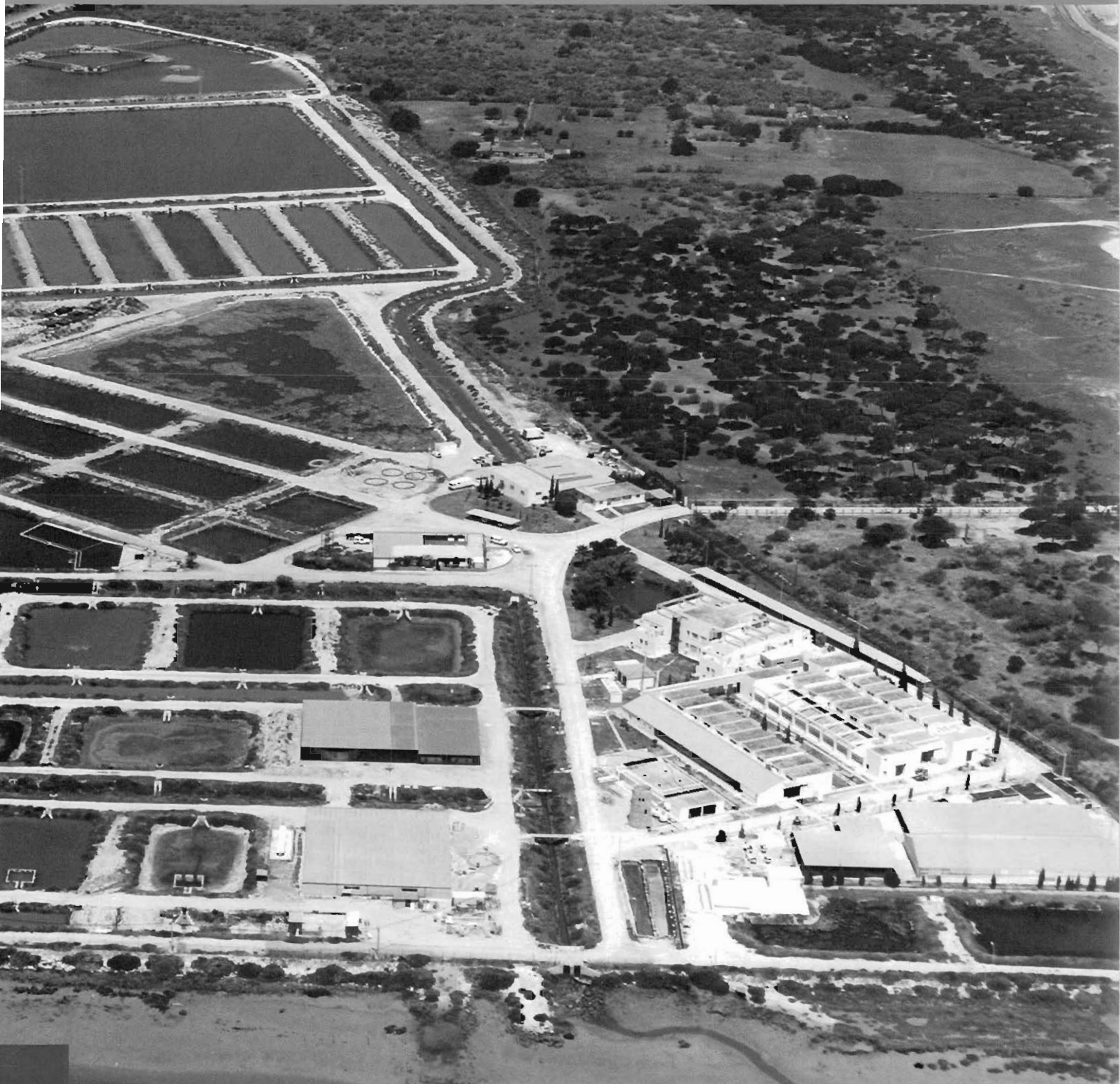


Fishery and aquaculture Research



Department of Agriculture and Fisheries



Edited by:
Published by:
Text:
Photography:
Design and layout:
Printed by:

REGIONAL GOVERNMENT OF ANDALUSIA, **Department of Agriculture and Fisheries**
VICE-DEPARTMENT Publication and Dissemination Services
J. Carlos Manzano Harriero, Justo Martín Martín, Eva Merino Martínez
Paisajes Españoles, Enfoque 10, Department of Agriculture and Fishing, D.a.p
FORMA animada S.C.A.
Artes Gráficas Novograf, S.A. (Sevilla), D.L.: SE-158-02



Centre for the Research and Farming of Marine Species "El Toruño", El Puerto de Santa María (Cádiz)

An aerial photograph of a coastal city, likely in Andalusia, showing a mix of urban buildings, green spaces, and a harbor area with several boats. The image is in black and white and serves as a background for the text.

PRESENTATION

Andalusia is a land with a seafaring tradition dating back several thousands of years, an aspect which is reflected in the importance fishing has had on its inhabitants over the ages. For several centuries fishing was one of the main sources of food and one of the basic pillars of the local economy all along the region's coastline.

However, recent decades have seen a progressive decline in this economic activity, brought on by several causes. Aware of this problem the Andalusian Department Ministry of Agriculture and Fisheries has produced an in-depth study of the fishery sector's situation, analysing its current state and future prospects. The result of this effort is the Modernisation Plan for the Andalusian Fishery Sector for the period 1997-2003.

This Plan recognises the important role that research work plays in the modernisation process, presenting it as one of the fundamental pillars for planning fishing as an activity that subsists on the exploitation of renewable natural resources. The Modernisation Plan accepts the fact that a series of structural problems exists that limit processes of technological innovation, with a series of obstacles preventing fishery research from playing the major role it deserves.

Taking these limitations into account, what the Modernisation Plan proposes is a research programme to resolve existing problems by responding to a general objective: to collect basic and reliable data on all aspects related to the fishing and aquacultural sector (resources, structures, industries and markets), and disclose the results of the scientific and technological development research programmes to all the public and private agents of the Andalusian fishery sector.

Considering the Plan's objectives as priority issues, and co-ordinating with the Andalusian Research Plan, the Andalusian Department Ministry of Agriculture and Fisheries has set up various initiatives of fishery research integrated into the Plan, either as a continuation of previous work or as new actions aimed specifically at achieving certain priority objectives.

The purpose of this document is to demonstrate and inform on this research initiative, with the main aim of publishing and disseminating the recent advances made in fishery and aquacultural research in Andalusia. These advances are the result of several initiatives undertaken by the Department Ministry of Agriculture and Fisheries, through its own research centres and co-operation activities with different public and private organisations linked to the sector.

*Paulino Plata Cánovas
Consejero de Agricultura y Pesca
Junta de Andalucía*

FISHERY R



SOURCES

As well as providing an essential area for certain activities, such as tourism, sailing and defence, to be carried out, the coastline of Andalusia and its sea are the source of a significant quantity of resources, both living and non-living. This second category of non-living resources includes sea salt extraction in Cádiz and Huelva on the Atlantic coast, and in Almería on the Mediterranean. Other examples are the extraction of aggregate, used both in the construction sector and to regenerate beaches, and the growing importance of desalination plants in the management of coastal hydric resources. Finally, the sea offers enormous possibilities as a future source of energy resources (hydrocarbon, biomass, harnessing the sea's currents and winds, etc.).

In terms of living resources, the fishing sector enjoys a long tradition in Andalusia. The favourable conditions for this activity, resulting from the region's almost 900 kilometres of coastline, led to an early development in sea fishing, which was already booming in Roman times. Since then fishing has continued to be, in varying degrees of intensity, one of the main food sources for the region's inhabitants, and a major part of its economy. During the last third of the twentieth century, fishing in Andalusia reached its peak, with a capture rate in the mid-1970s of over 240,000 tons per year.

However, after the 70s a decline set in. Apart from the problem that the Andalusian fishing sector is forced to depend on foreign fishing grounds, the capture of specimens requires an increasing effort, as a result of growing demand for fishing products. This has led to a worrying current situation, in which many of the fishing areas off the coast of Andalusia are subjected to such intense activity that some fishing grounds are in a situation of clear decline. Added to this problem is the growing pressure from the intense use that tourism, agriculture and industry make of the coastline. Many important fishing zones, particularly breeding grounds and areas inhabited by fry, are affected by the coast's occupation, both directly and as a result of the drop in water quality that it brings.

Recent history has shown that the sea's wealth is not inexhaustible and that, to assure its future, an orderly approach to human activities and a rational management of fishery resources are fundamental issues.

But suitable management is not possible without detailed prior knowledge of the ecosystems in which organisms live, the state of their populations and their natural dynamics, and the effects brought to bear on them by human activity. This first step is now one of the major objectives in research into fishing. Only by studying all the factors that affect the living creatures in question can the ideal mechanisms be established to assure future permanence.

This rational management of fishing resources is not possible without continued planning and control of the fishing activity that takes place. And this planning, in turn, requires rigorous and ongoing studies that consider the biological, social and economic aspects of the fishing sector. In this way, and with this information in the hands of managers, an integral assessment can be made of fishing resources and activities, establishing the most accurate and suitable measures to be taken at every step.

MARINE ECOSYSTEMS



Rocky seabed

The shores of Andalusia are lapped by two bodies of water with very different properties and characteristics: the Mediterranean sea, warm and salty, and the Atlantic ocean, much colder and with a lower salinity. They are linked by the Straits of Gibraltar, the narrow passage that both joins and separates the two seas and the biological communities that inhabit them.

