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# Análisis Estratégico de los Sistemas Socio-Ecológicos de Lagunas Costeras: Los Casos de Mar Menor (España) y Mar Chiquita (Argentina)

## Strategic Analysis of the Socio-Ecological Systems of Coastal Lagoons: The Cases of Mar Menor (Spain) and Mar Chiquita (Argentina)

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### Abstract

The present work has realized an integrated analysis of the pressures that affect the state of ecosystems and their services, as well as of the management mechanisms carried out in two socio-ecological systems of coastal lagoons located in dissimilar geographical areas: the socio-ecological system of Mar Menor, Spain, and the socio-ecological system of Mar Chiquita, Buenos Aires, Argentina. To do this, each lagoon system has been considered as a socio-ecological system through the realization of the DPSIWR model. Even if socio-ecological systems present a different degree of conservation and of damage caused by the anthropic activities, the work has shown that the anthropic development around the lagoons is the same and that both the drainage basin and the maritime front

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present the same threats to the conservation of the coastal lagoons. For this reason, the managers and institutional entities involved in the environmental management should consider, not only the effects caused by the maritime front, but also the effects contributed by the activities carried out in the drainage basin of the coastal lagoons.

## 1. Introduction

Coastal zones constitute highly complex systems thanks to the numerous ecological and social processes and the interactions that converge in them (Barragán Muñoz, 2003; de Andrés *et al.*, 2017). Therefore, an approach from an integrated perspective, focused on these interactions as a whole is required. Coastal areas should be considered as socio-ecological systems because they include complex interactions between ecological and social processes, which guarantee human well-being (Ostrom, 2009; de Andrés *et al.*, 2018). From this perspective, the concept of ecosystem services acquires relevance by linking ecosystems with human well-being. Ecosystem services are defined as the capacity of ecosystems to provide goods and services to humankind and, in this way, generate benefits that contribute to human well-being. The Millennium Ecosystem Assessment, in 2005, classified services into three categories: supply (benefits obtained by the structure of ecosystems), regulation (benefits derived from the functioning of ecosystems) and cultural (benefits intangibles from ecosystems) (MEA, 2005; Fisher and Turner, 2008; Haines-Young and Potschin, 2010). Among the services provided are mentioned fishing, climate and water regulation, storm protection, tourism, and landscape enjoyment (Marcos *et al.*, 2015).

Coastal lagoons, 13% of the world's coastal zone, constitute one of the most heterogeneous ecosystems on the planet (Nixon, 1982; Alongi, 1998). They are defined as those open spaces of shallow brackish coastal waters of variable salinity and volume of water, which may be totally or partially separated from

the sea (European Union, 2005). Coastal lagoons are systems with a very high ecological complexity and stability that justify their high productivity and importance. Nevertheless, they are also very fragile systems, since they are regulated by continuous changes in chemical-physical parameters (salinity, temperature, nutrients) due to the regulation of flows due to the tide and the connection with the river system within it (Velasco *et al.*, 2017; Carrada & Fresi, 1988; Elliott & Quintino, 2007).

In recent years, these ecosystems have faced an intensification of urban and productive sectors development in the drainage basin, causing negative impacts on the entire system (Vasconcelos *et al.*, 2007; Courrat *et al.*, 2009; Cardoni *et al.*, 2011; Martínez-López *et al.*, 2014). Among them, the development of tourism and real estate sectors has compromised the natural lagoon balance, generating continuous stress (Fernández *et al.*, 2013). Therefore, it is necessary to approach it as a socio-ecological system. The Socio-Ecological System (SES) is "*a system composed of two interacting subsystems: on the one hand, the biological (epidemiological ecosystem) and, on the other, the social (social and economic conditions of life of society), where the biological subsystem plays the role of governed object and the social subsystem acts as an internal regulator of these interactions*" (Berkes and Folke, 1998). For all these reasons, Integrated Coastal Zone Management (ICZM), including coastal lagoons, is approached from the perspective of social and ecological systems in continuous interaction (Ostrom, 2009; Greg & Duck, 2013) and the analysis is ap-

proached according to the three connected subsystems: physical-natural, socio-economic and legal-administrative (Barragán Muñoz, 2014).

In Spain there are 14 coastal lagoons, in a total area of 58.695 ha (FAO, 2015), among which the Valencia, Des Grau, Adra, Mallorca and Mar Menor lagoons stand out. The latter is one of the more anthropized socio-ecological systems of the country with different uses and developed activities which have generated strong pressure (Barragán Muñoz & García-Sanabria, 2018b). The Argentine coast, however, presents only the Mar Chiquita lagoon, in the province of Buenos Aires (Iribarne *et al.*, 2001). In its hydrographic basin, activities related, especially, with agriculture and tourism have developed so much that the impact on the whole system has increased in a consistent manner (Maresca, 2013; César, 2017a, 2017b).

Main objective of this work was to perform an integrated analysis on the state, problems derived from the pressures on the ecosystem and its services, as well as on the management mechanisms carried out in two socio-ecological systems of coastal lagoons located in dissimilar geographical areas: Socio-Ecological System of Mar Menor (SESMM), Spain, and Socio-Ecological System of Mar Chiquita (SESMC), Buenos Aires, Argentina.

### Study areas

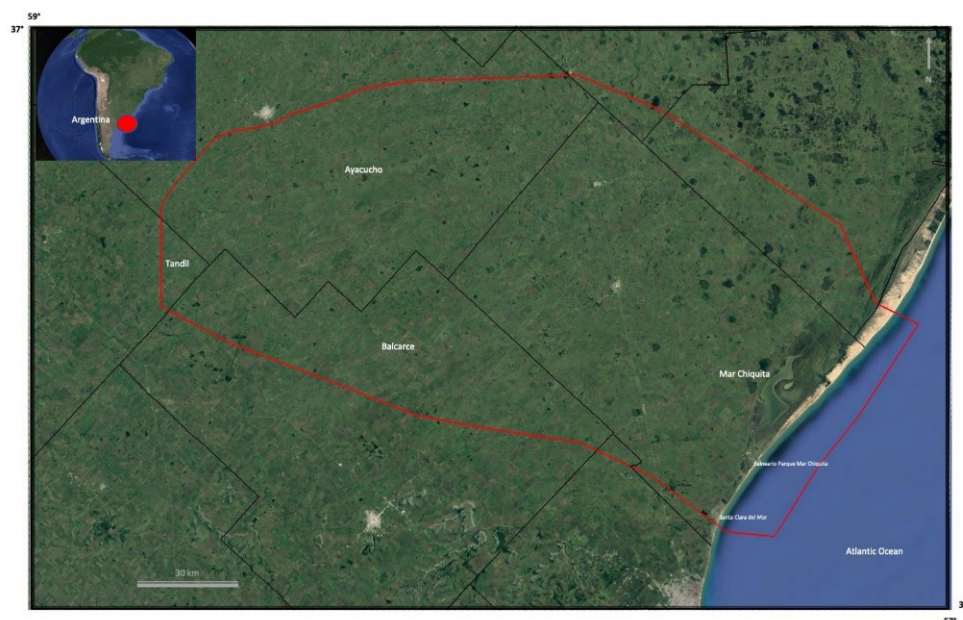
To analyse the areas of research in a ecosystemic approach, the coastal lagoons have been considered as social-ecological systems and has not been limited to analyse the simple lagoons (de Andrés *et al.*, 2018). For this reason, the entire socio-ecological system for each coastal lagoon has included the drainage basin, the coastal-marine boundaries and their respective ecosystemic factors. The methodology to analyse the coastal lagoon as a social-ecological system respect the principle of the methodology used in various previous research works, such as elaborated by Ostrom

(2009), Piwowarczyk *et al.* (2013) and de Andrés *et al.* (2018).

