European Marine Fish Farming: An Emerging Industrial Activity

YVES HARACHE[1] AND PHILIPPE PAQUOTTE[2]

A large region that includes the European Union (EU), Scandinavia, eastern Europe and the countries of the Mediterranean Basin is the basis for this article because of the importance of the movement of products, capital and technology within these countries. Nevertheless, aquaculture development is not homogeneous inside this region. An analysis of similar trends and different constraints that influence the marine fish farming of salmonids, seabass, seabream and turbot is presented.

Due to the rapid expansion of Asian productions, especially from China, the average annual growth rate of world aquaculture by volume during this period has been 15 percent according to the FAO. The share of European and Mediterranean aquaculture has declined from 9 percent to 5 percent between 1988 and 1995 (Table I), in spite of an average growth rate of more than 5 percent by volume per year. European aquaculture, which essentially does not contribute to the crustacean and seaweed sectors, provides 14 percent of the world volume of bivalves and 6 percent of the world volume of fish. Only fish farming has shown significant growth since 1988, which matches the growth rate of world aquaculture for this group of species.

In 1996 salmonid farming totaled 710,000 tons, both fresh and marine water, an amount that represents 39 percent of the zone's aquacultural production by volume. In value, its share has reached 60 percent, with a turnover of 2 million Ecu, excluding the production of juveniles. Because of the unavailability of new sites and strong pressure to protect rivers, the development of intensive fish farming in fresh water has slowed during the last few years.

Marine fish farming, which was still marginal in 1988, now represents 50 percent by volume and 75 percent by value of the region's fish farming production. This increase, due mainly to marine salmon farming, up to 420,000 tons in 1996, is a result of the continuous development of Atlantic salmon farming in floating cages based on accelerated technological progress. Norway, the United Kingdom, Ireland and the Faroës have experienced the greatest growth in their aquacultural sector since 1988 (Table II). The output of large trout in marine waters has been slowly growing mainly due to an increase of the Norwegian production. New opportunities are arising in southern Europe with brown trout (*Salmo trutta*) showing interesting signs of development in France (Table III). The production of salmon in floating cages, either in sheltered bays or in open sites, arose while the attempt to build on-shore plants failed due to high operating costs. Norwegian and European salmon production must be considered relatively to the 620,000 tonne total of world farmed salmon. Outside Europe, the leading countries in salmon production are Chile (121,000 tons) and Canada (43,000 tons), followed by Japan (25,000 tons), United States (15,000 tons), and Australasian productions in Australia and New Zealand (10,000 tons).

More recently, the intensive farming of seabass and seabream has increased rapidly in the Mediterranean Basin, although on a more reduced scale: 60,000 tons in 1996 (Table IV and Table V). The share of seabream, at one time less important, now dominates as a result of a nodavirus infection in seabass. Seventy percent of seabass are produced in cages in sheltered bays or open sea. On-shore intensive farms, using raceways, account for only 15 percent of the total production. The remaining 15 percent is produced in traditional earthen ponds or in valli.

Turbot farming is developing more slowly on the French and Spanish Atlantic coast, 3,200 tons in 1996, benefiting from the temperate climate in that area. Turbot farming requires on-shore production facilities using concrete raceways.

Various attempts to find new species for aquaculture has led to extensive work on several Mediterranean fish including sparid species such as *Puntazzo puntazzo*, *Pagrus pagrus*, and *Dentex dentex*, which production reached about 1,000 tons in 1996. In the meantime, extensive research has been devoted to the culture of Atlantic halibut in northern Europe countries,

Table I. Comparison of European and world aquaculture production in 1988 and 1996

1988 (tons)	Total	By group of species				By environment	
		fish	crustaceans	molluscs	seaweed	Inland	marine
Europe[1]	1,240,000	520,000	3,000	710,000		380,000	860,000
World	14,650,000	7,600,000	650,000	3,000,000	34,000,000	7,350,000	7,300,000
1988 (tons)	**Total**	**By group of species**				**By environment**	
		fish	**crustaceans**	**molluscs**	**seaweed**	**Inland**	**marine**
Europe[1]	1,770,000	1,062,500	2,500	700,000	5,000	500,000	1,250,000
World	34,100,000	16,670,000	1,150,000	8,550,000	7,730,000	15,600,000	18,500,000

[2]Includes Eastern Europe (except former USSR) and Mediterranean Basin.

