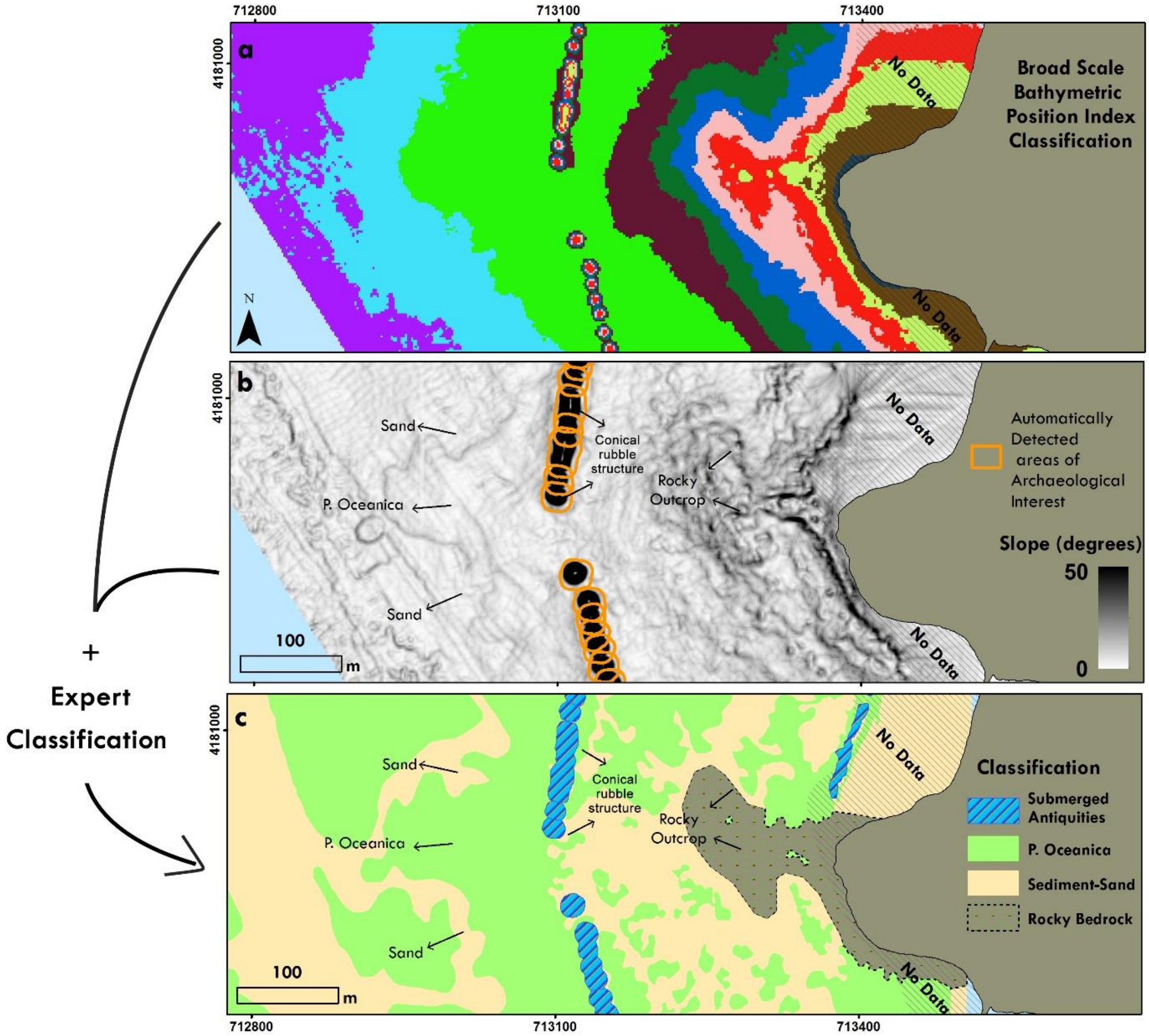

Figure 5. (**a**) Seafloor classification using the Benthic Terrain Modeler software (BTM) [89]; (**b**) automatic detection of possible archaeological targets using TargAn software [67]; (**c**) final classification map after validation with expert classification.

4.3. Implementation of the Third Level: In-Depth Inspection and 3D Mapping

- ROV Ground-truthing and Photogrammetry

To perform a high-quality visual inspection of the areas of interest, so-called "hotspots", which were mapped on the seafloor, the filming of a small part of a well-shaped conical rubble structure was performed. For the accurate inspection of the cone, a remotely operated vessel (ROV) was deployed. The ROV was always equipped with a USBL acoustic positioning system. At first, a ground-truthing survey was performed, which confirmed the existence of the rubble structures and that of the seagrass *P. oceanica* (Figure 6a,b). A carbon fiber tube was installed at the front part of the ROV, where three action cameras were screwed onto it (Figure 6c). The two side cameras were placed at a 30° angle on the Y-axis and 45° on the X-axis so that they both focus on the front and center view. The middle camera was also inclined 30° on the Y-axis, while it remained oriented to the front. The cameras were synchronized and set to record high-quality videos (1920 × 1080 pix) to acquire footage from three different cameras and three different angles. In this way, a very dense set of overlapping photographs was collected. The post-processing of the data collected was performed using Agisoft Metashape (www.agisoft.com, accessed on 5 August 2021) software, where 3D models were constructed [116,117] (Figure 6d). The photogrammetric survey revealed the size of the stones and was used to calculate the number of rocks needed for the cone construction.

Figure 6. (**a**,**b**) Ground-truthing survey showing the existence of the archaeological findings and the seagrass *P. oceanica*; (**c**) ROV equipped with three action cameras used for the ground-truthing and photogrammetric survey; (**d**) 3D model of the rubble cone as derived from the photogrammetric survey.

- 3D Sub-bottom Profiler

Since no buried targets were detected at the area of Aegina, an example of the use of the 3D SBP in the Saronic Gulf was selected to be presented for this part of the methodology from the island of Salamis, Ampelakia bay, where the ancient port of Salamis was found [101]. It is supported that this is where Greek naval forces gathered before the naval battle against the Persians in 480 B.C. [114]. An extended network of survey lines was performed at the bay of Ampelakia with a spacing of 5 m, while, at the areas where submerged features were detected, the lines were densified down to 1 m of spacing. In the following example, the top view of two selected targets found within the 1 m interval grid is presented (Figure 7). These two cubes consist of sub-bottom seismic data that were interpolated using sophisticated 3D interpolation software (Voxler©). The red colors represent the high backscatter intensity, the green is medium, and the blue represents low. The two targets are placed at a distance of 30 m and are of different geometries. Target A is located south of Target B, and it is buried at −1 m below the seafloor at a depth of −2.8 m and is fringe-shaped. The maximum length (*Y*-axis) is 14 m, and the maximum width is 7 m (*X*-axis). Target B is at a distance of 40 m NW from Target A, and it is buried at the same depth. It has a triangular shape, a maximum thickness of 0.5 m, and a depth of −2.8 m. Its length reaches 12 m and has a width of 8 m. The reflectivity of Target B is slightly lower.

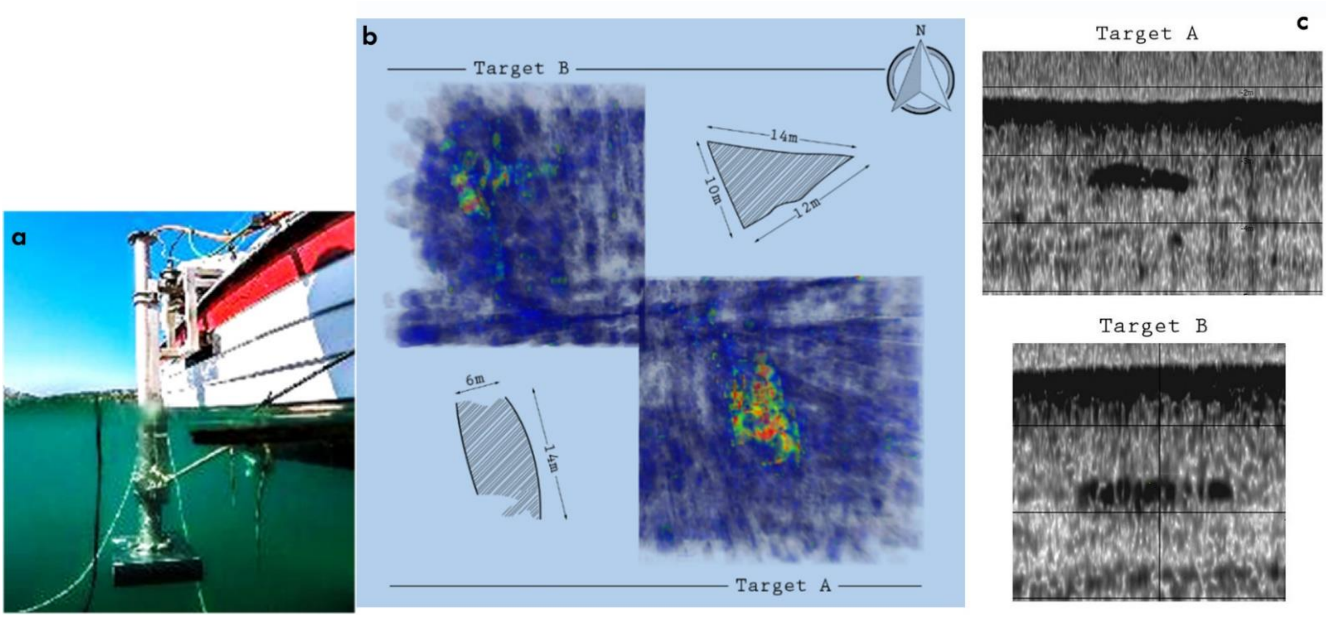

Figure 7. (**a**) 3D sub-bottom profiler installed over the side; (**b**) top view of 3D seismic data from two buried targets of potential archaeological interest; (**c**) seismic profiles of Targets A and B. (modified after Salamis 480 B.C. book) [114].

