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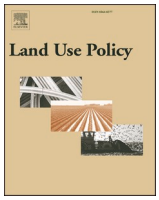

The limits of coastal and marine areas in Andalusia (Spain). A socio-ecological approach for ecosystem-based management

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ABSTRACT

Coastal and marine areas represent one of the most relevant spaces on a global scale to address management and conservation processes. Firstly, this is due to the interactions that characterise the area of exchange between land and sea. Secondly, it is the area where the main population settlements are located. However, there is no agreed definition of the scope of the coastal zone for management, and legal delimitations usually simplify the reality, making it impossible to develop Ecosystem Based Management in these areas. The research advances on a proposal for a conceptual and geographical delimitation of coastal areas from a socio-ecological perspective. The results show a delimitation of the coastal area based on two large geographical areas: The Coast and the Coastal Zone. The first one includes the Coastal Water, the Intertidal Area and the Shoreland. Seconly, the Coastal Zone is fundamental for understanding certain ecosystemic and social phenomena, and includes two units: Coastal Zone Water and Coastal Land. The proposed socio-ecological limits do not always coincide with the legal limits, which is why this article analyses in depth, for the case of Andalusia (Spain), the state and regional legislation on coastal matters. With all this, ideas are proposed on which to introduce socio-ecological delimitation into the legal limits and thus advance towards Ecosystem-Based Management in coastal and marine areas.

1. Introduction

Globally, marine and coastal areas represent one of the most relevant spaces for consideration of their management and conservation processes (Agardy et al., 2015). This is primarily due to the interactive characteristics of the area of exchange between land and sea (Barragan, 2014). Secondly, it is the area where the majority of population settlements have been established (Barragán and de Andrés, 2015). However, the implied space of coastal and marine areas is not defined in a universal manner (Barragán and Andrés, 2016), leading to the fact that criteria adopted to delimit coastal and marine zones countries depends on the approach or purpose pursued (Lins-de-barros and Batista, 2020).

Understanding ICZM as "*the process of public administration of coastal zones, in a complex area, made up of several environments, aimed at development and human well-being through the protection and conservation of natural capital*" (Barragan, 2014), researchers and international institutions have accepted ecological principles to define the scope of processes to address coastal zone issues, i.e. what would be the space that defines the coastal zone (Clark, 1992; FAO, 1998; Kay and Alder, 1999; UNEP, 2011, 1995; Vallega, 1999). However, the inherent nature of the coastal and marine environment makes it difficult to delimit them, as they are not spaces associated with a single ecosystem (Lins-de-barros and Batista, 2020). In addition, multiple human uses and activities coexist in the coastal zone, making it even more difficult to define and delimit the coastal zone in a broad sense.

Several authors have tried to establish theoretical boundaries in coastal zones, and accordingly, they work with coastal spaces as far as the marine influence stretches, such as the crest of a rocky slope or the boundary of an estuary (Woodroffe, 2002). Metric criteria, such as the first 100 km from the coastline (Cohen and Small, 1998) or 10 m above sea level (McGranahan et al., 2007), are also used as references.

In the marine environment there are fewer references, however, some authors have defined the coastal zone as being up to a minimum of the wave breaking zone (Bird, 2008). Others focus on estuarine areas, defining them up to the point where salinity reaches values above 35 ppm (Elliott and McLusky, 2002), or up to where the sediment plume extends (Pallero et al., 2017).

Although there are researches around the world that propose coastal zones be delimited using geographic or ecological criteria (Balaguer et al., 2008; Batista, 2017; Druzhinin et al., 2020), the prevailing legal

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reality in most coastal zones is that it is based on metric and administrative criteria. This is concluded in Perez-Cayeiro et al. (2019) were a compilation of legal boundaries in coastal countries in Latin America and the Caribbean was performed.

In the case of Spain, there is no formal delimitation of the coastal and marine zone. There are only limits established for the management of the first few meters from the coastline. This delimitation is regulated by the Shores Act (Jefatura del Estado, 1988) and its modification with the Protection and Sustainable Use of the Littoral Act (Jefatura del Estado, 2013). These laws establish three geographical areas that define the coast of the country: The Maritime Terrestrial Public Domain (MTPD), the Protection Easement (PE) and the Influence Zone (IZ) (Fig. 1).

The area delimited in the Shores Act is focused on the Maritime Terrestrial Public Domain (MTPD). The MTPD is a public, terrestrial and marine area that includes the seashore, inland waters and the territorial sea, as well as the natural resources of the Exclusive Economic Zone (EEZ) and the continental shelf (Suárez-de Vivero, 1992).

In addition to the MTPD, the Shores Act delimits a Protection Easement (EP) and an Influence Zone (IZ). The PE is a zone with restricted uses and activities, which is delimited from a distance of 100 m inland, starting from the inner limit of the seashore; this is reduced to 20 m in urban areas. Moreover, it is established a six-metre wide right of way. The IZ corresponds to an area extending up to 500 m from the inner seashore.

Based on the above, we can assume that scientific advances in delimiting coastal and marine areas are not consistant with the legal reality in most cases, and specifically, in Spain. necessitating efforts to bring the socio-ecological reality of coastal and marine areas closer to the regulations in force.

The research developed in this paper is focused on the delimitation of the coastal and marine zones of Andalusia (Spain) from a socio-ecological approach, where the geographical, ecological and socio-economic reality of both terrestrial and marine space is considered.

The research aims not only to propose criteria for delimiting coastal zones, but also to adapt and strengthen the needs of Spanish legislation in order to move towards a more realistic delimitation. Thus, future ICZM processes will have a delimited scope under socio-ecological, but also legal-administrative criteria.

Furthermore, Ecosystem Based Management (EBM), which is the approach towards advancing to, recognises that the natural and human components of an ecosystem interact in a complex way (Kelble et al., 2013a). Therefore, delimiting coastal zones from a socio-ecological approach would allow both ecosystems and human activities to be taken into account. Only if these interactions are contemplated will it be possible to establish Ecosystem Based Management mechanisms.

The specific objectives of this research are the following: a) To approximate a delimitation of the Coastal Socio-ecological System of Andalusia (CSES-A); b) To contrast the CSES-A with that of the current legal delimitation; c) Strengthen Spanish legislation with socio-ecological delimitation criteria to move towards EBM.

2. Study area and background

Andalusia is an Autonomous Community of Spain, located in the south of the Iberian Peninsula. It has an area of 87,592 km^2 (IGN) and a coastline of 910 km (IGN). The Andalusian coast has two distinct sectors: The Atlantic coast (from Huelva to the Strait of Gibraltar) and the Mediterranean coast (from the Strait of Gibraltar to Almería) (Fig. 2).

The Atlantic coast of Andalusia has a practically flat relief, corresponding to a sedimentary area, with an extensive and gently sloping continental shelf. It has some estuaries that provide fresh water to the coast, among which, the Guadiana and the Guadalquivir stand out. The Mediterranean coast is close to the Baetic System which gives rise to narrow beaches and a relief mostly in the form of cliffs, as corresponds to a mountainous orography (Consejería de Medio Ambiente y Ordenación del Territorio, 2015).

