ECONOMIC ASPECTS OF MEDITERRANEAN AQUACULTURE PRODUCTION

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Abstract

Mediterranean Aquaculture production has shown a steady growth over the years, and its production, 790,000 MT, represented in 1994 approximately 5% of the World Aquaculture production. Although Mediterranean aquaculture focuses mainly on molluscs (67.8%), the share of fish (31%) is in constant progression. So far, sea fish production is characterized by the dominance of 2 species, sea bass and sea bream (about 35,000 tonnes). This growth in production is evidence of the success of the Mediterranean mariculture as a sector. It is also the consequence of a great deal of private and public investment. However, many Mediterranean aquaculture enterprises have failed at all levels of investment and production. The growth in supply of these new aquaculture products has led to a considerable decrease in market price, which has provoked a crisis in this sector. In addition, the recession as well as the monetary crisis (devaluation of the Italian lira) have worsened the crisis of a sector highly dependent on a few markets. The present paper examines different economic aspects of the Mediterranean aquaculture production, such as production and trade; economic viability of production systems; potential impact on production cost of new technologies and new species; methodological aspects for aquaculture economics; the institutional context and the conditions of financing and of insurance; and the identification of specific economic data. Most of the information here presented comes from the Proceedings of the Seminar on Aquaculture Production Economics, that was held in Montpellier (France), from 17 to 19 May 1995, and was organized within the activities of the SELAM Network.

Résumé

La production aquacole méditerranéenne a montré une croissance régulière dans le temps, et sa production, 790.000 MT, représentait en 1994 environ 5% de la production aquacole mondiale. Mais bien que l'aquaculture méditerranéenne soit principalement axée sur les mollusques (67,8%), la part du poisson (31%) est en progression constante. Jusqu'à présent, la production de poisson de mer se caractérise par la prédominance de 2 espèces, le bar et la daurade (environ 35.000 tonnes). Cette croissance de la production est la preuve de la réussite de la mariculture méditerranéenne en tant que secteur. Ceci est également la conséquence d'un grand nombre d'investissements privés et publics. Néanmoins, beaucoup d'entreprises aquacoles méditerranéennes ont échoué à toutes les échelles d'investissement et de production. L'augmentation de l'offre pour ces nouveaux produits aquacoles a mené à une baisse considérable du prix de marché, ce qui a provoqué une crise du secteur. En outre, la récession ainsi que la crise monétaire (dévaluation de la lire italienne) ont aggravé la crise d'un secteur qui dépend fortement d'un nombre réduit de marchés. Le présent article examine différents aspects économiques de la production aquacole méditerranéenne, comme la production et le commerce; la viabilité économique des systèmes de production; l'impact potentiel sur les coûts de production des nouvelles technologies et des nouvelles espèces; les aspects méthodologiques de l'économie aquacole; le contexte institutionnel et les conditions de financement et d'assurance; et l'identification de données économiques spécifiques. La plupart de l'information présentée ici provient des Actes du Séminaire sur l'Economie de la Production Aquacole, tenu à Montpellier (France) du 17 au 19 mai 1995, et organisé dans le cadre des activités du Réseau SELAM.

Marine living resources provide an important source of protein in many countries. Although marine catches have increased during the last 20 years, that tendency has changed and at present landings have stabilized. Moreover, about 69 percent of the world's conventional species are fully exploited, overexploited, depleted or in the process of rebuilding as a result of depletion. On the contrary, Aquaculture production has constantly expanded during the last decade, reaching in 1993 an estimated production of 15.9 MT (excluding seaweed). This cultured fish production accounted for about 16% of total world fish production (101 million MT) (FAO, 1995a), but when considering fish as food for human consumption only, aquaculture acquires greater importance since approximately 21% of fish production for human consumption is cultured. Normale:Most of the aquaculture production comes from developing states. Asia, with about 84% of the world aquaculture production, is by far the main producer. Aquaculture production from other areas of the world is relatively lower in comparison with Asia. Thus, Europe produces 8.5% of the world's total; North America and South America 3.7% and 2.3% respectively (FAO, 1995b). In this context, in the Mediterranean, as well as in other world areas, during the 70s it became evident that fisheries would not be able to fulfill the market needs. This situation urged many Mediterranean States (mainly northern States) as well as other international institutions such as FAO and the EEC to promote actions towards the development of Aquaculture. Mediterranean Aquaculture production has shown a steady growth over the years, and its production, 790,000 MT, represented in 1994 approximately 5% of the World Aquaculture production. The characteristics of the Mediterranean partially influence the development of the Aquaculture. For example, the Mediterranean coast, of about 46,000 km, besides being highly populated (150 million people), also supports the effect of other human activities, such as the tourism which represents one third of world tourism (more than 117 million tourists in 1987 (Grenon & Batisse, 1989). This fact influences the establishment of aquaculture enterprises along the Mediterranean coast. The Mediterranean sea is also a very sensitive sea, and despite representing approximately 1% of the world seas, has a high diversity. More than 6.000 marine species have been identified here. One of the main prob-

