CHAPTER 9

Fishes and Fishermen. The Exploitable Trophic Levels

CARLES BAS, ENRIQUE MACPHERSON and FRANCESC SARDA

Instituto de Investigaciones Pesqueras, Paseo Nacional, s/n, 08003 Barcelona, Spain

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9.1. THE FISHING TRADITION IN THE WESTERN MEDITERRANEAN

Evidence of fishing activity going back to ancient times can be found all around the Mediterranean Sea and numerous centres of population along the coast can trace their origins to this activity. Progress has been rapid in recent decades, with new technology being particularly applied to navigation and changes in some of the most commonly used fishing techniques. Formerly it was possible to divide fishing into two main categories: that carried out from shore, using nets and fish traps, and that requiring the use of one or more fishing boats. Offshore, a wide variety of gillnets, pots and longlines were used, together with primitive forms of trawl gear, including beam trawls, pair trawls, and otter or bottom trawls. The latter has undergone the greatest development, with constant technical advances both in the gears themselves and in the trawl vessels. In the pelagic fisheries — primarily those directed at pilchard and

anchovy — the use of special gillnets for pilchard and the like has given way to purse seines, in which the bottom of the net is drawn shut to prevent the surrounded shoal from escaping.

Progress has not been smooth and occasionally has produced great tension, as, for instance, when gillnets were replaced by purse seines in the pilchard fishery. Other changes have resulted from alterations in the behaviour of the shoals, as, for example, with the disappearance of practically all tuna traps as the migrating tunas moved further and further offshore. Generally speaking, the increased economic value of fish products has been the major incentive underlying the development of modern fisheries in the Western Mediterranean.

Another important factor in fisheries development in the region is the great seafaring spirit of the peoples dwelling along these shores, a trait seen not only in fishing activities, but also in sailing in general. There were many notable shipyards for building crafts of all kinds, and the Catalonian and Genoese fleets, to name but two, were famous not only for their ships but for their sailors as well. This seafaring spirit also bore fruit in the field of fishing and explains the abilities of these peoples as entrepreneurs; for they ranged far and wide, founding important fishing and fish processing centres. There was a marked tendency for coastal fishermen, from the south-western Mediterranean, Italy and Spain, to move north, especially during this century, so that to a great extent it can be said that technological innovation has been concommitant with this migratory process. Thus as they settled in ports further and further north, the southern fishermen have supported or motivated technological progress. Even today, whenever concentrations of fish are detected, they are caught by large contingents of fishermen arriving from southern ports.

However, the basic origin of fishing as an artisan activity has not been abandoned, not even in recent, highly developed forms of exploitation, for the industrial side of fishing operations has penetrated the fishing strategy of these shores only with great difficulty. A certain spirit of adventure and a catch-oriented ethos, rather than the concept of industrial production, have been the driving force behind development. In other words, the industrial concepts of markets and production were totally foreign, with the result that, while fishermen progressed slowly and had to seek personal motivation in family tradition, in many cases centuries-old, the buyers and the markets rapidly improved their economic capabilities, manipulating the product under the stimulus of its economic value, becoming the true arbiters of fishing activity. The considerable technological advances in fishing methods and increasing contacts among fishermen from different ports have accelerated the transformation of artisan fishing into an industrial process: an activity whose objectives include not only the catches but also mass production and cost-effective performance, with proper pricing and marketing of the product.

The Mediterranean Sea as a whole, and the western basin in particular, has a relatively low productivity rate, with high mean temperature and salinity. It is, therefore, understandable that abundance should be reduced as far as exploitable fish concentrations are concerned. Nevertheless, using one innovation after another, Mediterranean fishermen are moving resolutely forward — as though the Mediterranean was really a sea rich in resources. This is, perhaps, one of the most distinctive features of the fishing tradition in this region.

It is important to analyse the recent history of developments in the field of fishing. The most striking aspect is undoubtedly the gradual disappearance of artisan gear (trammel nets, bogue gillnets, entangling gear in general, longlines, hand lines, and so forth) whereas certain others, such as pots, still remain in use. This apparent decline does not reflect a lack of interest in fishing, even in the face of higher paying jobs in the expanding building and tourist sectors. Rather it emphasizes a fundamental change in fishing methods towards greater effectiveness and selectivity. Consequently, although the number of small boats using artisan gear has decreased tremendously, and many of their crews have abandoned fishing altogether, other fishermen with a true love of their work have, in contrast, attempted with renewed vigour to develop the new trawling and seining techniques which are currently so extraordinarily successful.

The tendency to expand fishing activities towards offshore waters is confined to the ports of southern and south-eastern Spain. Elsewhere the general tendency is to exploit waters in the vicinity of the home port; greater mobility being apparent only in the purse seine fishery.

9.2. FISHING VESSELS AND GEAR

Despite important differences between regions and countries, the development of the inshore fisheries in the Western Mediterranean has, in recent years, exhibited a strong tendency towards uniformity in both the gear and vessels employed. Two important factors have contributed to this: the uniform topography of the sea bed and the fact that the species exploited are practically the same. Yet this does not mean that there are no differences in the relative proportions of these.

Generally speaking, bottom trawling and purse seining in surface waters are the two main fishing techniques, for artisan fishing methods — gillnets, longlines, different kinds of fish traps, etc. — have declined considerably. This has led to much uniformity between vessels, gear, and technological advances at the different ports.

There is a growing tendency to replace wood with steel in the building of ships' hulls, especially with trawlers, and some experimentation is under way with hulls built of glass reinforced plastic. Although technological development started with the trawlers, it is now the purse seiners that are undergoing rapid modernization, using vessels which are more like trawlers. Similarly, there is an extensive, but still not totally widespread, use of variable-pitch propellers, multi-cylinder high rpm engines, two-way radio communication, significant improvements in navigation and position-finding systems and the use of echo sounders to detect bottom features and fish schools, and many other innovations, especially on medium and larger vessels. Small boats engaging in different kinds of artisan fishing have been converted from older, smaller, low-power trawlers. Some of these boats are of recent construction, normally of wood with rather rudimentary support technology. Such boats carry auxiliary equipment to facilitate the handling of the most commonly used gears.

The average length of trawlers is around 25 m, corresponding to a mean GRT of some 75 tonnes. They are powered by engines averaging around 400 h.p. (the range of engine power running from 250 to 1,000 h.p.). The hold capacity for storing the catch is usually small, as fishing is normally carried out on a daily basis. On trawlers the crew size is around 10 and purse seiners about 14 men although these are decreasing as technology improves. For example, the crews on these boats have shrunk from 20-22 men since the introduction of power blocks. The catch is preserved on ice, which is loaded on board prior to sailing, although refrigeration plants are beginning to appear on some boats. On trawlers, the winch equipment has undergone the most intensive mechanical development, with considerable increase in power as the drive systems have been modified. Formerly, winches were driven by belt drives from the main engine, but they now have their own individual, normally hydraulic, drive systems. Purse seiners usually carry two small purse boats equipped with lights with luminous intensities of between 12,000 and 24,000 candlepower. Finally, relatively simple winches or hauling blocks have been installed on most artisanal boats to facilitate the setting and retrieval of the different kinds of gear.

Mediterranean trawl gear is considerably larger than that employed in other fishing areas. There are a number of different designs, nearly all aimed at achieving a wider mouth opening and to increase the fishing power of the net. Trawl net openings of up to 20 m are now common. A striking feature of net design is the length of the wings, which makes it possible to sweep a broad section of the bottom. The trawl otter boards are in most cases rectangular in shape (few trials have been carried out using oval or polyvalent boards). Long sweeplines (usually 200 m from trawl board to wing tip) are necessary to separate the wings and thereby increase the area swept by the net. Pelagic trawling gear is not used,

although similar designs are towed along the bottom. Polyamide and polypropylene fibres are used in the manufacture of this equipment. The codend mesh size is usually between 36 and 40 mm (measured diagonally with the mesh stretched).