- Sediment sampling

In the same area of Salamis, Ampelakia bay, at a close distance to "Target A", a 1.2 m length sediment core was acquired from the seabed. For this operation, a hammer-type corer was used by professional divers at a depth of 2.2 m (Figure 8a). The sediment core was carefully retrieved on land, where e-DNA samples were retrieved right after the core was retrieved. e-DNA constitutes a great tool in paleoecology. Sediment is a natural repository of the earth's and humans' history. After the e-DNA sampling, the core was moved to the sedimentology laboratory for further sampling and analysis. At first, the core was measured and scanned in order to make a photomosaic of it. Then, a detailed macroscopic description of the core was performed. In the macroscopic description, features such as the color of the sediment were described using a Munsell color swatch book, while an estimate of the grain size (cobbles, sand, silt) and grain size distribution (sorting: poor, medium, well) was described. In addition, an extended description of the biogenic material (size, kind, presence, etc.) and bioturbation was made (Figure 8b). This first part of the core description is very important since it provides the first pieces of information about the stratigraphy of the area and also shows the depths where transitions or abrupt events altered the sedimentary regime.

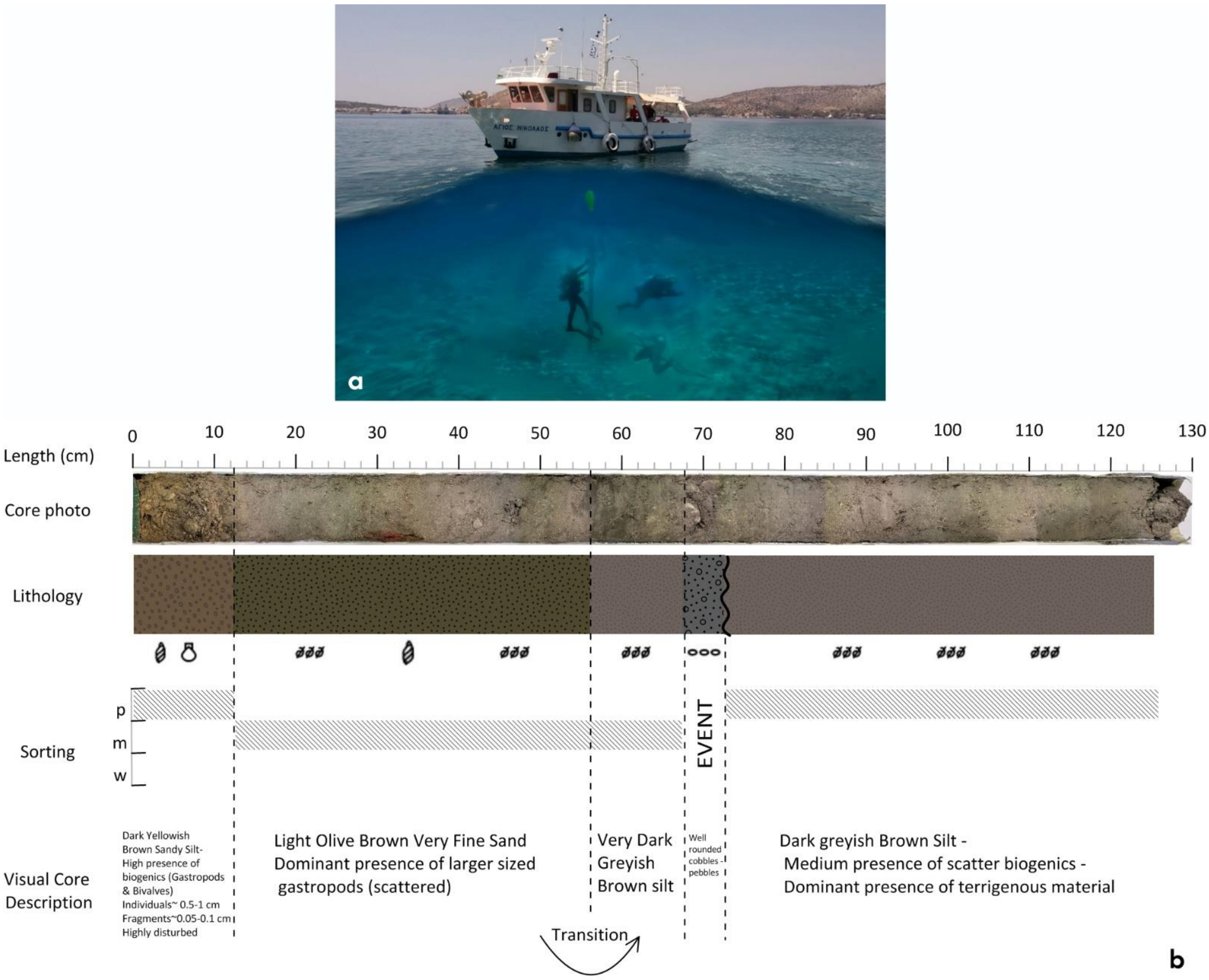

Figure 8. (**a**) Sediment core acquired using diver-operated hammer coring system and (**b**) core visual description.

5. Discussion

5.1. Marine Spatial Planning

The first objective of the proposed methodological plan is to create a multi-leveled and multi-thematic geodatabase that will allow users to correlate, join and combine datasets of different spatial analyses and information. These datasets include information regarding the seafloor, such as morphology (bathymetry, slope, backscatter intensity), the stratigraphy and composition of the substrate, the extent, type, and ecological assessment of marine priority habitats, and, to add to that, the extent and morphological characteristics of the archaeological findings (coastal-submarine).

After that, these data should be assembled in a univocal and easy-to-read map by the stakeholders and decision-makers. Therefore, a proposed marine spatial planning map was developed for the Saronic Gulf and was categorized based on already existing plans [118–121] adjusted to the modern needs of the society and ecological objectives [122] (Figure 9). It appears that the Saronic Gulf is a multifaceted area that contains a great amount of tourist/recreation areas and aquacultures even though it is heavily affected by marine pollution from the Attica peninsula, the most densely populated area of Greece. However, the presence of *P. oceanica* habitats is limited to the island of Aegina and the east part of the Saronic Gulf, while the areas of submerged underwater cultural heritage are also abundant. By focusing on the two areas surveyed, it was possible to observe the consequences of the lack of the implementation of marine spatial planning. In the area of the coastal zone of Aegina, the passenger vessels' route is crossing on top of shallow archaeological structures. This has damaged part of the archaeological site in front of the modern harbor, where water turbulence and mechanical disturbance from the passing-by vessels have wrecked them [115] (Figure 9c). In the northern part of the Saronic Gulf, which is heavily affected by marine pollution, the *P. oceanica* fields are not apparent [109–112]. At the area of Ampelakia Bay, Salamis (Figure 9b), the archaeological site is bounded to the east by shipyards during the last decades, risking the viability of the site and contributing to marine pollution.

