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Article

A Pilot Survey Investigating *Naturoid* Reefs as a Tool for Sustainable Marine Ecotourism

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Abstract: Recreational SCUBA diving is currently a nature-based USD multibillion tourism industry across the globe. However, degradation of many recreational diving destinations all over the world due to "soft" ecotourists necessitates the adoption of innovative management measures. Hellenic Centre for Marine Research (HCMR) developed an innovative technology for the creation of artificial underwater ecotourism attractions ("oases") to divert visitors away from sensitive marine natural areas of high ecological and aesthetic value. This innovative technology includes specially constructed artificial reefs in an attempt to simulate the functional and morphological characteristics and the aesthetics of the natural rocky reefs. In this study, a pilot survey was conducted in three diving centres of Crete Island, one of the most important tourist destinations in the Mediterranean Sea, involving the participation of 144 SCUBA divers from all over the world. The survey aimed at investigating SCUBA divers' profiles and perceptions concerning recreational diving activities and artificial reefs technology. Findings of this study indicate that large naval shipwrecks combined with innovative man-fabricated constructions simulating natural rocky reefs meet the preferences of the majority of the participants of the survey and they can be used as an alternative tool for relevant marine ecotourism sustainable applications.

Keywords: artificial reefs technology; underwater artificial habitats; recreational diving parks; blue growth; environmental awareness

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1. Introduction

The Mediterranean Sea is one of the top tourist destinations in the world. According to the World Tourism Organization, more than 400 million tourists visited the Mediterranean in 2019 [1]. Coastal and maritime tourism, including recreational diving, are essential economic activities for many Mediterranean countries. Recreational diving, as an ecotourism product, contributes to: (a) the local economy of many tourist destinations; (b) the local differentiation and upgrade of the tourist product; (c) the extension of the tourist season depending on the destination; and (d) the entry into new markets, e.g., tourists seeking alternative types of leisure with a high level of recreational activity [2,3].

Today, this tourist "market" is dominated by people in a high-income group, who dive consciously and repeatedly into various international diving destinations belonging mostly to the group of "soft" ecotourists [4–6]. However, many recreational diving destinations all over the world have been degraded mainly due to unconscious (e.g., due to lack of knowledge) or accidental contacts with sensitive marine organisms and this cumulatively results in their injury or even their extinction [7–9]. An increasing body of literature has demonstrated that diving activities, mainly on frequently visited sites, can affect marine life detrimentally, particularly sensitive benthic organisms such as corals, sponges, bryozoans, and gorgonians [10–12]. As tourism activities in coastal areas continue to increase, SCUBA

diving is expected to become more popular while there are not enough marine protected areas to meet the needs for sustainable use [13].

To deal with this situation, strict management measures need to be introduced, such as reducing the number of dives and diverting many visitors away from sensitive marine natural areas of high ecological and aesthetic value [14–16]. One of the proposed management solutions is an innovative technology developed by the Hellenic Centre for Marine Research (HCMR) for the creation of artificial underwater ecotourism attractions ("oases") using specially constructed artificial reefs in an attempt to simulate both the functional and morphological characteristics as well as the aesthetics of natural rocky reefs [17]. Each artificial reef unit comprises blind crevices and through holes leading to chambers and smaller or larger cavities constituting microhabitats and refuges for targeted benthic and benthopelagic organisms. The concept of "*naturoid*" was recently introduced referring to man's attempts to reproduce natural objects [18]. These objects are identified under the name *naturoids*, in order to be distinguished from other technological products which are not actually inspired by natural phenomena and are thus not intended to reproduce natural objects or processes [19]. We adapted this term for HCMR innovative artificial reef units in order to emphasize their major difference from the numerous other man-fabricated artificial objects that have been used for the same purpose [14]. This new technology has been tested, validated, and demonstrated successfully in the Underwater Biotechnological Park of HCMR in Crete (UBPC, Figure 1), a unique large-scale in situ research infrastructure about 2 km offshore on the northern Cretan coast, covering an area of 30,000 m^2, with a depth increasing from 18 to 22 m along the south–north direction [20–22]. By using the HCMR innovative technology, a network of artificial underwater "oases" suitable for recreational diving can be installed on small areas of the seabed, at relatively shallow depths, near the main urban and touristic centres and in coastal sites of no specific ecological, archaeological, or fishing importance [23].

