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**MEDITERRANEAN COASTAL LAGOONS:
SUSTAINABLE MANAGEMENT AND INTERACTIONS
AMONG AQUACULTURE, CAPTURE FISHERIES
AND THE ENVIRONMENT**



GENERAL FISHERIES COMMISSION FOR THE MEDITERRANEAN

4. FRANCE

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4.1 Introduction

The 20 French lagoons are located along the continental Mediterranean coastline (Languedoc-Roussillon and Provence-Alpes-Côte d'Azur regions) and along the eastern coastline of the Corsica island (Figure 1) and cover a total surface of 52 164 ha. Their general characteristics have been described in several reports and publications from which the information in the present country report is extracted (Quignard *et al.*, 1980; Reynal, 1980, Ceparlmar, 1984; 2003, Farrugio and Le Corre, 1985; Quignard, 1989; Le Corre, 1990; Arfi, 1991; DIREN, 2007; Barral *et al.*, 2007; Pôle Relais Lagunes, 2008; Ifremer, 2010; Charret and Passerieux, 2011; Gervasoni *et al.*, 2011).

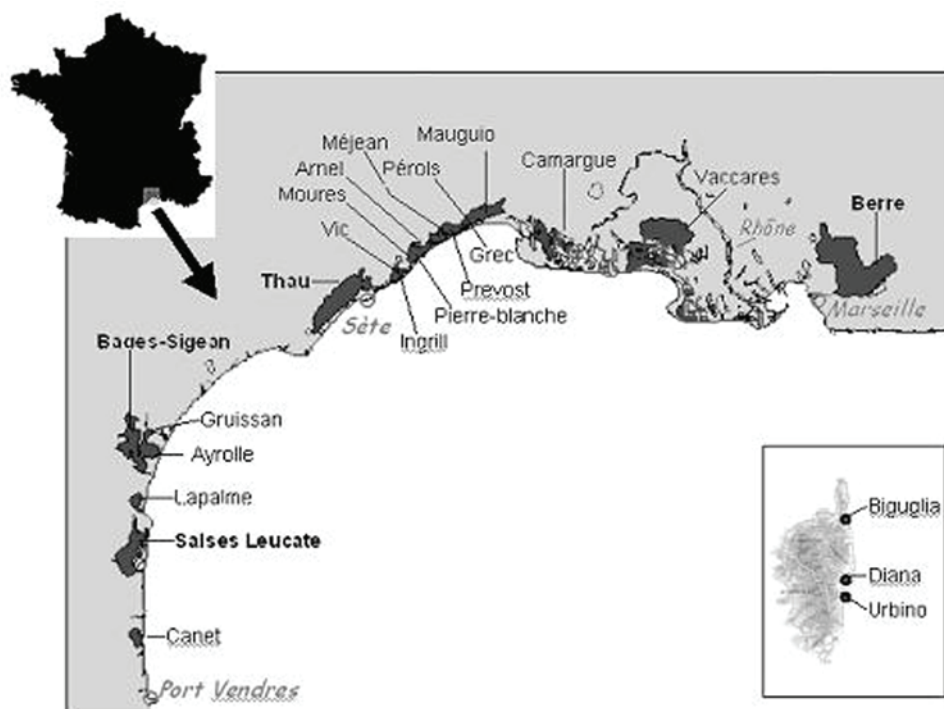


Figure 1. Geographical situation of the French Mediterranean lagoons

4.2 Generalities on coastal lagoons of France

The surfaces of the French lagoons vary from 15 000 ha (Berre lagoon) to 86 ha (Perols lagoon) and except in some cases (Berre, Thau) their average and maximum depths are generally very low (most of them less than 1 meter, Table I). Their water salinity is very different from one lagoon to another. It varies according to the seasons and depends mainly on the rain regime. The water temperature and the dissolved oxygen ratio are also very variable: due to the low depth of these lagoons, they follow the trends of the air temperature; in winter the surface water layer can freeze, while in summer it can reach up to 30°C. The oxygen concentration is very often near to the maximum except in summertime; during this season annual dystrophic crises caused by the biodegradation of opportunistic macroalgae resulting from anoxic conditions can be observed regularly. The main temperature variations are caused by the wind regime which can generate daily variations of 10° C.