The Mar Menor (SESMM), which comprises the coastal lagoon, its inland drainage basin and the coastal boundaries, is located on the southeast coast of the Iberian Peninsula, on the coast of the Region of Murcia (figure 1). It is the largest hypersaline lagoon on the European continent (León and Bellido, 2016). Its semi-circular shape occupies 135 km<sup>2</sup> of surface and its depth does not reach 7m (Pérez-Ruzafa *et al.*, 1987). The lagoon is separated from the Mediterranean Sea by a narrow sandy strip 21km long and between 100-900m wide, called La Manga. Communication with the Mediterranean Sea takes place through five shallow channels: Torre and Ventorrillo (both natural) and Marchámalo, Estacio and El Charco, artificially modified or created (Guirado *et al.*, 2010; Ibarra Marinas *et al.*, 2016). El Estacio, the widest canal located in the centre of La Manga, has been dug up to 5m to allow navigation (Pérez-Ruzafa *et al.*, 2005; Pérez-Ruzafa & Marco, 2005). The lagoon hosts five islands in its interior called Mayor or Barón, Perdiguera, Ciervo, Redonda or Rondella and the Sujeto. As a whole, the islands provide to the area a great environmental and landscape value. A good number of the streams and headwaters of ramblas are located, on the one hand, in the foothills of the Sierras de Carrascoy, to the west, and, on the other, on the slopes of that same mountain range. For this reason, those tributary areas that are developed in the municipalities of Fuente Álamo and Murcia have also been taken into account.

The ecosystems found in the Spanish study area are lagoon water bodies, beaches, dunes, sandy areas and, in the drainage basin, wetlands, salt flats, meadows and grasslands. All these ecosystems define all physical-chemical and biological peculiarities of the coastal lagoon (Concepción *et al.*, 2015a). The most representative ecosystem is the wetland, 15.000 ha, which includes the municipalities of San Pedro





**Figure 2.** Socio-Ecological System of Mar Chiquita, Buenos Aires, Argentina.

grassland system and wetlands (Olivier *et al.* 1972; Cabrera & Zardini, 1978; Bortolus, 2001; Stutz & Prieto, 2001). The communication with the ocean is through an estuarine mouth; in its interior zone it is surrounded by grasslands (marsh halophytes) watered by the Vivoratá Stream. The latter is the only one that discharges over the Estuary area (Bruno, 2014). In addition to this, the lagoon receives the contribution of fresh water streams, from the continental basin, born in the Tandil mountain system. The entire hydrographic basin includes the municipalities of Mar Chiquita, General Madariaga, Maipú, Ayacucho, Tandil, Lobería and Balcarce (Álvarez *et al.*, 1983; Gigena & Hesayne, 2017). The sub-basin of the Mar Chiquita lagoon provides fresh water through several streams. From the north there are channel 5, the Arroyo Grande, the Arroyo Dulce, the Arroyo Vivoratá, the channel 7 and, further south, the small Cangrejito stream.

The cities that compose the basin are medium in size (INDEC, 2001, 2010). However, they have shown great population growth. The main economic activity is agriculture (Maceira *et al.*, 2005; Cesar *et al.*, 2017a). In the coastal section, tourism is the most important activity. The Mar Chiquita Park Beach Resort near the coastal towns, offers seaside tourism, sport fishing and nautical activities, for local and occasional visitors (Benseny, 2012; Auer *et al.*, 2018).

As mentioned above, the context in which Mar Chiquita is located is the Argentine Republic, that is a representative, republican and federal democracy. Due to its federal nature, it has two government structures: The National Government and the 23 provincial governments, together with the Autonomous City of Buenos Aires, each of which is considered pre-existing to the Nation and exercises all powers not expressly delegated to the federal government.

Among the ministries that work for the National Public Administration there is the Ministry of Environment and Sustainable Development. Each province, then, is administered by its own government structured in provincial ministries. The executing agency of the Province of Buenos Aires, for the envi-

ronmental field, is the OPDS (Provincial Organism for Sustainable Development). Under the provincial authority, geographically and legally, municipalities are divided and administered by their own Municipal Authority and are called "Parties" (Dadon, 2010; Dadon *et al.*, 2020).

## 2. Methodology

The study of the problems in the SESMM and SESMC through a socio-ecological approach was carried out following the DPSIWR model (Driver - Pressure - State - Impact - Well Being - Response) (Cooper, 2013; Artabruzzo, 2018). The analysis scheme begins with driving forces (D: drivers), which push the mechanism towards the appearance of pressures (P: pressure), which in turn lead to changes in the state of the system (S: state) and, consequently, generate impacts (I: impacts) through the loss and gain of ecosystem services. This balance influences human well-being (W: welfare), thereby generating conflicts due to dysfunctions (UNEP, 2006, 2012). Finally, managers and administrators produce the responses (R: response) that influence, in turn, the pressures and impacts, and the cause-effect circle begins again.

For SESMM, the information to identify the driving forces, pressures and state, have been taken by the "Integrated Management Strategy of the SESMM" by Barragán Muñoz and García-Sanabria (2018a), approved in 2021, and by some studies developed by Pérez-Ruzafa *et al.* (1987, 1989, 1991, 2005, 2011, 2012). Mar Menor has been so studied by researches in the last 30 years that it wasn't be difficult recovery the data and the developed work already complied. The important contribute of the Integrated Management Strategy of the SESMM (2018a) has permitted to find all information and references useful for the analysis. The data by the Murcia Regional Statistical centre, or the extracted data from the Integrated

Management Plan for the protected areas of the Mar Menor by Marín (2011), can be mentioned as examples. The same study area taken in the Strategy of SESMM was taken as the study area in the present analysis for this SES.

The driving forces, pressures and state in the SESMC were addressed by the analysis of bibliography available on paper and on the websites of official institutions (Province of Buenos Aires, Municipality of Mar Chiquita, INTA, INDEC, etc.), aerial photos from 1957 to 1987 and satellite images from 2004 and 2018, granted by the Dr Alejandra Merlotto, researcher at CONICET (National Council for Scientific and Technical Research) and UNMDP (National University of Mar del Plata), specialist in the study area. Other aerial photographs, relative to coastal erosion, have been used, granted by various institutions, such as the Directorate of Geodesy of the Province of Buenos Aires (year 1957, 1: 15,000; year 1979 and 1987, 1: 10,000) and by INTA (National Institute of Agricultural Technology) for the year 1967 (E = 1: 20,000). To elaborate the historical analysis of Mar Chiquita, the study has been expanded with the maps of institutional sites, the cadastral plan of the Parque Atlántico Mar Chiquito centre granted by the municipality of the party, the plan of the historical variation of the coastline updated to the 05/01/2001 granted by the Provincial Directorate of Sanitation and Hydraulic Works and the advertising posters for the tourism sector and the sale of plots. The posters

do not bear dates, but it is inferred that they have been printed around the year 1990.

For the SESMC, in addition, field trips were carried out with interviews of several key informants: the Secretary of Tourism of the Municipality, the Responsible for the “Regatta and Fishing Club”, self-summoned habitants of the Municipality and the Park Rangers of the Mar Chiquita Provincial Natural Reserve. They were carried out in May and August 2018 by also using a survey carried out by Valles (1997) on the perception of the ecosystem, activities, processes and problems identified by individuals.

The impacts were studied by using the essential principles of indicators (Gallopín, 1997; Hammond *et al.*, 1995; OCDE, 1998; Olsen, 2003; Perevochtchikova, 2013). For the Spanish study area, have been chosen the indicators exposed in the “Integrated Management Strategy of the SESMM” by Barragán Muñoz and García-Sanabria (2018a). For the Argentine case, the same indicators have been used, when possible. For those services for which there is no officially published data or indicators equal to those of the Mar Menor, sub-indicators have been selected and measured (table 1). For supply services, 3 indicators were selected for each SES. Key data of the ICZM Strategy were used as sources for the SESMM. Data collected in interviews, field trips to the sporting “Regatta and Fishing Clubs”, Provincial documents about water resource destined to the local population and the risk assessing about the Mar Chiquita freshwater consumption (Lasta *et al.*, 2003), satellite images (2004 - 2018) and further data of the Agroindustry Ministry of the Nation, were used for the SESMC. Regulation services were analysed through 11 indicators for the SESMM. For the SESMC case, 15 indicators have been found by using bibliography about historical and actual status of the lagoon (Lagrange, 1993; Isla *et al.*, 1999; Merlotto and Bértola, 2007, 2008, 2009; Merlotto *et al.*,

2005, 2008; Zelaya and Maceira, 2007; Zelaya *et al.*, 2016; Morea and García, 2016), about the biological conditions (López-Lanús *et al.*, 2008), about the contamination of lagoon waters (Menone *et al.*, 2000a, 2000b, 2001; Marcovecchio *et al.*, 2006; Velasco *et al.*, 2009; Pérez *et al.*, 2017), satellite images (2004 - 2018), aerial photography (year 1957, 1: 15,000; year 1979 and 1987, 1: 10,000) and further data by the Provincial Organization for Sustainable Development and INTA, field trips and interviews with the Park Rangers. Cultural services were analysed using 9 indicators for the SESMM by its ICZM Strategy; 12 indicators were used for the SESMC. To do this, the population data about tourists’ quantity and distribution on the territory, granted by the Mar Chiquita Municipality Tourism Ministry, and some interviews with representatives of Municipality residents and of municipal institutions, were used (INDEC, 1991, 2001, 2010).