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lems of the Mediterranean is its low rate of water renewal (1.5% per year). Some "recent" work modifications, such as the Suez Channel and the Asswan dam have, respectively, provoked the introduction of 600 new species and a increase of coastal salinity due to the lower water intake from the Nile river. In 1992, while 65% (10,725,832 MT) of the total World Aquaculture production came from fresh waters in the Mediterranean, most of the production, 76%, came from marine aquaculture (Lacroix, 1995). Concerning Aquaculture commodities, Mediterranean aquaculture focuses essentially on shellfish culture, mainly on molluscs (67,8%), but the share of sea fish (31%), especially sea bass and sea bream, is in constant progression (it accounts for about 35,000 tonnes). Mediterranean production of crustaceans and seaweeds is negligible. Scientific and technical progress have helped Mediterranean Aquaculture to develop significantly over recent years. The Mediterranean marine aquaculture production is characterized by the dominance of 2 species, sea bass and sea bream, which represent 48% and 50% of total production and by approximately 10 other species, which represent only 2% of the total production (Stephanis, 1995a). The state of technology for sea bass and sea bream is well advanced. Thus, for these two species their production cycle is totally controlled from egg to genitor, and the majority of fry is produced in hatcheries. However, for most of the other species, whose biological cycle is not yet totally controlled, fry is obtained from wild. The evolution of the Mediterranean finfish mariculture has been described by J. Stephanis (1995) as a sectorial evolution having three phases: i) the research phase, which began almost from zero in the years 69 and 70 and targeted two species, sea bass and sea bream, ii) the pre-development phase, which began at the end of the 70s and resulted in the creation of enterprises in Northern Mediterranean countries (France, Italy, Greece, Spain, ex Yugoslavia) and iii) the development boom phase, which began in 1987 and 1990, when most technical production problems have been solved and production volumes started to climb. This growth in production is evidence of the success of the Mediterranean mariculture as a sector. It is also the consecuence of a great deal of private and public investment. However, the statistics do not show the level of individual failure that many Mediterranean aquaculture enterprises at all scales of investment and production. The growth in supply of these new aquaculture products have led to a considerable decrease in market price, which has provoked a crisis in this sector. In addition, the recession as well as the monetary crises (devaluation of the Italian lira) have worsened the crisis of a sector highly dependent on a few markets. Exports of sea bass and sea bream reach almost half of the production in the Mediterranean zone. In this context, there are many lessons that Mediterranean producers can learn from the developments in other regions, such as the salmon industry in Northern Europe, and the Shrimp industries of Asia and Latin America. Most of the information here presented comes from the Proceedings of the Seminar on Aquaculture Production Economics, that was held in Montpellier (France), from 17 to 19 May 1995, and was organized within the activities of the SELAM Netwotk (Network on Socio-economic and Legal Aspects of Aquaculture in the Mediterranean). The SELAM Network is co-ordinated by the International Centre for Advanced Mediterranean Agronomic Studies through the Mediterranean Agronomic Institute of Zaragoza (CIHEAM - IAMZ).

Aquaculture production and trade

Production

Aquaculture production in the countries all around the Mediterranean sea has increased from 685,000 tonnes in 1988 to 790,000 tonnes in 1994 (**table 1**). Such a slow annual growth rate of 2% only is due to the stabilisation of the traditional productions, i.e. bivalves and extensive fresh water fish, which are still the bulk of production. On the contrary, intensive fish farming, both in fresh water and in marine water, has reached a significant state of development, but represents only 20% of the total aquaculture production. These data include all the aquaculture productions of the Mediterranean countries, are they produced inland, on the Atlantic coastline or on the Mediterranean coastline (Lacroix, 1995). Nevertheless, during this period, the share of the production coming exclusively from the Mediterranean coastlines or watersheds has passed from 33% to 43% of the total production of the Mediterranean countries, which means an annual average increase of 9% per year (**table 2**). Such an increase is comparable to the world aquaculture average growth rate. In this case, all the sectors have increased, even bivalves, except traditional extensive freshwater fish farming. The species responsible for this growth are mussels and clams among the bivalves, mullet, sea-bass and sea-bream for marine finfish farming and trout for intensive finfish farming in fresh water. France, Spain and Italy are the top three countries in the Mediterranean area (**table 3**). The bulk of their production is made of bivalves, but Italy and France have a strong trout production too. When referring to the Mediterranean sea only, Italy becomes the major producer since only 8% of the French aquaculture production and 6% of the Spanish one are obtained from in the Mediterranean. Egypt and Greece are at the same level, the first one thanks to extensive freshwater fish farming (tilapia and carp) and the second one thanks to the dramatically fast development of sea-bass and sea-bream farming. In terms of value, total ex-farm production of all Mediterranean countries may be estimated at 1,3 billion of US dollars. Bivalves account for 43% of this amount, marine finfish for 31% and freshwater finfish for 26%. With regard to the Mediterranean sea itself (and its watersheds), marine finfish is now the most important activity with a turn-over of 200 million US$, i.e. more than 40% of the total aquaculture production. That is the reason why most of the research programs and most of the planning projects are devoted to this sector and, particullary, to intensive farming of sea-bass and sea-bream. Production of sea-bass and of sea-bream are similar,

Table 1 ***Evolution of the aquaculture production in the Mediterranean countries.***

(tonnes)	1988	1994	increase
Bivalves	525.000	545.000	4%
Marine finsfish (extensive rearing)	7.000	11.300	61%
Marine finsfish (intensive rearing)	3.500	37.700	977%
Freshwater finfish (extensive rearing)	65.000	73.000	12%
Freshwater finfish (intensive rearing)	83.000	131.700	59%
Total	683.500	798.700	17%

source: FAO, SIPAM, IFREMER.

about 15,000 tonnes each in 1994 (**table 4**). For 1995, the production is estimated at 36,300 tonnes (24% more than in 1994). As for the near future, given the number of fry, which has been produced in 1994 (180 millions units), after a reasonable increase, may be considered to reach 45,000 tonnes in 1996. Most of the production is obtained in cages in sheltered bays. Almost 500 farms were operating in 1994, with an average production capacity of 75 tonnes per year. This figure hides a disparity between numerous small scale farms below 20 tonnes, a smaller number of semi-industrial farms around 250 tonnes and a very limited number of industrial farms over 500 tonnes. Only 60 enterprises are equipped with a hatchery and perform their own fry production, but no enterprise has integrated a processing activity (Stephanis, 1995).

Trade

This recent activity of sea-bass and sea-bream farming has been developed with the aim of supplying the Italian market, where a tradition has been existing for a long time to consume these species. In 1994, 60% of the production in the area has been exported, mainly to Italy, but also a little to France and Germany. Till now, all the fish has been traded as plain raw guts-on fish, at a size between 300 and 500 g. But some producers try to sell bigger ungutted fish for the Northern markets. International trade of sea-bass and sea-bream has been so far very difficult to assess because these products did not use to be differentiated in the official statistical data. This situation will change from 1996 on, since sea-bass and sea-bream have received a specific status in these statistics. Traditional exchange of mussels exists from Spain to France (4,000 tonnes par year) and from Spain to Italy (7,000 tonnes per year), in order to alleviate the lack of Mediterranean production of mussels during winter time. More recently, new flows have been developed from Greece (6,000 tonnes per year) and from Turkey (3,000 tonnes per year) towards Italy, in order to provide an increasing demand of product at low price. Besides, France imports more and more processed mussels from Northern Europe, following the new trends of consumption for ready to cook products. As for clams, Spain is a major importer especially from Italy (around 10,000 tonnes a year, both fresh and frozen).
There is no significant exchange for the other aquacultured species in the Mediterranean area.

