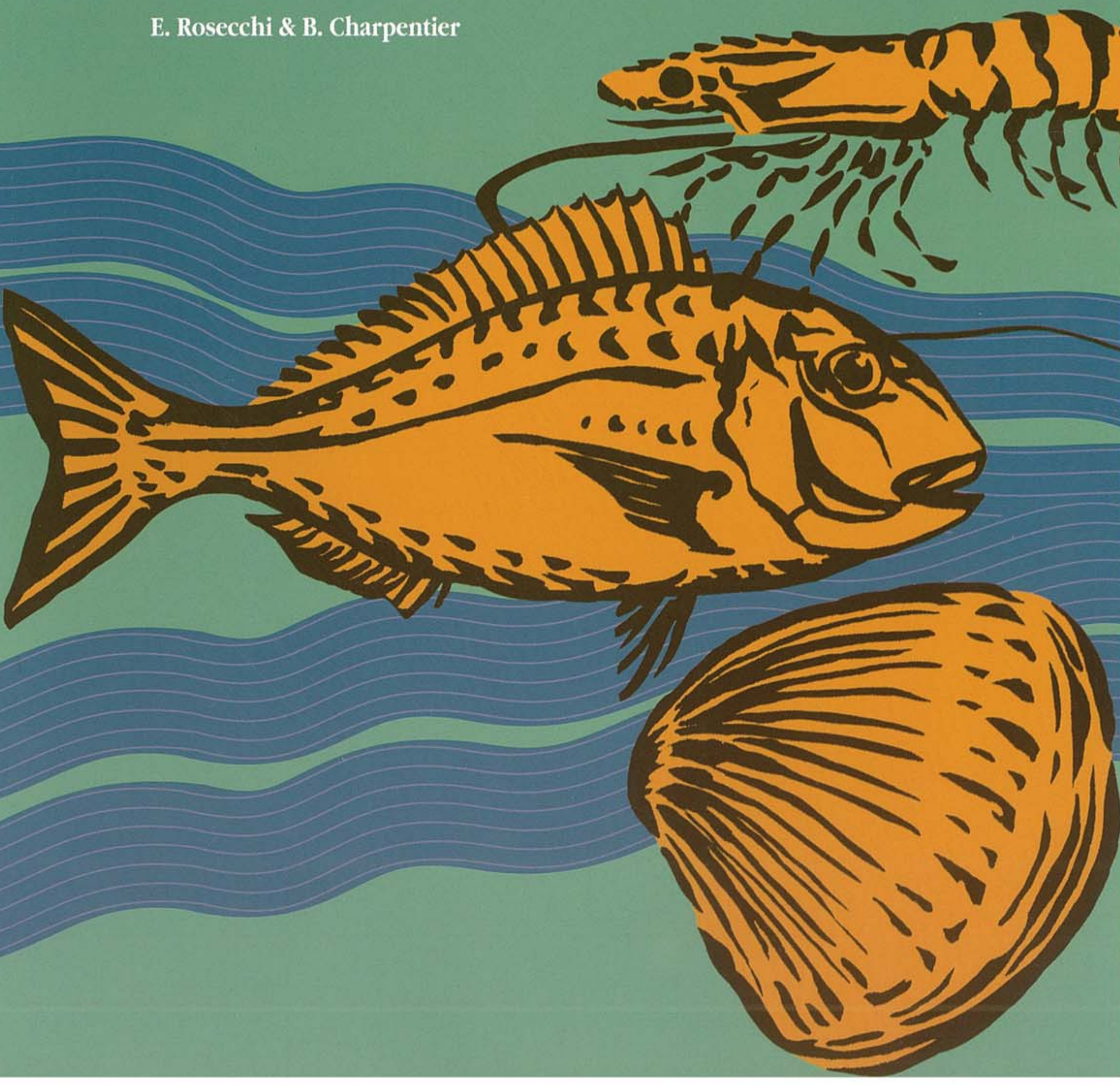
MedWet

Conservation of Mediterranean Wetlands

Aquaculture in Lagoon and Marine Environments

E. Rosecchi & B. Charpentier



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MedWet

The MedWet action

The Mediterranean basin is rich in wetlands of great ecological, social and economic value. Yet these important natural assets have been considerably degraded or destroyed, mainly during the 20th Century. To stop and reverse this loss, and to ensure the wise use of wetlands throughout the Mediterranean, a concerted long-term collaborative action has been initiated under the name of MedWet.

A three year preparatory project was launched in late 1992 by the European Commission, the Ramsar Convention on Wetlands of International Importance, the governments of Spain, France, Greece, Italy and Portugal, the World Wide Fund for Nature, the International Waterfowl and Wetlands Research Bureau (IWRB) and the Station Biologique de la Tour du Valat.

This project focuses on that part of the Mediterranean included within the European Union, with pilot activities in other countries such as Morocco and Tunisia. Two thirds of the funds are provided by the European Union under the ACNAT programme and the remainder by the other partners.

The concept of MedWet and its importance for the wise use of Mediterranean wetlands was unanimously endorsed by the Kushiro Conference of the Contracting Parties to the Ramsar Convention in June 1993.

The MedWet publication series

Wetlands are complex ecosystems which increasingly require to be managed in order to maintain their wide range of functions and values. The central aim of the MedWet publication series is to improve the understanding of Mediterranean wetlands and to make sound scientific and technical information available to those involved in their management.

Elisabeth Rosecchi & Béatrice Charpentier, 1995
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1. Characteristics of Mediterranean wetlands
2. Functions and Values of Mediterranean wetlands
3. Aquaculture in Lagoon and Marine Environments

Conservation of Mediterranean Wetlands

MedWet

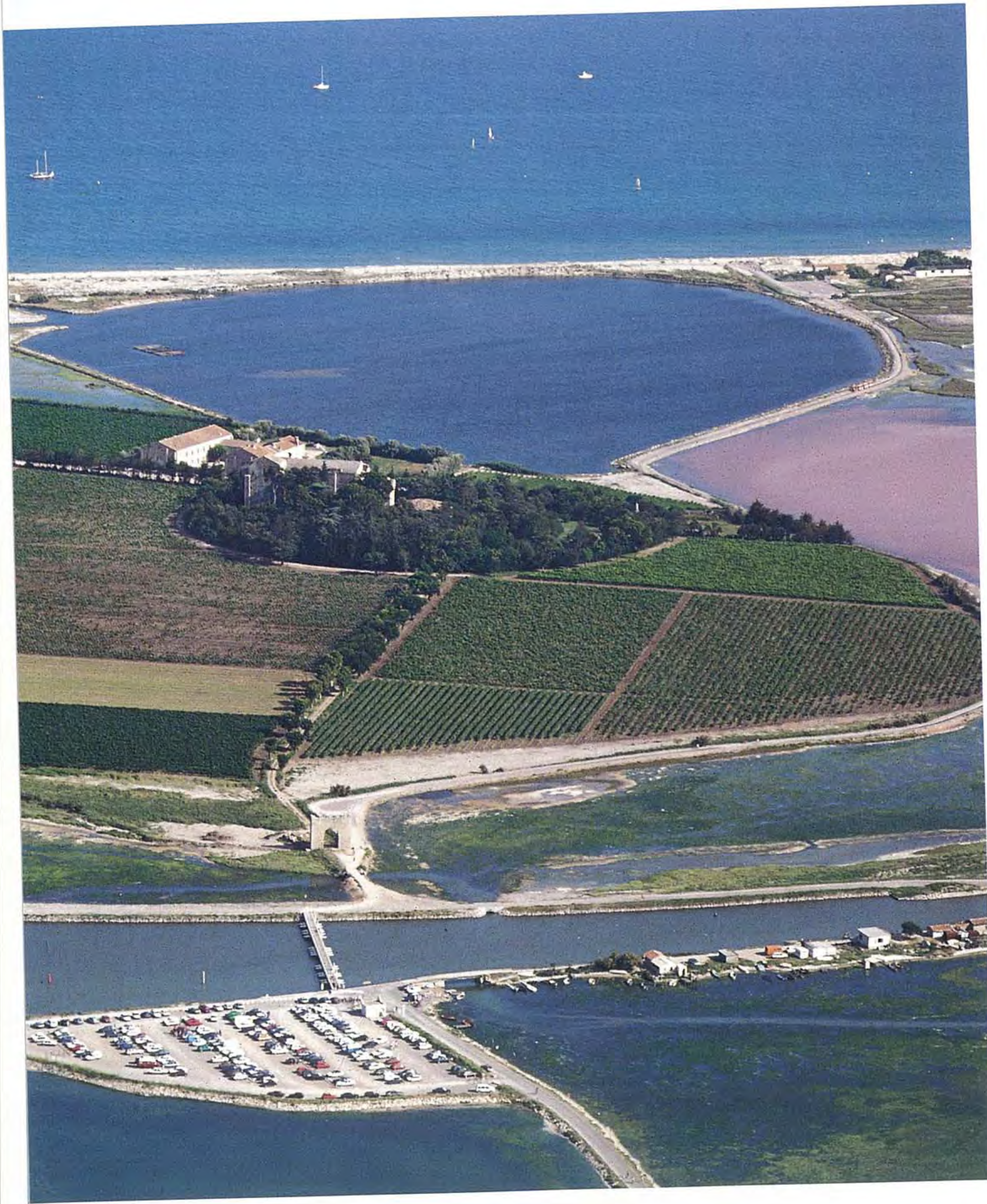
Aquaculture

in Lagoon and Marine Environments

E. Rosecchi & B. Charpentier

Number 3

Series editors : J. Skinner and A. J. Crivelli



Preface

As marine catches appear to have reached a level corresponding to or exceeding their potential means, mankind is forced to seek alternative fish supplies to feed the growing demand. This implies a transition through culture-based systems towards full control of all stages of the life cycle through aquaculture. Fish rearing traditions in the Mediterranean are almost as ancient as those in Asia. The availability of calm seas, an indented coastline and numerous coastal lagoons present a favourable geographic framework and the custom of eating fish as a major element of the diet creates a ready market for products from the sea. Aquaculture has grown steadily, passing from about 4 % of the total fish, shellfish and crustacean production by weight to 11 % over the last ten years. These gains have been achieved at some cost and the spreading aquaculture is frequently the subject of dispute on environmental and aesthetic grounds. The sea, and particularly the coast, of the Mediterranean is a resource of inestimable value for tourism to the various riparian countries. Coastal occupancy and tourism create tension with regard to the management of the aquatic resource. On the one hand there is a growing demand for fish that only aquaculture can now satisfy. On the other hand there is a requirement for ecosystem health which presupposes clear water and uncluttered views. This polarization is at the heart of the conflicts surrounding modern aquaculture development and its solution will determine the future potential of this growing industry. A number of organizations are involved in facilitating understanding and collaboration among the Mediterranean countries among which the MedWet programme makes a significant contribution. This small treatise on aquaculture examines the issues facing aquaculture in more detail and suggests an integrated approach to the solution of the problems. Although the text refers particularly to the Mediterranean it is representative of a situation found throughout the world and should also find an interested readership outside its area of immediate concern.

R.L. Welcomme

Chief of the Inland Water Resources and Aquaculture Service
Fishery Resources Division
Food and Agriculture Organisation of the United Nations

M. Gunther / Bios

The coastal lagoons of southern France are separated from the sea by a narrow sandbar.

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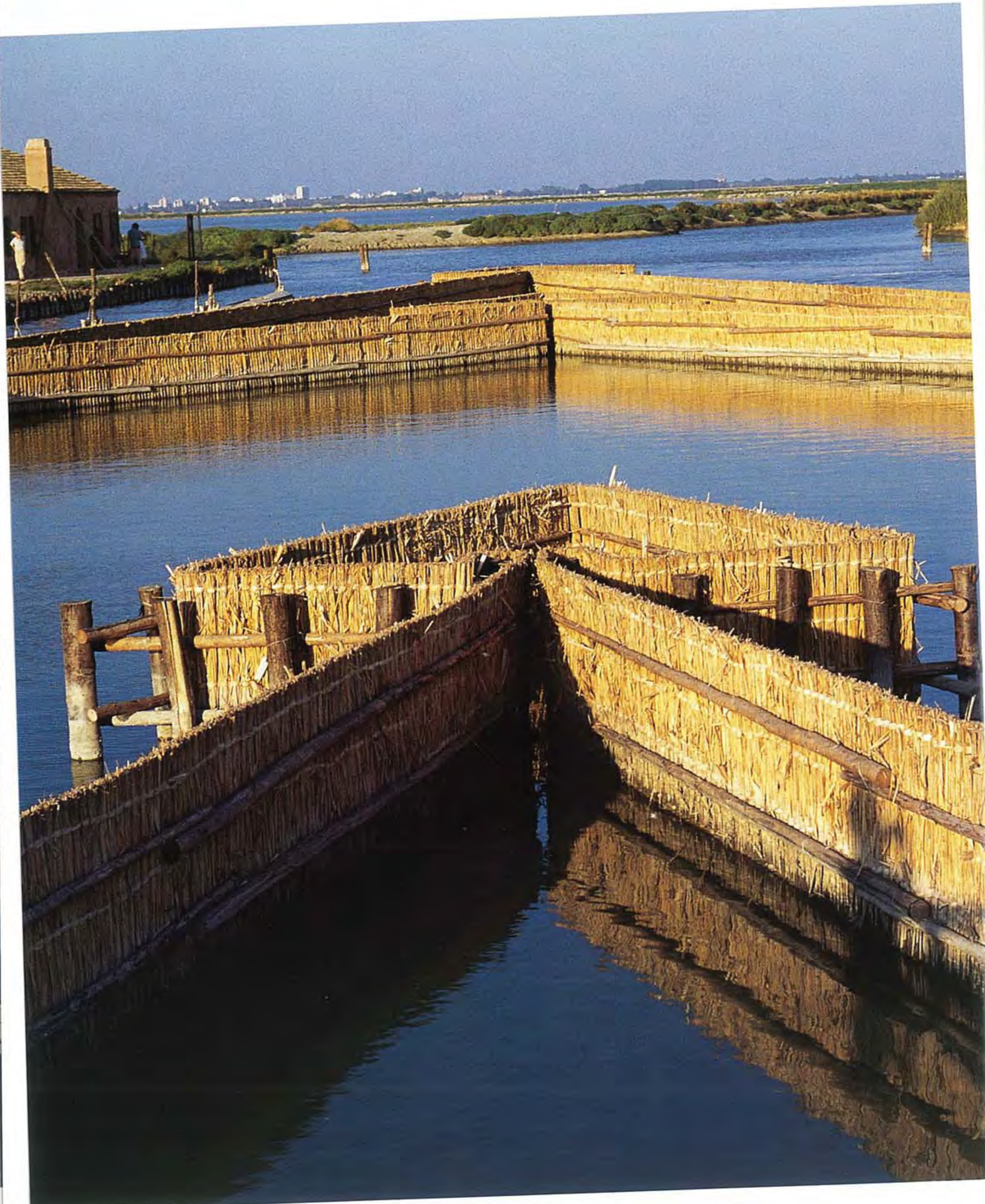


Introduction

A minimum of one million tonnes of fish are now caught each year in the Mediterranean, compared with 500,000 tonnes per annum between 1938 and 1955. The consumption of the local population accounts for 4 million tonnes per annum. This gap between supply and demand is promoting the cultivation of the most highly sought-after species along the 46,000 kilometres of Mediterranean coastline with consequences for the lagoon and marine environments.

The Mediterranean has relatively low productivity, for the amounts of naturally occurring nitrates and phosphates are not high. Plankton*, the basis of the trophic* chain, is in quite short supply and vertical mixing of surface and deep water is limited so that nutrients from the water bottom are unlikely to return to the surface. Consequently, "the sea adds a lot to the resources of the Mediterranean but not in such a way as to provide a daily living"[1]. Fishing in the Mediterranean was for a long time a cottage industry and did not even provide enough food for the fisherman and his family, so that they also had to be small farmers. Over the past few decades, fishing has been modernised and industrialised. As a result the marine environment is heavily worked.

Catching chamber of a bordigue* in the "valle" di Comacchio, Italy.

** - refer to glossary*
1 - Braudel (1985)

Around 38 % of the catch is taken in the Mediterranean west of Sardinia and Corsica, 47 % in the central Mediterranean and 15 % in the eastern Mediterranean.

However, the quality of the species caught in the Mediterranean has a high added value. For example, in 1975 the fish caught were equivalent to 2 % of landings worldwide but 6 % of the global turnover. This explains why fish in the Mediterranean has been exploited to such an extent that resources are now being pushed beyond their limits. In Italy, for example, "fish reserves have fallen to 20 % of their natural level in many places... and more or less everywhere the large species of fish such as swordfish as well as the smaller species such as sardines and anchovies, which make up the bulk of the catch in the Mediterranean, are overfished"[1]. Unless a halt is brought to such depletion, there will inevitably be a crisis in the fishing industry at a future date. This is the impetus behind the cultivation of the more sought after species which command high prices and are economically viable to raise in captivity.

One author comments "the scarcity of marine resources is pushing us to find better ways of transforming proteins from the sea. Aquaculture assumes a vital role in this development, but it is not the only tool and it must be able to match up to its forecast performance"[2].

Cultured fish are mainly fed on foodstuffs based on fishmeal. One kilogramme of fishmeal is needed to obtain one kilogramme of fish, and five kilogrammes of low quality, or "fodder", fish are required to make this amount of fishmeal. To reach the same weight in its natural state, a cod would consume eight kilogrammes of fish prey[2].

Aquaculture today is a rapidly diversifying sector both in terms of technology and with respect to the species cultivated. Because of the impact aquaculture makes on the natural environment, it should be governed by strict regulations protecting the quality of that environment. It also competes with other socio-economic activities for space, with conflicting objectives and requirements. These problems are of particular consequence in the most desirable of aquaculture sites, namely lagoons and estuaries.

