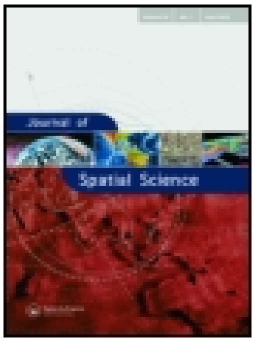

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Marine spatial planning on Crete Island, Greece: methodological and implementation issues

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ABSTRACT
Marine and coastal areas are under significant pressures due to the intense concentration of population and activities that often drive in conflicts. Marine spatial plans need to be enacted and implemented, considering the particularities of marine areas, the existing and future activities and uses and their environmental impact and the land–sea interaction. The paper main question concerns the emerge of uses conflicts on marine and coastal areas, with significant uses accumulation. Crete Island is used as the case study. It studied the conflicts or synergies of marine uses as well as their spatial and quantitative representation.

KEYWORDS
Marine spatial planning; local spatial planning; Crete Island; Greece

1. Introduction

In 2014, Directive 2014/89/EU of the European Parliament and the Council (EP&C) was enacted and established a common framework for marine spatial planning (MSP), targeting sustainable development of marine economies and marine areas, as well as the sustainable use of marine resources. According to this Directive, the EU Member States will have enacted and implemented MSP by 31 March 2021 at the latest, taking into account: (i) the particularities of marine areas; (ii) their existing and future activities and uses as well as their environmental impact; and (iii) the land–sea interaction (EP&C 2014).

In the international literature, a marine area is defined as a place that is used by various users from different sectors (Di Tullio *et al*. 2018, Schultz-Zehden *et al*. 2018, Kyvelou and Ierapetritis 2019, Schupp *et al*. 2019, van Hoof *et al*. 2020). The variety of marine uses can be classified in four major categories: (i) marine transport and connection infrastructure; (ii) extraction and resources exports; (iii) protected and exploited natural and cultural environments; and (iv) military uses (Douvere 2008, Smith *et al*. 2011, Tsilimigkas and Rempis 2018). Marine areas are in direct interdependence with terrestrial spaces and, more particularly, with coastal zones (UNCED 1992, EP&C 2002, Agardy *et al*. 2005, Kiousopoulos 2008), which are considered among the most productive, exploited, populated and vulnerable areas (Agardy *et al*. 2005, Kiousopoulos 2008, Koerth *et al*. 2013, Harris *et al*. 2019). Coastal zones have significant environmental, economic, social, cultural and recreational importance for human society (UNCED 1992, EC 2002, Monioudi *et al*. 2016, Harris *et al*. 2019).

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In recent years, coastal and marine areas have been under significant and increasing pressure due to: (i) intensification and expansion of existing traditional coastal and marine uses; (ii) emergence of new forms of activities and new marine uses; and (iii) environmental changes (Maes *et al*. 2005, Schultz-Zehden *et al*. 2008, Maes 2008, Dawson *et al*. 2009, Chang *et al*. 2016, Freeman *et al*. 2016, Van den Burg *et al*. 2016, Luz Fernandes *et al*. 2017, Kyriazi 2018, Le Tixerant *et al*. 2018).

In Greece, the importance of coastal and marine areas for social and economic development is reflected on the fact that the majority of the population (permanent and secondary residences) and economic activities, more specifically tourism, are concentrated in proximity to these areas (Newman 2005, Velegrakis *et al*. 2008, 2015, Koerth *et al*. 2013, Gounaridis and Koukoulas 2016, Kizos *et al*. 2017, Kyvelou and Ierapetritis 2019).

All the aforementioned together with the need to preserve and protect natural and cultural environments have led to competition and conflicts in coastal and marine areas (Maes *et al*. 2005, Maes 2008, Portman *et al*. 2013, Freeman *et al*. 2016), which can be conflicts among human-induced activities (user-user conflicts) and conflicts between human-induced activities and the environment (user-environment conflicts) (Kiousopoulos 2008, Ehler and Douvere 2009). These conflicts-pressures and their accumulative effect have led to inefficient and unsustainable use of marine and coastal resources that increase both the risk of habitat degradation and the risk for coastal communities, a fact that highlights the need for an integrated approach to coastal and marine space management (Dawson *et al*. 2009, Tsilimigkas and Rempis 2017, Papatheochari and Coccossis 2019).

Now as far as MSP is concerned, it is a process that both considers all interactions and conflicts between users (existing and future) and environment and identifies areas that are appropriate for use (Smith and Jentoft 2017, Smythe 2017) in a sustainable way, specifying by whom, how and when, so that issues of conflicts can be solved. It is a complex process that takes into account the multi-dimensional (seabed, water column and surface area) character of marine areas, where multi-use combinations can be achieved as it has already been analysed in an amount of international literature (CEC 2008, EP&C 2014, Di Tullio *et al*. 2018, Schultz-Zehden *et al*. 2018, Tsilimigkas and Rempis 2018, Kyvelou and Ierapetritis 2019, Schupp *et al*. 2019, van Hoof *et al*. 2020).

Although the object of MSP is the sea, land–sea interactions, as a key factor, should also be considered for its effective implementation, so that coherence between terrestrial and marine planning is ensured (CEC 2008; EP&C 2014). Over the years, land-based spatial planning has expanded its boundaries to the marine area, both in Integrated Coastal Zone Management and in the increased interdependence of maritime activities with the land area (Jay 2010).

Kidd and Shaw (2014) have highlighted that the land–sea interface needs special attention, since the effective MSP implementation at the sea-land limit is a complex place with significant land–sea and sea–land interactions. In proximity to the sea-land limit, the ecosystem resilience and persistence depend on interconnectivity and bidirectional ecological processes and flows between the land and sea (Harris *et al*. 2019). Moreover, the accumulation of economic activities of various sectors on the land or/and sea area in proximity to coastlines results in an increased interaction between these two areas, as: (i) the sustainability of coastal terrestrial uses usually depends on marine uses; (ii) the functionality and sustainability of marine uses depend on complementary terrestrial uses; and (iii) the presence of a marine or land use in the coastal zone and, especially, in proximity to coastlines frequently results in land-sea processes (Alvarez-Romero *et al*. 2011, Kidd and Shaw 2014, Lino 2016, Rempis *et al*. 2018, Papatheochari and Coccossis 2019, Schlüter *et al*. 2020).

Within this context, this paper attempts to highlight key issues on MSP implementation in marine and coastal areas with significant uses accumulation and conflicts, especially, in proximity to the sea-land limit. As a case study, the Region of Crete was chosen, where the local economy is significantly based on coastal and marine areas exploitation.

