Integrated water resources and coastal zone management in European lagoons in the context of climate change

Project partners

- University of Aveiro (PT)
- Bioforsk- Norwegian Institute for Agricultural and Environmental Research (NO)
- Institute of Hydro-Engineering of the Polish Academy of Sciences (PL)
- Atlantic Branch of P. P. Shirshov Institute of Oceanology of Russian Academy of Sciences (RU)
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- University of Dundee (UK)
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- Potsdam Institute for Climate Impact Research (DE)
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**THEME: Case study area description and end users**

# Case Study – Mar Menor (Spain)

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## Description of physical conditions

The Mar Menor coastal lagoon (135 $km^2$, mean depth 3.6 m, maximum 6 m), is located in a semi-arid region of southeast Spain (Fig. 1). This area is characterised by scarce precipitation (<300 mm $yr^{-1}$) which mainly occurs during storm events in autumn and winter. The lagoon is isolated from the Mediterranean Sea by a 22 km long sandy bar (La Manga), crossed by five very shallow channels. In the early 1970s, one of these channels (El Estacio) was dredged and widened to make it navigable. Since then, it has become the lagoon's main connection with the sea. The enlargement of El Estacio channel led to a substantial increase of water renewal rates from the Mediterranean, as well as subsequent changes in water temperatures and salinities. These changes favoured the colonisation of the lagoon by numerous marine species as lagoonal temperatures and salinities reached less extreme values (Pérez-Ruzafa et al., 1991).

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http://lagoons.web.ua.pt

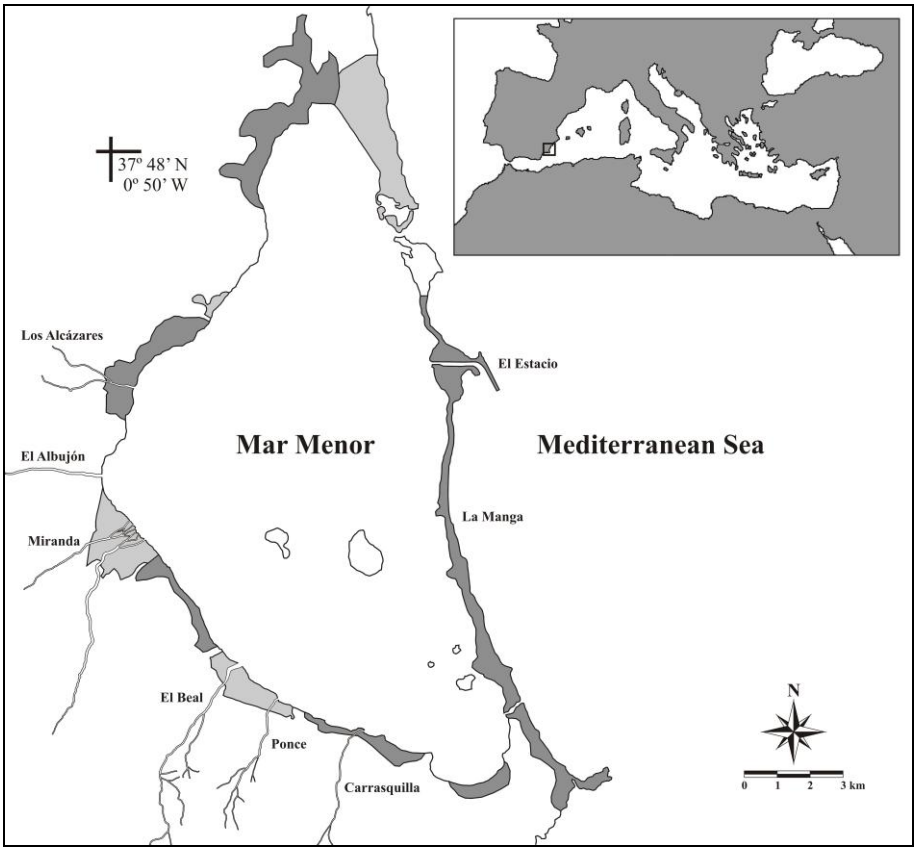


**Figure 1.** A map of the Mar Menor coastal lagoon showing the location of the main urban areas (dark grey), salt marshes (light grey) and watercourses.

One of the main events in relation to this 'Mediterraneanisation' process was probably the colonisation of the lagoon by the invasive alga *Caulerpa prolifera* (Forsskal) Lamouroux. Historically, the principal benthic macrophyte was the phanerogam *Cymodocea nodosa* (Ucria) Ascherson. During the early 1980s, only a few years after the enlargement of El Estacio channel, the bottoms were covered by a mixed meadow of *C. prolifera* and *C. nodosa*. At the present time, a dense monospecific bed of *C. prolifera* covers most of the bottom of the lagoon, and the distribution of *C. nodosa* is restricted to very small patches in the shallowest areas (Fig. 2 and 3).