Furthermore, although aquaculture produces fish with high added value to meet the demands of countries with strong purchasing power, it is neither helping the developing countries on the southern shore of the Mediterranean to be self-sufficient in terms of food, nor is it taking their eating habits into account. Within this web of somewhat contradictory elements, the future of aquaculture is far from clear.

1 - World Bank figures for 1990.
2 - Cueff (1991)

Introduction

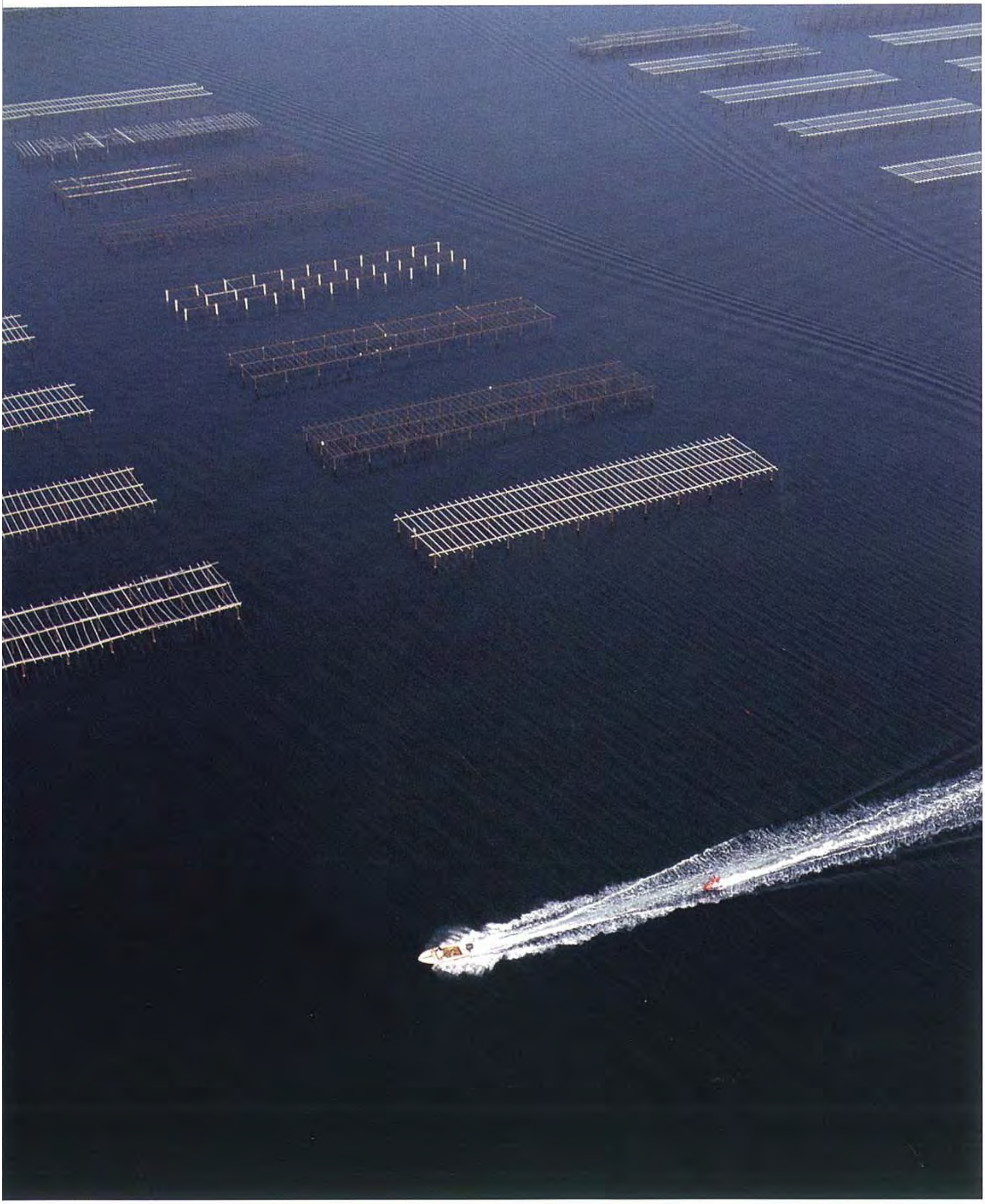
Over the last 15 years governments, the European Commission and multilateral aid agencies have sought to promote aquaculture in the Mediterranean region. As the technology and cultivation techniques have improved, and the inherent financial risk has declined the industry is becoming more market oriented as subsidies and aid programmes become scarcer, particularly within the EU.

Although the Mediterranean has yet to reach such levels, the recent overproduction of farmed salmon in northern countries and the resultant drop in prices has also shown the dangers of oversupply as fish farms are forced to close.

This booklet analyses the current status of aquaculture in the Mediterranean region, presents the economic issues surrounding its development and examines the impacts of this relatively new activity on the ecologically sensitive coastal wetlands of the region, already under threat from pollution and conversion.

T. Lafranchis / Bios

The historical importance of fishing is graphically illustrated in the Mediterranean cultural heritage. Mosaic from the Piazza Armenia, Italy.



M. Gunther / Bios

Aquaculture: past and present

What is aquaculture? "It is the culturing of aquatic organisms. It uses culturing techniques that aim to boost beyond the natural capacities of the environment the production of fish, crustaceans, shell-fish and aquatic plants, which throughout their period of culture remain the property of the breeder"[1].

Originally aquaculture was practised in lagoons, which offered the following advantages: easy access, shelter from storms, and water that is more productive than seawater. From the 5th century BC there is evidence that the Chinese raised carp *(Cyprinus carpio)* in fresh water. Pliny the Elder tells us that the Romans had mastered the technique of catching seed oysters *(Ostrea edulis)* using wooden barricades. They also fattened morays *(Muraena helena)* and eels *(Anguilla anguilla)* in fish ponds.

In the Middle Ages, aquaculture in the Mediterranean was a mixture of fishing and cultivation. In France, blue mussel *(Mytilus edulis)* culture dates back to the 13th century. In Italy, "valliculture"*, regarded as the precursor of aquaculture, dates back to 1325 when it was practised in the Comacchio "valle"*. In more recent times, the development of intensive aquaculture contributed to the deterioration of a lagoon environment already pushed to its limits by agricultural, industrial and urban waste. It consequently became necessary to move aquaculture to the sea.

Oyster cultivation in the Etang de Thau, France

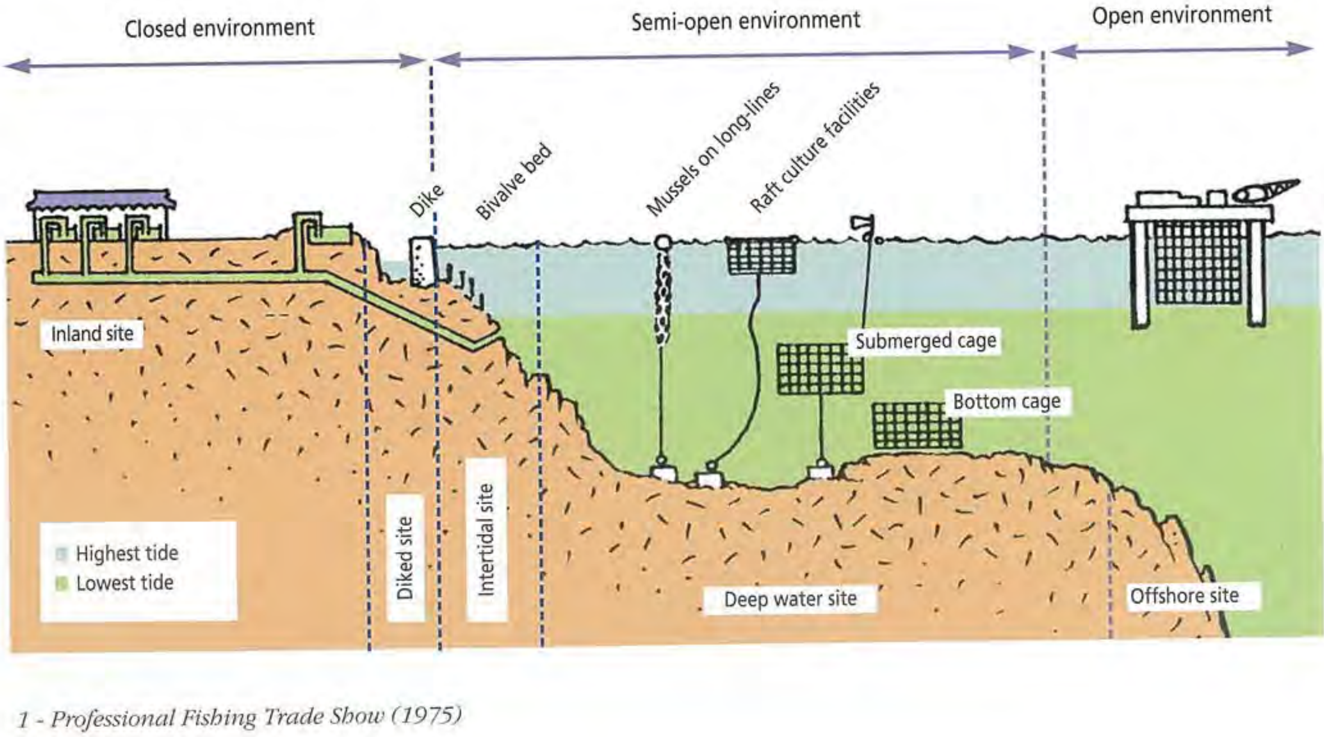
1 - According to the definigion of "Euraqua 92", a conference on aquaculture organised by EEC and inspired by that of the FAO.

However, the culturing of sea fish, molluscs and crustaceans is a recent phenomenon. It was not until the early 1930s that the complete culture of several species from these three groups was developed in the laboratory, and production did not start until the 1970s. At this point, great hopes for the future of aquaculture were voiced: "Fishing cannot be extended indefinitely... to meet the growing demand for seafood... supply from fishing remains limited... The development of aquaculture appears therefore to be inevitable and, by the year 2000, it will have become the only way to meet demand"[1]. Which brings us up to the present – the following overview of aquaculture, both shellfish and fish culture, analyses the current situation.

Aquaculture applies to all sea and fresh-water culture; mariculture* applies to all marine culture. Mollusc culture includes mussel, oyster and clam farming.

General layout of marine aquaculture.

Source: Barnabé (1991)



1 - Professional Fishing Trade Show (1975)

From extensive to intensive

Originally, aquaculture was extensive, being based on the exploitation of waters naturally rich in plankton and organic matter, and taking advantage of natural fish migration. As more knowledge of the animals' cycle was acquired, so aquaculture became semi-intensive or intensive.

Mediterranean mollusc culture: a century of expansion

In Italy shellfish culture is an age-old activity based on oyster culture. Mussel culture developed after the Second World War, particularly in the Venetian lagoons, and replaced oysters. The 1973 cholera epidemic halted production but health measures were taken in 1977. Since 1990, mollusc production has been diversified by the development of clam growing.

Mussel farming in Spain started in Catalonia in the harbour of Tarragona in 1903, followed by Barcelona harbour in 1909. At the same time, the first attempts to breed mussels in France were being made in the Mediterranean in the Sète canals and then, in the Etang de Thau in 1910-11. Whereas oyster culture had been practised in Italy for centuries, in France the first experiments were made in 1855 with floating beds, followed in 1900 by hanging baskets used in the Etang de Thau. In the 1930s, oyster culture developed after dredging destroyed the natural native flat oyster beds. However, these were wiped out in 1950 by an epidemic. The Portugese oyster *(Crassostrea angulata)*, introduced accidentally, took over until it too was affected by an epidemic in 1966, with massive mortalities in 1973. From 1967 it was replaced by imported Japanese oysters *(Crassostrea gigas)* from the Pacific.

From traditional lagoon fishing to extensive aquaculture

Traditional fishing using fish traps (bordigues*) led to the development of extensive aquaculture. It is still practised in Spain, Tunisia, Turkey, Greece, Albania, Egypt, Italy and France.

Despite the recession, there are still a large number of fish traps operating in lagoons in the Mediterranean. These use a system of fish traps (known as "bordigues"*) to capture euryhaline* species which enter the lagoons seasonally, when they return to the sea. The trapped fish are either caught or released into the lagoon to replenish natural stocks*, or are farmed until they reach marketable size.

Modern aquaculture: a biological victory

Modern aquaculture, which originated in Japan, involves controlling the water supply, the biological cycle of the species cultivated and the food supply. A big step forward was made by the introduction in 1960 of rotifers* as a foodstuff. Modern aquaculture dates from the 1970s and mainly focuses on sea fish, such as seabass *(Dicentrarchus labrax)*, seabream*[1] *(Sparus aurata)* and crustaceans. The introduced Japanese prawn *(Penaeus japonicus)* grows faster and is more competitive than the native caramote *(Penaeus kerathurus)* or than the fleshy prawns from the Far East *(Penaeus chinensis)* or the giant striped prawn *(Penaeus monodon)*, which are sensitive to low temperatures.

1 - In the whole document the name seabream refers to the gilt-head seabream (Sparus aurata) except when specified otherwise.

Mediterranean aquaculture: adaptable, profitable species

Although the number of species able to be cultured is growing, few of these promise much in terms of return and therefore do not lend themselves to production. Worldwide, more than two hundred species are being used in aquaculture. In the Mediterranean only a few are well adapted.
These include the following fish: seabream, seabass, sole *(Solea sp)*, turbot *(Psetta maxima)*, mullets *(Chelon labrosus, Liza ramada, Liza aurata, Liza saliens)*, greater amberjacks *(Seriola dumerili)*, European flounder *(Platichthys flesus)*,
eel, common two-banded seabream *(Dipodus vulgaris)* and white seabream *(Dipodus sargus)*.
Amongst the crustaceans cultured, various species of prawn have been tried: the camarote prawn, the Japanese prawn, the giant tiger prawn and the fleshy prawn.
The bivalve shellfish cultured include Mediterranean mussels *(Mytilus galloprovincialis)*, the European flat oyster, the Portuguese cupped oyster, the Pacific cupped oyster, the grooved carpet shell *(Tapes decussatus)*, the Manila clam *(Tapes semidecussatus)*, the carpet shell *(Tapes pullastra)* and the striped venus *(Venus gallina)*.

The seabream is one of the species commonly raised in the Mediterranean.

The process of cultivation and its three main stages

The biological and ecological features of the species as well as method of cultivation and type of site determine choice of species. The only thing that does not change is the cultivation process, which comprises three stages, even though the same aquaculture unit is not always responsible for all three.

The young and how to raise them in captivity

It used to be that the young of the species, or the parent, had to be caught in their natural environment. Scientific advances have meant that there is no longer the same dependence on the biological cycle. Reproduction in captivity now works well with freshwater species. In contrast, only a few marine species will reproduce successfully in hatcheries because their eggs are so small and the larvae are extremely fragile. Obtaining the young of these species remains a major problem.

Genetic engineering and its role in productivity

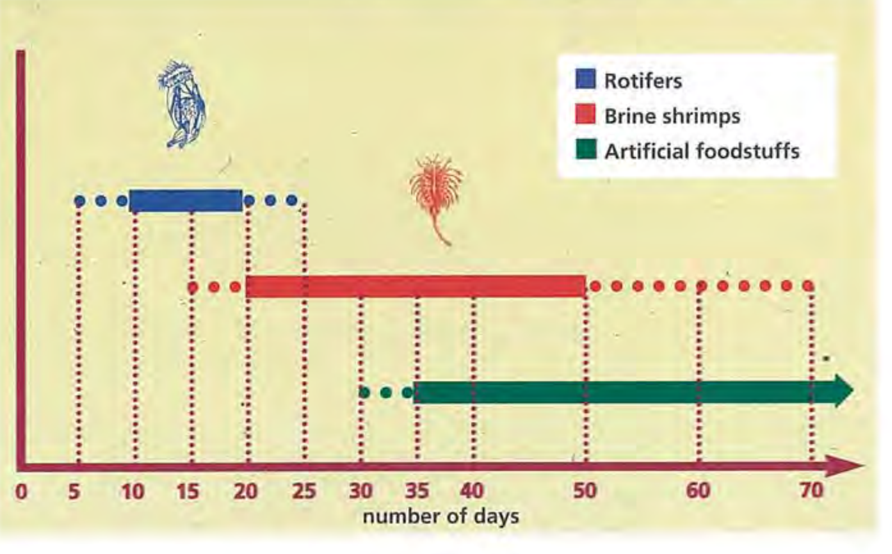
Genetic methods have been developed in recent times to obtain populations of monosexual or sterile fish. In many species sexual dimorphism affects growth rate as well as quality and quantity of flesh. Furthermore, certain species mature before reaching marketable size. Sexual maturity consequently causes a drop in productivity. Monosex culture is therefore a way of increasing and improving production. Another advantage of using sterile or monosex populations is that possible genetic contamination between introduced exotic species and native species is avoided.

The species most affected by such genetic methods are freshwater ones. Amongst seawater fish, monosex female seabass, which fatten faster, may be obtained by the use of steroids.

A new development is genetic transfer to produce fish specimens with phenotypes adapted to aquaculture production. This is a rapidly advancing field, and the use of such transgenic fish should be possible within the next ten years. A considerable number of experiments have been carried out on salmonid fish, carp and bass. Caged fish always manage to escape. At present genetic interaction has only been demonstrated between wild and raised salmonids. Negative impacts include the introduction of genes into wild populations, making them less well adapted to their environment and leading to loss of genetic diversity.