Finally, the answers were analysed using some of ten elements of the Decalogue of Coastal Management for each SES (Barragán Muñoz, 2003, 2014). The latter, constitutes a management analysis model composed by ten interconnected elements in the public policy process: policy, regulations, institutions, coordination, cooperation, strategies, instruments, resources, information and participation (Barragán Muñoz, 2014). The analysis of a decalogue is a very laborious job and that involves many months of investigation; due to this reason, only some of the elements of each decalogue have been analysed in order to better characterize the areas of study and have the essential elements for the comparative analysis. Among these, the political vision connected to the ICZM in recent years, the regulations, the institutions and the projects carried out, the current public participation, the strategies and instruments present to define the actions in the SESs, and lastly, the channels and the quality of information that reaches the local population and research centres, were analysed.

**Tabla 1.** Indicators used for the analysis of ecosystem services in the SESMM and SESMC.

Type	Description		Indicators used for SESMM in the ICZM strategy (Barragán Muñoz and García-Sanabria, 2018a)	Indicators used for SESMC
Supply	Traditional food	Traditional fishing	Fish landed in the Mar Menor ports (Concepción <i>et al.</i> , 2015b)	Number associated with the Irrigation and Fishing club and the Mar Pescador port (AOP - Annual Operating Plan, 2017; Interviews with Regattas and Fishing club and the Mar Pescador port club).
		Salt flats	Salt production	
	Technician food	Intensive agriculture	Intensive agricultural production (Martínez-Fernández <i>et al.</i> , 2013)	Ground cover (Agroindustry Ministry web site). Closeness of agricultural activity to the lagoon (INTA report by Maceira <i>et al.</i> , 2005).
		Aquaculture	Production of aquaculture (León and Bellido, 2016)	
		Livestock		Heads/hectares of the Municipality 2008-2017 (Agroindustry Ministry web site; INTA report by Maceira <i>et al.</i> , 2005; SENASA, 2018)
Water for human uses		Evolution of the piezometric level (García-Aróstegui <i>et al.</i> , 2016; León and Bellido, 2016). Volume of water stored in private reservoirs (ONU, 2013).	Availability of drinking water in the Municipality (Results of biological and chemical analyses by a private laboratory in Mar del Plata; Lasta <i>et al.</i> , 2003).	
Regulation	Water regulation		Nitrate and phosphate concentration in the Rambla de Albuñón and the lagoon (García-Pintado, 2015). Aquifer salinity (Martínez-Fernández <i>et al.</i> , 2013). Water quality index (Martínez-Fernández <i>et al.</i> , 2013). Surface flooded by runoff waters (León and Bellido, 2016).	Salinity of the lagoon: evolution of the smooth species ( <i>Mugil platanus</i> ) and sole ( <i>Paralichthys orbignyanus</i> ) (Zelaya <i>et al.</i> , 2016). Fishing/Salinity ratio (Zelaya <i>et al.</i> , 2016). Presence of gastropods Concentration of nitrates and phosphates in the lagoon. Heavy metal concentration in the sediment (Zelaya <i>et al.</i> , 2016). Water pollution status (PCB pesticides, DTT fertilizers, urban solid and liquid waste, sulphur, chloride, etc.) (Zelaya <i>et al.</i> , 2016)
	Morpho-sedimentary		Sediment quality in the lagoon (Martínez-Fernández <i>et al.</i> , 2013). Evolution of the coastline, the coverage of sand dunes and beaches and the sedimentary dynamics (Martínez-Fernández <i>et al.</i> , 2013).	Sediment quality in the lagoon (Merlotto <i>et al.</i> , 2005). Evolution of the coastline (Merlotto & Bértola, 2007; Merlotto & Bértola, 2008). Evolution of the coverage of sand dunes and beaches (Merlotto <i>et al.</i> , 2008; Witness photos at the investigation site, 2018). Evolution of sedimentary dynamics (Merlotto & Bértola, 2009)
	Damping perturbations		Wetland coverage (Pérez-Ruzafa <i>et al.</i> , 1987). Dune system coverage (García-Ayllón, 2014). Budget for beach regeneration/profiling (García-Ayllón, 2013, 2014)	Wetland coverage. Dune system coverage. Budget intended to fix homes for flood damage (INTA report by Maceira <i>et al.</i> , 2005).



**Tabla 1.** Indicators used for the analysis of ecosystem services in the SESMM and SESMC.

Type	Description	Indicators used for SESMM in the ICZM strategy (Barragán Muñoz and García-Sanabria, 2018a)	Indicators used for SESMC
Regulation	<b>Biological</b>	Evolution of the relationship between <i>Caulerpa prolifera</i> and <i>Cymodocea nodosa</i> in the Mar Menor lagoon (Pérez-Ruzafa <i>et al.</i> , 2012). Evolution of <i>Hippocampus guttulatus</i> (Faleiro <i>et al.</i> , 2008; León & Bellido, 2016). Evolution in the proliferation of jellyfish in the lagoon (Concepción <i>et al.</i> , 2015b)	Resulting threatened and endangered species (MAB-UNESCO report, 2005). Obstruction by polychaete reefs (Obenat, 2001)
Cultural	<b>Scientific knowledge</b>	Number of published scientific papers related to the Mar Menor per year (Own statistical elaboration of web data available)	Number of published scientific papers related to Mar Chiquita per year (Own statistical elaboration of web data available)
	<b>Cultural identity, belonging</b>	Budget for the management and enhancement of the cultural and environmental heritage of the Mar Menor (Mínguez, 2002; Griñán Montealegre, 2020). Degree of satisfaction in visits to visitor centres of natural/cultural spaces (León & Bellido, 2016)	Budget for the management and enhancement of the cultural and environmental heritage of Mar Chiquita (INDEC, 1991, 2001, 2010). Degree of satisfaction of the self-convened Habitants (Interviews with self-summoned neighbours)
	<b>Landscape - aesthetic enjoyment</b>	Recreational use of protected areas (number of visits to visitor centres). Number of active tourism companies (natural and rural) (Pérez-Ruzafa <i>et al.</i> , 2005; Barragán Muñoz & García-Sanabria, 2018a)	Recreational use of protected areas (Interviews with self-summoned neighbours). Number of active tourisms in natural and rural companies (active visits to the visitor centres)
	<b>Recreational activities - tourism</b>	Seaside tourism (percentage of tourists in summer compared to the total for the year) (Giménez-Casaldueiro <i>et al.</i> , 2012). Evolution of the number of tourists by origin, nautical-sports activities and the number of registered boats (García-Ayllón, 2014)	Seaside tourism (percentage of tourists in summer compared to the total for the year) (Lasta <i>et al.</i> , 2003; Benseny, 2012). Evolution of the number of tourists by origin (Institutional site maps; cadastral map of the Parque Atlántico Mar Chiquito centre (Municipality); map of the historical variation of the coastline (05/01/2001), Provincial Directorate of Sanitation and Hydraulic Works). Evolution of nautical sports activities (Advertising posters for the tourism sector and the sale of lots). Evolution of the number of registered vessels (Interviews with Regattas and Fishing club and the Mar Pescador port club)
	<b>Environmental education</b>	Number of environmental education campaigns organized by the Administration and/or NGO in the Mar Menor (León and Bellido, 2016). Number of routes/activities offered for environmental education open to the public (García-Ayllón, 2014). Number of registered associations with environmental aspects and/or cultural heritage of the Mar Menor (fauna, flora, landscape, assets of cultural interest) (Own statistical elaboration of web data available)	Number of environmental education campaigns organized (Own research by websites (Administration and / or NGO in Mar Chiquita). Number of routes/activities offered to the public (Field experience in the “Mar Chiquita lagoon day”; interviews with the park rangers of the Provincial Nature Reserve) (Own statistical elaboration of web data available).