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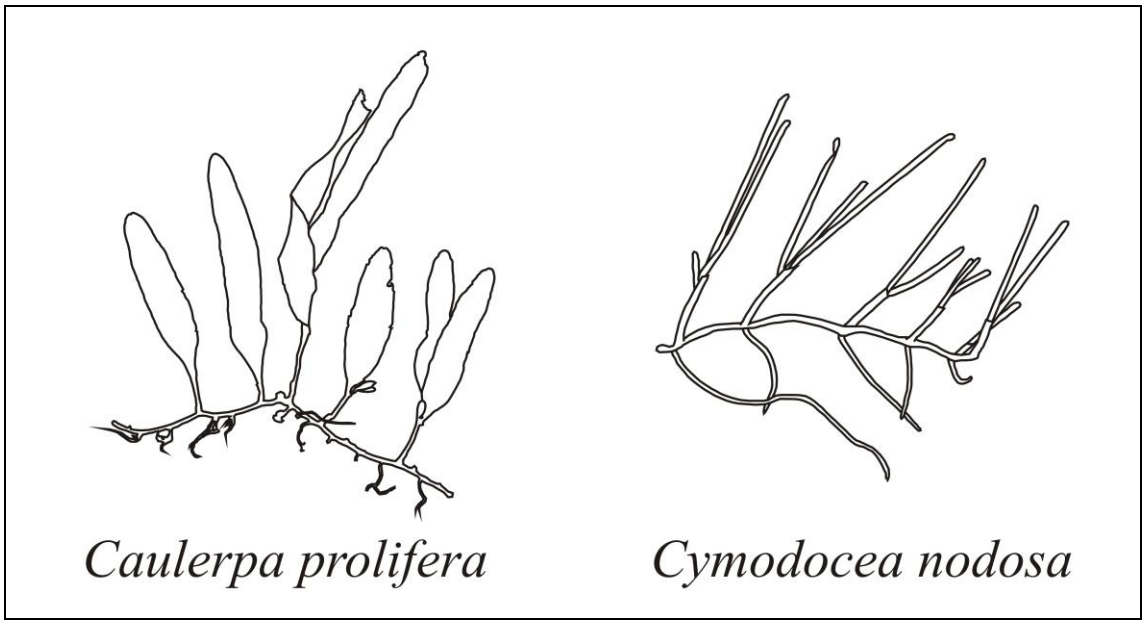


**Figure 2.** A schematic representation of the talli of the main macrophyte species *Caulerpa prolifera* (Forsskal) Lamouroux and *Cymodocea nodosa* (Ucria) Ascherson inhabiting the bottoms of the Mar Menor lagoon.

Several ephemeral watercourses called wadis flow into the lagoon. These wide, shallow gullies, also known as 'ramblas', are generally inactive, but can carry great quantities of water and sediment during flood episodes. The torrential nature of the supplies is aggravated by the impermeable soils and scarce vegetation cover of the watershed areas. Three of these wadis are located on the west margin of the lagoon. Los Alcázares wadi has a diffuse network of channels and reaches the Mar Menor at the town of Los Alcázares. El Albujón wadi constitutes the largest watercourse and drains the adjacent agricultural area Campo de Cartagena. Miranda wadi presents two main channels that converge diffusely in El Carmoli salt marsh.

The other three wadis that reach the lagoon are El Beal, Ponce and Carrasquilla wadis. These originate in the mountains located south of the Mar Menor lagoon, and during episodic rain events, carry metal wastes and mineral deposits from the mining areas located there.