In terms of population, Spain has a settlement pattern on coastal areas, with 56 % of the population being located in the coastal zone, of which 28 % of the population reside in cities in the coastal zone (de Andrés et al., 2017). Specifically, in Andalusia, the coastal zone represents the area with the highest population growth rates and, consequently, this is where the highest population densities originate. The urbanization process in Andalusia has multiplied the urban land in coastal areas several hundred times, causing significant impacts on the landscape, ecosystems and their services (IECA, 2011). An example of this can be seen in the Bay of Cadiz, located in the southwestern sector of

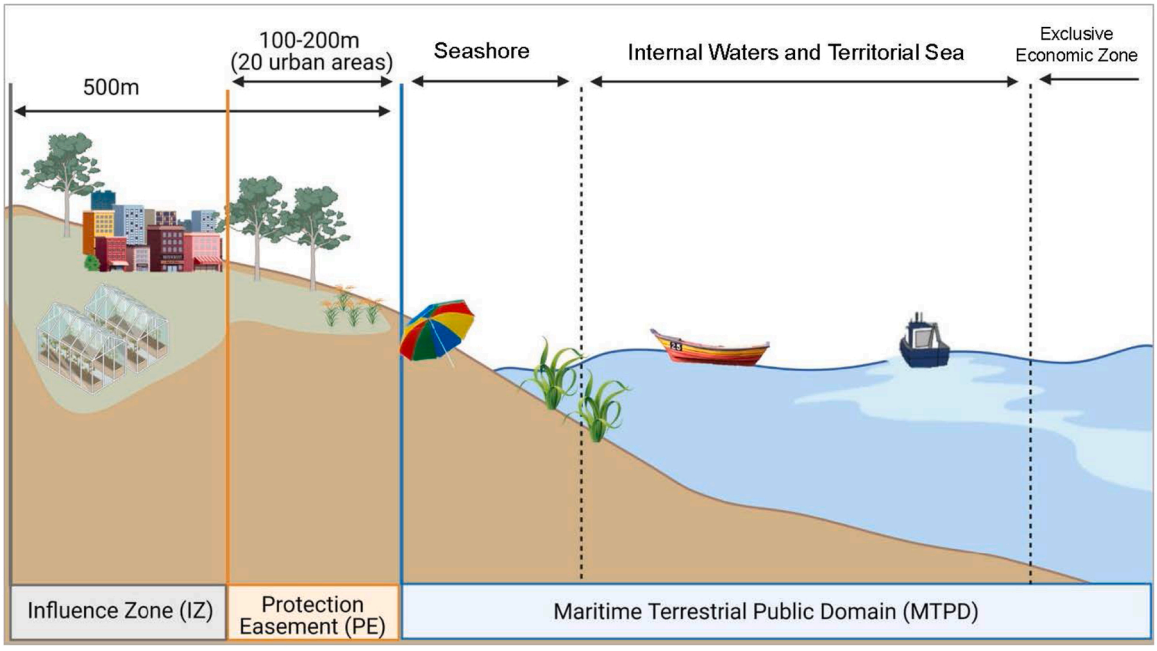

Fig. 1. Limits of the coastal zone in Shores Act.
Source: Authors´own based on limits established by Shores Act

Fig. 2. Study area, *Google Earth image of Andalusia highlighting the main features associated with the coastal zone.*

Andalusia, which is an urban metropolitan area resulting from the growth of cities located around a Protected Natural Area. This has led to fragmentation and loss of coastal and marine ecosystem services characteristic of the intertidal space of the bay (de Andrés et al., 2018a).

The starting point of this research is the geographic-ecological and socio-economic characteristics of the coastal zone of Andalusia. With this, the socio-ecological boundaries developed can support the current administrative delimitation, thus facilitating management processes on coastal and marine areas, with an ecosystemic approach.

3. Methodology

3.1. Using geographic-ecological and socio-economic criteria to delimit the Coastal Socio-ecological System of Andalusia (CSES-A)

The methodology to delimit the Andalusian coastal zone is based on the theory of socio-ecological systems. The foundations for understanding the physical world as a socio-ecological system have been studied and developed by different authors (Berkes, Folke, 1998; Cumming, 2011; Norberg and Cumming, 2008; Ostrom, 2009), based on the interaction of ecological and social processes, where adaptive management is necessary to ensure human well-being (Cumming, 2011; Norberg and Cumming, 2008). The term social-ecological systems is used to refer to the concept of the integration of humans with nature (Berkes, Folke, 1998). The complexity of the changes and challenges facing the environment have led to the need to understand the relationships that occur between social and ecological spheres.

For the delimitation of the coastal zone from a socio-ecological approach, a conceptual framework establishes boundaries based on geographic, ecological, socio-economic and administrative criteria (Barragán and de Andrés, 2016). This is comprised of three major geographic units: Coast, Coastal Zone and Coastal Influence Zone. The Coast (includes the Coastal Water, Intertidal Area and Shoreland) is the contact area on both sides between the terrestrial and marine environment, where physical-natural events occur with greater intensity and speed. The Coastal Zone (Coastal Zone Water and Coastal Land) is defined as the geographic area where the existence or influence of the sea most directly affects human activities (Barragán, 2004). Finally, the Coastal Influence Zone is identified as an area that, although it does not belong to the Coastal Zone due to it being further away, certain activities could have an impact on the coast. The proposed methodology has been developed in recent studies at the level of state, albeit only for the terrestrial domain (de Andrés et al., 2018b, 2017).

In this current research, two adaptations have been made to the conceptual framework described above. First, the delimitation of the socio-ecological system is performed based on socio-ecological characteristics, i.e. geographic-ecological and socio-economic criteria are considered to establish the boundaries ensuring both ecological continuity and continuity of uses and activities. In the case of overlaps between criteria, those that cover a larger coastal area are used, and in the last case, the geographic-ecological criteria are prioritized, due to the nature of the environment itself. The second adaptation made to the conceptual framework for delimitation is that the use of the concept of coastal area of influence is eliminated because the objective of this research is to establish the limits of the coastal zone, and the area of influence is beyond this delimitation.

Based on the initial conceptual framework, specific criteria are established to define and delimit the five geographical units of the coastal zone (Coastal Zone Water, Coastal Water, Intertidal Area, Shoreland and Coastal Land) (Fig. 3).

The ecological criteria used are based on those proposed in previous research on socio-ecological delimitation methodologies in coastal zones (de Andrés et al., 2018a, 2017; Palomo et al., 2014). In addition, ecological and ecosystemic characteristics of relevance for coastal and

Fig. 3. Graphic scheme for the delimitation of the coastal zone as a socio-ecological system.

marine zone management in the region are included (Barragán et al., 2008; Instituto Español de Oceanografía, 2012a, 2012b).

Table 1 presents the specific criteria used for the delimitation of each of the CSES-A units. In this regard, the general criteria established in Fig. 3 are concretised with the ecological and socio-economic characteristics of the coastal zone of Andalusia.

In order to choose the most appropriate terminology for the administration and to move towards Ecosystem Based Management, it is proposed that the coast be identified as the "immediate area on both sides of the contact line between the lithosphere and the salty hydrosphere, including the intertidal domain, where natural processes are most active and dynamic, and human interaction is most direct". The zonal character of the Coast will be applied to the bands determined by the regulations in force at any given time (e.g. 100 m of the MTD Protection Easement Zone).

On the other hand, the Coastal Zone is defined as "that geographical space, marine and terrestrial, identified with a surface of variable shape and dimensions, resulting from the interactive contact between nature and human activities that take place in areas that share the existence or influence of the sea" (Barragán, 2014).

Consequently, the units described will be located on the Coast, if they have geographical, ecological and socio-economic characteristics typical of this environment, or in the Coastal Zone, in the case of the Coastal Land and the Coastal Zone Water, which, although they belong to the socio-ecological delimitation area, are located further away from the coastline.

3.2. Delimiting the five units of the Andalusian coastal zone

Based on the socio-ecological criteria established in the previous section, the cartographies corresponding to each of the coastal zone units are developed. The cartography is developed from the combination of two geographic information systems (QGIS and ArcGIS) with layers of environmental information and occupation information being superimposed based on human uses and activities. QGIS software was used for the visualisation and processing of the information of each of the layers and WMS services, due to its greater speed of use. Subsequently, ArcGIS Pro was used to elaborate the layers corresponding to the different units of the SSL-A, as this software allows a more in-depth processing of the data as a whole, as well as the superimposition of layers.