Table I: Characteristics of French lagoons

Lagoon name	Surface (ha)	Average depth (m)	Maximum depth (m)	Fisheries	Aquaculture
Canet	480	0.4	1	yes	no
Salses-Leucate	5 400	1.8	3.7	yes	yes
Bages-Sigean	5 240	2	3.6	yes	no
Ayrolle	1 800	0.5	1.5	yes	no
Gruissan	136	0.4	1.1	yes	no
Thau	7 500	4.5	10	yes	yes
Ingrill	550	0.7	1.3	yes	no
Pierre Blanche	368	0.4	0.8	yes	no
Vic	1 370	1.2	1.6	yes	no
Prévost	380	0.5	1	yes	no
Arnel	469	0.3	0.6	yes	no
Pérols	86	0.5	0.8	yes	no
Méjean	380	0.5	1	yes	no
Mauguio	3 167	0.8	1.3	yes	no
Ponant	280	2.7	5.5	yes	no
Camargue	6 705	1	2	yes	no
Berre	15 000	6	9.5	yes	no
Biguglia	1 450	1.2	3	yes	no
Diana	570	4	11	yes	yes
Urbino	750		9	yes	yes

Legal framework and constraints

Fisheries and aquaculture activities in the French lagoons, as well as recreational activities, are submitted to the French national legislation.

4.3 Living resources

Flora

Except in some rare cases, few detailed information exist. In the Camargue area some 1 200 species of plants and seven natural habitats have been classified as preferential at the European scale. The Mauguio lagoon counts more than 25 species of green and red algae.

Aquatic fauna

The last census of the fauna indicates the presence of 31 different species in the Ayrolle-Campagnol lagoons. A census of 58 fish species was carried out in the Bages lagoon, 34 fish species in the Diana lagoon and 24 species in the Mauguio lagoon. In the Biguglia lagoon over 120 species of sedentary and migratory birds and 41 species of marine and freshwater fishes were censused. Everywhere the most abundant species are eels, seabass, seabreams, grey mullets, soles, atherinas, green crabs and shrimps.

Wildlife

The surface of the French Mediterranean lagoons and their surrounding peripheral wetlands is around 130 000 ha. This territory represents 17 percent of the French wetlands classified as important conservation areas of Community Interest, and all the lagoons constitute hot spots of plant and animal biodiversity and are included in the European network *Natura 2000*. Many commercially important migratory fish species spend a large part of their life cycle in these lagoons, which are also used by more than 200 species of sedentary or migrating birds among which 45 percent of the overall Mediterranean number of adult couples of flamingos. They also provide shelter for 40 percent of the French amphibian species.

The animal biodiversity of the Thau lagoon is high: 85 species of sedentary or migrating fish species and 60 species of sedentary or migrating bird species were censused. The invertebrates are also well represented, as shown in the Table II

Table II: Number of species present in Thau lagoon

Group	Number of species
Protozoa	several hundreds
Sponges	7
Coelenterata	28
Bryozoa	20
Worms	more than 50
Echinodermata	12
Molluscs	70
Crustaceans	110
Arachnids	2
Tunicata	8
Fishes	85
Birds	60

4.4 Land and water management

The French lagoons communicate with the sea through permanent or temporary openings, most of which have been artificialized to avoid their natural tendency of silting up. They receive freshwater inputs from permanent or temporary small rivers and from draining channels of their catchment basins, from temporary springs and from karstic resurgences.

The Mediterranean is connected to the Atlantic Ocean by the canal du Midi crossing the Palavasian lagoons between the Rhône River and the Thau lagoon. This canal is part of the world human patrimony (United Nations Educational, Scientific and Cultural Organization [Unesco]).