For the Spanish case, the work of Barragán Muñoz and García-Sanabria has been taken as a basis, while, for the Argentine case, each element was analysed from the principle through the bibliography, the interviews with representatives of public organizations (Municipality of Mar Chiquita, OPDS, Biosphere Reserve Management Committee) and with the inhabitants. These latter have allowed to fill several gaps in public information related to Integrated Coastal Zone Management in Mar Chiquita territory. Participation in various meetings of the Management

Committee of the Mar Chiquita Biosphere Reserve and the Advisory Committee of the Management Committee of the Biosphere Reserve were included in the research work to collect useful information for the analysis and updating of institutional progress in the ICZM. During the meetings, surveys to the members of the Management Committee have been delivered.

The material collected then allowed for the comparative analysis that constitutes the results section of this article.

### 3. Results

#### Socio-ecological System of the Mar Menor

The results of the SESMM are presented through DPSIWR analysis in figure 3. The overall view of the scheme lets understand, from the beginning, how some problems have evolved, causing the increase of the impacts that, in turn, have impacted the welfare of the local population.

Identified driving forces are population growth and the development of the tourism sector, which have encouraged excessive demand for building around the lagoon, not regulated by effective urbanization plans (Aliaume *et al.*, 2007). These have contributed to building in vulnerable areas that should have been protected due to the high ecological value they represent. One of them, is the coastal arrow “La Manga”, which has a fundamental role in the preservation of the semi-closed body from the Mediterranean Sea (Ibarra Marinas *et al.*, 2016). Inordinate use of space has generated a pressure that it has profoundly modified ecosystems and has contributed to change own interior balances (Pérez-Ruzafa *et al.*, 1991). Economic development has manifested itself in the intensification of agricultural activity and open-pit mining. The latter has reflected in an intensive economic development, with an excessive and an inor-

dinate modernization to the detriment of the place conservation (Pérez-Ruzafa *et al.*, 1987). The wetlands and grasslands around the lagoon have been replaced by areas of intensive cultivation and the salt flats have been replaced by cultivation areas and urban areas (Barragán Muñoz and García-Sanabria, 2018a). This has caused changes in the state of the socio-ecological system, traduced in loss of species of high ecological value, reduction in the surface of wetlands and clogging of the marsh (León and Bellido, 2016). Furthermore, heavy metals, nitrates and phosphates through leaching have caused a high contamination of the underground waters, the fluvial waters and the lagoon water body (Pérez-Ruzafa *et al.*, 2005; León & Bellido, 2016).

Cause-effect process mentioned above is also responsible for the loss of biodiversity. The modifications of the land-sea communication routes and of the lagoon bottom bathymetry, together with the tourist pressure on summer seasons have been steps to start a long-term degradation process that actually is not yet stopped (Pérez-Ruzafa *et al.*, 1987; Aliaume *et al.*, 2007; Giménez-Casaldueiro *et al.*, 2012; Fernández *et al.*, 2013). The high levels of nutrients reached, due changes of the climatic parameters as

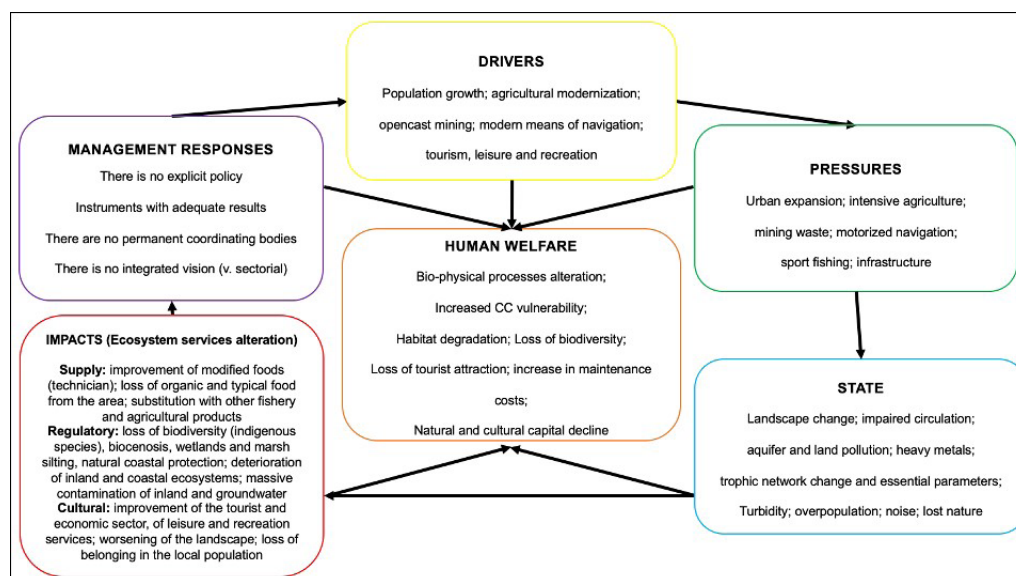


Figure 3. DPSIWR model for the SESMM.

temperature and salinity in the lagoon water, have affected the significant stages of the trophic chain of the system, compromising it (Fernández *et al.*, 2013; Velasco *et al.*, 2017). The alteration of the socio-ecological system has also been reflected on jellyfish plagues, erosion, and the colonization of exotic species (Concepción *et al.*, 2015a). Furthermore, the changes on the practice of fishing, in respect to the traditional one, have undermined quality and quantity of the fish species of elevate ecological value. The consequent changes of the landscape and the increased degradation of the environmental quality have impoverished the sense of belonging of the local. This, in turn, has caused a loss of investment in the beautification and maintenance of the place and, subsequently, has caused in a loss of tourist attraction. The estimated impacts, on ecosystem services, analysed through the indicators of the Mar Menor Strategy, are presented in table 2 (Barragán Muñoz and García-Sanabria, 2018a).

The analysis of the SESMM services balance has been carried out starting from the qualitative study, previously exposed by Barragán Muñoz and García-Sanabria in the ICZM strategy of SESMM (2018). To confirm the evolution of the ecosystemic services, a geo-historical analysis has been carried out (Annex 1). The data acquired in the geo-historical analysis has been inserted as more results to underline the trends of the ecosystemic services del SESMM from 1829 to 2005.

Supply services have been heavily impacted. Traditional fishing shows deterioration (Marcos *et al.*, 2015). In those services related to the salt flats, the balance is contrasted. On one hand, there are certain traditional salt flats that have stopped working, such as those of Marchámalo (Guirado *et al.*, 2010). Other salt flats, however, such as those in the San Pedro de Pinatar Regional Park, continue to sustain the activity, because they are considered compatible with the conservation place objectives, including the

**Tabla 2.** Balance of Ecosystem Services for the SESMM (Barragán Muñoz and García-Sanabria, 2018a).

Type of service	Socio-ecological system of Mar Menor		
	Description		Importance and evolution of service
Supply	Traditional food	Traditional fishing	↕ ↔
		Traditional agriculture	↕
		Salt flats	↕ ↔
	Technician food	Intensive agriculture	↕
		Aquaculture	↕
	Water for human uses		↕
Regulation	Water regulation		↕
	Morpho-sedimentary		↕
	Damping perturbations		↕
	Biological		↕
Cultural	Scientific knowledge		↕
	Cultural identity, belonging		↕
	Landscape - aesthetic enjoyment		↕
	Recreational activities - tourism		↕
	Environmental education		↕
<b>Low importance</b>	<b>Medium importance</b>	<b>High importance</b>	<b>Very high importance</b>
<b>Service worsens</b> ↕	<b>Service is maintained</b> ↔		<b>Improve service</b> ↕

improvement of biodiversity (PORN, 1995). Agricultural activity has undoubtedly increased activity, prioritizing the modernization of food products. The area of intensive agricultural use has increased from about 30.000 ha to about 55.000-60.000 ha (Martínez-Fernández *et al.*, 2013). Another supply service with technological support that is shown in the surroundings of the lagoon is aquaculture, with the production of sea bream, sea bass and bluefin tuna. Regarding service water for human consumption, studies show that it has been affected by salinization of the quaternary aquifer of the Campo de Cartagena, due to overexploitation of freshwater in the proximity of the coast (Rodríguez, 2015).