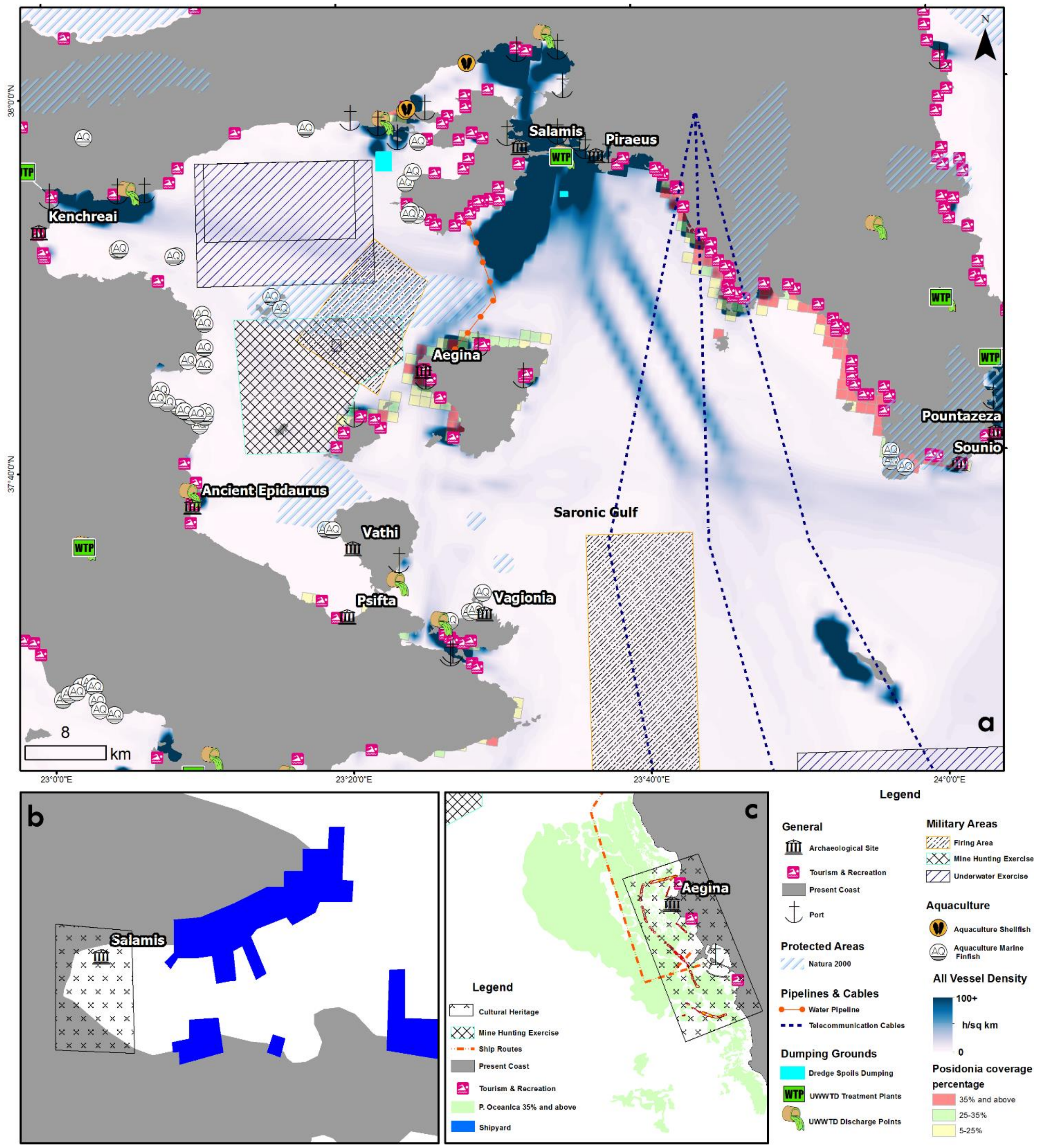

Figure 9. (**a**) Marine spatial planning (MSP) map of the Saronic Gulf; (**b**,**c**) MSP maps of the Salamina and Aegina surveyed areas.

The rising human activities and resource exploitation has increased pressure on the coastal zone and the marine environment. For this reason, the delimitation of areas including priority habitats and cultural heritage is essential. Stakeholders and decision-makers should be aware of the resources' spatial extent in order to plan a sustainable future that will allow the balanced management of sea resources' exploitation and nature's cultural heritage preservation. With the implementation of the proposed methodology, it is possible to perform marine spatial planning (MSP) and supply the local community with information for the establishment of an integrated coastal zone management plan (ICZM) [123]. Maritime and coastal cultural heritage is generally protected; however, cultural resources have been neglected in integrated coastal management plans thus far [10]. The development of holistic management plans is not universal and common for all countries, yet it has been found that marine spatial plans should be adjusted to the needs and resources of each area [124]. For instance, the Greek and the Mediterranean coastline, in general, contain an enormous part of human history that is of utmost importance to be preserved and available for educational and recreational purposes. This coastal and underwater wealth cannot be ignored from marine spatial planning since it constitutes a vital part of our history [10].

5.2. Open Challenges

The proposed methodological approach presents many advantages in mapping both MPH and UCH but also limitations that remain open as future challenges.

- Extremely shallow waters

Marine geophysics is an essential tool in offshore coastal mapping, yet its efficiency is restricted up to specific depths. In extremely shallow waters, where archaeological remains are primarily apparent, including many marine priority habitats, the acquisition and interpretation of acoustic data are much more complicated, even in perfect weather conditions [38]. Recently, this gap has been efficiently covered by using cost-effective USVs equipped with sonars especially for extremely shallow waters or with underwater cameras that can be used to produce detailed 3D models through photogrammetry [125–127]. To add to that, more efficient tools for mapping in very shallow waters are airborne systems, such as LIDARs [97,128,129], drones [117,130], and satellite images [131]. By using laser or imagery, researchers can produce highly accurate maps/3D models and fill the "white ribbon" zone between the offshore and onshore coastal parts. These are considered unique tools for connecting the offshore with onshore findings, without the need to merge different Digital Elevation Models, acquired through different instrumentation, while they are considered much more efficient than acoustics in very shallow waters [132].

The detection of buried features under the sediment and especially those of smaller sizes still remains a challenge for researchers since sub-bottom profilers are not able to work efficiently above the depth of 1 m. For this reason, electrical resistivity tomography has been used to map the extremely shallow buried archaeological remains with great success [133–135].

- Integrated Multi-Frequency Systems and Seafloor Classification

The advance in Multi-beams (MBES), Side-Scan Sonars (SSS), and ROVs have facilitated large-scale seafloor mapping compared to the classic surveying techniques (i.e., sample collection) that provided detailed information but only for a small area [136,137]. The integrated MBES and SSS systems allow the simultaneous acquisition of accurate backscatter intensity and bathymetric data, which can be corrected through the use of RTK GPS and motion sensors. In addition, the use of multi-frequency systems in a single vessel pass proved very efficient in marine habitat mapping [67] since it increased the accuracy of the seabed classification.

Lately, there is increasing interest in automated classification, especially in the detection of marine priority habitats, such as object-based image analysis (OBIA), geostatistical analysis, and machine learning methods [138–140]. These modern methodologies now have similar results with the "expert" classification, and they allow the repeating and unbiased classification [136]. However, "expert" classification is a common and trustworthy approach that is still a prerequisite for the evaluation of automated classification results. Automatic detection and classification of submerged archaeological remains are not so common [36] among geoscientists since it was a challenging task in previous years [141]. However, in the current article, the TargAn image analysis software proved highly efficient in their detection using the seafloor slope parameter.

A future challenge in seafloor automatic detection software is the creation of an all-inclusive software that will be able to combine acoustic data (backscatter intensity, bathymetry, and seismic profiles) and produce real-time seafloor classification maps (or probability classification maps) that will allow scientists to make decisions on the field.

6. Conclusions

To achieve sustainable coastal zone development and simultaneously protect the marine environment in times of increasing anthropogenic pressure, local stakeholders and decision-makers must be aware of the biological and cultural wealth that is hidden underwater. For this reason, we propose a time- and cost-effective methodological approach for its detection and detailed mapping. The downscale methodological approach consists of three methodological axes of increasing spatial resolution:

(i) Desk-based research: The desk-based research contributed to the establishment of a multi-thematic digital database created from online databases and literature, which contains all the available information regarding the broader area of interest. It contains geomorphological data (elevation, bathymetry, geology, tectonics, paleoshores, etc.), already known areas containing marine priority habitats, and submerged archaeological findings. The evaluation of this multi-thematic map will result in mining areas of possible archaeological and also ecological interest for further analysis.

(ii) Marine geophysics/Seafloor classification: The selected areas were further surveyed using marine geophysical means, resulting in the establishment of geomorphological maps of the coastal area (i.e., bathymetric, acoustic backscatter intensity, stratigraphy). Automatic combined with "expert" seafloor classification techniques produced a multi-thematic map where the different seafloor classes (sand, rock, seagrass, submerged antiquities) were outlined.

(iii) In-depth visual inspection/3D mapping: The outlined seafloor classes were validated using ground-truthing techniques (ROV). Photogrammetric techniques were used for the detailed 3D reconstruction of archaeological features, while 3D seismic profiling revealed the geometric characteristics of buried features under the seafloor.

The methodology proposed can be used to set the basis of the Integrated Coastal Zone Management (ICZM) and Marine Spatial Planning (MSP) strategies as it produces the necessary information for their establishment. It combines existing and new techniques that proved successful in the detection and mapping of marine habitats and submerged antiquities. The MSP map constructed for the Saronic Gulf demonstrated the lack of holistic coastal zone management plans due to impacts on UCH linked to anthropogenic intervention in the Aegina coastal zone and the sparsity of marine habitats owing to marine pollution in the broader area of Salamis.