In the gulf of Cádiz, the waters of the Atlantic ocean lap the shores of an essentially flat and sandy coastline. The rivers that flow into the sea form large estuaries and marshland at their mouths, helped by the lack of incline and the intensity depth of the tides. The tides draw important amounts of nutrients from the rivers, so that the waters of the Atlantic can be considered considerably rich.

The Mediterranean coast of Andalusia, meanwhile, has a very narrow continental shelf, predominantly rocky and abrupt in nature, where on the whole the tides are practically imperceptible. Moreover, the confined nature of the Mediterranean and the scant

renovation of its waters, together with the limited input of the rivers that flow into them, mean that the waters of the Mediterranean are poorer than those of the Atlantic.

All these circumstances confer a diversity to the Andalusian coastline that becomes manifest in the wide variety of species that are fished all along the region's coast.

Although the study of different marine ecosystems would appear to be an aspect with greater links to marine biology than to fishery management, the fact is that studies of this type have important applications, such as locating ideal sites for floating fish farms in a particular area.

Studying marine ecosystems can

also help predict phenomena of biological contamination and seasonal occurrences of nutrients, and can even develop models which, depending on the characteristics of the body of seawater in question, can make predictions as to the abundance of a certain type of fish.

In any case, when performing studies on a certain fishing resource, prior knowledge is required of the characteristics of the ecosystem inhabited by the species to be fished or farmed, so that this aspect of the study of ecosystems is always present in fishery research.

With regard to these aspects, the regional Department Ministry of Agriculture and Fisheries is carrying

F i s h e r y R e s o u r c e s



Beach on the south Atlantic coast



Beach in the Cabo de Gata Natural Park



Straits of Gibraltar



Bay of Cádiz



Cape of Trafalgar



Mouth of the River Guadalquivir

out an ambitious study of one of the areas of greatest current importance and with highest expectations on the Andalusian coast, namely the bay of Cádiz. This project involves an exhaustive analysis of the main physical and chemical, oceanographic and biological parameters of this unique area. Detailed knowledge of all these factors allow for an accurate assessment of all the bay's potential, as well as determining the current state of its resources, the degree of preservation of its beds and the most sensitive areas requiring protection.

A major study has been carried out on the coast of Huelva, with the aim of bringing together the scientific bases needed to delimit a Fishing Reserve

zone that will help to protect and improve the fishery wealth of this area. Numerous studies of ecological characterisation and systematic biological sampling have identified the most suitable areas for fishing, as well as providing valuable information on the state of the main fisheries and their biological cycles. This information will be highly useful to specify temporary prohibitions and to establish with greater accuracy the minimum capture sizes for species fished in this area.

Another line of research currently underway deals with applying teledetection techniques to the control and monitoring of the ocean's waters. A time and space database of the Huelva coastline has been created, with

a series of oceanographic and meteorological parameters; in the near future, by analysing all this accumulated information valuable conclusions can be reached on how the fishery resources of the south Atlantic coastline should be managed.

Finally, a detailed study is currently underway on the Andalusian coastline's potential for the installation of floating fish farms, dealing with the ecological characteristics of the locations, and technical and administrative factors. Upon completion, the study will have located and delimited the areas where aquacultural development of this kind is economically viable.

FISHERIES



Fishing port in Barbate (province of Cádiz)

Fishing has been and still is one of the most important economic activities in Andalusia. With its considerable implementation along the whole of the coastline, it generates highly valued and widely consumed products, and constitutes a major part of the local economy in the region's coastal towns.

The Andalusian fishing fleet currently exceeds 2,500 boats. In the year 2000 this fleet unloaded over 75,000 tons of fresh fish, molluscs and crustaceans, reaching a sales value on the market of over 25,500 million pesetas.

The fleet operates both in Andalusian waters and in fishing grounds located outside the exclusive economic zone, from where it is estimated that around half of the fish unloaded in Andalusia originates. The recent difficulties experienced by the fleet to operate in these foreign fishing grounds only serves to accentuate the importance of the grounds located within the coastal strip considered an economically exclusive zone.

The Andalusian fishing grounds are notable for both the value of the species fished and their impressive capacity for regeneration. The fleets fishing these areas are known as artisan coastal fleets, operating along a strip of water stretching approximately 60 miles from the coast. The greater wealth of the Atlantic fishing grounds over the Mediterranean is reflected in the fact that over two thirds of the fish extracted by this fleet comes from the Atlantic. Yet despite this greater wealth, the diversity of species and types of fishery in the Mediterranean beats those of the Atlantic.

The Andalusian fishery sector is currently going through a delicate moment. The increasing difficulties to

continue fishing in foreign waters and the drop in abundance in Spanish fishing grounds, where extraction is excessive, has led to a significant drop in capture volume in recent decades, though the current trend is towards stabilisation. Added to this are the consequences of international market liberalisation, which has led to a drop in the real value of captures, to the extent that the fishery sector throughout the European Union is now going through a very real crisis, with major economic and social consequences.

As has occurred in the whole of the European Union, the Andalusian Department/Ministry of Agriculture and Fisheries has analysed this problem

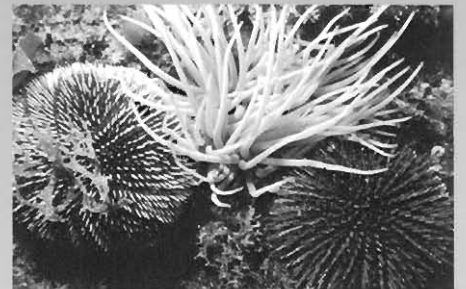
F i s h e r y R e s o u r c e s



Artisan trammel net fishing



Device used for catching octopus



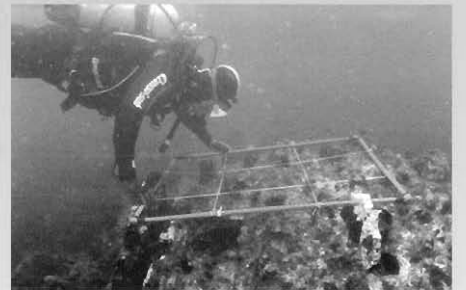
Sea urchins and anemone



Frigate tuna caught using trap net



Fishing boat



Underwater sampling

and has implemented a Modernisation Plan for the Andalusian Fishery Sector. The Plan recognises the importance of carrying out the necessary biological and socio-economic studies to accurately calculate the real operational possibilities of the Andalusian coast's fishery zones. Only in this way can the economic viability of the sector be guaranteed, through balanced operation and ordered management of fishery resources.

Within the framework of the Modernisation Plan, the DepartmentMinistry is devoting a major part of its human and economic resources to research work, in order to improve existing knowledge on the different fisheries that exist off the

Andalusian coast and make important headway in the complex socio-economics involved in the fishing sector. These studies are carried out by the DepartmentMinistry itself, through its research and development centres, and through collaboration agreements with various universities and research centres. In the near future they will provide the technical bases that will arbitrate the measures and activities needed to optimise operations and bring about a more rational use of Andalusia's fishing resources.

Research work, both completed and underway, includes biological studies into certain species of particular interest to the fishing industry (with distribution maps and management

plans), an analysis of the possibilities of fishing species that do not currently receive such intense marketing, the state of operations in certain fishing grounds, an integral analysis of certain major fisheries (toothed bream, octopus, baby clam), an assessment of the current state of the main shellfish resources on the Andalusian coast, and the impact of certain fishing practices in species captured both intentionally and unintentionally. Modern statistical techniques are also being applied to value and establish management policies for certain artisan fisheries, as well as developing a statistical information system to produce models for the various Andalusian fisheries.

FISHING TECHNOLOGY



Trawling ship

Over the centuries technological advances have been incorporated into fishing activities in order to increase both variety and volume. In the last century the application of new materials to boats and fishing instruments, and the incorporation of increasingly powerful engines, led to levels of production that would have been unimaginable only a few decades before.

With some fishing techniques, each catch hauled on board contains a certain amount of species of little or no commercial interest, known as discards. Once dead, this fish often ends up being returned to the sea. In some types of fishing, which have now been abandoned, discards made up the majority of each catch.

The end result of this occasionally excessive extraction and unselective fishing practices is the depletion in stocks that has been observed in many fishing grounds all over the world. Many species have been subjected to an unquestionable overexploitation, leading to the disappearance of fisheries with subsequent economic

losses and the destruction of the way of life of many people.

Fortunately, this depletion of fishing resources is slowly changing. Today fishing tends to be much more rational, and much work is now done on populations of fished species in order to assess available stocks and establish capture quotas that allow these populations to be maintained. At the same time there is a progressive abandonment of less selective fishing systems in favour of more efficient techniques with a much lower impact on the marine ecosystem.

In recent times, techniques are employed to optimise and minimise the impact of catches, and to protect and

promote existing fishing resources. New technologies are being implemented to recover depleted fisheries and support the maintenance of other fisheries suffering excessive pressure, and techniques now exist for aspects in which no previous technology had been available.

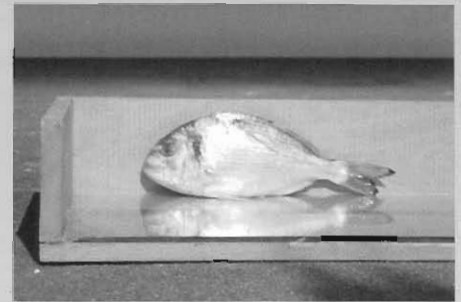
It is precisely along these last lines that the Andalusian Department Ministry of Agriculture and Fisheries has concentrated its activities in this field. For over ten years protection has existed for artisan fishing grounds and the most important nursery areas by installing artificial reefs all along the Andalusian coastline.



