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THE DEVELOPMENT OF MARINE FISH FARMING IN EUROPE: A PARALLEL WITH SALMON CULTURE

Yves Harache[1] and Philippe Paquotte[2]

[1] IFREMER, Direction des Ressources Vivantes, Département Ressources Aquacoles, rue de l'Ile d'Yeu, BP 21105,44311, Nantes Cedex 3, France
[2] IFREMER, Direction des Ressources Vivantes, Service Economie Maritime, 155 rue Jean-Jacques Rousseau, 92138 Issy les Moulineaux Cedex, France

Abstract

This paper is aimed at analysing the similar trends and different constraints which influence marine fish farming of new species such as sea-bass, sea-bream and turbot in Europe in comparison with the Norwegian salmon farming success. In a general context of low progression, European aquaculture has been characterised by the development of intensive fish farming. The most notable fact is the recent increase in intensive salmonid farming, with a turnover of almost 2 millions Ecu. More recently, the intensive farming of sea bass and sea bream has increased very rapidly in the Mediterranean Basin, although on a more reduced extent. Turbot farming is developing slowly too on the French and Spanish Atlantic coast, taking benefit of the temperate climate in that area. Although research has started as soon as the seventies with a strong public incentive both for salmon, sea-bass, sea-bream, the development of these different types of aquaculture has not been done at the same pace. Some elements of sectorial dynamics are analysed like research planning and financing, organisation of the production and public policy. For salmon and sea-bass, aquacultural production now greatly exceeds the fishermen's catch. This rapid development has led to declining prices. Salmon price on the French market in 1995 is two times less than in 1988, and sea-bass price on the Italian market is three times less. Technological and biological innovation, marketing organisation, product diversification and cooperation with public authorities may explain the success story of salmon farming, and could help southern European aquaculture to reach such a level of development.

Key-words : aquaculture, development, marketing, environment, Europe

Recent evolution and present state of European marine fish farming

A large region that includes the European Union, Scandinavia, eastern Europe and the countries of the Mediterranean Basin may be considered when studying aquaculture because of the important movement of products, capital and technology inside. Nevertheless, aquaculture development is not homogeneous inside that region. This paper is aimed at analysing similar trends and different constraints which influence marine fish farming of main species, i.e. salmonids, sea-bass, sea-bream and turbot.

What is noticeable first is that the growth of European and Mediterranean aquaculture is less rapid than that of world aquaculture. Despite an average growth rate of more than 3% by

volume per year, European and Mediterranean aquaculture's share of global production has declined from 9% to only 7% between 1988 and 1993 (Table I). It is true that, because of the formidable expansion of Asian and especially Chinese aquaculture, world aquaculture in this period has shown an average growth rate of 12 % by volume per year according to the FAO. European aquaculture, which is almost entirely absent from the crustacean and seaweed sectors, concentrates on bivalves (20% of world volume) and fish (6% of world volume). Moreover, it is only this last sector (fish farming) that has shown significant growth since 1988 (+40%), which matches the growth rate of world aquaculture.

Table I: Evolution of aquaculture production between 1988 and 1994

1988 (tonnes)	Total	by group of species				by environment	
		(1) fish	(2)crustaceans	(3)bivalves	(4)seaweed	(a) fresh water	(b) marine water
Europe (*)	1 290 000	520 000	3 000	760 000	-	380 000	910 000
World (**)	14 650 000	7 600 000	650 000	3 000 000	3 400 000	7 350 000	7 300 000
1994 (tonnes)	Total	by group of species				by environment	
		(1) fish	(2)crustaceans	(3)bivalves	(4)seaweed	(a) fresh water	(b) marine water
Europe (*)	1 560 000	730 000	2 500	820 000	5 000	390 000	1 140 000
World (**)	25 410 000	13 050 000	1 070 000	4 390 000	6 900 000	11 150 000	14 260 000

(*) including Eastern Europe and Mediterranean Basin - source : European Commission, IFREMER, SIPAM network, FAO
(**) source FAO

The most notable fact is the recent increase in intensive salmon farming (trout and salmon, both fresh water and sea water), which, totalling 630 000 tonnes, has, between 1988 and 1994, gone from 23% to 38% of the zone's aquacultural production by volume. In value, its share has reached 57%, with a turnover of almost 2 million Ecu (excluding the production of juveniles), more than two thirds of which is realised in marine production. However, because of the unavailability of new sites and strong pressure to protect rivers, the development of intensive fish farming in fresh water has slowed down in the last few years.