2. Methodology

2.1 A Case study

Crete is an exclusively insular Region of Greece, which is located in the South Aegean, in the eastern Mediterranean (Figure 1). It is the largest Greek island and the fifth largest in the Mediterranean Sea. It has a coastline length of 1,300 km, and a total area of 8,335,882 km^2 represents 6.3% of the territory of Greece (EL-STAT 2011, Tsilimigkas and Rempis 2017, 2018, Tsilimigkas *et al*. 2020). Its population is 682,928 people (EL-STAT 2011). The pillar of the local economy is the tertiary sector. The northern coast of the island is significantly uneven in relation to the southern part in terms of economic growth and population concentration, as the majority of the population and economic activities are located in the latter (Tsilimigkas and Rempis 2017, 2018, Tsilimigkas *et al*. 2020). The expansion of human-induced activities, combined with the effects of climate change, exert significant pressure on Crete's marine and coastal area (Alexandrakis *et al*. 2015). Therefore, the coastal and marine zone around Crete – along with the boundary of the Greek territorial sea 6 nautical miles from the natural coastline (OGG 1936) – was chosen as a case study.

Crete Island is not a typical example of EU coastal and marine area where a Member State is called upon to implement the MSP directive, since it presents certain particularities because of five different factors, as presented below:

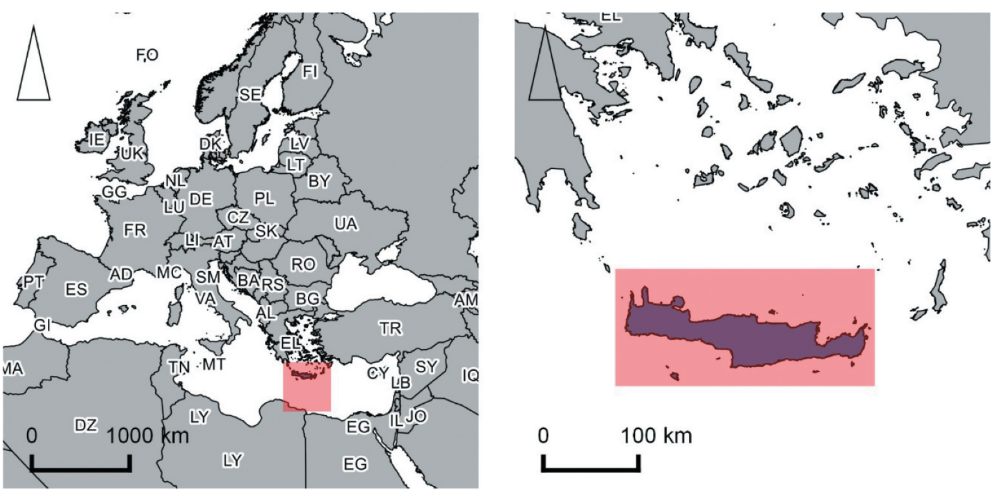

Figure 1. Case study.
Source: Authors' analysis

(i) **Special physical geography**. Crete is a mountainous island, as 49.4% of its total surface is characterized by mountainous zones, and 28.1% is characterized by semi-mountainous zones (EL-STAT, 2011). The extensive mountains create intense geomorphological relief in many parts of the island, even at the land–sea limit. This on the one hand causes fragmentation and discontinuity in the space, thus creating fragmentation and inequalities in the human environment in terms of economic development and population concentration, but on the other hand creates rich but fragile ecosystems.

(ii) **Natural and cultural environment**. Crete Island is a place of cultural and natural heritage. The great mountains, the climate conditions – which differ between the eastern and western part of the island, the long coastline and the multitude of historical monuments mainly of Minoan civilization and Venetian rule make up a rich and alternating natural-cultural environment. For this reason, a large part of the terrestrial and marine area of the island is covered by extensive nature protection areas – such as Natura 2000, wildlife areas, wetland areas, etc. – and protected areas of cultural environment. It is worth noting that there is a large number of underwater antiquities in the sea area of Crete.

(iii) **Regional location**. Although the Region of Crete is an autonomous spatial system, it has a regional location in terms of poles and development axes. The metropolitan centres of Athens and Thessaloniki are the main national development poles, while the Athens – Thessaloniki road section is the main development axis of the country. The particular geomorphology of the country – as it is characterized by extensive coastal and insular areas – on the one hand sets development constraints and, more specifically, creates barriers and discontinuities in the distribution of activities and opportunities in the territory and on the other hand creates accessibility and communication problems.

(iv) **Frontier location**. The Region of Crete is the southern border of Greece. It is located in a frontier zone with particular geopolitical and geostrategic importance, both for the country itself and for the EU. More specifically, Crete can play an important role in the outreach of the country, as it is close to the Mediterranean maritime development axis, which is a strategic route for the development of cooperation in the fields of entrepreneurship, tourism, environmental protection and cross-border control, as well as for the development of information, communication and energy infrastructures and networks with the South-East Mediterranean, the Red Sea and the Middle East (OGG 2008).

(v) **Economic development**. The sustainability of the local community is based primarily on tourism sector and more specifically on the exploitation of the coastal zone, where most economic activities and the population of the island are concentrated (Tsilimigkas and Rempis 2017, 2018). Significant tourism development occurs mainly in the northern part of the island for geomorphological and accessibility reasons, whereas, in the southern part of the island, the primary sector (esp. agriculture) has significant presence, since most population is employed. It is remarkable the presence of greenhouses that occupy large areas in various parts of the southern part of the island.

In the Region of Crete, 36% of the total area is covered by local spatial plans, of which 18.4% are under preparation, whereas 45.6% of the total area has no local plan. These plans define: (i) settlements organization: extensions, new settlements (main and secondary home); (ii) construction restricted areas; (iii) special protection areas; (iv) areas of organized development of productive activities; and (v) basic infrastructure networks. Furthermore, only 53.9% of the total coastline is covered by a local plan. A large part of the northern shores that are under significant pressure are not governed by any enacted land uses.

2.2 Geospatial data

Geospatial data are used in order to identify synergies and conflicts among marine and coastal uses and activities. Table 1 summarizes the geospatial data used.