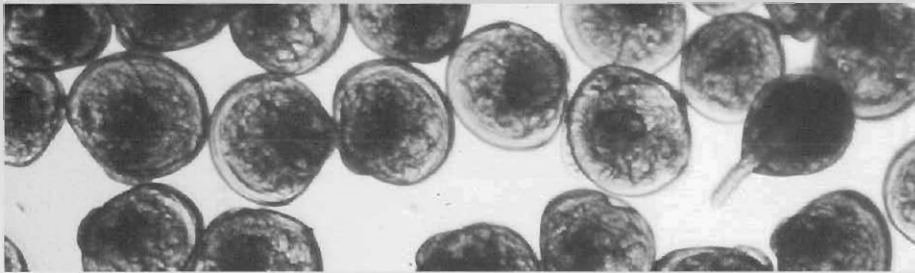
Installation of artificial reefs



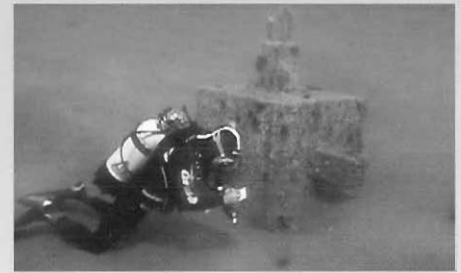
Repopulating gilt-head



Marked and recaptured gilt-head



Venus verrucosa larvae obtained by induced breeding



Underwater monitoring work

Most of these reefs are of a deterrent nature, installed mainly to prevent trawling activity in prohibited areas that are important for rearing and recruiting various species of interest to the fishery sector. Illegal trawling in these zones has highly negative consequences, as they seriously affect the sea bed, destroying marine vegetation and a huge number of eggs and young specimens. Illegal trawling also enters into conflict with the artisan method of fishing, which is gravely affected by such activities, with tension frequently arising within the fishery collective as a result.

Apart from this preventive aspect, artificial reefs are also where several

economically important species find food, shelter and opportunities for breeding. Thus, even though this is not generally their main objective, these artificial structures also help to strengthen fishery resources.

Regarding this last aspect, the Department Andalusian Ministry has carried out repopulating exercises, making use of production from its research and marine species farming centres. Numerous tests have been carried out over the last few years with fish and mollusc species, mainly off the Atlantic coast.

In the case of fish, various marking tests have been carried out in an attempt to assess both the success of

releases and the actual effectiveness of the different marking techniques. The most suitable areas have been established for repopulating initiatives of this kind by gathering basic information on the behaviour of specimens released and determining the ideal release so as to maximise the possibilities of survival.

All these costly and complex techniques require studies to assess their real effectiveness. It is therefore essential to continue the research programmes that provide the technical, scientific and technological bases to realise the full potential of initiatives of this kind.

A Q U A C



CULTURE

In comparison with similar activities such as agriculture and farming, the development of aquaculture is relatively recent. It was not until the twentieth century, particularly during the second half, when the breeding of aquatic species began to be fully developed, due mainly to the progressive depletion of artisan fisheries.

In Andalusia the first practices of this kind were linked to the salt industry. As part of estuary management, the saltworks encouraged the entry of young fish and crustaceans, keeping them until they reached minimum size for consumption. Precisely as a result of the decline of the salt industry in the mid-twentieth century, the real development of aquaculture for commercial purposes got underway. In a short time, the discovery of new cultivation techniques and the search for alternative activities to the increasingly smaller traditional fisheries led to the aquaculture that now exists in Andalusia. As a result of pioneering initiatives in Cádiz, it was not long before Huelva and the rest of the Andalusian coast followed suit.

In the current context of aquaculture in Spain as a whole, Andalusia is the main producer of seawater fish. The more than 5,000 tons obtained in the year 2000 represented 95% of production in Andalusia, with the remaining 5% divided equally between mollusc and crustacean farming. The surface area devoted to aquacultural activities currently exceeds 7,300 hectares, with most of this area located in the province of Cádiz.

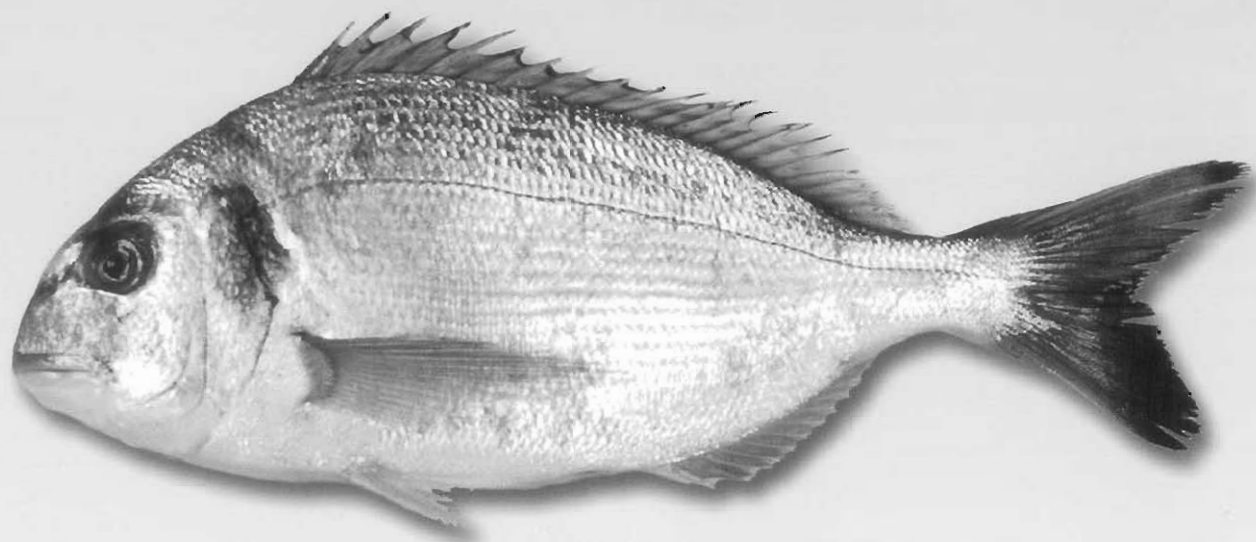
The Andalusian coastline combines what are in principle highly favourable conditions for the cultivation and production of a wide variety of species. The large expanses of marshland, saltworks and estuaries in the Atlantic area, with soft substrata and gentle inclines, are ideal for on-land marine cultivation. The Mediterranean coast, meanwhile, with mainly deep and rocky beds close to the shore, is better suited for farming in floating cages.

To develop the full potential offered by aquacultural activities, major research is needed from a biological, technical and economic perspective, on low-cost breeding of a species in question and in order to ensure economic viability in commercial terms. Considering that this process is different for each species and that for farming activity already underway perfecting techniques and increasing profitability is a constant necessity, research is clearly one of the most important aspects of aquacultural activity.

The Andalusian Department/Ministry of Agriculture and Fisheries channels most activities in this field through its two Marine Species Research and Cultivation Centres ("Agua del Pino" in the Huelva town of Cartaya and "El Toruño" in the Cádiz town of El Puerto de Santa María). The activities carried out in these centres are based on promoting, ordering and improving aquacultural practices, aimed mainly at the cultivation of molluscs in the first centre, and fish in the second. Since their creation in the 1980s, their work has been significant in areas such as technical assessment, training, support for co-operatives, aquacultural planning, environmental analysis, assessment of natural shoals, etc. These centres also participate in the National Plans for Marine Species Crops, conducting various studies and projects in collaboration with centres from other regions in Spain.

The research undertaken in recent years by the Andalusian Department/Ministry of Agriculture and Fisheries, both in its own centres and in collaboration with other research organisations (the Senior Council for Scientific Research, the Spanish Oceanography Institute and various Andalusian universities), has been extensive and varied. Much of this research has focused on the production of gilt-head and sole, the possibilities of cultivating fine-shelled and Japanese clams, and various aspects of farming microalgae. Much work has also been carried out to study the possibilities of farming new species of fish (bream, tuna and snapper) and invertebrates (scallop and octopus), and to produce analyses and economic assessments of the state of commercial aquaculture in Andalusia.

FISH AQUACULTURE



Gilt-head (*Sparus aurata*)

Andalusia is the main region producing seawater fish in Spain. The main species is dorada or gilt-head, which alone counts for three quarters of the Andalusian total and almost half of the species' production in the whole of Spain. Second to gilt-head, with much lower figures, is lubina or sea bass.

The bay of Cádiz and the marshlands of Huelva are where most of the fish farms are located. Both areas enjoy a long tradition of extensive cultivation in estuaries, where as well as gilt-head and varieties of bass, species such as mullet, eel, sole, spotted bass and meagre are also obtained.

Some seawater fish-farms produce an integral cultivation of the species in question. Most of the businesses in this sector are involved only in the fattening stage; a few provide fry, supplying the raw material for the others' activities. Recently, several companies on the coast of Cádiz have also begun to work on the nursery pre-fattening stage. They take

batches of small fry and ensure they reach pre-fatten them to the ideal size for the final fattening stage.