Source: European Commission, IFREMER, SIPAM network, FAO.

Table II. Salmon production in Europe (tons) from 1988 to 1996

	Norway	UK	Iceland and Faeroe Islands	Ireland	France	Spain	Total
1988	74,000	16,500	5,500	4,000	70	150	100,000
1989	110,000	28,000	9,500	5,500	100	150	153,500
1990	130,000	30,000	15,700	6,000	200	350	185,000
1991	155,000	41,000	20,500	9,300	200	550	226,500
1992	130,000	36,000	20,500	9,700	200	800	200,000
1993	180,000	49,000	17,200	12,400	240	600	260,000
1994	210,000	64,000	12,200	11,600	450	900	300,000
1995	249,000	72,000	13,000	12,500	500	1,250	350,000
1996	292,000	83,000	17,500	15,000	400	750	410,000

Source : IFREMER, Federation of European Aquaculture Producers

Table III: Trout (rainbow and brown) production in marine environments in Europe (tons) from 1988 to 1996

	Norway	Finland	UK	Ireland	Denmark	France	Total
1988	8,000	15,000	1,500	500	6,000	770	32,000
1989	6,000	16,000	1,500	500	6,500	880	31,500
1990	6,000	16,000	1,500	500	6,500	850	31,500
1991	6,000	16,000	1,500	600	7,000	780	32,000
1992	6,000	16,000	1,500	600	7,250	730	32,100
1993	6,000	15,000	1,500	600	8,500	700	32,300
1994	8,000	15,000	1,500	600	8,500	1,350	35,000
1995	13,000	13,000	1,500	600	8,500	1,350	38,000
1996	19,000	15,000	1,500	1,500	8,500	1,400	47,000

Source : IFREMER, Federation of European Aquaculture Producers

Table IV. Production of seabass in the Euro-Mediterranean region (tons) from 1988 to 1996

	France	Greece	Italy	Spain	Other Countries	Total
1988	150	200	930	30	200	1,510
1989	220	200	1,100	25	275	1,820
1990	350	650	1,050	30	350	2,430
1991	700	1,900	1,500	90	700	4,890
1992	1,000	2,700	1,800	150	2,000	7,650
1993	2,000	5,300	2,000	300	3,700	13,300
1994	2,200	6,500	2,150	500	4,800	16,150
1995	2,700	8,400	4,000	460	5,000	20,560
1996	2,300	10,000	3,800	700	8,800	25,600

Source : SIPAM, IFREMER

especially in Norway by the Institute of Marine Research. Today, the production remains at a pre-industrial level as no large scale postlarvae production exists. In 1993, 170,000 juvenile halibut were produced by the private firm, Stolt Sea Farm. About 20 tons of halibut, ranging from 3 to 7 kg, were sold to the Norwegian restaurant market in 1996[12].

Dynamics of marine fish farming in Europe

Institutional framework for research and development

Although research started in the 1970s with a strong public demand for salmon, seabass and seabream, farming of these species has not developed at the same pace.

Salmon farming

The Norwegian salmon industry has been supported from its inception by a voluntary public policy and a well organized farmers' association. Government incentives have helped many farms to grow. The Norwegian government has implemented strict regulations concerning the size of the farms and the capital ownership along the coast, from south to north. These regulations promoted a sector made of small scale independent farms, without vertical or horizontal integration. Nevertheless, organization of production was accomplished through a commercial structure called "FOS". The FOS held the monopoly of Norwegian salmon marketing and was in charge of generic promotion and relations with the exporters. One of the most important features was the tight link forged by research between public authorities and industry. Both parties invested in both research centers and program definition for genetics, pathology and nutrition.[7]

After the FOS and the government's failure to forecast the expanding supply of salmon and regulate the market, a new sector was organized. The regulatory role of the government has been reduced to the control of the environmental impact of aquaculture, while industrial groups and producers' associations have promoted a concentration of production and an integration of commercialization.