Figure 1. View of the seabed in the area of experimental installation of an artificial *naturoid* reef of HCMR in the Underwater Biotechnology Park of Crete.

The survey carried out in this study was aimed at investigating divers' profiles and perceptions concerning the use of artificial reefs technology for recreational diving. More specifically, a questionnaire was administered to SCUBA divers in order to explore whether the HCMR's innovative artificial reef technology, i.e., *naturoid* reefs simulating the functional and morphological characteristics as well as the aesthetics of the natural rocky reefs, can be proposed and used as a tool for sustainable marine ecotourism applications.

2. Materials and Methods

In 2019, a survey was conducted in three diving centres of Ag. Nikolaos of Crete Island, one of the most important tourist destinations in Greece, involving the participation

of 144 SCUBA divers from all over the world. The questionnaire applied was designed and developed taking into consideration previous research [24].

The questionnaire consisted of 14 questions (Table S1). The first nine questions are relevant to divers' profiles, including diving experience (e.g., type and level of certification and time and frequency of diving activities). The next two questions target marine biodiversity. The last three questions explore participants' perceptions concerning artificial reefs technology (e.g., type of artificial reefs) as well the development and management of diving parks using artificial reefs. The survey was developed in English as the common language among the participants. The questionnaire, which supported the anonymity of the participants, was administered to the SCUBA divers either before or after their diving activity; the time of completion ranged between 15 and 20 min.

Data analysis involved descriptive statistics to illustrate frequencies, mean values, and standard deviations by using the Statistical Package for Social Sciences (IBM Corp. Released 2020. IBM SPSS Statistics for Windows, v27.0., IBM Corp., Armonk, NY, USA)

3. Results

Considering the type and level of certification of the SCUBA divers that participated in this survey, the majority received their certification from the Professional Association of Dive Instructors (PADI, 66.2%), followed by Confédération Mondiale des Activités Subaquatiques (CMAS, 20.3%), American Nitrox Divers International (ANDI, 10.8%), and British Sub-Aqua Club (BSAC, 2.7%). Their level of certification was relatively high as more than half of them were "advanced open water" SCUBA divers (45.4%), along with dive masters (12.1%) and dive instructors (17.0%), while the lowest level (open water) represented only 25.5% of the total participants (Figure 2a). In addition, 19 participants (13.5%) referred to their specific diving activities as underwater photography, wreck, rescue, and cave. The duration of being a certified SCUBA diver ranged between 2 and 10 years (68.7%, Figure 2b), followed by 11–15 (13.2%), and <2 years (10.4%). The frequency of their diving activities (number of days of SCUBA diving during the last year, Figure 2c) ranged between 0 and 9 days (25.9%) followed by 10–39 days (48.3%) and even more (>60 days, 16.8%). Overall, answers to this group of questions were indicative of the high-level SCUBA diving experience of the participants.

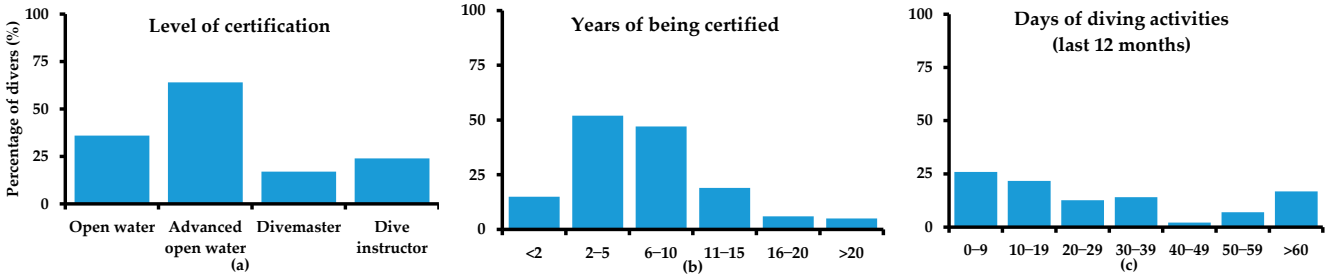

Figure 2. Diving experience of the participants: (**a**) level of certification; (**b**) duration of a SCUBA diver being certified; (**c**) days of diving activities during the last 12 months.