Sea fish aquaculture in Andalusia takes place in two different environments: in tanks on land, and in floating cages in the sea. These cages have a lower cost and higher yield, and as a result the more costly practice (in both terms of both investment and labour) of on-land fish farming tends to be used for the delicate nursery pre-fattening stages, with final fattening taking place in sea cages. This transition is slow, however, and only around a fifth of the production of gilt-head and sea bass, the two most important species, comes from farms in floating cages. Nevertheless, it is

expected for installations of this type to increase, particularly in the Mediterranean area, where conditions are highly favourable and farms already exist in Granada, Málaga and Almería.

Within this fish farming framework, the actions taken by the Andalusian Department/Ministry of Agriculture and Fisheries have concentrated on perfecting breeding techniques for the most important species, gilt-head, and on developing the necessary technology to diversify the number of species produced. The Department/Ministry has also shown support and provided assessment for both public and private initiatives by supplying biological material and

A q u a c u l t u r e



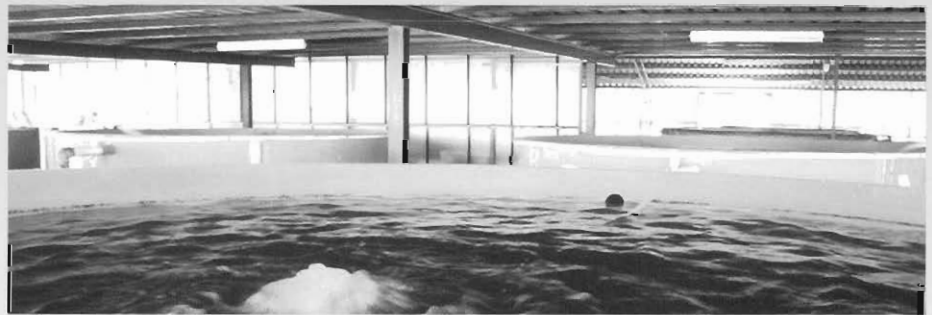
Tanks for fry



Gilt-head hatching



Extraction of samples from red tuna



Tanks for breeders

exchanging technology. Most of the research has been carried out in the Marine Species Research and Cultivation Centre of "El Toruño", on occasions in close collaboration with other research centres and companies working in the sector:

Research into improving gilt-head cultivation (production reached 4,234 tons in the year 2000) is aimed at increasing production at extensive and semi-intensive fattening installations, and at simplifying and lowering the cost of the nursery-pre-fattening and fry stages. The use of artificial diets at these stages has been one of the main ways of reducing production costs, instilling new impetus into the aquaculture industry. Given the

complexity of the studies progress is slow, but the results are bringing final success ever nearer.

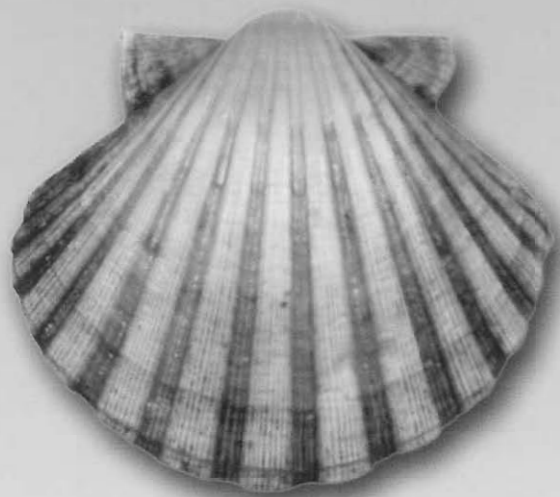
Research and experimentation work is being conducted on artificial diets in collaboration with the Institute of Marine Sciences of Andalusia, for gilt-head and other species such as sea bass and sole. Particular attention has been paid to sole in recent years through various research projects, and it seems that industrial-scale breeding will soon be a reality.

Other species in which investigation has begun include grouper, meagre, dentex, sturgeon, red tuna and various varieties of sea bream. As well as obtaining basic biological information for their maintenance and breeding in

captivity, important advances have been made in prophylactic aspects and the treatment of diseases that can affect their cultivation, as well as various systems of spawnegg induction. A pilot experience is also underway to farm fish in floating cages in the open sea, a technique which will allow existing fish-farming areas to be extended.

All these initiatives are expected to bear fruit and lead to a progressive diversification of seawater fish production, contributing to major development in Andalusian aquaculture.

AQUACULTURE OF MOLLUSCS AND OTHER INVERTEBRATES



Scallop (*Pecten* sp.)

The integral breeding of molluscs could become an essential instrument in managing the coastline's natural resources. Due to the overexploitation of most commercially viable species, repopulating with young specimens may well be a basic pillar in maintaining fisheries and the local economies dependent on them.

Of the different groups of molluscs, bivalves have been developed the most. Depending on the species, farming is either integral, with the whole reproductive cycle taking place in captivity, or in semi-cultivation, obtaining large quantities of wild larvae for controlled fattening. Integral farming is used for the various species of clams, and semi-cultivation for mussels and scallops.

Depending on the species and their ecological requirements, this fattening process is carried out in different ways. For most cultivated species the substratum is used, in what are known as intertidal parks or plots.

The south Atlantic coast of Andalusia is an ideal place for

installations of this kind, with several farms cultivating cross-cut carpet shell clams, grooved clams, Portuguese large oysters, flat oysters and, in particular, semi-fine or Japanese clams, with production reaching considerable proportions in the bay of Cádiz.

Although the conditions of the Mediterranean coast are much less suited to installing parks of this kind, it does present possibilities for floating farms. Long-line experiments have been conducted with two varieties of scallop off the Málaga coast, carried out by the Andalusian Department Ministry of Agriculture and Fisheries and the Spanish Oceanography Institute, together with mussel farms in Granada using floating troughs, and recently

installed farms of the same species in the bay of Algeciras. Experiments off the coast of Huelva are also underway on the use of long-lines for seed capture and scallop farming.

However, bivalve mollusc production in Andalusian aquaculture is still relatively low. In the year 2000 production reached just over 100 tons, with the main species being clam and large oyster. The vast majority of installations are devoted to the fattening process, with seeds generally obtained from specialist companies.

The excessive production to which most species of commercial interest are subjected, together with the huge possibilities offered by the coast of Andalusia, has led the region's

A q u a c u l t u r e



Sea farm centre seedbed



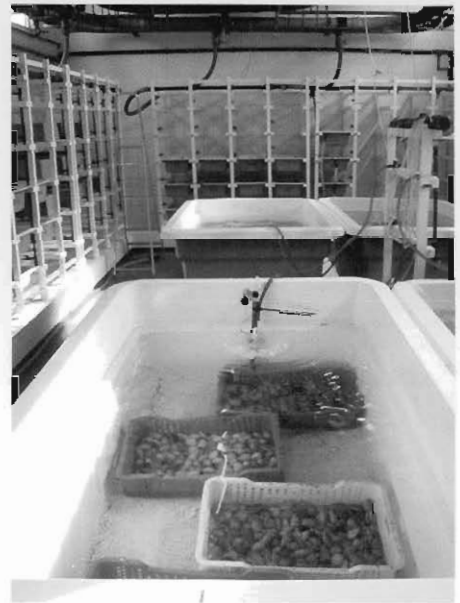
Scallop growthfattening basket



Floating troughs and cultivation park



Maintenance of breeders



Tanks for breeders

Department Ministry of Agriculture and Fisheries to prioritise development of this type of farming, with the Department's Ministry's research centres performing a highly important task. The "Agua del Pino" Marine Species Research and Cultivation Centre (CICEM) maintains a stock of bivalve mollusc reproducers, producing seeds that are used in various farming experiences and demonstrative projects. Collaboration also exists with local shellfish co-operatives in a variety of their activities. The CICEM of "El Toruño" has developed several studies and experiences for the nursery pre-fattening and fattening stages of bivalves in tanks and confined areas, as well as collaborating with co-

operatives from the bay of Cádiz and other shellfish producing areas.

Most studies in recent years have concentrated on the grooved clam and the Japanese clam, though experiments have also been carried out with other species, such as the oyster; ; pullet carpet shell a clam known as *madrealmeja*; Portuguese large oyster or *osti6n*; littleneck baby clam or *chirla*; cockle; and scallop.

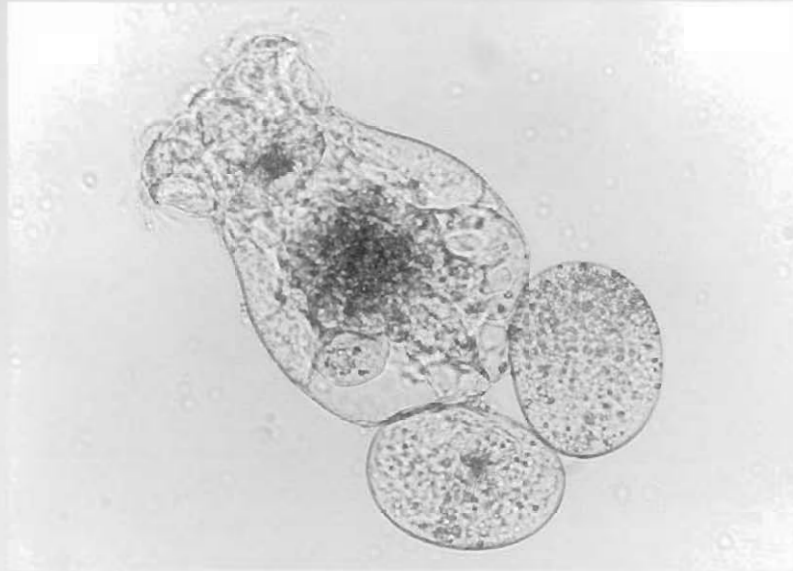
A pilot initiative is also underway to farm bivalve molluscs in long-lines in the open sea, in order to extend the possibilities of this type of cultivation.