Regulation services are among the most affected. Morpho-sedimentary regulation in the Mar Menor has been altered by the barrier effect of some port infrastructures, such as the port of San Pedro de Píñar. The changes in the hydrodynamics and the inadequate urban planning have also caused the disappearance of a large part of the sandbanks and the dune field of the La Manga and this, in turn, has compromised negatively the shock absorption service against the sea waves (CEOTMA, 1985). Among the services compromised, there is the important role of the Mar Menor wetland as a green filter, which partially retains the nutrients that come from the irrigation drainage waters of Campo de Cartagena.

Wetland degradation leads to a deterioration in the nutrient's regulation and affects negatively the biodiversity that dependent on its.

Lagoons also offer a biological regulation service since they are a breeding refuge for fish species that in particular periods may be found in the open sea and being of fishing interest (Pérez-Ruzafa *et al.*, 2005).

The opening of the Estacio has caused an increase of Mediterranean Sea waters flow towards the withing of lagoon and has equalized the temperature and salinity values of the lagoon waters with those of the sea. This has determined, in turn, instability conditions for some species accustomed to living in the extreme lagoon conditions, such as the case of the seahorse (*Hippocampus guttulatus*), whose decline has been evidenced by its inclusion in the Red Book of vertebrates as "Endangered species critical" (Robledano *et al.*, 2006; Barragán Muñoz and García-Sanabria, 2018a).

From the cultural services analysis, an improvement is observed in some services and a deterioration in others. Tourism and recreation have increased, especially since the La Manga urbanization. Scientific knowledge has intensified, Mar Menor represents one of the best known and studied lagoon of the world (León and Bellido, 2016).

However, positive evolution of tourism and scientific knowledge services is in contrast with the decline of others services, as the cultural identity, the sense of belonging and the aesthetic enjoyment of the place. About the impact of ecosystem services for human well-being, has been detected that the services related to technician foods have registered a greater importance for the well-being of the population of the Region of Murcia compared to traditional foods. A high and a very high degree of importance is represented by regulation services that reflect the state of equilibrium between the lagoon system, its drainage basin and its coastal-marine environment. And these generally get worse. Cultural services present a differ-

ent degree of importance: the cultural identity and the sense of belonging at the place represent a higher degree of importance compared to others. In second place, there is the aesthetic enjoyment of the landscape and, at the end, there are the services related to scientific knowledge and environmental education that have an average degree of importance for the well-being of the local population.

In the management field, and therefore in the field of managerial responses, it has been shown that the management of the area has been inefficient and sectoral, which is why, in 2017, an Integrated Management Strategy for Coastal Zones for the Mar Menor was drawn up (Barragán Muñoz & García-Sanabria, 2018a). The strategy has defined the bases to respond to the problems generated in the lagoon and its surroundings. There is no explicit, specific and consensual policy about the integrated management of socio-ecological system of Mar Menor. However, a growing interest and concern about the deterioration situation of the lagoon has been identified for three decades on the part of the AGE (General State Administration). The SESMM needs an explicit integrated management policy, effective instruments to use in the decision-making, permanent coordination bodies that control and monitor correct management practice. At the end, it needs a more integrated vision that can relate and interconnect the different social and active actors, involved in the public participation process in the Mar Menor.

### Socio-ecological System of Mar Chiquita

The results of the SESMC are presented through DPSIWR analysis in figure 4. The demographic growth that the municipalities of Balcarce, Tandil and the coastal areas in the last 30 years, have suffered has been recognized as driving force, which has pressured the lagoon system in different ways (Álvarez *et al.*, 1983; INDEC, 2010). Increasing population has necessitated an increase in constructions, leading to

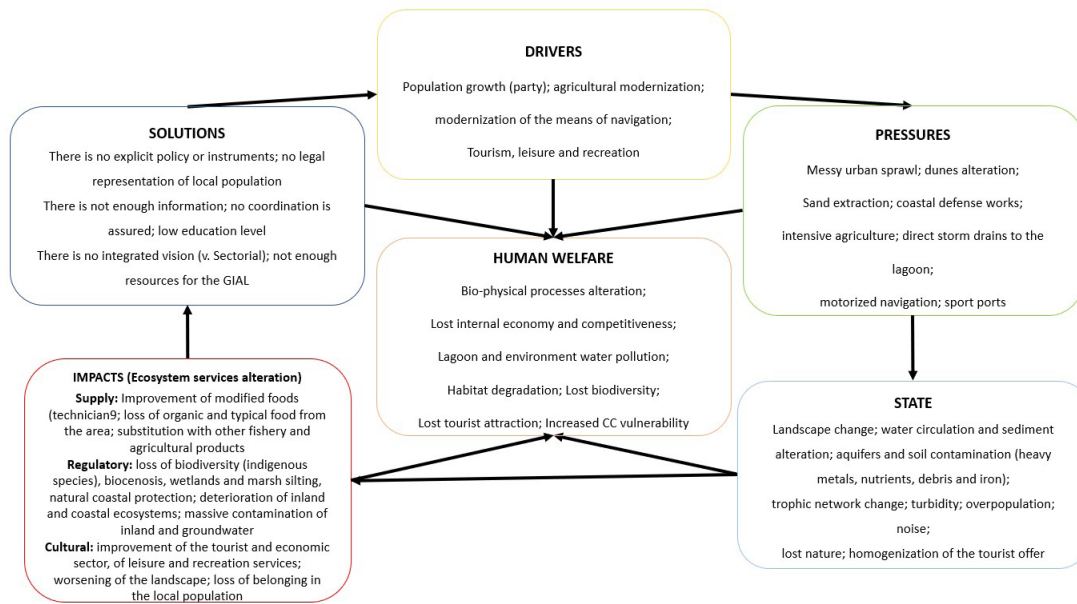


Figure 4. DPSIWR scheme for the SESMC.

inordinate urban expansion without correct planification criteria. The coastal towns have been built on the sandbanks, once they have been flattened and an excessive vegetation fixation was carried out in order to reinforce the sand bottom (Isla *et al.*, 1999; Merlotto and Bértola 2009). This manner of construction and the addiction of the legal and illegal sand extraction have caused acceleration of erosion processes with the consequent retreat of the coastline (Merlotto *et al.*, 2008; Merlotto and Bértola, 2009; Morea and García, 2016).

Agricultural activity has intensified and technified in the last 20 years, and its going to modify the natural landscape and alter profoundly the circulation of continental waters and sediments (Zelaya and Maceira, 2007; Zelaya *et al.*, 2016). Furthermore, sandbanks and sand dunes have been destabilized due to the thorough afforestation of them and the introduction of exotic species (César, 2017a). The agriculture activity added to livestock activities have profoundly

modified the grasslands of the sub-basin (Zelaya and Maceira, 2007).

The intensive use of pesticides and fertilizers have contaminated the water system of the basin. This especially relates to the intensive use in soybean and corn crops that have generated contamination of glyphosate and other herbicides in the ground and surface water (Menone *et al.*, 2000a, 2000b, 2001; Pérez *et al.*, 2017). More, the presence of solid and liquid contaminants has also been evidenced both on the beach and in water (Stutz and Prieto, 2001; Morea and García, 2016).

The tourism sector development, has implicated the construction of infrastructure and equipment to respond to the demands of tourists. Among them, sports activities such as kayaking, sport fishing, kite surfing, surfing, sailing, boating and rowing can be mentioned. Inside tourist facilities it is necessary to include both those that are used to develop sport activities and those necessary for the tourist accom-

modation from abroad. Regarding the pressure of tourism on the beaches of the town of Mar Chiquita, Fernández and Bértola (2014) have shown that the carrying capacity on the beaches has increased between 1955 and 2011. However, this increase has not been accompanied by orderly management and sustainable support from the tourism sector.