Author Contributions: Conceptualization, all authors; methodology, all authors; software, N.G. and X.D.; validation, all authors; investigation, all authors; data curation, N.G.; writing—original draft preparation, N.G. and X.D.; writing—review and editing, N.G. and G.P.; visualization, N.G.; supervision, G.P.; project administration, G.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research is co-financed by Greece and the European Union (European Social Fund-ESF) through the Operational Programme «Human Resources Development, Education and Lifelong Learning 2014-2020» in the context of the project "EnAktea: Integrated Methodological Approach for the Detection & Mapping of Marine Priority Habitats and Submerged Antiquities" -Gn. 504717.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The authors would like to thank the two anonymous reviewers for their contribution to the manuscript; Elias Fakiris, Dimitris Christodoulou, Maria Geraga, and George Ferentinos for their valuable help in the data acquisition; Kostantinos Merkouris for the interpretation of the photogrammetric data, and Giannos Lolos, Christina Marabea and Myrto Michalis for their valuable help and excellent cooperation in the Salamis project.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Jiménez-Illescas, Á.R.; Zayas-Esquer, M.M.; Espinosa-Carreón, T.L. Chapter 9—Integral Management of the Coastal Zone to Solve the Problems of Erosion in Las Glorias Beach, Guasave, Sinaloa, Mexico. In *Coastal Management, Global Challenges and Innovations*; Krishnamurthy, R.R., Jonathan, M.P., Srinivasalu, S., Glaeser, B.B.T.-C.M., Eds.; Academic Press: Cambridge, MA, USA, 2019; pp. 141–163. [CrossRef]
2. Sevilla, N.P.M.; Adeath, I.A.; le Bail, M.; Ruiz, A.C. Chapter 3—Coastal Development: Construction of a Public Policy for the Shores and Seas of Mexico. In *Coastal Management, Global Challenges and Innovations*; Krishnamurthy, R.R., Jonathan, M.P., Srinivasalu, S., Glaeser, B.B.T.-C.M., Eds.; Academic Press: Cambridge, MA, USA, 2019; pp. 21–38. [CrossRef]
3. Steven, A.; Appeaning Addo, K.; Llewellyn, G.; Thanh Ca, V.; Boateng, I.; Bustamante, R.; Doropoulos, C.; Gillies, C.; Hemer, M.; Lopes, P.; et al. *Coastal Development: Resilience, Restoration and Infrastructure Requirements Lead Authors About the High Level Panel for a Sustainable Ocean Economy*; World Resources Institute: Washington, DC, USA, 2020.
4. Lirman, D.; Ault, J.S.; Fourqurean, J.W.; Lorenz, J.J. Chapter 17—The Coastal Marine Ecosystem of South Florida, United States. In *World Seas: An Environmental Evaluation*, 2nd ed.; Academic Press: Cambridge, MA, USA, 2019; pp. 427–444. [CrossRef]
5. ICOMOS. *Heritage at Risk: Underwater Cultrual Heritage at Risk*; ICOMOS: Charenton-le-Pont, France, 2006; p. 132.
6. Georgiou, N.; Fakiris, E.; Koutsikopoulos, C.; Papatheodorou, G.; Christodoulou, D.; Dimas, X.; Geraga, M.; Kapellonis, Z.G.; Vaziourakis, K.-M.; Noti, A.; et al. Spatio-Seasonal Hypoxia/Anoxia Dynamics and Sill Circulation Patterns Linked to Natural Ventilation Drivers, in a Mediterranean Landlocked Embayment: Amvrakikos Gulf, Greece. *Geosciences* **2021**, *11*, 241. [CrossRef]
7. Antonioli, F.; De Falco, G.; Lo Presti, V.; Moretti, L.; Scardino, G.; Anzidei, M.; Bonaldo, D.; Carniel, S.; Leoni, G.; Furlani, S.; et al. Relative Sea-Level Rise and Potential Submersion Risk for 2100 on 16 Coastal Plains of the Mediterranean Sea. *Water* **2020**, *12*, 2173. [CrossRef]
8. Scardino, G.; De Giosa, F.; D'Onghia, M.; Demonte, P.; Fago, P.; Saccotelli, G.; Valenzano, E.; Moretti, M.; Velardo, R.; Capasso, G.; et al. The Footprints of the Wreckage of the Italian Royal Navy Battleship Leonardo Da Vinci on the Mar Piccolo Sea-Bottom (Taranto, Southern Italy). *Oceans* **2020**, *1*, 7. [CrossRef]
9. Anzidei, M.; Doumaz, F.; Vecchio, A.; Serpelloni, E.; Pizzimenti, L.; Civico, R.; Greco, M.; Martino, G.; Enei, F. Sea Level Rise Scenario for 2100 A.D. in the Heritage Site of Pyrgi (Santa Severa, Italy). *J. Mar. Sci. Eng.* **2020**, *8*, 64. [CrossRef]
10. Khakzad, S.; Pieters, M.; van Balen, K. Coastal cultural heritage: A resource to be included in integrated coastal zone management. *Ocean Coast. Manag.* **2015**, *118*, 110–128. [CrossRef]
11. Gregory, D.J. Development of tools and techniques to survey, assess, stabilise, monitor and preserve underwater archaeological sites: Sasmap. *Int. J. Heritage Stud.* **2012**, *1*, 367–371. [CrossRef]
12. Ricca, M.; Alexandrakis, G.; Bonazza, A.; Bruno, F.; Davidde Petriaggi, B.; Elkin, D.; Lagudi, A.; Nicolas, S.; Novák, M.; Papatheodorou, G.; et al. A Sustainable Approach for the Management and Valorization of Underwater Cultural Heritage: New Perspectives from the TECTONIC Project. *Sustainability* **2020**, *12*, 5000. [CrossRef]
13. Giakoumi, S.; Sini, M.; Gerovasileiou, V.; Mazor, T.; Beher, J.; Possingham, H.P.; Abdulla, A.; Çinar, M.E.; Dendrinos, P.; Gucu, A.C.; et al. Ecoregion-Based Conservation Planning in the Mediterranean: Dealing with Large-Scale Heterogeneity. *PLoS ONE* **2013**, *8*, e76449. [CrossRef] [PubMed]
14. Gibson, R.N.; Atkinson, R.J.A.; Gordon, J.D.M.; Ballesteros, E. Mediterranean Coralligenous Assemblages: A Synthesis of Present Knowledge. *Oceanogr. Mar. Biol.* **2006**, *44*, 123–195.
15. Sini, M.; Katsanevakis, S.; Koukourouvli, N.; Gerovasileiou, V.; Dailianis, T.; Buhl-Mortensen, L.; Damalas, D.; Dendrinos, P.; Dimas, X.; Frantzis, A.; et al. Assembling Ecological Pieces to Reconstruct the Conservation Puzzle of the Aegean Sea. *Front. Mar. Sci.* **2017**, *4*, 1–22. [CrossRef]
16. Gerakaris, V.; Panayotidis, P.; Vizzini, S.; Nicolaidou, A.; Economou-Amilli, A. Effectiveness of *Posidonia oceanica* biotic indices for assessing the ecological status of coastal waters in the Saronikos Gulf (Aegean Sea, Eastern Mediterranean). *Mediterr. Mar. Sci.* **2003**, *4*, 57–66. [CrossRef]
17. Geraga, M.; Papatheodorou, G.; Agouridis, C.; Kaberi, H.; Iatrou, M.; Christodoulou, D.; Fakiris, E.; Prevenios, M.; Kordella, S.; Ferentinos, G. Palaeoenvironmental implications of a marine geoarchaeological survey conducted in the SW Argosaronic gulf, Greece. *J. Archaeol. Sci. Reports.* **2017**, *12*, 805–818. [CrossRef]
18. Pasqualini, V.; Pergent-martini, C.; Clabaut, P.; Pergent, G. Mapping of *Posidonia oceanica* using Aerial Photographs and Side Scan Sonar: Application off the Island of Corsica (France). *Estuar. Coast. Shelf Sci.* **1998**, *47*, 359–367. [CrossRef]