With regard to other mollusc types, initial studies have begun for integral cuttlefish and octopus farming. Of these two, young cuttlefish have

recently been obtained, successfully overcoming the most critical stage of their development.

Apart from molluscs, in the marshlands of the Guadalquivir and in the bay of Cádiz autochthonous crustaceans are obtained in the estuaries devoted to extensive aquaculture, such as langostino prawns and, particularly, shrimps, with a total shrimp production of 110 tons in the year 2000. As for other invertebrates, preliminary work has been carried out on farming marine worms and sea urchins.

OTHER AQUATIC TECHNOLOGIES



Brachionus plicatilis

Conventional production techniques used in aquatic hatcheries are based on providing live food, namely phytoplankton and zooplankton, for the species being farmed. These elements have to be produced in the same installations as the species themselves, creating a dependence that is a serious limitation to growth in this activity. As a result, one of the main objectives in aquaculture research is to develop substitute foodstuffs.

In the case of phytoplankton, the solution to the problem lies in using micro-algae biomass, previously concentrated and conveniently preserved. For zooplankton, which is necessary during the first larva states of fish, the solution would appear to be developing food in the form of microcapsules. Although this technique is complex and problematic, it has several advantages for perfecting larva production in the future.

Recently, the application of modern biotechnology techniques has meant that the cultivation of microalgae can also have other uses. These include obtaining various types of natural substances to be sold to different the

food, pharmaceutical and chemical industries, which is the case with carotene, a pigment with highly diverse possibilities. There is also a healthy outlook for the use of marine microalgae as a source of polyunsaturated fatty acids for industrial use. These applications are being developed in the Marine Species Research and Cultivation Centre of "El Toruño", in collaboration with the University of Seville. An initiative also exists to investigate the possibilities of farming red bait with the aim of producing anti-tumour composites.

One of the main fronts that aquacultural R&D is working on is that of constant technical adaptation

and technological innovation to improve and perfect its means of production, which involves ongoing and possibly never sufficient work. This is certainly the case of the centres attached to the Andalusian Fisheries Department Ministry. Intense efforts to develop new aquacultural techniques, one of the main functions of these centres, require a costly infrastructure (large cultivation tanks, water catchment and renovation systems, etc.), requiring major investment for upkeep alone. Moreover, the farming systems and complex equipment installed in these centres must also adapt to the advances made in the fields that affect aquaculture, both

A q u a c u l t u r e



Sole larva



Production of microalgae



Dunaliella salina tank



Concentrated microalgae biomass bags

biology and applied engineering, through adaptive research and technical innovation.

But development in aquaculture also requires other lines of action to complement the biological and technical studies carried out. Particularly important are economic studies that allow the aquacultural industry to be monitored, evaluating both current performance and future viability. This control is fundamental to establish measures and open new installations, perform market analyses, design methodologies to optimise and improve production, and so on.

As a whole, research into this new and wide range of fields requires

participation and collaboration from a wide group of specialists from various backgrounds. As a result, many of the Andalusian Department's Ministry's activities have come about through collaboration agreements with various universities (Seville, Málaga, Almería and Cádiz) and the Andalusian Institute of Marine Science, in Cádiz.

Both in co-ordination with these centres and independently, in recent years the Department Ministry has initiated several research projects with wide-ranging objectives, such as: to obtain concentrated biomass from microalgae; to design and produce microcapsule diets; to design, on a pilot scale, a carotene production plant

using *Dunaliella salina* microalgae; to develop computer applications to control aquacultural installations; and to determine the feasibility of using biological filters in water recirculation systems for fish farms. Another important field of studies is the economics of aquaculture. In collaboration with the University of Málaga a strategic analysis has been produced of the aquaculture sector in Andalusia, as well as a major study on the evaluation and viability of projects from a business point of view.

PRODUCTION CONTROL



and QUALITY

Andalusia, and Spain in general, has a long tradition of fish consumption. Fish has been a key element in the regional diet since time immemorial, particularly in the coastal towns. Proof of this is the wide variety of dishes based on fish and seafood that enrich the area's gastronomy.

Over time, this ancient tradition led to the development of a large fishing fleet (for a time one of the largest in the world) and to a structuring within the national economy of an extensive and efficient network of fish distribution. The size of this fleet, helped by the amount of coastline, meant that for a long time Spain was among the world's main producers of fish and seafood. However, in recent decades and for various reasons, catches by the Spanish fleet have slowly dwindled, and Andalusia has not been exempt from this process.

This reduction in extraction capacity has been accompanied by an increase in demand, among other reasons due to the increase in income enjoyed by Spaniards. In Spain 40 kg of fish are now consumed per person each year, making it the second European country in consumption, behind Norway, equal to Portugal and fifth in the world. Spain also stands out, together with Japan, for the diversity of fish products consumed. The country has gone from being a net exporter to one of the main importers of fish in order to cover demand.

This increase in the demand for fish has been accompanied by a progressive selective trend in consumers, who are increasingly more demanding when it comes to the quality of fish products, both fresh and pre-prepared, to the extent that quality has an enormous influence on the end sale price of fish. Added to this market circumstance are the consequences of adapting to European Union standards in terms of quality control and the hygienic conditions of fish products, as well as regulations for their normalisation and characterisation.

This quality control in fish products is based principally on controlling the conditions of the marine environment in production areas, in terms of both water quality and the different pathologies that may be present and affect the species being farmed. These pathologies, even when they pose no threat for human health, affect the final quality of the product and, subsequently, its market value. In the worst case they can lead to a drop in fish resources, resulting in serious financial losses and endangering the continuity of entire fisheries and fully established aquacultural sectors.

With these objectives, for some years now the Andalusian Department/Ministry of Agriculture and Fisheries has been carrying out an intensive marine environment control programme, monitoring water quality in production areas and the organisms caught in them, establishing pollutant levels at every moment and declaring prohibitions when these levels are exceeded. The Department/Ministry also implements research programmes aimed at controlling the pathologies that affect both fishing and sea-farming installations.

However, all this effort to improve and control the quality of fishing along the coast of Andalusia and in its aquacultural installations is useless if the product cannot be correctly identified over other imported products that compete on the market. The Department/Ministry supports labelling and marketing programmes as required by current legislation, as well as the development of techniques to allow for the correct identification and characterisation of Andalusian fishing products. In the near future they will be clearly identifiable by consumers, avoiding confusion with other products brought from outside the region. This will be the end result of the efforts made by the Andalusian Department/Ministry of Agriculture and Fisheries, in which quality is a priority objective in order to guarantee the future of the region's fishery sector.

THE MARINE ENVIRONMENT



Sanlúcar de Barrameda (province of Cádiz)

The majority of the population of Andalusia lives on the coast. This area is also home to major industrial complexes and some of Spain's most well developed areas of intensive agriculture, as well as being a holiday resort for millions of people. The waters near the Strait of Gibraltar coast, meanwhile, have some of the busiest maritime oil traffic in the world.

In areas of dense population or industrial complexes, and at the mouths of the rivers crossing these areas, relatively high levels of pollution sometimes occur. Apart from the direct consequences on sea water quality, pollution can also have a negative influence on the fishery sector, leading to a drop in production or in value of fishery products due to their lower quality. In extreme cases pollution may even pose a threat to human health, either through direct exposure or as a result of consuming products obtained from contaminated waters.

The typical sea pollutants can be grouped into four categories: chemical products, heavy metals, sewage, and petroleum and its derivatives. To these

must be added the biotoxins produced by some species of microscopic algae present in phytoplankton. These biotoxins, which are toxic to humans, can be consumed by eating filtering molluscs which, due to their diet, accumulate them in their tissue.

All these circumstances mean that rigorous pollution control measures are needed, which the Andalusian government implements through its Department Ministry of the Environment and Department Ministry of Agriculture and Fisheries, which tends to deal with all aspects related to water quality and the control of pollutants that might affect the farming and sale of live marine resources, particularly in areas of

fishery and aquaculture production. The Department Ministry is also studying the effects of these contaminants on the different marine species of interest to the fishery and aquaculture sectors, and their incidence on the marketing of fish products in general.

With regard to this aspect, the technical project with the greatest scope is the Sanitary Control of Bivalve Mollusc Production Areas. This control is carried out in the 44 production areas along the coast of Andalusia. In all these areas, analyses are systematically and periodically carried out on microbiology, toxic and non-toxic phytoplankton, metals, pesticides and radionuclides, both in bivalve

P r o d u c t i o n a n d Q u a l i t y



Taking samples from bivalve molluscs



The industrial use of the coast



Taking seawater samples



Maintaining bivalves



Microalgae (*Odontella* sp.)



Production areas control laboratory

molluscs and in seawater, which is also analysed for its phytoplankton content.

When the results indicate levels over those legally established for a particular parameter, the Provincial Delegations of the Andalusian Department Ministry of Agriculture and Fisheries temporarily close off the affected areas, which are only opened once it is certain that the pollution has disappeared, for which results inside the legal limits must be obtained in at least two consecutive samples.