Seine gear, mostly purse seines, vary in size according to the home port (ranging between 400 – 700 m in length by 100 – 240 m in depth, stretched mesh size). The commonest mesh sizes vary only slightly, around 18 mm (again measured diagonally with the mesh stretched). Much smaller gear is used in Tunisia (170 – 280 m in length by 40 – 50 m in depth, with a slightly larger mesh size of around 20 mm). All this gear is used to catch surface pelagic fish — chiefly pilchard and anchovy — that tend to form rather dense shoals, which can be kept together with powerful lights carried in the purse boats. Formerly, purse seines used to take different species of tunas of varying, generally small, sizes. These nets were generally much larger (ranging from 1,200 to 1,500 m in length and from 150 to 240 m in depth). The mesh size was also much larger than that used for pilchard and anchovy, between 150 and 180 mm, stretched.

A comprehensive list of all the different types and variants of artisan gear could go on indefinitely: gillnets, longlines, hand lines, jigs, trammel nets, pots, dredges, different kinds of traps normally used at river mouths, and so on. However, special mention should be made of tuna traps, which, because of their large size, required very complicated setting techniques. The scarcity of migrating tuna in close inshore has, in turn, brought about the almost complete disappearance of these devices, especially along the coast of Spain. Although artisanal gears have practically disappeared at many ports, they are still extensively used at others, notably along the Mediterranean coast of France, Corsica, ports near the mouth of the Ebro River in Spain, the coast of Tunisia, and some parts of Italy. The so-called beach gear — shore hauled nets — are still used. These take not only a limited number of species commonly found in the coastal habitat — stargazers, scorpionfish, weevers, and sandeels — but also, and most importantly, large quantities of larvae and juveniles of deeper-water species, which are caught before they have had time to be normally recruited to their fishery.

9.3. THE STATE OF THE FISHERY IN THE WESTERN MEDITERRANEAN. PAST AND PRESENT

The fisheries in the Western Mediterranean have made steady technological progress, leading to the development of certain fisheries and to the almost total decline of many others. Artisan fisheries, using gillnets, trammel nets, longlines and pots, have practically vanished from many ports, although their use continues at others and are even staging a comeback in places from which they had all but disappeared. In contrast, the technology employed in the trawl and purse seine fisheries has made great advances, and this progress is continuing. The substantial increase in fishing power brought about by these technological innovations has resulted in a considerable decline in the available biological resources. This can be seen in the steady decrease in the catch per unit of effort (cpue), especially with species from specific habitats. The quantity of pelagic species taken by purse seines also fluctuates, although this does not seem to be directly related to technological development. Nevertheless, the pelagic fishery has undergone a profound transformation during the present century. Thus, although pilchard and anchovy used to be primarily caught with special drift gillnets, these species are now caught with purse seines which enable large quantities of fish to be taken at each haul. This change in fishing power is very important and, in addition, has converted a selective fishery into a mass fishery.

The pelagic fisheries exhibit another important trend: a continuing tendency for the replacement of the pilchard by the anchovy. This can be seen not only off the coast around Castellón de la Plana (south-eastern Spain), but also off northern Morocco. This change may be encouraged by the higher economic value of anchovy, though it is likely that ecological factors are also involved, for similar trends are apparent in other important fisheries.

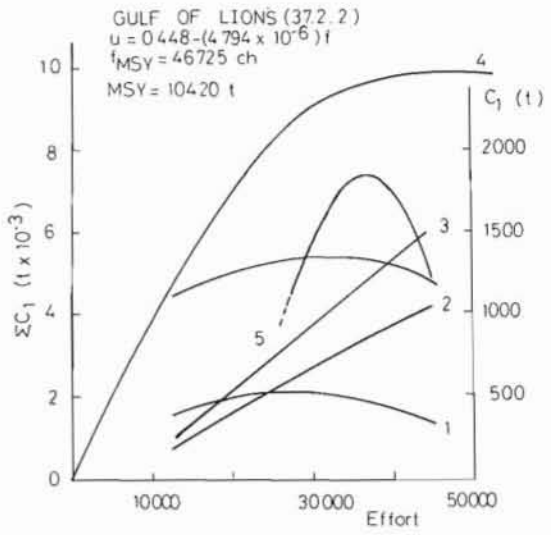

Fig. 9.1 Total catch and effort in the Gulf of Lions and particular relationship for selected species (1: horse mackerel; 2: foor cod; 3: hake; 4: mackerel and 5: cephalopods) MSY: maximum sustainable yield. (From FAO – GFMC)

The development of pelagic fisheries has not been unduly affected by these changes, for catches have increased by 40% off the coast of Spain between 1964 and 1976. The estimated potential of the resources around the Balearic Islands seem to be able to sustain such higher levels of exploitation. Off Morocco, the total pelagic catches of pilchard are estimated to be some 6,000 tonnes, whereas the maximum sustainable yield for the Sea of Alborán as a whole is calculated to be around 22,000 tonnes. Off southern France the exploitation rate of pilchard and other pelagic species is moderate, although insufficient information is available for Italy, the three large islands of Corsica, Sardinia, and Sicily. The pelagic fishery of Algeria is more important in the western sector.

The most prominent pelagic species are the pilchard, anchovy, horse mackerel, and mackerel. In some areas the latter two species probably support higher levels of fishing.

The importance of the different species of tuna, a major pelagic resource, has been decreasing with the decline of trap fisheries, but increasing offshore fishing occurs with large purse seines.

Trawl fisheries have also undergone significant technological change. These innovations involve the introduction of faster, keeled vessels, replacement of sails by motors (at first low r.p.m. one-cylinder engines and now high r.p.m. multicylinder engines), the use of radar and radio communications and modern navigational equipment, and, most recently, continuing improvement of net materials, design and handling. This technical innovation, with increasing power and tonnage of vessels, is still continuing with consequent high levels of overfishing. Overall landings show very little variation, despite the constant increase in fishing power, although slight fluctuations have been recorded in different areas. Trawl catches in the Gulf of Lions totalled 10,420 tonnes in 1979: only slightly more than that of 8,667 tonnes taken off south-eastern Spain (Alicante). A decline in blue whiting has been observed in this area, while hake appear to be on the increase. Fishing on the continental slope is important off Morocco and Algeria, the pink shrimp (*Aristeus antennatus*) being the main species caught, together with the norway lobster (*Nephrops norvegicus*), the mainstay of the slope fisheries throughout the Western Mediterranean. Nevertheless, a sharp drop in the total catch of pink shrimp has occurred during the past 2 years, especially off the coast of Spain.

The trawl fishery on the continental shelf is essentially similar in all regions. The principal species caught are the red mullet (*Mullus barbatus*), young hake (*Merluccius merluccius*), and the curled octopus

(*Eledone cirrosa*). A wide variety of other species are taken as well; while none of these are particularly outstanding, taken as a whole, they represent an important part of the fishery.

The first two species are really important only in regions where the continental shelf is wider — for example in the Gulf of Lions and off south-eastern Spain. Over-fishing has been so intense in these areas that rigorous management measures have become necessary (for example around Castellón, in south-eastern Spain, where positive results have been achieved).

In areas where the shelf is narrower and rockier, the red mullet *Mullus surmuletus* is abundant and is taken in with rough bottom species, such as scorpionfish (*Scorpaena*) and gurnards (*Trigla*). The proximity of the slope to the coast facilitates exploitation, especially of blue whiting (*Micromesistius poutassou*), which is particularly important in the northern part of the Western Mediterranean, greater forkbeard (*Phycis blennioides*), and wreckfish (*Polyprion americanus*), together with the scarce, but highly-prized, specimens of full-grown hake.

The steady increase in fishing capacity has produced competition between vessels for the scant resources available. This competition is motivated by the high economic value of the catches, which more than compensate for the high costs involved.