Table 2 ***Aquaculture production on the very Mediterranean coastlines and watersheds.***

(tonnes)	1988	1994	increase
Bivalves	130.000	177.000	36%
Marine finsfish (extensive rearing)	7.000	11.200	60%
Marine finsfish (intensive rearing)	2.500	25.800	932%
Freshwater finfish (extensive rearing)	53.000	62.500	18%
Freshwater finfish (intensive rearing)	35.000	60.500	73%
Total	227.500	337.000	48%

source: FAO, SIPAM, IFREMER.

Table 3 ***Aquaculture production in the Mediterranean countries in 1994 (*).***

	Bivalves	Marine finfish	Freshwater finfish	*All species*
Albania	300		300	*600*
Algeria	20	40	230	*290*
Croatia	1.600	1.100	8.900	*11.600*
Cyprus		210	80	*290*
Egypt		750	41.000	*41.750*
Spain	150.000	6.000	21.520	*190.880*
France	220.000	6.000	59.000	*290.050*
Greece	21.000	13.040	2.650	*36.690*
Italy	124.000	8.000	55.700	*187.700*
Israël		900		*900*
Lebanon			500	*500*
Libya			100	*100*
Malta		900	50	*950*
Moroco	1.400	610	160	*2.170*
Portugal	2.600	550	1.200	*4.350*
Syria			2.850	*2.850*
Tunisia	60	860	70	*990*
Turkey		3.600	7.100	*10.700*
All countries	*545.000*	*49.000*	*196.000*	*790.000*
Value (million US$)	*550*	*400*	*350*	*1.300*

(*) data from 1993 when not available for 1994.
source: FAO, SIPAM, IFREMER.

Potential impact on production cost of new technologies and new species

The successful development of the sea bass and sea bream production in the Mediterranean area has been achieved thanks to the overcoming of the various technical problems of the culture of sea bass and sea bream. The growth in supply of these species has led to a considerable decrease in market price, which has provoked a crisis in this sector. Producers have seen their profit margin decline and at the same time are facing a more and more competitive market. In this context, there is only a limited number of strategies that producers may follow in order to maximize their profitability and thus ensure a continuous expansion of the Mediterranean aquaculture industry. The main strategies included i) decrease in production cost, ii) increase in selling prices and iii) answer to the diversity of the demand. Of these three strategies the second one, increase in selling prices, although possible, seems difficult to be achieved, because it needs sophisticated methods of marketing and commercialization of the product. Diversification of products may refer to a) production of new cultured species, called species diversification, and to b) different market products for a given aquaculture species, called product di-

Table 4 ***Production of sea-bass and sea-bream in the Mediterranean countries.***

(tonnes)	1990	1991	1992	1993	1994	prevision for 1996
Spain	600	1.100	2.000	2.600	3.200	6.000
France	380	750	1.250	2.350	3.400	5.000
Greece	1.600	2.500	6.000	8.500	12.000	17.000
Italy	1.900	2.500	2.900	3.400	4.000	7.000
Portugal	100	300	380	500	600	800
Total E.U.	4.580	7.150	12.530	17.350	23.200	35.800
Croatia					1.200	1.500
Cyprus	50	60	70	190	210	800
Malta		50	300	500	1.000	1.400
Morocco	100	180	300	500	650	1.000
Tunisia	200	300	400	600	700	800
Turkey	180	250	1.200	1.500	3.500	4.500
Total non E.U.	530	840	2.270	3.290	7.260	10.000
All countries	*5.600*	*8.500*	*15.400*	*21.500*	*30.500*	*45.800*

(*) data from 1993 when not available for 1994.
source: SIPAM, Selonda, IFREMER, Ewos.

versification, i.e. different size, different manufacturing process, different presentation, different quality, etc. In this paper we only wish to underline the importance of developing new markets through a differentiation policy of products in terms of quality and price. All marketing aspects will be further discussed in a second paper, dealing with the marketing of Mediterranean aquaculture products. Therefore, we will speak about different ways to achieve a reduction in production cost. We will also summarize the present culture status knowledge about new Mediterranean finfish species (species diversification), which is a strategy to answer to the diversity of the market. In addition, we will briefly discuss some technical problems that are affecting the Mediterranean aquaculture development.

Reduction of production cost

The aquaculture industry, in order to maximize its profits, should achieve a reduction of its production costs. If we refer to what is happening in marine salmon farming and in freshwater fish farming, productivity gains are necessary to reduce production costs of Mediterranean aquaculture, i.e. labour productivity which is still very low.
In this context, research operations conducted on the optimization of production systems are a very important step. New technologies may offer solutions to some of the problems that Mediterranean aquaculture is facing today. Aquaculture industry as well as producers should be aware of the new available technologies, and whenever possible, be ready to implement them.

The cost of feed

In bass and bream farming, the cost of feed may account for about 30% of the total production cost, which is mainly due to the high FCR achieved for these two species; about 2.5:1 comparing with 1:1 or 1,5:1 obtained for salmon or trout. Although every Mediterranean farmer puts a great deal of effort into a feed price reduction from the supplier, there are great difficulties to control the FCR and relate feed to performance. Although we would estimate an improvement of FCR, we can hardly think current feed would reach a FCR below 1.5:1 (J.M. Fernandez et al., 1995). More research is needed in order to have fish food better adapted to sea bass and sea bream nutritional requirements. Before this food is available on the market, FCR can be improved and therefore reduce the cost of feeding, by following appropriate husbandry as well as an adequate method of feeding (feeding efficiency). There also exist the problem of the high number of fish food companies operating in the Mediterranean. In a market like Greece, which consumes about 25.000t of feed per year, there are 15 feed companies, while Norway (with some 300.000t/y) has only 5 companies (J.M. Fernandez et al., 1995). Therefore the cost-effectiveness of a feed company in Norway, due to the volume, is hardly impossible to ochieve in the Mediterranean area. Hence mass production advantages such as feed formula cost, overheads, R&D and so on will be always more expensive in low volume companies. Thus, one way to reduce the cost of feed will come from the benefits of critical mass production, where a reduction of the overhead and benefits from adequate R&D plans can take place.

Genetic quality of fish

Although the state of technology for the culture of sea bass and sea bream is well advanced, genetically improved strains are not available for these two species. By effective breeding programmes, improvements in growth rate as well as FCR may be achieved. Genetically improved and modified fish is now common when growing salmon, trout, carp or grass carp in developed countries. Research effort for selection of better performance strains of Mediterranean aquaculture species is desirable, such as the research and selection programmes followed for salmon by Norwegian researchers.