Intensive marine fish farming, which was still marginal in 1988, now represents 27% by volume and 50% by value of the region's aquaculture, because of the continuous development of Atlantic salmon farming in floating cages based upon elaborated technological progress (350 000 tonnes in 1995). The countries that have experienced the greatest growth in their aquacultural sector since 1988 are Norway, the United Kingdom and Ireland, thanks to marine salmon farming (Table II). Sea-trout farming which is realised especially in Denmark and Finland is rather steady, but a new development takes place in France thanks to the control of the fario trout culture (Table III). After the failure of some attempts to build on-shore plants for salmon farming due to high operating costs, all the production is realised in floating cages either in sheltered areas or in open sites. Norwegian and European salmon production has to be considered with regard to a world farmed salmon total of 550 000 tonnes in 1995, including different species of salmon. Outside Europe, the leader countries are Chile (100 000 tonnes) and Canada (37 000 tonnes), followed by Japan (22 000 tonnes), United States (14 000 tonnes), Australia (5 000 tonnes) and New Zealand (3 000 tonnes).

Table II : Evolution of Atlantic salmon production in Europe - in tonnes

	Norway	UK	Iceland and Faeroe Islands	Ireland	France	Spain	Total
1988	74 000	16 500	5 500	4 000	650	150	100 000
1990	130 000	30 000	15 700	6 000	200	350	185 000
1992	130 000	36 000	20 200	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

source : IFREMER, Federation of European Aquaculture Producers

Table III : Evolution of sea-trout (rainbow and fario) production in Europe - in tonnes

	Norway	Finland	UK	Ireland	Denmark	France	Total
1988	8 000	15 000	1 500	500	6 000	650	32 000
1992	3 000	16 000	1 500	600	7 250	750	30 000
1993	4 500	15 000	1 500	600	8 500	700	31 000
1994	5 000	15 000	1 500	600	8 500	1 350	32 000
1995	6 000	13 000	1 500	600	8 500	1 350	30 000

source : IFREMER, Federation of European Aquaculture Producers

Although some attempts to culture Atlantic halibut were initiated in Norway by the Institute of Marine Research in the early 70's, post-larvae production is still requiring much attention and is not realised at a large scale yet (Torrissen et al.). In 1993, 170 thousand halibut juveniles were produced by the private firm Stolt Sea Farm, and about 10 tonnes of halibut were sold to the Norwegian restaurant market that year, ranging from three to seven kilograms.

More recently, the intensive farming of sea bass and sea bream has increased very rapidly in the Mediterranean Basin, although on a more reduced scale (42 000 tonnes in 1995 - Table IV and Table V). Although it used to be less important, the share of sea-bream is in the process of being dominant, due to pathological problems encountered by sea-bass (nodavirus). Most of that production (70 %) is realised in cages in sheltered bays or in open sea. On-shore intensive farms using race-ways account for only 15% of the total production. The remaining 15% are produced in traditional earth ponds or in valli. Italy and Greece, and France to a lesser extent, produce other Mediterranean species in small quantities (Puntazzo puntazzo, Pagrus pagrus, Dentex dentex.... for less than 1 000 tonnes).

Table IV : Evolution of sea-bass farming in the Euro-Mediterranean region - in tonnes

	France	Greece	Italy	Spain	other countries	Total
1988	150	200	930	30	200	1510
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

source : SIPAM, IFREMER

Table V : Evolution of sea-bream farming in the Euro-Mediterranean region - in tonnes

	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	5 000	21 560

source : SIPAM, IFREMER

Turbot farming is developing more slowly on the French and Spanish Atlantic coast, taking benefit of the temperate climate in that area (3 000 tonnes in 1995). Turbot farming requires on-shore plants using concrete race-ways.