From the nursery to marketable size: pre-fattening and fattening

The larvae are placed in a nursery for the pre-fattening stage, during which the larva develops into a fry. Cellular algae are grown to feed the larvae of molluscs and crustaceans, as are rotifers*. In fact, rotifers play a vital role for, like zooplankton, they provide the older fish and crustacean larvae with living prey.
The next stage of fattening may be carried out in two ways. In extensive culture, the fry are released into their natural environment where they put on weight by hunting living prey. In intensive culture, they remain in the nursery until they reach marketable size. Initially they are fed with brine shrimps* *(Artemia salina)* and other small crustaceans. This is followed by dry or frozen food. Whether weaning from living food to artificial foodstuff succeeds or not depends on the quality of the artificial food and the vitality of the larvae.



The transition from natural food to artificial food during growth in seabass and seabream.

Source : modified from Pinosa et al. (1992)

Maturing: increasing the market value of the product

Maturing involves intervening in the final stages of fattening. Oysters, for example, may be matured by a period in coastal lagoons known in France as "claires"*, where they are fattened up and left to green. In certain circumstances the food indirectly increases the marketable value of the product. This is the case with the salmon family; a diet rich in carotenes gives their flesh the attractive pink colour sought after by the consumer.

Three types of culture for successful fattening


B. Pambour / Bios

The production of phytoplankton is the basis of the food chain.

In production aquaculture, the aquatic medium and primary production are managed, with nothing being added. In transformation aquaculture, the environment is controlled and food provided so that the water is merely the physical support for cultivation. As a consequence of these two approaches, fattening may be carried out in three ways.

Extensive cultivation: for production aquaculture

These use natural trophic* chains, without fertilisation or additional food, usually cover vast distances and have low density of cultivation. Examples of extensive culture in the Mediterranean are mixed rice and fish culture, particularly in Egypt, and valliculture in Italy.
In the salinas of Portugal and the Atlantic coast of Spain and France, extensive shrimp and/or fish cultivation is frequently associated with the salt production facilities.

Semi-intensive culture: partial intervention by man

This involves fattening ponds that are enriched either with manure – fertilisers or residual water – to increase primary productivity, or with food designed for the animals' consumption. It may happen that both types of enrichment be applied simultaneously.
Semi-intensive culture is applied in Egypt and Israel to fish-farming in earth ponds, in fresh or brackish water; or to prawn and saltwater fish cage culture in lagoons.

Intensive culture: the water as support

Densities are high in such types of cultivation and the organisms cultured depend entirely on artificial food and fertilisers, as well as on water being pumped into the cultivation unit, such as concrete ponds.
In the Mediterranean, intensive cultivation produces mainly fish, whether these be varieties that live in fresh water, sea water or brackish water.

An example of intensive aquaculture: cage farming

Although cage culture may be used in ponds, brackish lagoons or in estuaries, as for example is the case with seabass or seabream, cage farming has developed particularly in protected seawater sites such as clean bays, where currents dilute effluents and the temperatures are warmer than in lagoons, where there is a risk of freezing. This type of culture is spreading in Greece, Turkey, former Yugoslavia, Italy, the Côte d'Azur and Corsica in France. Seabream, and seabass cultivation is being practised therefore all round the Mediterranean coast, where the water temperature is suitable, and uses either semi-intensive culture in ponds or intensive culture in floating cages.

Cage farming presents certain disadvantages, notably the small number of favourable sites, the difficulty of treating stock in the event of an epidemic, the need for a boat to reach stock, and vulnerability to any change in the environment and to storms.

On the other hand, cages are not very expensive to buy or maintain; they are also light and enable the volume of stock raised to be changed and increased easily in a natural, open environment.

Under certain conditions (closed bays, high cage density, ponds lacking treatment of wastes) this type of culture may have a negative impact on the environment.

Aquaculture unit in the sea off Ithaca, Greece.

Aquaculture techniques: nature and research

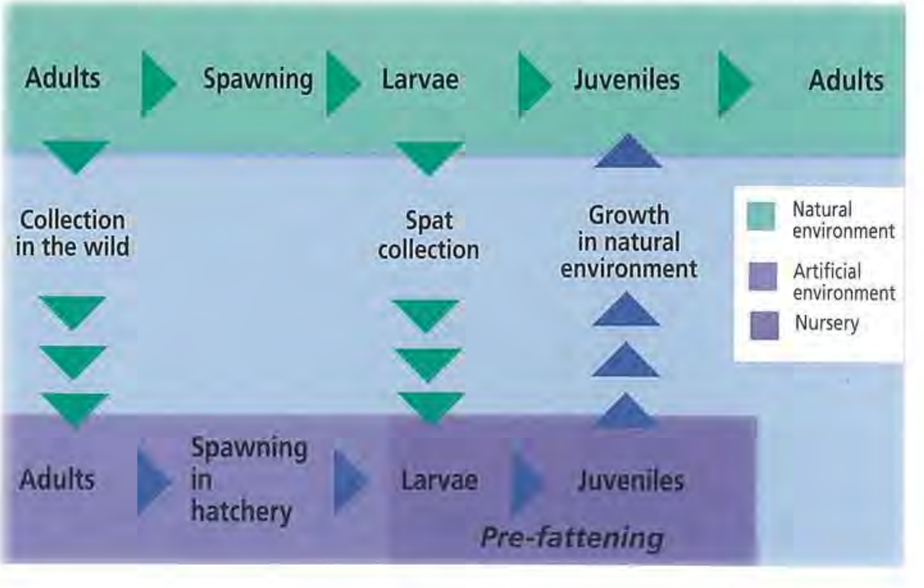
Regardless of species, aquaculture techniques have to take into account factors involving the natural environment as well as others related to research (biology) and technology, without losing sight of the cost/quality ratio.

Mollusc culture depends directly on the natural richness of the environment. Whereas in the past it could only be practised in lagoons, recent developments have made it possible to culture mussels and, on a smaller scale, oysters in the open sea. In this case the shellfish are cultured either on the sea bed or in hanging racks or sacks, or are suspended on ropes; these ropes are made up of a support to which are fastened the containers used for culture, with floats to ensure they do not sink.

Mollusc culture: from lagoons to the open sea

Traditionally, there were various ways of collecting mollusc spat* depending on the type involved. Spat could either be captured directly from the sea or, in the case of mussels, from wild stocks in lagoons. Seed oysters were collected in containers placed in natural sites while young clams were raked up or trapped with nets. Over the past twenty years, however, techniques of controlled reproduction of molluscs have been developed, so young shellfish are available throughout the year from hatcheries where spawning and fertilisation take place. Cultivating larvae and pre-fattening take place in a nursery whereas fattening follows traditional farming methods.

Mussels, for example, are raised either in beds or are suspended from poles or floating rafts, a technique especially used in the French Mediterranean. Oysters have to be detached from the trays they were collected in as seed and then cultured on the sea bottom where the water is deep enough. They may also be suspended. In the Mediterranean, they are hung from flat surfaces or rafts. Young clams are sown and left to fatten in marshes, in ponds created in disused salt marshes or in beds.



Three cultivation methods for molluscs (oysters, mussels and clams). The spat* can either be caught in the wild or come from a hatchery but fattening for sale always takes place in the natural environment.

Prawn culture: controlled spawning

Spawning takes place in the open sea and the traditional way of cultivating prawns was to capture the young as they migrated to the lagoons for food. Modern techniques for cultivating prawns artificially began in Japan. This in part explains why one of the most commonly cultivated species is *Penaeus japonicus*. Today, depending on the species, the spawn may be obtained either by capturing adult prawns ready to spawn or through a technique known as epidunculation*, or by controlled maturing. In the Mediterranean, the practice is to culture the larvae, followed by a period of pre-fattening in tanks, which is completed by semi-intensive culturing in lagoons or intensive culturing in ponds.

Fish: all techniques are used

Fish lend themselves equally well to extensive, semi-intensive (earth ponds, cages) and intensive culture (cages, concrete ponds).
In extensive aquaculture, water is supplied through a system of sluices and channels. But the more intensive the culture, the more difficult it becomes to supply quality water, and systems to pump, filter and regulate temperature have to be employed. In lagoons, the hatcheries and farms rely either on cages made of light fabric (semi-intensive system), or on earth or concrete ponds equipped with a closed-circuit water supply (intensive system). These two systems are sometimes combined. As far as impact on the environment is concerned, ponds win hands down because the water can be reoxygenated and the waste water treated. This is all the more the case now that EU regulations on waste are being applied.

However, ponds are more expensive to build and run and can have a negative environmental impact if they are situated in sensitive areas. This is the case at lake Prespa and at Amvrakikos in Greece. In both cases, the basins are in the heart of important wetlands whose conservation is essential.

Closed or open systems: water filtration

Closed systems are mostly used for freshwater aquaculture and for hatcheries and the pre-fattening units for marine fish. The recycling of water is greater than 90 % and metabolic waste and excess food are eliminated.

Current techniques are being developed that will make cultivation above ground possible. In Italy and France heated water is used in hatcheries and for pre-fattening to boost growth. In open systems, water is only passed through once and the waste, which is untreated, has a high environmental impact. These systems work just as well on land (ponds, raceways*) as in open water (cages).

Valliculture: a Mediterranean aquaculture technique

The northern Adriatic region in Italy has around one hundred "valli" distributed between six wetland complexes. Several of these "valli di pesca" support large population of wintering waterbirds and are registered as internationally important sites under the Ramsar Convention. Valliculture can be considered a model for integrated management of these wetlands and essential for their conservation.

In the past "valli" were open lagoons endowed with fishing rights. Then areas were marked out with reed barriers and were completely diked up so that the fish could not swim out to the sea. At the same time a complex system of dams was built in the channels connecting the lagoon with the sea. Today the "valle da pesca" refer to dammed-up areas within lagoons. They range in size from a few hectares to as many as 200, and contain shallow, brackish water.

Valliculture: a specific type of management

Valliculture[1] makes use of the natural migration of euryhaline fish (eel, seabream, seabass and mullet) between the sea and the estuaries, harbours or lagoons where they grow for a period, the duration of which depends on a number of factors including availability of food, population density, salinity and temperature. Regulating the flow of marine and fresh water, upon which migration and the life of the lagoon depend, means valliculture involves a specific type of management. The availability of fresh water is vital to the raising of fish, both to regulate temperature and salinity, and for recycling the water. The annual management cycle of the "valli" begins in spring when the fry enter ponds where they are kept until they are large enough. The food naturally available is sometimes supplemented artificially. Once they are fully grown, the fish are captured for sale or for wintering; this takes place in autumn-winter using fish traps and various types of net.

T. Salathé

Old installations for catching fish in the "valle" di Cannevié, Pô delta, Italy

1 - The term "valliculture" is often wrongly used to apply to any type of lagoon aquaculture.

A tradition under threat

Although there are still a hundred or so companies operating, valliculture has seen a progressive decline in the number of "valli" as the land has been drained to make way for agriculture. Between 1872 and 1975 the "valli" of Comacchio were reduced from 42,575 hectares to 9,600 hectares. Yields per surface unit have also fallen. This is the case with the "valli" of Orbetello where reduced production and increased management costs also aggravate the situation. It is not unusual for fry restocking to represent 50 % of costs, with artificial foodstuffs, energy consumption and salaries making up the remainder. Artificial fry production is far from adequate and all "valli" restock their farms using fish removed from the natural environment. Furthermore, over the past thirty years the increase in pollution, dystrophic* crises and the deterioration of the environment has undermined this activity, which is highly dependent on the quality of its environment.

M. Presini / Panda photo / Bios

Eels are stored alive in large perforated vessels. Fattened eels are one of the principal products of valliculture. "Valle" de Comacchio, Italy

A case study[1] carried out in 1989 looked at six areas of valliculture in the area around Venice. Average yield was 138.8 kilogrammes per hectare, broken down as follows: 7.5 % seabass, 5.3 % seabream, 2.2 % eels and 85 % mullet. Gross annual income from aquaculture in these areas was a little under zero. However, the profits made from associated activities such as agriculture in two areas and waterfowl hunting in all six ensures the future of valliculture in this region.

Aquaculture units in the "valle" of Orbetello, Italy.

1 - Donati et al (1992)

Various types of culture

Aquaculture products are used for various purposes: human and animal food, restocking, game fishing and keeping fish as a hobby, or supplying laboratories.

Mediterranean aquaculture covers all types of culture, from those that have been practised since Antiquity to those that are the result of the most recent research, whether this draws on empirical methods or the most advanced techniques.

Rice-cum-fish culture : a Chinese tradition

Raising fish in rice fields was practised in China 2000 years ago and in India 1500 years ago and is still widely spread in Asia. It is also an old practice in Egypt. It was introduced to Italy in the mid-19th century but the practice died out in the 1950s.

Salt marshes for prawns

When salt production is no longer a profitable activity, salt marshes may be reconverted for aquaculture. Extensive aquaculture and semi-intensive raising of prawns are being practised in disused salt marshes along the coasts of France, Spain and Portugal. Other still operative salt pans in the South of France are also being used to grow brine shrimp to supply intensive aquaculture.

D. Simeonidis / Bios

Palaemon serratus **is one of the species raised in the Mediterranean, particularly in Spain.**

"Lagooning": the perfect recipe for carp

In the Mediterranean region, treated domestic waste water is being used for aquaculture purposes. It has two major applications. Firstly, because it is so rich in plankton, it can be marketed as a foodstuff for larvae and fry. Secondly, waste water may be directly used to raise carp. However, one study[1] pointed out that the market for such fish may not be all that profitable because of reluctance on the part of the consumer and the fact that the very countries interested in buying the product, those in Northern and Eastern Europe, are themselves producers.

Polyculture: a little bit of everything

This is practised semi-intensively in Egypt with seabream and mullet, and in Israel with mullet and tilapias (*Tilapia* sp.) raised in ponds. Some systems combine cage culture with mollusc farming, or mix intensive culture using raceways* with semi-intensive pond culture.

Lagoon aquaculture: few suitable sites

Not all lagoons lend themselves to aquaculture activities. Moreover, the choice of species and techniques as well as yield and environmental impact are a function of the structure of the lagoon. Several key factors are involved, including water quality and temperature, the time taken for the environment to re-oxygenate and renew its marine elements, depth, salinity, grain size of the sediment, currents or even natural risks. With these factors in mind a study[2] of thirty-two lagoons in six different Mediterranean countries showed that only seven or eight of these were suitable for intensive cage culture and/or mollusc culture, while only three could be used for clam culture.
The other sites would only lend themselves to extensive fish and/or prawn culture.

1 - Guerrin (1990)
2 - Crivelli et Ximenès (1992)

Mollusc culture in the open sea on the increase

Experiments with mollusc culture in the open sea in the French Mediterranean were undertaken by mollusc farmers from the Etang de Thau in the late 1970s. Currently, there are four active production areas on the Languedoc coast: Gruissan, Vendres, Palavas and Marseillan-Sète. They grow mussels on suspended ropes and oysters on racks or rafts. These four areas cover 4,000 hectares and have led to the creation of huge plots. Each plot corresponds to a group of offshore concessions situated between isobath* 20 m and the three mile limit, or generally the 30 m isobath. Those concessions are connected to land-based facilities.

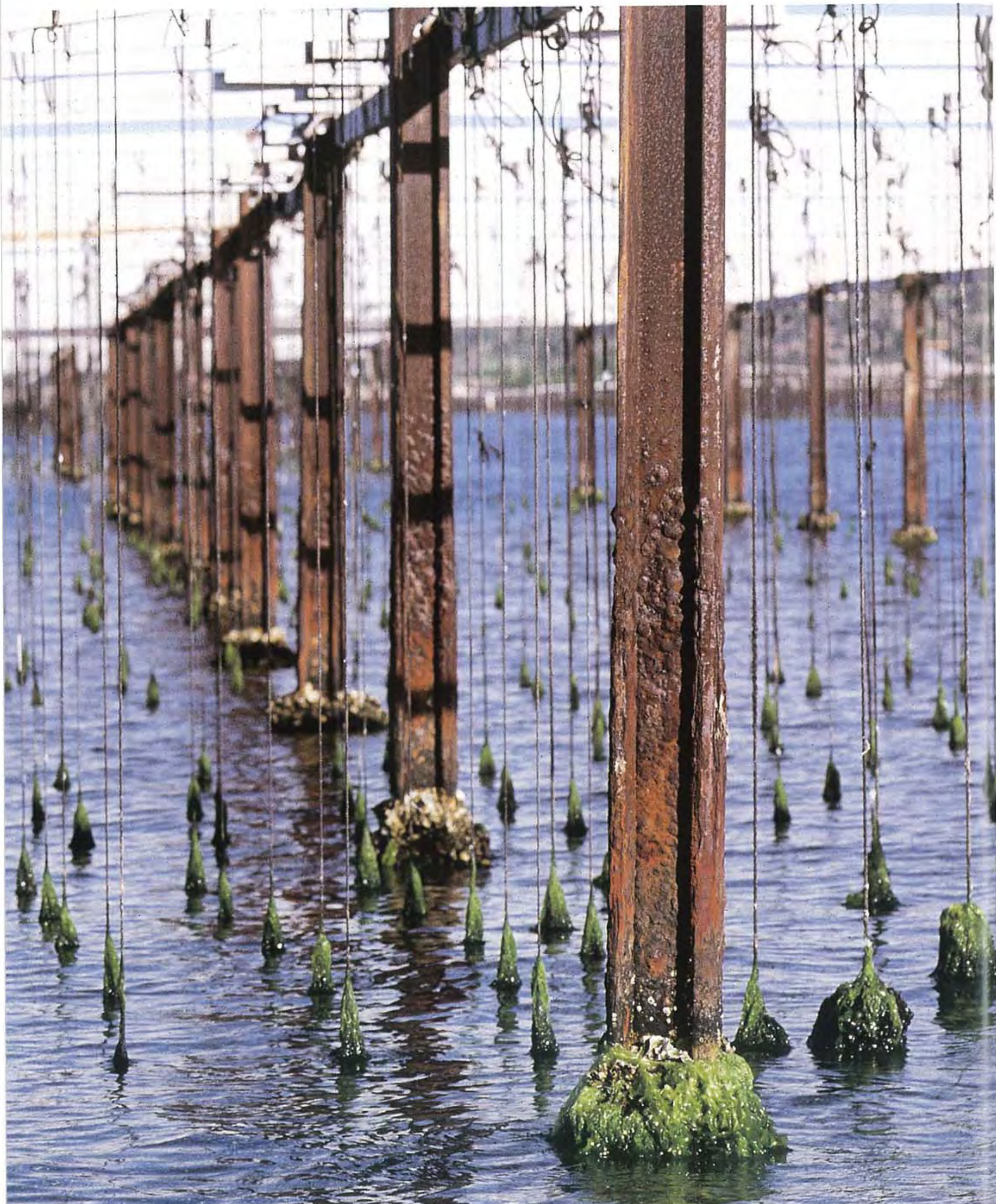
Since 1988 a ruling worked out with professionals of the industry attempts to define the rules for allocating concessions and reserving sites.