This programme requires an important and permanent deployment of equipment and personnel all along the Andalusian coastline to ensure continuity and effectiveness in both the collection of samples and their

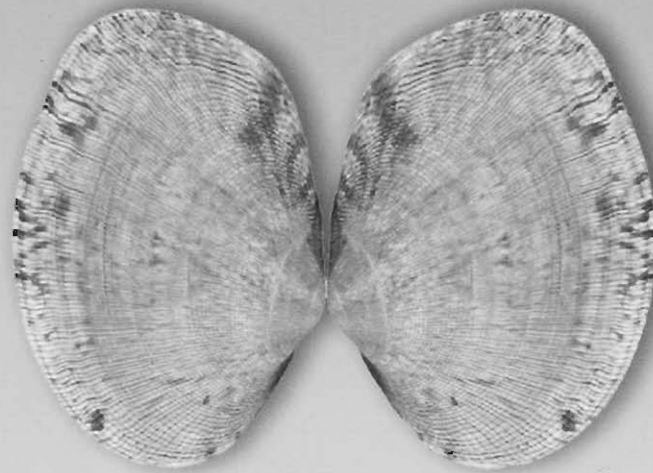
subsequent analysis, and in the speed and timeliness needed in the decision-making process. The programme implies adaptive research, aimed at using the latest analytical control techniques, and investigation geared towards surveying current conditions, as well as studies into the regulations to be applied in this field.

Another of the Department's Ministry's important line of work is the study of the effects of pollutants on the seafood and shellfish resources of the Andalusian coastline, in collaboration with the universities of Córdoba and Huelva. These investigations pursue the development of new analytical techniques and the improvement of existing knowledge on

the transformations that contaminants can undergo, how they act on living creatures, the way they are accumulated, and the periods of time and mechanisms that the animals use to eliminate them.

Among other experiences, various collaboration projects also exist between the laboratories dependent on the Department Ministry, and other Spanish and European laboratories, in terms of grading, analysis protocols, and so on. Tests have also been carried out to come up with simple treatments to eliminate biotoxins in certain species of mollusc.

PATHOLOGY AND ZOOSANITARY PROPHYLAXIS



Clam (*Ruditapes decussatus*)

In both fishery and aquaculture products, the diseases that affect sea organisms can result in a drop in quality and a fall in production, leading to major financial losses. This problem affects the aquaculture sector most, as pathogenic processes are favoured when the affected species live in a situation of high population density.

The special conditions in which aquacultural organisms are farmed (in a relatively confined medium, with a lower degree of renovation than in natural conditions, and a high population density) can lead to the appearance and development of infectious episodes, resulting in major financial losses. The capacity of water to transport and spread substances of all kinds adds a certain risk to aquaculture so that, just as in cattle farming and agriculture, strict and periodic health controls are necessary.

In the case of bivalve mollusc farming, some of the most important diseases which affect these species in terms of incidence and consequences are those caused by various protozoa and bacteria. In fish, the most

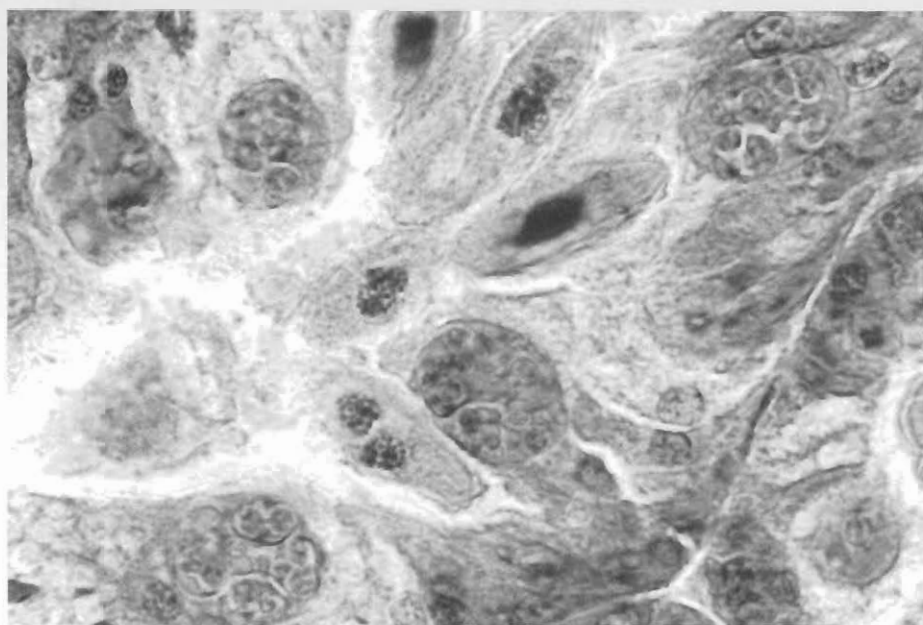
important pathological processes are of an infectious, environmental, nutritional and tumorous nature, together with malformations. Pathogenic infections (i.e. infectious diseases) are associated mostly with, all caused by viruses, bacteria and protozoa.

It has been proved that water quality plays a fundamental role in the development of infectious diseases and toxicological processes, so that its control in both the installations and the surrounding environment from where the water is taken is of vital importance for their prevention.

The conditions that the organisms are in are also highly important. Stressful and traumatic situations or conditions, which occur with relative

frequency during the farming process, and manipulating organisms, can be the origin of many infections. Other factors to take into account are nutrition and the characteristics of the specimens in question: their hereditary predisposition, size, age, stage in the reproductive cycle, and so on.

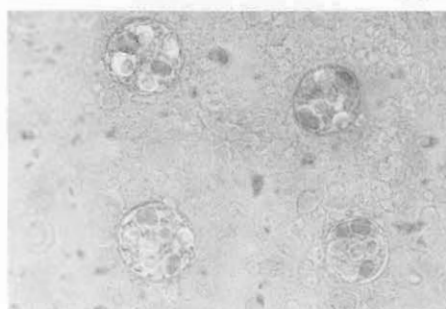
As a result, the prevention and control of various pathologies that can affect marine species production crops is a fundamental concern in aquaculture. Pathological studies are also important in the preliminary stage of farming research, as it may occur that the species in question has a natural tendency to develop diseases in farmed conditions that makes it unfeasible to invest in commercial breeding without resolving this



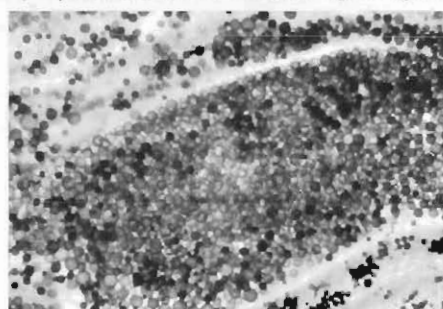
Marteilia refringens and *Ancistroma* in oyster digestive gland



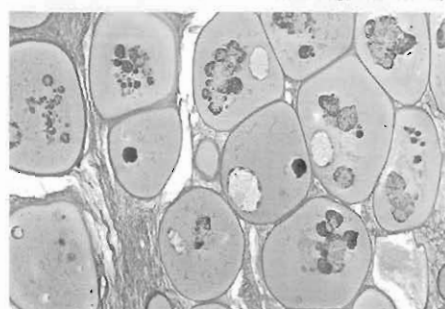
Pathology laboratory



Marteilia refringens in oyster



Perkinsus atlanticus in clam samples



Gilt-head tissue with lymphocystis

problem first.

For all these reasons strict control is necessary of all the possible pathogenic elements to prevent the infectious processes, reducing their incidence as much as possible and ensuring that aquacultural products are in a perfect state of health.

The Andalusian DepartmentMinistry of Agriculture and Fisheries has devoted much time to studying and monitoring pathologies that affect both the bivalve molluscs that are of most commercial interest for the fishery and aquacultural sectors, and farmed fish species, particularly gilt-head, because of its importance in Andalusian aquaculture. Although some of the research that is carried out takes place in collaboration

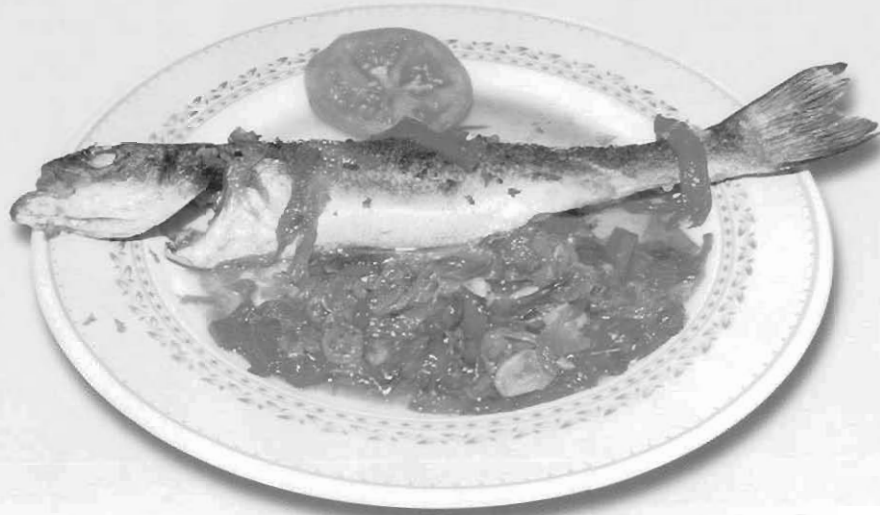
with other scientific centres (the universities of Málaga, Granada and Cádiz), the work done by the centres dependent on the DepartmentMinistry itself in their respective pathology laboratories is also moving in this direction.