Artisan fisheries vary greatly in extent. They are still important in some parts of the Gulf of Lions and on the islands of Corsica and Sardinia, but they have lost their former importance along the Spanish coast. However, it is precisely in Spain where this type of fishing is now making some recovery. This is seen in the improved fishing technology used on the numerous small boats still engaged in these fisheries. The catches include a variety of general coastal species, primarily sea breams, and large hake which are taken by longlining or by handlining.

Finally, there are the coastal lagoon fisheries — for example, in the Bassin de Thau, the Mar Menor and the Ebro delta. These support important fisheries for the prawn, *Penaeus kerathurus*, the common sole, *Solea solea*, as well as mullets (*Mugilidae*) and the bass, *Dicentrarchus labrax*. Management measures to rationalize these fisheries could yield substantial benefits for these coastal fisheries.

9.4. PELAGIC RESOURCES

Pelagic fishing is quantitatively more important than the demersal fishery, the mean catch for the period 1968 – 1978 being estimated at some 200,000 tonnes a year (Levi and Troadec, 1974; Massutti, 1981).

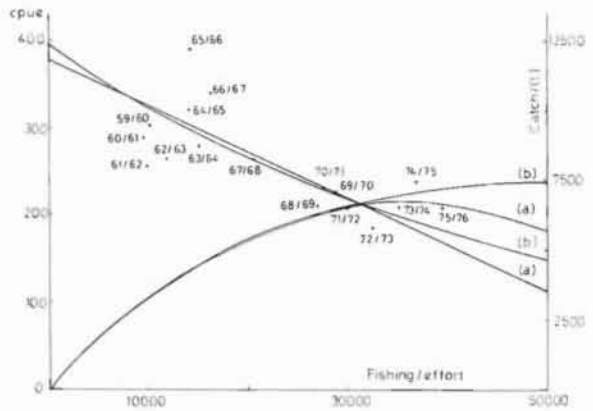

Fig. 9.2 Trawl fishery in the Gulf of Lions. Relationship between cpue and fishing effort and resulting yield curve. (a) linear fitting, (b) exponential fitting. Numbers refer to years. (From FAO – GFMC)

The pelagic fauna in the Western Mediterranean is rather similar to that in the subtropical Atlantic, the most important species belonging to the families Clupeidae, Engraulidae, Scombridae, and Carangidae.

There are two primary commercial species which comprise two-thirds of the total catch: the pilchard (*Sardina pilchardus*) and the anchovy (*Engraulis encrasicholus*). Both are taken all along the coast, especially in inshore areas.

The main catches are made off Catalonia and Castellón. Within this area, the main spawning area for pilchard is located near the mouth of the Ebro River. As the fish grow, one stock moves north and another south, towards the Columbretes Islands, when they reach 2 – 3 years of age. Exploitation of pilchard stocks begins at 7 – 8 cm, age groups 0 and 1 being the main contributors to the catches.

Pilchards are usually found nearest the coast in the winter spawning season, and then move seaward during the warmer seasons. The main catches are made during these warmer months, in part due to the higher commercial value of the fish (the quality of the product being enhanced by increased fat content). The thermocline plays an important role in the distribution of this clupeid, which aggregates in the thermocline.

Anchovy are normally found further offshore, catches being taken mainly at depths of from 50 to 200 m all year round. Age groups 0 and 1 are again the main contributors to the catches.

The depth distribution of anchovy follows the same pattern as in the case of pilchard, with younger individuals being found closest inshore. This behaviour is very well defined in regions like Castellón (Suau, 1979), but the pattern seems to change further north.

Catches of these two species have fluctuated over the years. Around Castellón pilchard underwent a sharp decline in 1965, and was followed by a sharp increase in anchovy. These changes seem to be less the result of fishing pressure and more the consequence of ecological factors, caused by variations in the composition of the phytoplankton on which the larvae feed, which affect larval mortality and subsequent recruitment (Larrañeta, 1981).

Certain carangid species are commercially important, particularly the horse mackerel (*Trachurus trachurus*, and to a lesser extent *T. picturatus*), some 18,000 – 23,000 tonnes of which, on average, were taken yearly over the period 1968-78. There are also less important species such as *Caranx rhonchus* and *Seriola dumerili*. These are generally migratory, for example: *S. dumerili*, greater amberjack, which usually moves inshore during the summer and forms aggregations before moving offshore during the winter.

The Scombridae, Thunnidae, and Scomberomoridae are extremely important in the region, not only because of their relative abundance but also for their high commercial value. These fishes include the bonito (*Sarda sarda*), mackerel (*Scomber scombrus*), bluefin tuna (*Thunnus thunnus thynnus*), tuna (*Euthynnus euthynnus quadripunctatus*), and frigate mackerel (*Auxis rochei*).

These species support an important trap fishery in the Strait of Gibraltar near Ceuta, where large quantities of juvenile tuna (younger than 1 year old) are taken at the end of summer and beginning of autumn. Tuna born the previous spring aggregate in an inshore area near Castellón during the autumn months.

The longline fishery is directed primarily at swordfish (*Xiphias gladius*), and to a lesser extent at tuna, the catches ranging between 100 and more than 500 tonnes a year.

Most of these species make long migrations. Adult bluefin tuna are normally found near the surface during the summertime and deeper in the wintertime, whereas young fish concentrate near the surface in the autumn and early winter. Spawning takes place inshore at the end of winter, one spawning area being located near the Balearic Islands. First-year fish then move south and are caught near the Strait of Gibraltar in the autumn. This seems to confirm the hypothesis that they migrate to the Atlantic. Other species such as bonito and tuna also migrate along the coast to the Atlantic (Rey and Cort, 1981). The main catches of bonito are made in autumn close inshore using gillnets and purse seines.

Mackerel is another commercially important resource with a yield of between 5,000 and 10,000 tonnes yearly, taken chiefly in the spring.

There is also a series of secondary species of small yield, but relatively high commercial value, when compared to that for the previously mentioned ones. The most important of these are the Mugilidae (*Mugil cephalus* and *M. capito*), mullet, which inhabit shallow waters all along the coast, and yield between 3,000 and 5,000 tonnes annually. The bogue (*Boops boops*), though not a highly esteemed species, is rather abundant, with between 13,000 and 15,000 tonnes caught each year, some with bottom gear. Other less important species are the pilot fish (*Naucrates ductor*), which usually forms small shoals a particular distance offshore and which is taken chiefly around the Balearic Islands, *Argentina sphyraena*, found primarily in autumn and winter, and a mixture of species, taken in varying amounts using bottom gears (*Spicara maena*, *S. chrysellis*, etc.).

Small quantities of shad, *Alosa* spp., are taken near the mouths of rivers, as are small clupeids of the general *Sardinella* (gilt sardines) and *Sprattus* (sprats), but catches of these have rarely exceeded 2,000 tonnes in recent years.

Some of the smaller boats often catch transparent goby (*Aphia minuta*) from November to March. Because of its economic value this species constitutes a resource of some importance, especially along the southern coast of Spain. However, major components of the catches of this gobiid are in fact larval stages of other species.

The dolphin (*Coryphaena hippurus*) is an epipelagic migratory species which is caught mainly in waters close to the Balearic Islands and Sicilia.

It is difficult to assess the state of the pelagic resources in this part of the Mediterranean, not only because of inadequate statistical information, but also because of a series of biological and environmental factors which have not been taken into account, when applying stock assessment models. An example of this is the effect of changes in plankton composition and the impact of such changes on recruitment, which is of particular importance in the case of short-lived species like pilchard and anchovy.

Most available information refers to anchovy and pilchard. Both of these species appear to be under-exploited over almost the entire area, especially off the coast of Africa, where maximum sustainable yield (MSY) for pilchard in this region is estimated at some 75,000 to 85,000 tonnes, mostly from Algeria. The maximum sustainable yield is lower off the coasts of Spain, France and Italy.