The production of open-sea mussels looks very promising, with between 20 and 40 tonnes per line. Between 1987 and 1991, mussel production rose from 1,500 tonnes to nearly 10,000 tonnes, generating a turnover of approximately 13 million US $ and nearly three hundred jobs. It is responsible for the 3 % annual increase in mollusc tonnage in the French Mediterranean.

While it is true that the open-sea mussel is sold at a slightly lower price than the lagoon mussel, it does have the advantage of being in season between March and November, a time when there are no other mussels on the market.

J.P. Quignard

Sheltered bays are suitable for marine mollusc culture. Kotor, Montenegro.



Aquaculture and the environment

Like many of man's activities, aquaculture is in constant interaction with its environment. In the long term the interests of aquaculturists and environmentalists find a common theme in maintaining the water quality, essential for the natural ecosystem and for an economically successful aquaculture operation.

The "Habitat" Directive[1] of the European Commission listed lagoons as ecosystems of Community importance, requiring member states to take action to ensure their long term conservation and to develop management plans to manage and, where necessary, control human activities in these sensitive areas. This gives rise to questions on environmental impacts of aquaculture and inevitably leads to an attempt to define the carrying capacity of different lagoon systems – how much aquaculture and of what type is compatible with ecosystem conservation ?

Mussel cultivation, Etang de Thau, France.

1 - Council directive 92/43/EEC of 21/05/92

Most environmental information on aquaculture is concerned with the repercussions of salmonids (12 %), carp (20 %) and shellfish (20 %) on the environment. Only about 1 % of publications mention marine species such as mullet, bass, bream and turbot, with 4 % on eels and 6,5 % on prawns.

Aquaculturists are also motivated by a desire to improve the product brand image, and by willingness to preserve the quality of the environment in which cultivation is practised. Aquaculturists are increasingly sensitive to pollution and deterioration of the environment, especially that caused by their own activities.

A study[1] carried out in 1992 by the European Union drew up a list of publications on the theme of the interactions between aquaculture and the environment. Worldwide, 35 % of publications originate within the European Union, 17 % in the United States and 12 % in Canada. Within the European Union, France, Great Britain and Germany top the table with more than 75 % of articles published. There are relatively few publications in the Mediterranean countries: Spain (4.5 %), Italy (3.5 %) and Greece (1 %). This helps to explain why there is so little information on the interrelationship between aquaculture and the Mediterranean environment.

Eutrophication of lagoon ecosystems leads to the proliferation of green algae.

1 - Munday et al. (1992)

Aquaculture: an activity with considerable impact

Aquaculture units have a strong impact on the surrounding environment, in particular because of the physico-chemical changes their effluents cause, as well as by introducing new species. Moreover, such units have substantial visual impact in areas that are rare, fragile or of scenic beauty.

Tidal fluctuations in the Mediterranean are small, reaching a maximum of one metre in the gulf of Gabès (Tunisia). The risks of eutrophication due to excreted wastes from aquaculture installations are therefore considerable. In the Atlantic tidal fluxes generally provide reoxygenation of the water and dilution of waste products.

The stiller the water, the more active the waste

The waste water from aquaculture units is rich in suspended matter, which increases water turbidity. Above a certain level, photosynthesis is affected and this can lead to higher mortalities amongst stock. The impact this has, however, is variable. It depends partly on the characteristics of the aquaculture unit, such as its size, the type of operation, total biomass* and size of the fish cultured, and the feed used. But it also depends on the ability of the water to handle such matter, which in turn depends upon a number of other factors, currents being the most important. Other factors include the depth of water, the climate, water quality, the type of sediment, the density and diversity of the benthos*, the tendency to eutrophication*, and whether there are other activities or occupiers.

The main components of organic effluents are organic carbon, ammonia and phosphates. These enrich the water and so stimulate primary production. This influences the composition of the phytoplankton and favours the occurrence of algal blooms*. These are somewhat undesirable for they are often toxic, an example being the diatoms that produce branchial irritations in fish. Such waste also alters the sediment. It raises the levels of chemical compounds, including organic carbon, silicates, and organic and inorganic nitrogen. Furthermore, it causes a change in the distribution of bacterial species. In cage farming, for example, anaerobic bacteria develop, and their activity in organic deposits produces gases such as methane, carbon dioxide and toxic hydrogen sulphide.

Moreover, as bacterial decomposition increases so the sediment consumes more oxygen; since cultivated organisms are drawing off dissolved oxygen simultaneously, de-oxygenation of the water occurs and this may lead to deaths among the species cultured.

Lagoon eutrophication: a disturbing situation in the Mediterranean

Lagoons occupy a surface area of between 600,000 and 700,000 hectares in the Mediterranean basin. Their waters are enriched by nutrients carried there by currents and by the deliberate release of domestic waste water from the villages on their shores (Tunisia, the Nile delta, Sardinia) in an effort to increase fishing yields. While these fragile environments managed to sustain a balance in the past, drainage and development, as well as the recent and considerable amounts of urban, industrial and agricultural waste, seriously affect them today.

An overabundance of nutrients in an environment whose productivity is naturally high has negative consequences such as a reduction in numbers of phanerogams*, and increased biomass of algae resulting in eutrophication of the environment.

In the south of France, there is even a word, "malaïgue"*, for situations such as this where high summer temperatures, lack of wind and an excess of nutrients lead to lack of, or even complete absence of oxygen in the water. This results in proliferation of sulphate-reducing bacterial species, which release hydrogen sulphide, followed by the development of photosynthetic bacteria. The water becomes cloudy and turns red, white or brown. Huge mortalities occur amongst the natural population and amongst cultured species.

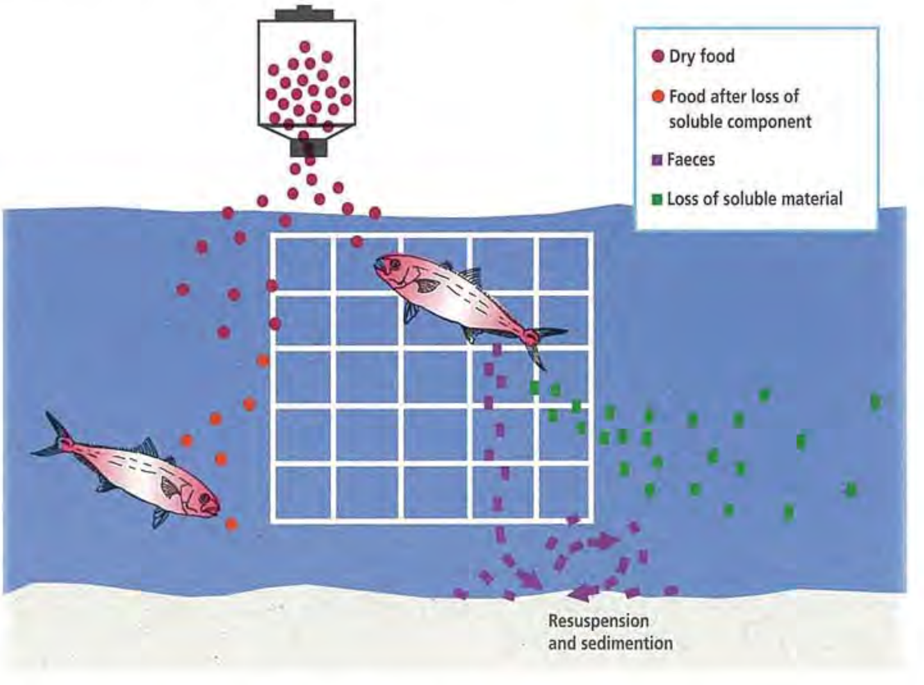
Aquaculture is not unconnected with the increase in frequency of "malaïgues". In the bays of Fangar and Alfaces in the Ebro delta, mussel production soared in the space of ten years, from 0 to 8,000 tonnes per annum (in 1988). But, development of the delta, conflicting claims on water use and the issuing of too many licences to culture, without any account being taken of production capacity and without market studies being carried, led to a downturn in production. The 8,000 tonnes did not sell, part of the stock died as a result of eutrophication and companies partially closed down.

Overproduction is therefore both damaging to the environment and to wild and cultivated populations. The following years production (3,000 tonnes in 1992) would seem to be nearer the carrying capacity of the ecosystem.

An assortment of chemicals and antibiotics

Aquaculture units also release disinfectants, pesticides, fertilisers, antibiotics, hormones, vitamins and anaesthetics from the distributed foodstuff. Because these feedstuffs are not consumed in their entirety, particularly in the case of cage culture, the insoluble part drops to the sea bottom. Of the portion swallowed by the fish, part of these substances is excreted directly and is concentrated in the sediment where it remains for many years to create resistant layers.

Biocides used to control parasites also kill other organisms, as do chemicals used for controlling algal growth. The waste from intensive systems (faeces, food, urine...) can cause local changes to biodiversity, principally through loss of habitat diversity.



The fate of dry foodstuffs fed to caged fish.

A new concept: the carrying capacity

Over the last few years a new concept has developed, which takes into account the environment's carrying capacity. It is based on the hypothesis that the environment has a limited, calculable capacity for assimilating waste without affecting resources and their uses.
A study[1] on a fish farm in the bay of Ajaccio (France) showed that its main impact was on the Posidonia seagrasses *(Posidonia oceanica)*, which grew less densely under the cages. One of the reasons for this is the wealth of epiphytes more abundant in this situation, so making them more attractive to grazing fish such as salemas *(Sarpa salpa)*. On the other hand, the wastes that fall from the cages attract wild species, which encourages fishing and restricts the deposits of chemicals on the sea bottom.

1 - Verneau et al. (1994)

Biodeposition in the Etang de Thau : the fight is on

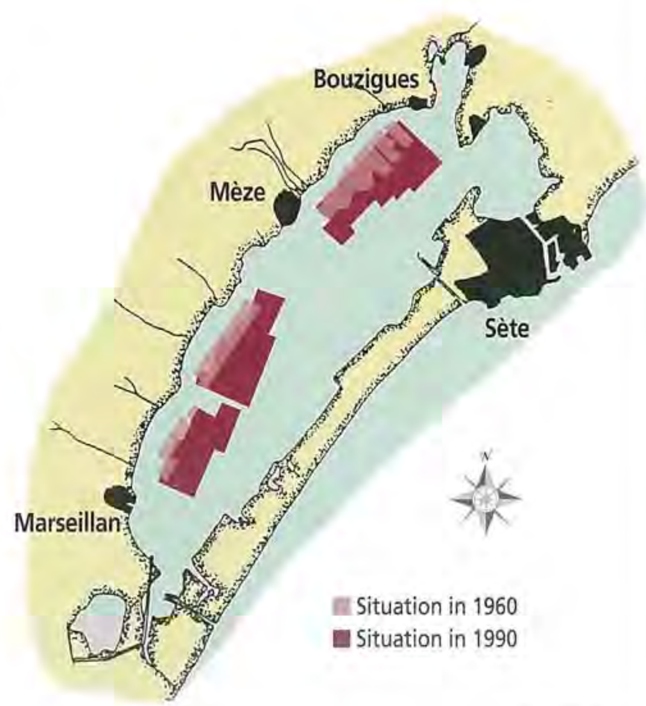
The Etang de Thau, extending over 7,500 hectares at a depth of 4 metres, accomodates mussel farms (around 9,000 t in 1990), oyster farms (some 25,000 t in 1990) and other aquaculture activities (25 t of seabass in cages in 1990). In 1990, 1,324 hectares were dedicated to molluc culture, with 2,816 racks covering 352 hectares.

The molluscs filter the water and retain dissolved organic substances, oxygen and suspended matter. This matter, mixed with mucus filaments, forms pseudofaeces, which sediment on the bottom, creating biodeposits. Bacterial action releases nutrients from these biodeposits making them available for primary production, and wave action may resuspend the sediments providing food for the molluscs above. These anoxic biodeposits on the mollusc-growing surfaces amount to between 40,000 and 50,000 tonnes in dry weight. They accumulate under the mollusc platforms reducing the depth of the water and cause a drop in diversity and density of benthal* species. Worms of the class *Polychaeta* (ragworms, lugworms), good indicators of pollution, have developed as have *Zostera* seagrasses, which point to the organic richness of the environment. Consumption of phytoplankton around the mollusc-growing racks also reduces oxygen concentrations.

The quality of the water depends upon management of the water source and upon climatic conditions, as only one channel continues to provide water from the sea. In calm weather, the lagoon is stagnant and oxygen declines, making the risk of "malaïgues" high. This situation occurred in 1975, 1982, 1983 and 1987, with mortality as high as 70 % of the stock in 1975.

Proposals for cleaning up the lagoon include pumping sea water into the lagoon, creating another channel, control of run-off from the catchment... However, opinions differ and these proposals have stirred up controversy.

In November 1990, a five-year contract for the Etang de Thau was signed to increase understanding of the pollution process, improve water quality and update mollusc culture. Costing 36 million US $, it is financed by the European Union, the local water authority and the regional authorities. It must be said that the economic importance of the site, rather than the ecological balance, led to the establishment of this rescue plan.



High quality water is required for aquaculture

While aquaculture activities generate pollution, they are also at the mercy of environmental deterioration. Any type of contamination, whether from germs or from chemicals, causes mortalities or makes the animals unfit for consumption. Top quality water is therefore essential.

Bodies such as the I.C.E.S.*, have suggested global, integrated sanitary management of farms, taking into account both the quality of the environment and the eco-physiological needs of the species raised: production of healthy fry, veterinary checks, use of suitable foodstuffs, notification of known illnesses, advice to aquaculturists on disinfection techniques in the event of an epidemic, setting up of integrated, computerised follow-up so that at any time the general health of the culture may be compared with standard data.

When water stresses fish

Water quality has a direct influence on fish. Variations in the water cause stress in fish and this may lead to delayed growth and may affect their resistance. Studies[1] of wild fish populations have shown that parasites are more likely to proliferate in lagoon water than in sea water, while intensive monoculture offers almost ideal conditions for the appearance of new diseases and the persistence of existing illnesses. Blooms of cyanobacteria*, which commonly occur in culture, may lead to massive mortalities or make the fish taste muddy.
Water also has an indirect influence. The nutritional quality and healthiness of artificial feedstuffs is vital for, if the fish is not in top condition, it will have low resistance to impaired conditions in the environment, and to stress, and its growth may slow down. Most foodstuffs are in fact based on dehydrated fish and fish oils. If the fish used to manufacture these products are highly contaminated with micropollutants and organochlorine compounds, there will be repercussions on the organisms cultivated.

Trends in areas occupied by mollusc culture (1960-1990). Etang de Thau, France.

Source : Manaud *et al.*, (1992)

1 - Maillart et al. (1980)

Water under strict surveillance

Because they are sedentary, bivalves are at the mercy of the slightest deterioration in the environment, and this can lead to a downturn in productivity or to massive losses. As they filter the water, molluscs accumulate pathogenic agents in their bodies, which remain for the most part alive. Since they are often eaten raw, molluscs may be the source of bacterial infections, including cholera and typhoid. Contamination may also be caused by pollution from pesticides, detergents and organometallic compounds. These pollutants either fix onto the animal tissue, a phenomenon referred to as bioaccumulation, or accumulate in the food chain, which is known as biomagnification.

Algae may also be toxic. Some forms of phytoplankton secrete a biotoxin that causes diseases including D.S.P. (Diarrhetic Shellfish Poisoning) and P.S.P. (Paralytic Shellfish Poisoning). The most common toxic algae are the *Dinophysis*, which contain a diarrhetic toxin. When shellfish eat these toxins they poison their predators, whether animal or human. *Dinophysis* blooms are occurring more and more frequently, probably because of being disseminated by the hulls and anchors of boats as well as by the water transported as ballast. In France, *Dinophysis* was first reported in the English Channel, but in 1987 it was found for the first time in the Mediterranean. Similarly, in 1988, *Alexandrium minutum*, which is responsible for paralytic shellfish poisoning, appeared in Brittany and, since 1990, has been found in the Mediterranean.

Preventative measures have been set up in the producing countries; these include purification with successive baths, and disinfection, especially for shellfish that are eaten raw. In France, the standards of cleanliness required for waters for mollusc culture are much stricter than those for bathing, and IFREMER* has set up three networks, one to check the quality of the marine environment, one to check phytoplankton and one for microbiological surveillance. The trend however is to explore cleansing mechanisms for shellfish. so as to minimise losses made by producers.