Moreover, the answers to question 5 showed that, for most of the participants, diving is among their most important outdoor activities (first, second, or third most important outdoor activity representing 43.1%, 29.9%, and 16%, respectively). The type of diving activities that SCUBA divers mostly participated in during the last year were: wreck diving (33.8%), followed by marine life identification (19.9%), cave diving (18.4%), and underwater photography (17.6%) (Figure 3a). Furthermore, Figure 3b,c show their preference to dive with people from their diving club (38.2%) and their friends (32.6%), as well as between 20 and 30 m water depth range (69.8%) but less in shallower (22%) or deeper waters (8.1%).

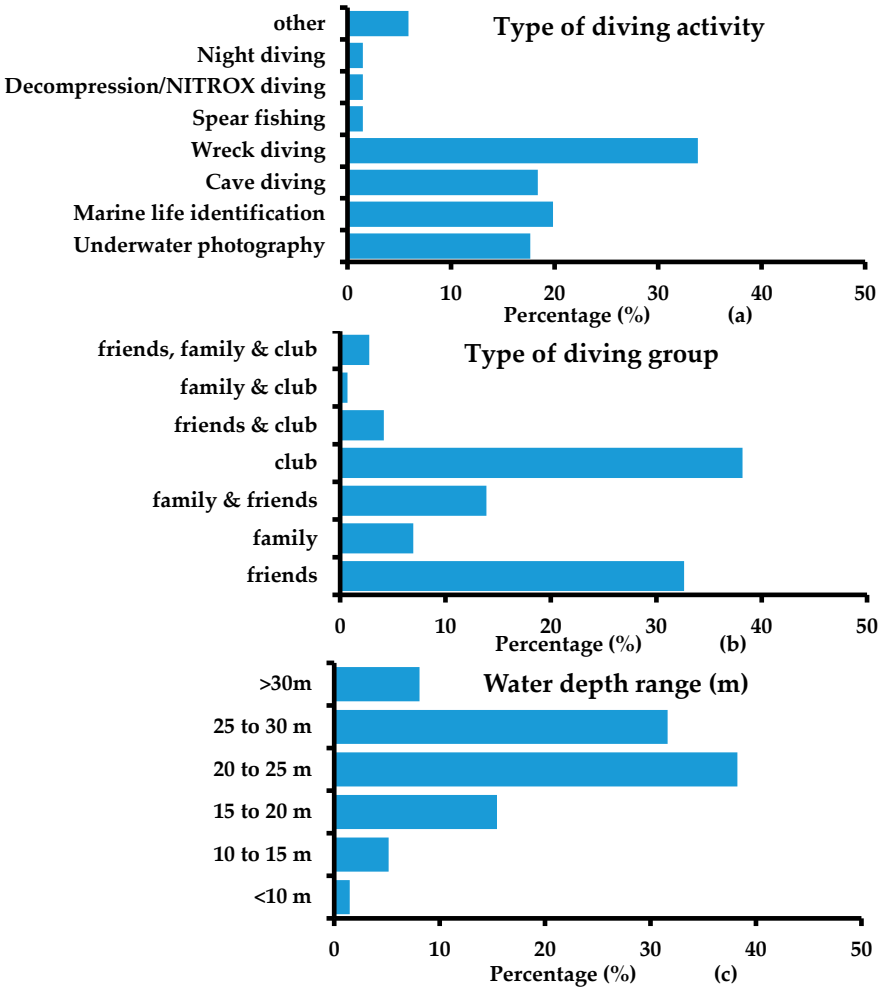

Figure 3. Diving profile of the participants: (**a**) type of diving activity they performed during the last 12 months; (**b**) type of diving group they prefer; (**c**) water depth range they prefer to dive.

Reasons provided as very important for the participants' diving activities were: to look at fish and other marine life; to develop their diving skills and abilities; and to be with their friends to experience adventure and excitement (Table 1). Family recreation was less important. The most important marine organisms to participants' diving experiences were: large fish (e.g., groupers), corals, sponges, and shells and other animals such as marine mammals (e.g., whales and dolphins), turtles, sharks, and seahorses (Table 2). Lesser-known organisms such as crustaceans and marine worms were less important.

Table 1. Importance of the listed reasons for the participants' diving activities.

Reasons	Mean ± SD
For family recreation	3.51 ± 1.29
To learn more about the marine environment	4.11 ± 0.79
To look at fish and other marine life	4.49 ± 0.63
To experience adventure and excitement	4.32 ± 0.94
To identify marine organisms	4.03 ± 0.94
To experience underwater tranquillity	4.29 ± 0.92
To be with friends	4.33 ± 1.08
For exercise	4.11 ± 1.24
To develop diving skills and abilities	4.45 ± 0.92

Table 2. Importance of the listed marine life to participants' diving experiences.

