1. Aquaculture production by species

This study includes all European countries without the successor states of the former Soviet Union (Map 1). The study covers the following entities: Albania, Andorra, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Channel Islands, Croatia, Czech Republic, Denmark, Faeroe Islands, Finland, France, Germany, Greece, Holy See, Hungary, Iceland, Ireland, Isle of Man, Italy, Liechtenstein, Luxembourg, Macedonia, Malta, The Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, Yugoslavia FR.

Map 1 **Europe**

The very beginning of European aquaculture is hard to determine exactly, however, it is proven that smaller ponds were constructed, or natural waters were used for fish culturing already in the Roman Empire. Accordingly the European – such as the Asian – aquaculture has more than a thousand years' long traditions. The boom of European aquaculture started the late 19th century, and it reached its full extent during the 20th century when the technical and biological background of new technologies became available. Both in the past and present intensive and extensive methods were used simultaneously. In Central-and Eastern Europe extensive and semi-intensive pond fish culture specialised in cyprinids were characteristic, while in Northern and Southern Europe various methods *(cage-, pond-, recirculation-system)* of intensive marine, fresh- or brackishwater aquaculture were practised.

The continuously decreasing marine and freshwater fish-catches, due to rapidly declining natural fish stocks is a tendency observed both globally and in Europe, at the same time consumer demand for fish and fishery products is continuously increasing. Another tendency is the increasing population resulting in new challenges for food production both in quantity and quality. In areas of economic welfare – such as in the European Union – the quality, while at the less developed areas of the Europe the quantity is the key element. In order to permanently meet new consumer demands in fish and fishery products the development of the aquaculture industry – and increasing of its share against conventional capture fisheries – is to be emphasised.

The role of recreational fisheries in aquaculture is more and more important. It is a general tendency that the development of a country and the increasing living standards result in the waning of the time spent on work and increasing the time spent recreation. People will be engaged in more hobby activities that will require new industries and services. Typical examples for this are the recreational-, and sport-fishing, already highly significant in Western Europe. This industry became especially appreciated during the past three decades as an ever increasing market for the European aquaculture through the continuous stocking of sport-fishing grounds. Beyond the recreational fish supply and food-fish production, the requirements of nature conservation *(e.g. for restocking rare or endangered fish-, crayfish- and mollusc species into their original habitats)* is another significant market for European aquaculture.

A long-term tendency is the growing importance of recreation and nature conservation within the triple purpose of aquaculture *(economic, recreational, nature conservation)* with the increasing well being of a country.

European aquaculture production is presented in this chapter both in terms of quantity and value, detailing the most important species groups and the current situation in the aquaculture production in each of the European countries. Summarised data[1] are presented in figures and tables, while correlation and tendencies are aimed to be lined up and evaluated. This study does not cover the European successor states of the former Soviet Union *(Belarus, Estonia, Latvia, Lithuania, Rep. of Moldova, Russian Federation, Ukraine).*

[1] The statistical data presented are primarily based on FAO, FishStat Plus 1999.

Aquaculture production is important to many countries of the European region because, on the one hand, it is a rather important food supply and, on the other hand, it can be a source of employment. European aquaculture production represented 4.6% of total world production in quantity and 7.5% in value in 1997 *(Figure 1,2,3).*

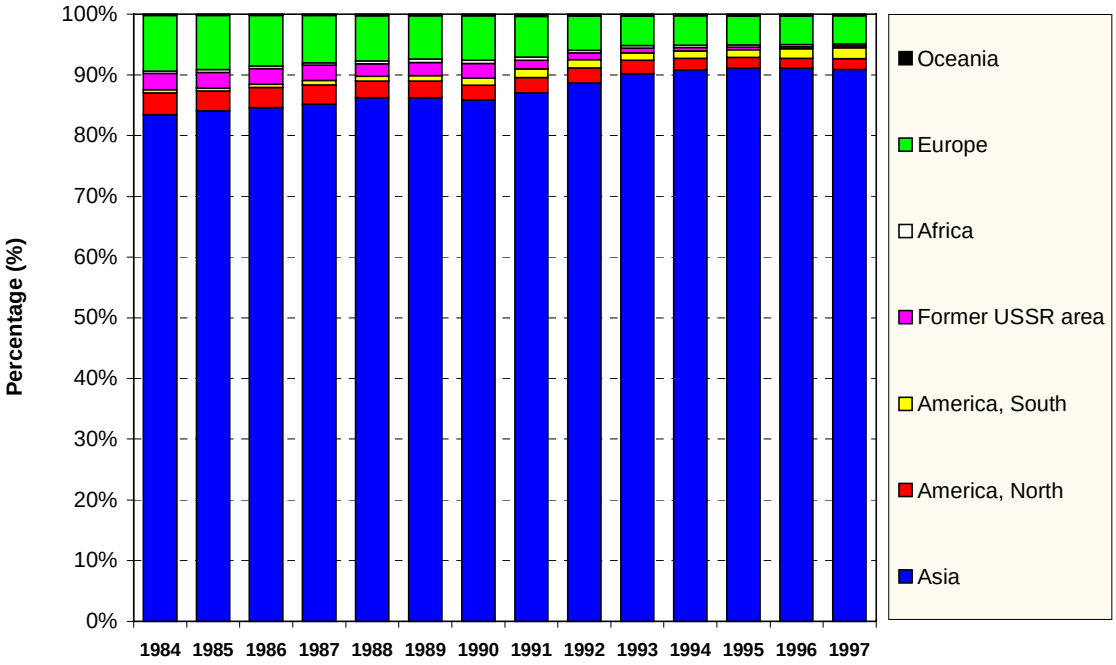


Figure 1 **Distribution of aquaculture production volume by continent**

Reference: FAO, FishStat Plus 1999

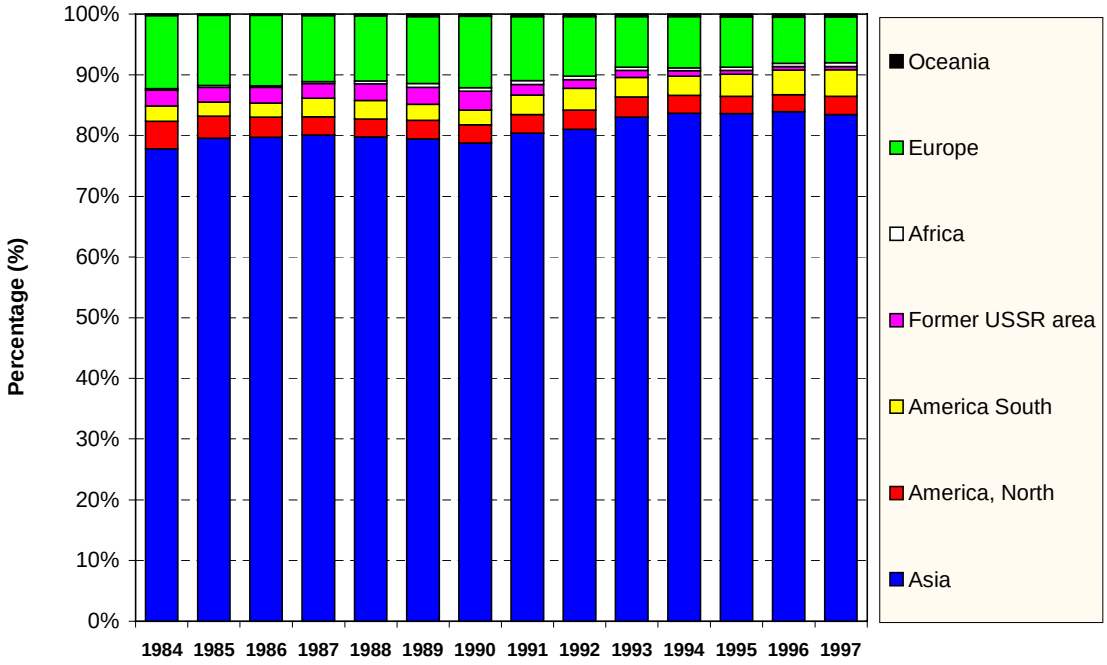


Figure 2 **Distribution of aquaculture production value by continent**

Reference: FAO, FishStat Plus 1999

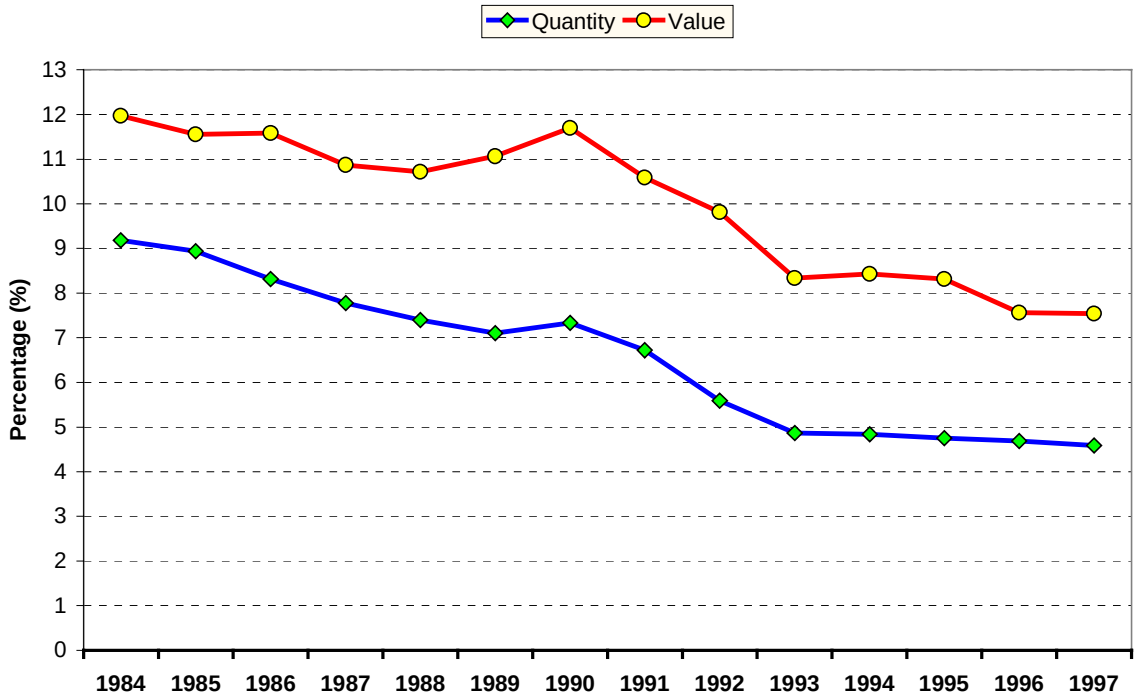


Figure 3 **Share of European aquaculture production volume and value from total world aquaculture production**

Reference: FAO, FishStat Plus 1999

The share of European aquaculture from the World aquaculture production is continuously decreasing since 1984 *(Figure 1, 2 and 3)*, while it grew in absolute terms. The reason for this is the difference in growth rates of European and the World aquaculture *(in which the Asian production is significant)*.

During the ten-year period from 1988 to 1997, aquaculture production in Europe increased from 11.5 million tons to 16.5 million tons *(Table 1, Figure 5)*. The share of aquaculture from the total aquatic production is increasing in Europe throughout the 1980's and also in the late 1990's *(Figure 4)*.

Table 1 **Total aquaculture production in Europe**[2]

Quantity (1000 tons), Value (million US$)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Quantity	1 150.5	1 171.2	1 234.0	1 227.8	1 189.1	1 195.5	1 342.4	1 486.0	1 592.0	1 655.3
Value	2 618.4	2 837.4	3 240.7	3 174.5	3 255.5	3 038.6	3 484.9	3 739.9	3 612.6	3 800.3

Reference: FAO, FishStat Plus 1999

[2] Excluding the former USSR.

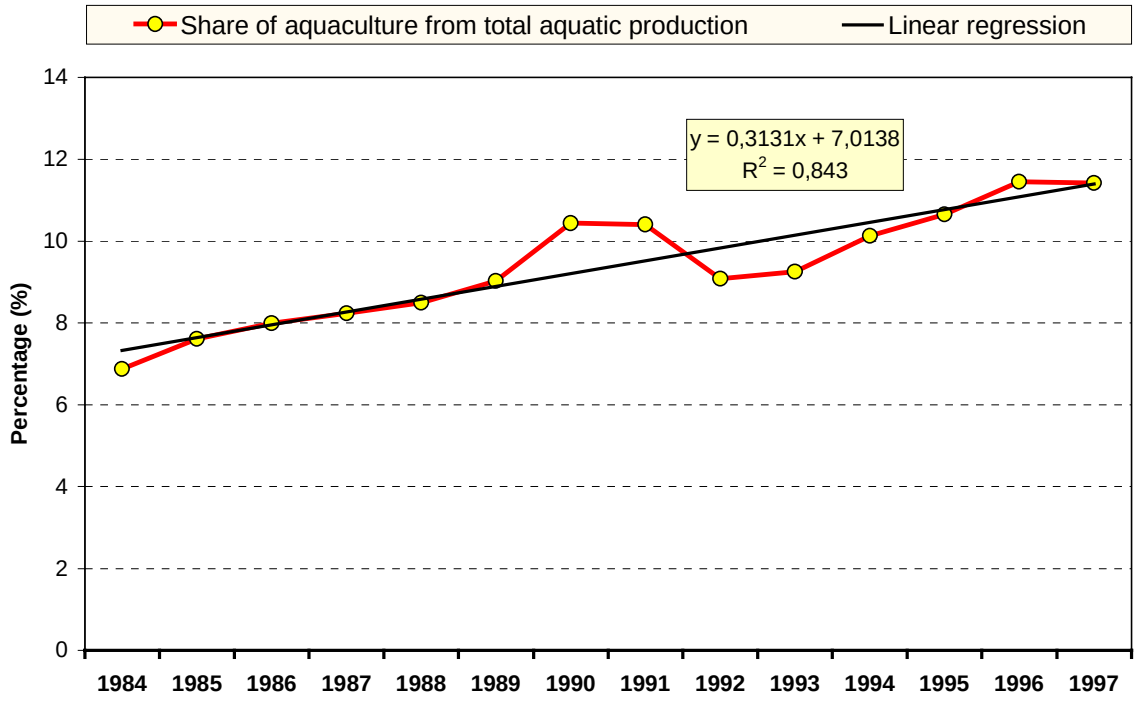


Figure 4 **Contribution of aquaculture production volume to total aquatic production in Europe**

Reference: FAO, FishStat Plus 1999

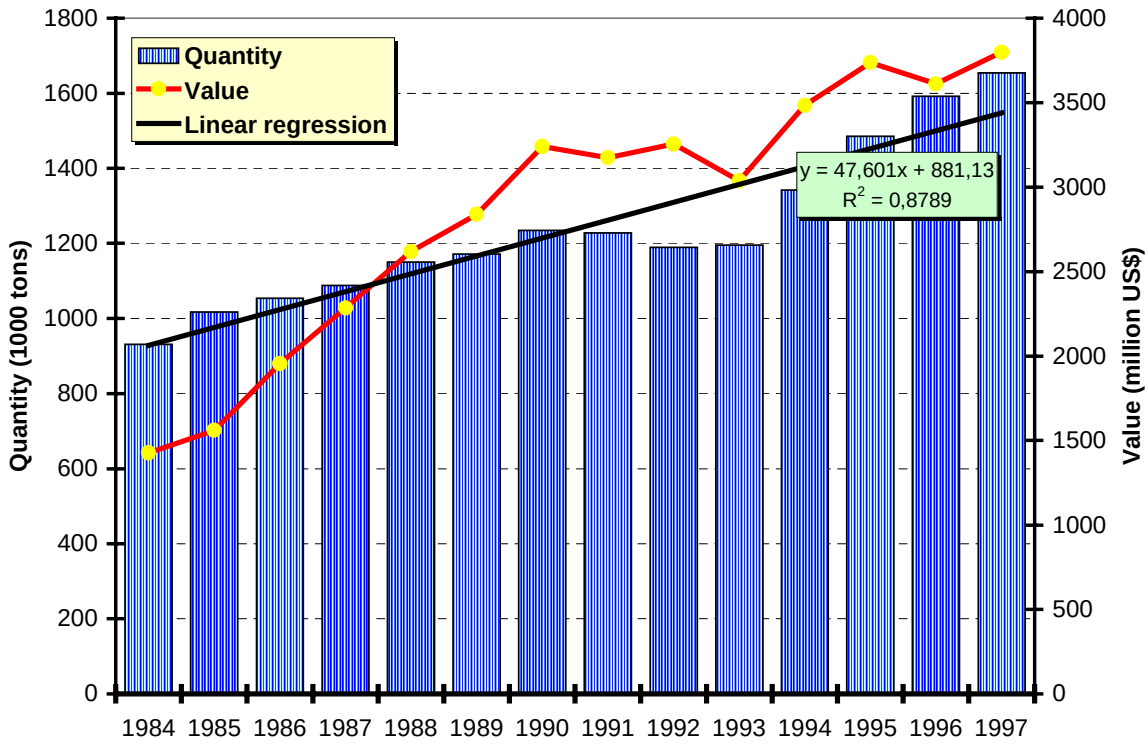


Figure 5 **Growth of aquaculture production in Europe**

Reference: FAO, FishStat Plus 1999

According to the linear trend function shown in *Figure 5* European aquaculture production will reach 1.8 million metric tons in five years *(by 2002)*. If the 14 years' data are examined it is seen that the European aquaculture production was increasing annually *(save the years 1991-93)*. The slow growth of the aquaculture sector within the region, especially between the late 1980's and the early 1990's, was due to several factors, including the political and economic transition *(shift from centralised to market economy)* in Central and Eastern European countries and the consequent decline in carp production, the drastic fall in mussel production in Spain due the increasing occurrence of red tides, and to a lesser extent due to the progressive saturation of the mollusc markets in the region.