Labour cost

If we refer to what happens in marine salmon farming and in fresh water fish farming, labour productivity is still very low. Thus, labour productivity for Mediterranean enterprises ongrowing sea bass and sea bream range from 10 to 25t per person, depending on the production effiency and moreover on the size farm, small, medium or large. This productivity contrasts with yields more than 50t per person obtained for trout or salmon (Stephanis, 1995b). Although salaries are not the same, they are growing at a higher rate than in central Europe, and this cost advantage is decreasing. An appropriate farm design, adequate equipment (pumps for live fish, automation), high quality fish husbandry as well as efficient feeding systems are all aspects to be improved in order to gain labour productivity.

Health management

Parallel to the development of the Mediterranean aquaculture, disease problems have significantly increased in recent years in Mediterranean cultured marine fish. Thus, Disease may be considered one of the most limiting factors in the continued development of the aquaculture. Therefore, producers should pay special attention to their farm health management, and not try to save money in these aspects, and at the same time they should give confidence and support to experts working on finding solutions to fish and shellfish disease problems. The most frequent bacterial problems are due to *Vibrio anguillarum*, and more recently to *Pasteurella piscicida*. Virosis include a new Picornavirus-like (Nodavirus) that causes encephalitis and produces high mor-

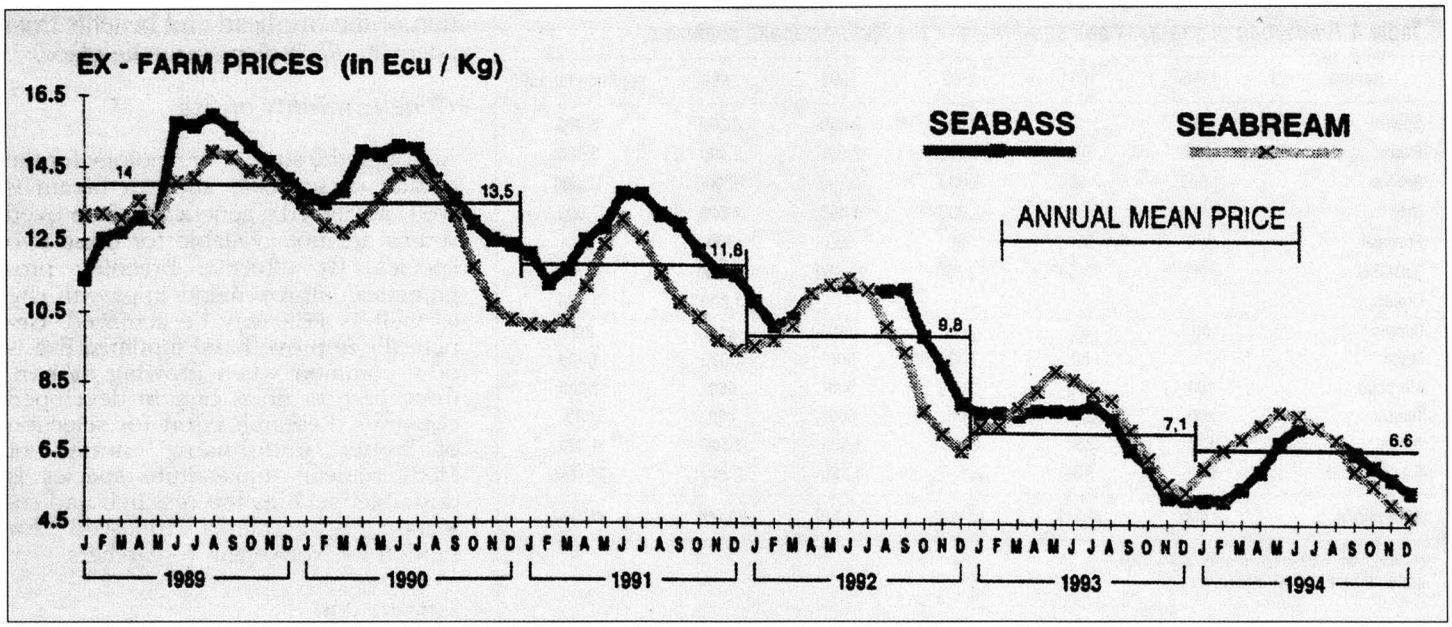

Figure 1 - Sea bass and sea-bream ex-farm price evolution in Greece (Source: SELONDA).

talities in sea bass. Other virosis are lymphocystis (Iridoviridae) from sea bream and erythrocytic infection (VEI) from sea bass. Reports of parasites are increasing, mainly ectoparasitic flagellates, monogeneas and some endoparasitic protozoans (Alavarez-Pellitero & Sitjà-Bobadilla, 1995). New commercial and/or experimental vaccines are now available againts some diseases, such vibriosis or pasteurellosis. However, future research should be focused in developing new diagnostic techniques with regards to Mediterranean disease problems, in developing new commercial vaccines (i.e. pasteurellosis) and in enhancing the immunocompetence of cultured fish.

New technologies

At present most Mediterranean farms are established in inshore waters. The need for new space has become higher and aquaculture is competing for other coastal space consuming activities such as tourism, industry, navigation, coastal defense, etc. Thus, open sea exposition became a growing need for increasing space resources as well as for escaping coastal environmental degradation. As a consequence, a trend to draw marine aquaculture out of sheltered sites, towards more exposed ones, has been observed for several years. It is driven both by the need for available space and environment quality. Different types of architectures are now available in the market. The exposed site cages nets usually come from a reinforcement of coastal structures, mostly in the flexible mode. We also have the offshore cages, submersion or semi-submersion cages, and boats, which offer different ways to escape from surface forces or abate them. In the meanwhile, discharge of effluents in the environment has become harmful for the activity itself. Especially when the environment already receives influences from other aggressive activities such as agriculture, industry and human residence. All regulations obliging to treat the effluents will have negative effects on cage culture development. Being subject to severe environmental constraints, marine aquaculture must adopt more controllable production processes, compatible with the industrial systems of management used by the other sectors of the foodstuff industry.

In this context, closed systems may be presented as an alternative, by offering certain benefits, such as independence of outside climatic conditions, minimal use of water, continuous optimal growth for stocks and protection from disease. These systems have the advantage of being less polluting because of the continuous internal treatment of the water and of the elimination of most dissolved nitrogen. Concentrated waste treatment becomes more available both technically and financially. Closed systems, already used for hatcheries, are now able to operate with fresh and cold water and have a great potential for many types of aquaculture. Results of the ongrowing experimental facilities have proved good enough to make it possible to conceive industrial projects for sea-bass and turbot.