The sub-category shipping routes, includes areas with high navigation densities and a marine channel in the bay of Souda, Chania (Navionics Webapp 2017). High navigation densities areas were identified from the on-line density map of the Marine Traffic site, based on data for 2017 (AIS Marine Traffic 2017). The sub-category port infrastructure and anchorages includes the endpoints of the port infrastructure which were identified and digitized in polygons by using aerial orthophotos (Hellenic Cadastre of the Ministry of the Environment and Energy 2017), as well as the International Ship and Port Facility Security (ISPS) anchorages which were identified and digitized in polygons from Navionics maps (Navionics Webapp 2017). The sub-category submarine cables and pipelines was obtained from Navy maps (Navionics Webapp 2017).

The sub-category fishing areas includes the areas where fishing is permitted irrespective of mechanical means. These areas were obtained from the Hellenic Coast Guard (Directorate of Fisheries Control 2017). The sub-category aquaculture facilities includes the two existing fish farming infrastructures which were identified with the use of aerial orthophotos Hellenic Cadastre of the Ministry of the Environment and Energy 2017). The sub-category extraction zones includes the areas that have been leased for exploration and exploitation of hydrocarbons by the Ministry of the Environment and Energy (MEE 2011).

The sub-category underwater cultural heritage includes data related to underwater antiquities, both declared and non-declared, and diving areas. Declared archaeological sites have been identified by the corresponding OGGs (Official Government Gazettes) issued by the Ministry of Culture and Sport and provided by both the Standing List of Proclaimed Archaeological Sites and Monuments [*Diarkis Katalogos Ton Kirygmenon Archaiologikon*

Table 1. Geospatial data categories.

Category	Sub-category
(i) Marine transport and connection infrastructure	(a) Shipping routes (b) Port infrastructure and anchorages (c) Submarine cables and pipelines
(ii): Extraction and resources exports	(a) Fisheries areas (b) Aquaculture facilities (c) Extraction zones (Oil and gas)
(iii) Protected and exploited for recreation natural and cultural environment	(a) Underwater cultural heritage - Underwater antiquities - Diving areas (b) Natural heritage - Natura 2000 - Posidonia meadows - Underwater research park - Rivers estuaries and Coastal wetlands - Bathing beaches
(iv) Military uses	Military areas
(v) Coastal erosion	Coastal erosion areas

Choron kai Mnimeion, in Greek] and the Ephorate of Underwater Antiquities of Crete [*Eforeia Enalion Archaiotiton Ktitis*, in Greek]. The non-declared antiquities, which were not available in the Ministry's on-line database, were indicated as points by the Ephorate of Underwater Antiquities of Crete (Hellenic Ministry of Culture and Sports 2017). Diving areas have been identified by the corresponding OGG issued by the Ministry of Culture and Sport and provided by the Standing List of Proclaimed Archaeological Sites and Monuments.

The sub-category natural heritage includes: (1) the marine part of Natura 2000 sites, which were obtained from the Ministry of the Environment and Energy (MEE 2011); (2) the areas where Posidonia meadows were derived from Special Framework for Spatial Planning and Sustainable Development of Aquaculture and strategic environmental impact assessment (SFSPSD) Maps for Aquaculture (OGG 2011); (3) an underwater research park of the Institute of Marine Biology, Biotechnology and Aquaculture of Hellenic Center for Marine Research, which was identified when aerial orthophotos were used (Hellenic Centre for Marine Research 2017, Hellenic Cadastre of the Ministry of the Environment and Energy 2017); (4) river estuaries which were provided by the Directorate of Water of the Decentralized Administration of Crete (DWDAC 2017) and coastal wetlands, which were obtained from the Ministry of the Environment and Energy (MEE 2011); and (5) bathing beaches were provided by the Special Secretariat for Water of the Ministry of the Environment and Energy (MEE 2011).

The sub-category military areas includes marine areas that are used for military training and they were identified and digitized in polygons from Navionics maps (Navionics Webapp 2017).

Despite the fact that Category (v) is not a use, coastal erosion areas are included so that land–sea interaction can be identified. The original data shows the shoreline eroded (line) (Alexandrakis and Kampanis 2013). In order for the marine uses that are in contact with eroded shoreline to be identified, a 10 metre buffer to the sea was created. The uses data collected for the Region of Crete are depicted in Figure 2.

At this point, it should be noted that offshore renewable energy production, submarine energy interconnection of Crete with mainland Greece and the eastern Mediterranean, dive parks and underwater tourism are expected to grow in the next few years (MEE 2017; OGG 2017).

2.3 Working scale

The working scale was determined based on two key issues: (i) data availability; and (ii) the character of the central question which is the determination of key issues on MSP implementation in marine and coastal areas with significant uses accumulation, conflicts and potential conflicts. (Tsilimigkas *et al*. 2016). Therefore, in this study, the chosen working scale is 1:10,000 which is a typical scale for physical spatial planning and serves the paper's questions. Therefore, based on Waldo (1988) the spatial resolution of the data-set is set on 10*10 m.

2.4 Methodological approach

The geospatial data presented in Table 1 are vector files. Each vector file, which corresponds to a single subcategory, was transformed to raster layer based on the chosen working scale with pixel resolution 10*10 m. For each raster layer, the pixels take value '1', if they contain the use or activity of the subcategory, otherwise they take value '0'. A total