These Norwegian companies first invested in Scotland and Ireland, then in other countries world-wide, including Chile. In Europe, salmon farming developed in the mid-1980s through transfer of research information in genetics and nutrition from Norway, technological innovation in offshore cage design, and European Union investment subsidies.[1] Salmon farming trials commenced in western Ireland in the early 70's, with little growth until the mid-1980s when output and investment in the sector began to increase substantially. The lack of protected sites was resolved by the successful development of appropriate cage technology, thus increasing the potential area available for salmon farming along the Irish coast. Salmon production in Scotland, after years of experimentation and slow growth in the 70's, has grown rapidly throughout the 1980s. New technology continues to evolve with the introduction of new cage designs and automated production systems.

Seabass, seabream and turbot

Initiated in France and Italy in the 1970s, seabass and seabream farming has developed around the Mediterranean Sea during the late 1980s and the early 1990s. These two species have even been farmed in the north of France, using hot water from a power plant. Private entrepreneurship and international cooperation have been important to this development. The private sector contributed to two forms of technological transfer; technology purchased from consultants by national investors, and joint-ventures with technology brought by the foreign partner. Some international research programs were conducted by private companies, especially on nutrition and off-shore technology, involving food and equipment suppliers.[4]

From the public side, MEDRAP (Mediterranean Regional Aquaculture Project) programs of the FAO, based in Tunis, have played a major role. Between 1983 and 1995, MEDRAP I and II organized seminars and training courses throughout the Mediterranean countries about aquaculture in the fields of biology, technology and management. In the framework of the Commission of the European Communities, General Directory XIV for fisheries, funds have been provided for research programs carried out between countries. The main research centers in France, Greece, Italy and Spain have a similar level of cooperation. The only non-European Union country to have participated in these actions is Cyprus, in the fields of species diversification and technology. Most of the countries produce their own fry from many hatcheries that have been built during the last five years.

The incentive policy of the European Union

In the countries belonging to the European Union, aquaculture has benefited from a strong incentive policy from the European Commission. In the framework of the regulations number 2903/83 and number 4028/86, aquaculture projects have received subsidies for their initial investment. These subsidies may be associated with national or local subsidies if the total stays below 4percent of the investment, 6percent in some regions where high economic difficulties prevail.

From 1983 to 1990, salmon projects have benefited from these subsidies; 38 salmon projects in Ireland (25 companies) and 32 salmon projects in UK (Scotland) for a total investment of 15 million Ecu. The annual amount of these subsidies has been consistent from 1988 to 1994, providing about 42 million Ecu per year. Since 1988 Spain, France, and Italy have been the principal recipients of these subsidies, especially for seabass, sea beam, and bivalve projects. In 1993, Greece received almost 50 percent of the total amount of the European subsidies for aquaculture.

Even if the production of fish had not increased dramatically in other countries as it had in Norway, this incentive policy would be considered successful for marine fish farming, including salmon, seabass, seabream and for mussels on long-lines, in the European Union. Most of the projects aimed at shrimp farming have been disastrous because the rearing techniques in semi-intensive conditions are not under control and the growing season is very short. Eel or sturgeon projects have not been very successful either, because of high production costs. Disease problems and high production costs have caused clam culture to fail in all countries. Italy is an exception, where new stocks of clams have been stabilized because spat are obtained from hatcheries.