Aquaculture and wild species: dynamic interactions

Interactions between aquaculture and wild animal and plant species are many and sometimes hazardous. Aquaculture units attract wild species while cultivated species may escape into the natural environment.

When wild species are attracted by the farms

B. Pambour / Bios

The culture of introduced species is especially common for freshwater species such as the American black bass *(Micropterus salmoïdes)*.

Many species of wild fish are attracted by aquaculture units. They come to feed on rejected foodstuffs. Furthermore, the accumulation of shells, the presence of cages and other structures encourage colonising by a variety of organisms and plants, as well as the fixing of an epifauna*. Predators other than the usual marine types, such as birds, rodents and snakes, are also attracted by fish and shellfish farms. A study[1] carried out in Spain showed that mussel culture had brought about changes in the diet of the swimming crab *(Liocarcinus arcuatus)*, which started to feed on mussels.

Such behaviour is favourable to the propagation of infectious or parasitic diseases. It has also been known for wild species to contaminate the farms. This happened in the Mediterranean where the crustacean (isopod) *Nerocila orbignyi*, a parasite of mullet under natural conditions, was transmitted to seabass in fish farms off Corsica (France). However, if aquaculture installations attract some species, they also repel others due to increased noise levels, disturbance and traffic, and therefore have a substantial influence on wild animals.

The use of fish meal to make food pellets raises another problem. In the Atlantic natural fish stocks are already over-exploited to provide food for farmed salmon. The direct impacts are obvious, those on wild predators which no longer find their natural prey are less obvious. Research is currently underway to identify other potential protein sources for fish pellets.

The dangerous roads to freedom

When cultured species escape into the natural environment, they may also transmit to the natural populations diseases previously unknown to these species, but which are common in culture, especially intensive culture. Furthermore, even where the species raised are indigenous, there is still risk of loss of genetic identity, or danger of competition with the wild populations. In 1988, around 1,2 million salmon escaped from Norwegian fish farms. This is equivalent to the annual catch of wild salmon for the whole country.

1 - Fernandez et al. (1991)

The capture of wild fry: another way to run down stocks

Although there are bans in many countries aimed at preservation of wild stocks of those fish already affected by overfishing, and despite the recent development of hatcheries, many Mediterranean aquaculture activities still depend on the capture of fry in the wild.

A F.A.O*.[1] report in 1989 showed that collecting seed-oyster in the wild was so well organised that the two French artificial hatcheries had problems keeping going! In the past, valliculture relied entirely on the natural input of fry. When wild fry became rare, partly because of pressure from fishing, the fry captured at sea or in the estuaries were placed in ponds to be raised.

Today all the "valle da pesca" in the Northern Adriatic practise fry culture using wild fry fished in Italy and other Mediterranean countries: Spain, Turkey and Tunisia. Increase in surface areas operated and the recent installation of a number of fattening units have increased demand for fry. Attempts to increase the numbers of fry caught at sea have failed to satisfy demand from the "valli". The dependence of marine aquaculture on the collection of wild fry stops it from developing further.

Current experiments are looking at ways to improve artificial reproduction but the problem has yet to be solved. On the one hand, there is overproduction of seabream fry in the Mediterranean (currently about 30 million are produced a year in hatcheries) and the price they now fetch has dropped by half.

Ph. Garguil / Bios

Eel fry or "elver".

On the other, many aquaculturists are critical of the inconsistent quality of hatchery fry. Furthermore, imports to countries in the European Union of hatchery fry produced in non-member countries is expensive because of import taxes. Finally, mullet and eel culture continue to rely entirely on the capture of wild fry. Other non-target species are affected by this activity – it is estimated that 10 kg of larvae of non-commercial species are thrown away for every 1 kg of post-larval shrimps caught.

The Spanish pluri-annual economic plan emphasises that hatcheries should be developed to remedy two of the problems associated with aquaculture, namely supply of fry and pillage of natural banks of shellfish. But, simultaneously, it proposes increasing on a national scale the capture of fry in the wild for species that cannot yet be reproduced artificially or where this method does not supply enough fry ! The system adopted in Turkey seems more appropriate. The government only authorises the capture of fry in the wild for the first two years of an aquaculture farm's operations. After that time, it must meet its own needs by setting up a hatchery. However, it is difficult to ensure that producers respect existing legislation.

1 - Girin (1989)

The introduction of species is on the increase

Up to now, the introduction of species mainly focused on freshwater environments. The introduction of marine species is recent and it is not always possible to assess their success or impact. The best-known example is that of the Manila clam, which adapted well after it was introduced to Italy and production of which is booming. It is very resistant and is developing in the wild in the Adriatic at the expense of the native European clam. Some are of the opinion, however, that this introduction saved the European clam, which up to then had been overexploited, from extinction. Of marine fish, the only species imported to the Mediterranean (also in Italy) is the silver seabream *(Chrysophris major)*, whose market presence makes it a strong competitor with the native seabream.

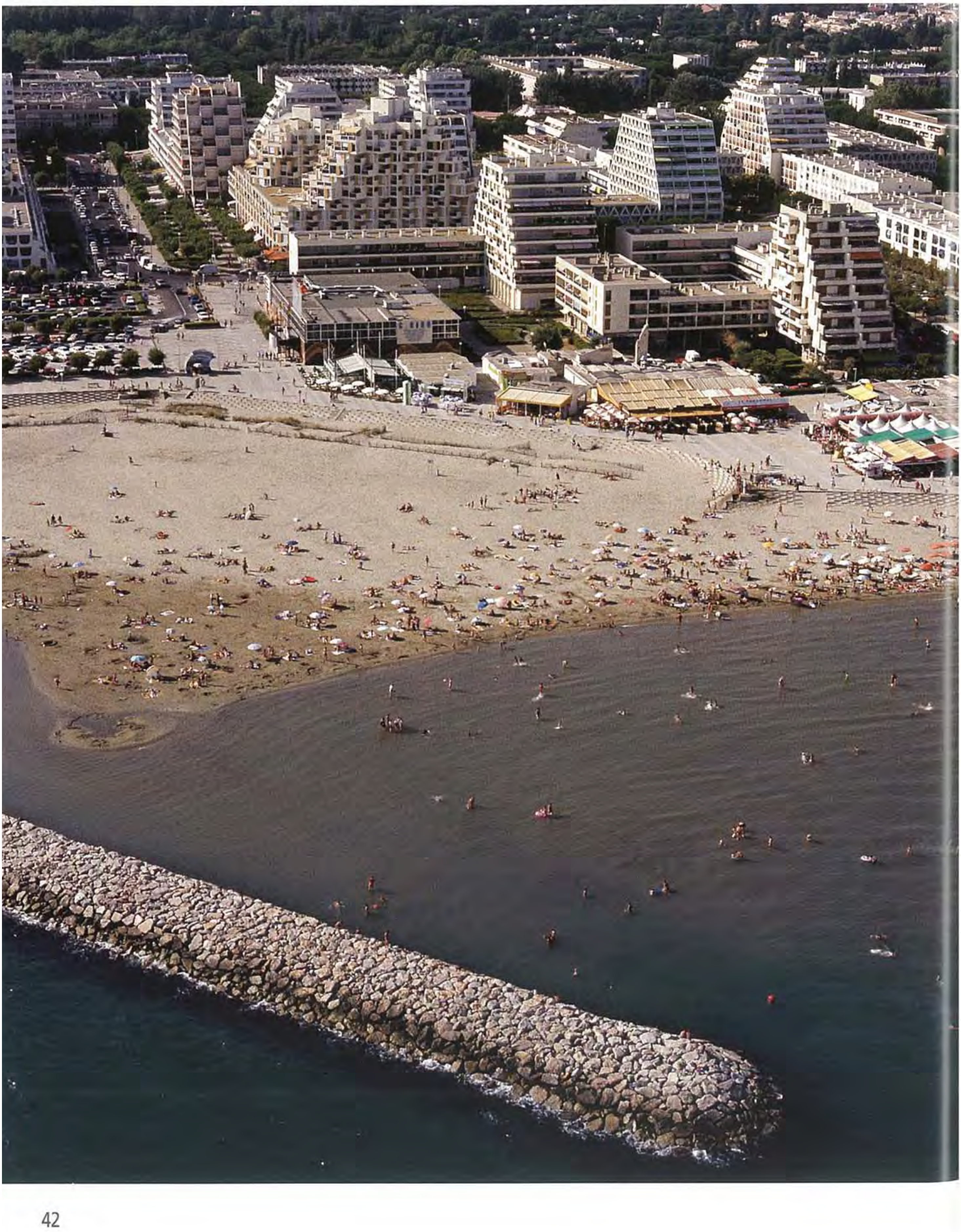
Recently, a study[1] pointed to a change in the motives for introducing freshwater species. In the 1950s aquaculture accounted for only 41 % of the motives, the others being sport fishing, restocking of lakes and rivers, ornament and accidents. In the 1980s, aquaculture represented 68 % of the total. The aim is, firstly to obtain species that are better adapted to culture in captivity, that are more resistant to disease and with a higher commercial value or more rapid growth. Secondly, there is an attempt to use as yet unexploited resources. The species is very often imported along with its culture technology so that production may follow quickly.

Aquaculture of exotic species presents different risks, of which escape of cultured animals into the wild and ensuing competition with, and possible elimination of, native species is not the least. Contamination of wild species with diseases and parasites previously unknown to them is also a major danger. This occured when Japanese *(Anguilla japonica)* and short-finned eels *(Anguilla australis)* affected by nematode parasites were imported to Europe and led to the contamination of European eels. High mortalities occurred in eel farms, and wild eels seemed to have problems returning to the spawning grounds in the Sargasso sea because of the after-effects of the disease (angulosis*). As far as shellfish are concerned, many plants and invertebrates were imported to the Mediterranean at the same time as the Japanese oyster. No less than 9 species of exotic algae are thriving in the Etang de Thau on oyster lines. The introduction of this bivalve is now considered to be a possible cause of the local elimination of the Portuguese and the European flat oyster.

A number of countries have taken steps to ensure that the introduction of exotic species for aquaculture purposes does not go hand in hand with the introduction of diseases, parasites or epifauna. The success of such controls are rather limited, most especially because they do not apply to all Mediterranean countries.

Another risk is hybridisation with native species. There are many examples in Northern Europe of loss of the genetic heritage as a result of escaped cultured salmon. The long term consequence of species introductions are always difficult to predict and even to demonstrate. The precautionary principle demands that this practice should be banned.

1 - Welcomme (1992)



Coastal wetlands under pressure

The Mediterranean coast is the focal point for a number of activities that are often at variance or in direct competition with each other. For it is an area of dense and not always controlled urbanisation, and is the arena for a whole range of economic activities, in particular tourism. The Mediterranean basin is the leading tourist destination worldwide.

These activities, whose requirements often conflict with one another, "gobble up" what is a limited amount of space. The coastal area is also, through the rivers and streams, the catchment basin for waste water from towns, industry and agriculture. These factors are particularly pertinent to the coastal wetlands, which are exceptionally fragile, precious areas that are vital to the survival of many animal and bird species, including migratory birds. Recently, protection of landscapes and natural habitats has come into play, but in an increasingly interventionist manner.

Construction along the narrow coastal belt of the Mediterranean has been rapid since the 1970s.

In France, fishermen and mollusc farmers negotiate with the authorities to maintain their rights to retain or extend their fishing activities or marine culture. Because of the increasing difficulties encountered in traditional activities, fishermen sometimes request the granting of maritime concessions to develop a complementary culture activity.

Aquaculture, with its special requirements, its advantages and disadvantages, generates conflicts of interest, particularly where aquaculture farms are close to densely populated coastal towns, areas of leisure activity or protected nature reserves. This is particularly the case because it is a rapidly expanding activity. Before an aquaculture unit can be set up, it has then to be compatible with the specialised activities already in place and their future, and to comply with a policy of integrated management of competing activities, notably tourism, which brings in foreign currencies. The aim then is to be accepted by the local communities, the nature protection organisations and the socio-professional categories already existing, and ideally to be covered by clearly defined governmental policies.

Aquaculture is practised on various levels, from the small, family-owned pond fish farm to the aquaculture megafarm owned by a multinational, with a fully integrated production and marketing chain. It attracts newcomers with no previous experience of the fishing sector, and new technologies, applied in intensive aquaculture on a large scale, are introduced.

To support their claims in the face of strong competition, professional fishing and aquaculture organisations focus on one or other facettes of their activities, such as non-disturbance of the environment, integration with other activities on the site, the economic value of the activity or the cultural priority of professional fishing over leisure activities.

Fixed nets in lagoons are traditionally used to catch eels and mullets.

Aquaculture and fishing: an age-old clash

Fishing is based on harvesting from a natural environment whereas aquaculture generates selected products. The competition between these two activities, which in the mind of the public and decision-makers are often associated, is strong. It goes back to the age-old opposition between nomadic hunters and sedentary farmers.

Competition for sites

A competitive context occurs when the concessions granted to aquaculturists encroach on fishing zones.

Small-scale fishing is very sensitive to any inroads made on its territory, which is often in inshore waters. Marine culture for its part is dependent on specific sites (e.g. coastal lagoons and sheltered bays).
Since 1986 in France the allocation of aquaculture concessions have involved consultation between fishermen and aquaculturists. The fishermen in the Etang de Thau for example demanded the granting of maritime concessions to compensate them for the loss of fishing zones caused by mollusc farms being introduced to the lagoon. In other cases, fishermen have accepted as compensation the fact that cage culture attracts large numbers of wild species.

Competition for resources

Such competition is explained by the fact that both professions draw on the same stock. Aquaculturists reproach fishermen for overworking the stocks of parent fish, whose spawn could be used to build up a "reserve" of fry for the fish farms. In addition, aquaculturists now supply the market with high-value fish which were previously only caught by fishermen. The resulting drop in prices has disenchanted professional fishermen. Sometimes however competition turns into cooperation, with fishermen providing aquaculturists with fry and shellfish larvae, or catching prawns in lagoons stocked with hatchery-reared post-larvae. Such cooperation however is the exception rather than the rule.

Competition for subsidies

The distribution of subsidies is another source of conflict. Aquaculture receives considerable investments as a result of advertising and hopes of high production and profits. Since fishermen do not receive a share of this capital, they feel left out.

The Mediterranean fishery has become increasingly industrialised over recent decades.

Aquaculture, a solution to the decline of fisheries ?

Some people see aquaculture as a solution to over-fishing and wastage (non-marketable species represent 50 % of the catch in the gulf of Tunis and 60 % in Sicily). They consider it a way of restocking and ensuring better returns from lagoon systems. Others argue that aquaculture remains a complement to fishing, and is a less economical activity. This is why aquaculture is focusing on new products or ones with high added value. On balance, it may be said that aquaculture stabilises a market that would sometimes be very irregular if it relied on fishing alone. For a long time the development of aquaculture was based solely on immediate economic benefits. In future, the industry will have to take account of environmental factors if it is to remain viable, i.e. wise use of ecosystem resources and strict control of waste products. In order to survive, it will require criteria for installation, and appropriate production methods.

Aquaculture: where the economy and culture meet

Within a socio-economic context, aquaculture generates activity, creating jobs and new companies. But it may also be influenced by cultural traditions.

Aquaculture and job creation

Aquaculture plays a socio-economic role when the economy is in crisis, unemployment is high and the standard of living is rather low. This is why many governments have encouraged it, often in fact supporting the retraining of fishermen for aquaculture. The problem however is that although fishing is a skilled profession, the techniques of modern aquaculture are such that it is not an easily accessible profession and the instances of successful conversion are rare.

Aquaculture has led to job creation in northern Spain, and France is now the European country with the most workers in this field. But it is not easy to assess whether aquaculture creates jobs or takes over from other sectors, nor is the extent of its role simple to determine, especially given that seasonal labour is involved. In addition we lack accurate data showing the proportion of fishermen's jobs linked to aquaculture for each Mediterranean country.

Overall, in 1990 only 0.2 % (i.e. 3,611 jobs) of the active population in the French Mediterranean were involved in fishing, and 0.17 % (i.e. 3210 jobs) involved in aquaculture.

Aquaculture sector	Number of jobs
Shellfish culture	3000
Fish farming	185
Others	25

Aquaculture sector	Number of jobs
Traditional aquaculture	94.5%
Modern aquaculture	5.5%

Employment in aquaculture in Mediterranean France (1990/1991)

Source : Dabat et al (1992)

Industry and exports

One of the most significant economic impacts of the aquaculture industry is the development of production for export. Examples of this are salmon farming in Northern Europe and the raising of seabass and seabream in the Southern Mediterranean. It is supported by waves of investment and the development of fish farms. Such a focus favours intensive culture with operating costs that are too high for countries with low purchasing power. This means that products are exclusively for export and self-sufficiency in terms of foodstuffs is not a consideration. Unlike transformation aquaculture, however, production aquaculture may well contribute to self-sufficiency when only natural resources are used. It has to be said though that extensive aquaculture does not very often show good returns.

New products are also appearing and improvements have been made in terms of both quality and quantity. Certain products, such as seabass, have dropped in price over the last few years and, combined with overproduction and competition between producers, such downturns in price may threaten the viability of the activity in the Mediterranean.

The weight of tradition

Aquaculture also makes a socio-cultural impact. Broadly speaking, the developing Mediterranean countries tend to produce expensive species for export to countries north of the Mediterranean. It provides for industrialised countries species of high marketable value that are not fished in sufficient quantities. The demand in the richer countries is even more selective, in that products must have certain nutritional characteristics, in particular low calorific value.