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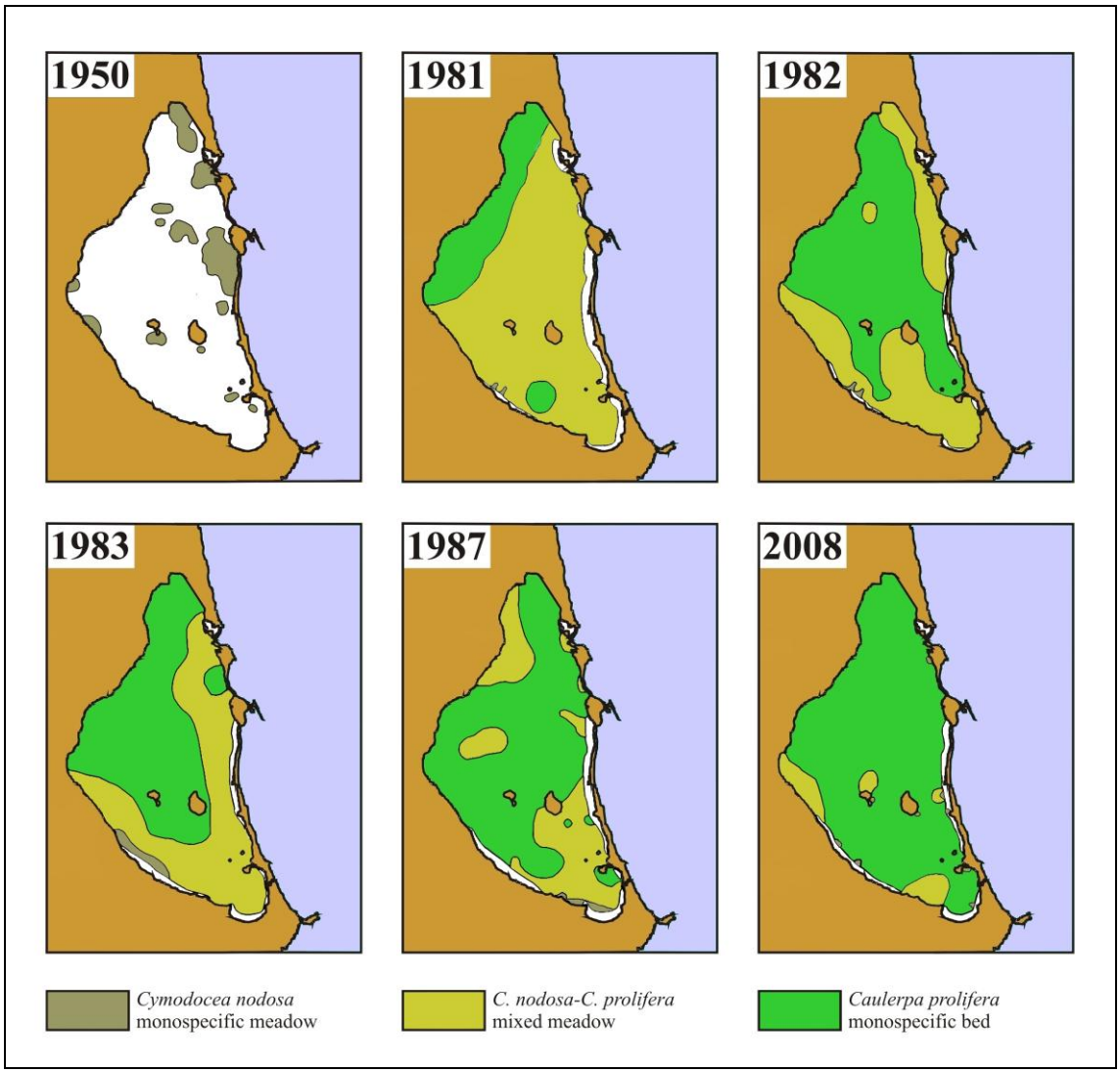


**Figure 3.** Evolution of the coverage of the bottom by the main macrophytes in the Mar Menor lagoon (Redrawn and adapted from Lozano, 1954 and Pérez-Ruzafa et al., 2009).

## Main water management problems (ecological/environmental, social and economic)

Historically, external nutrient inputs to the Mar Menor were mainly via groundwater and atmospheric deposition, in part due to the high ratio of sediment surface area to water volume and lack of major watercourses. However, as in many other Mediterranean coastal zones, the area surrounding the Mar Menor has experienced an intensification of agricultural practises and marked increase in tourist activities that have resulted in increased nutrient inputs to the lagoon.

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El Albujón wadi is the principal watercourse responsible for major inputs of organic and inorganic nutrients that flow into the lagoon (Velasco et al., 2006, García-Pintado et al., 2007). It drains a surface of 441 $km^2$, about one third of the total surface of the adjacent agricultural area (Campo de Cartagena). The principal source is drainage from irrigated crops, but sometimes waste-water treatment plants located in the watershed area, discharge large amounts of untreated or insufficiently treated water into the channel (Fig. 5).