Structure of the European marine fish farming industry

In Europe, including Norway, aquaculture is characterized by differences in

Table V : Production of seabream in the Euro-Mediterranean region (tons) from 1988 to 1996

	France	Greece	Italy	Spain	Other Countries	Total
1988	10	100	750	60	450	1,370
1989	15	400	850	340	1,200	2,805
1990	25	950	850	560	1,500	3,885
1991	50	1,400	1,000	1,000	1,550	5,000
1992	250	2,300	1,100	1,600	2,340	7,590
1993	350	4,700	1,500	2,200	3,640	12,390
1994	1,200	6,500	1,850	2,200	4,500	16,250
1995	950	9,400	3,500	2,710	7,000	23,560
1996	1,050	11,000	3,700	3,800	11,350	30,900

Source : SIPAM, IFREMER

the size of the enterprises, many of which are small. The creation of industrial groups and the increasing integration of production and processing are new developments in the farming of sea fish. A regional agro-industrial sector is being formed, at a faster pace for salmon than for other species. The growth of these companies generally is based upon multiplying the number of production sites rather than increasing the productive capacity of existing sites. Technology, geography and government regulations are responsible for this trend. Except for the plants that are in open sea or on shore, few coastal sites can support a large number of cages. Although there are a few sites where production exceeds 1,000 tons, the average annual production of industrial farms is about 300 to 500 tons.

Salmon farming

As a result of the government's discontinuation of the strict regulations concerning the size of the enterprises and scattering of the capital ownership, the industry has become more concentrated. Almost half the Norwegian salmon production coming from 700 farms is now sold by four major Norwegian companies, which are vertically integrated from egg production to world-wide export. These companies, which have invested in Scotland and Ireland, are Hydro Seafood (40,000 tons in 1995), Stolt Sea Farm (25,000 tons in 1995), Leroy, and Royal Norwegian Salmon. The Scottish company, Marine Harvest-McConnel (25,000 tons in 1995), which belongs to a multinational food industry based in the United Kingdom, has reached the same level of production as the Norwegian groups. These groups have not diversified either into freshwater farming, except for the production of juveniles, or into the farming of other saltwater fish.

Seabass, seabream and turbot farming

Around 550 intensive seabass/seabream farms were operating in 1996, with an average production capacity of 100 tons per year. This figure actually hides a range of production with numerous small scale farms below 20 tons, a small number of semi-industrial farms around 250 tons and a limited number of industrial farms over 500 tons. Only 60 enterprises have a hatchery to produce their own fry and no enterprise has integrated a processing activity. Countries belonging to the European Union account for 80 percent of the total production. In the near future, given the number of fry that has been produced in 1996 (240 millions units), an increase to 80,000 tons in 1998 is expected.

The main turbot hatchery is in France, which supplies 80 percent of the current European production. In 1996, there were only 5 farms producing turbot in France (800 tons), 1 farm in Portugal (150 tons) and 12 farms in Spain (2,200 tons).

Most of the interest in seabass, seabream and turbot farms is in Southern Europe; however, a limited number of farms still belong to salmon groups. Fish farming companies operating in Greece are quite small in comparison to those of salmon producers. The two largest among them, Nireus and Selonda, produced less than 5,000 tons each in 1996. Currently, there is little integration but an effort is underway to develop industrial groups by gathering former independent production units into a few industrial groups.

Environmental concern and the development of marine fish

Most of the regulations applying to marine finfish aquaculture are based on regulations for freshwater aquaculture. However, these regulations are not appropriate for marine aquaculture conditions, where emissions are diluted more rapidly. Effluents are difficult to measure because they disappear rapidly. Because of the lack of knowledge, the definition of proper environmental protection and monitoring is usually set on a case-by-case basis in dialogue with research organizations. Such a procedure is very expensive and time consuming[3].