Species diversification

The assessment of diversification of cultured species must aim at winning more important markets in order to ensure a large-scale development of the Mediterranean aquaculture. There must be a multidisciplinary approach of diversification, and therefore the species introduced have to be selected under economical and biological limitations. The selection of new species should be preceded by preliminary market and economic analyses to assess prices, demand, etc. In addition, the new culture species should match the wild fish standards, having the same organoleptic properties of their wild counterparts. In this sense the high quality of the aquaculture products is secured. The biological limitations concern the rearing of the species (reproduction, growth, easy culture adaptation, endemic species, etc.). Like sea bass and sea bream during 70s and 80s, the limiting factor for the successful introduction and culture development of new aquaculture species is the lack of biological knowledge for the control of the whole production cycle, especially in the field of reproduction control and the larvae rearing. However, the information, as well as other biological data, on the culture of new species has been increasing at a fast rate during the last years. Among all the alternatives of diversification, that related with high growth, medium priced fish (i.e. *Thunnus tynnus, Coryphaena hippurus, Seriola dumerilli*) and with lower growth, better priced fish (*Pagrus pagrus, Dentex dentex, Puntazzo puntazzo, Diplodus sargus, Epinephelus* sp.), are more discussed. Some of the new species are nearing production on a commercial scale, i.e. *Puntazzo puntazzo*, while

others still need more research work, i.e. *Seriola dumerilii*.
The present culture knowledge of several Mediterranean finfish species is here presented. Most of the information comes from a Workshop on Marine Aquaculture Finfish Species Diversification that was held in Nicosia, Cyprus, during June 1995: The Workshop was organized within the activities of the TECAM Network (Technology of Aquaculture in the Mediterranean) which is co-ordinated by the CIHEAM - IAMZ. It can be seen that most of the species belong to the sparid family, so we may classify new species between "sparids" (*Puntazzo puntazzo, Pagrus sp., Dentex dentex, Diplodus sargus, Pagellus sp., etc*) and "non-sparids" (*Solea sp., Seriola dumerilii, Ephinephelus sp., Coryphaena hippurus, etc*). The sparid hybrids, such as the cross between Sparus aurata and Dentex dentex, may also be considered as new species.

Puntazzo puntazzo

This species has been cultured on a commercial scale during the last couple of years in several Mediterranean countries like Greece, Morocco, Cyprus and Italy. The knowledge on its culture has advanced rapidly. Aspects such as larval rearing and growout have been studied thoroughly; however, more work remains to be done on the maturation and spawning as well as on the nutritional requirements and diet formulations. These will improve production costs making production more competitive.

Pagrus pagrus

This fish has a high price demand, and presents a high rate of growth. It has a good adaptability to culture conditions and presents no serious disease problems. Data on reproductive biology, growth and larval rearing as well as information related to the intensive farming problems is already available. However, technological and nutritional improvements must be made in larval rearing, in order to avoid problems, such as the discolouration of *Pagrus pagrus* body, apparently due to its nutritional requirements.

Dentex dentex

The broodstock maturation and spawning is feasible. Larval rearing especially during the weaning stage is problematic. Its growout to commercial size still presents considerable problems mainly due to poor survival from cannibalism and inadequate nutrition. Much more work on nutrition and husbandry methods of *Dentex dentex* is needed before it can be commercialized.

Pagellus acarne

Research on the culture of the species is at an initial stage. Presently the maturation and spawning of broodstock is under study.

Solea sp.

The sole, Solea solea, with difficulties under intensive conditions presents a good growth performance in lagoon zones. For *Solea senegalensis*, larval production is commercially feasible. Its reproduction and larval rearing has been managed successfully. Its growout, however, presents problems mainly relating to nutrition and husbandry techniques. Fertilization will increase pond monoculture production. It can be used in polyculture with other species thus enhancing the income of traditional semi-intensive farming. Its nutrition needs further study. It has a global market potential.

Seriola dumerilii

This is a very fast-growing pelagic fish reaching large sizes. Already considerable work is carried out on its culture in the Mediterranean area but also in some Asian countries. It could be a promising species. More work must be carried out on reproduction and larval rearing. At present production is based on fry collected from the wild, which, however, is becoming scarce. Nutrition today is mainly based on low priced fish and partially on moist diets.

Coryphaena hippurus

A fast growing pelagic fish reaching large sizes. Its market appreciation is not homogeneous in all Mediterranean countries. Reproduction is not as successful in Mediterranean hatcheries as in the USA and other countries. More research is needed on nutrition.

Epinephelus marginatus (E. guaza)

Groupers are appreciated in almost all Mediterranean countries. Present research on the culture of this species refers to broodstock formation, maturation spawning and on the growout to commercial size. Today fry is found only from the wild. More research is needed in all aspects of its culture. It is a species considered for restocking programmes, the management of coastal areas, as well as for aquaculture. Latest results are encouraging.

Sciaenops ocellatus

This species is not indigenous to the Mediterranean sea. Its culture has been studied in several countries in the American continent. Recently its culture in the Mediterranean is studied in some countries. Indigenous species of the same family are cultured in Mediterranean countries. Finally and although for most species discussed above, the present biological knowledge is still considered to be far from satisfactory, small commercial production for some species, such as *P. Puntazzo* is already produced, and we may expect this and other species to gain more importance in the years to come.

Economic viability of production systems

Very little information is available about the traditional productions of extensive fish farming, either in marine water or in fresh water. These productions are integrated in local agricultural economic systems the viability of which depends on a lot of different factors, far beyond the aquacultural activity itself. That is the reason why only the viability of the new production systems has been approached till now. Two factors play a major role in the economic viability of production systems, i.e. the production cost and the ex-farm price. In the case of sea-bass and sea-bream, both of them have been changing a lot for the past five years. Indeed, not only the increase of the supply of these products has had an impact on the market, but the fish market itself has changed during the period. On the other hand, biological and technological progress as well as economies of scale have contributed to a decrease of the production costs.