For the delimitation of each of the units, a GIS-based multi-criteria analysis was carried out. To do this, first of all, the mapping of each of the socio-ecological and socio-economic criteria in Table 1 was overlaid. Based on this overlay, a series of priority criteria were established:

1º. We started with the delimitation of the Intertidal Area, inland and offshore. The criteria were therefore identified on the basis of this first unit.

2º. In both the overlapping of socio-ecological and socio-economic criteria, those criteria that involve a larger surface area were considered, starting from the Intertidal Area. In this sense, all criteria with a certain link to the coast were included in a management unit closer to the coast.

3º. In case of differences between the socio-ecological and socio-economic criteria, the first criterion prevailed. This is because the ultimate goal of moving towards EBM must ensure ecosystem continuity also in management.

The GIS analysis based on the above prioritisation of criteria makes it possible to delimit each of the Andalusian CSES units. Furthermore, this prioritisation, with the establishment of specific criteria for each place, allows the analysis to be replicated in other locations.

The sources of information used for the cartography are found in the REDIAM (Environmental Information Network of Andalusia) and the National Geographic Institute databases. In the terrestrial environment, land occupation is obtained from the Corine Land Cover 2018 information, completed with data from the Spanish Land Occupation Information System (2013) for areas where more detailed information is required. The area to be delimited is very large and the use of SIOSE for all boundaries was inoperative. For this reason, the CLC information was used (it is also more recent) and then SIOSE was used for those areas that required special attention. Table 2 summarizes the different sources of

Table 1
Criteria for the delimitation of CSES-A units.

Zoning	Coastal Zone	Coast			Coastal Zone
Unit of CSES-A	Coastal Zone Water	Coastal Water	Intertidal Area	Shoreland	Coastal Land
Ecological criteria	Seagrasses	Coastal lagoons	Deltas and estuaries	Vegetation typical of coastal environments	Coastal aquifers
	Photophilic algae	Bays, estuaries or inlets	Beaches, dunes and sandbanks	Coastal pine forests	Lagoons with coastal birdlife
	Spawning and nursery areas	Maximum low tide	Salines and saltmarshes	Areas vulnerable to flooding and natural risk	Lowland watersheds
	Salinity with values above 35 ppt	Salinity below 35 ppt	Escarps and cliffs		Coastal forests
	Coastal birdlife		Between high tide and low tide		
Socio-economic criteria	Artisanal fishing (Mediterranean)	Aquaculture (Mediterranean)	Marine salt farming	Urban areas	Areas of intensive agriculture
	Aquaculture (Atlantic)	Authorised discharge areas	Aquaculture in marshes	Large facilities (wastewater treatment plants)	Large road, rail and reservoir infrastructures
	Maritime shipping routes	Artisanal and sport fishing		Port and industrial areas	

geographic information used.

In addition to applying socio-ecological criteria, it is necessary to take into account a series of premises that characterize the area of study:

1. **Difference between catchment areas:** In the marine environment, it is important to point out the existence of different ecosystems, uses and economic activities on the Atlantic and Mediterranean catchment areas. This is due, on the one hand, to the non-existence of an appreciable tidal range in the Mediterranean, meaning that the delimitation of the Intertidal Space in this area is restricted to beach areas, salt marshes or aquaculture activities. On the other hand, the inclination of the seabed on both sides causes the Mediterranean to reach deeper depths at a shorter distance from the coast than the Atlantic. This leads to differences in the distribution of ecosystems, species and associated maritime activities.
2. **The Guadalquivir river basin:** This area presents singularities due to its delimitation. In the Guadalquivir River, the effect of the tides can be felt as far as Seville - more than 100 km inland. In this area, the Coastal Water host an important socio-economic activity (maritime-fluvial transport), and the Intertidal Area has an important ecosystem diversity (saltmarshes). Inland, the socio-ecological areas typical of the Coastal Lands are predominant.
3. **Protected Natural Areas:** The extension of protected coastal ecosystems in Andalusia is significant. Specifically, the coastal strip included in some types of protection can be found to have a length of 308 kilometers, representing a protected coastal zone of 35.8% (Consejería de Medio Ambiente y Ordenación del Territorio, 2015). This renders coastal Protected Natural Areas a useful tool for the delimitation of the coastal zone.

3.3. To compare the current legal-administrative delimitation of the coast with that established by socio-ecological criteria

Once the delimitation of the geographical units of the coastal zone has been established following socio-ecological criteria, a comparison of the established limits with the delimitation established by state legislation (BOE-A-1988–18762; BOE-A-2013–5670) is carried out.

For this purpose, a cartographic analysis of the coastal zone delimited by the regulations, i.e., the Maritime Terrestrial Public Domain, Protection Easement and Influence Zone, is required. This analysis uses as sources of information those provided by the Ministry for Ecological Transition and the Demographic Challenge for the MTPD, as well as the Rediam cartography for the Protection Easement. Additionally, it is necessary to consider the jurisdictional limits of the Inland Waters, the Territorial Sea and the Exclusive Economic Zone, as all of them are included in the MTPD.

4. Results

4.1. The socio-ecological system of Andalusia

The application of the socio-ecological criteria on the geography of Andalusia has resulted in the constitution of the Coastal Socio-ecological System of Andalusia (CSES-A). The CSES-A designed for management is formed by a first strip that would be the Coast, and is where the main coastal-marine ecosystems are concentrated, as well as the most intense economic uses and activities. The Coast includes three geographical units: Coastal Water, Intertidal Area and Shoreland. In addition to the Coast, the CSES-A includes a larger area, the Coastal Zone, which

Table 2
Sources of geographic information for the delimitation of the Andalusian coastal zone.

ITEM	DESCRIPTION	Reference
Aquaculture	Aquaculture facilities (ESRI shaefile-ETRS 89–1:50.000)	Rediam (www.juntadeandalucia.es/medioambiente/site/rediam)
Upwelling water	Upwelling areas in the marine environment of influence (ESRI shapefile-ETRS 89–1:1.000.000)	Rediam (www.juntadeandalucia.es/medioambiente/site/rediam)
Fishing areas	Fishing areas (WMS-1:100.000)	Rediam (www.juntadeandalucia.es/medioambiente/site/rediam)
Bathimetry	Coastal bathimetry (WMS-1:400.000)	Rediam (www.juntadeandalucia.es/medioambiente/site/rediam)
Corine Land Cover 2018	CLC 2018 (ESRI shapefile-1:100.000)	Corine Land Cover (https://land.copernicus.eu/pan-european/corine-land-cover)
MTPD	Maritime-terrestrial public domain boundary line (ESRI shapefile- 1:25.000)	Ministry for Ecological Transition and the Demographic Challenge (www.miteco.gob.es)
Protected Areas	Natural Protected Areas (ESRI shapefile-1:50.000)	Ministry for Ecological Transition and the Demographic Challenge (www.miteco.gob.es)
Coastline	Natural coastline (COALNE)+ artificial coastline (SLCONS) (ESRI shapefile-1:25.000)	National Geographic Institute (www.ign.es)
Maritime routes	Maritime route lines (ESRI shapefile)	National Geographic Institute (www.ign.es)
Salinity	Average salinity of influential marine water (ESRI shapefile- 1:400.000)	Rediam (www.juntadeandalucia.es/medioambiente/site/rediam)
Spanish land occupancy information system	SIOSE (ESRI shapefile-1:10.000)(2013)	SIOSE (www.siose.es)
Average sea temperature	Average sea temperatura (WMS- 1:100.000)	Rediam (www.juntadeandalucia.es/medioambiente/site/rediam)
Seagrasses	Underwater vegetation (WMS-1:50.000)	Rediam (www.juntadeandalucia.es/medioambiente/site/rediam)
Zooplancton	Zooplancton distribution (ESRI shapefile- 1:400.000)	Rediam (www.juntadeandalucia.es/medioambiente/site/rediam)
EUNIS marine habitats	EUNIS marine habitats (ESRI shapefile- Mediterranean and Atlantic shapes)	EUNIS (https://eunis.eea.europa.eu)

includes all those ecosystems, uses and activities that are associated in some way with the coast. The Coastal Zone is delimited in its terrestrial part, giving rise to the Coastal Land, and marine, originating in the Coastal Zone Water (Fig. 4).