9.5. OTHER VERTEBRATES

9.5.1. Marine mammals

A total of eighteen different marine mammals are found in the Western Mediterranean, five Mysticeti species, twelve Odontoceti species, and one Pinnipedia species (Casinos and Vericad, 1976; Deguy *et al.*, 1983).

The Mysticeti group is poorly represented, and only the fin whale can be regarded as common. Its abundance increases in the summer, chiefly in the region between Corsica and the French Côte d'Azur. At the end of summer it migrates towards the south-western Mediterranean. The other species, (the minke whale (*Balaenoptera acutorostrata*), Sei Whale (*B. borealis*), humpback whale (*Megaptera novaeangliae*), and Biscayan right whale (*Baleana glacialis glacialis*) are seldom encountered and their presence is usually accidental. The latter species was only reported during the 19th century, and its disappearance from the Mediterranean is considered certain.

Of the Odontoceti, the family Delphinidae accounts for the most abundant and the largest number of species in the region. The striped dolphin (*Stenella coeruleoalba*) and the common dolphin (*Delphinus*

delphis) are found along the entire coastline and form large schools, although they differ slightly in their geographical distribution: the former is more common along the coasts of Spain and France, while the latter is more common off the coast of Africa. These species appear to have declined in abundance in recent years.

The remaining dolphin species, the bottlenosed dolphin (*Tursiops truncatus*) and the rough-toothed dolphin (*Steno bredanensis*) are rarer, though the former is relatively abundant in the waters off North Africa and Spain (especially in the Ebro delta). In contrast to the striped dolphin and the common dolphin, *Tursiops truncatus* lives in small groups.

The long-finned whale (*Globicephala melaena*) is common all along the Western Mediterranean coastline, particularly off North Africa and southern Spain and in the Ligurian Sea, where large numbers congregate in July, then scattering in August. This concentration, like that of the fine whale indicated above, also seems to be due to increased food abundance.

The other species of the family Delphinidae, the false killer whale (*Pseudorca crassidens*), killer whale (*Orcinus orca*), Risso's dolphin (*Grampus griseus*), and harbour porpoise (*Phocoena phocoena*) are rare. The latter species was common last century and enters the Mediterranean following the cold Atlantic current.

Other Odontoceti species, the sperm whale (*Physeter catadon*), Cuvier's beaked whale (*Ziphius cavirostris*), and Blainville's whale (*Mesoplodon densirostris*), are relatively common, except for the latter, which has only been reported once.

The only Pinnipedia species found in the Mediterranean is the monk seal (*Monachus monachus*), which is occasionally seen in the western part of the sea and, though in danger of extinction, is somewhat more common in the Adriatic and Eastern Mediterranean.

These marine mammals are not presently an important commercial resource, although some individuals, mainly dolphins, are taken incidentally or to avoid damage in the purse seine fishery. The resource was, however, fairly important during the last century and early in the present century, and there was a factory in Algeciras.

The impact of these species on fish and cephalopod stocks (their usual food) may be considerable, although unfortunately the parameters for assessing this impact have not yet been established.

9.5.2. Turtles and seabirds

Two species of turtles are relatively common in the Mediterranean Sea: the loggerhead turtle (*Caretta caretta*), which is found offshore and the green turtle (*Chelonia mydas*) which lives near the coast. Several years ago their eggs were highly esteemed as food and they were found in the beaches around the Mediterranean. At present, they have no economic importance because of the scarcity of both species and only the carapace is used for decorative purposes.

A third species of turtle, the leather turtle (*Dermochelys coriacea*) is occasionally seen in the Mediterranean, following the Atlantic current.

The most common seabirds belong to the families Laridae, Procellaridae and Phalacrocoracidae.

The species of Laridae accounts for the most abundant in the region. The herring gull (*Larus argentatus*) is found living in groups in cliffs, beaches and estuaries. The parent population is estimated in 40,000 pairs (60% in France, north-east of Spain and Corsica). The black-headed gull (*Larus ridibundus*) is also common along the western coastline, particularly in France, and the breeding population is evaluated in 9,000 pairs. Furthermore, the hivernal stock, coming from Central Europe, is being estimated, for France and north-east of Spain at some 20,000 to 250,000 pairs. The Audouin's gull (*Larus audouinii*) is a very interesting species, because the most important breeding population in the world (around 4000 pairs) is found in the Western Mediterranean. Other species, as the common tern

(*Sterna hirundo*) is estimated in 3500 – 4000 pairs (breeding population) inhabit mainly in France and Ebro delta.

The family Procellaridae is important in the region, in particular the Cory's shearwater (*Procelaria diomedea*: 10,000 pairs) usually living in islands. The shag (*Phalacrocorax aristotelis*; family Phalacrocoracidae) shows a similar behaviour, living in islands and the breeding population is estimated in 1500 pairs.

The seabirds are not presently an important commercial resource. However, several years ago, their eggs were used as food. On the other hand, their incidence in the pelagic fishes, which are a very important prey in the diet of the seabirds, could be important, though this effect is poorly studied.

9.6. DEMERSAL RESOURCES

Due to the variety of the features which characterize the fishing grounds in the Western Mediterranean basin, demersal resources must be classified according to their different biocenoses: those located on the continental slope, comprising deep, narrow submarine canyons often ringed by rocky barriers (as in the case of Italy, Corsica and Sardinia, Sicily, Catalonia, the Balearic Islands, or Algeria); those located on a broad, gently sloping continental shelf (such as the south-eastern coast of the Iberian Peninsula and the Gulf of Lions); and those located over shallow rocky or sandy bottoms running along the shoreline.

Certain other special habitats are worthy of note, such as large river deltas like those of the Ebro and the Rhône, and the Alborán Sea, which contains a number of Atlantic species as a result of the currents flowing through the Strait of Gibraltar. There is, thus, a wide variety of benthic species in the Western Mediterranean, distributed according to the different types of continental shelf. The demersal fishery in this area is, for this reason, a multispecies fishery, with no single species predominating. The principal demersal species on the slope are the hake (*Merluccius merluccius*), blue whiting (*Micromesistius poutassou*), greater forkbeard (*Phycis blennioides*), and pouting (*Trisopterus minutus capelanus*), among others, which make up the greater part of the biomass.

The first species, hake, is an important resource in the Mediterranean area. It is widely distributed at depths ranging from 40 to 400 m, depth distribution depending on size, which runs from 9 to 60 cm, with adults dwelling at the greatest depths.

Nevertheless, the hake yield can be considered to be relatively low compared with that taken in the Atlantic Ocean, although the species' high reproduction rate causes temporary population spurts composed of small individuals that contribute to an incidental but highly profitable fishery. The effect of this is to limit the adult stock, resulting in the low yields obtained in this fishery.

This is not the case for blue whiting, the species with possibly the highest biomass in the Mediterranean, and which certainly gives the highest yield, with catches still rising in recent years. The distribution of this species is also regular (the size of individuals ranging between 16 and 24 cm) and, again, the larger individuals are found at greater depths. The largest concentrations are located at depths of around 400 m, with substantial aggregations forming during the spawning season. Spawning takes place in winter, large quantities of juveniles subsequently gathering at about 80 m. However, in contrast to hake, the mushy consistency of its flesh and its low commercial value means that this fishery is not directed at the smaller length groups, which thus sustain a large adult stock.

In addition, other similar species such as greater forkbeard and pouting are important in terms of their biomass within the community. Anglerfish (*Lophius*) should not be overlooked in view of its economic importance, though larger fish are uncommon in the Mediterranean fishery.

Norwegian lobsters (*Nephrops norvegicus*) typically inhabit and form shoals at depths of between 300 and 400 m. It is the most abundant and highly prized of the lobsters, though stocks have been depleted of late through overfishing. Nevertheless, because this species is largely nocturnal in its habits (dawn and

management of existing resources on both a national and region-wide basis as the most appropriate fisheries policy for the region and, in certain special cases, even for areas more restricted in scope.