Value of aquaculture production is growing much faster than its quantity, and this is especially so in the late 80's. This dynamic growth is explained by increasing prices. In *Figure 6* the change in price-level of a theoretical ***'average aquaculture product'*** is shown, this is obtained by dividing the production value (US$) with the volume (kg). It can be clearly seen that the value was 1.5 US$/kg in the mid 80's, and exceeded 2.5 US$/kg by the early 90's. The peek has been reached in 1992 (2.74 US$/kg) afterwards the price decreased year by year, and dropped below 2.5 US$/kg in 1996. According to the trend function further decrease in the price-level of aquaculture products can be predicted in the coming years, down to the values similar to those of the 80's. Naturally this does not apply to all of the products, since this is only an average indicative figure, thus the price of one product may increase while others will decrease.

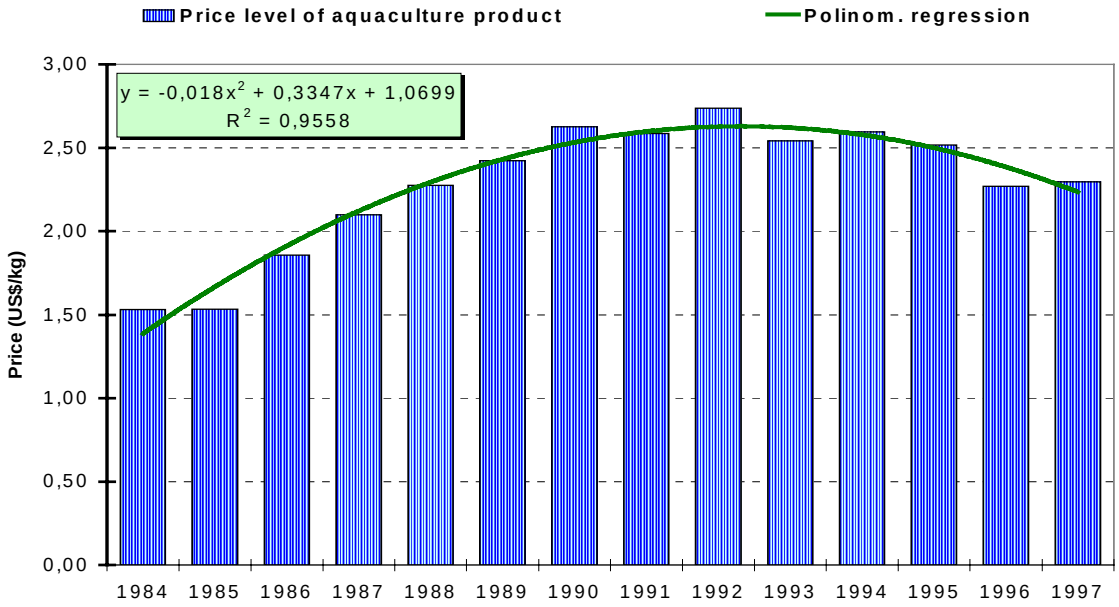


Figure 6 **Average price level of aquaculture products in Europe**

Reference: FAO, FishStat Plus 1999

In summary the volume of aquaculture production will increase, but its average value may decrease in the years to come. Individual countries contribute to the total aquaculture production to a different extent. At present the most significant producers are: Norway, France, Spain, Italy, United Kingdom, and the Netherlands. The former European socialist countries *(Albania, Czech Republic, Hungary, Poland, Romania, Bulgaria, Macedonia, Croatia, Slovakia, Slovenia, Yugoslavia Fed. Rep.)* represent 5% of the total European production. The share of individual countries from the total European production is shown in *Figure 7-10.*

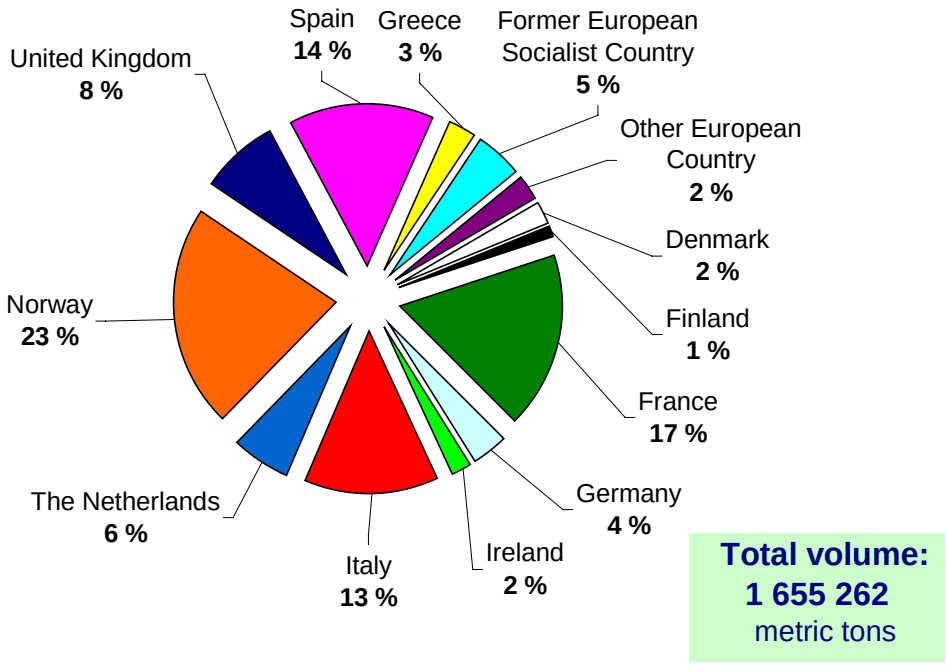


Figure 7 **Distribution of aquaculture production by countries in Europe (1997)**[3]

Reference: FAO, FishStat Plus 1999

[3] **Former European socialist countries:** Czech Republic, Hungary, Poland, Romania, Bulgaria, Macedonia, Croatia, Yugoslavia Fed. Rep., Slovakia, Albania, Slovenia.

Other European countries: Portugal, Belgium, Sweden, Switzerland, Austria, Iceland, Malta, Faeroe Islands, Channel Islands.

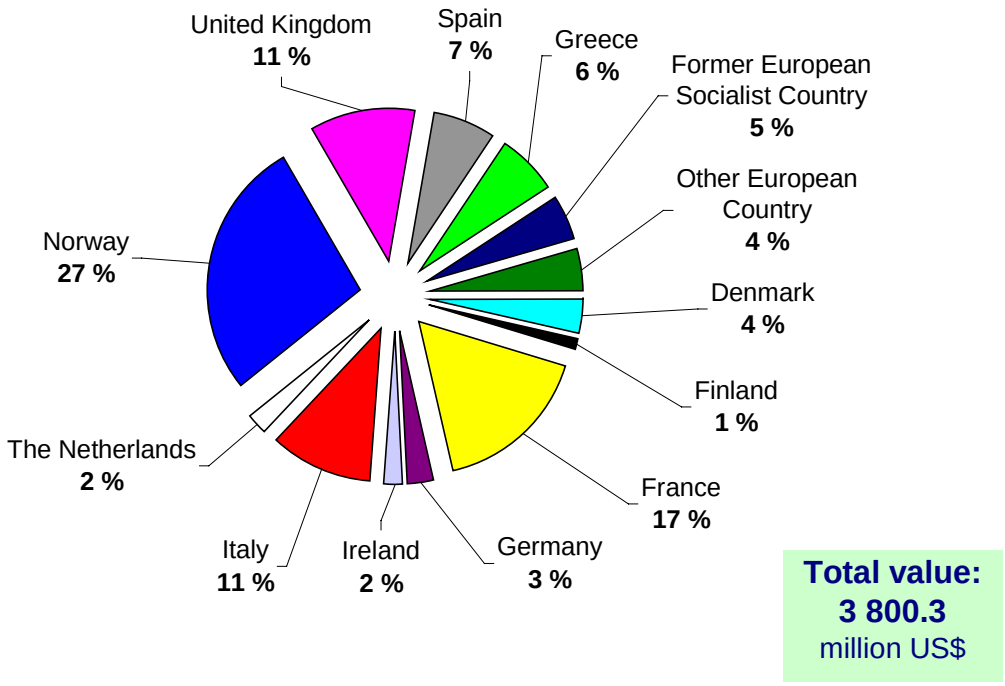


Figure 8 **Distribution of aquaculture production value by countries in Europe (1997)**

Reference: FAO, FishStat Plus 1999

If the share of countries from European aquaculture production is examined in the period between 1980's and 1990's, one can observe changes in the relative significance of some countries. The decrease is especially outstanding in the case of Spain and the former socialist countries. Spain, being responsible for 25-26% of the total European production in the 80's, represents only 14% nowadays. In the former socialist countries production dropped because of the political and economic transition, but after a stabilisation processes production will grow, thus an increase of their relative share in the total European production is expected.

Norway, Greece and the United Kingdom increased its contribution to the total European aquaculture production, and is expected to grow further, but probably slower than in the early 90's.

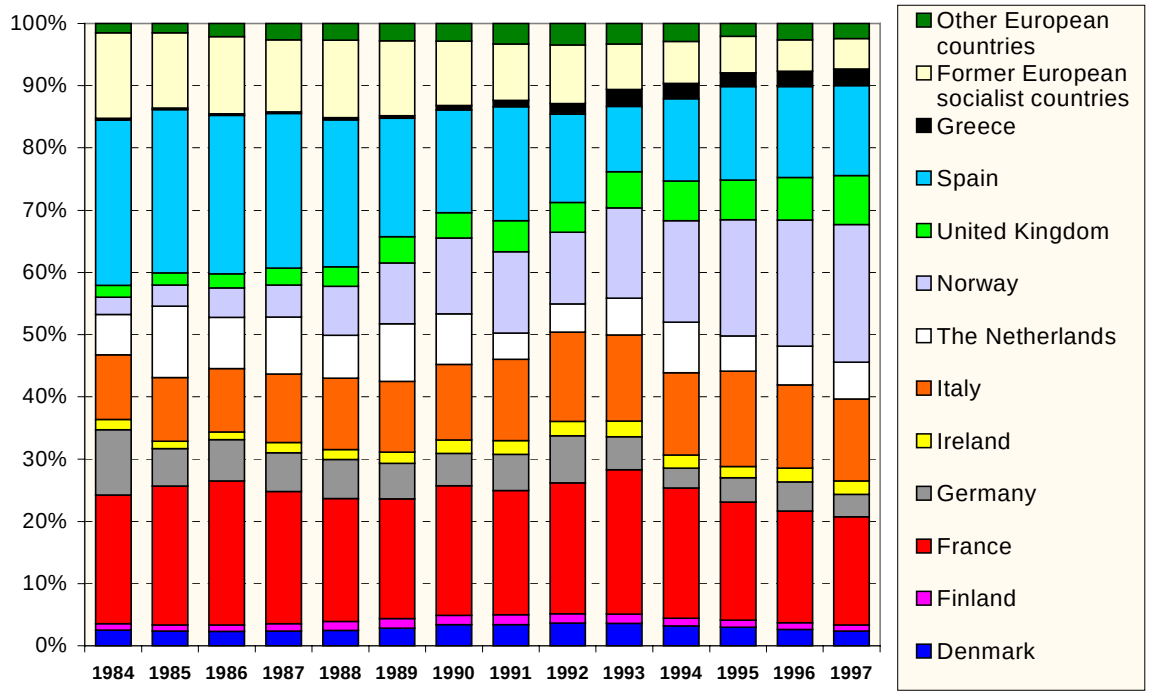


Figure 9 **Distribution of aquaculture production volume by countries in Europe**[4]

Reference: FAO, FishStat Plus 1999

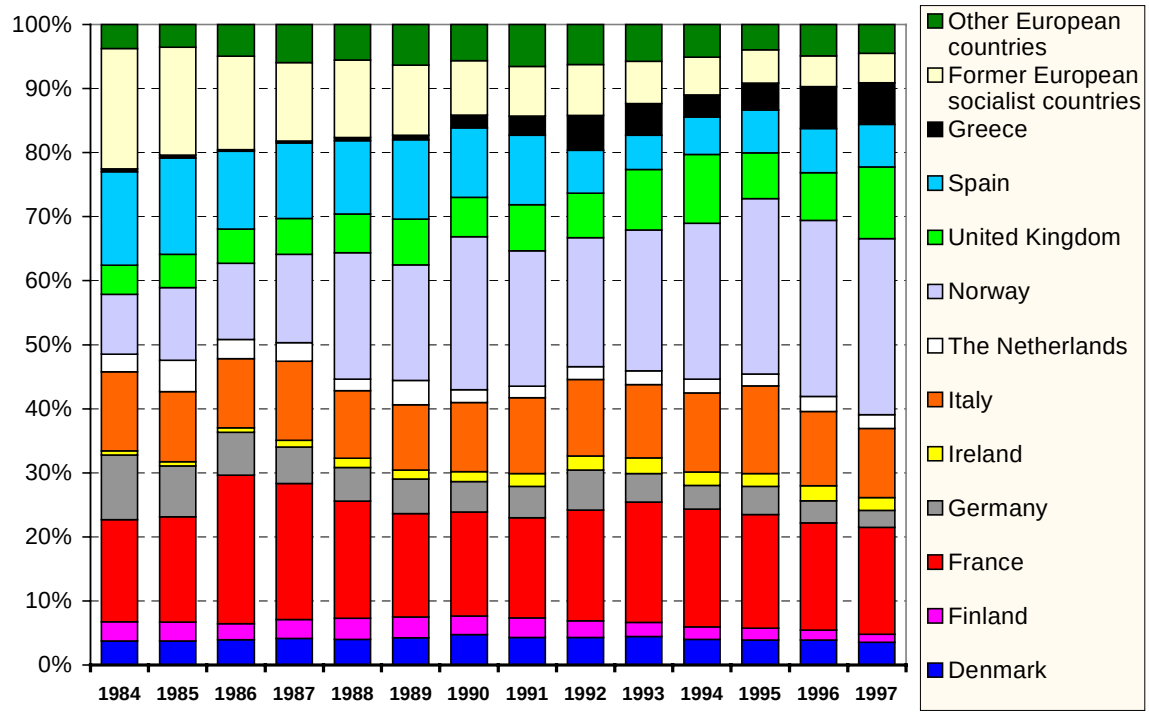


Figure 10 **Distribution of aquaculture production value by countries in Europe**[4]

Reference: FAO, FishStat Plus 1999

[4] **Former European socialist countries:** Czech Republic, Hungary, Poland, Romania, Bulgaria, Macedonia, Croatia, Czechoslovakia Yugoslavia Fed. Rep., Slovakia, Albania, Slovenia.