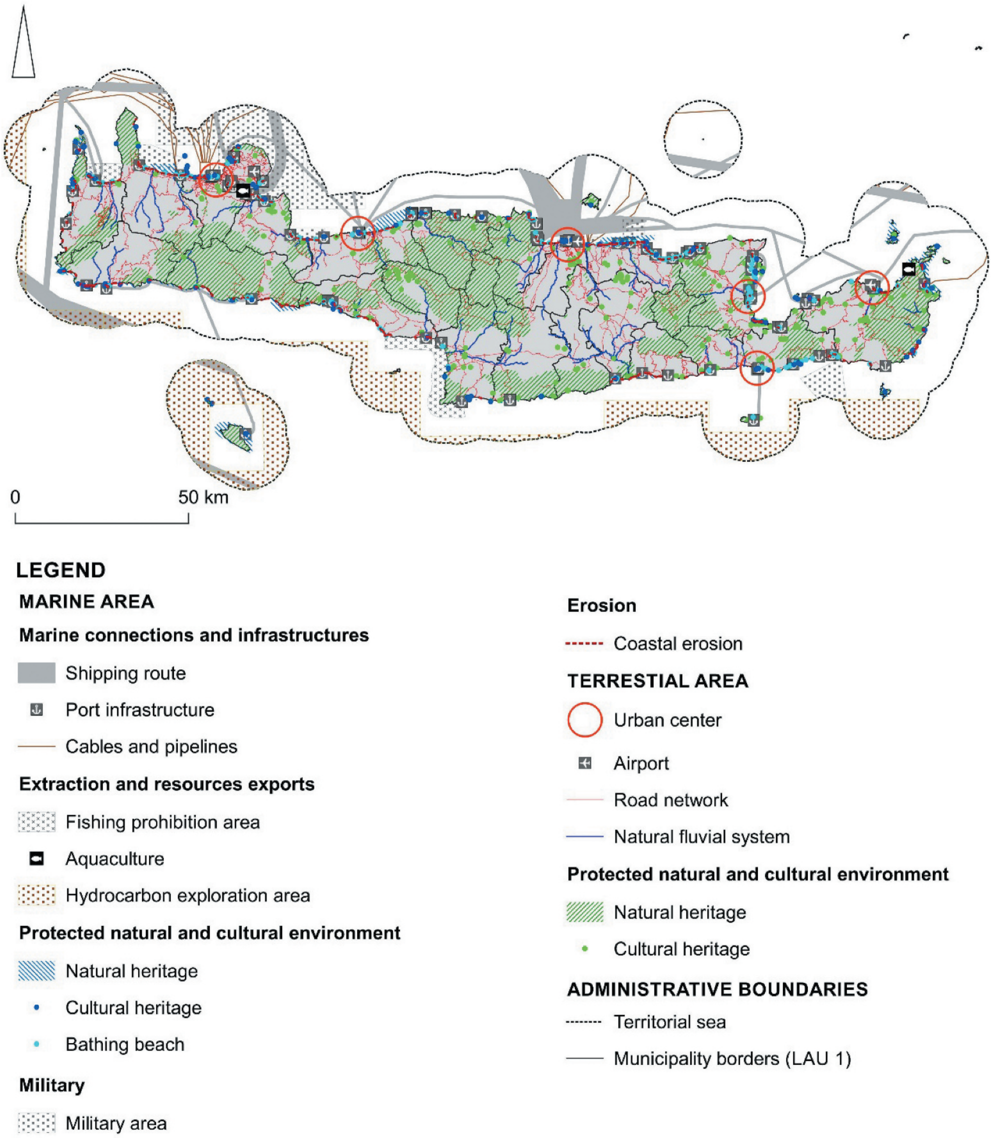

Figure 2. Marine and terrestrial uses.
Source: Authors' analysis; AIS Marine Traffic 2016; Directorate of Water of the Decentralized Administration of Crete; Hellenic Center for Marine Research 2017; Hellenic Directorate of Fisheries Control; Hellenic Ministry of Culture and Sports; (MEE (Ministry of the Environment and Energy) 2011; Navionics Webapp 2017).

of 10 rasters, one for each sub-category of Table 1, was created. Rasters (Figure 2) are crossed out to result a new raster that includes all possible combinations of uses. More specifically each pixel of the new raster contains one of the combinations presented in Table 2. The methodology is appropriate to identify marine typologies, in a systematic way, according to chosen physico-geographical and human-induced variables, and to provide key issues of their characteristics, patches, geometries and spatial distribution (Tsilimigkas and Rempis 2018).

A key step towards the integrated management of marine space is the identification of the compatibility or not of the marine uses. In the present work, the mobility, the spatial scale, the vertical scale, the temporal scale (Gramolini *et al*. 2013), the character-purpose and the environmental impact of each use and activity were taken into account in order to determine the compatibility of uses. More specifically, the following assumptions are adopted to determine the compatibility of uses: (i) Military use (Table 1; iv), due to the purpose of the particular use is considered incompatible with almost all other uses; (ii) Fishery and aquaculture uses (Table 1; ii.a;b) are considered incompatible with environmentally sensitive or/and degraded areas (i.e. underwater cultural heritage, natural heritage, shipping routes, port infrastructure and anchorage); (iii) Protected and exploited for recreation natural and cultural environment (Table 1; iii.a;b) is considered to operate under distinct terms and conditions in order to coexist with another use; (iv) the use of Extraction (Table 1; ii.c), due to environmental hazards in the event of an accident, is considered necessary to be carried out under terms and conditions in order to coexist with another use; and (v) the coexistence of use or uses with an erosion area (Table 1; v), highlights the land–sea interaction and the need to define terms and conditions for the location and the exercise of activities and uses both in the marine and land part of the coastal zone.

3. Results

3.1 Synergies and conflicts

As illustrated in Figure 3, conflicting uses accumulation is located mainly along the northern part of Crete Island. Significant accumulation of incompatible uses is also observed both in coastal areas of large urban centres and in areas that receive a large number of visitors during the summer period.

More specifically, on the one hand, Heraklion Gulf – located on the northern central coastal and marine zone – presents significant marine use accumulation and incompatibilities. Heraklion, the administrative capital and the principal urban centre of the Region, is located in this area. Shipping is a dominant marine use, as the wider area of Heraklion hosts the third largest in passenger traffic port in Greece (ELSTAT 2011) that links Crete with Athens, the capital of Greece, and many southern Aegean islands and industries that directly depend on the marine area for the transport of raw materials and merchandise. Every year, a total of 1.5 million passengers board or disembark in the port of Heraklion, while about 2.2 million tons of goods are handled (ELSTAT 2011). Moreover, there are a lot submarine cables and pipelines in Heraklion Gulf. All the above – combined with the existing tourism activities, coastal cultural and natural heritage areas and the demand for fishing areas – result in marine conflicts.

On the other hand, the wider marine and coastal areas of Chania – the second largest urban centre of Crete in the North-Western area – also presents significant use accumulation and conflicts. Military is the main marine use which causes conflicts, as there is a nautical base (with large-scale military zones) located in Souda, which is a few miles east of Chania. However, the port of Souda also links Chania

Table 2. Marine typologies.