Fisheries management must be based on one basic concept: that a clear state of over-fishing exists in the case of the demersal resources. With respect to pelagic resources as a whole, strict monitoring is called for, especially in view of the high instability of these resources and the possibility of replacement between some of the principal species, namely pilchard and anchovy. The first priority of a truly comprehensive fisheries policy in scope must be to achieve the optimum fishing effort/catch relationship (i.e., maximum sustainable yield).

Another very important difficulty stems from the very structure of the particular demersal biocenosis exploited. It is characterized by a large number of species, all of which are subject to some degree of exploitation, although certain species are more highly sought than others. From this it follows that the basic biological behaviour of the different species — growth rate, reproduction, age at recruitment, etc. — will differ. Furthermore, conservation measures to be applied in each case also differ, both with respect to management as well as to the policies necessary to achieve optimum protection. There are numerous examples which clearly illustrate these discrepancies. A particular case is the reactions of hake, *Merluccius merluccius*, and the red mullet, *Mullus barbatus*, to the use of codend mesh of trawl gear. The appropriate mesh size, to ensure adequate protection for mullet, is 40 mm (measured diagonally, stretched mesh). However, this size is insufficient to afford proper protection to hake, which require larger mesh. Furthermore there is no spatial and temporal segregation of these species and separation on the basis of size difference and their economic value is also not feasible. It was decided, therefore, to give priority to conservation of mullet off the south-eastern coast of Spain (because of its greater abundance and its far from negligible economic value) despite the fact that such a measure would have a detrimental effect on the hake stocks, by catching excessive numbers of immature hake by the small mesh. If the opposite measure were taken (i.e., if priority protection were afforded to hake), the result would be the loss of substantial amounts not only of striped mullet and red mullet but also of many other species which, due to their generally reduced size, would escape in large numbers through the mesh. The recommended codend mesh size may vary according to the popularity of one or another of the numerous species caught in each region. However, as previously mentioned, the high degree of similarity existing among the different biotic and environmental aspects in the Western Mediterranean basin has conferred a certain uniform character on the most common management measures all through the area.

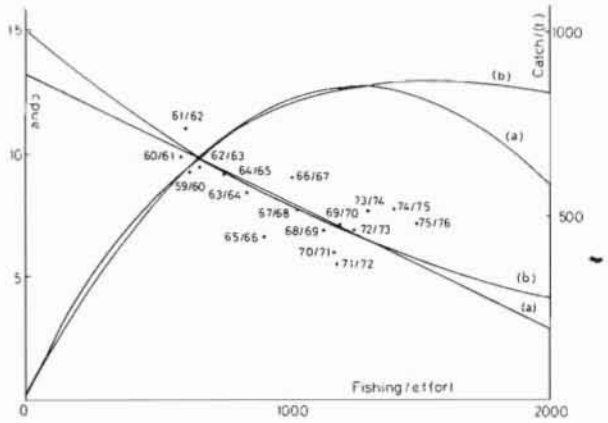

Fig. 9.4 Bottom fisheries in Corsica: cpue/effort and resulting yield curve. (a) linear fitting, (b) exponential fitting. Numbers refer to the years 1960 – 76. (From FAO – GFMC).

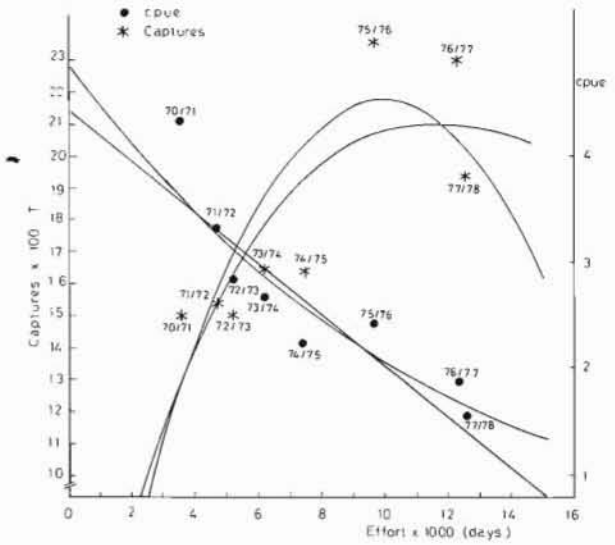

Fig. 9.5 Pilchard fisheries in Alboran Sea. Relationship between cpue and fishing effort and yield curve. Numbers refer to years. (From FAO – GFMC).
(a) linear fitting $u_i = 3.82 - 1.68 - 10^{-4}$
(b) exponential $u_i = 4.92 \times e^{-0.98} \times 10^{-4}$

A summary of the main management measures would have to include the following: in the trawl fishery, a codend mesh size of 40 mm, stretched mesh; in the purse seine fishery, a mesh size of around 16 mm, stretched; limitation of time at sea in the daily trawl fishery; limits on the light intensity used to attract pelagic fish shoals; and finally, regulatory measures establishing closed areas and seasons. There is also a large body of regulations relating to artisan gear, as extensive as the many different types of gear. Last of all, minimum legal size regulations, though their degree of effectiveness is a very controversial point, are extremely varied, depending on the species and area concerned.

The purpose of a true management measure is none other than to ensure continuity of exploitation in optimal conditions or, if conditions have deteriorated, to try to guide the situation back to the desired point. This cannot be achieved unless there is a policy based on the biological, ecological, and economic characteristics of the fishery. In any case fisheries policy in the Western Mediterranean has to bring about a sweeping reduction in fishing power or, better still, in the amount of fishing effort expended. While, on the one hand, for socio-economic reasons, it is difficult to hold back technological development leading to a steady increase in fishing power, the necessary steps must be taken to limit effort — fishing power times operating time — which can only be achieved by drastically reducing fishing time and the area where it occurs. There are two types of time limitations: shortening the fishing day or week, or prohibition of fishing for extended periods of time, which in most cases also tends to ensure good recruitment. Closing certain areas to fishing is advisable in order to improve the chances of survival of juveniles prior to recruitment or in some cases to protect spawning adults, especially when the size of the shoals of spawning fish is a critical factor, and even to protect certain kinds of artisan fisheries from competition from purse seine and trawl gear.

An extremely urgent measure, particularly in the trawl fishery, is the limitation of engine power, which is dangerously excessive at the present time.

In the coastal countries as a group, these measures are not applied in a uniform manner, and in fact only the 40 mm mesh size in the trawl fisheries and 16 mm in the purse seine fisheries have been widely adopted.