Other European countries: Portugal, Belgium, Sweden, Switzerland, Austria, Iceland, Malta, Faeroe Islands, Channel Islands.

The relative contribution of key environments to the European aquaculture production is shown in the *Table 2* and *Figure 11*. Marine aquaculture has a predominant role, both in quantity and value of production, compared to inland aquaculture (freshwater and brackish water) in Europe.

Table 2 **Contribution of freshwater, brackish water and marine aquaculture to total aquaculture production in Europe (1997)**

	Quantity	Value
▪ **Freshwater**	20.4 %	26.3 %
▪ **Brackish water**	7.1 %	5.5 %
▪ **Marine water**	72.5 %	68.2 %

Reference: FAO, FishStat Plus 1999

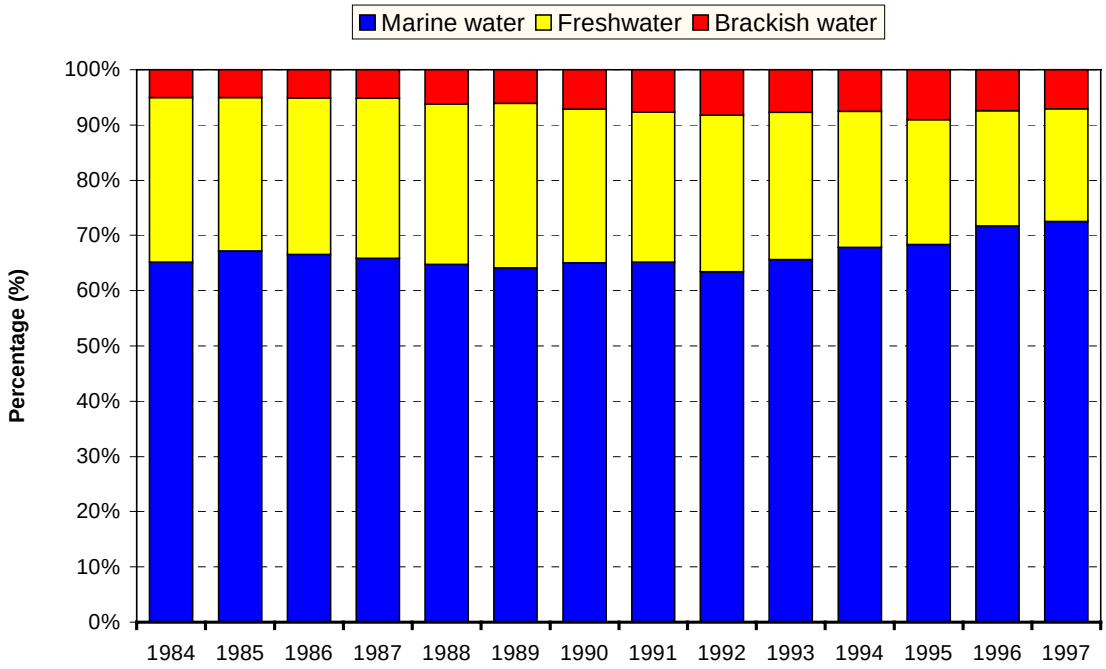


Figure 11 **Contribution of freshwater, brackish water and marine aquaculture to total aquaculture production volume in Europe**

Reference: FAO, FishStat Plus 1999

The distribution of aquaculture production volume and value by species groups in Europe is shown in *Figures 12,13,14,15.* The role of molluscs is dominant in volume but it is decreasing from 65% in 1984, to 44% in 1997. The share of diadromous fishes *(mainly salmonids)* is also important in volume and it is increasing from 20% in 1984, to 45% in 1997. *Figure 13* shows that the share of diadromous fishes from the total aquaculture value is dominant, because it was 62% in 1997 and increasing in the past twelve years.

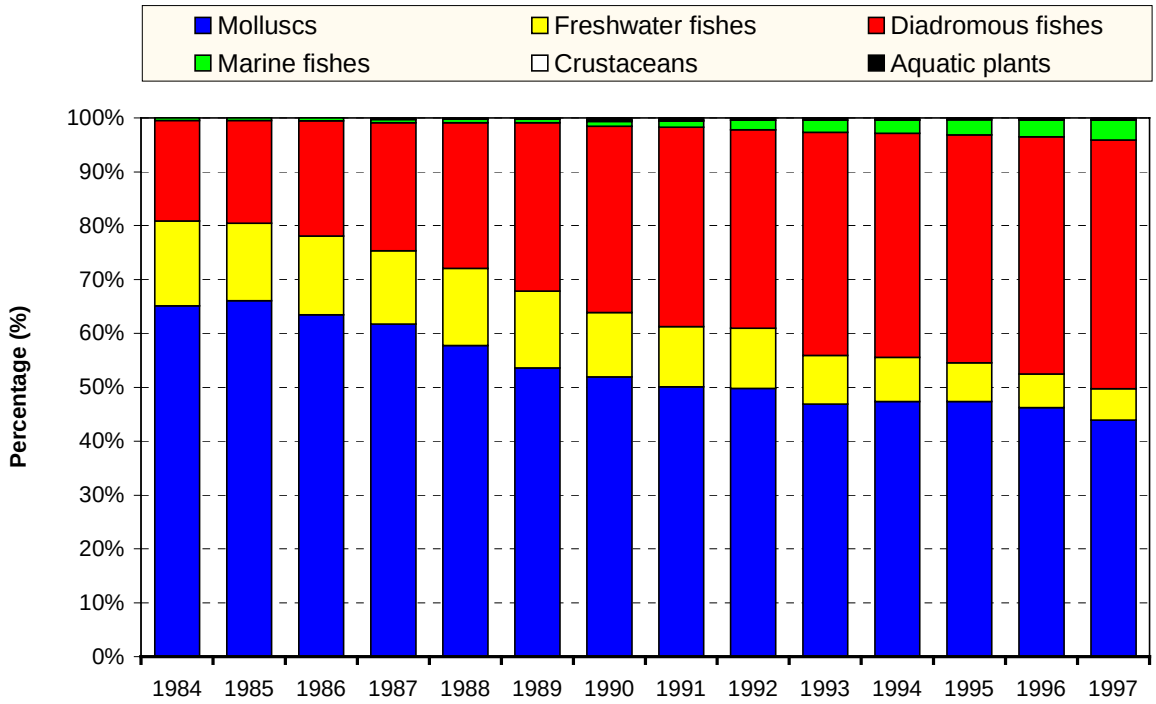


Figure 12 **Distribution of aquaculture production volume by major species groups in Europe**

Reference: FAO, FishStat Plus 1999

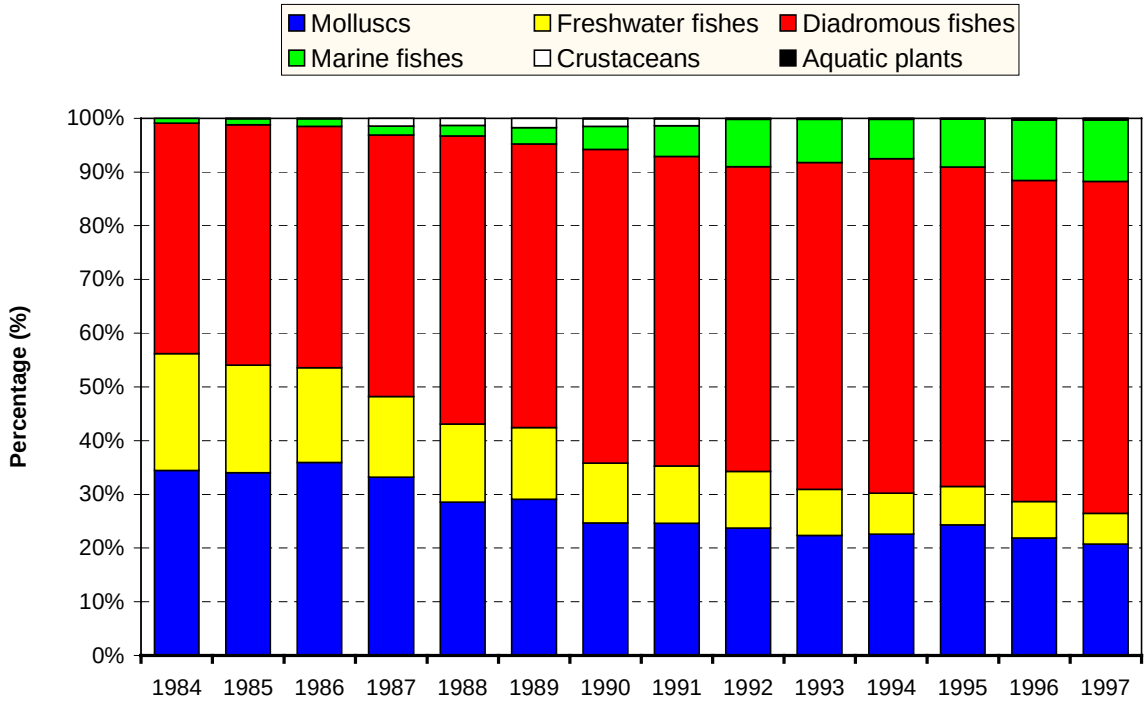


Figure 13 **Distribution of aquaculture production value by major species groups in Europe**

Reference: FAO, FishStat Plus 1999

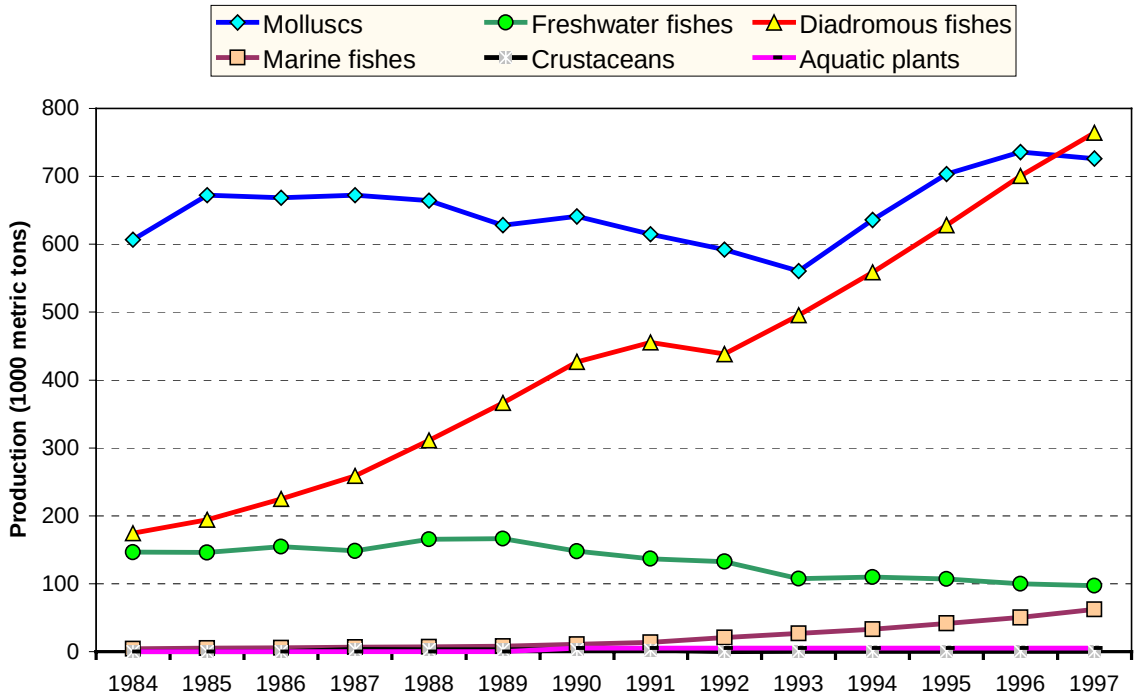


Figure 14 **Volume of aquaculture production by major species groups in Europe**

Reference: FAO, FishStat Plus 1999

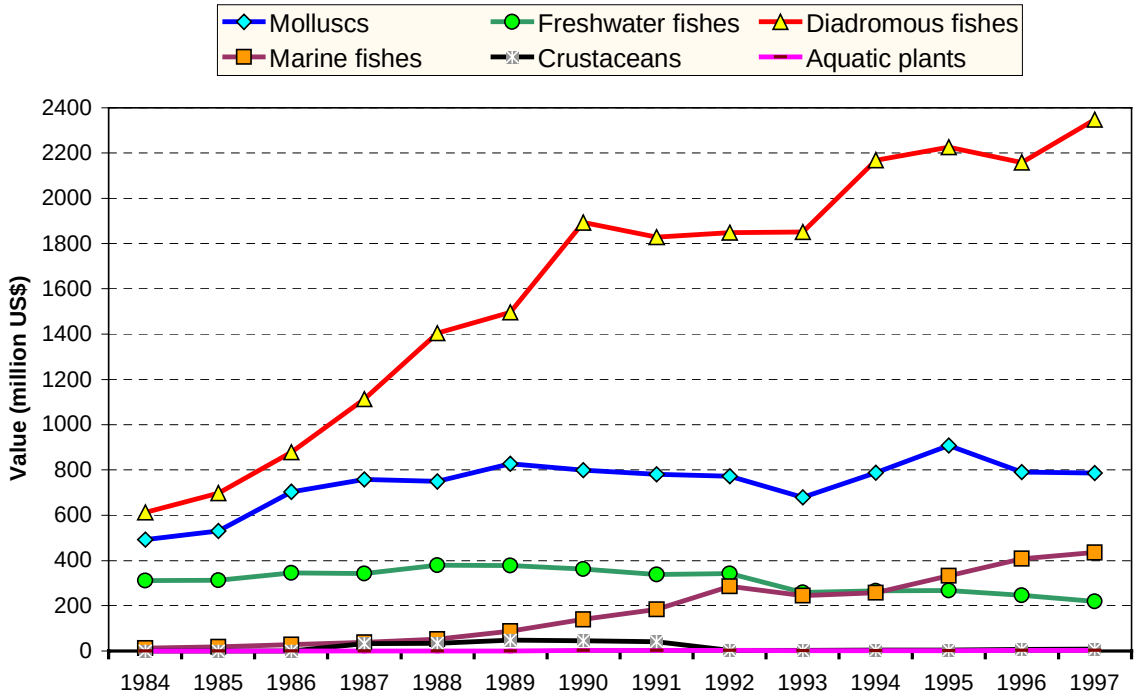


Figure 15 **Value of aquaculture production by major species groups in Europe**

Reference: FAO, FishStat Plus 1999

Several species are produced in the European aquaculture. The distribution of the most important species groups in quantity and in value is shown in *Figure 16, 17* and in *Table 3* and *4*.