Salmon farming and environmental issues

The initial development of salmonid farming in Norway occurred in sheltered embayments with little regard for environmental consequences. Enrichment of the seabed ecosystem, and of the water column, and resistance of sea-lice populations to pesticides were noted, but did not lead to a reduction of the activity[5]. Given the ability of the soils to regenerate, rotation of cages was advised. Later, technological innovation allowed access to more open waters with higher dispersion capacity. Despite this trend, the industry still reached its environmental limits in many areas. Size limits, which were previously expressed in surface area of cages, will be established in the future according to production volume because area does not define a limit on environmental impact. The new regulation is based upon distance between farms, fish density in cages and maximum food conversion ration. Control of effluents and

survey of the bottom are now compulsory.

Very low anthropic pressure on most of the Norwegian coast is probably one reason why aquaculture has developed to its present stage. Nevertheless, even without the constraints that arise from external pollution and claims for other uses, aquaculture development can be self-restrictive. In many fjords water exchange with the open sea is low and aquaculture tends to destroy its own environment and the environment of wild salmon populations. In response to the need to limit the farmed stocks in relation to the interests of the industry and to claims from other interest groups, the LENKA program was established. This "nation-wide assessment for the suitability of the Norwegian coast and water courses for aquaculture" started in 1987. Nevertheless, such an assessment is based on the present dominant farming technology and the findings will have to be revised if major technological changes occur.

Regulation in Scotland has developed on an empirical base, without a coherent set of rules. The present system has been in operation since 1989 and the key objective is to avoid long term degradation of the ecosystem. An impact study is compulsory only when a certain volume of production or cage area is exceeded. The values are established according to the exchange rate of the water. For example, in closed lochs where aquaculture waste, feces and uneaten feed, may modify the ecosystem significantly, impact assessment is needed when a cage area exceeds 2,000 square meters whereas in the open sea the limit is set at 12,000 square meters or 500 tons. A study published in 1992 by the Nature Conservancy Council confirmed that the impact of salmon farming on water quality depends largely upon the opening of the area to the sea. The River Purification Boards (RPBs) are authorized to monitor the effluents in coastal waters up to 3 miles from the coast emitted by aquaculture farms. If tests show a level of waste higher than permitted, the farm may loose its right to use public space and the case may be brought to the court[9]. The regulation system is similar in Ireland.

Environmental issues in the Mediterranean

The major environmental conflict is with the tourism industry, especially a key issue along the Mediterranean coast, where tourist pressure, at 33 percent of world tourism, is heavy. The economic importance of tourism makes it a strong interest group that opposes, in many locations, the development of aquaculture. The preservation of the marine landscape is an argument used to refuse the issue of licenses or to obtain their withdrawal. Such conflicts are numerous. For example, in France farming in floating cages is often prevented or sometimes subject to court proceedings to foreclosure.

At the present time, there is no evidence of one aquaculture farm negatively impacting another. A few cases of self-pollution by degradation of the bottom condition are recorded in Greece[6]. Yet scientific controversy remains about the impact of marine fish farming on the Mediterranean environment. The scientific information used was based on salmonids, which behave differently from the species reared in the Mediterranean. Consequently, the regulations that were established have a weak scientific base and deal more with a precautionary principle than with a rational approach.

In the decision to allow farming activity, the weight of environmental concerns varies from one country to another. In France, fish farms over 20 tons must perform an environmental impact assessment as part of the application for an exploitation permit. In Greece, an impact study is always required and a minimum distance from other farms must be kept. Other criteria are set concerning the rearing density, the feed quality, the monitoring of sea bottom and site rotation. But these criteria are more suggestive than controlled[13].

Marketing issues and technological progress

Market targets and trade flows

The European market is the major outlet for Norwegian salmon, 200,000 tons of a total production of 300,000 tons in 1996. The French market alone accounts for 20 percent of the Norwegian export. Tariff agreements allow an especially low duty on fresh Norwegian salmon when entering the European Union, 2 percent instead of 15 percent. Smoked salmon is subjected to higher a duty, 13 percent, to protect the EU processing industry. Aware that the European market is limited and highly competitive, the Norwegian, Scottish and Irish salmon producers now tap new markets in Asia, seeking new outlets for their increasing production.