General trends for ex-farm price and for production costs of sea-bass and sea-bream

As Greece remains the major producer of sea-bass and sea-bream, it is particularly interesting to analyse the evolution of the Greek ex-farm prices (**figure 1**). The ex-farm prices for sea-bass and sea-bream have been very similar and have followed the same downward trend since 1989, with some seasonal fluctuations. Prices are lower in winter than in summer, because both the supply of wild and cultured fish are more important at that time of the year. Between 1989 and 1994, the ex-farm

prices of both species have decreased by more than 50%, while the production was jumping from 5,000 tonnes to 30,000 tonnes. In 1994, the average price was around 6.5 Ecu/kg, and no significant change has been noticed during 1995 (Stephanis, 1995). The biggest drop has been observed between 1992 and 1993, due to the devaluation of the Italian Lira. Indeed, as most of the production is sold on the Italian market, the price paid to the foreign producers has been reduced when converted into their national currency. This monetary disturbance has particularly affected the French producers who have partly retired from the Italian market, for the benefit of Greek and Spanish producers.

Such a phenomenon of price fall has been observed in the salmon industry, but less suddenly and at higher level of production. Indeed, the price of salmon has been cut by two between 1986 and 1994, whilst production was increasing from 30,000 tonnes to 300,000 tonnes (Josupeit, 1995). The overreaction of the price of sea-bass to the increasing supply may be explained by marketing considerations which will be discussed in a further paper. Meanwhile, the salmon activity has reached a much wider consumer target thanks to the diversification of the products, including small fish, big fish (till 8kg), fillets, slices, smoked fish and other processed items. On the contrary, the Mediterranean fish farming has based its development only on the market for small fish, which is not expanding because of the evolution of the consumption habits towards prepared food.

In the same time, the average production costs have decreased from 7 to 10 Ecu/kg in 1989 to 5 to 7 Ecu/kg in 1994 (Stephanis, 1995). The first factor which explains this trend is the efficiency which has been developed in the fry production. Hatcheries, which used to demand a lot of investment and manpower are now much smaller units, with lower production costs. While a sea-bass fingerling was sold one Ecu in 1989, its price does not exceed 0.25 ECU in 1995. Other productivity gains have been obtained in fish ongrowing, especially thanks to better survival rate, lower food conversion ratio and better labour management. Moreover, the financial expenses are not any more so heavy a burden since most of the farms settled down five years ago and have already reimbursed a big part of their loans. Anyhow, the ratio of profitability (result on turn-over) is now very low, rarely over 10% (before taking into account financial expenses), which does not seem very attractive for new investors.

Factors of variation of production costs for sea-bass and sea-bream

Given the variety of countries, of sites, of technologies, and of farm sizes which are involved in Mediterranean sea-bass and sea-bream production, production costs are also very variable. This variety of production costs is all the bigger as most of the enterprises are not five years old and have not reached routine yet.

A study carried out by IFREMER in France (La Pomélie, 1995) shows that production costs are slightly higher for an on-shore farm using concrete raceways and pumping than for an off-shore farm using floating cages in a sheltered bay. Indeed, for the same production capacity, i.e. 300 tonnes per year, depreciation costs are similar because the investment for raceways is higher, but cages and nets have to be renewed more often. Onshore farms have a better labour productivity but are much more energy consuming because of the pumping system.

The question of economies of scale is relevant in Mediterranean fish farming, as it is shown by a study carried out by SELONDA in Greece. Productions costs in small scale farms using floating cages (production capacity around 50 tonnes) are 30% higher than in semi-industrial farms (over 350 tonnes). This difference is mainly due to a better labour productivity in big farms, since the investment in cages is roughly proportional to the production capacity. But the diversity of techniques, of know-how and of socio-economic contexts (family or salaried labour force) makes the existence of such firms possible. In fact, these firms can develop their own competitive advantages and enhance their productions on the different markets. Convenience markets (markets of proximity), which are more profitable, are the target of small scale familial firms while industrial firms focus on export markets and new distribution means.

The differences between countries are much more difficult to assess, because of the variety of conditions of production. Nevertheless, the comparative study carried out on the occasion of the SELAM seminar on aquaculture economics held in Montpellier in May 1995, has not shown very important differences. For the same size of production unit, the highest production costs are only 20% more than the lowest. So the international differences are not as big as the differences due to the size of the production units. The breakdown of production costs shows that feed accounts for 25% to 35% and labour for 10% to 15%, which is significant of a young aquacultural activity, not mature yet. In salmon farming for instance, labour is below 8% while feed is usually over 60%, as a consequence of the better zootechnical performances (food conversion ratio, labour productivity, high rearing density).

Production costs for mussel farming on long-lines in France

Mussel farming in the Mediterranean has been traditionally practised in lagoons, like in Venezia lagoon or Tarento bay (Italy) or Thau lagoon (France). Given the problems of environmental quality and of overstocking in these lagoons, some attempts have been done to cultivate mussels off-shore as soon as the beginning of the eighties. In order to resist to the rough sea conditions in the Mediterranean sea, particularly in autumn, special rearing structures have been designed. These are the long-lines, which may be floating like in Trieste or Manfredonia (Italy), or submersed five meters deep like in front of Sète (France). At the present time, this type of mussel cultivation accounts for 25% of the mussels farmed in the Mediterranean. In the case of the French production in front of Sète, which is entirely done with submersed long-lines, it has involved high investments in boats equipped with hydraulic cranes and winches and in on-shore installations to process the mussels. That is the reason why only big enterprises or groups of enterprises have succeeded in this adventure towards the open. A study carried out by CEPRALMAR (Loste, 1995) estimates the production cost of such mussels at 0.6 ECU/kg without financial expenses, which is above the usual price of mussels on the Italian or Spanish markets. As these mussels are aimed at the French and Belgian markets with a usual ex-farm price around 0.8 ECU/kg, the activity remains profitable but depends a lot on the natural conditions (storms, red tides). That is why several small enterprises have failed, for they have not been able to face with these risks.

The key elements which influence the profitability of Mediterranean aquaculture

In both cases, sea-bass and mussels, two major issues arise in the economic viability of the new developments of Mediterranean aquaculture: the ade-

quation of the products to the demand and the variations of parity of the currencies. In the context of internationally extended markets, firms must face up not only to differences in production costs but also to sudden variations of the exchange rates. The latter induce competition distortions and hinder the process of a management based on rational anticipations. This situation concerns fish producers, but also shellfish producers especially those who have made large investments on new techniques in open sea. These issues will be discussed in a special paper devoted to marketing aspects, but are related to technological and biological questions. Indeed, before considering a great industrial development for Mediterranean aquaculture, a lot of progress has still to be achieved in husbandry practices, genetic selection, food formulation and automatisation in order to reduce production costs and to propose a wider range of products instead of small fish at a high price only, as it is the case at the present time.