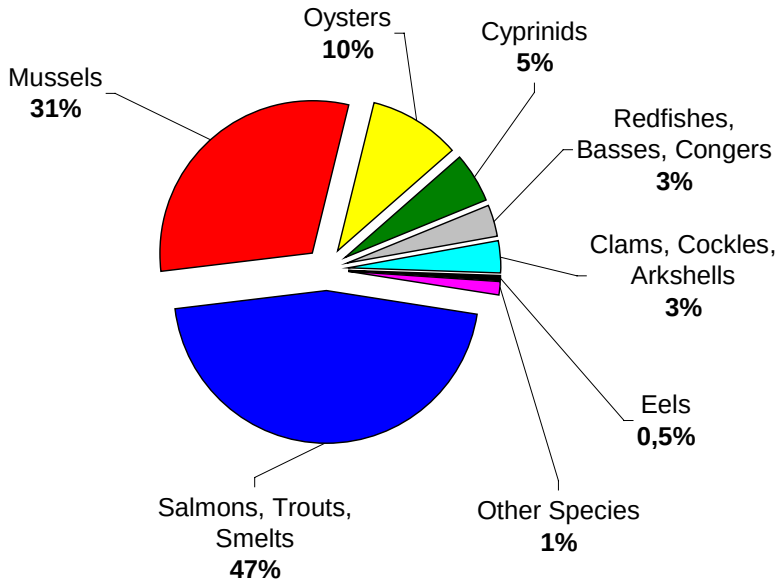


Figure 16 **Distribution of aquaculture production volume by selected species groups in Europe (1997)**

Reference: FAO, FishStat Plus 1999

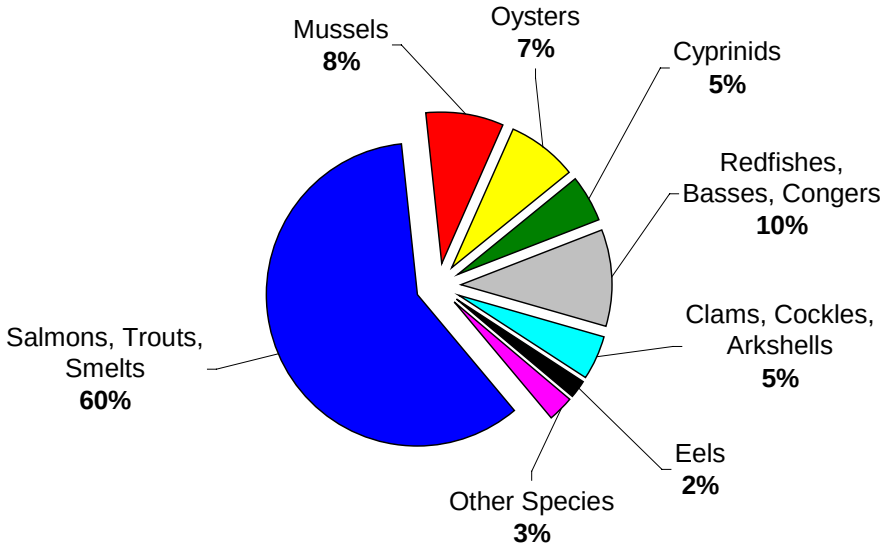


Figure 17 **Distribution of aquaculture production value by selected species groups in Europe (1997)**

Reference: FAO, FishStat Plus 1999

Salmonids are the most important species group in the aquaculture production of Europe. Mussels are the second in quantity with about 31%, but because of their lower unit value, their contribution is only about 8% of the total value. Oysters also have a significant role in the European aquaculture. Although cyprinids are only the fourth important species groups taking into account the whole of Europe, they represent the most significant species group of the inland aquaculture in Central and Eastern Europe. It is worth mentioning that although redfishes, basses, congers contributed only 3% of production by volume, because of their higher unit value they contributed 10% to the total value in Europe.

If the share of the species-groups in the European aquaculture production in the 1980's and 1990's are compared, one can observe a change in the relative importance of some groups. The share of salmonids grew significantly, from 26% to 45% in the 80's and the late 90's, respectively. Their growth is slower in the last 10 years *(only 8%)*. Despite this, it is important to emphasise, that over 50% of the value of the total European aquaculture production is originating from cultured salmonids.

Table 3 **Share of selected species groups in the total volume of aquaculture production in Europe (1997)**

(%)

Species groups	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
▪ **Salmons, trouts, smelts**	**26.5**	30.7	34.0	36.5	36.2	40.8	40.9	41.8	43.5	**45.6**
▪ **Mussels**	**44.0**	40.0	37.6	35.8	34.7	30.8	31.6	31.6	32.6	**30.8**
▪ **Oysters**	**12.4**	11.7	12.1	11.1	11.9	12.9	11.7	10.5	10.3	**9.7**
▪ **Cyprinids**	**13.8**	13.6	11.4	10.3	10.2	8.2	7.5	6.6	5.6	**5.4**
▪ **Redfishes, basses, congers**	**0.2**	0.3	0.5	0.8	1.3	1.8	1.9	2.3	2.7	**3.3**
▪ **Clams, cockles, arkshells**	**1.2**	1.7	2.0	2.9	3.0	3.0	3.9	5.1	3.2	**3.3**
▪ **European eel**	**0.5**	0.5	0.5	0.5	0.5	0.6	0.6	0.5	0.5	**0.5**
▪ **Other species**	**1.4**	1.5	1.9	2.1	2.2	1.9	1.9	1.6	1.6	**1.4**
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Reference: FAO, FishStat Plus 1999

Table 4 **Share of selected species groups in the total value of aquaculture production in Europe (1997)**

(%)

Species groups	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
▪ **Salmons, trouts, smelts**	**51.6**	50.7	56.0	55.0	54.2	58.2	59.5	57.5	57.3	**59.5**
▪ **Mussels**	**13.4**	14.4	11.8	11.0	9.3	8.1	7.4	8.0	8.7	**8.3**
▪ **Oysters**	**11.9**	10	9.6	8.9	10.1	10.3	10.0	10.1	8.4	**7.4**
▪ **Cyprinids**	**13.4**	12.1	9.8	9.2	9.2	7.2	6.4	6.2	5.6	**5.1**
▪ **Redfishes, basses, congers**	**1.6**	2.3	3.5	5	7.8	7.2	6.3	7.7	10	**10.2**
▪ **Clams, cockles, arkshells**	**3.2**	4.4	3.1	4.4	4.1	3.8	5.0	6.0	4.5	**4.8**
▪ **European eel**	**1.9**	2.0	2.1	2.3	2.4	2.5	2.5	1.8	2.2	**2.0**
▪ **Other species**	**3.0**	4.1	4.1	4.2	2.9	2.7	2.9	2.7	3.3	**2.7**
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Reference: FAO, FishStat Plus 1999

1.1. Atlantic salmon *(Salmo salar)*

1.1.1. Natural distribution

Atlantic salmon is one of the rare species, and therefore a high value product. Farming of Atlantic salmon begun in the 1960's in Norway, and has now been developed successfully in Scotland (United Kingdom), Ireland and the Faeroes, but also in Chile, North America and Australia. In its natural life cycle this anadromous species hatches in freshwater, later grows and matures in saltwater, finally returns to the original rivers to spawn. This anadromous habit divides salmon farming into two stages, implemented in fresh- and saltwater, for which clean and well-oxygenated, temperate water is required. After a period of 3-4 years, the whole life cycle of the salmon can be reproduced in captivity using intensive farming systems.

1.1.2. Culture techniques

Freshwater stage: The production process begins in land-based hatcheries in the autumn when the broodstock is stripped. The eggs hatch at early spring. Different types of tanks or cages are used to grow the fry to parr and then to smolt. Smolting occurs normally only once a year, in the spring, at an age of about 17 months, and prepares the fish to be transferred into the sea. Different methods of manipulating the light and/or temperature regimes have been developed in order to ensure year round supply of smolts for ongrowing in seawater.

Seawater stage: Commercial size of 2-5 kg salmon is obtained in a period of 1-2 years in floating net cages in well protected areas of the sea. Environmental setbacks and scarcity of suitable protected sites has led to the development of offshore cages and also to land based sites using pumped seawater. However, the salmon production currently is dominated by floating cages.

1.1.3. Production and markets

In volume terms and after trout, salmon is the second major finfish farmed, dominated by, Ireland, Scotland (United Kingdom), and Norway, which both amount for around 52% of the total world's farmed salmon production *(Atlantic and Pacific salmon)* in 1997. Small but growing quantities are produced in Spain and France. Production has grown rapidly throughout the 1980's, from only 1 000 metric tons in 1981 to 34 600 metric tons in 1989.

The main salmon producer countries in Europe are: Norway, United Kingdom, Ireland, Finland and Sweden *(Map 2)*.

(Atlantic salmon)

Map 2 **Main Atlantic salmon farming areas in Europe.**

The quantities and values of cultured Atlantic salmon production in Europe are shown in *Table 5* and *Figures 18,19 and 20.*

Table 5 **Total cultured Atlantic salmon production in Europe**

Quantity (metric tons), Value (million US$)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Quantity	107 642	154 663	201 304	227 010	198 871	246 227	297 647	356 441	416 358	465 471
Value	644.8	727.3	1 039.2	978.7	948.7	1 000.8	1 240.9	1269.5	1 247.0	1 398.8

Reference: FAO, FishStat Plus 1999

The most important salmon producer country in Europe is Norway, where production increased rapidly between 1987 and 1997, from 47 418 metric tons to 331 367 metric tons. The United Kingdom is also an important salmon producer, its production increased rapidly too. In Ireland, Iceland and the Faeroe Islands the production also increased continuously between 1988 and 1997, however, with a slower rate.

According to *Figure 18* and *19*, despite the fact that the average prices in the 1990's were well below the price level of the 1980's, the production grew both in quantity and value.

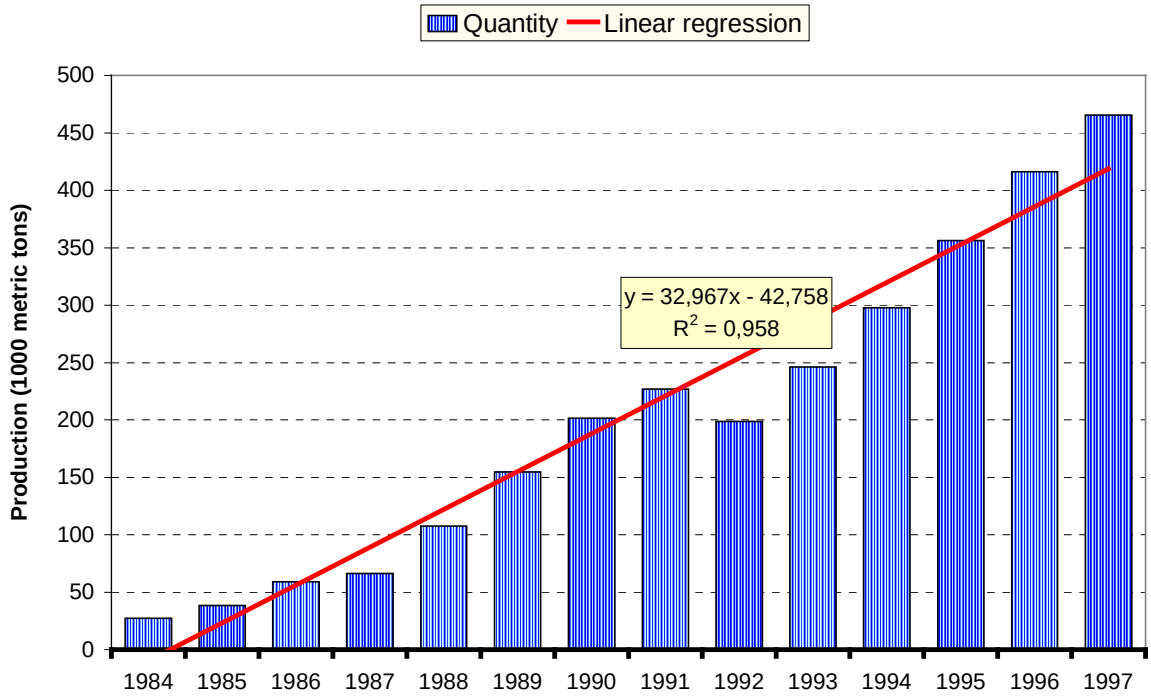


Figure 18 **Cultured Atlantic salmon production in Europe**

Reference: FAO, FishStat Plus 1999

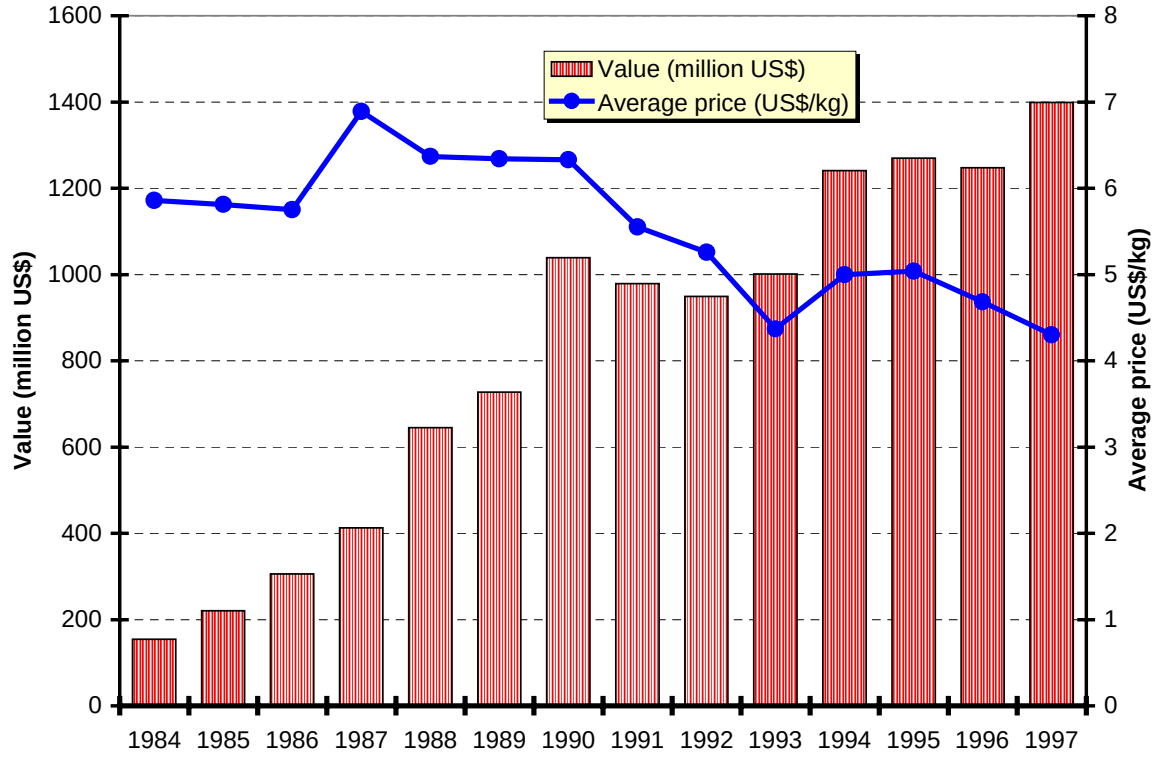


Figure 20 **Value of cultured Atlantic salmon production in Europe**

Reference: FAO, FishStat Plus 1999

The production of the main European Atlantic salmon producer countries in 1997 is shown in the *Figure 19.*

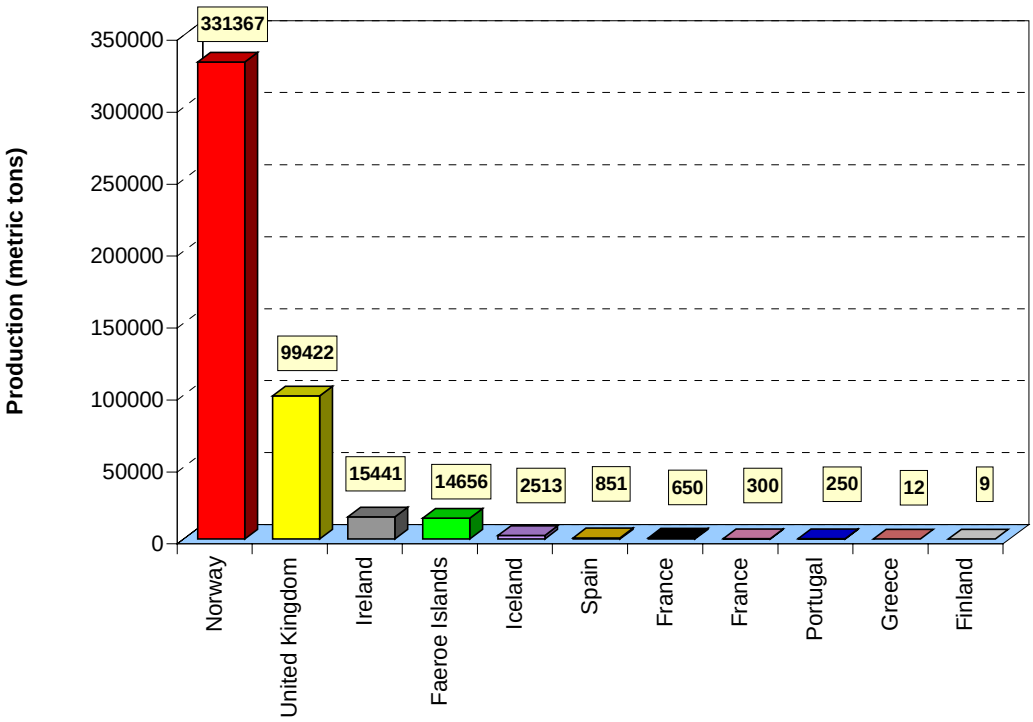


Figure 19 **Cultured Atlantic salmon production by countries in Europe (1997)**

Reference: FAO, FishStat Plus 1999

The bulk of the production is marketed inside Europe mainly as smoked and fresh.