S/N	USES CROSS	COVER (KM)	COVER (%)	USES COMPATIBILITY
1	Shipping routes	5.60	0.05	C
2	Shipping routes; Port infrastructures and anchorage	0.12	0.00	C
3	Shipping routes; Port infrastructures and anchorage; Fishery	5.07	0.05	I
4	Shipping routes; Port infrastructures and anchorage; Fishery; Cultural heritage	0.00	0.00	I
5	Shipping routes; Port infrastructures and anchorage; Fishery; Cultural heritage; Military areas	0.00	0.00	I
6	Shipping routes; Port infrastructures and anchorage; Fishery; Natural heritage	0.42	0.00	I
7	Shipping routes; Port infrastructures and anchorage; Fishery; Natural heritage; Cultural heritage	0.01	0.00	I
8	Shipping routes; Port infrastructures and anchorage; Fishery; Natural heritage; Bathing beaches	0.00	0.00	I
9	Shipping routes; Port infrastructures and anchorage; Fishery; Military areas	0.95	0.01	I
10	Shipping routes; Fishery	844.38	7.58	I
11	Shipping routes; Fishery; Cables and pipelines	0.79	0.01	I
12	Shipping routes; Fishery; Cables and pipelines; Bathing beaches	0.00	0.00	I
13	Shipping routes; Fishery; Cables and pipelines; Military areas	0.04	0.00	I
14	Shipping routes; Fishery; Cultural heritage	3.20	0.03	I
15	Shipping routes; Fishery; Cultural heritage; Natural heritage	1.52	0.01	I
16	Shipping routes; Fishery; Cultural heritage; Military areas	0.12	0.00	I
17	Shipping routes; Fishery; Natural heritage	8.18	0.07	I
18	Shipping routes; Fishery; Natural heritage; Bathing beaches	0.06	0.00	I
19	Shipping routes; Fishery; Natural heritage; Bathing beaches; Military areas	0.00	0.00	I
20	Shipping routes; Fishery; Natural heritage; Military areas	0.01	0.00	I
21	Shipping routes; Fishery; Bathing beaches	0.31	0.00	I
22	Shipping routes; Fishery; Bathing beaches; Military areas	0.22	0.00	I
23	Shipping routes; Fishery; Military areas	154.14	1.38	I
24	Shipping routes; Fishery; Aquaculture; Military areas	0.00	0.00	I
25	Shipping routes; Fishery; Extraction	131.26	1.18	I
26	Shipping routes; Bathing beaches	0.02	0.00	I
27	Port infrastructures and anchorage	0.13	0.00	C
28	Port infrastructures and anchorage; Fishery	3.42	0.03	I
29	Port infrastructures and anchorage; Fishery; Cables and pipelines	0.00	0.00	I
30	Port infrastructures and anchorage; Fishery; Cultural heritage	0.09	0.00	I
31	Port infrastructures and anchorage; Fishery; Cultural heritage; Natural heritage	0.02	0.00	I
32	Port infrastructures and anchorage; Fishery; Cultural heritage; Bathing beaches	0.01	0.00	I
33	Port infrastructures and anchorage; Fishery; Natural heritage	0.47	0.00	I
34	Port infrastructures and anchorage; Fishery; Natural heritage; Military areas	0.01	0.00	I
35	Port infrastructures and anchorage; Fishery; Bathing beaches	0.06	0.00	I
36	Port infrastructures and anchorage; Fishery; Bathing beaches; Military areas	0.03	0.00	I
37	Port infrastructures and anchorage; Fishery; Military areas	0.12	0.00	I
38	Port infrastructures and anchorage; Bathing beaches	0.05	0.00	I
39	Fishery	7012.12	62.94	C
40	Fishery; Cables and pipelines	2.12	0.02	CUC
41	Fishery; Cables and pipelines; Extraction	0.13	0.00	CUC
42	Fishery; Cables and pipelines; Cultural heritage	0.01	0.00	CUC
43	Fishery; Cables and pipelines; Cultural heritage; Natural heritage	0.02	0.00	CUC
44	Fishery; Cables and pipelines; Cultural heritage; Natural heritage; Bathing beaches	0.00	0.00	CUC
45	Fishery; Cables and pipelines; Cultural heritage; Bathing beaches; Military areas	0.01	0.00	I
46	Fishery; Cables and pipelines; Cultural heritage; Military areas	0.02	0.00	I
47	Fishery; Cables and pipelines; Natural heritage	0.04	0.00	CUC

(*Continued*)

Table 2. (Continued).

S/N	USES CROSS	COVER (KM)	COVER (%)	USES COMPATIBILITY
48	Fishery; Cables and pipelines; Natural heritage; Bathing beaches	0.01	0.00	CUC
49	Fishery; Cables and pipelines; Natural heritage; Military areas	0.02	0.00	I
50	Fishery; Cables and pipelines; Bathing beaches	0.00	0.00	CUC
51	Fishery; Cables and pipelines; Military areas	1.05	0.01	I
52	Fishery; Aquaculture	0.00	0.00	I
53	Fishery; Aquaculture; Natural heritage	0.08	0.00	I
54	Fishery; Extraction	1676.08	15.05	CUC
55	Fishery; Extraction; Cultural heritage	1.21	0.01	CUC
56	Fishery; Extraction; Cultural heritage; Natural heritage	0.07	0.00	CUC
57	Fishery; Extraction; Natural heritage	1.01	0.01	CUC
58	Fishery; Extraction; Military areas	2.56	0.02	I
59	Fishery; Cultural heritage	36.20	0.32	CUC
60	Fishery; Cultural heritage; Natural heritage	16.74	0.15	CUC
61	Fishery; Cultural heritage; Natural heritage; Bathing beaches	0.35	0.00	CUC
62	Fishery; Cultural heritage; Natural heritage; Bathing beaches; Military areas	0.00	0.00	I
63	Fishery; Cultural heritage; Natural heritage; Military areas	0.00	0.00	I
64	Fishery; Cultural heritage; Bathing beaches	0.76	0.01	CUC
65	Fishery; Cultural heritage; Bathing beaches; Military areas	0.18	0.00	I
66	Fishery; Cultural heritage; Military areas	2.71	0.02	I
67	Fishery; Natural heritage	188.17	1.69	CUC
68	Fishery; Natural heritage; Bathing beaches	3.37	0.03	CUC
69	Fishery; Natural heritage; Bathing beaches; Military areas	1.61	0.01	I
70	Fishery; Natural heritage; Military areas	24.08	0.22	I
71	Fishery; Bathing beaches	7.60	0.07	CUC
72	Fishery; Bathing beaches; Military areas	3.83	0.03	I
73	Fishery; Military areas	793.63	7.12	I
74	Cultural heritage	0.31	0.00	C
75	Cultural heritage; Natural heritage	0.06	0.00	C
76	Cultural heritage; Natural heritage; Bathing beaches	0.07	0.00	CUC
77	Cultural heritage; Bathing beaches	0.13	0.00	CUC
78	Natural heritage	2.22	0.02	C
79	Bathing beaches	2.33	0.02	C
80	Bathing beaches; Natural heritage	0.04	0.00	CUC

with Athens and presents significant shipping. Furthermore, the wider area of Chania is a place which receives a significant number of tourists as it hosts a large number of tourism attractions (cultural and natural heritage sites, famous bathing beaches). Every year in the wider area of Chania about 1 million tourist arrivals in hotels are recorded, which spend a total of about 6 million overnight stays (ELSTAT 2011). Many attractions are accessible with day ships [*imeroploia*, in Greek], which make frequent transportation during the summer.