As well as investigating several aspects of the major pathologies that affect Andalusian aquaculture, these laboratories have developed specific methods of prevention, diagnosis and treatment of different diseases that have proved to be efficient at least in reducing their impact; to which must be added their ongoing work monitoring the dispersion and incidence of these pathologies along the Andalusian coastline.

Another field in which the

DepartmentMinistry is conducting research work is that of the diseases that fishery products can potentially pass on to humans. One of the most widespread of these is anisakidosis, produced by a parasitic sea worm. The DepartmentMinistry has tackled this problem with a study aimed at determining the risk of infection, which may occur by eating raw or undercooked fish. The results have shown that, given the usual eating habits and the indices of presence of these parasites in fish, in Andalusia this risk is minimal.

FISHERY AND AQUACULTURAL PRODUCTS



Dish prepared with farmed sea bass

The removal of import duties and market globalisation have meant that an unprecedented variety of fish and derived products are now available to consumers. Transformed presentation practices (removing the head, slicing or filleting the fish, etc.) or processing (cooked, smoked or pre-cooked), makes it impossible for them to be identified, to the point that distinguishing between similar species can be practically impossible.

Many similar species of fish often have different qualities, and therefore different commercial value. This can lead to certain irregularities in the marketing of species and their derived products, despite the fact that the regulations in force require the scientific name of the species to be included on the labelling of a substantial part of the fishery products that are marketed. However, frozen and conserve products, which make up over 50% of fish product imports, fall outside these regulations.

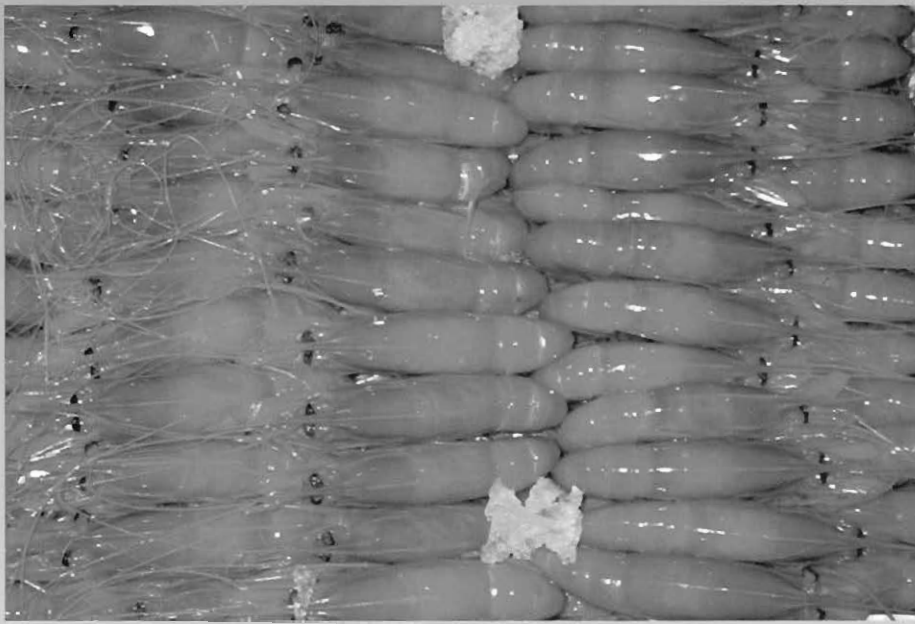
The fact that Spain is a major consumer of fish and that commercial relations with other regions are on the increase means that the near future will bring a progressive increase of

fishery products imported from other countries that are difficult to identify, particularly in processed or ready-prepared products.

If added to this is the increasing role of genetically modified foodstuffs in our eating habits, the need clearly arises to develop techniques that will ensure labelling regulations are complied with. Accurate information needs to be given to consumers, who already find it practically impossible to identify many species. Finally, a perfect characterisation of fishery products is the only way consumers can differentiate between locally produced and imported fishery products. The only way for the Andalusian fishery sector to compete with imported

products is through quality. Viability comes by the consumer associating that quality with Andalusian products, making perfect labelling and identification of products and species a fundamental necessity.

The Andalusian Department/Ministry of Agriculture and Fisheries, a firm believer in promoting this quality, is aware of the need to bring about perfect control and identification of both fresh and ready-prepared products. A laboratory is therefore being installed in "El Toruño", one of the Department's/Ministry's Marine Species Research and Cultivation Centres, which by using modern techniques based on identifying DNA will allow marketed



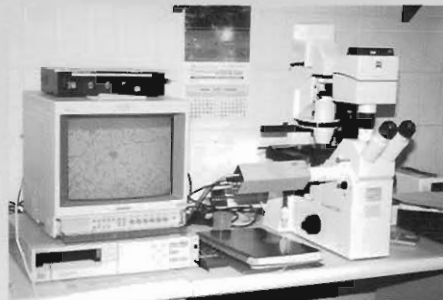
Scarlet shrimp prepared for market sale



Canning factory



Farmed gilt-head



Analysis laboratory



Salted fish being prepared

species and derived products to be correctly recognised, and it will also be possible to differentiate between local and imported species. Apart from improving their marketing, in time this will inject the Andalusian fishery sector with the fresh impetus it needs.

Apart from the identification of fishery products, it is also important to develop new processes to improve existing preservation techniques. Thus, one of the most important fields in the fresh product market is that of seafood and shellfish. The high prices that these products fetch on the market can drop considerably if consumers detect any characteristic that makes them doubt the freshness of the product, even though this does not actually

affect its quality.

The Andalusian Department Ministry of Agriculture and Fisheries is focusing another line of work on this aspect. In collaboration with the universities of Almería and Huelva, and with the Instituto del Frío (part of the Senior Council for Scientific Research), studies are being made on the effectiveness of various preserving agents in small fished and farmed crustaceans. The aim of this research is to guarantee ideal conditions for marketing the products and that legislation is complied with in terms of using preservatives that do not pose a threat to consumers' health.

Investigations have concentrated on melanosis, a natural process that leads

to black stains appearing on seafood, an aspect which while not affecting its hygienic quality does lead to a considerable depreciation in market value. The process and its inhibition are being studied, as is the development of preservatives that meet atoxicity and commercial effectiveness needs. Preliminary results are promising, as some substances, such as hexyl-resorcinol, used either on their own or in combination with bisulphites, appear to be effective preserving agents that prevent this phenomenon.



*MARINE SPECIES
RESEARCH and
CULTIVATION
CENTRES*

Modern research into aquaculture began in Andalusia in the 1970s, coinciding with the South-Atlantic Region Plan for Shellfishing and Marine Aquaculture Seafood and Marine Crop Farming Plan. Once powers were transferred to the Andalusian Government, research began in earnest when two Centres for the Research and Farming of Marine Species (CICEMs) were opened in 1986, "El Toruño" in Cádiz, and "Agua del Pino" in Huelva.

These centres were created with the objectives of fostering, planning and improving shellfishing/seafood and marine aquaculture along the Andalusian coast, particularly on the Atlantic side. Since their creation research work has been divided between the two. The CICEM at "El Toruño" focuses mainly on fish farming, and the "Agua del Pino" centre concentrates on molluscs and crustaceans. Their work also includes providing technical advice, training, support for co-operatives, producing aquaculture planning projects, studies of natural shoals, environmental analyses, etc.

The "Agua del Pino" CICEM is located in Cartaya, in the province of Huelva. The centre has a main building, where administrative duties and the research itself take place, a hatchery and nursery area, where aquacultural production and investigation are conducted, and a series of external installations, used for work supporting production, industrial-scale research and water treatment.

The other CICEM, "El Toruño", is located in the municipal boundaries of El Puerto de Santa María, in the province of Cádiz. Next to the centre's main building is the hatchery and nursery and seedbed, for fish and mollusc production and initial growth/producing and pre-fattening fish fry and mollusc seeds, with adjacent installations used for production and investigation support work. The centre also has a marinesea farm with several tanks for pre-fattening and intensive farming, and 30 land pondstanks on land with two reserve ponds, covering a total surface area of 33 hectares.

The equipment used in the two centres for the research, experimentation, information and training work entrusted to them, includes the following:

- Pumping installations. In the case of the "Agua del Pino" CICEM, the pumps are located on the edge of the maritime/terrestrial area on the left bank of the River Piedras, with a capacity of 150 m³/h of seawater. The other CICEM, "El Toruño", on the right bank of the River San Pedro, has pumping installations in the farm area, with one 3,000 m³/h and two 1,000 m³/h capacity pumps, together with another installation covering production and research needs in the buildings, with two pumps capable of 150 m³/h.
- Seawater treatment and filtration installations, including a set of sand filters, cartridge filters, heat pumps with compressors, and saltwater-fresh water heat exchange systems.
- Cultivation rooms.
- Laboratories, used for production control, physical and chemical analysis, analysis of sediments, pathology, microbiology, planning, cryopreservation and cultivation environment preparation.
- Auxiliary installations, where cultivation environments and feeds are prepared, with a freezing chamber and a preservation refrigerator.
- Electrical, mechanical and carpentry workshops for the installations' upkeep.