Furthermore, more than 10 percent of the surface of the French Mediterranean lagoons and their peripheral wetlands have been bought by an institution aimed at the protection of the coastal zone, the Conservatoire du Littoral; two regional natural parks (Camargue, 84 360 ha and Narbonnaise, 81 170 ha) include large lagoons systems in the heart of their areas; their main objectives are the protection of the natural environment, the maintaining of the artisanal fishery and the equilibrium between the various activities (professional and recreational fisheries, sailing and other touristic activities).

4.5 Lagoon exploitation

4.5.1 Aquaculture and capture fisheries

There is a very old tradition of fishing and collecting shellfish in the French Mediterranean lagoons. Only some partial historical series of catches in some of the French lagoons can be found in the official statistical reports or in the published or "grey" literature. From these data, it appears that these activities have been decreasing from the early eighties, due to the unequilibrium between the retiring of aged persons versus the arrival of young people and an increasing sharing of the effort between lagoon and sea, probably linked to a stock size diminution of some target species. The fishing activity in the French lagoons is based on eels, seabass, seabreams, grey mullets and atherinas.

Fishing gear

Different types of gear, essentially set nets, traps and lines, are used seasonally with varying frequencies in different areas. There are no more fixed fishing gear at lagoon openings to the sea and the main type of gear currently used to catch fish is the classical fyke net (*capéchade*). Other gear categories, gillnets, trammel nets, trolling lines and a few longlines are also used, but they are less important.

Work force, establishments and institutions

The professional people exploiting the lagoons are officially registered at the maritime Administration. In 2010 there were 526 aquaculturists and around 600 fishers. They are members of different socio-professional organizations, the "Prud'homies" that manage the organization of fishing by enforcing the general rules but also by developing their own internal rules. They own a Court, elected for three years, which can impose fines on violators. Every year they also distribute the fishing posts for the fyke nets by drawing lots between their members.

Aquaculture and capture fishery management

The management regulations include several types of measures: a part of them concern the regulation of the access to the resource by limiting the number of fishers and aquaculturists by means of licences and by the conditions of obtaining of the professional status. The number of aquaculture plants is regulated. The allocation of the fishing places to install the fyke nets is made at random and there are calendars of opening/closing of fishing zones. The number of nets is also regulated, as well as the mesh sizes. Other measures concern the technical characteristics as the dimensions and the spacing between nets and size of the net dams, which do not have to exceed two thirds maximum of the width of the passages between sea and lagoons to favour the escape of the spawning migration to sea.

Fish production

There is a general lack of statistical series on fish production. More than 30 species of fishes are captured in the French lagoons, from which the main commercial ones are the eels, grey mullets, seabasses, seabreams, soles and atherinas. For these species some indication on the production by unit of surface can be found in the literature: according to the lagoon this production varies between 20 kg/ha and 90 kg/ha, the eel being the main bulk of the catch (up to 75 percent but very variable from one year to another.).

More than 20 species of fishes and crustaceans are commonly caught in the fyke nets, among these the European eel, *Anguilla anguilla*, is the most important target species, representing 70 to 80 percent of the total catches and the most important commercial revenue of the overall lagoon fishery. Glass eels fishing is prohibited on the French Mediterranean coast and the adults (yellow or silver eels) are fished all along the year, and in autumn large quantities of adults eels migrate to the sea; during this season in some lagoons several hundreds of fyke nets are installed along long net barriers to close the passage at sea (national regulation prohibits the

installation of barriers of more than two thirds of the opening wide in all the French Mediterranean lagoons, however this rule is not completely implemented).

Eel production in the French lagoons has always been irregular, however in the last 20 years this production has shown a regular decreasing trend. On some lagoons like the Etang de Thau, clams are the most commercially important target species of the fishery; traditionally they are caught using rakes but they are also intensively exploited by scuba divers. Poaching is very common for the catching of clams and glass eels.

Regarding aquaculture production, according to the official data the French lagoons have produced 8 825 tonnes of oysters and 4 180 tonnes of mussels in 2010.

4.5.2 Recreational activities

The touristic pressure on the French lagoons is very variable from one lagoon to another. Nevertheless, in general the cities surrounding the lagoons receive in summer a quite important number of tourists attracted by the long sandy beaches on the seaside and their population can be ten times more important in summer than in winter. In several cases there is also an important industrial activity around some lagoons.