Dynamics of marine fish farming in Europe : the importance of research, of organisation of the production and of public policy.

Although research has started as soon as the seventies with a strong public incentive both for salmon, sea-bass and sea-bream, the development of these different types of fish farming has not been done at the same pace.

Institutional framework for research and development

Salmon farming

The Norwegian salmon industry has been supported at its inception both by a voluntary public policy and a rigorous organisation of the profession. In order to have an economic development all along the coast, from south to north, the Norwegian government has implemented strict regulations concerning the size of the farms and the capital ownership. Government incentives have helped many farms to settle. These regulations have promoted a sector made of small scale independent farms, with no vertical or horizontal integration. Nevertheless, organisation of the production has been done through a commercial structure so called "FOS". The FOS used to have the monopoly of Norwegian salmon marketing and was in charge of generic promotion and of relations with the exporters. But one the most important features is the tight link between public authorities and industry as far as research was concerned. Both parts have invested in research centres and in the definition in programs for genetics, pathology and nutrition (Lucet, 1994).

After the FOS and the government turned out unable to forecast the expanding supply of salmon and to regulate the market, a new sectorial organisation has been set up. The government regulatory role has been reduced to the control of the environmental impact whilst industrial groups and producers' associations have induced a concentration of the production and an integration of the commercialisation.

These Norwegian companies have invested first in Scotland and Ireland, then in other countries world-wide including Chile. In Europe, salmon farming has developed in the mid 80's thanks to research transfer from Norway (genetics, nutrition), technological innovation in offshore cage design and European Union investment subsidies (Shaw, 1989). Salmon farming trials commenced in the west of Ireland in the early 1970's with little major growth until the mid 80's when output and investment in the sector began to increase substantially. Many of the difficulties which related to the lack of protected sites have been successfully overcome through the 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 80's. Technology is still evolving with the introduction of new cage designs and production systems (automatization) to deal with industry problems.

Sea-bass, sea-bream and turbot

Initiated in France and Italy on the basis of an important mostly public research effort (UK, France) which started as soon as the seventies, sea-bass and sea-bream farming have been developed then all around the Mediterranean sea (and also in north of France, using hot water from an electricity plant) in the late eighties and the early nineties. Private entrepreneurship and international cooperation have both taken part in this development. As far as private sector is concerned, two forms of technological transfer can be observed. On the one hand it may have been purchase of technology from consultants by national investors. On the other hand, joint-ventures with technology brought by the foreign partner as part of his equity have occurred. Moreover, some international research programs may be carried out by private companies, especially on nutrition and off-shore technology, involving food and equipment suppliers (Bakela and Paquotte, 1996).

From the public side, the major role has been played by the MEDRAP (Mediterranean Regional Aquaculture Project) programs of the FAO which used to be based in Tunis. Between 1983 and 1995, MEDRAP I and II have organised seminars and training courses about aquaculture in the fields of biology, technology and management throughout the Mediterranean countries. 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 centres of France, Greece, Italy and Spain are deeply involved in such a cooperation. Till now, the only non E.U. country having participated in these actions is Cyprus, in the fields of species diversification and technology. Most of the countries are now self sufficient for fry production since many hatcheries have been built during the last five years thanks to technological transfers and to the development of national research sectors in aquaculture.

The incentive policy of the European Union

In the countries belonging to the European Union, the sector of aquaculture has benefited of a strong incentive policy from the European Commission. In the framework of the regulations number 2903/83 and 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 stays below 40% of the investment (60% in some regions encountering high economic difficulties).

From 1983 to 1990, mostly 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 millions Ecu. Then, the annual amount of these subsidies has been quite regular from 1988 to 1994, providing around 42 millions Ecu per year. Spain, France and Italy have been the principal recipients of these subsidies from 1988 on, especially for sea-bass/sea-beam and bivalves 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.