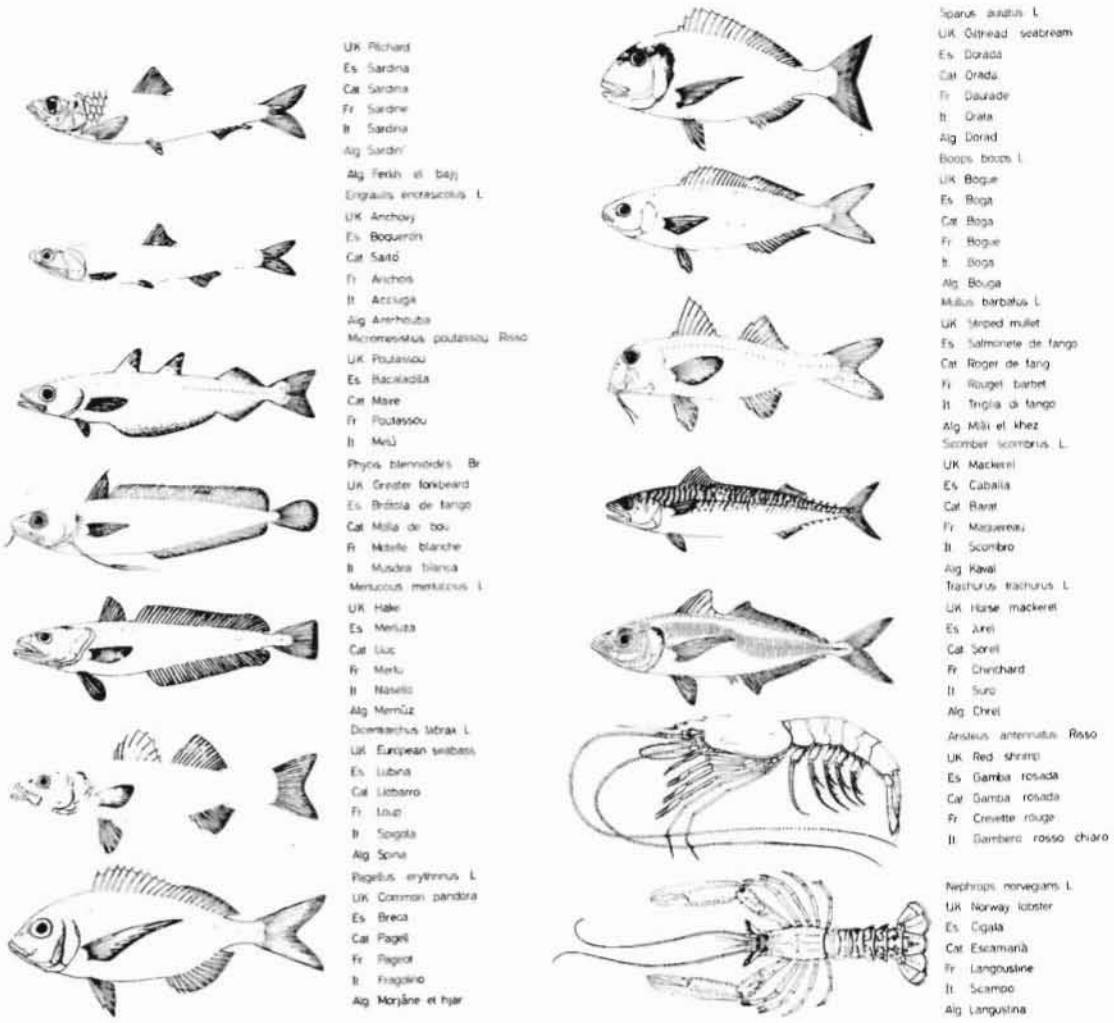

Fig. 9.6/7 Animals used as food.

9.9. THE FUTURE

The low level of resource availability in the Mediterranean in general and in the Western Basin in particular is primarily due to the low productivity of these waters. The production rate in carbon per m^2 is considerably lower than in the Atlantic, and the immediate result of this is the existence of a highly diversified ecosystem with a low renewal rate. A comparison of the biotic composition of the Western Mediterranean with that of any of the ocean regions characterized by a high primary production rate shows that there is a wide variety of species in the Mediterranean but that none of these clearly predominates over the others. As important as they are, neither the hake nor the mullet (among the demersal fishes) are pre-eminent as are, for example, hake in Namibia or cod in the north-west Atlantic.

TABLE 9.1. Annual catches by major species groups in West Mediterranean (From FAO – GFMC)

Species	Total Annual Catches (Metric Tonnes)										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Anguilla spp.	3917	5003	2766	3018	2807	1872	2532	2040	2602	1970	1842
Alosa spp.		77			24	34	9	57	988	22	5
Psetta ssp.	85	61	82	90	87	94	104	92	81	92	92
Pleuronectiformes	2679	2904	3045	2537	2618	2444	2593	2407	2347	2074	2325
Gadiformes	19076	23184	23134	14464	18363	17386	18529	21465	20159	28651	27298
Sparidae	14687	15740	16946	12429	16790	19065	19795	22843	20478	21784	22026
Maena spp.	4593	4696	4920	1289	1539	1989	2138	1637	1006	1290	1211
Mullidae	8193	9080	9292	6962	6905	6651	8745	8247	6825	6855	6620
Gobiidae	929	1093	1095	529	495	345	467	396	461	392	508
Demersal percomorphs	7130	10549	13095	11902	17118	9002	10782	14192	11937	16431	8112
Mugil spp.	2738	2602	2213	3032	4345	4470	4261	4960	4309	4945	4302
Carangidae	18137	17503	17352	13249	12700	13889	19786	20642	15015	17079	15216
Clupeidae	101959	106907	109592	85859	101547	111746	105397	113440	103205	101573	95609
Engraulis encrasicholus	45540	32311	38981	51409	46250	43134	60001	51147	51267	60840	54114
Pomatomus saltatrix	1	4	4		1	36	24		46	39	18
Scomber spp	18049	12392	8564	6938	7564	8126	3371	6513	6464	6778	7432
Pelagic percomorphs	719	1298	1429	1135	850	339	331	1210	1802	379	328
Sharks, Rays, Chimaeras	3660	3896	4154	2089	2943	2403	3031	3147	2592	2836	4066
Crabs	16	84	115	12	264	468	531	531	364	13	588
Lobsters	1613	1881	2094	1684	1462	1269	1953	1678	1422	1496	1360
Shrimps & prawns	7607	7145	7839	4995	5458	4624	4592	5005	4752	5018	4962
Marine crustacea	1384	1585	1733	1599	4743	3255	3479	2728	2257	2113	1639
Pelecypods/Gastropods	13171	17267	20773	14293	18242	13954	18143	17920	11464	10472	13717
Cephalopoda	22056	23949	24821	16179	16791	18783	20751	17162	16512	14907	17270
Marine molluscs	1546	1376	1369	1705	2614	2326	3164	2399	1105	2136	1083
Sponges								0	4		1
Marine Fishes, others	23226	19293	21211	12014	22132	40160	36738	29169	35030	28842	34487
TOTAL	322712	321879	336620	269411	314651	327865	351246	351028	324494	339027	326231

Not even the pelagic community as a whole (which is closer to the primary production level) exhibits high abundance levels. There exists a dynamic equilibrium among the components of the ecosystem, and maintaining this equilibrium is of the utmost importance in any attempt to regulate exploitation.

In addition, the system possesses some important defence mechanisms, particularly in certain areas and in connection with certain species. The blue whiting, *Micromesistius poutassou*, undergoes an extended juvenile stage in which it lives scattered throughout the pelagic layer, thus making capture impossible and ensuring good recruitment. The decapod, *Aristeus antennatus* (the pink shrimp), which is very abundant on the continental slope throughout the Western Mediterranean, inhabits areas distant from the usual fishing grounds, which, as with the blue whiting, favours recruitment. Some species which normally dwell on the continental shelf commence their benthic existence in relatively shallow water. The red mullet (*Mullus barbatus*), for example, moves to deeper water as it grows older (because the shelf is narrow along much of the coast), but the habitat of the juvenile stages of this species is located so close to the shoreline that it is impossible to take them with trawl gear. Lastly, the many rocky areas of the sea bed existing inshore furnish a source of adequate shelter for many species, enabling them to survive in spite of intensive fishing.

These circumstances must be considered when evaluating the future of the fisheries along these coasts, since, on the one hand, they help to protect certain species, while, on the other, they are necessary for the proper management and administration of the renewable resources.

The future of the fishery in the Western Mediterranean basin depends upon the management measures and policies adopted, as well as upon adequate co-ordination among all the coastal countries. The exploitation of the resources which are primarily pelagic in nature will be discussed first, followed

by a consideration of the demersal resources.