1.1.4. Potentials for future development

The internationally traded salmon faces an highly competitive market. The exponential increase in production has led to substantial decreases in prices between 1987 and 1993. Hence, efforts are needed to develop additional processing methods into new value added products.

Environmental constraints and scarcity of well protected sites have led to the development of offshore and land based culture techniques, which will become more important as these constraints increase.

1.2. Trouts *(Oncorhynchus mykiss, Salmo trutta, Salvelinus fontinalis)*

1.2.1. Natural distribution

Trout is the major finfish cultured in Europe with a long tradition in several countries. Trout farming has been developed in a wide range of latitudes throughout the world. The main species is rainbow trout *(Oncorhynchus mykiss),* it is farmed mainly in freshwater to portion size *(up to 300 g individual weight).* After the freshwater stage, this anadromous salmonid species is also grown in seawater to bigger size (1-2 kg). For both fresh and seawater culture, well oxygenated temperate water is required. Other freshwater salmonid species farmed in Europe, mainly for restocking purposes, are the brown trout *(Salmo trutta)* approximately 3.500 metric tons/year and the brook trout *(Salvelinus fontinalis),* approximately 750 metric tons/year.

1.2.2. Culture techniques

A variety of culture systems are used throughout Europe. Land based systems are the most popular, using tanks, raceways and ponds, but ongrowing in cages in both fresh and seawater is also practised. Artificial reproduction is long since a well-known and widely utilised technique. After a period of approximately 8 months from hatching, marketable fish of 250-300 g is obtained. To ensure year-round supply of marketable fish, different methods of manipulating light and/or temperature regimes have been developed. At an age of around 14 months maturing males appear. Maturation hinders growth and decreases overall growth rate. To avoid this problem different technique of sex reversal to obtain all female stocks and triploid fish are being used.

1.2.3. Production and markets

Intensive farming of trout is a well established industry in Europe, Denmark, France, Italy and Germany being the major producers. Cultured rainbow trout production has grown steadily from the beginning of the 70's. The European production in 1989 amounted to 198 065 metric tons and represented around 66 % of the world's production (approximately 240 000 metric tons/year), and realised a turnover of about 425 million ECU-s (ex-farm prices). Trout is marketed in a variety of different forms ranging from live and fresh fish to prepared trout dishes.

The main trout producer countries in Europe are: Italy, France, Denmark, Norway, Spain, Germany, Finland and United Kingdom *(Map 3).*

(Rainbow trout)

Map 3 **Main trout farming areas in Europe.**

Quantities and values of cultured rainbow trout production in Europe are shown in the *Table 6* and *Figure 22,23 and 24.*

Table 6 **Total cultured rainbow trout production in Europe**

Quantity (metric tons), Value (million US$)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Quantity	191 028	198 065	211 088	214 922	225 178	234 743	245 666	256 736	267 603	281 463
Value	685.2	682.4	750.0	746.8	784.4	741.8	806.4	850.6	795.4	834.5

Reference: FAO, FishStat Plus 1999

Trout production includes several different species, each of which can be presented in a wide variety of manners *(Figure 21).* As an example of these differences, the descriptions "Pink Rainbow Trout" and *"White Rainbow Trout"* both refer to the production of portion (pan)-size fish *(under 400 g individual weight)* of rainbow trout the difference being the flesh colour. *"Salmon Trout"* refers to the larger sizes of rainbow trout that are on-grown in seawater and always have pink flesh, noting that production of the same fish can also be done in freshwater *(Large Rainbow Trout).*

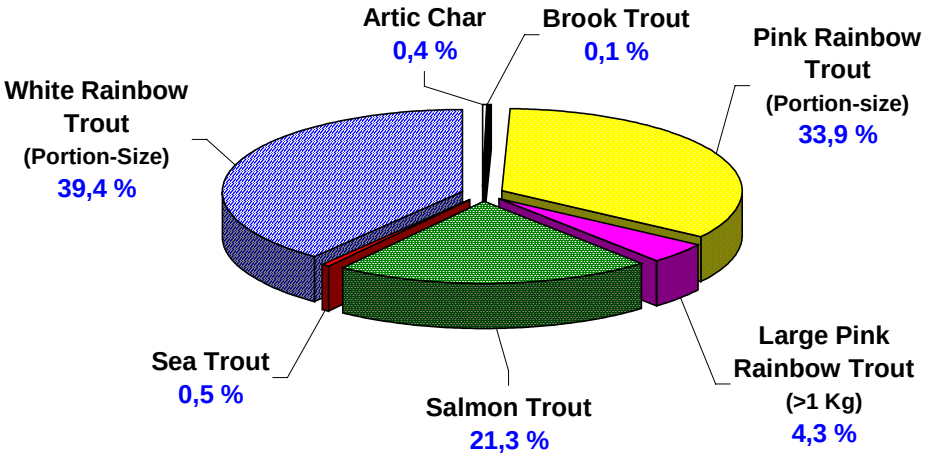


Figure 21 **Distribution of cultured trout products in Europe (average of 1996,1997,1998)**

Reference: FEAP 1999, European Aquaculture Production (http://www.fishlink.co.uk/feap/trout.html)

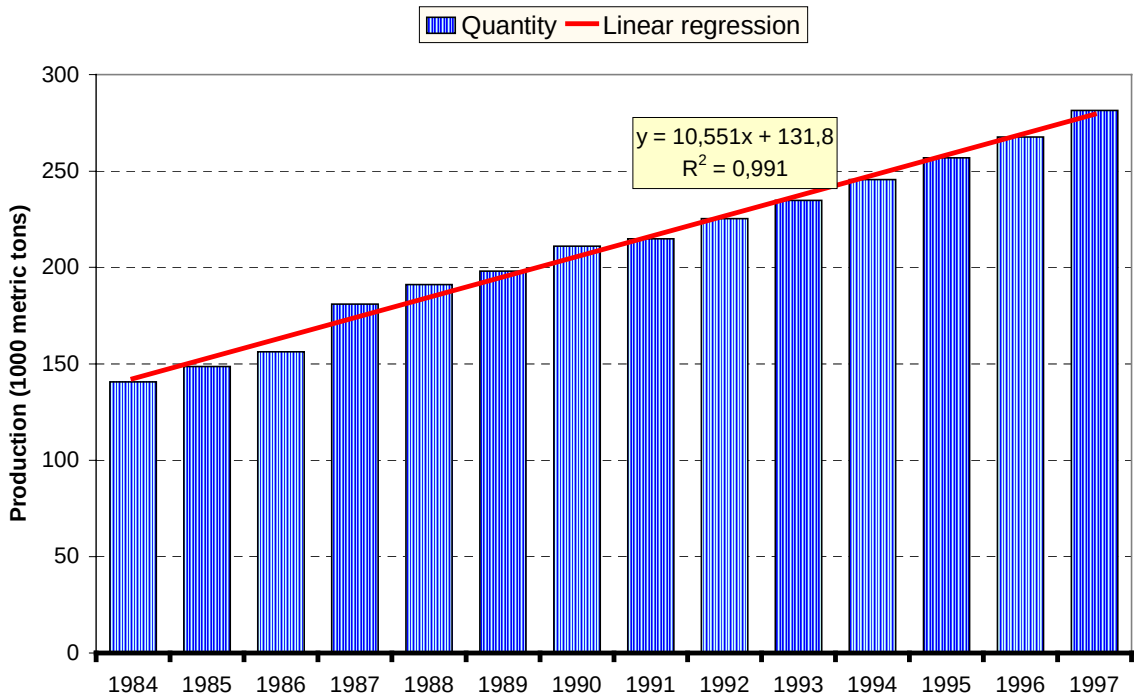


Figure 22 **Cultured rainbow trout production in Europe**

Reference: FAO, FishStat Plus 1999

Main European rainbow trout producer countries and their production in 1997 are shown in *Figure 23.*

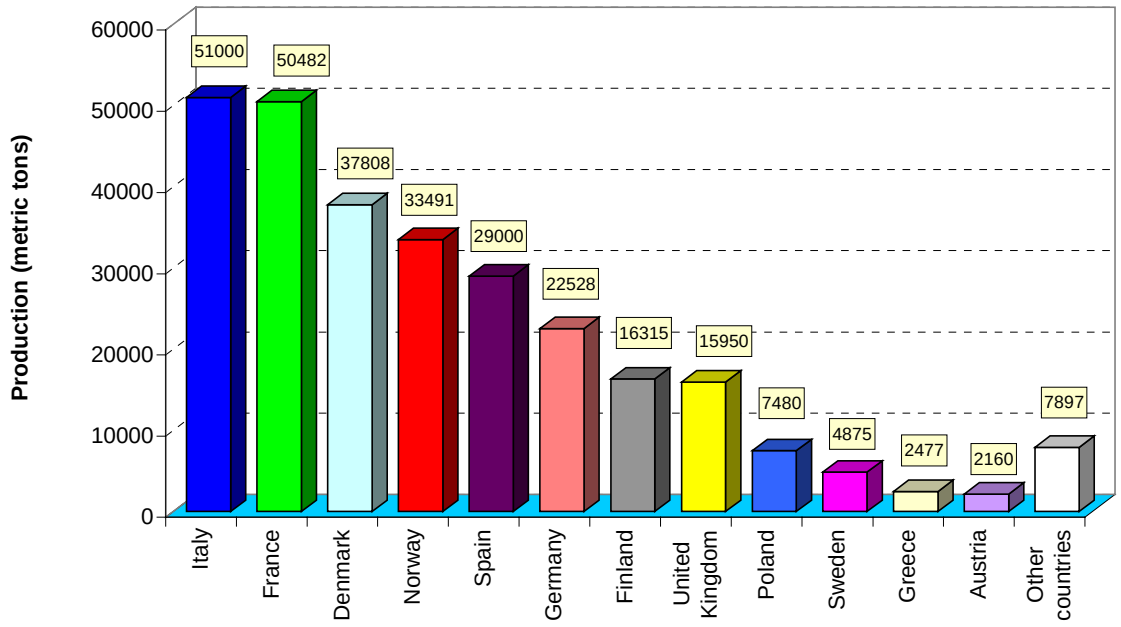


Figure 23 **Cultured rainbow trout production by countries in Europe (1997)**

Reference: FAO, FishStat Plus 1999

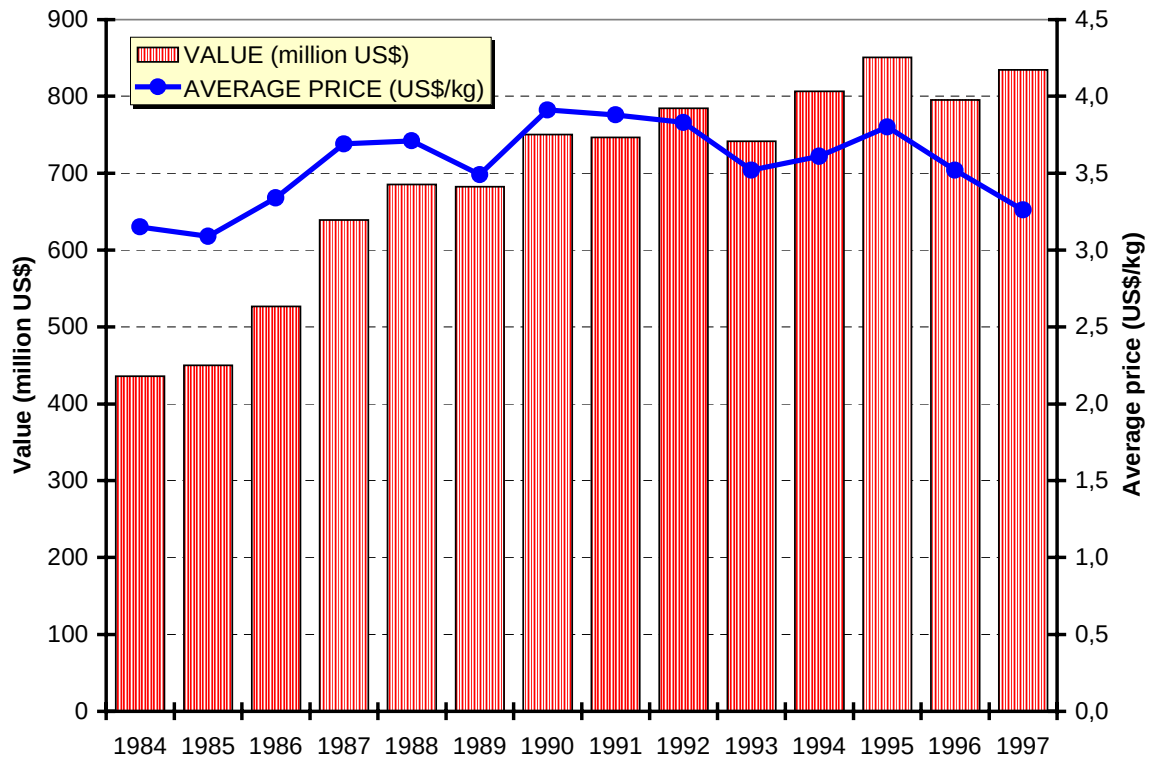


Figure 24 **Value of cultured rainbow trout production in Europe**

Reference: FAO, FishStat Plus 1999

1.2.4. Potentials for future development

The trout industry is in a matured stage. Limitations include the lack of sites increasing concern about the environment and the market prospects. New regulations related to water abstraction and effluent discharge, and control over feed conversion will pose severe constraints to the development of the industry in Europe. In order to continue succeeding, this industry has to maintain profitability and develop good marketing strategies. In the future little growth is expected, but trout will remain an important aquaculture product in Europe.

1.3. European eel *(Anguilla anguilla)*

1.3.1. Natural distribution

There are two species of eel farmed in large quantities in the world: the Japanese eel *(Anguilla japonica)* culture of which is concentrated in Asian countries *(Japan, Taiwan, China)*, and the European eel *(Anguilla anguilla)* farming of which is practised in Europe. European eel is a carnivorous catadromus fish, breeding exclusively in the Sargasso Sea. Its larvae *(Leptocephalus)* are passively transported through the Atlantic Ocean by the Gulf Current. Juveniles enter fresh and brackish watercourses, where they mature. The species is distributed all over Europe and the African coast down to approximately 25^{o} N.

1.3.2. Culture techniques

The farming techniques of European eel can be grouped in 3 main categories: extensive, intensive and superintensive recirculating systems.

Extensive farming: the most ancient technique, it exploits the natural tendency of the fish to enter brackish lagoons to grow. After 5-7 years (on average) the mature fish leaves the lagoon for reproductive migration and is captured by fixed devices ("lavoriero", bordigue"). Fishing with mobile gear is also fairly common in many lagoons.

Intensive farming: this technique is based on the catch of wild glass eels or elvers and their on-growing in concrete or earthen basins. The size of the basins varies largely but rarely exceeds 2 000 m^2, water intake (mainly fresh) is sometimes injected with liquid oxygen; fish density can reach (in very good conditions and with oxygen addition) 30 kg/m^2. The availability of sufficiently warm water is the cornerstone of this technique. This industry is particularly developed in Italy. It is performing relatively well, however, it has to face some limiting factors: insufficient recruitment of elvers, excessive cost of the weaned glass-eel, diseases, tendency of the eel to mature as a male (which stops growing at a lower size) in high density farming conditions.