- Coastal Zone Water:

  Following the criteria set out in Table 1, the Coastal Zone Water is the marine area, farthest from the coast, but whose ecological characteristics, such as the uses and activities that are developed, are closely linked to the terrestrial environment. This marine geographic unit occupies an area of 11,096 km^2, and it is related to the circalitoral zone described in EUNIS (European Nature Intormation System), which is defined as the area below the deepest subtidal water with insufficient light penetration to allow algae to dominate (Davies et al., 2004; European Environment Agency, 2015). Coastal Zone Water is within the Continental Shelf, as beyond the Continental Shelf, the characteristics of the marine environment change (as well as the jurisdiction) and therefore would not be within the scope of coastal zone management. Thus, the distance from the coastline to the outer limit of the Coastal Zone Water is less than 12. n.m and its extension at each point is determined by the ecological and socio-economic characteristics of the environment.

  From an ecological point of view, the Coastal Zone Water is delimited towards the marine environment up to the area where there are the greatest sightings of coastal birds (Arroyo et al., 2020; González-Paredes, 2012), always considering that the scope corresponds to that area on the continental shelf, as its ecological and hydrodynamic characteristics are more associated with the coast (Zhelezov, 2018). Additionally, Coastal Zone Water encompasses those areas where there is a higher concentration of zooplankton associated with coastal areas (Navarro et al., 2012).

  Regarding marine uses in the Coastal Zone Water, there are differences in the Atlantic and Mediterranean basins. Thus, the Atlantic Coastal Zone Water is associated with shellfish production. In the maritime zone of Isla Cristina, in particular, production of mussels in floating rafts can be found (Consejería de Agricultura Ganadería Pesca y Desarrollo Sostenible, 2014a). For their part, those of the Mediterranean are occupied by fishing grounds associated with artisanal fisheries, most of which use longline and trammel net gear (García et al., 2012).

- Coastal Water:

  Coastal Water occupies an area of 1630 km^2, and is delimited from the minimum low tide including coastal lagoons, bays, estuaries or inlets, as well as the warmer water masses coming from river mouths. The term Coastal Water coincides with that stated in the Water Framework Directive (WFD) (European Commission, 2000) and Marine Strategy Framework Directive (MSFD) (European Union, 2008). However, the limits to the marine environment presented in the legislation correspond to a nautical mile, whereas in the socio-ecological approach it depends on the characteristics of each area.

  From an ecological point of view, the Coastal Water encompasses up to the outer limit of the seagrasses. In addition to large bays and estuaries. In Andalusia there are meadows of the four species of marine phanerogams that are endemic in Europe: *Posidonia oceanica, Cymodocea Nodosa, Zostera Noltei and Zostera marina*. The most extensive Posidonia oceanica meadow is located in Almeria, occupying an area of 56 km^2 (Ruiz et al., 2015).

  From a socioeconomic perspective, coastal waters are delimited towards the sea, mainly up to the limit of aquaculture and artisanal fishing areas. Artisanal fishing carried out in the *Coastal Water* is mainly with drag nets, dredgers and the handjigs (Piniella et al., 2007). Regarding marine aquaculture, the cultivation of mussels, in particular, in floating long-lines structures, mainly on the coast of the province of Malaga (APROMAR, 2019; Consejería de Agricultura Ganadería Pesca y Desarrollo Sostenible, 2014b; Consejería de Agricultura Pesca y Desarrollo Rural, 2014).

- Intertidal Area:

  Occupying a transitional space between the terrestrial and marine environments, the Intertidal Area is not represented on most maps because the coastline is usually used as a separation between land and sea. However, the Intertidal Area has highly significant ecosystems of great ecological value (Barbier et al., 2011; Costanza et al., 1997), making it necessary to define it from a socio-ecological point of view, as an independent geographical unit.

  In the delimitation of the CSES-A, the Intertidal Area occupies 963 km^2, highlighting its prevalence on the Atlantic coast, where the most outstanding intertidal ecosystems are found, such as marshes, sandbanks and extensive beaches. A notable example of which is the intertidal of Huelva, being mostly occupied by the Doñana Natural Park with extensive marshes developed by the filling of the Guadalquivir estuary (Martín-López et al., 2017a). These marshes, although no longer influenced by tides, are noteworthy for their evolutionary stage, from an exorheic to an endorheic situation.