Changes in the ecosystem state are reflected in the alteration of the balance between coastal and marine ecosystems, local coastal hydrodynamics comprised. Furthermore, changes are reflected in the depletion of river transport, the coastal erosion, the alteration of temperature and salinity of the lagoon and, finally, in the contamination in the waters and the beaches by iron and debris, which derive from the discards of breakwaters barriers built along the coast (Lagrange,

1993). By tourism sector, overcrowding and congestion of the roads have been evidenced, as well as increasing of noise and loss of naturalness, especially in the summer season and a homogenization of the tourist-cultural offer (Benseny, 2012; Morea and García, 2016).

The impacts on ecosystem services in the SESMC are varied and notorious. The results of analysis can be seen in table 3.

In the analysis of the evolution of ecosystem services that represent the SESMC, a geohistorical analysis was carried out with the data acquired during the field investigation. the first settlements around the lagoon are recorded at the beginning of the twentieth century. The data acquired from the geohistorical analysis are reported in Annex 2, which support the

**Tabla 3.** Balance of Ecosystem Services for the SESMC.

Type of service	Socio-ecological system of Mar Chiquita		
	Description		Importance and evolution of service
Supply	Traditional food	Traditional fishing	↕ →
		Traditional agriculture	↕
		Traditional Livestock	↕ →
	Technician food	Intensive agriculture	↑
		Industrial meat product	↑
	Water for human uses		↕
Regulation	Water regulation		↕
	Morpho-sedimentary		↕
	Damping perturbations		↕
	Biological		↕
Cultural	Scientific knowledge		↑
	Cultural identity, belonging		↕
	Landscape - aesthetic enjoyment		↕
	Recreational activities - tourism		↑
	Environmental education		↑
<b>Low importance</b>	<b>Medium importance</b>	<b>High importance</b>	<b>Very high importance</b>
Service worsens ↓	Service is maintained →		Improve service ↑

thesis of the negative evolution of many ecosystem services of the SESMC despite its anthropogenic occupation being more recent than the SESMM.

Among the supply services, the traditional agricultural and livestock products stand out. Available data, in the SENASA web site (2018), show that livestock products (2008 and 2017) continue to have the same standard. Land cover by agricultural activity has registered a significant increase since 1998 and appears to continue to grow steadily (Zelaya & Maceira, 2007). This increase, according to Zelaya *et al.* (2016), could be explained by the technological advance of the sector, through machines to work the land, the use of fertilizers, pesticides and genetically modified organisms (GMO), and, more, the change in the economic sector directed towards external markets of the East like China, India and Russia (Gileta and Bongiovanni, 2010; IMF, 2006). The yields of the oats, wheat, sunflower and corn productions have grown in the period 1969/2018. Since 1999, soybean production has registered a steady growth until 2010 and a sudden decrease around the 2018. Regarding the sport fishing service, considering that there is no data related to artisanal fishing and that the current depth of the lagoon does not allow the use of large boats, a modernization of the methods has not been detected. Sport fishing is carried out in the area with rental equipment, boats and rods comprised. The presence of poaching with metal nets has been documented, which affects the bottom of the body of water and species not intended for fishing.

The analysis of the regulation services evolution shows that they have had a considerable decrease due to contamination status of the area with the consequent reduction of its water's regulation service. Documents have been found about heavy metals concentration in sediments, the alteration in salinity, temperature and the concentration of nitrates and phosphates (Marcovecchio *et al.*, 2006; Menone *et al.*, 2000b; Velazco *et al.*, 2009). Services related to

regulation morpho-sedimentary showed a negative relationship with evident irreversible problems in most of the points of the coast (Merlotto and Bértola, 2007, 2009; Merlotto *et al.*, 2008; Zelaya *et al.*, 2016). In the services related to biological regulation, the concern about the conservation and the endangered and threatened status of some species present in the Mar Chiquita lagoon such as the amphibians and reptiles, stands out; as well as the statements supported by the Reserve Park Rangers, regarding illegal hunting (López-Lanús *et al.*, 2008).

Cultural services analysis has found an increase of studies and researches tied to the improvement of the Mar Chiquita scientific knowledge. Services related to the cultural identity and the sense of belonging at the place by resident habitants show a decline, due to the lack by municipal institutions interest in local population management issues. In the meanwhile, services related to the recreational, leisure activities of the landscape, as well as those touristic, show an increase. Particularly, a lot of "sustainable visits" to the reserve area are organized by Mar Chiquita Municipality. This touristic activity is increasing and it is allowing to register an exponential increase in lagoon visitors (Morea and García, 2016; Auer *et al.*, 2018).

Environmental education represents the principle at the base of the last analysed service. A growing number of environmental education campaigns, organized by the Administration and NGO in Mar Chiquita, has been found. To these, add also an increase of activities open to the public and the number of associations tied to both environmental aspects and cultural heritage. Another project, to affirm a wider awareness of the importance of this service, is the creation of Mar Chiquita Sustainable School, the first in Argentina and the second in South America (the first is in Paraguay), where several awareness-raising initiatives with the purpose of educating visitors about the resources of environment are developed.



The impacts generated by all of changes of state explained above, have affected human well-being. Health risk data for the local population have been reported. In 2003, Mar Chiquita municipality registered 44,7% for the potential risk for health and 7.4% for the certain risk both linked to the local freshwater consumption, especially (Lasta *et al.*, 2003). These data reflected the bad conditions of freshwater in the Mar Chiquita town. Furthermore, interviews to the habitants of the surrounding villages of Mar Chiquita denunciate a high health risk, caused by the inadequate conditions of most of the homes. Critical conditions are represented by lack of insulation from humidity, continuous flooding in winter, massive erosion in the houses along the coast, etc. The habitants of the Mar Chiquita Resort

#### 4. Discussion

The comparative analysis allowed to highlight the differences and similarities between the two lagoon systems. In the physical-natural aspect, Mar Chiquita shows some differences respect to Mar Menor related to the form and the manner in which it is connected with the external waters. Mar Chiquita is connected to the Atlantic Ocean through a rectified mouth; instead, the Mar Menor presents many exchanges with external waters, due to the expansion of communication channels towards the Mediterranean Sea. Lagoon bodies present similar temperature values, but different salinity values. In the Argentine lagoon, the salinity trend is very inconstant due to the low marine contribution and the continuous river system intake. The salinity values of the winter and summer seasons show, if compared, the greatest discontinuity (Iribarne *et al.*, 2001). On the other hand, as several studies show, Mar Menor maintains the same salinity range throughout the year, due to

interviewed lament the lack of treatment of sewage waste, the contamination by solid and liquid waste in all territory and in the lagoon and, among other problems of management, the lack of conduits for the proper functioning of the energy.

At the end of the analysis, several responses have been developed. In general, the situation of the SESMC is confusing, especially in the management model seems not correctly planned. Institutions, in the different territorial dimensions, do not present a clear line of work on which to act, and conflicts seem to increase every time some actions apply. For a long time, a sectoral and non-integrated management vision has been utilized, and this has privileged some sectors over others.

the “*Mediterraneanization*” phenomenon (Pérez-Ruzafa *et al.*, 2005).

The hydrodynamic force faced from the coastal barrier is different. Mar Menor suffers less the sea waves power, while the Argentine lagoon constantly faces more powerful waves by the Atlantic Ocean. Regarding the river streams, the number of the streams that provide freshwater to the lagoon system, is different: Mar Menor has the greatest contribution by the Rambla de Albuñón and then by other smaller ones. Mar Chiquita, on the contrary, present a systematic river streams composed by five streams.

Another difference is identified in the surface and in the depth. Spanish lagoon presents a greater surface and depth occupied by the water body than the Argentine lagoon. Furthermore, in according with Obenat (2001), Mar Chiquita shows an important presence of the polychaete reefs which, due to its low depth, obstruct the natural flow of currents and prevents the migration of tidal-dependent species.

Eco-systemic characteristics are similar in the two socio-ecological systems, but differ for the area of land actually used. The pasture area is more extensive in the surroundings of Mar Chiquita compared with the pasture area of Mar Menor.