Large Fish (e.g., Grouper)	Small Fish (e.g., Gobies)	Corals, Sponges, Shells	Marine Worms	Crustaceans (e.g., Shrimps, Lobsters)	Others
4.51 ± 0.77	4.35 ± 0.73	4.41 ± 0.79	3.21 ± 1.40	4.15 ± 1.00	4.36 ± 1.19

The vast majority of the participants (73.6%) realized that informative material (e.g., a waterproof guide for the identification of marine species) is required for marine life identification. Less than half of the participants (43.1%) have visited sites with artificial reefs, mostly wrecks (sunk vehicles, vessels, and airplanes), concrete reefs, platforms, stonewalls, caves. However, if HCMR were to develop a new artificial reef in the area they dive most often, they would prefer by far naval ships (79.3%) and artificial reefs simulating natural rock (10.4%), while small fishing boats, concrete blocks, airplanes, or even replicas of ancient Greek statues were also proposed, though with much lower percentages (Figure 4).

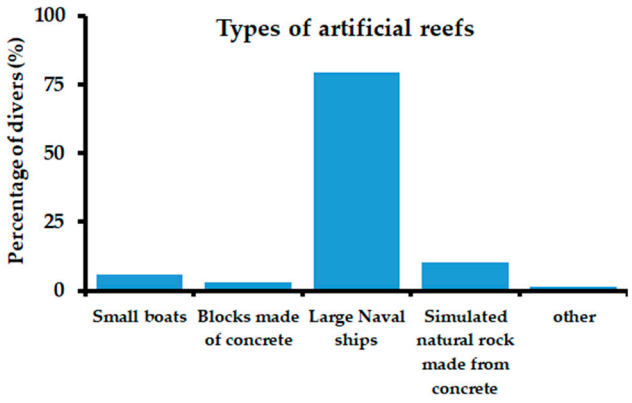

Figure 4. Types of artificial reefs the participants prefer if a new artificial reef is to be developed in the area where they most often dive.

Answers to the open question, 14 (Table S1), concerning aspects that local authorities should consider in order to develop and manage a recreational diving park with HCMR's innovative artificial reefs, i.e., *naturoid* reefs simulating the functional characteristics and the aesthetics of the natural rocky reefs, were many and various. In grouping the responses, the most important aspect was the conservation and protection of the marine environment (e.g., control number of visitors, and enhancing and protecting existing marine environment). Security and safety of diving activities, as well as several proposed prerequisites for the development of the diving park (e.g., decompression chamber, mooring points, weather conditions that prevail in the location, surface of the area, depth, visibility, and type of reefs) were also considered to be very important. Measures against boat traffic, fishing activities, and pollution should be also taken. Easy accessibility from the shoreline or by boat for all levels of divers is also required.

4. Discussion

This pilot survey, conducted in diving centres of Crete Island which is one of the most important tourist destinations in Greece, included a relatively short questionnaire aiming at investigating divers' perceptions concerning the development of innovative HCMR artificial reefs technology for recreational activities in marine diving parks. Most of the participants of the survey had relatively high diving experience and preferred diving with members of their club and friends between 20 and 30 m depth. Several studies have noted the need for further research in order to investigate whether higher levels of experience in SCUBA diving are accompanied by greater responsibility, better environmental knowledge and awareness, and increased support for conservation strategies [9,25].

The United Nations Environment Programme defines artificial reefs as submerged structures deliberately constructed and deployed on the seabed to emulate some functions

of natural reefs such as protecting, regenerating, concentrating, and enhancing populations of living marine resources [26]. The objectives of an artificial reef may also include the protection, restoration, and regeneration of aquatic habitats, and the promotion of research, recreational opportunities, and environmental awareness of the area (e.g., [27,28]). Among the participants of this survey, identification of marine life was the second most favourable type of diving activity while looking at large fish (e.g., groupers) and other benthic animals (e.g., corals, sponges, and shells) was one of their most important reasons to dive, as has also been observed elsewhere [29]. Preliminary results on early succession patterns of benthic assemblages on artificial reefs in the UBPC indicate enhancement of marine biodiversity and significant increase in local fish stocks [22]. In all cases where relevant research has been conducted, the most crucial factor of attraction of interest to visitors remains the observation of marine life [9]. Results of the survey also indicate that divers embrace the use of material and tools (e.g., field guides) for a better understanding of marine biodiversity. The diving industry can perform an important role in the promotion of environmental awareness, also leading to changes in accidental or unconscious (e.g., due to lack of knowledge) reef damaging behaviour [30]. Towards further development of this concept, artificial reefs have been used in order to trigger students' interest in natural sciences [31].