  In the Mediterranean, although there is no tidal range (Izquierdo

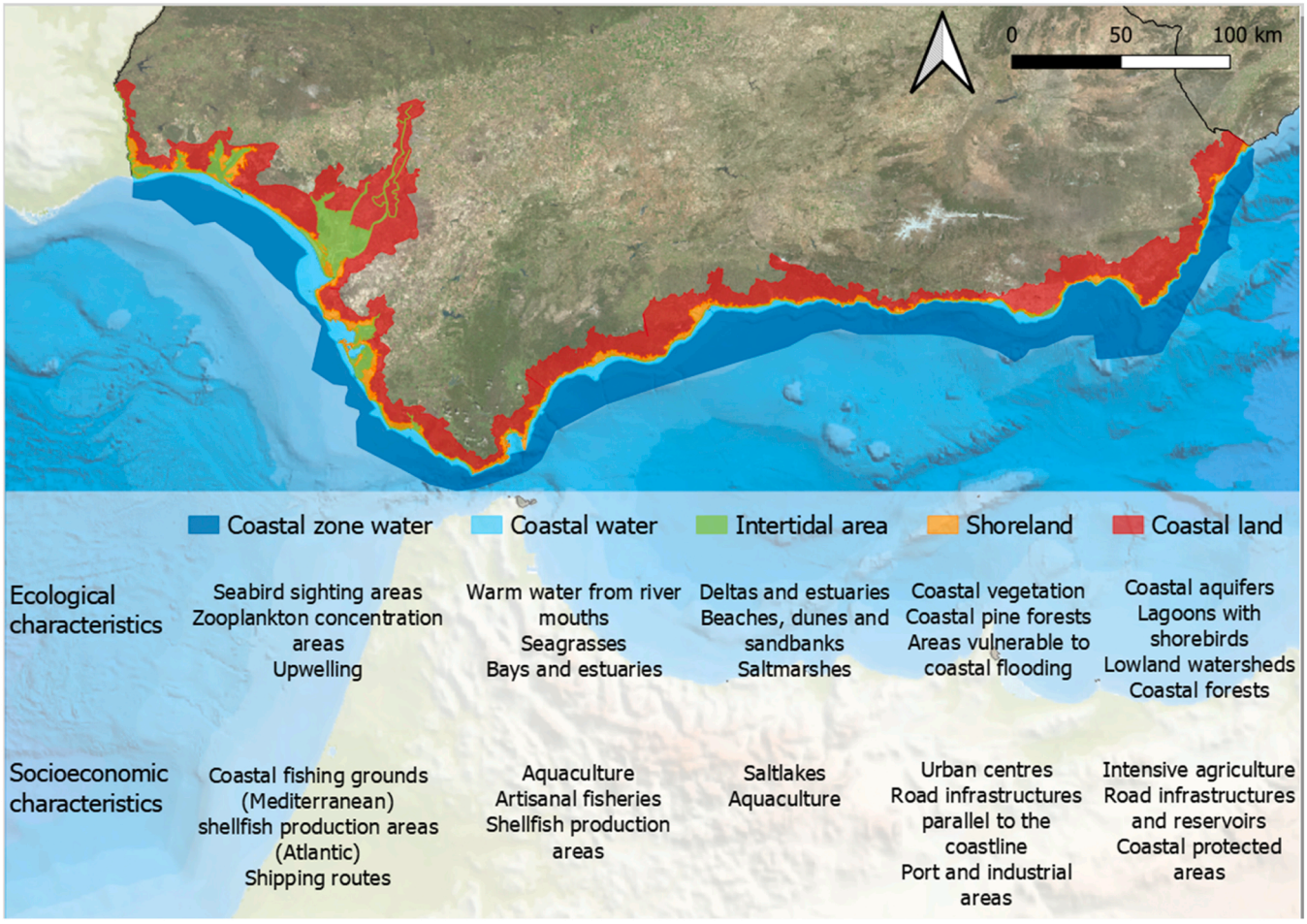

Fig. 4. Map and characteristics of the Coastal Socio-ecological System of Andalusia.

and Mikolajewicz, 2019), beaches are included in this geographical unit, as they are transition ecosystems between the terrestrial and marine environments. In this area, the beaches and coastal lagoons that occupy the Punta Entinas-Sabinar Natural Park, in Almeria, stand out for their extension. With an area of 19 km^2, it is home to species that tolerate high salinities such as *Pancratium maritimum* (Díaz Garretas et al., 2019; Gimenez Luque et al., 2003).

From a socioeconomic point of view, the Intertidal Area is delimited from the aquacultural and saline uses that are established in the Atlantic Intertidal mainly because there is larger space for their location (Villalobos, 2001).

- Shoreland:

This occupies an area of 1175 km^2, representing 1% of the Andalusian territory. This narrow strip extends from the limit of the maximum high tide or ecosystems with intertidal characteristics, to the inner limit of the ecosystems or urban areas adjacent to the coastline.

Shoreland vegetation is characterized by the presence of species capable of living in a space with the presence of salts. In this sense, the Shoreland is dominated by shrubs and grasslands (227 km^2) as opposed to forest-type ecosystems (109 km^2). Specifically, Sclerophyllous shrubs, a species that in coastal areas usually occupy stabilized dunes (Gómez-Serrano and Sanjaume, 2009), account for more than half (52%) the shrubs found in the Shoreland.

With regard to land uses in the Shoreland, the most important are those associated with urban, industrial and port uses, which account for an area of 539 km^2. This means that almost half of the Shoreland, specifically 46%, is an artificial surface. The high artificialization of the Shoreland is largely due to tourism, the main economic activity in the Andalusian coastal zone (Díaz Garretas et al., 2019; Manno et al., 2016). In addition, agricultural activity occupies an area of 299 km^2, representing a quarter of the Shoreland's extension. It is worth noting that 85% of the agriculture in the Shoreland is irrigated.

- Coastal Land:

They occupy an area of 7277 km^2, representing 8% of the area of Andalusia. Coastal Land is delimited from the end of the Shoreland, that is, from the end of urban centers or waterfront vegetation to the inner limit of coastal forests, lagoons with coastal birds, as well as main roads, areas of intensive agriculture and the inner boundary of waterfront Protected Areas.

From an ecological point of view, shrubs and grasslands are the most characteristic vegetation types of the Coastal Land, with 2323 km^2 of extension, representing 32% of the total area. Of these, 61% are Sclerophyllous scrub, which, as in the Shoreland, is the most common type of vegetation on the coast. On the other hand, cork oak forests, form the bulk of several vegetation series that could potentially extend along the coastal strip through the provinces of Malaga, Cadiz and Huelva (Consejería de Medio Ambiente y Ordenación del Territorio, 2015).

In addition, Coastal Land includes those inland lagoons that have coastal avifauna. Such is the case of the Brazo del Este, a former Guadalquivir riverbed transformed by anthropogenic action, which acts as an alternative habitat for some of the birds of Doñana (Rodríguez and Perea, 2015).

From a socio-economic point of view, Coastal Land is characterized for use mostly for agriculture. Specifically, 53% of the space is occupied by agricultural land. Of these, 85% are irrigated crops, so the demand for

water is one of the conditioning factors on the Andalusian coast. This irrigation water is obtained, in many cases, from coastal aquifers (Contreras París, 2014), in this sense, the limit of aquifers is a significant criterion for delimitation of the Coastal Land. On the other hand, urban uses are not as widespread as in the Shoreland, with 7% of the area being artificially shaped, of which almost half (49 %) is occupied by urban centers.

4.2. Comparison between the legal-administrative boundaries and the CSES-A

As mentioned in the introduction, the legal limits of the coast in Spain and, specifically, in Andalusia, are based on the provisions of the Shores Act (Act 22/1988) and its modification by the Act for the Protection and Sustainable Use of the Coast (Act 2/2013). The space thus considered a coastal zone based on the legislation, represents an area in Andalusia of 16,959 km^2. Of which, 867 km^2 correspond to the terrestrial and intertidal environment, while 16,093 km^2 are in the marine environment.

Specifying the details of the Shores Act, it can be deduced that the spaces intended for management are mainly intertidal, i.e., those included in the Shoreland or Intertidal Area (Torres Alfosea, 2010). The regulations developed through this law provide in depth details for the uses and activities that may or may not be developed and the legal manner in which to do so (BOE-A-2014-10345, 2017).

As for the marine environment, this is included in the MTPD up to the outer limit of the Territorial Sea (12 n.m.), as well as the natural resources of the Exclusive Economic Zone and the Continental Shelf. In this sense, all marine waters in which the state has competences are included in the MTPD, giving mention to specific legislation (Division for Ocean Affairs and the Law of the Sea, 1982).

Fig. 5 shows a comparison between the coastal-marine jurisdictional boundaries and the proposed Coastal Socio-Ecological System delimitation. It should be noted that from the MTPD inland it is considered private property, while from the MTPD line seaward it is coastal public property. In this sense, in general, the Intertidal Water, Coastal Water and Coastal Zone Water are included in the MTPD. However, occasionally, some ecosystems of the Intertidal Area can be observed that are outside the MTPD. Moreover, in the marine environment, in general, the jurisdictional Internal Waters coincide in many sectors with the Coastal Water, while the Territorial Sea would be occupied in part by the Coastal Zone Water.

Although there are some cases where the socio-ecological characteristics of the area mean that they do not coincide with the administrative and legal boundaries. Such is the case of the Costal Water area at the mouth of the Guadalquivir, which gives these waters characteristics that extend beyond the Internal Water (Fig. 5A). On the other hand, in Fig. 5B, we can see the Gulf of Almeria, whose waters are included in the Internal Water, due to the Straight Baselines; however, the depth of these waters, the absence of marine phanerogams and the fishing activities carried out are typical of the Coastal Zone Water.

With the above described, it can be observed that the coastal area on which the legislation focuses on is a narrow strip compared to the proposed delimitation from a socio-ecological approach (Table 3). Specifically, the MTPD covers an area of 712 km^2, and the PE, 155 km^2. On the other hand, the Shores Act forgets the terrestrial area, i.e., the coastal area beyond the Protection Easement (500 m considering the area of influence), is not considered in the management of coastal zones, according to the legislation.