Even if the production of fish has not soared like in Norway, this incentive policy may be considered as having been successful for marine fish farming in the European Union (salmon, sea-bass 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.

Structure of the European marine fish farming industry

In the whole European area, including Norway, the sector is characterised by a very great diversity in the size of the enterprises, a great majority of which are small scale. Two new phenomena, however, are noticeable in the development of the farming of sea fish: on the one hand, the creation of industrial groups and, on the other hand, the increasing integration of production and processing. A regional agro-industrial sector in the process of formation, but not at the same pace for salmon and for other species. Nevertheless, as well for salmon farming as for sea-bass/sea-bream and turbot farming, the growth of these companies generally occurs by multiplying the number of production sites rather than by increasing the productive capacity of existing sites. Technology, geography and government regulations explain this trend. Except for the plants which are in open sea or on shore, it is difficult to find coastal sites which can receive a very large surface of cages. Although there are a few sites whose production exceeds 1 000 tonnes, the average annual production of industrial farms is about 200 to 300 tonnes.

Salmon farming

Since the government has given up the strict regulations concerning the size of the enterprises and the scattering of the capital ownership, the industry has been more and more concentrated. Almost half the Norwegian salmon production coming from 700 farms is now sold by four major companies, which are integrated from egg production to world-wide export. These Norwegian companies have invested in Scotland and Ireland. These companies are Hydro Seafood (40 0000 tonnes in 1995), Stolt Sea Farm (25 000 t in 1995), Leroy and Royal Norwegian Salmon. The Scottish company Marine Harvest-McConnel (25 000 tonnes in 1995), which belongs to a food industry multinational based in the United Kingdom, has reached the same level of production as the Norwegian groups. For the moment, these groups have not diversified very much into fresh-water farming, except for the production of juveniles, or into the farming of other salt-water fish.

Sea-bass, sea-bream and turbot farming

Almost 500 intensive sea-bass/sea-bream 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 small 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 realise their own fry production, but no enterprise has integrated a processing activity. The share of E.U. countries in that production has been steady around 80% for the last five years. As for the near future, given the number of fry which has been produced in 1994 (170 millions units), a reasonable increase may be considered to reach 46 000 tonnes in 1996.

As for turbot, the main hatchery is in France, which provides 80% of the on-growing production, in France and in Spain. Although there are only 6 farms producing turbot in France in 1995 (700 tonnes), 12 are operating in Spain (1700 tonnes).

Despite big interest shown ten years ago in investment in southern Europe for sea-bass, sea-bream and turbot farms, a very limited number of these farms are still belonging to salmon groups. The fish farming companies operating in Greece appear quite small in comparison with salmon producers, because the largest among them, Selonda, produced no more than 1 500 tonnes in 1995. At the present time, there is few downstream integration but a strong will to develop industrial groups by gathering former independent production units in a few industrial groups is noticed.

Environmental concern and its impact on the development of marine fish farming

Most of the regulation applying to marine finfish aquaculture are based on freshwater aquaculture regulation. But those are not fitted to marine aquaculture conditions where emissions are more rapidly diluted. Effluents are difficult to measure as they rapidly disappear. Because of the lack of sufficient knowledge, the definition of proper environmental protection and monitoring is usually set case by case in dialogue with research organisations, which is a very expensive and time consuming procedure at present (Bailly and Paquotte, 1996).

Salmon farming and environmental issues

The initial development of salmonid farming in Norway took place in sheltered embayments with little regard for environmental consequences. Enrichment of the seabed ecosystem, enrichment of the water column and resistance in sea-lice populations to pesticides were noted, but did not lead to a reduction of the activity (Gowen and Rosenthal, 1993). Given the ability to the soils to be regenerated thanks to water flows, rotation of cages has been first advised. Later, technological innovation allowed for the access to more open waters with higher dispersion capacity. Despite this trend, the rapid growth of the industry met its environmental limits in many areas. Size limits which used to be expressed in surface of cages are going to be given in production volume because area didn't really work as a limit of the impact on the environment. The new regulation concerns distance between farms, fish density in cages and maximum food conversion ratio. Control of effluents and survey of the bottom is now compulsory.