About uses and activities which have generated impacts, some differences have been identified. Nevertheless, among the most relevant driving forces to have created problems, have been identified the increasing of population, the modernization of agricultural techniques, especially in Mar Menor, tourism and sports activities. In Mar Chiquita, the cities are smaller and the agricultural activity takes place in most of the disponible areas around the lagoon. Instead, the develop of the industrial sector is showing a delay by comparing it with that of Mar Menor, that is fed by a higher number of intensive industries around the lagoon body.

In addition to industrial areas, Mar Menor presents many urban areas, which have affected the lagoon integrity, together with the tourist pressure in the summer season and intensive agricultural activity. Furthermore, salt production and aquaculture have implied intense modifications in the Spanish ecosystems. These activities are not yet present in the Mar Chiquita reality. Tourism activities, in both systems, seem instead to have the same trend of development and reflect a single political design.

The changes of state have defined several evolutions in ecosystem services. In the supply services field, Mar Chiquita presents a greater importance in traditional products of fishing, for sports purposes, agriculture, salt and livestock, respect to Mar Menor. It is due to the necessity of Mar Chiquita to present typical products by the area to sustain its economy, satisfying the need for supply and, at the same time, keep itself in the market. Mar Chiquita traditional product services, instead, are decreasing in the last years.

Intensive agriculture sector is present in both systems as important and in development sector, even if Mar Menor present a higher degree of development than Mar Chiquita. Salt production and aquaculture activity are present in Mar Menor and not in Mar Chiquita. The latter, by contrast, present the livestock activity. Relative technician products of these activities in Mar Menor and in Mar Chiquita have the same degree of importance. In general, both systems follow an increasing trend of technician products and a loss of products offered from traditional methods.

About water for human consumption service, both systems have a negative trend caused by the decrease of quality of local water purification plants.

Regulatory services in general have a negative trend in both systems, although Mar Chiquita is in a situation of lower degradation than Mar Menor. Morpho-sedimentary regulation services of Mar Chiquita, particularly, showed a negative change, due to the continuous exposure of massive erosion and to the disorderly extraction around the lagoon. These phenomena have increased the risk of disappearance of the lagoon system. Thus, Mar Chiquita presents a higher degree of importance for this type of service than Mar Menor.

Cultural services show change in trend about needs of local population. Scientific knowledge in Mar Chiquita seems to be constantly increasing, although economic difficulties to invest in science research by the Argentine government, don't help the research progress of the lagoon status. The cultural identity and the landscape aesthetics services have worsened in both systems. As mentioned above, the touristic activity in both systems has developed in the same drawing but with different intensity. Mar Menor tourism has continued to increasing at elevate intensity, supering the difficulties due to continuous negative changes of the lagoon status, such as the plagues

of jellyfish, the quality of the water, etc. In according with the interviews of the Santa Clara Tourism Centre, the Mar Chiquita tourism demand, instead, in the last years seems to be decreasing. Tourism centre staff testify a worsening in the percentage of registered tourists in the last four years. The threats at the touristic demand, according with some interviewed workers of the Santa Clara Tourism Centre and of the Mar Chiquita Biosphere Reserve visitor centre, are correlated with the risks of erosion in the beaches and the crags around all the coastal strip. Morea and García (2016) argue that this is causing a change of mentality and an increase in awareness by local population, even if not in the sufficient measure to convert new intentions into a sustainable and, above all, viable tourism offer.

In administrative field, the countries of the two lagoon systems present important differences in their legal systems and framework. Spain is a parliamentary monarchy and is a member of the European Union. Argentina, is a representative, republican and federal democracy.

The legal framework of the two lagoon systems is very broad; both present a series of laws and decrees that, if applied, could achieve good results in the management of some sectoral aspects. Mar Chiquita's management model still seems confused about the milestones to be faced in order to achieve an integrated management policy, despite the presence of the Management Committee, an important entity, but which is not carrying out many initiatives for the conservation of the lagoon and its surroundings. In Mar Chiquita there is no collaboration between institutions entities, belonging to different territorial scales, and there is no much information useful at the lagoon status management, which is not accessible in some cases and not clear in others. This substantially influences the good behaviour of the local and tourist population, who, depending on the occasion, adopt more or less correct behaviour towards the surround-

ing environment. Another problem in Mar Chiquita is the lack of specific updated instruments. Taking the Mar Menor, and the updated strategy of ICZM by Barragán Muñoz and García-Sanabria (2018a), as an example, it will be important to create as soon as possible an instrument that includes the integrated diagnosis on the SESMC to have an overview of the problems that influence the entire system. Mar Menor there has a better situation represented by the institutions, which are interesting to the lagoon situation and, together with environment associations, have a real desire to carry out the objectives of the management strategy, despite a clear sustainable development plan is not yet present.

The results observed in the SESMM and the SESMC are consistent with the occupation processes and relative pressures occurred in different coastal areas of the world, as showed by De Andrés *et al.* (2018), Barragán Muñoz and de Andrés (2020), and García-Sanabria *et al.* (2015). As can be seen from the entire analysis, coastal lagoons and their drainage basins represent highly complex socio-ecological systems, which provide a large number of ecosystem services and that continuously suffer for the high intensity of pressures generated by uses and activities in its surrounding (MEA, 2005; Vasconcelos *et al.*, 2007; Courrat *et al.*, 2009; Cardoni *et al.*, 2011; Martínez-López *et al.*, 2014). Thus, it is necessary to implement an integrated management model. The application of the DPSIWR framework in this work has yielded useful results for strategic management, as has happened in others coastal socio-ecological systems, such as the Bay of Cádiz by De Andrés *et al.* (2018) and the Barragán Muñoz and de Andrés (2020), the Colombian coasts through the work by Arenas Granados (2007) and the Santa Catalina port, in Brazil thanks to the contribute of García Onetti *et al.* (2017).

The data acquired about Mar Chiquita are consistent with the data used in works carried out by others

Researchers, such as Isla *et al.* (1999), Merlotto *et al.* (2008), Maresca (2013), Morea and García (2016), about natural processes, activities and institutional analysis of the area. Thanks to this coherence, it can be affirmed that this work could improve the overview of the process of development and increment the future management of the lagoon.

Through the long analysis of the DPSIWR model for both systems, it is evident that the trend of the development processes of Mar Chiquita is following the same process followed by Mar Menor and

that the problems that Mar Chiquita is facing are the same or similar of the Spanish lagoon, by comparing the development stages. According with the compared data, is however present a different careful in these problems by the political and civil sphere which represent the public participation. A future management strategy for Mar Chiquita lagoon and the district should be supported by scientific knowledge, and research progress carried out by expert, that should provide the necessary information to develop useful measures in the making decision.

## 5. Conclusion

The Mar Menor and Mar Chiquita present a different degree of intensity of the impacts caused by anthropic occupation and they have been modified in a different manner. The results of the comparative study indicate that the urbanization intensity of Mar Menor is higher than that Mar Chiquita. In Murcia the real estate business was a real “industry”, thousands of apartments were built on the sandy arrow, and many constructions were destined towards the second residences. For this reason, it has been decided to compare two ecosystems about dynamics, problems and management systems. The comparative analysis proved the idea that every lagoon system, in any socio-economic context and degree of development and in any legal-administrative position, is affected by the sea front and the drainage basin in its surrounding. This confirms the assumption that the coastal is a barrier that connects the external and the internal portions of territory through the waters. To resolve the conflicts that are generated by actions

implemented without environmental management criteria, the measures that consider a socio-ecological lagoon system as a set of intercorrelated factors must be defined.

Although important differences are observed about the legal framework and the activities intensity between the two lagoon systems, is evident that Mar Menor and Mar Chiquita present a common point, which is that the interior portion of the drainage basin, as well as the sea front, threatens the conservation status of the coastal lagoon.

Therefore, in making decisions, managers should have to consider the inland areas impacts and those derived by the coastal-marine areas, by considering the stream system as a means of communication between the drainage basin and the coastal front, and by following a long-term vision thanks to the integration of the monitoring actions of the ecosystemic services in the managed areas.