The limits established in national legislation are based on geographic, metric and legal criteria. In this sense, only the MTPD, in its terrestrial part, has socio-ecological criteria for its delimitation both in the Shores Act and in its Regulations. Among the criteria for delimiting the terrestrial area of the MTPD, the following stand out: geographical and ecological criteria; wich are beaches, dunes, marshes, areas of loose material deposits, land invaded by the sea and cliffs. And, socio-economic criteria; wich are that land reclaimed from the sea by works, harbors and port facilities built in MTPD.

The Protection Easement and the Influence Zone however, are delimited on the basis of metric criteria. For the PE, a width of 100 and 200 m is established in natural areas from the shore and 20 m in urban areas. The IZ is defined up to 500 m from the coastline (Fig. 6).

The lack of socio-ecological criteria for the delimitation of the PE and IZ can cause fragmentation of coastal ecosystems that would be inside and outside the limits for management. Such is the case represented in Fig. 6, south of the urban center of Algeciras in the Strait of Gibraltar. The delimitation of the MTPD (in the land area) follows geographical criteria, therefore, in those areas where coastal features are displaced inland, so the line of MTPD is also displaced.

PE delimitation however, occurs at a fixed distance resulting in management that fragments coastal ecosystems. In this example, the Sclerophyllous vegetation of the coastal zones would be subject to coastal zone management in the strip delimited by the PE, in contrast to the remaining vegetation cover, which would be managed as an inland ecosystem. It should be noted that both the hardwood forest and the Sclerophyllous vegetation are included in a Natural Protected Area, thus guaranteeing their conservation (Decreto 308/2002). However, this implies another management mechanism independent of the delimitation of the coastal zone that is the subject of this research.

The MTPD in the marine environment, in contrast, is defined on the basis of legal criteria. Specifically, they are defined as the spaces occupied by the Inland Waters and the Territorial Sea. The Internal Waters are those that are found from the straight baselines towards land (defined according to BOE-A-1977–23967), while the Territorial Sea extends up to a distance of 12 n.m. from these straight baselines.

It should be noted that the definition of straight baselines made in the United Nations Convention on the Law of the Sea, article 7, follows a geographical criterion, since they are obtained by joining the protruding points of the coast, in those areas of the coast that are rugged or have notable protrusions, without departing in an appreciable manner from the general direction of the coast. However, the definition of the MTPD in the marine environment does not have more criteria than those established in UNCLOS.

The socio-ecological limits within the marine environment demonstrate that, in the majority of cases, the limit of the Coastal Zone Water is less than the outer limit of the Territorial Sea. This is because the ecosystems and maritime activities associated with the coast in Andalusia, usually occur at a distance of less than 12 n.m.

5. Discussion for the adaptation of the current legal-administrative delimitation to the proposed socio-ecological boundaries

5.1. Is the delimitation established in the Shores Act sufficient to guarantee an EBM?

As expanded on in the results, the coastal zone of Andalusia does not have a formal delimitation in force that goes beyond the limits established in the Shores Act for the MTPD and the PE. Furthermore, in the case of PE, the established limits lack socio-ecological criteria, making it difficult to move towards Ecosystem Based Management if the delimitation of the coast itself does not consider these as ecosystems.

Moreover, the delimitation established in the legislation is associated with a distribution of competences between the different levels of the Public Administration, which makes an EBM even more difficult (Chica Ruiz and Barragán Muñoz, 2011). In general terms, the State Administration is responsible for the MTPD, i.e. the Intertidal Areas, Coastal Water and Coastal Zone Water, mainly. While the Regional Administration has the competences from the PE inland. Although there are many overlaps, as in the case of Ports, those that are state-owned, the State Administration has the responsibility, while marinas are the responsibility of the Regional Administration. The same occurs with

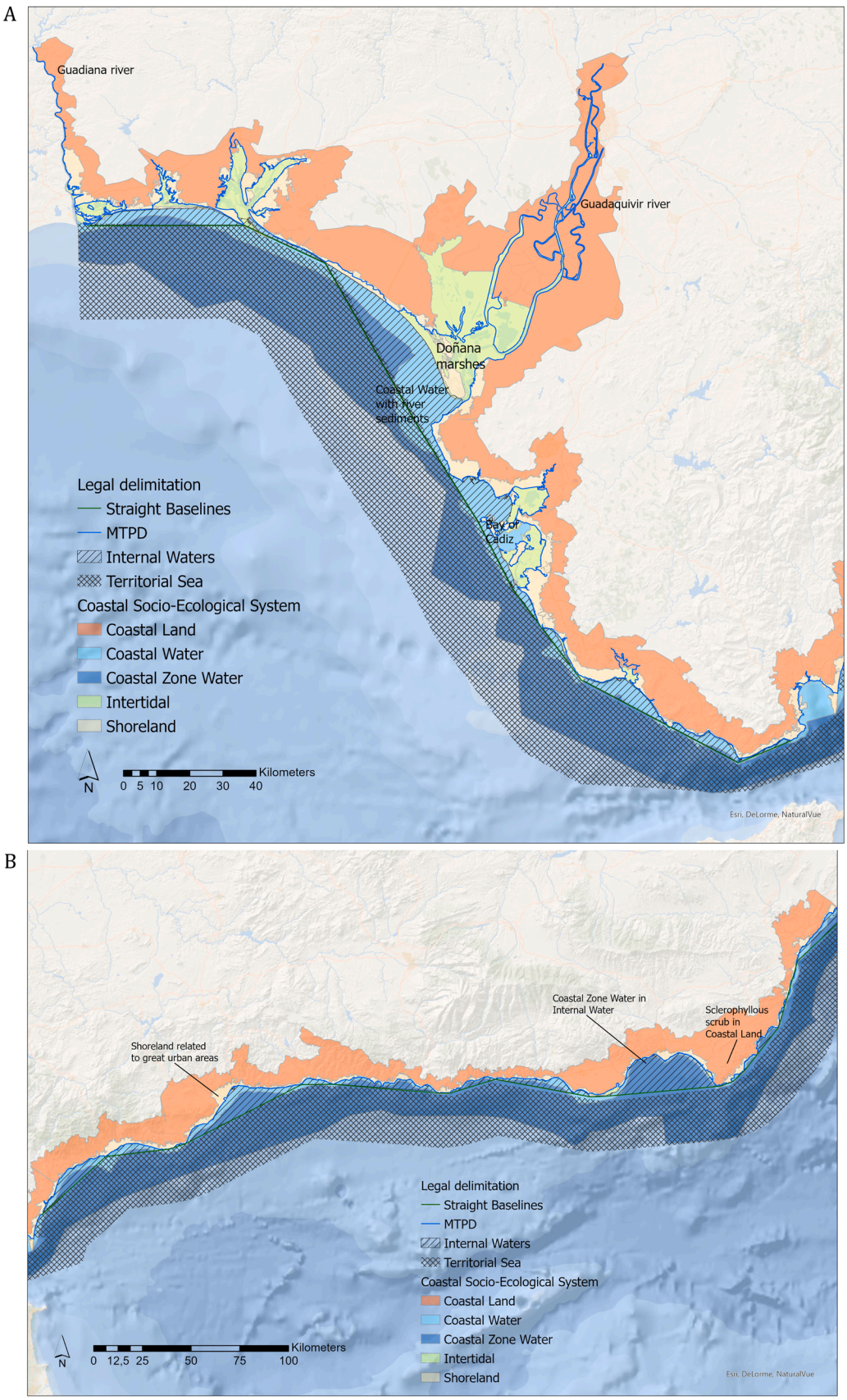

Fig. 5. A. Comparison between legal marine limits and Coastal Socio-Ecological System delimitation (Occidental sector). B. Comparison between legal marine limits and Coastal Socio-Ecological System delimitation (Oriental sector).