Not many of the participants of the survey have actually visited sites with artificial reefs (e.g., wrecks, sunk vehicles, vessels and planes, and concrete reefs). Nevertheless, wreck diving was by far the most favoured type of diving activity among the divers of this pilot survey and consequently large naval ships, used as artificial reefs, were their first preference. The typology of artificial reefs used to date for recreational-ecotourism purposes, based on their appearance below sea level and their construction materials, classifies them in the following general categories [14]: (a) artificial reefs from conversion of the use of human constructions (e.g., old boats, planes, and cars); (b) artificial reefs that functionally resemble natural reefs, though they differ significantly in the exact simulation of form and their aesthetics (e.g., prefabricated units fabricated of metal, concrete, and car tires), and (c) artificial reefs attempting to simulate natural rocks imitating the function, form and the aesthetics of the latter one. The third category includes efforts related to use natural rocks or boulders transported from land locations and submerged in the seabed surface to form irregular piles of various dimensions. However, such formations are simple and monotonous in appearance compared with natural rocky reefs, and as a result they do not attract visitors and divers today. Recently, Tickell et al. [32] suggested a new typology reframing artificial reefs as artworks. Nevertheless, a large part of the public and especially the visitors of artificial reefs areas almost reject all the above-mentioned anthropocentric types of intervention in the natural environment [33,34]. Some even consider such practices to be pretentious and actually a form of pollution by dumping or deliberate concealing of "ocean junk piles" on the seabed [35]. In order to provide a solution to the above environmental issues, HCMR already developed and implemented a comprehensive alternative technological proposal to build artificial submarine "oases" by using *naturoid*-type reefs in an attempt to simulate both the functional and morphological characteristics as well as the aesthetics of natural rocky reefs [3,20,22]. Advantages offered by applying this *naturoid* reef concept can be communicated and disseminated through diver training organisations and management agencies having developed initiatives concerning environmental awareness.

The advantages of the development of recreational diving "oases" by using HCMR artificial reef technology meet a number of criteria of the 2030 Agenda for Sustainable Development approved by the United Nations member states, which integrates 17 Sustainable Development Goals (SDGs) aiming to cover all aspects of sustainability through several targets (e.g., innovation, blue growth, ocean issues, and environmental awareness), and can be summarized as follows: (a) they offer protection and upgrading of the wider marine ecosystem with simultaneous enhancement of marine biodiversity and significant increase in local fish stocks; (b) their installation even in environmentally degraded coastal areas contributes to their protection and upgrading; (c) they can be installed near large

tourist/urban centres which offer easy access and control of the whole activity; (d) they provide safety and the possibility of immediate intervention in case of accident as well as saving time and fuel; (e) they occupy a small seabed area (0.005–0.02 km^2) enjoying relatively low usage costs (if deemed institutionally necessary); (f) they ensure the acceptance and at the same time provide the benefits of a harmonious coexistence with other users of their coastal zone (mutual development business interests); (g) and they can be used as a tool for environmental awareness and training activities, exercise, and entertainment.

Based on the results of this pilot survey, HCMR proposed to the Municipality of Apokoronas in Crete the development of the first recreational diving "oasis" in Greece, in an area of the seabed covering 60,000 m^2 in depths from 8 to 30 m. The deployment of 40 units of HCMR innovative artificial habitats from concrete and the sinking of two naval shipwrecks will be used for the creation of three separate underwater dive trails (see details in Figure 5). The recent completion of all administrative procedures including space concession and its announcement in the Official Government Gazette mark the beginning of project's construction that is expected to become functional in summer 2023. In addition, Environmental Impact Assessment for the establishment of four other Recreational Diving "oases" in Crete are currently in the approval process stage.