Recirculation systems: indoor recirculated systems began to operate in the early 1980's in Northern Europe, and is currently developed mainly in Denmark, Germany and the Netherlands, where approximately 85 farms are operational. The basic idea is that heating of the water to optimum temperature is economically feasible and water quality parameters and

diseases can be controlled. Fish basins are small *(rarely exceed 25 m^2)* and fish densities very high *(from 30 to 90 kg/m^2, with an average of 50 kg/m^2)*. Apart from some Danish farms producing fingerlings, these units have shown poor economic viability so far. It is indeed true that due to the short time of operation a great number of these farms have not reached the stage of full production, so a definitive conclusion cannot be drawn. The main reasons for poor economic performance are: over-estimated growth rates, lack of knowledge concerning optimal water flows and efficiency of filters, lack of management capabilities and farmers' skills.

1.3.3. Production and markets

European farms produce approximately 7.914 metric tons of marketable eel (1997), which represents approximately 38 % of the estimated world landings of European eel. Between 1988 and 1997 a relatively slow increasing tendency was experienced in the total production of European eels in the European producer countries *(Table 7, Figure 25)*. Extensive and intensive units in Italy represent the bulk of farmed production. The main eel producer countries in Europe are: Italy, The Netherlands and Denmark *(Map 4)*.

(European eel)

Map 4 **Main eel farming areas in Europe**

Table 7 **Total cultured European eel production in Europe**

Quantity (metric tons), Value (million US$)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Quantity	6 160	5 875	6 909	6 670	6 718	7 310	7 973	6 924	8 120	7 914
Value	50.99	57.09	69.81	74.68	77.95	75.90	88.45	68.89	81.54	78.83

Reference: FAO, FishStat Plus 1999

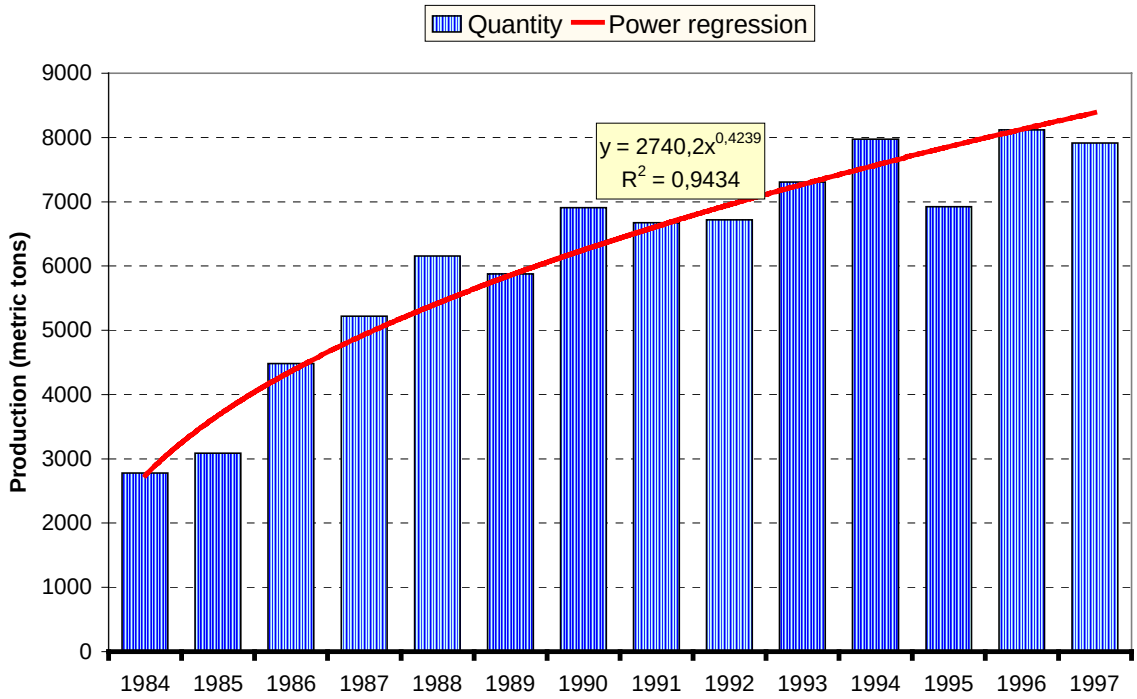


Figure 25 **Cultured European eel production in Europe**

Reference: FAO, FishStat Plus 1999

Production of cultured European eel grew dynamically in the 1980's, but the pace slowed down in the 1990's.

The most significant growth in cultured eel production was in the Netherlands. The production increased also in Denmark. In Belgium, Greece and Spain production of eels was not too significant but a rapid increase occurred between 1988 and 1997. Italy was the main European eel producer country in the studied period but the production there was slowly decreasing. The eel production of Sweden was relatively constant in the observed period. In Portugal the production was rather variable between 1988 and 1997. The other countries *(Croatia, Hungary, Macedonia, Malta and the former Yugoslavia)* produced only insignificant volumes and not continuously. *Figure 26* shows the distribution of cultured eel production by country in 1997.

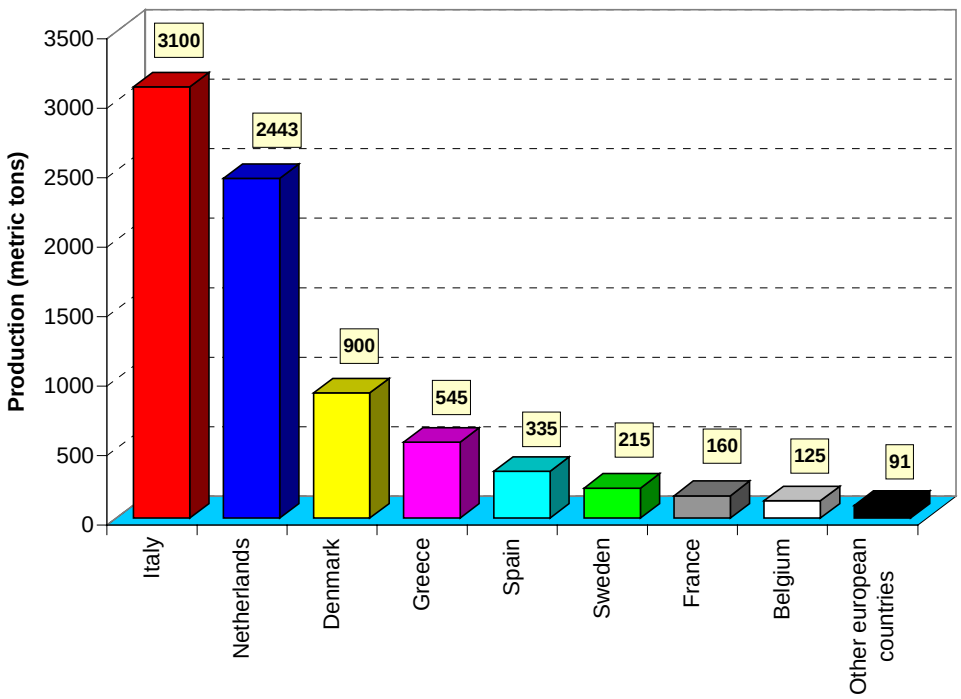


Figure 26 **Cultured European eel production by countries in Europe (1997)**

Reference: FAO, FishStat Plus 1999

Value of European eel production and the average prices are shown in *Figure 27*.

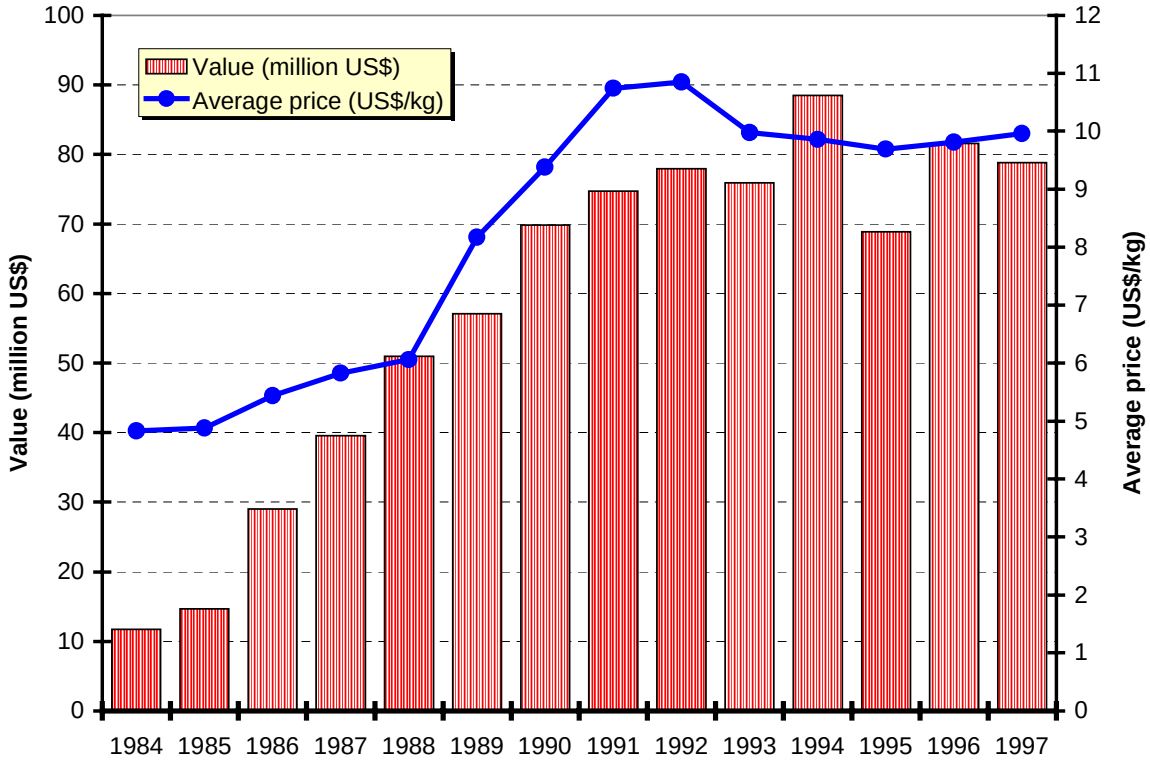


Figure 27 **Value of cultured European eel production in Europe**

Reference: FAO, FishStat Plus 1999

The most dynamic growth in the production of European eel occurred between 1988 and 1991, due to the growth both in quantity and price. The average price-level dropped to 10 US$/kg in 1992 and remained around that level since then. The total value of European eel production is about 80 million US$/year in the late 1990's.

Eel trade in Europe is a very special business, because of the highly specific requirements of each market regarding product quality and size. Fish of larger size (300-500 g) find a better price (approximately 20% higher) than the smaller ones (150 g). In Italy demand is focused on large sizes (300-400 g) during the Christmas period, in other periods smaller sizes (200-250 g) are preferred and consumed marinated. In the German market about 90% of the demand is for smoked eels, and traditionally large eels (400-800 g) are utilised for smoking. Due to the limited supply, smaller sizes (200-250 g) are now also utilised for smoking. The Dutch and Belgian eel consuming market are focused on small eels (100-200 g). The French market is limited to about, 1 500 metric tons/year, both small and large eels are consumed. Generally speaking, during the last ten years the eel market was rather stable in Europe.

1.3.4. Potentials for future development

Apparently there is no potential for a significant increase in eel consumption in Europe, at least in the short term. However, the decreasing volume of wild eel catches and the little chance of an increase in Asian farmed eel exports to Europe leaves the European farmers with the opportunity of further developing their production. Some bottlenecks must be solved: the insufficient elver supply, the excessive cost of weaned glass-eels, some disease problems, the technical and managerial weaknesses of recirculating systems, the competition with other sectors for the use of water resources and land sites.

Slow, but stabile growth can be predicted which is partly designated to new production plants, primarily in Central and Eastern Europe (e.g. Hungary) using Danish, Dutch or Italian technologies.

1.4. Cyprinids *(Cyprinus carpio, Hypophthalmichthys molitrix, Aristtichthys nobilis, Ctenopharyngodon idella, Tinca tinca)*

1.4.1. Natural distribution

There are five species dominating the European scene: the common carp *(Cyprinus carpio)*, the silver carp *(Hypophthalmichthys molitrix)*, the bighead carp *(Aristtichthys nobilis)*, the grass carp *(Ctenopharyngodon idella)* and the tench *(Tinca tinca)*. The three Chinese carp species were introduced in Europe in the 1960's.

Cultured cyprinids are found throughout the world in ponds both in monoculture and polyculture. Carps as omnivorous and herbivorous animals can easily be reared both for food and ornamental purposes (e.g. koi).

1.4.2. Culture techniques

Aquaculture in ponds is traditionally associated with carp culture. It's an extensive form of rearing freshwater species such as tench, roach and pike and of course for carps, which makes up the main species. Carp farming is carried out primarily in ponds where production is maintained essentially from renewable resources through the pond's aquatic ecosystem. One can, however, distinguish several carp culture systems.

Extensive culture: This type of farming dates back to the Middle Ages in Europe and to ancient China where it represents an important source of animal protein. The culture technique is based on the optimisation of the pond's tropic chain in order to achieve maximal fish yield. To achieve this, it's necessary to use suitable polycultural stocking, to fertilise the pond and to eliminate possible competitors. Juvenile production is carried out in spawning ponds called "pose" where the breeders spawn and juveniles are reared on a rich natural food supply. The fish-rearing stocks cohabitate in balance with the environment.

Semi-intensive culture: This is characterised also by polyculture and by a substantial external food supply allowing higher stocking densities and the use of hatching and larval rearing in controlled facilities. Different types of ponds are used for the young stages of rearing and then for ongrowing. The semi-intensive pond culture of cyprinids is typical in Hungary, Poland, the Czech Republic, Slovakia, Romania, Germany, France, Belgium, Croatia and Bulgaria.

Intensive culture: Heated water is used in certain high density farming with permanent aeration in which carp often represents a secondary species with the *eel (water recycled rearing).*

Cultivation which takes place in the framework of developing rural areas with many ponds such as "Hortobágy" in Hungary and "la Sologne" and "les Dombes" in France, is moving towards intensive methods with the aim of producing fillets of white fish for a high demanding European market. Therefore, pond culture can contribute to the diversifying efforts of agricultural projects recommended by the new Common Agricultural Policy. The environmental constraints relative to this type of farming are low, however one can point out depredation carried out on ponds by fisheating birds (heron, cormorant).

1.4.3. Production and markets

Between 1988 and 1997 the total production of cyprinids dropped by some 50% in Europe. Such decreasing tendency had been experienced in Austria, Bulgaria, Romania, Croatia, Germany, Greece, Hungary, Spain and the successor countries of the former Yugoslavia. World production of carp is estimated to be 2 237 422 metric tons and China holds first place in this production. The European countries represents only a small part of this total with an estimated cyprinids *(common carp, bighead carp, silver carp, grass carp, tench, crucian carp)* production in 1997 of 83 367 metric tons approximately with a value of 182 758 thousands US$ *(Table 8, Figures 28, 29).*

Table 8 **Cultured cyprinid[5] production in Europe**

Quantity (metric tons), Value (million US$)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Quantity	142 284	148 175	134 454	120 200	114 612	91 780	93 897	91 874	83 756	83 367
Value	311.23	315.93	303.85	274.61	279.19	202.08	206.93	213.72	187.45	182.76

Reference: FAO, FishStat Plus 1999

[5] **Cyprinids:** common carp, bighead carp, silver carp, grass carp, tench, crucian carp.