Table 3
Extent of the coastal units established in the legislation and according to socio-ecological criteria.

	Geographical units	Area (km^2)
Legal limits	Marine MTPD	16,093
	Land MTPD	712
	Protection Easement	155
Socio-ecological limits	Coastal Zone Water	11,096
	Coastal Water	1630
	Intertidal Area	963
	Shoreland	1175
	Coastal Land	7277

National Protected Areas (state responsibility and regional management), as in the case of the Doñana National Park, and Natural Protected Areas (regional responsibility), such as the Cabo de Gata-Níjar Natural Park.

Furthermore, in the case of Andalusia, the Statute of Autonomy contemplates a series of transfers of competences from the State Administration to the Regional Administration. In this sense, the Statute of Autonomy of Andalusia contemplates that the Regional Administration is responsible for both the planning of the coast and the management of the occupation and use of the MTPD, especially in the granting of authorisations and concessions. This transfer of competences was carried through Royal Decree 62/2011, of 21 January. Furthermore, Decree 66/2011, of 29 March, assigns the functions, resources and services transferred to the Regional Ministry of Development and Housing, Environment and Territorial Planning, and Agriculture, Fisheries and Rural Development.

In consequence, the main competences of the Regional Administration related to coastal management have been selected from the second Statute of Autonomy, which has been in force since 2007. It could be observed that there are significant responsibilities related to living coastal resources, coastal ecosystems, protected natural areas, urban planning and land use planning, as well as marinas and fishing ports. It also highlights management functions for beaches, including uses of the Shoreland and Intertidal Area (MTPD and PE). The principles on coordination and cooperation that are established by the European Union for spatial planning (Faludi, 2010), should be further considered if the ultimate aim is to move towards ecosystem-based management rather than sector-based management.

Despite the difficulties of competence in the coastal zone, there are initiatives in the region that are moving towards an EBM, such as the project to establish management criteria in the PE. This led to 14 socio-environmental scenarios being constructed, each of which relates the characteristics of the PE with those of the corresponding MTPD (Barragán-Muñoz, 2004). In this manner, the classification of Andalusian Protection Easment according to different socio-environmental scenarios is proposed.

Additionally, there have been initiatives to delimit the coastal zone beyond the narrow strip on which state legislation is focused. In this regard, the Andalusian Integrated Coastal Zone Management Strategy Proposal (Barragán et al., 2008) and the Protection Plan for the Andalusian Coastal Corridor (Consejería de Medio Ambiente y Ordenación del Territorio, 2015) should be mentioned.

The Andalusian Integrated Coastal Zone Management Strategy Proposal includes a delimitation of coastal zones focused on management for both the terrestrial and marine environment. With this regard, physical-natural, socio-economic and legal-administrative criteria specific to coastal zones are established to address the scope of action of the strategy (Barragán et al., 2008).

With regard to the Protection Plan for the Andalusian Coastal

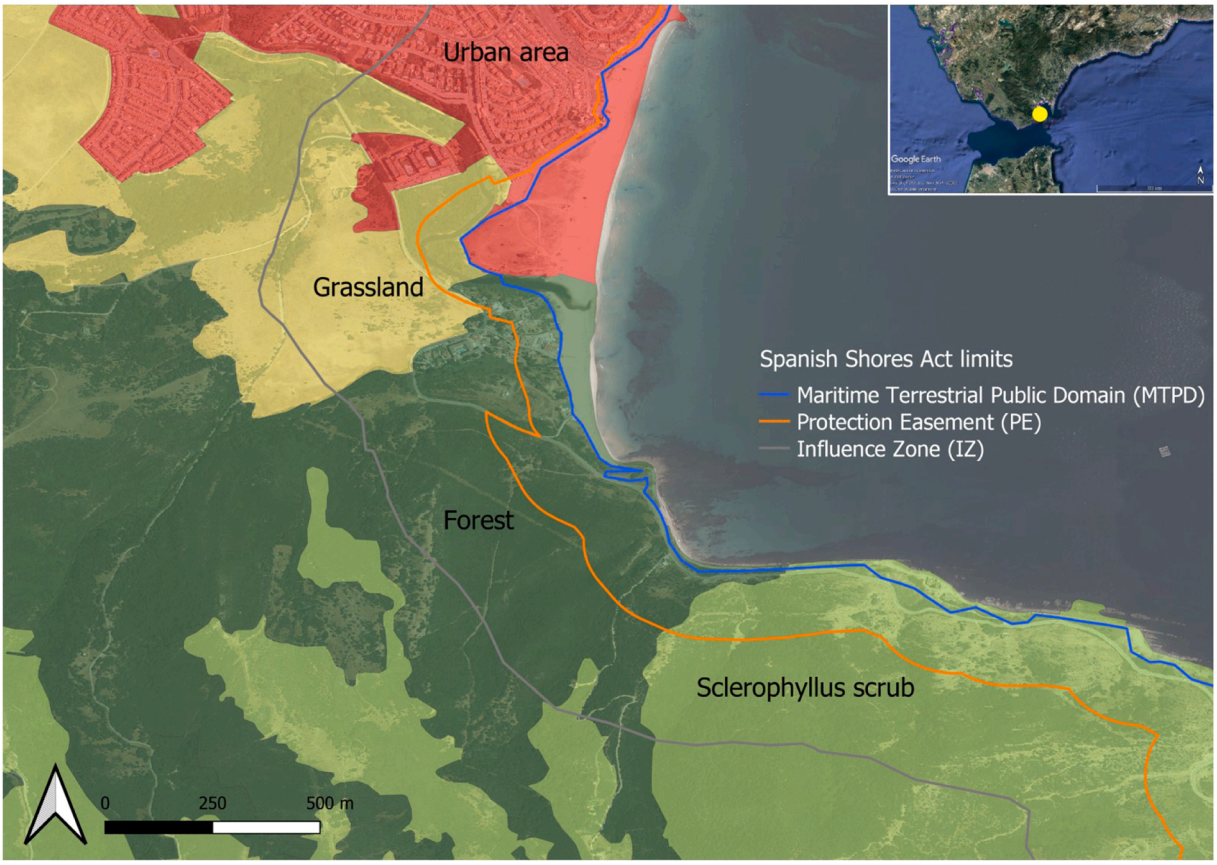

Fig. 6. Example of delimitation of the MTPD, PE and IZ over different vegetation and land uses, *Land use from CLC on the cartographic basis of the National Aerial Orthophotography Plan and legal boundaries according to the Shores Act.*

Corridor, it provides for a delimitation of the coastal zone of the first 500 m from the inner limit of the shore. This is in addition to coastal areas of special conservation, granting special protection to this area and thus avoiding its urbanization (Sanchez García, 2019).

Despite the fact that these documents did not manage to be approved for development in a binding manner (the last-mentioned plan was in force for only two years (2015–2017)), they serve to highlight the need for better specification of a space beyond that which is established by national legislation for the Andalusian coastal area. Furthermore, in order to move towards an EBM of coastal areas, it is necessary that the delimitation be carried out with socio-ecological criteria, with the aim of facilitating management processes as well as conflict resolution based on the actual reality of the different sections of the Andalusian coastal zone.

5.2. Is it necessary to delimit the marine environment from a socio-ecological approach to guarantee EBM?

Although the Shores Act includes the marine area under Spanish jurisdiction within the MTPD, it does not establish criteria for the specification of specific areas, as is the case for the terrestrial environment. Nevertheless, Spain has new management instruments for the marine environment that would allow, in the future, complementing the provisions of the Shores Act for the marine environment.