Anthropic pressure is very low on most of the Norwegian coast. This is probably one reason why aquaculture could develop to its present stage. If external pollution and claims for other uses didn't constrained the aquaculture development, it is presently self-constraining. The water exchange with the open sea is rather low in many fjords. Thus aquaculture tends to destroy its own environment and the environment of wild salmon populations. The need to limit the farmed stocks in relation to the interests of the industry and to the claims from other interest groups motivated the LENKA programme. 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 conclusions would have to be revised if major technological change is to happen.

Regulation has been progressively developed in Scotland on an empirical base when and where problems appeared before being put in a coherent set of rules. The present system is operational since 1989 with the key objective to avoid long term degradation of the ecosystems. An impact study is compulsory only above a certain volume of production or cage area. The values are set according to the exchange rate of the water. In closed lochs, the impact assessment is needed above 2.000 m^2 cage area. In the open sea the limit is set to 12.000 m^2 or 500 tonnes. A study published the Nature Conservancy Council published in 1992 confirmed that the impact of salmon farm on water quality depends largely upon the opening of the area. In closed lochs, aquaculture waste (faeces and uneaten feed) may significantly modify the ecosystem. The River Purification Boards (RPBs) are responsible for monitoring the effluents in coastal waters down to 3 miles from the coast. They have the authority to measure wastes emitted by aquaculture farms. If the control proves a higher level of waste, the farm may loose its right to use public space and the case may be brought to the court (Richards, 1992). The regulation system is quite similar in Ireland.

Environmental issues in the Mediterranean

Environmental concern is a key issue along the Mediterranean coast which is under high touristic pressure (33% of the world tourism). At the present time, there seem to be no major problem of negative impact on an aquaculture farm by another farm. Few cases of self-pollution by degradation of the bottom condition are recorded in Greece (Klaoudatos, 1994). But the scientific controversy which exists about the impact of marine fish farming on the Mediterranean environment is all the bigger as the scientific knowledge has been got with salmonids, which behave differently from the species reared in the Mediterranean. So, the regulation which has been set up has usually few scientific base, and deals more with the 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 tonnes have to realise an environmental impact assessment as part of the application for the exploitation permit. In Greece, an impact study is always requested and a minimum distance from other farms should be left. Other criteria are set concerning the rearing density, the feed quality, the monitoring of sea bottom and site rotation. But these criteria are more indicative than effectively controlled (Zanou, 1994).

The major environmental conflict is with the tourism industry. The economic importance of tourism makes it is a strong interest group that opposes in many locations against the

development of aquaculture. The preservation of marine landscape is argued to refuse licenses or to obtain their withdrawal. Such conflicts are numerous. They sometime prevent the development of aquaculture, like in France as far as farming in floating cages is concerned, or go to court in order to forces farms to close down.

Marketing issues and technological progress : their impact on the profitability of European fish farming industry

Market targets and trade flows

European market is still the major outlet for Norwegian salmon (171 000 tonnes of a total production of 200 000 tonnes in 1994), and especially the French market (25% of the Norwegian export). This position is helped by tariff agreements which give a specially low duty on fresh Norwegian salmon when entering the European Union (2% instead of 15%). Nevertheless, smoked salmon is submitted to higher duty (13%) in order to protect the processing industry of the European Union. Being aware that the European market is limited and highly competitive, the Norwegian, Scottish and Irish salmon producers now tap new markets in far-east Asia in order to find outlets for their still increasing production

The more recent activity of sea-bass and sea-bream farming has been developed in the aim of supplying the Italian market, where a tradition has been existing for a long time to consume these species. In 1994, 55% of the Mediterranean production 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. On the opposite, trade flows for fingerlings of sea-bass and sea-bream exist from Italy, Spain and France but they do not account for more than 20% of the production of these countries. They are aimed mainly at supplying farms operating in Greece (where 9 million fingerlings have been imported in 1992) Malta and Croatia. Given the cost of freight, it is less and less worthwhile to export fingerlings from north to south of the Mediterranean. That is the reason why the big industrial hatcheries in France, Italy and Spain try to promote the quality of their production, especially concerning the prevention of pathologies.