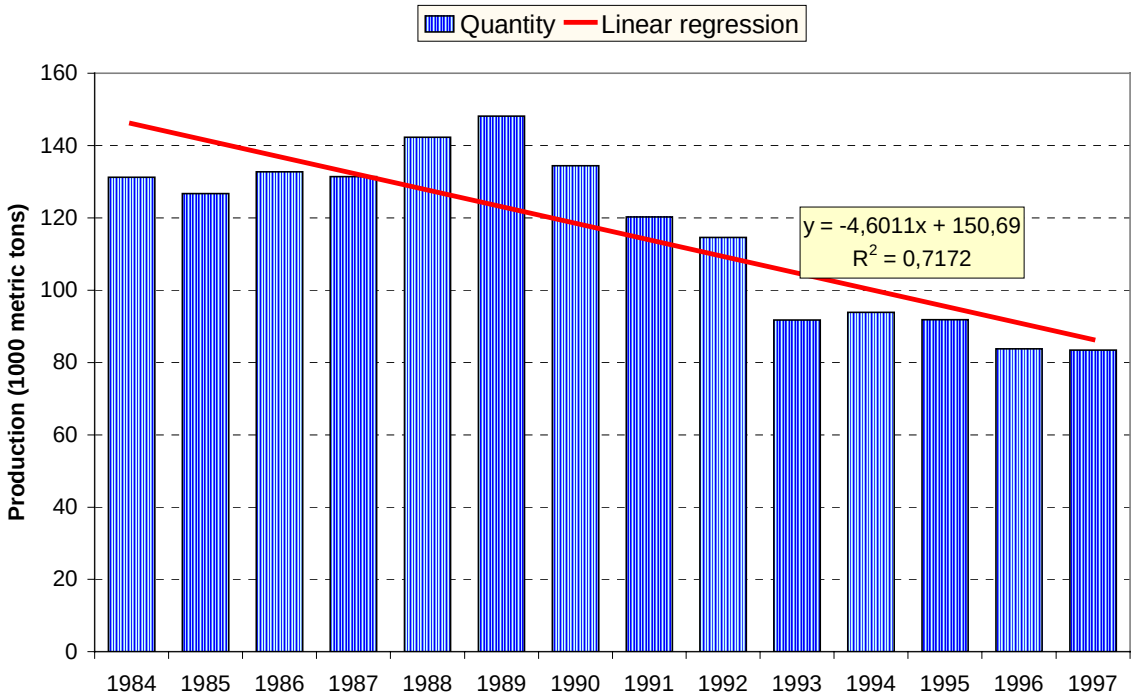


Figure 28 **Cultured cyprinids[6] production in Europe**

Reference: FAO, FishStat Plus 1999

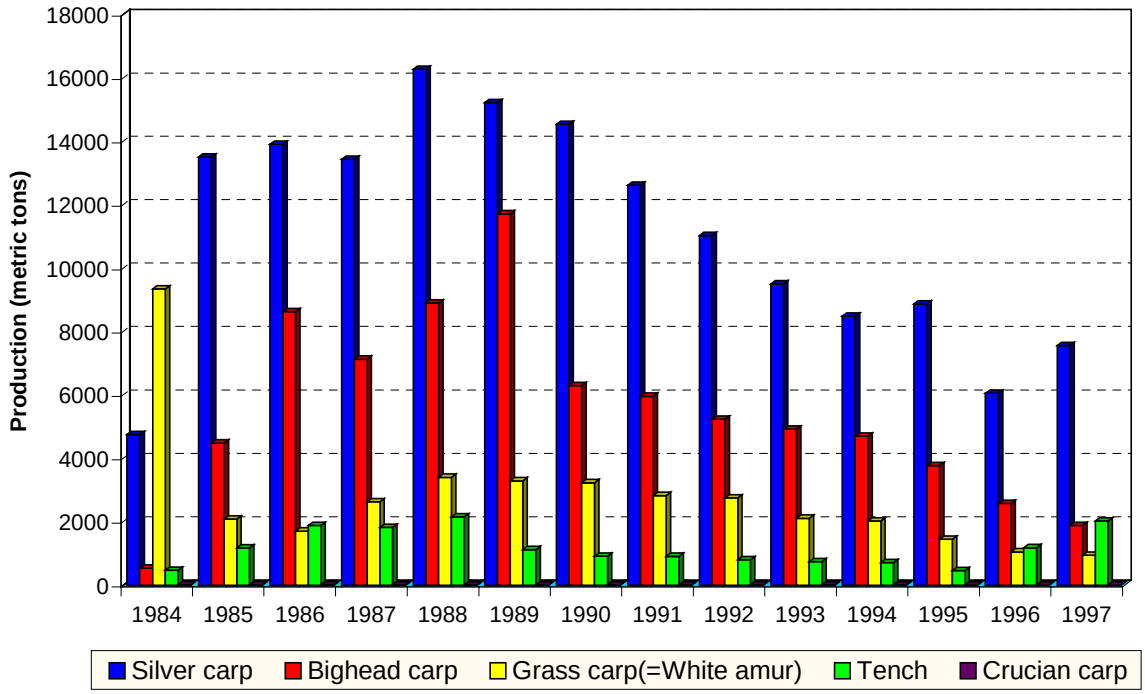


Figure 29 **Cultured silver carp, bighead carp, grass carp, tench and crucian carp production in Europe**

Reference: FAO, FishStat Plus 1999

[6] **Cyprinids:** common carp, bighead carp, silver carp, grass carp, tench, crucian carp.

The main Chinese carp (silver carp, bighead carp and grass carp) producer countries in Europe are: Romania, Hungary and the Czech Republic. Chinese carp production is based on the extensive and semi-intensive pond culture systems.

The main common carp producer countries in Europe are: Poland, the Czech Republic, Germany, Hungary, France and Bulgaria *(Map 5).*

(Common carp)

Map 5 **Main common carp farming areas in Europe**

Table 8 **Cultured common carp production in Europe**

Quantity (metric tons), Value (million US$)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Quantity	111 560	116 818	109 479	97 890	94 796	74 500	77 980	77 332	72 888	70 952
Value	244.66	247.60	248.77	223.38	231.77	162.09	169.55	180.69	161.88	163.35

Reference: FAO, FishStat Plus 1999

The common carp production of Albania and the United Kingdom also decreased and even it broke in 1997. The situation of the carp production in Poland, Hungary and Romania worked out in a peculiar way. In 1998 Romania was the second most important producer country but from that time the decreasing was so rapid that its carp production fell its one fifth until 1997. Despite of the above, in Belgium the carp production increased rapidly between 1988 and 1997. In France and Slovenia the carp production had been experienced slowly increasing. The production was also increasing in Poland but it touched bottom in 1993. The carp production was almost constant in the Czech Republic, Slovakia and Switzerland.

Quantities and values of cultured common carp production in Europe are shown in *Figures 30 and 31*.

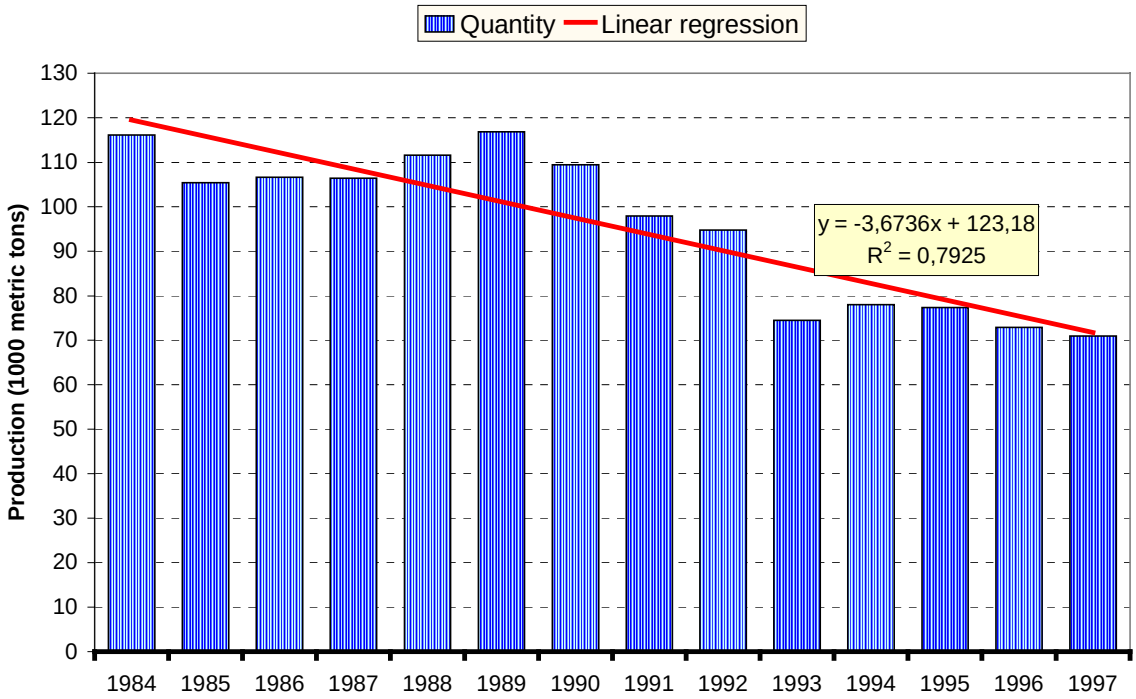


Figure 30 **Cultured common carp production in Europe**

Reference: FAO, FishStat Plus 1999

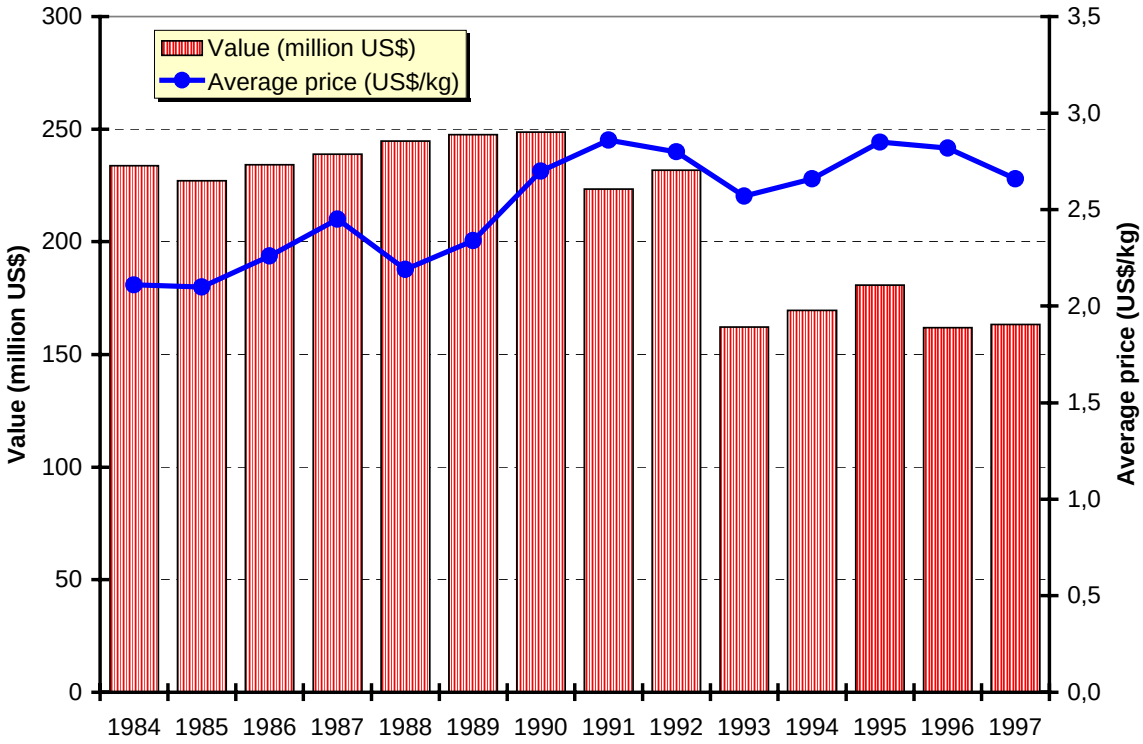


Figure 31 **Value of cultured common carp production in Europe**

Reference: FAO, FishStat Plus 1999

The production of the main common carp producer countries in Europe in 1997 is shown in *Figure 32.*

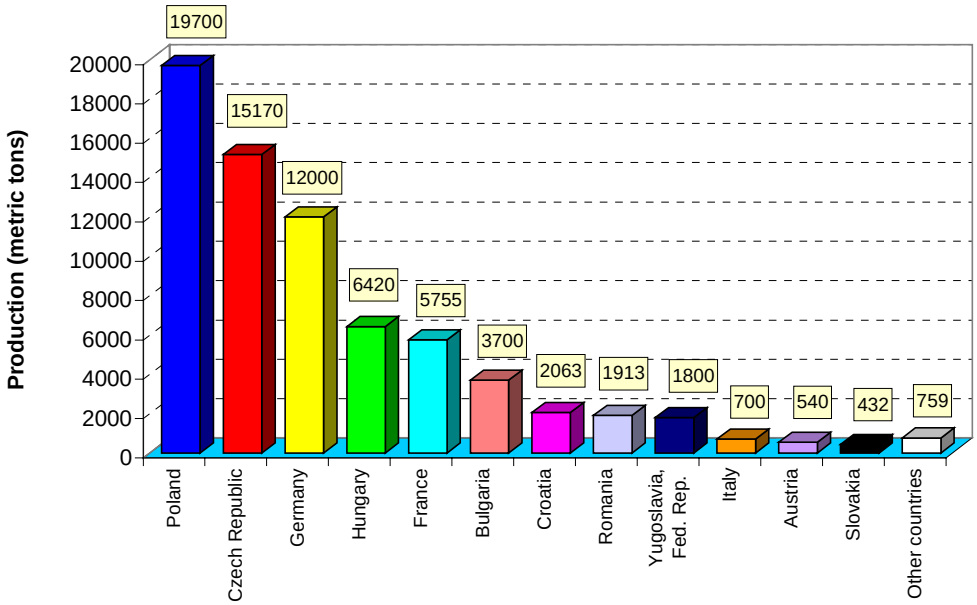


Figure 32 **Cultured common carp production in Europe (1997)**

Reference: FAO, FishStat Plus 1999

1.4.4. Potentials for future development

The most important limit on developing carp farming in Europe seems to be a limited market demand. Furthermore, western and central European producers have to compete with low cost Eastern European producers, which naturally leads to intensification of culture systems where water management takes on a new importance. It is also necessary to develop new method of processing and improved products in order to develop market outlets. Finally, the use of carp culture for non-food purposes, like restocking for recreational fishing or for ecological purposes may also be developed.

1.5. Catfishes *(Ictalurus melas, Ictalurus punctatus, Clarias gariepinus, Silurus glanis)*

1.5.1. Natural distribution

The black bullhead (*Ictalurus melas)* is very similar in outlook to the brown bullhead *(Ictalurus nebulosus)* that is widely spread in Europe, thus the distinguishing requires practical skills especially because the two species can easily hybridise. Originally it was native in Central/North America. It has been stocked outside of this area, first of all for sport-fishing purposes, thus became present in the Pacific coast of North America by the late 19th Century. The exact date of its stocking to European waters can not be determined, but it was present at the end of the 1800's. It is not cultured in ponds in North-America, and in Europe it has importance only in Italy, where has similar value as rainbow trout.

Natural western boundary of the natural occurrence of wels *(Silurus glanis)* is the Doubs river in France and the Rhein river watershed, where it is quite rare. The eastern boundary is the Aral lake's watershed. It is extinct in Denmark, despite several restocking efforts. Its typical habitat is the stagnant or slowly flowing rivers with non-rocky bottoms. It is one of the significant secondary species of the traditional polycultures widely practised in Central and Eastern Europe, feeding on trash fishes growing in the ponds *("police fish").* Its artificial propagation has been elaborated in Hungary.

The North African catfish *(Clarias gariepinus)* is not endemic in Europe, there is no natural self-sustaining population. It is cultured with exceptionally good results in intensive warmwater aquaculture, since it has extreme growth rate, good feed conversion, can tolerate high stocking densities, has low oxygen requirement, so, it has many technological advantages.

1.5.2. Culture techniques

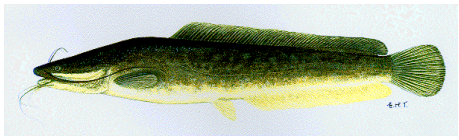
Following the development of this industry in the USA, in the early 1970's catfish farming was introduced in Europe. There are four species dominating the European scene: the black bullhead *(Ictalurus melas),* wels *(Silurus glanis),* North African catfish *(Clarias*

gariepinus) and the channel catfish *(Ictalurus punctatus),* which was introduced in Europe in the 1980's. The black bullhead is a sturdy warmwater species, which is usually farmed in earth basins in semi-intensive culture. It is an easy-to-farm species, its requirements for water quality and flow are rather modest, the spawning occurs naturally in the ongrowing ponds, the growth cycle (from birth to a marketable size of 150 g) usually does not last for more than two years. Consumption of this species is only locally developed in southern of Europe, but in some countries this fish is also used for game fish purposes.