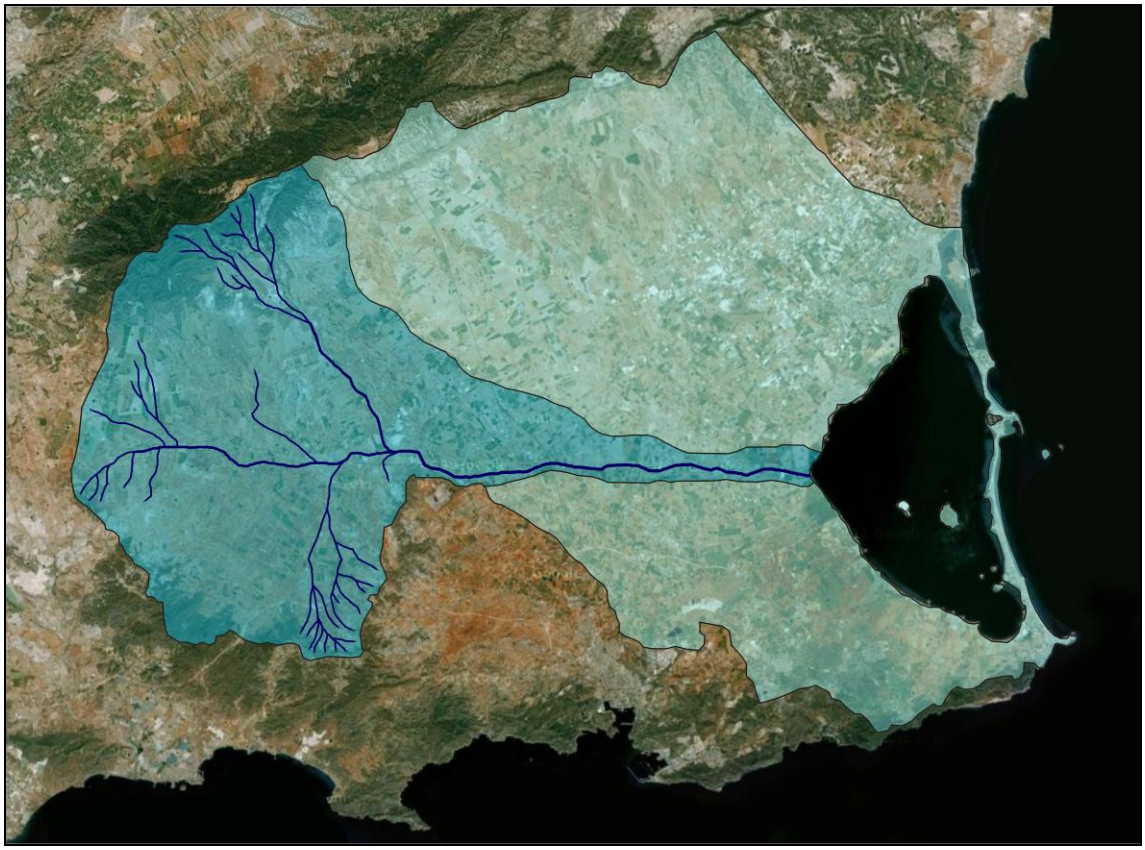

**Figure 5.** Satellite view of the agricultural area of Campo de Cartagena (light blue area) and El Albujón watershed (dark blue area).

As a consequence of increased inputs, the waters of the Mar Menor have experienced rising nutrient levels that have led to planktonic changes in the lagoon (Gilabert, 2001, Pérez-Ruzafa et al., 2005). These changes have also favoured the proliferation of the jellyfish species *Cotylorhiza tuberculata* and *Rhizostoma pulmo*, with severe consequences for touristic activities in the area (Pérez-Ruzafa et al., 2002). Furthermore, modified light conditions of the lagoon waters might have favoured the expansion of *C. prolifera* on the bottoms of the lagoon and the confinement of the

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traditional phanerogam *C. nodosa* to small patches in shallow areas. These changes have caused a progressive deterioration of the sediments through the accumulation of organic matter and subsequent appearance of anoxic conditions and the production of toxic acid volatile sulphides, all of which have diminished the water quality in several zones of the Mar Menor lagoon (muddy bottoms, bad smell, etc.). In addition, the local fishing industry is negatively affected by decreased populations of commercial fish, as these species, mainly Sparidae and Mugilidae, prefer feeding on patches of the phanerogam or unvegetated bottoms, which are now covered by a dense and continuous bed of the macroalga (Verdiell-Cubedo et al., 2007).

Although these changes have been reported, more severe eutrophication events have not occurred, such as phytoplankton blooms, floating macroalgae proliferations or dystrophic events, despite the fact that the magnitude of inputs is of the same order as that found in other coastal lagoons where eutrophication processes have been reported. This fact highlights the existence of certain biotic feedbacks that may be helping to reduce the level of nutrients in the water column and thus favouring the environmental quality of the lagoon (Lloret et al., 2008; Lloret and Marín, 2009; Lloret and Marín, 2011) .

**End users**

On national level:

- Oficina Española del Cambio Climático
- Dirección General de Calidad y Evaluación Ambiental y Medio Natural
- Dirección General de Sostenibilidad de la Costa y del Mar
- Dirección General del Agua
- Instituto de Turismo de España (Turespaña)

On regional and local level:

- Consejería de Agricultura y Agua (CARM)
- Consejería de Obras Públicas y Ordenación del Territorio (CARM)
- Consejería de Cultura y Turismo (CARM)
- Parque Natural de las Salinas y Arenales de San Pedro del Pinatar
- Paisaje Protegido de los Espacios Abiertos e Islas del Mar Menor
- Municipalities (Cartagena, San Javier, San Pedro del Pinatar, Los Alcázares)

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