Religious practices also influence consumption and encourage the culture of certain fish species. For example, the demand for large eels increases in Italy at Christmas time. The same phenomenon occurs in Israel where fish farming focuses very much on local consumption, with only tentative dabbles in crustacean culture.

Competition with other activities

Over the last few decades, the Mediterranean coast has seen the development of dense urbanisation and economic activities that negatively affect the environment. Aquaculture will only develop if it remains compatible with other activities and with nature conservation.

Aquaculture and agriculture: space and water

Traditional mediterranean aquaculture sometimes uses the runoff from agriculture (waste waters, fertilizers...) but most of the time these two activities compete for space and freshwater. Furthermore, aquaculturists complain about pollution caused by the pesticides used in agriculture, whilst agriculturalists accuse aquaculture of increasing the salinity and acidity of adjacent farmland.

Aquaculture and tourism: the use of sites

Before they can set up in tourist areas, aquaculturists must show that their activity would have no more than a minor effect on such sites.

These two activities very often compete with each other for the use of sites and stretches of water. Firstly, leisure activities interfere with fishermen and aquaculturists in the exercise of their trade. Every summer there are complaints about damage to fishing equipment, unofficial competition from amateur fishermen and pollution from the extra waste water associated with tourism. For their part, tourists do not much care for the intrusion on stretches of water, the visual impact and the smell of aquaculture units. These problems do not occur with extensive aquaculture.

One way of integrating tourism and aquaculture is through mollusc farming, which interests tourists, or by selling aquaculture products, which enjoy a "natural" brand image.

C. Weiss / Bios

Around the tourist resorts pleasure boats and fishing boats ride side by side.

Aquaculture, urbanisation and industry: space and pollution

Urban, industrial, coastal sites imply competition for space and high levels of pollutants in waste water and in the streams and channels that feed wetlands. This means that fishermen and aquaculturists have to reckon with heavy pollution. Before setting up, aquaculturists are required to arrive at an agreement limiting the responsibility of industrialists in the event of pollution caused by their activities.

The establishment of marine culture was judged incompatible by the managers of the industrial site of Fos-sur-Mer in the South of France. The argument was that aquaculture units would have reduced the surface area of zones for heavy industry and that they would have increased the measures for depollution of industrial wastes[1].

Aquaculture and nature conservation: the exclusion of predators

Fish-eating birds such as the great cormorant *(Phalacrocorax carbo)*, great crested grebes *(Podiceps cristatus)*, grey herons *(Ardea cinerea)* and black-headed gulls *(Larus ridibundus)* may cause widespread damage in aquaculture farms. A study carried out in Sardinia estimated at 111 tonnes per annum the quantity of fish removed by a population of two thousand wintering cormorants over a period of a hundred and eighty days. Fish farmers are increasingly turning to methods for excluding predators, rather than killing them. Unfortunately in many countries (Great Britain, France...) permits can be issued to kill otherwise protected species, such as cormorants. Many birds may also drown entangled in the anti-predator nets covering the basins. Studies show that dissuasive methods are more effective than destructive ones in the long term in preventing fish eating predators from feeding in the basins.

The best way of preventing this situation is not to install aquaculture farms in wetlands renowned for their fauna and flora. This is the position adopted by the European Court of Justice concerning the Santoña marshes, a wetland of international importance in Spain. It judged the proposal to install four aquaculture farms incompatible with the Wild Birds Directive (79/409/CEE) and likely to cause serious changes to the ecosystem.

The piscivorous cormorant is a protected species but is a nuisance to aquaculturists.

1 - Tempier (1992)

F. Marquez / Bios

The salinas of Portugal are important habitats for waders such as the black-winged stilt.

The saltworks of Portugal: a favourite habitat for black-winged stilts

Saltworks play an important role for breeding and wintering waders, particularly due to the density of food for these birds. Scientific studies[1] have shown that natural saltworks are more favourable to waterbirds, especially black-winged stilts *(Himantopus himantopus)* than those converted to aquaculture.
The conversion of salinas to aquaculture should not therefore be encouraged as this leads to loss of habitats for waders. A management plan for saltworks should be put in place to allow both their sustainable use and the conservation of key habitats.

1 - Rufino and Neves (1992), Rufino et al. (1984), Perez-Hurtado and Hortas (1993)


SUN-SEA
travers le monde

The economic role of aquaculture

In 1989, production from aquaculture worldwide amounted to 12 % of the global production of fish, and it is already forecast that this figure will double by the year 2000. Fish consumption has already risen worldwide from 11.4 kilogrammes per head of population in 1977-1979 to 13.1 kilogrammes per head of population in 1986-1988, with aquaculture partially responsible for this increase.

In 1993, aquaculture production, excluding seaweeds, amounted to about 16,371 million tonnes of fish (both marine and freshwater varieties) and shellfish. The same year, aquaculture production of fish within the European Union rose to 309 077 tonnes[1].

Molluscs, especially mussels and oysters, are the principal species cultivated in the Mediterranean basin.

1 - For Spain and France, these figures refer to both the Atlantic and Mediterranean coasts.

Aquaculture production of fish of each member state of the European Union in 1993.

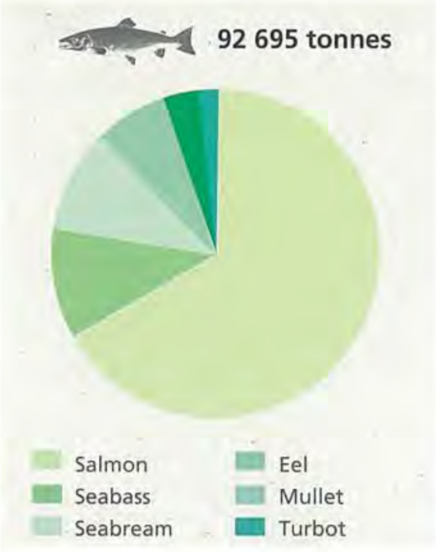
Source : FAO, Fisheries Information, Data and Statistics Service

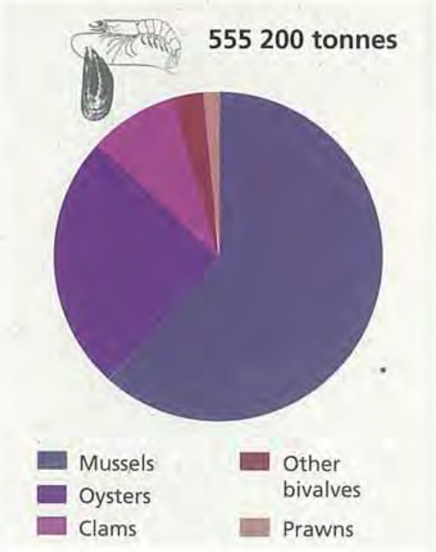
Pays	Tonnes
United Kingdom	62 246
France	57 710
Italy	50 210
Denmark	41 600
Germany	38 614
Spain	24 531
Greece	15 878
Ireland	13 949
Portugal	1 818
Netherlands	1 675
Belgium	846

Global production (excluding seaweeds) amounted to 670 483[1] tonnes in 1993 in the Mediterranean basin. The main production focuses on molluscs, especially mussels and oysters (65 % of the total). 94 % of this comes from Spain, Italy and France, with 98 % of oysters grown in France. Migratory fish, mainly salmonids, represent 18 % of the total. Freshwater fish, excluding salmonids, come from Egypt, Israel, and Italy (11 % of the total). Production of marine fish and shrimps lie at the bottom of the table (6 %). Mediterranean production is carried out in inland fresh waters (25 %), brackish waters (15 %), in the Mediterranean (16 %) and in the Atlantic ocean (47 %)

Aquaculture production of marine and euryhaline species in the European Union in 1993.

Source : FAO, Fisheries Information, Data and Statistics Service





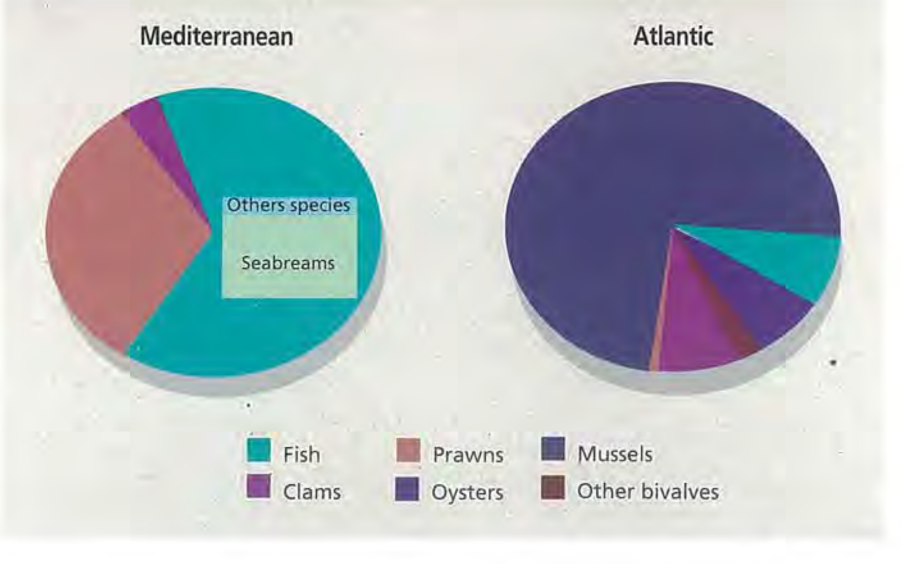
1 - For Spain and France, these figures refer to both the Atlantic and Mediterranean coasts.

Aquaculture production in the Mediterranean countries[1]

Aquaculture in Spain: lots of mussel

Aquaculture production on both the Atlantic and Mediterranean coasts is characterised by mollusc culture, especially mussel farming. Developed in Galicia, it meets domestic demand, with a certain amount left over for export. However, the increasing numbers of bateas* have led to overproduction and environmental deterioration. Mussel production fell from 195 220 tonnes in 1991 to about 110 000 tonnes in 1994. A restructuring programme is being developed.

With respect to fish, the catch of the Spanish fleet in 1992 only met 50 % of needs. As a result, imports have increased and the cultivation of marine fish continues the expansion that began in the 1980s. Although a variety of species are cultivated, pride of place goes to turbot, a luxury product raised in Galicia on the Atlantic. Despite major investments, production is insufficient to hold its own against imports from the North Sea.



Aquaculture production of marine and euryhaline species in Spain in 1993.

Source : FAO, Fisheries Information, Data and Statistics Service

1 - According to FAO (FIDI, Rome) figures for 1993 and to IFREMER (SEM Station of Palavas) for 1994.

Aquaculture in Mediterranean France: mollusc farming comes of age

Many farms have closed down. Some extensive farms have been offering lagoon-fishing packages, whilst others have turned to polyculture in order to use various levels in the water column. One solution involves finding new markets, especially in Northern Europe where Mediterranean products are still relatively unknown.

For the combined coasts of the Atlantic and Mediterranean, aquaculture production in 1994 is dominated by molluscs, well ahead of fish and shrimps. Mediterranean aquaculture has a turnover equivalent to 30 % of the global fishing turnover (including aquaculture). However, only mollusc culture in lagoons has really come of age. In 1990 this sector, 83 % of which is in and around Sète, dominated aquaculture production along the Mediterranean coast. Mussels account for the bulk of this at 14,000 tonnes, or nearly a quarter of France's production.

In addition, intensive production of seabass and seabream is booming, equivalent to 75 % of France's aquaculture production. However, its development is beset by competition for land and poor outlets. Furthermore, high production costs, notably the price of marine fry, prevent producers from being competitive with other Mediterranean countries. For example, in 1988 a seabass weighing 1 gramme was fetching 0,61 US $, a young seabream was worth 0.76 US $ and a young turbot 1.34 US $. Fish farmers using off-shore cage culture have been forced to drop their prices over the past five years.

Aquaculture production* of marine and euryhaline species in France, in 1994.

* Atlantic and Mediterranean coasts combined

Source : IFREMER, SEM, Station de Palavas

Fish	Tonnes	Crustaceans and shellfish	Tonnes
Seabass	2,450	Oysters	140.000
Salmon	1.150	Mussels	57.000
Seabream	790	Clams	440
Turbot	550	Other bivalves	340
Other fish species	122	Prawns	85

Aquaculture in Italy : mussels and clams top the bill

An economic profitability study[1] has shown that the return on capital of an aquaculture unit cultivating seabass and seabream (gross income minus various costs and depreciation) was 1.09 US $/kilogramme for semi-intensive culture and 1,49 US $/kilogramme for intensive culture.

In 1993, the highest production in saltwater was mussels, followed by fish and clams. In 1992, out of a total aquaculture production of approximately 160,000 tonnes, more than 60 % was still obtained by using natural feeding resources. This figure rose to 95 % in the case of production of marine organisms.

But there is a marked trend towards intensive production for euryhaline species, with the intensive/extensive ratio rising from 1:1 in 1986 to 2:1 in 1992. In the future, intensive systems are likely to steal a lead over extensive culture.

In 1993, the working party preparing the 4th triennial plan for Fishing and Aquaculture identified factors likely to limit the development of aquaculture in Italy. These included environmental problems associated with aquaculture, low production capacity of fry resulting in high costs, lack of cooperation between researchers and professionals, lack of an efficient system of recording statistics and the need for a training programme. Figures vary according to the source ; moreover, lagoon fishing is amalgamated with production from the "valle da pesca".

Eel culture: as old as it is dynamic

Extensive eel farms date back to ancient times in Italy, and for nearly two centuries eels have been fattened in the bay of Arcachon in south-west France. In its intensive form on the other hand, eel culture is of recent date. In 1993, european eel production within the European Union amounted to 6,152 tonnes of marketable size eels, equivalent to 91 % of production worldwide for this species. Italy tops the table with 49 % of cultured eels. Notwithstanding, Italy does not produce enough to satisfy domestic demand. In 1990, for example, 2,800 tonnes of eels were imported to Italy, both in the form of elvers* and juveniles for culture, for which Italy depends entirely on other countries, and as adult eels for consumption. 30 % of national production, however, was exported to the countries of Northern Europe. Spain also imports and exports eels whereas France, Greece, Morocco, Tunisia and Turkey are uniquely exporters.

Eel culture comes up against substantial problems, including the difficulty of controlling reproduction in captivity, variability of individual growth, temperature requirements and the lack of elvers. Stocks of European eels are falling and this species is considered to be in need of protection. Various reasons have been put forward for this, amongst which are overfishing, destruction of natural habitats, in particular rivers, and the illness known as angulosis*. Although Morocco and Italy still allow sale of live elvers for consumption, in France (only on the Atlantic) capture is merely tolerated and in Turkey it is banned.

1 - Anonymous (1993)

Aquaculture production of marine and euryhaline species in Italy, in 1993.

Source : FAO, Fisheries Information, Data and Statistics Service

Fish	Tonnes	Crustaceans and shellfish	Tonnes
Eel	3 000	Mussels	80 000
Mullets	3 000	Clams	26 400
Seabass	2 000	Prawns	25
Seabream	1 300		

Clams: Italian production is booming

At the present time, Europe obtains clams from three sources: open-sea fishing, lagoon fishing and, since the 1970s, cultivation in Mediterranean countries. The farms cultivate the Manila clam from fry produced in hatcheries, capture of fry in the sea having proved to be worthwhile only in the Po delta. In 1993, European clam production[1] stood at 33,483 tonnes. Italy, at 26,400 tonnes, was the leading producer, followed by Spain (3,751 t), Portugal (2,700 t) and France (650 t). These four countries supply almost all the mediterranean production.

But Italy is a victim of its own success and, despite the recent opening of two hatcheries, demand for spat to restock the natural banks is so high that domestic requirements cannot be met. The effect this has on production costs (the purchase of spat represents 34 % of cultivators' expenditure) is such that profit-margins are being constantly eroded while prices have shown a steady decline over the past ten years. The future development of clam culture in the Adriatic region is a function of this trend, the consequence of which is overworking of the wild resource. Clam culture is also subject to the omnipresent risks of eutrophication, which caused a drop in production in 1992 compared with 1991. Export markets also play a decisive role, particularly with respect to the striped venus in Spain. Moreover, imports of Italian clams have led to a 40 % drop in price in Spain, so that the current price scarcely covers Spanish cultivators' production costs.

The establishment of a North Adriatic clam-growers' association may promote rational management of resources, with the setting up of hatcheries, improvements in technique, control of introduced seed, better sanitary conditions and management of markets.

1 - In statistics, cultured clams and those fished on restored natural beds are often combined.

Aquaculture in Turkey: getting marine culture going

A decade ago, production focused mainly on freshwater fish. Since then, marine culture has developed, backed heavily by subsidies. In 1992, over one hundred and fifty seabass and seabream farms were operating in the Aegean, with production of 2,000 to 2,500 tonnes, largely for export due to low domestic demand. In 1994 production reached 4,000 tonnes. This country also produces mussels (8,000 tonnes in 1994) and clams (2,500 tonnes in 1994). However, the Turks have difficulties exporting, mostly because of the 15 % taxes they have to pay to sell their products within the European Union.

Aquaculture in Israel: freshwater fish rule

Production (13,604 t in 1993) is based on freshwater fish cultivated in ponds: carp (58 %) and tilapia (31 %). Production of mullet and silver carp *(Hypophthalmichthys molitrix)* is on the decline, while grass carp *(Ctenopharyngodon idella)* production ceased in 1990. Experiments with seabass and seabream have been undertaken and, in 1992, a farm in the Mediterranean and another in the Red Sea were practising mariculture*.