19. De Falco, G.; Baroli, M.; Cucco, A.; Simeone, S. Intrabasinal conditions promoting the development of a biogenic carbonate sedimentary facies associated with the seagrass *Posidonia oceanica*. *Cont. Shelf Res.* **2008**, *28*, 797–812. [CrossRef]
20. Gacia, E.; Duarte, C.M. Sediment retention by a Mediterranean *Posidonia oceanica* meadow: The balance between deposition and resuspension. *Estuar. Coast. Shelf Sci.* **2001**, *52*, 505–514. [CrossRef]
21. Buia, M.C.; Zupo, V.; Mazzella, L. Primary Production and Growth Dynamics in *Posidonia oceanica*. *Mar. Ecol.* **1992**, *13*, 2–16. [CrossRef]
22. Gacia, E.; Duarte, C.M.; Middelburg, J.J. Carbon and nutrient deposition in a Mediterranean seagrass (*Posidonia oceanica*) meadow. *Limnol. Oceanogr.* **2002**, *47*, 23–32. [CrossRef]
23. Gobert, S.; Cambridge, M.T.; Velimirov, B.; Pergent, G.; Lepoint, G.; Bouquegneau, J.M.; Dauby, P.; Pergent-Martini, C.; Walker, D.I. Biology of Posidonia. In *Seagrasses: Biology, Ecology and Conservation*; Springer: Dordrecht, The Netherlands, 2006. [CrossRef]
24. Corriero, G.; Pierri, C.; Mercurio, M.; Nonnis Marzano, C.; Onen Tarantini, S.; Gravina, M.F.; Lisco, S.; Moretti, M.; De Giosa, F.; Valenzano, E.; et al. A Mediterranean mesophotic coral reef built by non-symbiotic scleractinians. *Sci. Rep.* **2019**, *9*, 3601–3610. [CrossRef]
25. Martin, S.; Charnoz, A.; Gattuso, J.P. Photosynthesis, respiration and calcification in the Mediterranean crustose coralline alga Lithophyllum cabiochae (Corallinales, Rhodophyta). *Eur. J. Phycol.* **2013**, *48*, 163–172. [CrossRef]
26. Georgiadis, M.; Papatheodorou, G.; Tzanatos, E.; Geraga, M.; Ramfos, A.; Koutsikopoulos, C.; Ferentinos, G. Coralligène formations in the eastern Mediterranean Sea: Morphology, distribution, mapping and relation to fi sheries in the southern Aegean Sea (Greece) based on high-resolution acoustics. *J. Exp. Mar. Biol. Ecol.* **2009**, *368*, 44–58. [CrossRef]
27. Rovere, A.; Stocchi, P.; Vacchi, M. Eustatic and Relative Sea Level Changes. *Curr. Clim. Chang. Rep.* **2016**, *2*, 221–231. [CrossRef]
28. Lambeck, K.; Yokoyama, Y.; Purcell, T. Into and out of the Last Glacial Maximum: Sea-level change during Oxygen Isotope Stages 3 and 2. *Quat. Sci. Rev.* **2002**, *21*, 343–360. [CrossRef]
29. Benjamin, J.; Rovere, A.; Fontana, A.; Furlani, S.; Vacchi, M.; Inglis, R.H.; Galili, E.; Antonioli, F.; Sivan, D.; Miko, S.; et al. Late Quaternary sea-level changes and early human societies in the central and eastern Mediterranean Basin: An interdisciplinary review. *Quat. Int.* **2017**, *449*, 29–57. [CrossRef]
30. Bailey, G. World Prehistory from the Margins: The Role of Coastlines in Human Evolution. *J. Interdiscip. Stud. Hist. Archaeol.* **2004**, *1*, 39–50.
31. Bailey, G.N.; Flemming, N.C. Archaeology of the continental shelf: Marine resources, submerged landscapes and underwater archaeology. *Quat. Sci. Rev.* **2008**, *27*, 2153–2165. [CrossRef]
32. Geraga, M.; Papatheodorou, G.; Ferentinos, G.; Fakiris, E.; Christodoulou, D.; Georgiou, N.; Dimas, X.; Iatrou, M.; Kordella, S.; Sotiropoulos, G.; et al. The study of an ancient shipwreck using marine remote sensing techniques, in Kefalonia Island (Ionian Sea), Greece. *Archaeol. Marit. Mediterr.* **2015**, *12*, 183–200.
33. Papatheodorou, G.; Geraga, M.; Chalari, A.; Christodoulou, D.; Iatrou, M.; Ferentinos, G. Hellenistic Alexandria: A palaeogeographic reconstruction based on marine geophysical data. In *Alexandria under Mediterranean*; CEAlex: Alexandria, Egypt, 2015.
34. Fakiris, E.; Zoura, D.; Ramfos, A.; Spinos, E.; Georgiou, N.; Ferentinos, G.; Papatheodorou, G. Object-based classification of sub-bottom profiling data for benthic habitat mapping. Comparison with sidescan and RoxAnn in a Greek shallow-water habitat. *Estuar. Coast. Shelf Sci.* **2018**, *208*, 219–234. [CrossRef]
35. Geraga, M.; Christodoulou, D.; Eleftherakis, D.; Papatheodorou, G.; Fakiris, E.; Dimas, X.; Georgiou, N.; Kordella, S.; Prevenios, M.; Iatrou, M.; et al. Atlas of Shipwrecks in Inner Ionian Sea (Greece): A Remote Sensing Approach. *Heritage* **2020**, *3*, 67. [CrossRef]
36. Ferentinos, G.; Fakiris, E.; Christodoulou, D.; Geraga, M.; Dimas, X.; Georgiou, N.; Kordella, S.; Papatheodorou, G.; Prevenios, M.; Sotiropoulos, M. Optimal sidescan sonar and subbottom profiler surveying of ancient wrecks: The 'Fiskardo' wreck, Kefallinia Island, Ionian Sea. *J. Archaeol. Sci.* **2020**, *113*, 105032. [CrossRef]
37. Ferentinos, G.; Gkioni, M.; Geraga, M.; Papatheodorou, G. Early seafaring activity in the southern Ionian Islands, Mediterranean Sea. *J. Archaeol. Sci.* **2012**, *39*, 2167–2176. [CrossRef]
38. Galanidou, N.; Dellaporta, K.; Sakellariou, D. Greece: Unstable landscapes and underwater archaeology. *Coast. Res. Libr.* **2020**, *35*, 371–392. [CrossRef]
39. Harvati, K.; Röding, C.; Bosman, A.M.; Karakostis, F.A.; Grün, R.; Stringer, C.; Karkanas, P.; Thompson, N.C.; Koutoulidis, V.; Moulopoulos, L.A.; et al. Apidima Cave fossils provide earliest evidence of Homo sapiens in Eurasia. *Nature* **2019**, *571*, 500–504. [CrossRef] [PubMed]
40. Theodoulou, T. A Brief Review of Underwater Archaeological Research in Greece. Available online: https://www.slideshare.net/AfroditiGoudeli/ariande-17-2011013084theotokistheodoulou (accessed on 5 October 2021).
41. De Giosa, F.; Scardino, G.; Vacchi, M.; Piscitelli, A.; Milella, M.; Ciccolella, A.; Mastronuzzi, G. Geomorphological Signature of Late Pleistocene Sea Level Oscillations in Torre Guaceto Marine Protected Area (Adriatic Sea, SE Italy). *Water* **2019**, *11*, 2409. [CrossRef]
42. Krause-Jensen, D.; Serrano, O.; Apostolaki, E.T.; Gregory, D.J.; Duarte, C.M. Seagrass sedimentary deposits as security vaults and time capsules of the human past. *Ambio* **2019**, *48*, 325–335. [CrossRef]
43. Loy, M. The islands of the Saronic Gulf: Connections & cultural histories. *Archaeol. Rep.* **2020**, *66*, 161–172. [CrossRef]