Methodological aspects for aquaculture economics

Aquaculture is faced with marketing and technical difficulties which make profitability of the activity sometimes difficult to reach. Time has long gone when the price of some top-grade sea products was very high and the demand seemed limitless. In a context of high international competition where social and economic conditions, institutional rules and characteristics of the demand are uncertain, it is very important to have tools to facilitate decision-making by investors, bankers, entrepreneurs, researchers and public-policy makers.

The importance of the socio-economic context

The socio-economic context appears to be one of the key elements, on a par with site quality and market conditions, which must be taken into account by promoters of new projects. A study carried out by Duché for SEPIA Conseil (1995) on the basis of three examples of aquacultural projects in countries surrounding the Mediterranean sea (Greece, Croatia and Tunisia) has identified some of the most important issues. In the case of the Greek project which has been for sale after only five years in operation, the reason for the failure may be imputed to the little financial involvement from local investors. Being considered as a foreign project, it has received no local political support and has been accused of endangering the environment. On the contrary, the Croatian and Tunisian projects have taken advantage of a good local financial partnership and of a clear share of duties in the farm management to develop the enterprises according to the expectations. In Tunisia, a major ecological impediment has obliged the farm to reduce its activity, but it is not due to managerial problems. Taking lessons from these experiences, the key elements for success seem to be the sharing of initiatives and the pooling of financial and political assets, in a structure beneficial for both parts.

Project analysis and enterprise diagnosis

Formal accounting sheets usually turn out to be inappropriate to identify the technical or managerial elements causing the financial situation of an enterprise and to imagine the future of that enterprise as well. That is the reason why, as it has been widely developed in agriculture, a technical-economic approach linking the physical flows related to the activity of the enterprise and the resulting financial flows should be a better answer to the need of vigilance on husbandry practices and to the need of projection in the future. The realisation of a computerised simulation tool taking into account some relevant technical, biological and economic criteria makes it possible to assess the feasibility of a new project or to figure out the consequences of investment decisions on the cash-flow and on the viability of an enterprise (Calleja and Paquotte, 1995).
For that purpose, project analysis using a table sheet software has proved to be a very useful tool. It makes possible to have a good knowledge of what will be produced in terms of cost and quality, by taking into account the comparative advantages given to this project. A full range of criteria have to be presented to evaluate the project from different view-points including return on investment, financial feasibility during the first years, profitability on the long run and breakdown of production costs. Moreover, links have to be done with a market analysis in order to assess the possibilities to look for price-competitiveness or quality-competitiveness when entering the market. Indeed, a market analysis is necessary to check adequacy between supply and demand. Such a study should be aimed at describing the present state of the market for a range of products (origin, characteristics, seasonality, volume and price) in order to focus the marketing target of the project (Paquotte, 1994).

The Aquaculture Planning Simulator (APS)

In order to provide references and elements of comparison for aquaculture planning or for private investors, the FAO is developing a special tool for technico-economic simulation called APS (Aquaculture Planning Simulator). In this objective of assessment of the economic feasibility of new projects, such a tool can offer some useful elements in the decision-making process. Indeed, thanks to an incorporated database, APS makes it possible to compare the results with those of other firms in other countries. The APS design allows both a technical and a financial tuning of the project proposals and is intended for use by the private sector, banking institutions and government offices responsible for aquaculture development (Pedini, Coppola and Moretti, 1995).

The institutional context and the conditions of financing and of insurance

The incentive policy in the European Union

In the countries belonging to the European Union, the sector of aquaculture has benefited from a strong incentive policy from the European Commission. In the framework of the regulation number 4028/86, aquaculture projects have been receiving subsidies for their initial investment. These subsidies may be associated with national or local subsidies, if the total remains below 40% of the investment (60% in some regions encountering high economic difficulties).The annual amount of these subsidies has been quite regular from 1988 to 1994, providing around 42 million ECU's per year (**table 5**). Spain, France and Italy have been the principal recipients of these subsidies from 1988 on, especially for sea-bass and sea-beam projects. In 1993, Greece became by far the first country to receive European subsidies for aquaculture (almost 50% of the total amount), which proves the dynamism of the Greek sector. The survey of the average amount of aquaculture investments having received European subsidies shows that till 1992 the Italian projects were much more costly than the projects in other countries, like Spain or France (**table 6**). This difference is due to the use of on-shore techniques

in Italy, with race-ways and pumping, contrary to the use in the other countries of floating cages less demanding in initial investment. In France, the main characteristic is the recent decrease of the share devoted to fish farming. Indeed, because of the marketing problems and the difficulties in finding available sites which have encountered the fish farms, very few fish farming projects have been submitted, whilst the recent developments in offshore mussel farming have induced a high demand of subsidies to buy specialised boats and equipment.
This incentive policy may be considered as having been successful for seabass and sea-bream, and for mussels on long-lines also. On the contrary, most of the projects aiming at shrimp farming have been a disaster, because the rearing techniques in semi-intensive conditions are not really under control and because of the very short duration of the growing period. Eel or sturgeon projects have not been very successful either, because of high production costs. Except in Italy where new stocks of clams have been settled thanks to spat from hatcheries, projects of clam culture have been failures anywhere else, because of diseases problems and of high production costs.

Table 5 ***Evolution of the European subsidies in aquaculture (regulation 4028/86).***

1000 ECU's	France	Greece	Italy	Spain	Other countries	Total
1986	1.721		1.231	7.304	14.470	17.422
1987	1.268	2.896	4.094	8.940	15.177	23.435
1988	2.609	4.970	5.768	11.657	26.630	39.977
1989	3.997	4.087	6.094	6.842	18.254	32.432
1990	4.795	6.198	11.416	9.340	24.099	46.508
1991	5.616	7.506	8.125	8.289	17.747	38.994
1992	6.950	7.422	8.481	5.340	15.514	38.367
1993	3.429	21.257	14.655	3.429	11.871	51.212

source: European Commission DGXIV.

Table 6 ***Evolution of the average amount of investment for aquaculture projects having benefited of European subsidies (Mediterranean countries).***

1000 ECU's	France	Greece	Italy	Spain	Portugal
1990	390	401	1538	290	614
1991	346	569	1913	301	399
1992	477	528	1302	433	840
1993	218	750	983	300	417

source: European Commission DGXIV.