Aquaculture in Egypt: the importance of the Nile Delta

Freshwater culture in earth ponds and in ricefields predominates, with carp, catfish *(Clarias lazera)*, tilapia and mullet being produced. Aquaculture has been developed in the dyked basins of the Nile delta and the production reached 22,000 tonnes in 1994 (seabass, seabream, mullets and tilapia). As far as marine culture in the open sea is concerned, a few sites have been developed in the Mediterranean for sole (*Solea* sp.), and mullet cultivation and cage culture is recommended by the authorities for seabass and seabream.

Aquaculture in Greece: expanding in all directions

Aquaculture in Greece is a rapidly expanding sector: between 1983 and 1990 the number of seabass and seabream farms boomed from two to ninety-five and average annual yield per company rose from 6 to 23.16 tonnes. In 1994 production reached 14,500 tonnes, 56 % of which were seabass. Although seabream fry cost more than seabass fry, the Greeks focus their efforts on seabream production rather than seabass, because the latter is more difficult to export. Two new species, seabream (*Pagrus* sp.) and dentex (*Dentex* sp.), are now being cultivated on a small scale (around 500 tonnes in 1994). Cultivation of crustaceans and molluscs has also developed enormously, with fifty-two units producing 5,420 tonnes in 1994.

	Production (tonnes)	Number of fish farms	Average production per fish farm
1983	12	2	6.00
1984	19	3	6.33
1985	28	5	5.60
1986	89	12	7.42
1987	105	32	3.28
1988	200	50	4.00
1989	500	70	7.14
1990	2200	95	23.16

Evolution of seabass and seabream production in Greece (intensive aquaculture).

Source : Paquotte, 1992

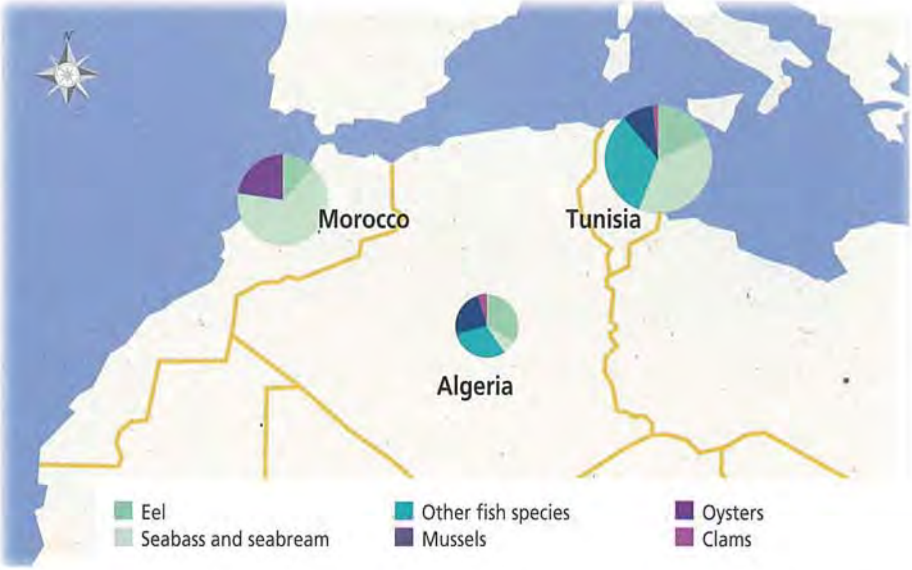
Aquaculture in Portugal : mostly extensive

In Portugal, aquaculture represents 2 % of the fisheries output. In 1993, migratory fish represented 1,411 tonnes, marine fish (soles, seabream, seabass) 376 tonnes and molluscs 4,153 tonnes, mostly clams, but also oysters.

In the saltworks the production of salt is often associated with extensive fish culture and/or shrimps which enter the basin, flooded all the year round for aquaculture purposes. This type of aquaculture provides saltworkers with additional revenue.

The economic role of aquaculture

Aquaculture in the North African countries: a start



Aquaculture production of marine and euryhaline species in the Maghreb, in 1993.

Source : FAO, Fisheries Information, Data and Statistics Service

Tunisia has the most broadly-based production (eel, seabass, seabream, mullets, mussels, Pacific cupped oysters, clams...). In 1994 productivity of seabass and seabream reached 580 tonnes; other species are marginal. In Algeria, aquaculture is not much developed. On the Mediterranean coast of Morocco, the aquaculture farm at Nador has mollusc and shrimp culture, fish farming and undertakes research. The 1994 Moroccan output, largely from this farm, was estimated at 800 tonnes of molluscs, 572 tonnes of seabream and seabass, 340 tonnes of oysters and 120 tonnes of shrimps.

Algeria	3.5
Morocco	6.0
Lybia	7.5
Tunisia	8.0
Italy	12.0
Greece	17.0
France	22.0
Spain	31.0

Consumption of marine products in the Mediterranean countries (kg/person/year)

Source : Derbal & Kara (1993)

Aquaculture in other countries: targeted production

At the present time some countries, have only low-level output of less than 200 tonnes, such as Lebanon, and Libya. Other countries concentrate their efforts almost solely on certain groups. Seabass and seabream are raised in Malta (622 tonnes in 1994), in Cyprus (460 tonnes in 1994) and Croatia (600 tonnes in 1994). In Albania, aquaculture concerns shellfish, mostly mussels (240 tonnes in 1994). In Syria, only freshwater species (mostly carps and tilapia) are raised (5,000 tonnes in 1993).

Aquaculture of seabass and seabream: more and more integration

In 1990, aquaculture production of seabass and seabream in intensive culture was as follows: Greece (2,200 tonnes), Spain (1,760 tonnes), Italy (1,000 tonnes), France (375 tonnes). The number of aquaculture operations producing seabass and seabream intensively amounted to twenty-eight in the French Mediterranean, thirty-six in Spain, twenty-five in Italy and ninety-five in Greece. Average production of seabass and seabream per intensive operation varied from 11.36 tonnes in France to 48.89 tonnes in Spain, with 23.16 tonnes in Greece and 40 tonnes in Italy. Overall, production of seabream is lower than that of seabass, mainly because of biological and pathological factors and the inadequate supplies of fry.

In France, the setting up of seabass and seabream farms is levelling off as a result of the small number of sites available. Shortages of fry and the high price they fetch has led many farms to add hatcheries, giving them the benefit of forward integration. At the same time, existing hatcheries are practising backward integration by setting up fattening units to offset possible overproduction.

M. Gunther / Bios

Fry hatcheries for seabass are usually composed of solid tanks in outdoor sheds.

Companies have to work hard at product quality, so upping already high production costs, and at marketing. Deciding on the size of the company is a complex matter. This is why more and more small companies are grouping together.

Today, increasing numbers of cultured seabass and seabream from Greece (14,500 tonnes produced in 1994) and Turkey (4,000 tonnes produced in 1994), countries that enjoy ideal weather conditions, cheap labour and favourable sites, are arriving in those countries (Spain, France and Italy) where there is high demand, so putting production in these countries at economic risk. The Italian market, which has the highest demand for Mediterranean products, is in fact reaching saturation as a result of imports and increased domestic production.

Seabass and seabream: top-performance hatcheries

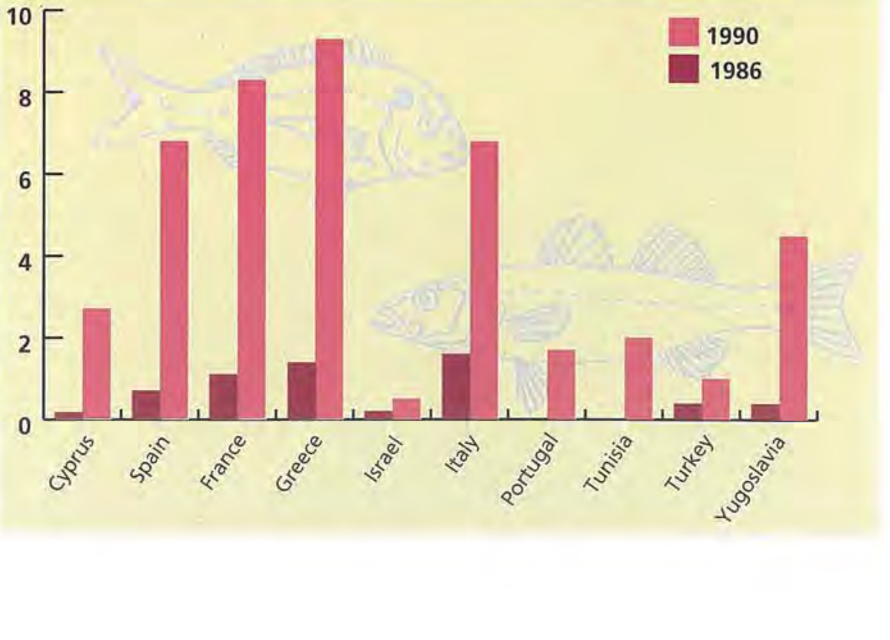
In the early 1990s, twenty-seven seabass and seabream hatcheries were listed in the Mediterranean region: eight in Italy, six in France, four in Spain, three in Cyprus, two each in ex-Yugoslavia and in Tunisia, one in Greece and one in Morocco. In France, the hatcheries are not very big, the largest one producing about three million fry as against 15 million in the largest Spanish farm.


B. Pambour / Bios

Seabass fry, a species sought after by consumers.

In 1989, these hatcheries produced 7.265 million fish, of which 75 % were seabass and 20.5 % were seabream, which is equivalent to about a quarter of the international production of fry. 48.8 % of seabass fry and 20.3 % of seabream fry were kept in France to supply farms, the remainder being exported.

In all Mediterranean countries, production of seabream and seabass fry increased markedly between 1986 and 1990. If growth in international production of fry continues at its present rate, some Mediterranean operations may encounter difficulties related to overproduction.



Production of juvenile seabass and seabream in the Mediterranean (millions).

Source : Sweetman, 1992

Aquaculture: an expanding activity

The socio-economic importance of aquaculture is such that international funds are allocated to Mediterranean countries and public financing is available to entrepreneurs[1].

"Blue Europe" and the development of aquaculture

In January 1983, a regulation "instigating a community plan for the conservation and management of fishing resources" created the term "Blue Europe".

The European Union, the main economic community in the Mediterranean region, is both the largest buyer of aquaculture products from outside countries and the largest supplier of technology, equipment and products for the aquaculture sector. It is also the main source of technical assistance and capital for producers.

The 1983 regulation, which is applicable until the year 2002, lays down a policy for the development and modernisation of aquaculture techniques, as well as defining common standards for regulating fishing given the increasing scarcity of this resource.

Recent allocation of funds

Despite willingness to develop and allocate funds for its development (limited after 1978), aquaculture was not classified in terms of "fish production", nor was it considered to be an activity worth developing for social reasons until the "Blue Europe" banner was launched between 1983 and 1989. Eight hundred and eighty-six aquaculture projects received 172 million US $, with EU aid varying from 40 % in priority areas down to 25 %. Since 1986, these grants, which depend upon the projects being part of annual national development programmes, have been allocated through the E.A.G.G.F.*. Since this degree of financial assistance is inadequate, the French State, for example, has set up a system of grants for installation as well as government-subsidised loans, while the Regions can grant subsidies for running costs and the Departments can supply grants for equipment.

The European Union can also support aquaculture through programmes aiming to support regional development. In particular, the I.M.P.* aimed to encourage environmental protection and promote the improvement of socio-economic structures within the context of the adaptation of southern regions to greater Europe. This took the form of aid with investment, especially on the French Mediterranean coast, in the Northern Adriatic lagoons and throughout Greece.

1 - See page 82 for explanation of the abbreviations in this section

The economic role of aquaculture

A wide range of aid packages

The Mediterranean countries are involved in United Nations' organisations. In 1976, under the aegis of the U.N.E.P.*, they met in Barcelona to sign an agreement, which was the legal arm of the Mediterranean Action Plan. This includes a socio-economic section comprising planning of development and management of natural resources, which are the responsibility of the P.A.P.* and the Blue Plan. MEDPOL, the scientific section, as well as a number of protocols, are concerned with protection of the marine environment. The Regional activity centre for P.A.P. has recently established an "Aquaculture and Environment Network" in the Mediterranean region with the support of IFREMER*.

M.E.D.R.A.P.* 1 (1981-1987) came into force at the same time under impetus from the U.N.E.P. and the F.A.O. Affecting all Mediterranean countries, it involved a system of aquaculture institutions working together to increase the production of cultured fish. In 1993 M.E.D.R.A.P. 2 took over to establish a network of information to complement national initiatives and mobilise skills and regional financial resources.

The U.N.D.P.* has also set up a Programme for the Development and Coordination of Aquaculture in four regions, including the Mediterranean. Its aim is to provide information necessary to assess direct investments and support cooperation in aquaculture.

A wide range of publications aimed at scientists, aquaculturists and civil servants have appeared in the last twenty years.

G. Vlassis

Governmental policies tend to be "protectionist"

All national development plans in the Mediterranean countries include statements on aquaculture. To maintain control of this sector, these countries take steps to make it difficult for large financial groups to gain access to this activity. But it is only in the three leading producing countries that aquaculture is a key political issue.

Aquaculture in Mediterranean countries: planned and controlled

The five Mediterranean countries belonging to the European Union prepared a Pluri-annual Orientation Programme for Aquaculture, laying down priorities and production objectives, and designed to serve as a reference for the granting of subsidies to aquaculture projects. To this, the European Union added new measures controlling health and hygiene. The Council of Europe directive dated 28/01/91 regulates the marketing of animals from aquaculture and defines standards of health, means of transport and the quality of water during transport, as well as the introduction of new species. All these items are subject to control from European Union experts in collaboration with the appropriate national authorities. The directive defines authorised zones and lays down conditions for imports from outside, or from unauthorised countries. Other countries have drawn up plans that emphasise the importance of aquaculture as an export activity.

Some countries with no traditional lagoon fishing industry (Libya, Malta, Algeria) have no laws on aquaculture. Greece, Tunisia, Turkey and Morocco do have lagoon fisheries and relevant legislation; they encourage fishermen to engage in aquaculture, and make it attractive to foreign investors. France, Italy and Spain have considerable legislation on aquaculture and this is being constantly improved to help aquaculturists become more competitive and make the most of EU subsidies.

Some national plans

In Spain, the national budget supports expansion of aquaculture, emphasising the excellent climate, diversity of sites and demand for marine products in this country. Its objectives are: rational exploitation of resources, protection of the coastline area, increased production and the rapid development of new species.

Even though most potential sites in the Mediterranean have been studied and numerous publications (including "Aquaculture minutes" from the A.D.C.P*.) and symposia are available, there is still widespread lack of information about what aquaculture really involves.

In Turkey, the government encourages investment and has taken steps to train students in colleges and through apprenticeships in other countries.

In Morocco, the public authorities encourage the development of aquaculture through administrative, legislative and economic measures. Promotion of pilot plants is one of the arms of a new strategy for developing the maritime sector. The number of favourable sites is limited however. In 1978, M.E.D.R.A.P. enabled studies to be carried out on the Nador lagoon, classified as a pilot site. This scheme materialised with the creation of the Nador farm, a truly integrated complex extending over 11.5 hectares and which, in 1991, provided 80 % of national production, equivalent to 410 tonnes.

In Egypt, the national budget and research activities have been directed towards developing aquaculture activities involving the setting up of carp and mullet hatcheries over the next ten years.

In Italy, the policy on aquaculture support includes financing. In the future, integrated complexes comprising centres for artificial reproduction, production of foodstuffs and technical assistance will be developed. What is new is the integration of extensive and intensive culture. For example, extensive culture in "valli" will be combined with young fish and living prey from intensive-type cultures. Measures have been adopted to classify aquaculture as an agricultural activity, thus opening access to funds in this sector.

In Greece, the aquaculture industry is taking off and the long term strategy envisages a production of 31,000 tonnes/year (intensive culture of seabass and seabream) by 1999.

In Tunisia, the National Centre for Aquaculture was established in 1985. Various laws encourage aquaculture operations and make it easier for non-resident promoters to follow through their projects. They also place restrictions on effluents to safeguard the quality of the natural environment. However despite this, water quality problems in enclosed bays caused massive mortalities and forced the closure of several farms.

Towards sustainable development

The Mediterranean basin provides natural conditions ideal for the development of aquaculture. The number of suitable sites is high, with about one million hectares of sheltered bays and lagoons rich in nutrients from the rivers. High temperatures, especially in the central-southern zone, encourage photosynthesis and ensure that the lagoons are zones of high primary productivity.

However, the risks related to the activity are far from negligible. High temperatures, as well as excessive enrichment and stagnation of the water, caused by lack of tidal action or high wind, certainly encourages primary production but it also leads to eutrophication. Before it gets to this extreme, excessive biomass may undermine the health of living organisms and so make them more vulnerable to pathogens and epidemics.

Harvesting of clams in the Po delta, Italy

Within mollusc farms, epidemics develop according to a standard sequence. First there is a peak in production, then a slight falling off, followed by the appearance of epizootics* and a slump in production. The peaks appear to correspond to excessive load on the capacity of the ecosystem. Overloading the ponds beyond their nutritional capacity tends to lead to dwindling economic performance. There are different methods for assessing the biotic capacity of ecosystems in which oyster and mussel growing are practised, with production yields showing whether an appropriate balance has been reached between the stock cultivated and the availability of food.

B. Pambour / Bios

A fish auction in Grau-du-Roi, France. The marketing network is different for wild-caught and cultivated fish.

The capture of fry also threatens the existence of wild populations, which are already the victims of intensive fishing, for it breaks into the biological cycle of the species. Effluents from fish farms are also far from neutral in their impact. As the turbidity of the water increases, so photosynthesis is restricted and various forms of marine life, especially the seagrasses such as Posidonia, are adversely affected. Faecal matter and uneaten foodstuffs under the cages change the composition of the adjacent sediment and reduce the diversity and density of benthal species.