In addition, in the Western and South-West marine zone, there is use incompatibility due to commercial and passenger ships that cruise to other ports of the Mediterranean Sea. Similarly, on Gavdos Island, which is located in the southwest of Crete, there are use accumulation and incompatibility in the wider area of its port due, nevertheless, to the presence of natural and cultural heritage areas.

The South-Western coastal zone also presents significant use accumulation and conflicts, since there are numerous tourism attractions and cultural and natural heritage area accumulation in the area. However, there is another impediment in this region: due to its

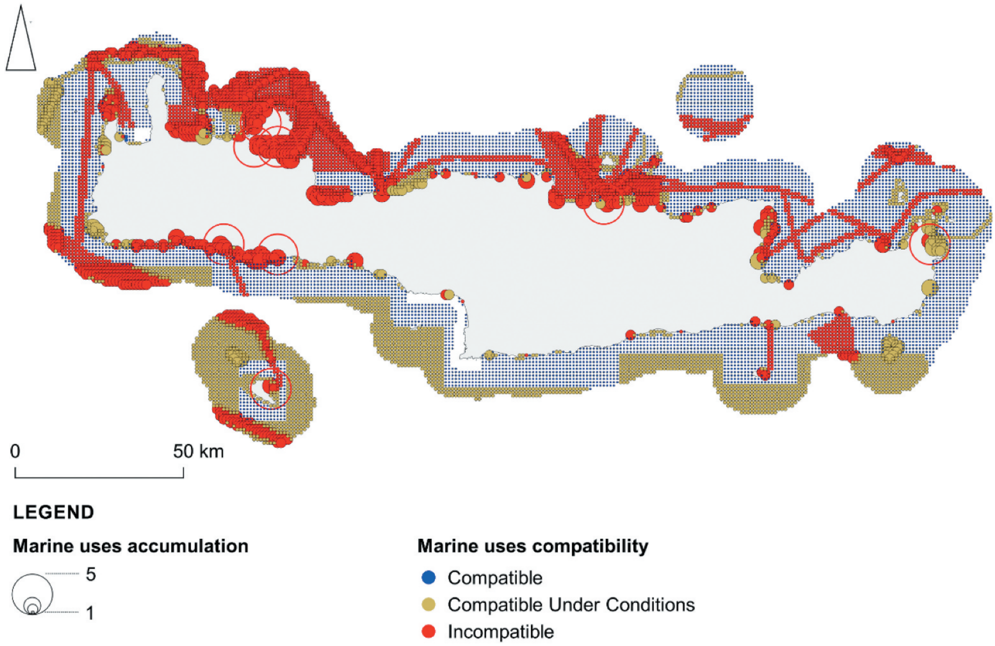

Figure 3. Marine uses accumulation and compatibility.
Source: Authors' analysis

intense geomorphological relief, there is limited road network, thus, the transport is mainly served by ships.

In the southern central coastal and marine zone, there is no significant use accumulation as the expansion of human-induced activities is limited mainly due to the intense geomorphological relief of the area. In the South-East coast, conflicts are detected either due to navigation of day ships or due to the delineation of the military zone.

In the North-East coast, use accumulation and conflicts are detected mainly near larger urban centres. Generally, the North-East coastal zone is a place that is characterized by a significant number of tourist attractions and areas of natural and cultural environment. In the marine zone the conflicts are the result of marine transport.

As it is illustrated in Table 2, when more than one marine use coexist, conflicts or potential conflicts may occur or occur. Use compatibility occurs only when there is only one marine use, except for the case of Shipping routes, Port infrastructure and anchorage (Table 2; s/n 2). The dominant marine typology is Fishing which represents 62.94% (Table 2; s/n 39) of the total study area. This marine activity can take place in almost all the study area. Incompatibilities or compatibilities under conditions are mainly identified in marine typologies involving Shipping routes or/and Fishery or/ and Military.

Marine typology Fishery and Extraction (Table 2; s/n 54), which is located in the South of the island and around the island of Gavdos, presents the highest percentage (15.05%) among the marine typologies characterized as Compatibly Under Conditions, a fact that reveals the need to set precise conditions and delineations as to how each activity is to be exercised. Shipping routes and Fishery (Table 2; s/n 10) and Fishery and Military areas

(Table 2; s/n 73) are the marine typologies which present the highest percentage (7.58% and 7.12%, respectively,) among the marine typologies characterized as Incompatibles.

3.2 Land–sea interaction

Uses accumulation is located mainly in proximity to the coastal zone and especially in proximity to sea-land limit. In particular significant uses accumulation is identified in the Northern and the South-Western coastal zones, where there is significant human presence in its terrestrial part as large urban centers and important tourist destinations are located in these areas. This fact on the one hand reveals a direct land – sea or/and sea – land interdependence and on the other hand reflects unevenness in terms of marine human activity concentration between the northern and the southern parts of the island in correspondence of the unevenness in terms of population and terrestrial human activity concentration between these parts of the island.

In addition, the results from the cross of marine uses with coastal erosion data showed that a large part of the coastal zones where accumulation of uses is identified succumb to intensive erosion phenomena. The marine typologies which were identified to be in contact with coastlines with significant erosion pressures are often those that include bathing beaches, port infrastructures and cultural and natural heritage areas. These facts, reveal both the interconnection between terrestrial and marine uses as well as the effects of human interventions in the coastal zones and in particular in proximity to sea-land limit. These effects cause many negative social, economic and environmental impacts which are enhanced by the effects of climate change and natural hazards.

3.3 Marine zoning key issues

The effective implementation of marine zoning depends on the adoption of the MSP principles as they come out of the Road Map for MSP (CEC 2008); the Directive 2014/89 (EP&C 2014); and the Directive 2008/56 (EP&C 2008). MSP principles could be grouped into three main categories. The first category concerns definition issues on and clarification of concepts as described below. More specifically, MSP implementation does not require topological continuity. Marine characteristics, rights and international obligations and the MSP scope can configure implementation area; Furthermore, all three dimensions of the marine space and the dimension of time should be taken into consideration so that the simultaneous marine use by non-conflicting marine uses and activities are ensured; Also, the character of MSP is defined based on the type of the existing activities, their intensity, their interrelationships and their environmental impact; and finally, MSP should manage existing and future marine uses and activities by promoting synergies among them and ensuring coherence among spatial, sectoral and development policies.