4.6 Interactions among aquaculture, capture fisheries and the environment in coastal lagoon management

4.6.1 Competition for space (location of aquaculture facilities in fishing grounds, existence of "planning management" for lagoon areas, etc.)

Some conflicts between the professional fishers and farmers against the non-registered ones or against the tourists, or against the people coming from different regions can exist. In the past, they have been sometime very important, mainly in the Thau lagoon, but nowadays it can be said that the situation is calm.

4.6.2 Organic input from aquaculture activities

The main interaction between fishery and aquaculture is due to the presence of large amounts of shellfish allowing for the development of a massive benthos, while organic enrichment from biodeposition changes the specific composition of soft-bottom benthos. In the deeper areas where summer thermoclines limit oxygen transfer from surface water, the organically enriched substrate induces oxygen depletion and ammonium and nitrogen sulfide accumulation in the water column. This ecosystem dysfunction kills benthic populations, and sometimes reaches pelagic populations and affects at the same times the shellfish farming and the fisheries economy.

4.7 Environmental considerations

Coastal lagoons face the following problems with respect to ecosystem productivity and capacity to sustain fishers' livelihoods.

Most of the French lagoons have to face increasing anthropogenic pressures as they are the final receivers of pollution, in particular the incoming quantities of nutrients coming from the water treatment plants of the surrounding cities or drained together with pesticides from the agricultural activities in their catchment basins are high (for example those coming from rice culture in the Camargue area, from vineyards in the Thau lagoon, from maintenance of urban gardens or from chemical treatments against mosquitoes in the Palavasian area). Detergents are particularly concentrated during the summer touristic season, while pesticides are more abundant in winter during the periods of rain.

Some lagoons like Berre are subject to pollution coming from the oil industry, while others like Bages-Sigean are threatened by the proximity of chemical plants.

In the Berre lagoon from 1966 to 1993, the diversion of the Durance River to feed a hydroelectric power plant has induced an inflow of freshwater of almost four times the volume of the lagoon water, at least doubling the annual natural discharge of suspended matter and nutrients. The current global discharges are now lower due to the restrictions applied to the power plant and also to dryer conditions and better treatment of sewage waters along the catchment basin. Until 1966 the Berre lagoon was a salty lagoon with a highly diversified marine fauna and flora. The decrease in biodiversity, the eutrophication processes and the chemical pollution of water and sediments have deeply altered that natural environment. Almost all the vegetal species have disappeared, including the eelgrass *Zostera marina*, a keystone species that previously constituted extensive meadows in the lagoon; while the marine animal populations have declined or have disappeared and they have been substituted by a euryhaline macrofauna. Due to the anoxic conditions existing in the deeper parts of the lagoon, the benthic life has disappeared.

The faecal germs have an impact on filter-feeders (shellfish), which can become contaminated and unfit for consumption (risk of typhoid, hepatitis). The fecal bacteria (*Escherichia coli* and *Streptococcus*) show periods of particular abundance after heavy rainfall and in the lagoon where shellfish aquaculture is developed, consumption of shellfish is regularly prohibited for some time.

The phenomenon of "malaïgue", an eutrophication due to the excess of nutrients combined with the high summer temperatures, is regularly observed in most of the French Mediterranean lagoons; they have biological (mortalities of shellfishes and fishes, development of unwanted plants or animals), economic (benefit loss resulting from oysters and mussels mortalities) and touristic (bad water quality, bad smells due to the production of hydrogen sulphide). Another recurring problem for the French lagoons is the sporadic development of toxic microalgae and especially those of the genus *Alexandrium* and *Dinophysis*, the toxins of which are dangerous for humans and are concentrated by the oysters and the mussels.

Since 2009, there is a high mortality of young oysters, the origin of which has not yet been completely determined. This crisis led 20 percent of the producers to change their strategy, some of them increasing their mussel production, others beginning to produce mussels for the first time.

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