Driven by the European Union, Directive 2014/89/EU of the European Parliament and of the Council, of 23 July 2014, establishing a framework for maritime spatial planning has been approved. This regulation promotes the sustainable development of marine spaces, taking into account the interactions between land and sea. The Directive is transposed into Spanish law through Royal Decree 363/2017, of April 8, establishing a framework for maritime spatial planning.

The decree establishes that five management plans must be developed, one for each of the five marine demarcations established in Law 41/2010, on the protection of the marine environment. The demarcations that affect Andalusia are, according to the Law: "*[.] b) South Atlantic marine demarcation: marine environment in which Spain exercises sovereignty or jurisdiction between the limit of the jurisdictional waters between Spain and Portugal in the Gulf of Cadiz and the meridian passing through Cape Espartel. c) Marine demarcation of the Strait of Gibraltar and Alboran: Marine environment in which Spain exercises sovereignty or jurisdiction between the meridian passing through Cape Espartel and an imaginary line with orientation 128° with respect to the meridian passing through Cape Gata, and marine environment in which Spain exercises sovereignty or jurisdiction in the area of Ceuta, Melilla, the Chafarinas Islands, the islet Perejil, Peñones de Vélez de la Gomera and Alhucemas and the island of Alboran. d) Levantine-Balearic marine demarcation: the marine environment over which Spain exercises sovereignty or jurisdiction, comprised between an imaginary line oriented at 128° to the meridian passing through Cape Gata and the limit of the territorial waters between Spain and France in the Gulf of Lions.*" (BOE-A-, 0, 2010–, 2005).

The marine environment management plans are currently in draft stage. Within them, the spatial scope of implementation is established, considering the entire space of the aforementioned marine demarcations. Based on these limits, all activities that could be carried out in the marine environment are developed, making reference to the sectoral legislation in each case. Although it is not currently contemplated, the marine environment management plans represent an opportunity to develop specific socio-ecological limits in the sea, which would allow for the management of uses and activities considering the geo-ecological characteristics of the different marine areas.

In this regard, land-sea interactions play a fundamental role. They are considered since Directive 2014/89/EU to ensure coherence between marine and terrestrial management. Both types of planning arise in different ways and have different objectives (Kerr et al., 2014). However, uses and activities that occur on land have an impact on the marine environment. Similarly, all activities carried out at sea require structures and services provided from the terrestrial environment. For this reason, the Maritime Spatial Plans that are being drawn up for all the demarcations in Spain include in the planning methodology the consideration of different types of land-sea interactions: among natural processes, among uses and activities, and among management mechanisms (MITERD, 2021). In this sense, the consideration of the CSES-A as a management unit in which interactions exist may be of help to future management plans. Indeed, the established limits allow to be of connection between terrestrial and marine uses policies.

There is growing concern among academic researchers in the field regarding the management of the marine environment and its delimitation (Suárez de Vivero and Rodríguez Mateos, 2012) with recent research in other regions of the country advancing towards EBM of the marine environment. Both, in the case of the Bay of Biscay, in the north of the country (Pınarbaşı et al., 2020), and in the Macaronesian Region, which includes the Canary Islands (García-Onetti et al., 2019), studies have been conducted to overcome jurisdictional boundaries in the marine environment and move towards EBM from transboundary management processes with neighboring countries. Accordingly, environmental and socio-economic objectives would be approached from a holistic perspective, beyond that which is established within the limits of each country.

Furthermore, the European Nature Information System, EUNIS is part of the European Biodiversity Data Centre. Its aim is to bring together European data from various databases and organisations. Thus, a classification of habitats in the coastal and marine environment is created, which makes it possible to move towards a socio-ecological delimitation in this area (Mavroulidou et al., 2014). Specifically, coastal habitats are largely associated with the intertidal spaces defined in the CSES-A. Whereas the infralittoral habitats are related to the Coastal Waters and the circalittoral habitats to the Coastal Waters of the CSES-A. Although the classification with a socio-ecological approach also takes into account social criteria, the relationship with the criteria used for the definition of EUNIS coastal and marine habitats is high.

5.3. How does a socio-ecological delimitation help EBM?

Ecosystem Based Management is a novel form of management, holisticic in its approach, it takes into account both the elements and interactions within a given ecosystem. EBM recognizes that the natural and human components of an ecosystem interact in complex ways. From this perspective, society depends on ecosystems, and ecosystems, in turn, are affected by human activities (Kelble et al., 2013b).

Consequently, delimiting coastal zones from a socio-ecological approach allows taking into account both ecosystems and human activities. Only if these interactions are taken into account can Ecosystem Based Management mechanisms be established. In this sense, there is a recent in which the delimitation of specific areas of the Andalusian coast has been conducted from a socio-ecological approach. Martín-López et al. (2017b) establish the boundaries of the Doñana Protected Area and the Adra River watershed based on their socio-ecological characteristics and public participation.

The relationships between socio-ecological delimitation, EBM and ICZM are highlighted in the present research. ICZM and EBM, although they coincide in most of their objectives (Haines-Young and Potschin, 2011), the main divergences occur in the scope of application. In this sense, while ICZM focuses on integrating sectoral activities, legislation and administrations, EBM focuses on ecosystems and the conservation of ecosystem services as the central area of action (Le Tissier, 2020). Thus, the socio-ecological delimitation allows linking both disciplines, including characteristics of the legal-administrative, socio-economic and physical-natural systems, and their link to ecosystem services. Thus, when developing an ICZM process, a socio-ecological delimitation should be carried out, considering the principles of EBM.

It poses a challenge for the development of EBM plans and projects on the coast, since the delimitation described in the legislation does not coincide in its entirety with the socio-ecological limits proposed.

Therefore, understanding and delimiting the coastal zone from a complete perspective, i.e., from a legal-administrative, geographical, ecological and socio-economic point of view, establishes the pillars of an ecosystem-based Integrated Coastal Zone Management (ICZM) (UNEP-MAP, 2006).

Thus, the mechanisms for delimiting the coastal zone considering both socio-ecological criteria and state legislation can be approached from two different perspectives. On the one hand, near-shore and intertidal terrestrial areas, which are deeply delimited in legislation, can be characterized based on the proposed socio-ecological criteria. On the other hand, the delimitation units established in the marine environment would allow for their consideration in the development of marine spatial plans.

Understanding the coastal zone as a socio-ecological system allows connecting land use policies (with a long history) and maritime policies (currently under development), to establish mechanisms for ICZM in a joint way, where decision makers can understand and manage the coastal area in a holistic and complete way.

6. Conclusions

The interactions between ecosystems and human activities are of particular relevance in coastal and marine areas, leading to the understanding of this space as a socio-ecological system. The proposed delimitation makes it possible to link the principles of EBM in an ICZM process, based on an area of study in which administrative, socio-economic and ecological elements are combined.

The delimitation of the Andalusian coastal area as the Andalusian Coastal Socio-ecological System (CSES-A) reveals some similarities with national legislation, such as the ecological characteristics of the MTPD, which practically coincides with the Shoreland and the Intertidal Area, or the extension of the EEZ, which could identify the outermost limit of the CSES-A.

However, some differences between the proposed delimitation and the legislation are also evident. For this reason, it is not intended to modify the current legislation, but to complement the existing one, understanding the coastal zone from a complete perspective, i.e., from a legal-administrative, geographical, ecological and socio-economic point of view; and in this sense, to move towards an ICZM with an ecosystemic basis.

Furthermore, the proposed delimitation allows linking the Shores Act with the recent Marine Management Plans. In this sense, bridges and connections could be created in order to jointly manage the whole system.

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