Evolution of the prices

For these species, aquacultural production now greatly exceeds the fishermen's catch. This rapid development has led to declining prices. Salmon price on the French market in 1995 is two times less than in 1988, and sea-bass price on the Italian market is three times less (in constant terms - Table VI).

Table VI: Salmon and sea-bass/sea-bream production in Europe - import prices for salmon in France and for sea-bass in Italy (prices in Ecu per kilo - production in tonnes)

		1988	1989	1990	1991	1992	1993	1994	1995
salmon	production	100 000	130 000	185 000	185 000	200 000	260 000	300 000	350 000
	price in France	8,2	6,3	5,8	5,3	5,5	4,8	4,5	3,8
bass/bream	production	3 000	4 600	6 300	10 000	15 500	26 000	32 400	42 000
	price in Italy	20,9	20,9	19,3	16,1	12,9	8,1	7,3	7,2

source : IFREMER, Lucet (prices converted in 1995 currency)

The market for salmon has been able to develop to a great extent while the consumption of fish has remained stable over the period, especially in France where it is now the most common fresh fish for household consumption with a market share of 25%. Two factors may explain this success i.e. the excellent image world-wide of salmon and the ability of this species to be diversified in size (from 1 to 7 kilos) and in presentation (whole or filleted, fresh, smoked or frozen, ready-cooked). The price of salmon is now a reference price on the French market, which means that the price of most wild species follow the decrease of the salmon price. As a result of the increase in aquacultural production and in the absence of a diversification of products, the price of sea bass and sea bream has fallen much more quickly, and at a much lower level of production. Indeed, the « connoisseur » market for a small and expensive fish is not so large as the market for a reasonably priced big fish (which means fillets, slices and other preparations) such as salmon.

Evolution of production costs

Thanks to joint public/private research in genetics, nutrition and pathology, zootechnical performance of salmon farming has constantly improved, permitting the professional sector to reduce the costs of production by more than 40% and to overcome market crisis resulting from the rapid increase in supply. This gain is due to the considerable increase in yield per egg and per juvenile, the shortening of the fresh water rearing cycle, the larger size of smolts transferred to the sea, the reduction of the duration of the marine cycle, the higher rearing density and the better food conversion ratio (Lucet, 1994). Nevertheless, this high performances may have sometimes higher mortality as counterpart. Salmon farms are considered now as more risky than sea-bass farms from some insurance companies.

On the contrary, the productivity gains have not been so important in sea-bass farming, due to small size of the farms and to lack of genetic and nutrition improvement. The breakdown of production costs for sea-bass in different European countries shows that feed accounts for 25% to 35% and labour 10% to 15%. These data are 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). There has been so far few genetic improvement and the food industry has not invested the same attention in sea-bass as in salmon, which relates to a much wider market. The FCR has decreased from 2.5 in 1988 to 2 in 1994, the survival rate in cages has increased from 80% to 95% but the duration of the ongrowing phase is still very long, between 14 to 24 months to get a 350 to 500 g weight. So, the profitability ratio which used to be very high at the early phase of the activity (40% in 1988 for a French farm), has decreased dramatically to be now under 10%. After taking into account risk and financial plan, this profitability does not seem very appealing for new industrial investors.

Product diversification and quality approach

Salmon producers have succeeded in offering a wide range of products on the European and more widely world market (whole fish, fillets, slices, smoked, marinated...). This approach may be considered as a form of horizontal differentiation. Moreover, taking advantage from different geographical origins and different rearing conditions, a vertical differentiation is in the process of being implemented, in order to reach all consumers from mass market to

connoisseurs niche targets. As a response to the increasing competition on the European sea-food market, some producers have initiated a specific quality approach on the basis of collective structures. So, several associations of salmon farmers in Scandinavia, Scotland or Ireland have adopted rigorous specifications concerning the production process. In the case of Scotland, this approach has been finalised by the award of the French top-grade sign of quality called "Label Rouge" and resulted in a price premium to Scottish salmon on the French market (Paquotte, 1995).