Seabass and seabream farming has developed to supply the Italian market, a traditional consumer of these species. In 1996, 57 percent of the Mediterranean production was exported, mainly to Italy, but some also to France and Germany. All of the fish has been traded as raw whole fish, between 300 and 500 g. Some producers try to sell bigger, ungutted fish to the northern markets. Hatcheries from Italy, Spain and France sell around 20 percent of their production on foreign markets. The fingerling trade primarily supplies farms operating in Greece, Malta, and Croatia. Given the cost of freight, it is costly to export fingerlings from the north to the south of the Mediterranean. Therefore, the big industrial hatcheries in France, Italy, and Spain seek ways to promote the quality of their fingerling production, especially the disease-free aspect.

Evolution of the prices

For these species, aquaculture production now greatly exceeds the fishermen's catch. This rapid development has led to declining prices. In 1996 salmon prices on the French market were two times less than those in 1988, and seabass prices on the Italian market are three times less (Table VI).

The market for salmon developed while the consumption of fish has essentially remained stable over the same period in Europe. In France, salmon is the most common fresh fish for household consumption with a market share of 25 percent. Three factors explain this success: the excellent world-wide image of salmon, the availability of this species in sizes from 1 to 7 kilos, and the variety of presentation, whole or filleted, fresh, smoked or frozen, ready-cooked. The price of salmon is now a reference price on the French market, so that the price of most wild species follow the decrease of the salmon price. The price of seabass and seabream has fallen much more quickly as a result of the increase in production and in the absence of a diversification of products. The connoisseur market for a small and expensive fish is not as large as the market for a reasonably priced big fish, such as fillets, slices and other prepa-

Table VI: Salmon and seabass/seabream production and price in Europe from 1988 to 1996[1]

		1988	1989	1990	1991	1992	1993	1994	1995	1996
Salmon	Production	100	130	185	185	200	260	300	350	410
	Price	8.9	6.8	6.3	5.7	6.0	5.2	4.9	4.1	3.7
Bass/Bream	Production	3	4	6	10	16	26	32	42	57
	Price	22.6	22.6	20.9	17.4	14.0	8.8	7.9	7.8	7.8

Source : IFREMER, FAO (prices converted in 1996 currency)
[1] Import prices for salmon in France and for seabass in Italy (prices in US$ per kilo - production in 1,000 tons)

rations of salmon. Consequently the price has dropped when the level of production has increased.

Evolution of production costs

Because of joint public/private research in genetics, nutrition and pathology, zootechnical management of salmon farming has improved, permitting the professional sector to reduce the costs of production by more than 40 percent and to overcome market crises resulting from the rapid increase in supply. This improvement is a result of an increase in yield per egg and per juvenile, the reduced duration of the fresh water rearing cycle, the larger size of smolts transferred to the sea, the reduced duration of the marine cycle, the higher culture density and the better food conversion ratio. So, the average production time at sea to produce salmons till the weight of 4 kg decreased from 20 months in 1980 to 12 months in 1993. In the meantime, the average slaughter weight passed from 3 kg to 5 kg[7]. Nevertheless, greater incidence of mortality may be a consequence of high performance and some insurance companies now consider salmon farms more risky than seabass farms.

In contrast, the productivity gains have not been considered as important in seabass farming; explanations for this trend include the small size of the farms and lack of genetic and nutritional improvements. The proportional breakdown of production costs for seabass in different European countries shows that feed and labor accounts for 25 percent to 35 percent and 10 percent to 15 percent, respectively. These data are important in determining the success of a young aquacultural activity. In salmon farming, for instance, the cost of labor is less than 8 percent, while feed costs usually exceed 60 percent, a consequence of better zootechnical management, food conversion ratio (FCR), labor productivity, and high rearing density. Little progress in genetic improvement has been realized with the Mediterranean species and the food industry has not devoted the same level of attention to seabass as to salmon. Thanks to better husbandry practice, the FCR for seabass farming has decreased from 2.5 in 1988 to 2.0 in 1994, while survival in cages has increased from 80percent to 95 percent. However, the duration of the grow-out phase is comparatively long, between 14 to 24 months to attain a weight of 350 to 500 g. The profitability ratio that was very high in the early phase of the activity, 40 percent in 1988 for a French farm, has substantially decreased to under 15 percent. After consideration of risk and financial planning, this level of profitability does not seem very appealing for new investors, all the more as the payback is over 7 years because of the long rearing cycle.