The second category concerns methodological features of MSP implementation Particularly, the adoption of participatory procedures involving interested parties is crucial for the acceptance of a MSP project; Furthermore, monitoring and assessment procedures should be integrated as both natural and human environments are constantly transformed; Also, the choice of the appropriate implementation and management body is crucial for effective MSP implementation; and finally, the multidimensional and interdisciplinary MSP process requires a reliable database of geospatial data.

The third category concerns policy implementation and institutional enactment. More particularly, land–sea interaction must be taken into account by ensuring consistency between terrestrial and marine spatial planning; Also, users and the local society's acceptance of institutional framework is necessary for the effective MSP implementation; and finally, the development of common standards and procedures between States that share common marine areas, whose cooperation is crucial so that coherence between neighbouring MSP is ensured (CEC 2008; EP&C 2014; EP&C 2008).

4. Discussion

4.1 European Union marine spatial planning experience

MSP is a complex process – tool that takes into account the multi-dimensional character of the marine area, the land–sea interaction and the need for an interdisciplinary approach. As European MSP legislation is very recent, and Member States have a margin until March 2021 to enact MSPs, there are not many Member States that have implemented plans (European MSP Platform 2020). Each EU Member State manages the issues raised by the European MSP Directive in accordance with its spatial planning policy, taking into account the compatibility with the commitments to the EU and the international conventions (European MSP Platform 2020). There are activated MSPs primarily in the North Sea and the Baltic, whereas pilot projects are implemented or planned by several States. In the Mediterranean Sea, Malta is the only EU country with an enacted MSP up to 25 nautical miles (European MSP Platform 2020). Although Croatia does not have an institutionalized MSP, its sea area is also covered in its existing spatial plans (European MSP Platform 2020).

4.2 Spatial planning in Greece

In Greece, MSP elements are included in the existing spatial, sectoral and development policies. All the existing spatial plans, from national to local level, contain issues that directly or indirectly affect coastal zones and marine areas. Furthermore, existing sectoral and development policies have spatial impact on coastal and marine areas.

Sectoral policies (i.e. on tourism, fishery, transportation, and on energy) provide directions and strategic options for sustainable development of activities and uses in coastal and marine area. The opportunities arising from the maritime activities are of strategic importance for the Greek economy, as highlighted in the Partnership Agreement for the Development Framework 2014–2020 (MDC 2014). Despite the existing uses more opportunities are identified to: (i) the development of blue energy; (ii) the protection of marine ecosystems; (iii) the development of fish shelters and regeneration of fish population as well as the simultaneous use of these areas for diving tourism; (iv) the promotion of the Navy culture and marine natural resources; (v) development of yachting and sport tourism, cruise tourism; (vi) the exploitation of marine mineral resources; and (vii) the development of blue biotechnology. Moreover, additional objectives for the coastal areas are to: (i) prevent risks caused by climate change; and (ii) implement MSP and ICZM in order to: (a) manage the increasing number of marine and coastal activities; (b) protect the marine environment; and (c) to avoid conflicts of uses (MDC 2014).

However, the aforementioned opportunities are characterized by fragmentation, inconsistency and absence of strong binding ties, a fact that results in implementing interventions, mainly in coastal zones, with significant spatial impact based on *ad-hoc* procedures that cause significant environmental, social and economic costs and negative land–sea interactions (Tsilimigkas and Rempis 2017, 2018, Rempis *et al*. 2018).

In Greece, the transfer of the MSP Directive into the national legislation was carried out under the Law 4546/2018 (OGG 2018) in June 2018, according to which, the MSP includes: (i) the national spatial strategy for the marine environment as part of the National Spatial Strategy; and (ii) marine spatial plans that correspond to the regional planning level and cover areas of marine and coastal spatial units indicated by the National Spatial Strategy and may be sub-regional, regional or interregional areas.

The Greek spatial planning framework is distinct in strategic planning and regulatory planning. Whereas strategic planning takes place at national and regional level, regulatory planning takes place at local level (OGG 2016) (Table 3). Therefore, the way the MSP Directive has been incorporated implies that the MSP will be strategic in its entirety, either as strategic guidelines at national level or as more specialized strategic guidelines at sub-regional, regional or interregional level.

Based on the results, it also seems that there is the need for the MSP to focus on a lower level in which the national level directions will be specialized based on the local needs and characteristics. As mentioned above, the character of MSP is based on existing activities, their intensity, their interrelationships and their environmental impact. Therefore, questions arise as to how a strategic vision at national level is capable of identifying local characteristics, which may impose a focus on regulatory planning rather than on a strategic one.

Table 3. Greek spatial planning system.

STRATEGIC	NATIONAL LEVEL		**National strategy for Spatial Planning:** Set key spatial organization guidelines, key axes, medium and long-term spatial development objectives, and proposed measures and actions to achieve the desired development.
			Special Spatial Plans: Set strategic guidelines related to: residential network, productive activities, land-use policy, protection of cultural and natural landscapes, coastal, marine and island areas, mountainous and degraded areas, promotion of plans, programs or projects. • Prisons (2001) • Renewable Energy Sources (2008) • Industry (2009) • Tourism (2009, 2013) • Aquaculture (2011)
	REGIONAL LEVEL		**Regional Spatial Plans:** Set strategic guidelines related to the spatial organization of the Regions by taking into account the strategic guidelines of the national level spatial plans which are specified and/or complemented. • 12 Regional Spatial Plans • 1 Master Plan of Athens
REGULATORY	LOCAL LEVEL	1st level	**Local Spatial Plans:** Regulate the sustainable spatial development and organization on municipal level **Special Spatial Plans:** they are recipients of plans, projects and programs regardless of administrative boundaries
		2nd level	**Urban plans:** Specialize and implement the first level spatial plans

→ Arrows indicate incorporation of directions that comes from upper planning level

4.3 Marine spatial planning implementation issues

At large, spatial scales the MSP framework should set strategic guidelines on the overall management of marine space by ensuring and promoting synergies and compatibilities between spatial, development and sectoral policies and by respecting European and International conventions. These strategic guidelines should be specified at local spatial scales based on local characteristics and set specific regulations, identifying marine uses zones and managing existing and future marine uses and activities in a sustainable way. As illustrated in Figure 4, the revised Regional Spatial Framework (RSF) of Crete (OGG 2017) sets directions which will extend the use of marine and coastal areas. These directions concern: (i) new energy submarine links; (ii) energy hubs; (iii) port infrastructure combined with the development of hydroplane infrastructure, (iv) development of marine productive activities; (v) enhancement of marine tourism; and (vi) terrestrial urban, tourism and RES development zones. It should be noted that initial version of the (RSF) of Crete (2003) did not contain extensive guidelines for the management of the marine and coastal area. The only directions