The projects and lines of research and technical development carried out in these centres focus on three main aspects: Marine Ecosystems, Aquaculture, and Production and Quality Control. The centres' performance in all three is outstanding, working both individually and in co-operation with other scientific and industrial organisations, and actively participating in aquacultural production processes, studying new species and farming techniques, experimental production works, technological monitoring of farms, installations technology, marine resources management, environmental control, etc. Both centres also work on information disclosure and on training technicians in all these aspects.

ACTION TAKEN BY THE ANDALUSIAN DEPARTMENT MINISTRY OF AGRICULTURE AND FISHERIES IN AQUACULTURE AND FISHERY RESEARCH AND TECHNOLOGY

The projects developed and actions taken by of the Andalusian Department Ministry of Agriculture and Fisheries are governed by situated within the framework of its powers in matters of fishery and oceanographic research, aquaculture and the disclosure of fishery technology. These activities have been carried out since 1997, in accordance with the priorities of the Modernisation Plan for the Andalusian Fishery Sector, as part of in the corresponding operative research programmes for on research into fishery resources, structures, industry and markets, and to consolidate aquaculture as a commercial activity.

As well as these fishery and aquacultural R&D initiatives carried out in the Marine Species Research and Cultivation Centres (CICEMs) assigned to the Andalusian Department Ministry of Agriculture and Fisheries (Agua del Pino in Cartaya, province of Huelva, and El Toruño in El Puerto de Santa María, province of Cádiz), several other research and technological innovation projects are also carried out under the auspices of the General Directorate of Agrarian and Fishery Research and Training, and developed in collaboration with various scientific and technical organisations, as well as other technical studies promoted by the Fishery and Agriculture General Directorate Services, including the following actions classified into thematic areas:

FISHERY RESOURCES

- Study of the bay of Cádiz: Protection of natural fishery resources and application for aquacultural installations.
- Locating suitable places for open-sea fish farming in Andalusia.
- Creation and operation of a grading database, validation for oceanic spatial sensors.
- Assessment programme for seafood resources in Andalusian waters.
- Economic-financial analyses of aquacultural businesses in Andalusia. Management indicators.
- Development of a Statistical and Fishery Information System for Andalusia.
- Bioeconomic and Statistical Analysis of Andalusian Fisheries. Conil and Tarifa Fishing Grounds.
- Monitoring development programme for artificial reefs along the Andalusian coast.
- Production and repopulation of fish for the coast of Cádiz.
- Recovery project for the artisan fishing ground off the south Atlantic coast of Cádiz: Repopulation and diversification in aquaculture (autochthonous species).

AQUACULTURE

- Study for experimental farming of sea species on the coast of Granada.
- Feasibility of cultivation in marshland areas. Development of an aquaculture that is profitable and compatible with the environment in Andalusia.
- Improvement of production levels by means of technological advances in farming new marine species.
- Formation and maintenance of reproductive shoals of sea fish.
- Acclimatisation and cultivation/fattening of octopus (*Octopus vulgaris*) and cuttlefish (*Sepia officinalis*) in different farming conditions. Obtaining spawn, larva production.
- Octopus cultivation/fattening in different farming conditions and systems. Production and feeding of post-larvae.
- Creation of a shoal of select reproducers of sea bream (*Pagellus bogaraveo*).
- Genetic studies on sea bream (*Pagellus bogaraveo*).
- Co-ordinated project to develop integral farming of sole (*Solea senegalensis*).
- Pilot-scale assessment of a microcapsule diet for farming sea fish larvae (gilt-head and sole).
- Assessment of the possibilities of producing meagre (*Argyrosomus regius*).
- Domestication of red-banded sea bream (*Pagrus auriga*). Growth and reproduction (first and second stages).
- Controlled reproduction of red tuna (*Thunnus thynnus*).
- Development of techniques for massive farming of sea bream (*Pagrus pagrus*) and dentex (*Dentex dentex*) larvae.
- Feeding and handling gilt-head in tanks.
- Practical improvements for in gilt-head at nursery stage/pre-fattening: farming in cages.
- Incorporation of probiotics into microdiets for sea fish larvae.
- Optimisation and improvement of semi-intensive gilt-head (*Sparus aurata*) farming in sea farms in San Fernando (province of Cádiz).
- Farming of scallops in open-sea floating systems.
- Programme to develop and run pilot experiences with open-sea cages.
- Obtaining concentrated microalgae biomass to be used as feed for sea species larvae.
- Conservation of the collection of microalgae and zooplankton tetrameric strains.
- Development of technologies to obtain carotenoids from microalgae.
- Assessment of the production of carotene by *Dunaliella salina* off the Andalusian coast.
- Development and implementation of computerised application for technical-economic management in aquacultural fattening farms. E

PRODUCTION AND QUALITY CONTROL

- Characterisation and mapped information studies on the control and monitoring system for seawater quality and the incidence of toxic algae in areas of production along the Andalusian coast.
- Production of an information system for the characterisation and mapping of seawater quality and mollusc pathologies on the Huelva coast.
- Study on the effects of pollutants on Andalusian fishery resources.
- Bivalve mollusc detoxification test.
- Production of a zoosanitary map of pathologies affecting the farming of gilt-head (*Sparus aurata*) in Andalusia.
- Production of a zoosanitary map of *Perkinsus* spp. on the Andalusian coast.
- Development of a molecular diagnosis method for *Perkinsus atlanticus*.
- Development of a molecular diagnosis method for *Marteilia retringens*.
- Studies on melanosis inhibitors in crustaceans. Assessment of preserving agents.
- Studies on the identification and characterisation of fishery products.

DIRECTORY OF RESEARCH CENTRES BELONGING TO THE ANDALUSIAN AGRICULTURE AND FISHERIES DEPARTMENT, AND RESEARCH ORGANISATIONS WITH WHICH SPECIFIC FISHING AND AQUACULTURE COLLABORATION AGREEMENTS HAVE BEEN REACHED

"El Toruño" Marine Species Research and Cultivation Centre
Apdo. 16
11500 El Puerto de Santa María (Cádiz)
Tel: (+34) 956 56 23 40 / 42 / 47
www.cap.junta-andalucia.es

"Agua del Pino" Marine Species Research and Cultivation Centre
Apdo. 104
21450 Cartaya (Huelva)
Tel: (+34) 959 39 91 04
www.cap.junta-andalucia.es

**Dept. of Applied Biology
Faculty of Experimental Science
University of Almería**
Carretera Sacramento s/n
La Cañada de San Urbano
04120 Almería
Tel: (+34) 950 21 51 11
www.ual.es

**Dept. of Animal Biology, Vegetable Biology and Ecology
Faculty of Marine Sciences
University of Cádiz**
Polígono río San Pedro s/n
11510 Puerto Real (Cádiz)
Tel: (+34) 956 016 018
www.uca.es

**Dept. of Biochemistry and Molecular Biology
Veterinary Faculty
University of Córdoba**
Avenida de Medina Azahara 9
14071 Córdoba
Tel: (+34) 957 21 86 86
www.uco.es

**Dept. of Genetics
Faculty of Biological Science
University of Granada**
Avenida Fuerteventura s/n
18071 Granada
Tel: (+34) 958 248 924
www.ugr.es

**Dept. of Chemistry and Material Science
Senior Polytechnic College
University of Huelva**
Ctra. Palos de la Frontera s/n
Tel: (+34) 959 017 829
www.uhu.es

**Dept. of General Economics and Statistics
Faculty of Business Science
University of Huelva**
Plaza de la Merced 11
21002 Huelva
Tel: (+34) 959 017 829
www.uhu.es

**Dept. of Economics and Business
Administration
Faculty of Economics
University of Málaga**
El Ejido s/n
29071 Málaga
Tel: (+34) 952 13 11 50
www.uma.es

**Dept. of Microbiology
Faculty of Science
University of Málaga**
Campus de Teatinos s/n
29071 Málaga
Tel: (+34) 952 13 18 99
www.uma.es

**Institute of Plant Biochemistry and Photosynthesis
Isla de La Cartuja Scientific Research Centre
Senior Council for Scientific Research (CSIC)-
University of Sevilla**
C/ Américo Vespucio s/n. Isla de la Cartuja
41092 Sevilla
Tel: (+34) 954 48 95 01
www.ibvf.cartuja.csic.es

Fishery Biological Station
(run by the Oceanographic Centre of Málaga)
East Pier (Fishing Port)
Aula del Mar, Apdo. 2609
11106 Cádiz
Tel: (+34) 956 261 333
www.ieo.es/centros.html

**Oceanographic Centre of Málaga
Spanish Institute of Oceanography (IEO)**
Puerto Pesquero s/n
Apdo. 285
29640 Fuengirola (Málaga)
Tel: (+34) 952 476 955
www.ieo.es/centros.html

Andalusian Institute of Marine Science (CSIC)
Campus río San Pedro
11510 Puerto Real (Cádiz)
Tel: (+34) 956 83 26 12
www.icman.csic.es

Institute of Cold (CSIC)
C/ Ramiro de Maeztu s/n
Ciudad Universitaria
28040 Madrid
Tel: (+34) 91 544 56 07
www.if.csic.es

**Oceanographic Centre of A Coruña
Spanish Institute of Oceanography (IEO)**
Muelle de las Ánimas, s/n
Apdo. 130
15001 A Coruña
Tel: (+34) 981 205 362
www.ieo.es/centros.html



JUNTA DE ANDALUCÍA

Department of Agriculture and Fisheries