The main pelagic species, the pilchard and anchovy, are currently in a critical state in that the latter species is replacing the former. At least in the coming years, the outlook is for a preponderance of anchovy which, if correctly managed — minimum mesh size and minimum legal size — will surely support large catches. Increasing catches of juveniles are being made in the springtime, especially off the coast of Catalonia (north-western Mediterranean). The presence of large aggregations of juveniles clearly indicates that shoals of adults could become very abundant merely by avoiding the catching of this species until it attains a minimum size to be established in accordance with the findings of fishery biology studies. As long as conditions remain minimally favourable, the rapid growth rate of this species combined with its high reproduction rate promise sustained high catches at the present level of fishing effort. In contrast, the pilchard, with a longer than average life span, is more directly dependent on years of good recruitment, which produce generations that are progressively fished to depletion. Pilchard shoals are normally composed of 2- to 3-year-old individuals, but 4-year-olds are also relatively numerous. The difference in the turnover rates between anchovy and pilchard are likely to favour replacement of the latter by the former.

Horse mackerel and mackerel are two other species of interest. Both species alternate between pelagic and demersal habitats, which results in higher pressure on shoals of these species. Horse mackerel, *Trachurus trachurus trachurus*, *Trachurus trachurus mediterraneus*, and *Trachurus picturatus*, especially the first two subspecies, is abundant in the commonly exploited fishing areas. *Trachurus picturatus* is not particularly abundant and inhabits outlying areas. Mackerel, *Scomber scombrus*, undergoes considerable fluctuations in abundance, and its future is unclear. The chub mackerel, *S. japonicus*, similar to the mackerel, is seldom encountered. Other pelagic species with a certain local importance are the dolphinfish *Coryphaena hippurus*, picarels and smares, *Spicara* spp., and different species of tuna, which

TABLE 9.2. Annual catches by major species groups in the Balearic Zone (From FAO – GFMC)

	Annual Catches (Metric Tonnes)										
Species	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Anguilla spp.					700		65	66	55	113	
Alosa spp.					24	23	8	56	82	22	4
Psetta ssp.										5	3
Pleuronectiformes	483	799	793	894	994	905	1179	1002	1106	1054	1106
Gadiformes	9512	12786	11319	8491	11253	8802	8269	10367	12350	20817	18708
Sparidae	3716	4116	5388	4545	8835	11034	11314	14568	13693	15148	15795
Mullidae	3010	3234	3309	3244	3477	3620	4344	4015	3511	3854	3850
Demersal percomorphs	841	4176	5598	5827	11090	3041	4699	10120	4787	9142	3852
Mugil spp.	211	13	76	119	902	858	1019	788	934	992	561
Carangidae	11845	11065	10529	9984	10030	11065	16899	17656	12192	13659	12046
Clupeidae	53603	60012	68541	55273	70967	77026	78829	89116	78219	72041	69259
Engraulis encrasicholus	16735	11158	12269	25769	20122	23626	33020	30388	37077	48267	41656
Pomatomus saltatrix	1	3	1				24		3		
Scomber spp	7856	6378	3646	3343	4594	4836	770	3758	3779	3293	3158
Pelagic percomorphs	222	678	637	754	420			545	1222	52	59
Sharks, Rays, Chimaeras	237	213	237	274	1009	238	276	515	696	700	1590
Crabs					200	389	403	393	358		588
Lobsters	397	517	606	609	585	307	863	748	657	641	598
Shrimps & prawns	3040	2453	2150	2674	3340	2477	2825	3278	3651	3494	3450
Marine crustacea	1	20	24	21	3193	1545	1613	957	857	627	47
Pelecypods/Gastropods	1221	1065	1305	160	4135	2952	3138	4307	3947	1866	953
Cephalopoda	8947	9802	8767	7059	6999	7170	8087	7656	8141	6371	8610
Marine mollucs		16			497	77	1113	697		750	12
Marine Fishes, others	2568	119	278	872	10969	30531	25636	16254	23430	16729	22625
TOTAL	124446	128623	135473	129912	174335	190522	204392	217251	210747	219637	208530

TABLE 9.3. Annual catches by major species groups in Lions Zone (From FAO – GFMC)

	Annual Catches (Metric Tonnes)										
Species	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Anguilla spp.	3071	3866	1696	1878	1166	987	1659	1295	1762	1176	908
Alosa spp.		77							901		
Psetta ssp.	85	61	82	90	87	94	104	92	81	87	89
Pleuronectiformes	511	526	533	573	467	389	360	566	491	278	356
Gadiformes	1180	1057	1008	1385	2103	2960	2745	2713	2205	2770	3685
Sparidae	301	438	295	1076	1124	1284	1357	1551	1631	1410	1452
Maena spp.				225	211	340	370	269	225	218	174
Mullidae				264	199	212	258	426	214	165	180
Gobiidae									38		24
Demersal percomorphs	2207	1971	1967	3116	3123	3069	3043	1622	5267	5292	2016
Mugil spp.				470	496	604	559	842	1291	1950	1681
Carangidae	412	452	450	334	388	462	410	482	552	463	810
Clupeidae	22090	17528	18341	13727	11315	15485	11308	12389	11413	14514	15371
Engraulis encrasicholus	2300	1547	1041	1905	3843	3259	2857	1293	2122	2462	2441
Scomber spp	1482	1601	1413	1136	1201	1415	1082	1142	928	1464	2299
Pelagic percomorphs								64	8		8
Sharks, Rays, Chimaeras	581	592	553	517	485	403	358	342	268	386	542
Crabs	6	66	98			47	96	138	6		
Lobsters	39	36	40	69	71	59	53	37	34	33	19
Shrimps & prawns	95	212	172	134	46	38	30	34	34	31	42
Marine crustacea	71	125	110	132	56	63	46		4	86	8
Pelecypods/Gastropods	8984	9736	13319	9903	12409	8896	12405	11735	5368	5739	8998
Cephalopoda	197	932	1291	2438	2830	4256	4146	1778	1604	1672	1684
Marine molluscs	857	579	491	660	802	504	443	324	179	343	178
Sponges								0	2		
Marine Fishes, others	4220	3386	2943	707	1310	1070	1112		828	978	680
TOTAL	48689	44788	45843	40739	43732	45896	44801	39135	37455	41517	43645

sometimes form large shoals. Looking to the future, it should be noted that the tunas have been abandoning their traditional inshore migratory routes, which has led to the disappearance of tuna traps from much of the Western Mediterranean shoreline. No prediction can be made with regard to shoals which migrate further offshore, as assessment of these is practically impossible at the present time.

Many demersal species are clearly undergoing a downward trend, if not in terms of the resource as a whole, which has even shown signs of increasing slightly, at least in terms of catch per unit of effort (yield). As long as the present overfishing persists, the prospects can only be for a minimum yield. Total depletion will thus be avoided (for the reasons mentioned above) by the special protective mechanisms which exist for certain species, with small fluctuations related to the general primary production cycles (i.e. 7 to 11 years). Because of the steady increase in fishing capacity brought about, firstly, by the high economic value of fish products and, secondly, by the small cyclic variations already referred to, the future situation can improve only if measures aimed at reducing effort to the maximum sustainable yield level are applied. If such measures are not adopted, the prediction would be for the persistence of an extremely reduced parent stock which will maintain a more or less abundant first generation depending on environmental conditions.

9.10 PROSPECTIVES IN AQUACULTURE

Aquaculture in the Western Mediterranean is a promising prospect. There is generally a mild water temperature, with a number of areas which are particularly well-suited for exploitation (coastal lagoons,

river deltas, abandoned salt workings and the like). There is also a long-standing practice of semi-culture of molluscs, such as the raft culture of mussels, or the retaining of certain species in lagoons by preventing their escape back to sea so that they can grow under favourable conditions. Despite the interest aroused by this activity, aquaculture is still in the early stages of research into the many problems affecting production. In most countries aquaculture is, in fact, only just getting under way, with preliminary research being directed to scientific study of such problems as feeding, reproduction, and disease. Unfortunately, basic physiological and behavioural studies, without which it will be difficult to lay a solid groundwork for the industrial development of aquaculture, are still rare.