At the present time, it is very difficult to realise such an operation with sea-bass and sea-bream because there are few possibilities of differentiation of the products. Indeed, in Greece, Spain, Italy (except in the valli) or France, all the fish is fed with the same pellets, comes from the same hatchery strains and is reared with the same marine practices (density, prophylactics, handling conditions). So the competition is very tough, and especially focused on price competitiveness. In order to ensure a large scale development of Mediterranean aquaculture, diversification of cultured species is another mean. Among all the ways of diversification which are attempted in the Mediterranean area, two alternatives are discussed, that related with high growth, medium priced fish (i.e. *Thunnus tynnus, Coryphaena hippurus, Seriola dumerilli, Polyprion americanus*) and that with lower growth, better priced fish (*Pagrus pagrus, Dentex dentex, Puntazzo puntazzo, Diplodus sargus, Epinephelus sp.*). In the first case, new outlets may be considered, but in the second case, it is more oriented toward competition inside the same connoisseur market in order to provide larger market shares for the pioneer firms.

The definition and the recognition of quality for sea-food is not something easy to reach because it has to deal with different personal interests (producers, wholesalers, retailers, consumers) which may be conflictual. It is a real social process which requires an organisation of all the actors involved along the production chain, from the equipment and input suppliers to the final consumer, including the administrations. For the consumers, the products of fisheries have usually a very positive image, because they are regarded as healthy. Aquaculture products also benefit from this positive image because most of the time, consumers do not really their origin and whether they are farmed or wild ones. Nevertheless, given the example of poultry or veal, producers have to be aware of the consumer's reluctance toward intensive rearing.

To a larger extent, the technological advances obtained so far, and particularly in the field of larval rearing, could 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 devoted large means to biological research and strong incentive policies to help investment. Despite this identical public willingness, results are not at the same level. Natural endowments (sheltered areas, less conflict with urbanisation and tourism, cheap fishmeal and energy) are factors which may explain partly the salmon farming success story. But other institutional and organisational factors have to be taken into account. For instance, the efficient cooperation between government and private sector in the financing and the management of Norwegian

research in salmon farming. Scientific bases (genetics, nutrition, excretion) are more advanced for salmon than for other species and are at the origin of productivity gains and easier product differentiation. The producer's ability to be organised for marketing is also noticeable and has played a big role in Norwegian salmon farming development, but some issues are still at stake such as the control of production increase and the adaptation to specific quality requirements of different end users (fat and colour control).

On the contrary, aquaculture production in European Union used to be poorly organised but some attempts to change are in process. For instance, the Federation of European Aquaculture Producers (FEAP) has received recently European funds to establish a network for the collection of marketing information. This project which is aiming 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 (Theodorou, 1996). This is a first step toward aquaculture planning according to market requirements which is necessary because aquaculture is in competition with all the activities producing animal proteins. From the consumer point of view, substitutions between meat and fish are possible. Aquaculture products will be compared with other products in terms of price and quality and have to be competitive.

Following the Norwegian case, special attention has to be paid to environmental regulation in Europe. Indeed, regulation applying specifically to aquaculture in Europe concerns mainly aquaculture as a source of pollution to the overall quality of the ecosystem. But marine fish farming needs good environment too, and is concerned by the issue of self pollution. Responsible participatory management, where users groups such as aquaculturists would be involved with the backing of public authority, is necessary for aquaculture industry to have its environment needs legally recognised. Moreover, environmental concern is developing among European consumers, who will claim soon for environmental sound aquaculture products. Good information, observance of guidelines in the production process, coordination between producers and cooperation with public authorities will be required to avoid consumers turning away from farmed fish. Fish farming development may be realised under various forms, according to the socio-cultural context of each country and according to the biological specificity of each species. Aquaculture planning and production organisation must be flexible enough to evolve with the activity, as it has been seen in Norway, where an industrial vertically integrated organisation has succeeded to an organisation of small scale producers in a State regulated context.

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