44. Tartaron, T.F.; Tzortzopoulou-Gregory, L.; Pullen, D.J.; Dill, A.; Dunn, R.K.; Boyce, J.I. The Saronic harbors archaeological research project (SHARP): Investigations at Mycenaean Kalamianos, 2007–2009. *Hesperia J. Am. Sch. Class. Stud. Athens* **2011**, *80*, 559–634. [CrossRef]
45. Kolaiti, E.; Mourtzas, N.D. Upper Holocene sea level changes in the West Saronic Gulf, Greece. *Quat. Int.* **2016**, *401*, 71–90. [CrossRef]
46. Mourtzas, N.D.; Kolaiti, E. Historical coastal evolution of the ancient harbor of Aegina in relation to the Upper Holocene relative sea level changes in the Saronic Gulf, Greece. *Palaeogeogr. Palaeoclim. Palaeoecol.* **2013**, *392*, 411–425. [CrossRef]
47. Papatheodorou, G.; Geraga, M.; Christodoulou, D.; Iatrou, M.; Fakiris, E.; Heath, S.; Baika, K. A marine geoarchaeological survey, cape Sounion, Greece: Preliminary results. *Mediterr. Archaeol. Archaeom.* **2014**, *14*, 357–371.
48. Valavanidis, A.; Vlachogianni, T.; Triantafillaki, S.; Dassenakis, M.; Androutsos, F.; Scoullos, M. Polycyclic aromatic hydrocarbons in surface seawater and in indigenous mussels (*Mytilus galloprovincialis*) from coastal areas of the Saronikos Gulf (Greece). *Estuar. Coast. Shelf Sci.* **2008**, *79*, 733–739. [CrossRef]
49. Orfanidis, S.; Panayotidis, P.; Stamatis, N. Ecological evaluation of transitional and coastal waters: A marine benthic macrophytes-based model. *Mediterr. Mar. Sci.* **2001**, *2*, 45–66. [CrossRef]
50. Zenetos, A.; Simboura, N.; Panayotidis, P. *Effects of Sewage on the Distribution of Benthic Fauna in the Saronikos Gulf (Greece)*; National Centre for Marine Research: Hellenikon, Greece, 1994.
51. Simboura, N.; Zenetos, A.; Pancucci-Papadopoulou, M.A. Benthic community indicators over a long period of monitoring (2000–2012) of the Saronikos Gulf, Greece, Eastern Mediterranean. *Environ. Monit. Assess.* **2014**, *186*, 3809–3821. [CrossRef] [PubMed]
52. Pavlidou, A.; Simboura, N.; Pagou, K.; Assimakopoulou, G.; Gerakaris, V.; Hatzianestis, I.; Panayotidis, P.; Pantazi, M.; Papadopoulou, N.; Reizopoulou, S.; et al. Using a holistic ecosystem-integrated approach to assess the environmental status of Saronikos Gulf, Eastern Mediterranean. *Ecol. Indic.* **2018**, *96*, 336–350. [CrossRef]
53. Helmis, C.G.; Papadopoulos, K.H.; Kalogiros, J.A.; Soilemes, A.T.; Asimakopoulos, D.N. Influence of background flow on evolution of saronic gulf sea breeze. *Atmos. Environ.* **1995**, *29*, 3689–3701. [CrossRef]
54. Belibassakis, K.A.; Karathanasi, F.E. Modelling nearshore hydrodynamics and circulation under the impact of high waves at the coast of Varkiza in Saronic-Athens Gulf. *Oceanologia* **2017**, *59*, 350–364. [CrossRef]
55. Zenetos, A.; Ovalis, P.; Giakoumi, S.; Kontadakis, C.; Lefkaditou, E.; Mpazios, G.; Simboura, N.; Tsiamis, K. Saronikos gulf: A hotspot area for alien species in the mediterranean sea. *Bioinvasions Rec.* **2020**, *9*, 873–889. [CrossRef]
56. Ioakeimidis, C.; Papatheodorou, G.; Fermeli, G.; Streftaris, N.; Papathanassiou, E. Use of ROV for assessing marine litter on the seafloor of Saronikos Gulf (Greece): A way to fill data gaps and deliver environmental education. *SpringerPlus* **2015**, *4*, 463. [CrossRef]
57. Baeye, M.; Quinn, R.; Deleu, S.; Fettweis, M. Detection of shipwrecks in ocean colour satellite imagery. *J. Archaeol. Sci.* **2016**, *66*, 1–6. [CrossRef]
58. Davis, D.S.; Buffa, D.C.; Wrobleski, A.C. Assessing the Utility of Open-Access Bathymetric Data for Shipwreck Detection in the United States. *Heritage* **2020**, *3*, 22. [CrossRef]
59. Pasqualini, V.; Pergent-Martini, C.; Pergent, G.; Agreil, M.; Skoufas, G.; Sourbes, L.; Tsirika, A. Use of SPOT 5 for mapping seagrasses: An application to *Posidonia oceanica*. *Remote Sens. Environ.* **2005**, *94*, 39–45. [CrossRef]
60. Rende, S.F.; Bosman, A.; Di Mento, R.; Bruno, F.; Lagudi, A.; Irving, A.D.; Dattola, L.; Di Giambattista, L.; Lanera, P.; Proietti, R.; et al. Ultra-high-resolution mapping of *Posidonia oceanica* (L.) delile meadows through acoustic, optical data and object-based image classification. *J. Mar. Sci. Eng.* **2020**, *8*, 647. [CrossRef]
61. Topouzelis, K.; Makri, D.; Stoupas, N.; Papakonstantinou, A.; Katsanevakis, S. Seagrass mapping in Greek territorial waters using Landsat-8 satellite images. *Int. J. Appl. Earth Obs. Geoinf.* **2018**, *67*, 98–113. [CrossRef]
62. Fornes, A.; Basterretxea, G.; Orfila, A.; Jordi, A.; Alvarez, A.; Tintore, J. Mapping *Posidonia oceanica* from IKONOS. *ISPRS J. Photogramm. Remote Sens.* **2006**, *60*, 315–322. [CrossRef]
63. Leriche, A.; Pasqualini, V.; Bernard, G.; Bonhomme, P.; Clabaut, P.; Denis, J. Spatial, temporal and structural variations of a *Posidonia oceanica* seagrass meadow facing human activities. *Aquat. Bot.* **2006**, *84*, 287–293. [CrossRef]
64. Kruss, A.; Wiktor, J.; Wiktor, J.; Tatarek, A. Acoustic detection of macroalgae in a dynamic Arctic environment (Isfjorden, West Spitsbergen) using multibeam echosounder. *J. Acoust. Soc. Am.* **2019**, *141*, 4004. [CrossRef]
65. Pratson, L.F.; Edwards, M.H. Introduction to advances in seafloor mapping using sidescan sonar and multibeam bathymetry data. *Mar. Geophys. Res.* **1996**, *18*, 601–605. [CrossRef]
66. Hughes Clarke, J.E.; Mayer, L.A.; Wells, D.E. Shallow-water imaging multibeam sonars: A new tool for investigating seafloor processes in the coastal zone and on the continental shelf. *Mar. Geophys. Res.* **1996**, *18*, 607–629. [CrossRef]
67. Fakiris, E.; Blondel, P.; Papatheodorou, G.; Christodoulou, D.; Dimas, X.; Georgiou, N.; Kordella, S.; Dimitriadis, C.; Rzhanov, Y.; Geraga, M.; et al. Multi-frequency, multi-sonar mapping of shallow habitats-efficacy and management implications in the National Marine Park of Zakynthos, Greece. *Remote Sens.* **2019**, *11*, 461. [CrossRef]
68. Viala, C.; Lamouret, M.; Abadie, A. Seafloor classification using a multibeam echo sounder: A new rugosity index coupled with a pixel-based process to map Mediterranean marine habitats. *Appl. Acoust.* **2021**, *179*, 108067. [CrossRef]

69. Di Maida, G.; Tomasello, A.; Luzzu, F.; Scannavino, A.; Pirrotta, M.; Orestano, C.; Calvo, S.; Di Maida, G.; Tomasello, A.; Luzzu, F.; et al. Discriminating between *Posidonia oceanica* meadows and sand substratum using multibeam sonar. *ICES J. Mar. Sci.* **2011**, *68*, 12–19. [CrossRef]
70. Savini, A.; Basso, D.; Bracchi, V.A.; Corselli, C.; Pennetta, M. Maerl-bed mapping and carbonate quantification on submerged terraces offshore the Cilento peninsula (Tyrrhenian Sea, Italy). *Geodiversitas* **2012**, *34*, 77–98. [CrossRef]
71. Westley, K.; Plets, R.; Quinn, R. Holocene Paleo-Geographic Reconstructions of the Ramore Head Area, Northern Ireland, Using Geophysical and Geotechnical Data: Paleo-Landscape Mapping and Archaeological Implications. *Geoarchaeology* **2014**, *29*, 411–430. [CrossRef]
72. Plets, R.; Quinn, R.; Forsythe, W.; Westley, K.; Bell, T.; Benetti, S.; McGrath, F.; Robinson, R. Using Multibeam Echo-Sounder Data to Identify Shipwreck Sites: Archaeological assessment of the Joint Irish Bathymetric Survey data. *Int. J. Naut. Archaeol.* **2011**, *40*, 87–98. [CrossRef]
73. Bates, C.R.; Lawrence, M.; Dean, M.; Robertson, P. Geophysical Methods for Wreck-Site Monitoring: (RASSE) programme. *Int. J. Naut. Archaeol.* **2011**, *40*, 404–416. [CrossRef]
74. Blondel, P. *Handbook of Sidescan Sonar*; Springer Praxis; Springer: Cham, Switzerland, 2009.
75. Fakiris, E.; Papatheodorou, G.; Geraga, M.; Patsourakis, M.; Ferentinos, G.; Kiparissis, S.; Kapareliotis, A.; Ramfos, A.; Trifonopoulos, G.; Kornaros, M.; et al. Mapping of P. Oceanica meadows using Side-scan and seafloor classification system (Texturean): Case studies of Laganas and Alikes Bays (Zakinthos Island, Greece). In Proceedings of the 9th Symposium on Oceanography & Fisheries, Patra, Greece, 13–16 May 2009; pp. 128–133.
76. Kiparissis, S.; Fakiris, E.; Papatheodorou, G.; Geraga, M.; Kornaros, M.; Kapareliotis, A.; Ferentinos, G. Illegal trawling and induced invasive algal spread as collaborative factors in a *Posidonia oceanica* meadow degradation. *Biol. Invasions* **2011**, *13*, 669–678. [CrossRef]
77. Montefalcone, M.; Giovannetti, E.; Morri, C.; Peirano, A.; Bianchi, C.N. Flowering of the seagrass *Posidonia oceanica* in the NW Mediterranean: Is there a link with solar activity? *Mediterr. Mar. Sci.* **2013**, *14*, 416–423. [CrossRef]
78. Sánchez-carnero, N.; Rodríguez-pérez, D.; Couñago, E.; Aceña, S.; Freire, J. Using vertical Sidescan Sonar as a tool for seagrass cartography. *Estuar. Coast. Shelf Sci.* **2012**, *115*, 334–344. [CrossRef]
79. Collier, J.S.; Humber, S.R. Time-lapse side-scan sonar imaging of bleached coral reefs: A case study from the Seychelles. *Remote Sens. Environ.* **2007**, *108*, 339–356. [CrossRef]
80. Bonacorsi, M.; Pergent-Martini, C.; Clabaut, P.; Pergent, G. Coralligenous 'atolls': Discovery of a new morphotype in the Western Mediterranean Sea. *Comptes Rendus Biol.* **2012**, *335*, 668–672. [CrossRef]
81. Sañé, E.; Ingrassia, M.; Chiocci, F.L.; Argenti, L.; Martorelli, E. Characterization of rhodolith beds-related backscatter facies from the western Pontine Archipelago (Mediterranean Sea). *Mar. Environ. Res.* **2021**, *169*, 105339. [CrossRef]
82. Schimel, A.C.G.G.; Healy, T.R.; Johnson, D.; Immenga, D. Quantitative experimental comparison of single-beam, sidescan, and multibeam benthic habitat maps. *ICES J. Mar. Sci.* **2010**, *67*, 1766–1779. [CrossRef]
83. Drap, P.; Papini, O.; Merad, D.; Pasquet, J.; Royer, J.P.; Motasem Nawaf, M.; Saccone, M.; Ben Ellefi, M.; Chemisky, B.; Seinturier, J.; et al. Deepwater Archaeological Survey: An Interdisciplinary and Complex Process. *Coast. Res. Libr.* **2019**, *31*, 135–153. [CrossRef]
84. Gambin, T. Side Scan Sonar and the Management of Underwater Cultural Heritage. In *Future Preparedness: Thematic and Spatial Issues for the Environment and Sustainability*; University of Malta: MSIDA, Malta, 2014; pp. 259–270.
85. Damuth, J.E. Use of high-frequency (3.5–12 kHz) echograms in the study of near-bottom sedimentation processes in the deep-sea: A review. *Mar. Geol.* **1980**, *38*, 51–75. [CrossRef]
86. Papatheodorou, G.; Geraga, M.; Christodoulou, D.; Fakiris, E.; Iatrou, M.; Georgiou, N.; Dimas, X.; Ferentinos, G. The Battle of Lepanto Search and Survey Mission (1971–1972) by Throckmorton, Edgerton and Yalouris: Following Their Traces Half a Century Later Using Marine Geophysics, Remote Sensing. *Remote Sens.* **2021**, *13*, 3292. [CrossRef]
87. Monnier, B.; Pergent, G.; Mateo, M.Á.; Carbonell, R.; Clabaut, P.; Pergent-Martini, C. Sizing the carbon sink associated with *Posidonia oceanica* seagrass meadows using very high-resolution seismic reflection imaging. *Mar. Environ. Res.* **2021**, *170*, 105415. [CrossRef]
88. Monnier, B.; Pergent, G.; Mateo, M.Á.; Clabaut, P.; Pergent-Martini, C. Seismic interval velocity in the matte of *Posidonia oceanica* meadows: Towards a non-destructive approach for large-scale assessment of blue carbon stock. *Mar. Environ. Res.* **2020**, *161*, 105085. [CrossRef]
89. Walbridge, S.; Slocum, N.; Pobuda, M.; Wright, D.J. Unified Geomorphological Analysis Workflows with Benthic Terrain Modeler. *Geosciences* **2018**, *8*, 94. [CrossRef]
90. Fakiris, E.; Papatheodorou, G. Quantification of regions of interest in swath sonar backscatter images using grey-level and shape geometry descriptors: The TargAn software. *Mar. Geophys. Res.* **2012**, *33*, 169–183. [CrossRef]
91. Nornes, S.M.; Ludvigsen, M.; Ødegård, Ø.; Sørensen, A.J. Underwater photogrammetric mapping of an intact standing steel wreck with ROV. *IFAC Pap. Online* **2015**, *28*, 206–211. [CrossRef]
92. Drap, P.; Seinturier, J.; Hijazi, B.; Merad, D.; Boi, J.M.; Chemisky, B.; Seguin, E.; Long, L. The ROV 3D project: Deep-sea underwater survey using photogrammetry: Applications for underwater archaeology. *J. Comput. Cult. Herit.* **2015**, *8*, 1–24. [CrossRef]
93. Carrivick, J.L.; Smith, M.W.; Quincey, D.J. *Structure from Motion in the GeoSciences*; John Wiley & Sons: Hoboken, NJ, USA, 2016.