In the Western Mediterranean basin, research facilities, and pilot operations for preliminary trials of industrial aquaculture production, exist in France, Spain, and Italy. In Italy aquaculture is more developed in the Adriatic than in the Ligurian and Tyrrhenian Seas, probably because of its ancient practice in the 'Valli' along the coast around Venice.

Extensive aquaculture is also being carried out along the coasts of France and Corsica (over an area of some 2,500 ha) to produce around 100 tonnes of various species such as mullets, eels, basses, breams, and soles. The techniques employed are similar to those used in the 'valli' of the upper Adriatic. There is also intensive culture of certain freshwater species (such as the Coho salmon *Oncorhynchus kisutch* and the rainbow trout *Salmo gairdnerii*) which are raised in sea-water in special pens, as is done on a large scale in other countries like Japan. However, the high water temperature in the summer months prevents year-round culture of these species, so that this kind of fish culture is restricted to the colder months. Cages and pens are also being used for marine species such as the bass, *Dicentrarchus labrax*. As already mentioned, most of this work is at the research stage, primarily under the auspices of ISTPM and CNEXO, sometimes in cooperation with industry. As with fish, the problems encountered in the

TABLE 9.4. Annual catches by major species groups in the Sardinia Zone (From FAO – GFMC)

	Annual Catches (Metric Tonnes)										
Species	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Anguilla spp.	846	1137	1070	1140	941	885	808	680	785	681	934
Alosa spp.						11	1	1	5		1
Pleuronectiformes	1685	1579	1719	1070	1157	1150	1054	839	750	742	863
Gadiformes	8384	9341	10807	4588	5007	5624	7515	8384	5604	5064	4905
Sparidae	10670	11186	11263	6808	6831	6748	7124	6723	5153	5226	4779
Maena spp.	4593	4696	4920	1064	1328	1649	1768	1368	782	1072	1037
Mullidae	5183	5846	5983	3454	3229	2819	4143	3806	3100	2836	2590
Gobiidae	929	1093	1095	529	495	345	467	396	423	392	484
Demersal percomorphs	4082	4402	5530	2959	2905	2892	3040	2450	1883	1997	2244
Mugil spp.	2527	2589	2137	2443	2947	3088	2683	3331	2085	2003	2060
Carangidae	5880	5986	6373	2931	2282	2362	2477	2504	2271	2957	2360
Clupeidae	26266	29367	22710	16859	19264	19235	15260	11935	13573	15018	10979
Engraulis encrasicholus	26505	19606	25671	23735	22285	16249	24124	19466	12068	10111	10017
Pomatomus saltatrix	0	1	3		1	36			43	39	18
Scomber spp	8711	4413	3505	2459	1769	1875	1519	1613	1757	2021	1975
Pelagic percomorphs	497	620	792	381	430	339	331	601	572	327	261
Sharks, Rays, Chimaeras	2842	3091	3364	1298	1449	1762	2397	2290	1628	1750	1934
Crabs	10	18	17	12	64	32	32			13	
Lobsters	1177	1328	1448	1006	806	903	1037	893	731	822	743
Shrimps & prawns	4472	4480	5517	2187	2072	2109	1737	1693	1067	1493	1470
Marine crustacea	1312	1440	1599	1446	1494	1647	1820	1771	1396	1400	1584
Pelecypods/Gastropods	2966	6466	6149	4230	1698	2106	2600	1878	2149	2867	3766
Cephalopoda	12912	13215	14763	6682	6963	7357	8518	7728	6767	6864	6976
Marine molluscs	689	781	878	1045	1315	1745	1608	1378	926	1043	893
Sponges									2		1
Marine Fishes, others	16438	15788	17990	10435	9853	8559	9990	12915	10772	11135	11182
TOTAL	149577	148468	155304	98760	96584	91447	102053	94643	76292	77873	74056

TABLE 9.5. Annual catches of *Sardina pilchardus* in the Bilearic Zone (From FAO – GFMC)

		Annual Catches (Metric Tonnes)										
Species	Contries	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Sardina pilchardus	Algeria	15497	15442	19048	15918	20197	25665	21069	27753	19707	21479	21479
	Morocco	6349	10022	13455	11249	14325	10260	15651	19142	15272	13930	9403
	Spain	31657	34382	35926	27638	35032	40542	41335	40247	41460	34783	34640
	TOTAL	53503	59846	68429	54805	69554	76467	78055	87142	76439	70192	65522

culture and fattening of the prawns, *Penaeus japonicus* and *P. kerathurus*, are being investigated, although the high costs involved in the culture of these species makes successful commercial operation appear unlikely. In the main current research centers on feeding during the early stages of the life cycle prior to the growth and attainment of marketable size.

The situation along the coast of Italy is similar, both with respect to the species being studied and to the areas of research. Again, effort is mainly concerned with nutrition and lowering mortality rates. Very interesting preliminary work is being done on bluefin tuna, *Thunnus thynnus*, in close cooperation with Japan, for the purpose of aiding the recovery of shoals of this species off the coast of Sicily. Research is in progress on reproduction and feeding problems in peneid crustaceans and some molluscs, such as *Tapes decussatus*.

On the coast of Spain, two institutes, the Instituto Español de Oceanografía (Spanish Institute of Oceanography, at its laboratory on the Mar Menor) and the Instituto de Acuicultura (Aquaculture Institute, at Torre de la Sal in Castellón), have been conducting several lines of research into the culture of the prawns *Penaeus kerathurus* and *Palaemon serratus*, especially on post-larval feeding. High survival rates have frequently been achieved during the first few days, but there are still serious difficulties associated with feeding in the post-larval stage. The culture of *Artemia salina* is important for its use as food, and Spanish research workers feel that this approach is very promising and that it will also be important for industrial production. Research on fish species has concentrated on bass, the gilt-head bream, *Sparus auratus*, the common sole, *Solea solea*, and mullets (*Mugil* spp.). Survival rates of 20 – 30% have been attained for bass through the first 60 – 67 days of life. Experimental studies on the common sole *Solea solea* are under way at the Instituto de Acuicultura in Torre de la Sal (Castellón), where promising growth rates have been achieved.

As in the other countries bordering the Western Mediterranean basin, the problems associated with feeding have received the most attention, not only for fish, but also for crustaceans and molluscs. The main and most pressing problems relate to feeding of the juvenile stages.

As has been emphasized, aquaculture in this part of the Mediterranean is still in its preliminary and largely experimental stages. The initial research has been satisfactorily concluded (and that with only partial success) in the case of bass, which has been reared from eggs to marketable size in small-scale projects. The bream seems to hold out better prospects than bass in many areas, although current successes are less numerous. On the whole more attention is paid to fish culture than to that of crustaceans, and even less to molluscs. Experiments have mostly been limited to those problems that seem to have a direct bearing on the industrial development of aquaculture. With respect to feeding and

TABLE 9.6. Annual catches of Shrimps and Prawns in Spain in the Balearic Zone (From FAO – GFMC)

	Annual Catches (Metric Tonnes)										
Species	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Shrimps and prawns	956	829	535	646	1200	982	1514	1777	1930	1915	1845

the production of suitable granular feeds for these fish, indications of reduced fertility rates found for certain species may be related to improper diet. The main objectives of research in the immediate future will undoubtedly be to improve conversion rates while maximizing survival rates.

Research into the pathology of animals in confinement is rapidly growing in importance in response to the many diseases that have been detected. It appears that marine species are less resistant to attack by different disease organisms and are also more subject to stress.

The physical features of the coast and the water temperature would seem to be ideal for the development of aquaculture in the Western Mediterranean. However, thriving industries of this nature will require highly diversified research, with trials at pilot stations of varying types (pools offering controlled conditions, breeding and culture in estuaries and coastal lagoons, as well as mariculture in special cages and pens). Lastly, more effective and purposeful support from both the public and the private sectors is needed to bring about widespread industrial development.

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