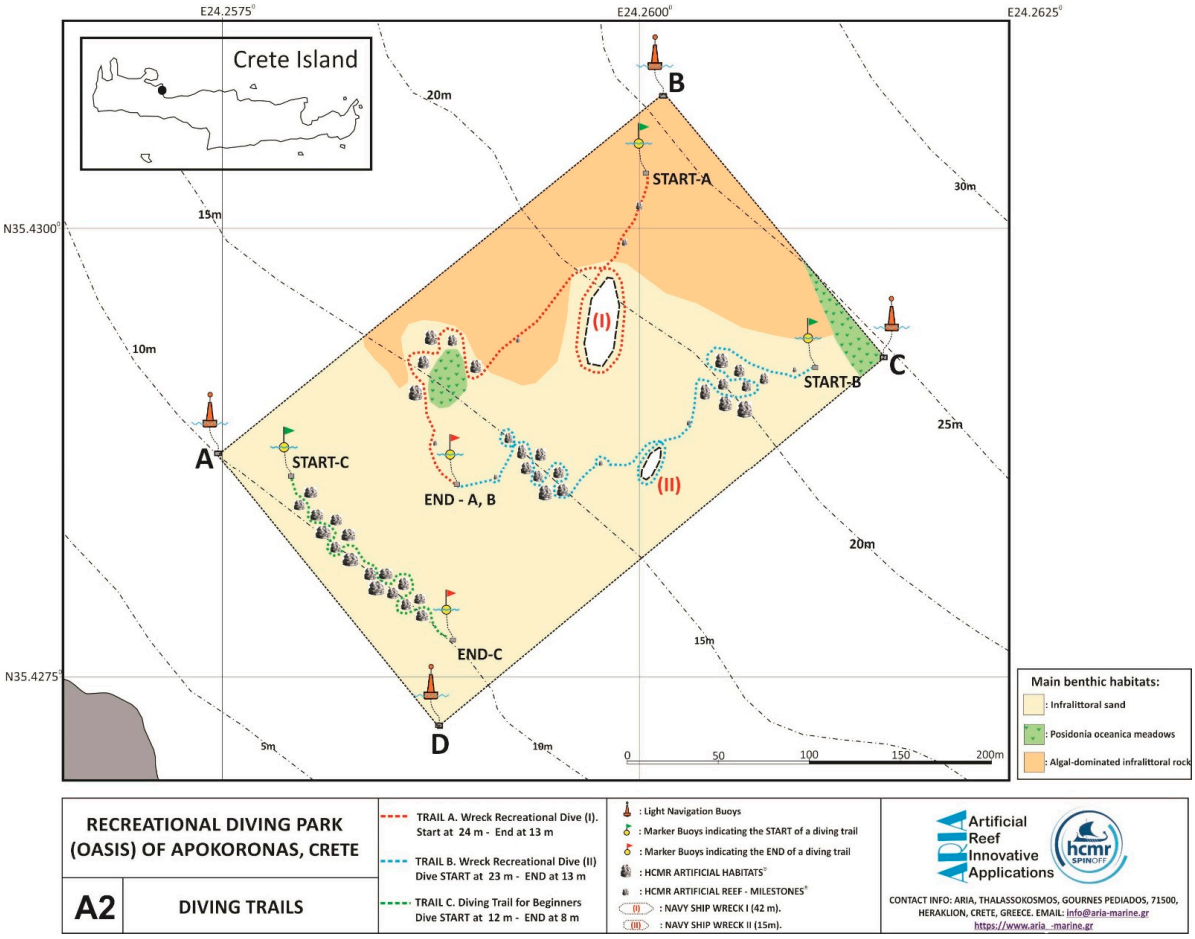

Figure 5. Three different underwater dive trails (trails A and B consisting of naval shipwrecks and artificial *naturoid* reefs for advanced-level divers; trail C consisting of artificial *naturoid* reefs for divers who are beginners) of the under-construction Apokoronas Recreational Diving Park ("oasis") located in the north–west coasts of Crete Island using both HCMR Artificial Reef innovative technologies and the deployment of two naval ship wrecks in accordance to the findings of this survey.

5. Conclusions

This pilot survey indicated that large naval shipwrecks combined with innovative man-fabricated constructions simulating natural rocky reefs meet the preferences of the majority of the participants and they can be used as an alternative tool for relevant marine ecotourism sustainable applications. Design and development of similar surveys concerning the perceptions of a larger number of SCUBA divers not only from the Mediterranean Sea region but also worldwide should be carried out, targeting not only to the promotion of the innovative concept of artificial *naturoid* reefs of HCMR but also to environmental awareness, leading to changes in reef damaging behaviour.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/jmse10081080/s1, Table S1: Questionnaire.

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