Product diversification and quality approach

Salmon producers have succeeded in offering a wide range of products, whole fish, fillets, steaks, smoked, and marinated, to the European and world market, a form of horizontal differentiation. Moreover, by taking advantage of different geographical origins and different rearing conditions, a vertical differentiation is being implemented and all consumers, from mass market to connoisseur's niche, are being reached. As a response to the increasing competition within the European seafood market, some producers have initiated a specific quality approach based on collective structures. In response, several associations of salmon farmers in Scandinavia, Scotland and Ireland have adopted rigorous specifications concerning the production process. In Scotland, this approach is signified by the award of the French top-grade sign of quality called "Label Rouge" and results in a price premium to Scottish salmon on the French market[8].

Presently, development of a similar quality assurance/control operation for seabass and seabream is difficult because possibilities for differentiation of the products are few. In Greece, Spain, Italy (except in the valli) or France, all of the fish are fed similar diets, come from the same hatchery strains, and are reared according to close marine practices, including density, prophylactic use, and handling conditions. Competition is intense, and especially focused on price. To ensure a large-scale development of Mediterranean aquaculture, diversification of cultured species is another approach. Two approaches toward diversification have been attempted in the Mediterranean area, one involving rapid growth, medium priced fish, *Thunnus tynnus, Coryphaena hippurus, Seriola dumerilli,* and *Poly-prion americanus,* the other, slower growth, higher priced fish, *Pagrus pagrus, Dentex dentex, Puntazzo puntazzo, Diplodus sargus,* and *Epinephelus sp.* In the first case, new outlets should be considered while inn the second case, the orientation should be toward competition within the same connoisseur market to provide larger market shares for the pioneer firms.

The quality of seafood is not defined and recognized easily because personal interests of producers, wholesalers, retailers, and consumers often conflict. Agreement among parties involved along the production chain, from the equipment and input suppliers to the final consumer, including the administrators is a necessary social process. For the consumers, the fishery products usually have a very positive image because they are regarded as healthy. Aquaculture products also di-

rectly benefit from this positive image because most of the time, consumers have no way of discriminating the origin, farmed or wild. Nevertheless, given the experience with poultry or veal, producers must be aware of the low regard of some consumers for intensive rearing.

To a larger extent, the technological advances obtained so far, particularly in the field of larval rearing, have potential to be transferred to other kinds of aquaculture such as ornamental fish culture.

Conclusion

A parallel analysis of marine fish farming development in northern and southern Europe shows common trends and specific constraints. In both cases, governments have dedicated a large amount of funding for biological research and strong incentive policies to help investment. Despite public willingness, results are not the same for all species. Availability of natural sheltered areas, less conflict with urbanization and tourism, and inexpensive fishmeal as a feed ingredient and energy are factors that contribute to the success of salmon farming. Other institutional and organizational factors must be recognized. Efficient cooperation between the government and the private sector in the financing and the management of Norwegian research in salmon farming is an example. Scientific information, especially genetics, nutrition, and metabolism, are more advanced for salmon than for other species and is beginning for productivity gains and easier product differentiation. The producer's ability to market has also played a positive role in the development of Norwegian salmon farming. However, the issues of control of production and the adaptation by producers to specific quality requirements of different end users have not been totally solved.