94. Price, D.M.; Robert, K.; Callaway, A.; lacono, C.L.; Hall, R.A.; Huvenne, V.A.I. Using 3D photogrammetry from ROV video to quantify cold-water coral reef structural complexity and investigate its influence on biodiversity and community assemblage. *Coral Reefs* **2019**, *38*, 1007–1021. [CrossRef]
95. Bingham, B.; Foley, B.; Singh, H.; Camilli, R.; Delaporta, K.; Eustice, R.; Mallios, A.; Mindell, D.; Roman, C.; Sakellariou, D. Robotic tools for deep water archaeology: Surveying an ancient shipwreck with an autonomous underwater vehicle. *J. Field Robot.* **2010**, *27*, 702–717. [CrossRef]
96. Aucelli, P.P.C.; Mattei, G.; Caporizzo, C.; Cinque, A.; Troisi, S.; Peluso, F.; Stefanile, M.; Pappone, G. Ancient coastal changes due to ground movements and human interventions in the roman portus julius (Pozzuoli Gulf, Italy): Results from photogrammetric and direct surveys. *Water* **2020**, *12*, 658. [CrossRef]
97. Doneus, M.; Doneus, N.; Briese, C.; Pregesbauer, M.; Mandlburger, G.; Verhoeven, G. Airborne laser bathymetry—detecting and recording submerged archaeological sites from the air. *J. Archaeol. Sci.* **2013**, *40*, 2136–2151. [CrossRef]
98. Chase, A.S.Z.; Chase, D.Z.; Chase, A.F. *LiDAR for Archaeological Research and the Study of Historical Landscapes BT—Sensing the Past: From Artifact to Historical site*; Masini, N., Soldovieri, F., Eds.; Springer International Publishing: Cham, Switzerland, 2017; pp. 89–100. [CrossRef]
99. Shih, P.T.; Chen, Y.-H.; Chen, J.-C. Historic Shipwreck Study in Dongsha Atoll with Bathymetric LiDAR. *Archaeol. Prospect.* **2014**, *21*, 139–146. [CrossRef]
100. Pan, Z.; Glennie, C.; Fernandez-Diaz, J.C.; Starek, M. Comparison of bathymetry and seagrass mapping with hyperspectral imagery and airborne bathymetric lidar in a shallow estuarine environment. *Int. J. Remote Sens.* **2016**, *37*, 516–536. [CrossRef]
101. Papatheodorou, G.; Geraga, M.; Christodoulou, D.; Dimas, X.; Fakiris, E.; Ferentinos, G. The palaeogeography of the strait of Salamis: Marine geoarchaeological survey in the strait of Salamis and the Ampelakia Bay, in Salamis 480 B.C. *Hell. Marit. Mus.* **2020**, *2020*, 392–411.
102. Green, J. The application of side scan sonar and magnetometer to the location of archaeological sites. *J. Australas. Inst. Marit. Archaeol.* **2021**, *26*, 119–131. [CrossRef]
103. Papadopoulos, N.; Oikonomou, D.; Cantoro, G.; Simyrdanis, K.; Beck, J. Archaeological Prospection in Ultra-Shallow Aquatic Environments: The Case of the Prehistoric Submerged Site of Lambayanna. Available online: https://onlinelibrary.wiley.com/doi/10.1002/nsg.12174 (accessed on 5 August 2021).
104. Levy, T.E.; Sideris, T.; Howland, M.; Liss, B.; Tsokas, G.; Stambolidis, A.; Fikos, E.; Vargemezis, G.; Tsourlos, P.; Georgopoulos, A.; et al. At-Risk World Heritage, Cyber, and Marine Archaeology: The Kastrouli–Antikyra Bay Land and Sea Project, Phokis, Greece. In *Cyber-Archaeology and Grand Narratives. One World Archaeology*; Springer: Cham, Switzerland, 2018. [CrossRef]
105. Francus, P. *Image Analysis, Sediments and Paleoenvironments*; Springer: Dordrecht, The Netherlands, 2005.
106. Tanaka, A.; Nakano, T.; Ikehara, K. X-ray computerized tomography analysis and density estimation using a sediment core from the Challenger Mound area in the Porcupine Seabight, off Western Ireland. *Earth Planets Space* **2011**, *63*, 103–110. [CrossRef]
107. Gebregiorgis, D.; Giosan, L.; Hathorne, E.C.; Anand, P.; Nilsson-Kerr, K.; Plass, A.; Lückge, A.; Clemens, S.C.; Frank, M. What Can We Learn from X-Ray Fluorescence Core Scanning Data? A Paleomonsoon Case Study, Geochemistry. *Geochem. Geophys. Geosyst.* **2020**, *21*, 1–17. [CrossRef]
108. Ellegaard, M.; Clokie, M.R.J.; Czypionka, T.; Frisch, D.; Godhe, A.; Kremp, A.; Letarov, A.; McGenity, T.J.; Ribeiro, S.; John Anderson, N. Dead or alive: Sediment DNA archives as tools for tracking aquatic evolution and adaptation. *Commun. Biol.* **2020**, *3*, 1–11. [CrossRef]
109. Duarte, C.M.; Borum, J.; Short, F.T.; Walker, D.I. Seagrass ecosystems: Their global status and prospects. In *Aquatic Ecosystems: Trends and Global Prospects*; Polunin, N.V.C., Ed.; Cambridge University Press: Cambridge, UK, 2008; pp. 281–294. [CrossRef]
110. Cambridge, M.L.; Chiffings, A.W.; Brittan, C.; Moore, L.; McComb, A.J. The loss of seagrass in Cockburn Sound, Western Australia. II. Possible causes of seagrass decline. *Aquat. Bot.* **1986**, *24*, 269–285. [CrossRef]
111. McNeely, J.A. The sinking ark: Pollution and the worldwide loss of biodiversity. *Biodivers. Conserv.* **1992**, *1*, 2–18. [CrossRef]
112. Thomas, G.E.; Cameron, T.C.; Campo, P.; Clark, D.R.; Coulon, F.; Gregson, B.H.; Hepburn, L.J.; McGenity, T.J.; Miliou, A.; Whitby, C.; et al. Bacterial Community Legacy Effects Following the Agia Zoni II Oil-Spill, Greece. *Front. Microbiol.* **2020**, *11*, 1706. [CrossRef]
113. Gauss, W.; Kolonna, A. *The Oxford Handbook of the Bronze Age Aegean*; Oxford University Press: Oxford, UK, 2012; pp. 1–14. [CrossRef]
114. Lolos, Y.G.; Simossi, A. Salamis Harbour Project, 2016–2017. Summary of Results, no. October 2017. In Proceedings of the 'Under the Mediterranean' The Honor Frost Foundation Conference on Mediterranean Maritime Archaeology, Nicosia, Cyprus, 20–23 October 2017; pp. 1–26.
115. Georgiou, N.; Dimas, X.; Fakiris, E.; Christodoulou, D.; Geraga, M.; Koutsoumpa, D.; Baika, K.; Kalamara, P.; Ferentinos, G.; Papatheodorou, G. A multidisciplinary approach for the mapping, automatic detection and morphometric analysis of ancient submerged coastal installations: The case study of the ancient Aegina Harbour Complex. *Remote Sens.* **2021**, *13*, 4462. [CrossRef]
116. Ullman, S. The Interpretation of Structure from Motion. *Proc. R. Soc. Lond. Ser. B Biol. Sci.* **1979**, *203*, 405–426.
117. Casella, E.; Rovere, A.; Pedroncini, A.; Stark, C.P.; Casella, M.; Ferrari, M.; Firpo, M. Drones as tools for monitoring beach topography changes in the Ligurian Sea (NW Mediterranean). *Geo-Mar. Lett.* **2016**, *36*, 151–163. [CrossRef]
118. Surís-Regueiro, J.C.; Santiago, J.L.; González-Martínez, X.M.; Garza-Gil, M.D. An applied framework to estimate the direct economic impact of Marine Spatial Planning. *Mar. Policy* **2021**, *127*, 104443. [CrossRef]