The banking system and its support to the development of aquaculture

According to what has been observed in Greece (Agricole Bank of Greece, 1995), the tough competition between the banks can bring about problems of over-financing of aquacultural projects in the absence of reliable data on the sector. Beyond purely technical or financial criteria, human factors within the firm are very important and must be taken into consideration in the assessment made by bankers. In the case of Greece, the banks have granted funds to investors always under specific conditions. But despite all the subsidies received by the farms, many enterprises have reached a poor level of profitability. So, some producers cannot pay back their loans on due time, which obliges the banks in return to enhance their interest rates or to be very reluctant to grant new loans. As intensive fish farming is a new activity along the Mediterranean, most enterprises have still heavy financial expenses, around 10%. At the beginning of the activity, it was not a major constraint, since the ratio of profitability was over 20% thanks to very high market prices for sea-bass and sea-bream. It is much more a constraint for the new investors now, because of the very small margin provided by this activity. National differences still exist concerning interest rates, because of the different inflation rates, but they tend to be harmonised.

Insurance and reinsurance for Mediterranean aquaculture

According to the principles of the insurance system, risks in aquaculture may be covered by insurance policies only if they are well known and measurable and if there is a large enough number of farms to apply the law of the big numbers. That is the reason why insurance companies are aiming at building portfolio associating different species in different countries. Most often, these portfolio include salmon farms in Norway, Scotland and Chile as well as seabass farms in Greece and France. According to the assessment of the risks, to the nature of the site and to the techniques involved, the premium goes from 2% to 6%. The insurance companies attach special importance to the franchise, in order to avoid moral hazard and to have to support risks the enterprises should be able to cover by themselves. Indeed, insurance companies think their role is not to cover any small risk nor any loss of market, but to enable firms which have undergone heavy losses, to resume their activity in the best economic conditions. Although this sector is not very profitable for insurance companies, they want to stay on the market and are optimistic about the future development of aquaculture in the area.

The need of co-operation and information. The SELAM and SIPAM Networks

Due to good natural conditions and political will, marine aquaculture has developed recently around the Mediterranean sea. Both private entrepreneurship and public international cooperation have participated in this fast development. However, one of the weekness of this development is the scarcity of cooperation as well as lack of Aquaculture data and related information. In order to develop a competitive aquaculture sector on both sides of the Mediterranean, a cooperation is necessary between the different Mediterranean countries. The implementation of networks for research and information purposes seems one of the best way to achieve this goal.
In this context, the Mediterranean Regional Aquaculture Project has constituted a link of exchange of knowledge and tranfer of technologies among the north and south of the Mediterranean. During its first phase, coordinated by the IFREMER, many activities aiming at vulgarizing aquaculture and elaborating pilot projects, as well as socio-economic studies at the national and the regional levels, were realized. During its second phase, MEDRAP II (FAO/UNDP) was called to establish networks to ensure the conti-

nuity of the co-operation and to favour the exchange of information among the Mediterranean countries.
Thus, in 1993 four specialized networks were established in order to conduct various activities in the different aspects of Aquaculture development in the Mediterranean. The FAO / GFCM has been identified to assume the overall coordination of the Networks and to directly manage the SIPAM Network (Information System for the Promotion of Aquaculture in the Mediterranean). The International Centre for Advanced Mediterranean Agronomic Studies, through the Mediterranean Agronomic Institute of Zaragoza (CIHEAM - IAMZ) agreed to co-ordinate two other Networks: the SELAM (Socio-economic and Legal Aspects of Aquaculture in the Mediterranean) and the TECAM (Technology of Aquaculture in the Mediterranean) Networks. And the MAP-PAP/RAC to coordinate the EAM (Environment and Aquaculture in the Mediterranean) Network activities.

The SELAM Network

The SELAM Network has as objective the development of aquaculture in the Mediterranean through promoting the co-operation between institutions and experts working on socio-economic and legal aspects of Aquaculture, as well as by facilitating the exchange of ideas and information on the different socio-economic and legal aspects of Aquaculture.
To achieve this objective, the CIHEAM-IAMZ, as co-ordinating institution of the SELAM, has a programme of activities that includes: (i) the organization of advanced courses, seminars, workshops and other technical meetings, (ii) the publication of proceedings of seminars, workshops or other meetings, (iii) the support for the establishment of collaborative research groups, and (iv) the support of short technical stays of experts from South Mediterranean countries in Mediterranean institutions.
In order to undertake these different activities the SELAM Networks counts on the participation and collaboration of experts (belonging to research institutions, private companies or other national or international institutions), from Mediterranean countries.

The SIPAM Network

The SIPAM (Information System for the Promotion of Aquaculture in the Mediterranean) Network which is dealing with information aspects, is co-ordinated by the FAO/GFCM Secretariat. SIPAM is a system created by the Fisheries Department of the FAO within a world strategy for the establishment of similar information systems in different world regions. SIPAM is a tool conceived to allow the management, in predefined sub-systems, of data and information of a different nature, though all pertaining to the aquaculture sector, retrieved from various national, regional and global sources. Its final objective is the establishment of a Decision Support System (DSS) for Aquaculture.
Thus, SIPAM aims to establish a permanent and reliable regional information system to facilitate the exchange of information on aquaculture aspects of interest to beneficiaries, such as status of production, data about research centers, aquaculture experts, technology, etc. The SIPAM system has achieved the phase of the software allowing collection and exchange of international and national data on aquaculture in the Mediterranean. Moreover, SIPAM is having access to other FAO Software, such as AQUASTAT (Time Series of Aquaculture Production), AGRIS-Fishery (Fisheries Bibliograhic Reference DataBase), APS (Aquaculture Planning Simulator), etc. The firts software release is due for summer of 1996.
The SIPAM Network counts on the support of a regional centre which receives and compile the data from the participating countries. This center, after an agrement between the FAO and the Tunisian Government, is located in Tunis. There is already 9 national centers (Cyprus, Croatia, Egypt, France, Greece, Portugal, Spain, Tunisia, and Turkey) participating in this Network by providing data information. In adition the French Geverment has contributed to SIPAM with a small project entrusted to FAO. The end users of the aquaculture information systems are classified into groups according to their position and fields of interest. The primary end user is the staff of the fisheries and aquaculture services of the national offices who utilize the system mainly for reporting and planning purposes but also for answering to queries addressed by the private sector. This group is the most important for data supply to the system.
A second group of users are aquaculturists/economists, fisheries specialist traders and investors in the industry, and trade and educational institutions, both in the public and the private sectors.
The SIPAM system is also conceived as a support tool for the other EAM, SELAM and TECAM Networks. Thus, in constant development for the creation of specialised databases. ●

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