Aquaculture production in the EU was organized poorly and efforts to change these conditions are being made. For example, the Federation of European Aquaculture Producers (FEAP) has received European funds to establish a network for the collection of marketing information. This project, which is aimed at updating prices and volumes marketed every two weeks, has been initiated by the Federation of Greek Mariculturers with the participation of the Scottish Salmon Growers Association, the British Trout Association and the Association of Italian Fish Farmers. This first step toward aquaculture planning based on market requirements is necessary because aquaculture competes with all the activities that produce animal protein. From the consumer point of view, substitutions between meat and fish are acceptable. Therefore aquaculture products are compared with other products in price and quality and must be competitive.

Following the Norwegian case, special attention must be paid to environmental regulation in Europe. Regulations that apply specifically to aquaculture in Europe, deal mainly with aquaculture as a source of pollution. Marine fish farming also needs to maintain good environmental quality because self-pollution is the main issue of concern. Responsible participatory management, where user groups, such as aquaculturists, are involved and supported by public authority, is necessary for the aquaculture industry to have its environmental needs recognized legally. Moreover, environmental concern continues to increase among European consumers who will soon call for environmentally sound aquaculture products. Good information, observance of guidelines in the production process, coordination among producers and cooperation with public authorities will be required to prevent consumers from turning away from farmed fish. Fish farming development can be realized under various forms, according to both the socio-cultural context of each country and the biological specificity of each species. Aquaculture planning and production must be flexible enough to evolve with the activity, as achieved in Norway, where a vertically integrated industrial organization has succeeded an organization of small scale producers in a state regulated context.

Notes and References

1. IFREMER, Direction des Resources Vivantes, Département Resources Aquacoles, rue de l'Ile d'Yeu, BP 21105,44311, Nantes Cedex 3, France
2. IFREMER, Direction des Resources Vivantes, Service Economie Maritime, 155 rue Jean-Jacques Rousseau, 92138 Issy les Moulineaux Cedex, France
3. **Bailly D**, Paquotte P. 1996. Aquaculture and environment interactions in the perspective of renewable resource management tehory. *Coastal Management*, 24:251-269.
4. **Bakela Z**, Paquotte P. 1996. Mediterranean marine aquaculture sector: present state of development and perspectives for cooperation. Proceedings of the VIII annual conference of the European Association of Fisheries Economists Conference. Barcelona, April 1996. 45-66.
5. **Gowen RJ**. Rosenthal H. 1993. The environmental consequences of intensive coastal aquaculture in developed countries : what lessons can be learnt - in Environment and Aquaculture in Developing Countries. Edited by Pullin, Rosenthal and Mac Lean. 102-112.
6. **Klaoudatos**, 1994. The situation and the outlook of the Greek aquaculture. Proceedings of the seminar on Mediterranean marine fisheries and aquaculture G.I.S. Montpellier, September 1994.
7. **Lucet P**. 1994. La filière salmonicole norvégienne: état du développement en 1994. IFREMER - Cabinet P. Lucet. 62 p.
8. **Paquotte P**. 1995. La qualité en aquaculture: un enjeu dans la concurrence internationale. *Economie rurale*, 227: 44-50.
9. **Richards R**. 1992. Control and regulation of the environmental impact of fish farming in Scotland. Séminaire MEDRAP Aquaculture et environnement en Mediterranee. Publication ADA. n 29:15-23.
10. **Shaw SA**. 1989. Economies of scale and salmon aquaculture. Communication at Aquaculture Europe B Brussels, October 1989.
11. **Theodorou J**. 1996. Pan-European aquaculture data base project by FEAP. The Greek contribution. *Cahiers Option Mediterranée*, volume 17, Marketing of aquaculture products: 231-236.
12. **Torrissen OJ**, Holm JC, Naevdal G, Hansen T. 1995. Aquaculture in Norway. *World Aquaculture* 26(3): 11-20.
13. **Zanou B**. 1994. Les aquaculteurs et leur développement en Grèce - Mémoire de DEA, Universités de Paris VII et Paris VIII.