119. Surís-Regueiro, J.C.; Santiago, J.L.; González-Martínez, X.M.; Garza-Gil, M.D. Estimating economic impacts linked to Marine Spatial Planning with input-output techniques. Application to three case studies. *Mar. Policy* **2021**, *129*, 104541. [CrossRef]
120. Hadjimitsis, D.; Agapiou, A.; Themistocleous, K.; Mettas, C.; Evagorou, E.; Soulis, G.; Xagoraris, Z.; Pilikou, M.; Aliouris, K.; Ioannou, N. Maritime Spatial Planning in Cyprus. *Open Geosci.* **2016**, *8*, 653–661. [CrossRef]
121. Chalastani, V.I.; Tsoukala, V.K.; Coccossis, H.; Duarte, C.M. A bibliometric assessment of progress in marine spatial planning. *Mar. Policy* **2021**, *127*, 104329. [CrossRef]
122. Kelleher, G. Guidelines for Marine Protected Areas. *Pac. Conserv. Biol.* **2000**, *6*, 352. [CrossRef]
123. Douvere, F.; Maes, F.; Vanhulle, A.; Schrijvers, J. The role of marine spatial planning in sea use management: The Belgian Casemar. *Policy* **2007**, *31*, 182–191. [CrossRef]
124. Collie, J.S.; Vic Adamowicz, W.L.; Beck, M.W.; Craig, B.; Essington, T.E.; Fluharty, D.; Rice, J.; Sanchirico, J.N. Marine spatial planning in practice. *Estuar. Coast. Shelf Sci.* **2013**, *117*, 1–11. [CrossRef]
125. Mattei, G.; Troisi, S.; Aucelli, P.P.C.; Pappone, G.; Peluso, F.; Stefanile, M. Multiscale reconstruction of natural and archaeological underwater landscape by optical and acoustic sensors. In Proceedings of the 2018 IEEE International Workshop on Metrology for the Sea, Learning to Measure Sea Health Parameters, MetroSea 2018, Bari, Italy, 8–10 October 2018. [CrossRef]
126. Mattei, G.; Rizzo, A.; Anfuso, G.; Aucelli, P.P.C.; Gracia, F.J. A tool for evaluating the archaeological heritage vulnerability to coastal processes: The case study of Naples Gulf (southern Italy). *Ocean Coast. Manag.* **2019**, *179*, 104876. [CrossRef]
127. Menna, F.; Agrafiotis, P.; Georgopoulos, A. State of the art and applications in archaeological underwater 3D recording and mapping. *J. Cult. Herit.* **2018**, *33*, 231–248. [CrossRef]
128. Zavalas, R.; Ierodiaconou, D.; Ryan, D.; Rattray, A.; Monk, J. Habitat Classification of Temperate Marine Macroalgal Communities Using Bathymetric LiDAR. *Remote Sens.* **2014**, *6*, 2154–2175. [CrossRef]
129. Chust, G.; Galparsoro, I.; Borja, Á.; Franco, J.; Uriarte, A. Coastal and estuarine habitat mapping, using LIDAR height and intensity and multi-spectral imagery. *Estuar. Coast. Shelf Sci.* **2008**, *78*, 633–643. [CrossRef]
130. Ventura, D.; Bonifazi, A.; Gravina, M.F.; Belluscio, A.; Ardizzone, G. Mapping and classification of ecologically sensitive marine habitats using unmanned aerial vehicle (UAV) imagery and Object-Based Image Analysis (OBIA). *Remote Sens.* **2018**, *10*, 1331. [CrossRef]
131. Cerdeira-Estrada, S.; Heege, T.; Kolb, M.; Ohlendorf, S.; Uribe, A.; Müller, A.; Garza, R.; Ressl, R.; Aguirre, R.; Mariño, I.; et al. Benthic habitat and bathymetry mapping of shallow waters in Puerto morelos reefs using remote sensing with a physics based data processing. In Proceedings of the 2012 IEEE International Geoscience and Remote Sensing Symposium, Munich, Germany, 22–27 July 2012; pp. 4383–4386. [CrossRef]
132. Kotilainen, A.T.; Kaskela, A.M. Comparison of airborne LiDAR and shipboard acoustic data in complex shallow water environments: Filling in the white ribbon zone. *Mar. Geol.* **2017**, *385*, 250–259. [CrossRef]
133. Simyrdanis, K.; Papadopoulos, N.; Cantoro, G. Shallow Off-Shore Archaeological Prospection with 3-D Electrical Resistivity Tomography: The Case of Olous (Modern Elounda), Greece. *Remote Sens.* **2016**, *8*, 897. [CrossRef]
134. Papadopoulos, N.; Oikonomou, D.; Simyrdanis, K.; Heng, L.M. Practical considerations for shallow submerged archaeological prospection with 3-D electrical resistivity tomography. *Archaeol. Prospect.* **2021**. [CrossRef]
135. Tsourlos, P.I.; Tsokas, G.N. Non-destructive Electrical Resistivity Tomography Survey at the South Walls of the Acropolis of Athens. *Archaeol. Prospect.* **2011**, *18*, 173–186. [CrossRef]
136. Gumusay, M.U.; Bakirman, T.; Kizilkaya, I.T.; Aykut, N.O. A review of seagrass detection, mapping and monitoring applications using acoustic systems. *Eur. J. Remote Sens.* **2019**, *52*, 1–29. [CrossRef]
137. Brown, C.J.; Smith, S.J.; Lawton, P.; Anderson, J.T. Benthic habitat mapping: A review of progress towards improved understanding of the spatial ecology of the seafloor using acoustic techniques. *Estuar. Coast. Shelf Sci.* **2011**, *92*, 502–520. [CrossRef]
138. Diesing, M.; Green, S.L.; Stephens, D.; Lark, R.M.; Stewart, H.A.; Dove, D. Mapping seabed sediments: Comparison of manual, geostatistical, object-based image analysis and machine learning approaches. *Cont. Shelf Res.* **2014**, *84*, 107–119. [CrossRef]
139. Ierodiaconou, D.; Laurenson, L.; Burq, S.; Reston, M. Marine benthic habitat mapping using Multibeam data, georeferencedvideo and image classification techniques in Victoria, Australia. *J. Spat. Sci.* **2007**, *52*, 93–104. [CrossRef]
140. Blondel, P.; Prampolini, M.; Foglini, F. Acoustic textures and multibeam mapping of shallow marine habitats—Examples from eastern Malta. *Proc. Inst. Acoust.* **2015**, *37*, 250–257.
141. Bailey, G.N.; Harff, J.; Sakellariou, D. *Under the Sea: Archaeology and Palaeolandscapes of the Continental Shelf*; Springer: Cham, Switzerland, 2017; p. 20. [CrossRef]