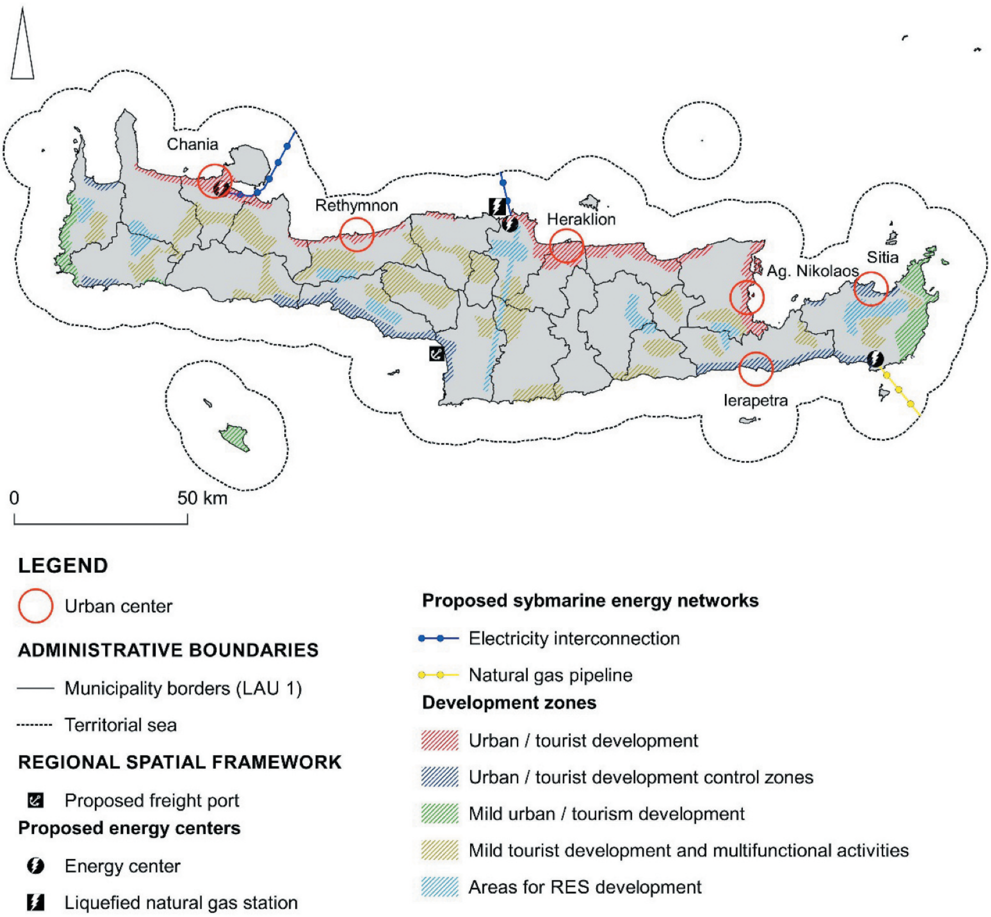

Figure 4. Regional spatial framework of Crete.
Source: Authors' analysis (OGG 2017).

concerned the functional and aesthetic upgrade of the ports, as well as the reduction of the urban sprawl in the land part of the coastal zones (Tsilimigkas and Rempis 2017).

Regional spatial plans highlight the need for specialization of directions at a lower spatial level through physical planning. There is also the same need for the marine area; that is, for physical planning to be implemented. Zone limits and sub-categories of permitted uses must be specified at local level in order to serve the needs of each specific marine area, preserve the environment and achieve synergies between spatial, developmental and sectoral priorities.

As mentioned before, the coherence and the coordination between terrestrial and marine space is a key factor of MSP implementation. The capture of land – sea interaction is crucial, should this goal be achieved. As the Results indicate, a significant number of uses and conflicts occur in proximity to the sea-land limit and, especially, in proximity to coastlines with significant erosion pressure. According to Rempis *et al*. (2018), the implementation of a use or infrastructure in proximity to the sea-land limit either in the terrestrial or the marine part often results in significant positive and/or negative socio-economic and environmental effects and in land–sea interactions – interconnections. In Greece, this phenomenon is even more intense due to the absence of an integrated coastal management policy and framework.

In countries like Greece, where sustainability of local societies significantly depends on coastal and marine areas, exploitation and management of the coastal zone are based on fragmented approaches and tools. Thus, an integrated spatial planning system that addresses simultaneously land and marine areas issues is needed. Thus, during spatial planning procedures and when integrated approaches are adopted, land-sea interconnection-interaction should be addressed in an efficient way. In contrast, the adoption of two separate-parallel spatial plans for the terrestrial and marine areas may result in fragmented approaches. At the local level, the implementation of local spatial plans must consider the terrestrial and the marine areas of a Municipality. In this way, the needs of the local community will be served, erosion phenomena and the impact of climate change will be more effectively addressed by local authorities and a smooth transition from land to sea and vice versa will be ensured.

Furthermore, given that the natural and human environment are constantly transformed, it is important that MSP implementation will be based on reliable geospatial data from various scientific fields and, after a plan has been accepted, it is crucial that monitoring and assessment procedures should be integrated. To that end, an integrated spatial data infrastructure concerning the coastal zones and the marine area needs to be developed.

5. Conclusions

According to the MSP principles, the character of the adopted MSP i.e. regulatory or strategic planning depends on a number of factors, such as: (i) the nature; (ii) the intensity; (iii) the covered area; (iv) the interrelationships; and (v) the environmental impact of marine activities.

On Crete island, which is an atypical example of European coastal and marine area due to its geopolitical, geomorphological, geographic, natural and socio-economic characteristics, the results – that is, the conflicts and the potential conflicts that have been identified as well as their distribution – reveal on the one hand the interconnection –

interdependence between the terrestrial and the marine part of the coastal zone especially in proximity to the sea-land or land-sea limit and on the other hand the need for a regulatory MSP. Addressing the needs of the study area through a strategic MSP may have been precarious in achieving the MSP objectives, since specific zones with specific terms and limitations should be adopted.

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