Contact between wild and farmed populations may also have serious consequences, amongst which are contamination, loss of genetic identity or even elimination of native species.

In socio-economic terms, aquaculture is often in a situation of conflict, especially in the Mediterranean where other local activities already exist. These activities compete strongly with aquaculture, particularly in the areas of management of the landscape, urban development and pollution. The virtual absence of any research into pollution and its sources before the development of aquaculture, means that it is extremely difficult to trace the origin of such pollution. Competition with the biotopes of fragile, already damaged wetlands, which are nonetheless vital to the survival of fish and bird life, also occurs. Aquaculture, especially when practised intensively, totally disrupts lagoon ecosystems. Since aquaculture cannot function profitably in a deteriorating environment, good aquaculture management implies optimal conservation of the ecosystems, in other words putting a stop to damage caused by the activity or by outside factors.

Mediterranean aquaculture: expansion under threat

Despite promising beginnings, aquaculture today is seen as an activity complementary to fishing. The future of marine fish culture looks promising, provided the difficulties associated with competition and drop in production are resolved.

Is aquaculture the magic answer?

At the present time, aquaculture remains an activity complementary to fishing. In 1994 aquaculture worldwide produced close to 19 million tonnes of fish as against 85 million from fishing.

Aquaculture, one of the pillars of ensuring self-sufficiency of foodstuffs in an overpopulated world, an alternative for fishermen "in danger of extinction", a booming sector able to absorb some of the unemployed... Twenty years after such arguments were put forward to promote aquaculture, it is hard to assess whether these hopes have been justified.

Some are of the opinion that fishing worldwide is not doomed to decline and that fishermen will catch species in greater quantities and at lower prices than aquaculturists will ever be able to do. Others see fishing as having merely marked time for the past twenty years or so and consider that no future expansion is likely, so that aquaculture will exceed production through fishing.
It would seem probable that development of marine fish farms will occur as a result of the increase in numbers of intensive farms[1]. Clam culture and marine aquaculture using cages provide the best return[1]. In many countries (France, Cyprus, Greece, Italy, Morocco, Spain and Tunisia), the emphasis is very much on this type of aquaculture. By contrast, pond fish farming will not develop very much except in Egypt, Israel and, on a smaller scale, Italy, with the culture of catfish *(Clarias lazera)*. Aquaculture is however beset by two dangers, market competition and drastic falls in production (as a result of epidemics, pollution, storms etc.).

Competition needing to be regulated

The salmon *(Salmo salar)* "miracle" in northern Europe was paralleled in the Mediterranean by seabass, with all the advantages and shortcomings of such a development.

The Italian market, which is the most dynamic one for fresh Mediterranean fish or for similar species from other origins, is an excellent example. Foreign competition in the domestic market has been so strong over the past three years that retail prices have plummeted. The devaluation of the Lire made matters worse. To the traditional countries exporting fish to Italy (Spain, France, Portugal, Scandinavia and Argentina), have been added Greece, Morocco, Egypt, Tunisia and Brazil, countries that have changed the way their exports are directed. Limits on production must be set for the Italian seabream,

1 - According to the FAO


B. Pambour / Bios

Fishermen and aquaculturists are in direct competition for the most sought-after species such as seabream and seabass.

Plentiful subsidies attracted more investors to aquaculture than were justified in terms of economic feasibility. What is worse is the financial support given to intensive systems, which are expensive for developing countries and which result in the production of species of high marketable value that are not eaten on the domestic market. The narrow profit margin, added to the lack of a domestic market, makes such companies extremely vulnerable. Furthermore, the intensive system does not create many jobs, nor does it contribute to creating a balance in distribution of income.

seabass and clam industry to develop in a balanced manner. In order to do this, aid to countries where fry are produced in excess must be slowed down, imports of fry from the natural environment must be banned and European hatcheries must be managed in such a way that production is dove-tailed to market capacity.

Production threatened by collapse

Physical factors, which are difficult to control, are strongly implicated in the risks of collapse, despite huge technical advances. Such risks vary with the type of production. Fish farms are at the mercy of bad weather conditions, pollution, diseases, poor management and overproduction. With lagoons, there are the following additional dangers: rising water levels, cold temperatures and dystrophic* crises. Cage culture in the open sea is vulnerable to storms while that in shallow bays may suffer from eutrophication.

Bivalve cultivation is particularly sensitive to epidemics, which may cause massive mortalities or spread disease to the consumer. In 1973, a cholera epidemic in Italy halted mussel production. Despite cleaning up operations instigated in 1977, Italian mussel growing has suffered from the poor quality of water in bays close to big cities, an example being the Venetian lagoon where production slumped to under 50 %. In France, the presence of salmonella led to a market ban on shellfish from Thau between December 1989 and mid-January 1990. Losses over this festive period amounted to 4,500 tonnes of oysters and 1,000 tonnes of mussels, in other words a financial loss of about 10.5 million US $. Weather conditions also play a role. A storm off the French coast in 1982 damaged five hundred shellfish racks in the Etang de Thau, causing 25 % of the stocks of oysters and mussels to be wiped out.

Risks differ as well according to the type of aquaculture. In production aquaculture, when production is too high the environment cannot nourish the animals. In transformation aquaculture, suspended waste matter may cause pollution. Another danger besets transformation aquaculture when supply balloons from virtually non-existent to overproduction. This situation occurred within fifteen years in Norwegian salmon farms, so that out of the eight hundred and thirteen farms, two hundred went bankrupt in 1991.

Towards equilibrium

Sustainable development combines management and conservation of natural resources with a move towards technological and institutional change so as to ensure that human needs of the present and of future generations will be met and satisfied[1].

A new concept applied to aquaculture

The development of aquaculture must be married with respect for the environment in order to guarantee its long-term survival.

Sustainable development must ensure that the earth, its water resources, and animal and plant life are preserved, and that the activity is technologically suitable, economically viable and socially acceptable. To respect such a direction, aquaculture must become an integral part of the rational management of coastal resources.

The conception of aquaculture has therefore evolved. It is no longer seen as the solution to a poor socio-economic situation. Environmental issues have assumed priority over the socio-economic aspects. Aquaculture is destined therefore to become an integral part of the structure of local production and the national economy.

A. Petretti / Panda photo / Bios

The cultivation of mussels has increased considerably along the Atlantic coast of Spain causing problems of overproduction and eutrophication.

1 - FAO definition (1990)

Aquaculture and the Mediterranean Action Plan

To assist countries bordering on the Mediterranean in planning and promoting of aquaculture, the M.A.P.* recommends drawing up an inventory of those resources that are limited, in particular suitable sites, and taking account of physical features (climate, hydrography, plankton etc.) before looking at the socio-economic aspect. Details of the type of construction, density of the operation, health standards and the aquaculturist's degree of training should be given and feasible decisions should be matched by effective measures for control and protection. Assessment of environmental impact should take into account production models and competing activities.

By including ecological factors, the M.A.P. is thus advocating vertical integration of aquaculture. The challenge confronting aquaculture in the future is to reduce the negative impact of the activity and make its technology compatible with the functioning of ecosystems. Public money for research and development should be allocated to new, experimental technology.

Aquaculture: a large water consumer

Water is essential for aquaculture; studies[1] have shown that the aquaculture industry had a low ratio of production per m^3 of water used and a concomitantly large rate of pollution compared to other water-using industries (cotton, oil, paper...) Water can be obtained by gravity, through tidal fluxes or through pumping. This latter method is expensive and is used only for high-value species.

M. Gunther / Bios

Both traditional and modern aquaculture require large quantities of water.

The other reason for high costs is the reduction in water quality due to aquaculture itself. As available water resources worldwide are in decline, the aquaculture industry must in future use efficient, economic methods which allow water to be shared with other users.
It should therefore develop in harmony with the available water resources, their quantity and quality.

1 - Muir and Beveridge (1987)

Aquaculture and the European Union

Since 1987, the European Union has sponsored programmes for scientific and technical research into aquaculture. These also give priority to environmental protection and try to ensure that the development of aquaculture is not damaging. The environment is assuming an increasingly important place in new EU regulations. Licence to operate depends on professional competence, and an enquiry is carried out, and sometimes an impact study as well, before a licence is issued. The authorisation order may include certain limitations on the operation and technical guidelines for protection of the environment. This procedure is already followed for salmon farms and should be extended to seabass and seabream farms.

Several countries mention the impact of aquaculture on the environment in national economic programmes. An impact study is compulsory for all units in Greece, whereas in France it is only required for fish farms whose production tops 2 tonnes. The present trend is to promote those companies which pollute the least, and a pollution tax to protect the coastal environment has been proposed. In some countries fines have been imposed on polluting aquaculture farms.

Conclusion

Towards an integrated policy

This booklet has discussed the way in which aquaculture has developed in the Mediterranean region, responding to market forces, environmental concerns and the technical problems of raising marine fish and molluscs under controlled conditions, not to say in captivity.

It is difficult to work out a system of priorities for factors as varied as fish production, job creation, protection of ecosystems or maintaining tourism. The best approach would instead be to try and find a rational way to make economic and social development compatible with protection of the environment and political considerations.

Extensive lagoon aquaculture is an ancient practice in the Mediterranean basin. In its intensive form, it is a new technology, as is aquaculture in the open sea. The results are encouraging but, whereas mollusc farming has proved to be successful, it is more difficult to assess in real terms whether modern intensive aquaculture has paid off or not.

The primary issue for the future is how to ensure that markets are satisfied while avoiding the negative environmental consequences of aquaculture developments, which can be considerable if they are badly sited. There is no longer any excuse for decision-makers to plan in ignorance of these impacts. Twenty years of experience have demonstrated that the risks of eutrophication, genetic pollution of wild stock, imported parasites and introduced non-native species can, and should, be factored into national and local policies for aquaculture development. This booklet provides a summary of the necessary technical information.

Water inflow to a stocking basin.

Productive dynamic management implies optimal conservation of the ecosystem. Badly managed coastal strips or lagoons mean low, irregular production and a reduction in the number of species.

Perhaps the most important trends at present are the exclusion of new aquaculture developments from coastal lagoon systems due to the risks of eutrophication and dystrophic crises, and the trend towards hatcheries for all principal fish species raised rather than catching of fry from wild stocks.

The new approach gives priority to environmental concerns, recognising both lagoon and coastline as sensitive environments, whose multiple uses, of which aquaculture is only one, increase their value. The allocation of space for aquaculture should be backed up by ecological studies for the necessary regulations to ensure the long term sustainability of the industry.

The "Habitats" directive of the European Commission classifies lagoons among the ecosystems of community importance.

Glossary

Angulosis: disease affecting eels caused by various species of nematodes (eel-worms of the genus *Anguillicola* spp.), parasites of the swim bladder.

Bateas: floating racks used in Spain for culture

Benthal: relating to the sea or lake bed

Benthos: area at the sea, river or lake bottom; it is made up of the sediments that cover the bottom and the organisms that live there.

Biomass: all living matter in a given area at a given time.

Bloom, algal bloom: an explosive increase in the density of phytoplankton within an area.

Bordigue: name used in France for a fish trap enabling migrating fish to be captured and also for management of fish populations in lagoons; in the past they were made of wickerwork or reeds but today they are made of concrete with metal grids.

Brine shrimp: small crustacean able to live in extremely saline water.

Cyanobacteria: blue-green algae, formerly classified as the Cyanophyta, but now considered to have more in common with bacteria.

Dystrophic: imbalance in the aquatic environment caused by an excess of nutritive elements, resulting in total oxygen consumption by the living organisms.

Elver: a young eel that migrates up a river from the sea.

Epidunculation: removal of the eyestalk to stimulate sexual maturity and spawning in shrimps and prawns.

Epifauna: organisms living on the surface of sediment or on various substrates or on other living organisms but without being parasites.

Epizootic: disease affecting a large number of animals simultaneously, corresponding to epidemic in man.

Euryhaline: qualifies aquatic species able to tolerate wide fluctuations in salinity.

Eutrophication: excessive enrichment of water with nutrients, resulting in excessive growth of organisms and depletion of oxygen.

Isobath: line on a chart connecting points of equal depth.

Malaïgue: name given in the South of France to dystrophic crises.

Mariculture: the culture of marine organisms.

Plankton: all small, living organisms, either animals (zooplankton) or plants (phytoplankton) that drift with the surrounding water, usually vertically. Nekton refers to all animals that, unlike plankton, swim actively.

Phanerogam: plant with conspicuous sexual reproductive organs (in cones or flowers).

Raceway: long, narrow pond made of concrete, or plastic, in through which water flows.

Ramsar Convention: Agreement on wetlands of international importance, especially as waterfowl habitat. Intergovernmental treaty signed in Ramsar, Iran in 1971, coming into force in 1973.

Rice-cum-fish: freshwater fish cultivation in rice fields.

Rotifers: planktonic organisms living mainly in fresh water; some species live in brackish water or in the sea.

Spat: spawn or young of bivalve molluscs.

Stock: population; a group of individual of one species within a specified area or volume.

Telluric: originating on or in the earth. Telluric waters are underground waters.

Trophic (or food) chain: sequence of organisms in which each is the food of the next member in the chain.

Valli: lagoons in the upper Italian Adriatic.

Valliculture: extensive lagoon aquaculture practised in the valli, mainly involving eels, seabass, seabream and mullet.

Abbreviations

A.D.C.P. : Aquaculture Development and Coordination Programme

ECU : European Currency Unit

F.A.O. : Food and Agriculture Organization of the United Nations

E.A.G.G.F. : European Agriculture Guidance and Guarantee Fund

G.N.P. : (or Gross National Product) : the total value of all final goods and services produced annually by a nation (including income from foreign sales and investments).

I.C.E.S. : International Council for the Exploration of the Sea

I.M.P. : Integrated Mediterranean Programmes (27 July 1985)

IFREMER : French Institute for Research and Maritime Studies

M.A.P. : Mediterranean Action Plan

MEDPOL : Long-term programme for Mediterranean pollution monitoring and research

M.E.D.R.A.P. : Mediterranean Regional Aquaculture Development Project

P.A.P. : Priority Actions Programme of the M.A.P.

S.I.P.A.M. : System of Information for the Promotion of Aquaculture in the Mediterranean

U.N.D.P. : United Nations Development Programme

U.N.E.P. : United Nations Environment Programme

List of species mentioned in the text

Atlantic salmon : *Salmo salar*

Black bass : *Micropterus salmoïdes*

Black-winged stilt : *Himantopus himantopus*

Blue mussel and Mediterranean mussel : *Mytilus edulis* and *Mytilus galloprovincialis*

Brine shrimp : *Artemia salina*

Caramote prawn : *Penaeus kerathurus*

Carp : *Cyprinus carpio*

Carpet shell : *Tapes pullastra*

Catfish : *Clarias lazera*

Common two-banded seabream : *Diplodus vulgaris*

Cuttlefish : *Sepia* sp.

Dentex : *Dentex* sp.

European eel : *Anguilla anguilla*

European flat oyster : *Ostrea edulis*

European flounder : *Platichthys flesus*

European seabass : *Dicentrarchus labrax*

Fleshy prawn : *Penaeus chinensis* (or *Penaeus orientalis*)

Giant tiger prawn : *Penaeus monodon*

Gilt-head seabream : *Sparus aurata*

Golden grey mullet : *Liza aurata*

Grass carp : *Ctenopharyngodon idella*

Greater amberjack : *Seriola dumerili*

Grooved carpet shell : *Tapes decussatus*

Japanese eel : *Anguilla japonica*

Kuruma prawn : *Penaeus japonicus*

Leaping mullet : *Liza saliens*

Manila clam (or Japanese carpet shell) : *Tapes semidecussatus* (or *Tapes philippinarum* or *Ruditapes philippinarum*)

Mediterranean moray : *Muraena helena*

Octopus : *Octopus sp.*

Pacific cupped oyster : *Crassostrea gigas*

Portuguese cupped oyster : *Crassostrea angulata*

Posidonia : *Posidonia oceanica*

Salema : *Sarpa salpa*

Seabream (or Red Porgy) : *Pagrus sp.*

Short-finned eel : *Anguilla australis*

Silver carp : *Hypophthalmichthys molitrix*

Silver seabream : *Chrysophris major*

Sole : *Solea* sp.

Striped venus : *Venus gallina*

Thicklip grey mullet : *Chelon labrosus*

Thinlip grey mullet : *Liza ramada*

Tilapia : *Tilapia* sp., *Sarotherodon* sp., *Oreochromis* sp.

Turbot : *Psetta maxima*

Velvet swimming crab : *Liocarcinus arcuatus*

White seabream : *Diplodus sargus*

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Le Sambuc - 13200 Arles - France
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The **Station biologique de la Tour du Valat** was established in the Camargue (France) in 1954 by Dr. Luc Hoffmann as a private research institute, primarily for field ornithological studies.

In 1993 the estate consists of 2500 ha of land belonging to the Fondation Sansouire, created under French law in 1976. The estate is one of the few in the eastern Camargue on which extensive areas of near-natural landscapes have survived the post-war expansion of arable agriculture. Funding for the research and conservation programme of the Station comes from a variety of national and international organisations, but the major part of the core funding is provided by the Fondation Tour du Valat, a foundation under Swiss law.

The scientific programme of the station has evolved over the years, and has included programmes on the management of vegetation using domestic herbivores, fish ecology, optimal foraging strategies, behavioural studies, and migration and breeding success of colonial waterbirds. Most of these studies have been undertaken in the Camargue, but the Station has increasingly worked in collaboration with other scientists in the Mediterranean region.

This programme has provided the Station with a fundamental understanding of Mediterranean wetland ecology which can be applied to wetland management problems in the region.

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