## 6. Refernces

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Annex 1. SESMM Geo-historical analysis according to the anthropic activities resulting in the status of ecosystem services.		
Year / Period	Activity	Effects on the Ecosystem
1950 - 1970	<p>Beginning of usual tourism+ Urbanization in inland. Implementation of meadows. Urbanization in La Manga. Construction of marinas + 27 malacological and dominant species planted. <b>INHABITANTS increasing:</b> 15.685 (1900) - 24.683 (1950) - 26.904 (1960) - 30.097 (1970).</p>	<p>Heavy metals direct to Portman Bay (Since 1950). Gradual increase in organic material in sediment: Since 30mm/s to 30cm/s. Change of meadows + Domain malacological meadows + <i>Caulerpa</i>, <i>Cymodocea</i> and other .species above autochthonous Salinity decreasing (%): Since 60-70 to 50-52 (Since 1970). Lagoon perimeter decreasing (m): (C. IV AD) 92.592 m - (1935) 54.000 - (1981) 58.000. Natural Backfilling + Decrease in depth and lagoon surface (Km): (since 185 to 135). Sediment increase + Heavy metals direct to the lagoon. Gradual increase in organic material in sediment: Since 30mm/s to 30cm/s.</p>
1970 - 1981	<p>Construction and opening of the channel: El Estacio. Beaches and buildings in the sea. <b>INHABITANTS:</b> 37.195 + (tourists or vacationers: 185.000).</p>	<p>Temperature decreasing (°C): Since 48,5-53,4 to 42,8-46,7 (Process started in 1950). Loss of biodiversity and 80% of <i>Posidonia oceanica</i></p>
1980 - 2010	<p>Intensive tourism + 2nd residence phenomenon + Intensive agricultural in the drainage basin</p>	<p>Increased O<sub>2</sub> in the body of water. Jellyfish invasion. NO<sub>3</sub> (mg/l) high: 7. PO<sub>4</sub> (mg/l) very high: 6,8-7</p>

Annex 2. SSEM Geo-historical analysis according to the anthropic activities resulting in the status of ecosystem services.		
Year / Period	Activity	Effect on the Social-Ecological System
1939-1949	1939: Foundation of the Parque Mar Chiquita Centre, the Compañía General de Tierras began the subdivision in plots. In 1930 he had built the oldest building in the town "El Refugio" which today functions as a Visitor Service Centre.	1920: beginning of evidence of erosion in localities north of MDP. "Domino" effect to the north (each work has affected the area near the north).
1949-1957	1949: Evidence of erosion in S. Clara	Continued erosion continued until 1979.
	f Foundation of Mar Chiquita party (already raised in 1939): flattening and excessive fixation of ditches for urban construction + no construction of storm drains (the streets arrive on the beach perpendicular and carry the solid and liquid waste of the city) + urban pressure on the cliffs since the founding of the MC party	1940-1973: Coastal erosion, return of the 2.5 km coastline.
	Increase urbanization and alteration of cliffs: Afforestation (artificial implantation of plants) by the company ARSA + Soil softening	Cliff ecosystem alteration by: a) flattening and fixing of cliffs themselves (loss of mollusc species). b) underground and shallow urban waters. c) urban pressure (start of buildings). d) lack of treatment prior to arrival at sea of solid and liquid urban and inland waste. <i>Ex: S. Martin</i> drags the sand towards the sea
1958-1979	Urbanization growth + Excessive fixation of cliffs by vegetation. <b>1967. The CELPA bridge (Argentine armed force) and the erosion of banks:</b> Acceleration of the clogging of the marsh + Preventing the drainage towards the sea + Obstruction of natural tidal processes of the body of water. 1973: construction of breakwater at the mouth of the lagoon (breakwater + low wall). Invasive polychaete reef formation: <i>Ficopomatus enigmaticus</i> por el 86% of the lagoon, caused by the obstruction of the CELPA bridge. Beginning of sand extraction due to increased demand (construction). 1977: Decree Law 8.758: Prohibition of sand extraction in Mar Chiquita district. 1979: Coastal defence campaign	a) Decrease in coastline return (m / year): from 17.71 to 1.41. b) Increase buildings and adjacent communication routes. c) 1973: Momentary stabilization at the mouth of the lagoon erosion rate: 200m/year. Until 1979: Destabilization and progressive erosion along the entire urbanized coast. d) Salinity traits (from 0 with rain to 43 without rain in summer). e) Influence on the loss of non-tolerant species at high salinity range. f) Significant changes in sediment suspension (increase in turbidity). g) Loss of biodiversity. h) Invasion of the exotic species <i>Ficopomatus enigmaticus</i> on the autochthonous. i) Loss of sand on the coast of the MC party coast and surroundings. j) However, in 1980-90 the municipality allowed extraction in the MC party by state public entities to respond to the demand for sand from the interior departments of the province.

Annex 2. SSEM Geo-historical analysis according to the anthropic activities resulting in the status of ecosystem services.		
Year / Period	Activity	Effect on the Social-Ecological System
1980-2000	<p>The Municipality grants public entities to extract sand for buildings despite the prohibition of Decree Law 8.758.</p> <p>Permanent inhabitants registered in Mar Chiquita (1980): 133.</p> <p>1982: Increase and improvement of the tourism sector (increased economy and relations with the region and the nation).</p> <p>Construction works parallel to the coast, material on the beaches: concrete and rubble.</p> <p>1983: Remodelling of the breakwater at the mouth of the lagoon.</p> <p>1983: construction of 7 breakwaters along the coast.</p> <p>1990: construction of 3 breakwaters in <i>Mar del Cobo</i> Construction of 4 breakwaters on the coast of the Mar Chiquita district: in front of <i>Calle Funes, Gallardo, S. Martin (80m) and Carriego</i>.</p> <p>Permanent inhabitants registered in <i>Mar Chiquita</i> (1991): 162.</p> <p>1995: Provincial law for erosion 11.723.</p> <p>UNESCO Biosphere Reserve Declaration.</p> <p>Before 1996: 100-230 inhabitants (INDEC 2001) recreational use and mild urbanization.</p> <p>After 1996: the coast became a protected area and the awareness of institutions to conserve it increased.</p> <p>1996: Provincial law for erosion 13.516</p>	<p>Coastal defence works parallel to the coast to fix the erosion from S. Clara to the north + live dunes are allowed to be created in the southern portion of the coast (registering low erosion Sand loss increasing on the MC coast and surroundings districts.</p> <p>Increase in the use of the largo del mar space for the local population + active intervention in the public sector for the municipality).</p> <p>Residues of rocks, concrete, rubble and tractor covers on the beaches + Conflicts between the local population and tourism and construction entrepreneurs + Conflicts between citizens and the municipality.</p> <p>Momentary stabilization of the lagoon mouth erosion rate: 3.5-6m / year.</p> <p>The union of coastal defence works has worsened the situation of the MC resort, reducing the contribution of sand. 3 of 4 protect the area: visual infection (debris scattered on the beaches).</p> <p>Coastal Defence Management</p> <p>MC becomes a destination with great potential at the regional level (BsAs):</p> <ol style="list-style-type: none"> <li>Area not prepared for massive urbanization.</li> <li>Disorderly building and without criteria of coexistence with the environment.</li> <li>Previously built coastal defence methods to protect themselves from natural phenomena but without success</li> </ol>
2000 - 2016	<p>Project: "Protection and stabilization of the coast of the MC district" (Merlotto and Bertola, 2007).</p> <p>Permanent inhabitants registered in MC (INDEP 2001): 394.</p> <p>Law 12,211 declares MC as an emergency zone</p> <p>Increase in urban evolution Mar Chiquita party weekend: 5000 registered visitors (measurement by O.P.D.S. - 2008)</p> <p>South-eastern storms.</p> <p>Permanent inhabitants registered in Mar Chiquita (INDEP 2010): 487 .</p> <p>Currently the extraction of sand is still legal / illegal due to the inadequate management of the municipality of the party.</p> <p>Tourists registered on weekends:</p> <ul style="list-style-type: none"> <li>- winter: 600-1000.</li> <li>- summer: 1000-3000.</li> </ul>	<p>Coastal defence and public works management.</p> <p>2nd residence phenomenon due to tourism.</p> <p>Shoreline at the foot of the cliff.</p> <p>In the last decade tourism, no more in growth, that is due to:</p> <ul style="list-style-type: none"> <li>- normo-political changes</li> <li>- massive erosion problems</li> <li>- cultural awareness about risks</li> </ul>