The channel catfish farming had a fast development in the 1970's in the USA, where it is currently one of the most important cultured freshwater fish species. It is considered a very good game fish too and it is very popular for human consumption, mainly in filleted form. Commercial size and growth rate are remarkably higher than those of the black bullhead: two year specimens easily attain 500g. This industry is slowly developing in Europe[7], replacing the black bullhead farming. Other catfish species *(Ictalurus nebulosus, Clarias spp.)* are occasionally farmed, more or less in pilot scale.

1.5.3. Production and markets

Probably due to ignorance on past of the consumer and the industry both, and scarce promotion campaigns (which made the success of channel catfish possible in the USA) these species are poorly farmed and consumed in Europe. Recent and comparable data on production and markets are not available, but the total European farm production can be estimated to be no more than 2 500 - 3 000 metric tons/year *(Table 9, Figure 33, 34),* all species together. The main producers are Italy, the Netherlands, France, Czech Republic, Slovakia, Croatia, Germany and Hungary *(Map 6).*



(North African catfish)

(Black bullhead)

Map 6 **Main catfish farming areas in Europe**

[7] The FAO statistic does not include the channel catfish production data although Italy produces this species.

Table 9 **Cultured catfish production in Europe**[8]

Quantity (metric tons), Value (1000 US$)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Quantity	2 003	2 382	2 200	2 447	2 589	3 029	3 237	2 356	2 104	2 460
Value	5433.0	6758.9	10085.0	11092.1	11521.3	11774.7	13541.5	8197.3	7158.2	8711.5

Reference: FAO, FishStat Plus 1999

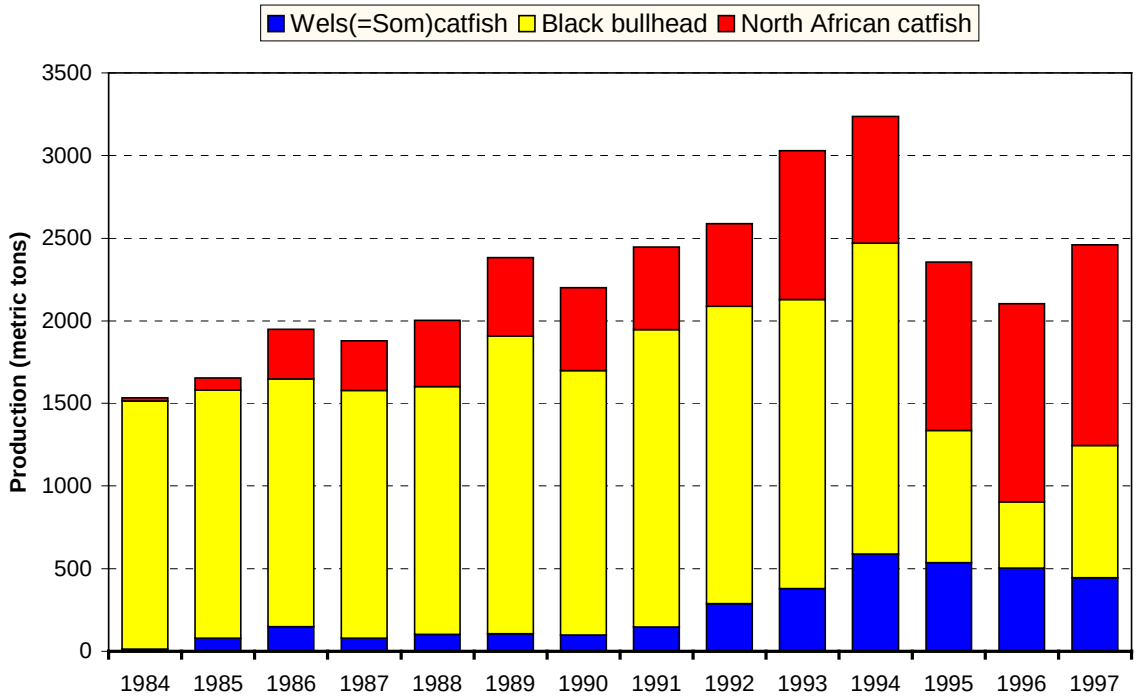


Figure 33 **Volume of cultured catfish production by species in Europe**

Reference: FAO, FishStat Plus 1999

Figure 33 shows, which the production of Black bullhead (produced only in Italy) was gradually decreasing from the middle of 1990's, while that of the North-African catfish increased. This increase is – first of all – due to the marketing efforts done to introduce this boneless tasty fish to European consumers. The production of European catfish is first of all depending on the pond fish culture, since the most economic way of its production, is in polyculture, although intensive production technology is also elaborated.

[8] Maybe, the FAO database is not complete.

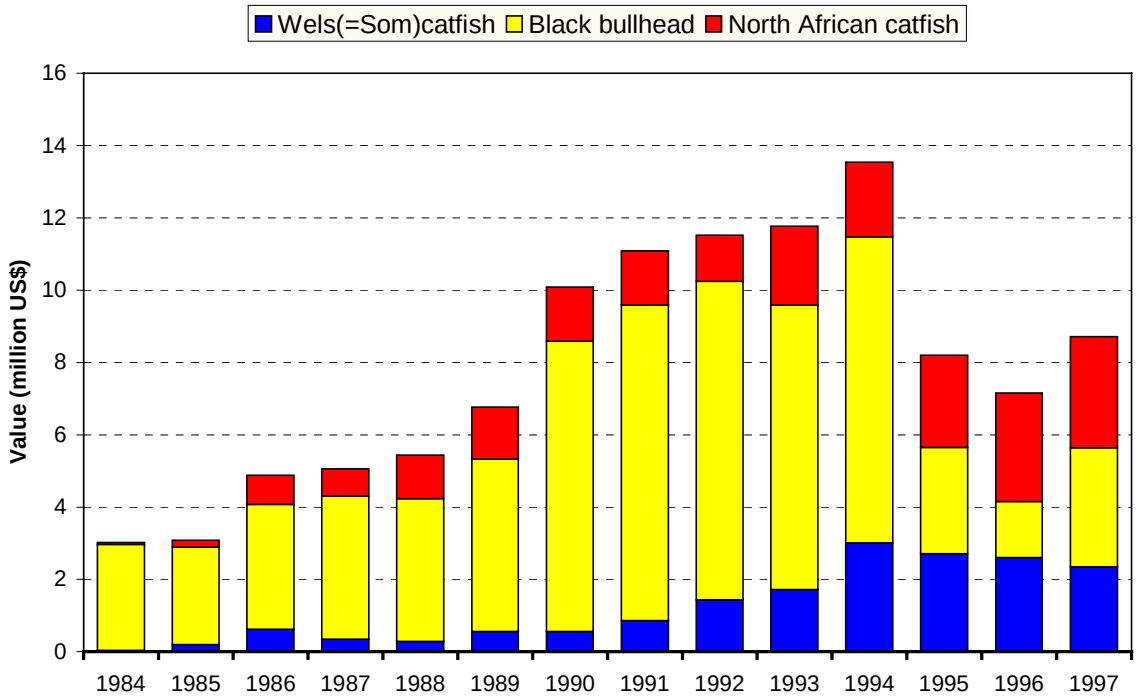


Figure 34 **Value of cultured catfish production by species in Europe**

Reference: FAO, FishStat Plus 1999

1.5.4. Potentials for future development

The black bullhead has economic importance only in Italy, and this will remain so in the future. Hybridised stock *(Ictalurus melas x Ictalurus nebulosus)* can be found in most of the Central and Eastern European fishponds, but has importance only as secondary fish.

The North African catfish can be produced economically in intensive and semi-intensive systems and it might have market success in the next future. Its production will grow in the long-run in the Central and Eastern European countries, and also in Southern-Europe, as sport-fish.

The flesh of the wels is tasty, boneless, white coloured, and very appreciated by the consumers. It has economic importance first of all in Eastern Europe, but as sport-fish it is more and more popular in Western Europe, as well. There is no problem in selling the produced amount.

1.6. European seabass and gilthead seabream *(Dicentrarchus labrax, Sparus aurata)*

1.6.1. Natural distribution

Carnivorous fish belonging to *Serranidae* (seabass) and to *Sparidae* (seabream) extend geographically from the South of the North Sea to the Mediterranean. They are inshore fish that prefer to be near rocky zones, in estuaries and lagoons.

1.6.2. Culture techniques

Currently three type of rearing are used:

Extensive rearing: It is practised primarily in Italy (valliculture), in Greece (lagoons), in France (development in marshes) and in Portugal (aquaculture development of the old salt marshes). This type of farming depends on the migratory behaviour of the species in question, which enter the lagoon in their early stages in order to grow and then leave for reproduction purposes. Harvesting is carried out at the borders of the lagoon with the open sea by means of traps. Production is dependent on the natural seed stocks that enter the lagoon, production capacity of which is determined by its trophic level.

Semi-extensive rearing: Semi-extensive farming of seabass and seabream is based on a better management of the rearing sites through the introduction of wintering ditches that act as refuges for the fish in case of excessive decline of the surface water's temperature and where external food is supplied to improve growth (converted salt marshes in Portugal, improved "valliculture" in Italy).

Intensive rearing: Aims to produce seabass and seabream in high stocking densities. It includes: HATCHERIES (eggs up to 2 g), NURSERIES (2 g up to 5 g or 20 g), and ONGROWING FACILITIES (5-20 g up to 300-500 g), which can be earthen ponds or off-shore cages. Earthen ponds are mostly used in Italy, Spain and Portugal. Off-shore cages are the most recent culture systems used in the Mediterranean by Greece and France.

1.6.3. Production and markets

Production in "valliculture", lagoons, salt marshes, as well as intensive production yielded 3300 metric tons in 1989. This corresponded to a turnover of 51.8 million ECU-s. Italy, Greece, France and Spain *(Map 7)* are the major producers and although this production

represents only 1.5% of the fish production in terms of volume in the Europe, it amounts to 6.5% in terms of turnover. Nowadays (1997) the seabass and seabream production is 52 824 metric tons with a value of 375,7 million US$ in Europe.

(*European seabass*)

Map 7 **Main seabass and seabream farming areas in Europe**

The quantities and values of cultured European seabass and gilthead seabream production in Europe are shown in *Table 10, 11* and *Figures 35, 36, 37, 38.*

Table 10 **Cultured European seabass production in Europe**

Quantity (metric tons), Value (million US$)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Quantity	1 266	1 679	3 335	4 727	7 926	11 541	12 733	16 901	19 153	23 685
Value	19.47	30.02	58.35	88.29	142.98	119.28	108.13	147.46	160.25	180.56

Reference: FAO, FishStat Plus 1999

Table 11 **Cultured gilthead seabream production in Europe**

Quantity (metric tons), Value (million US$)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Quantity	1 429	1 827	3 198	4 522	7 539	10 230	13 412	17 254	23 304	29 139
Value	21.11	31.59	51.88	70.13	106.52	98.12	110.21	139.25	199.37	195.15

Reference: FAO, FishStat Plus 1999

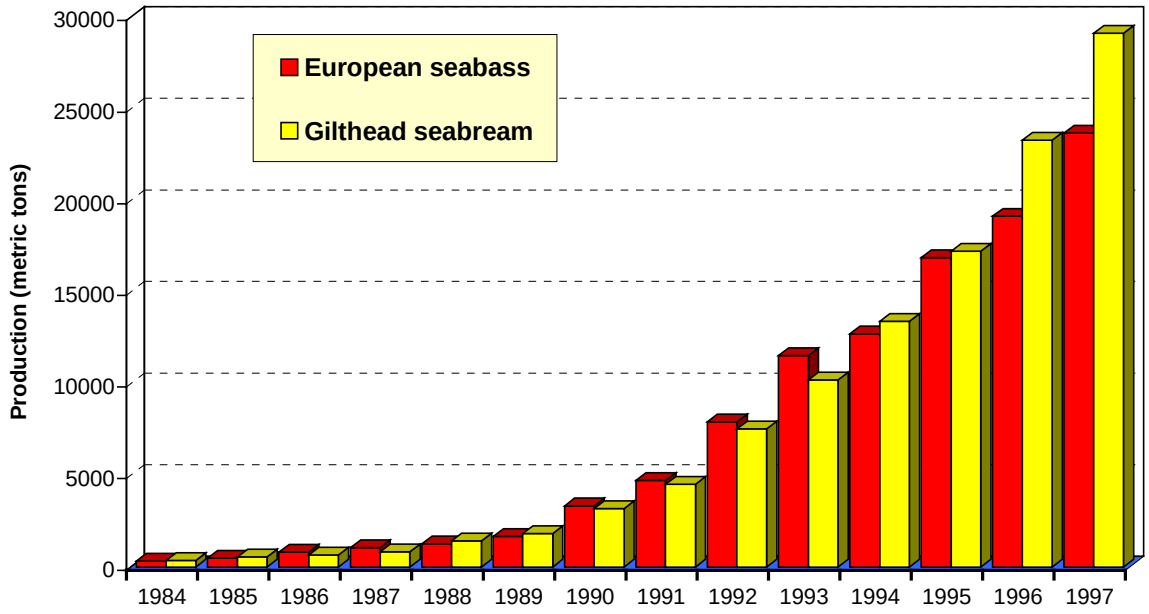


Figure 35 **Cultured seabass and seabream production in Europe**

Reference: FAO, FishStat Plus 1999

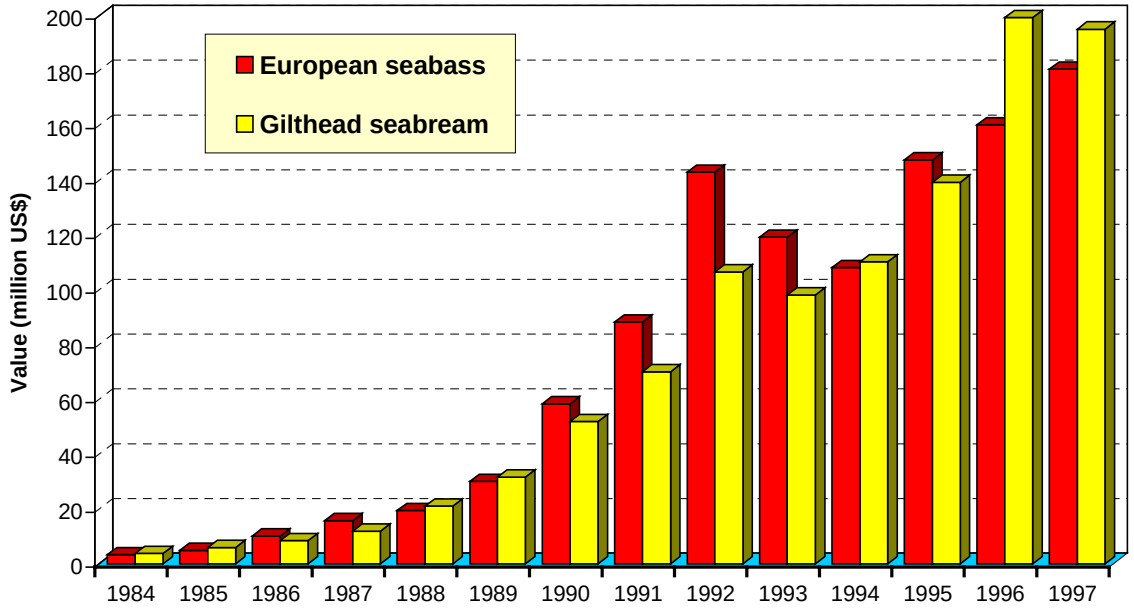


Figure 36 **Value of cultured seabass and seabream production in Europe**

Reference: FAO, FishStat Plus 1999

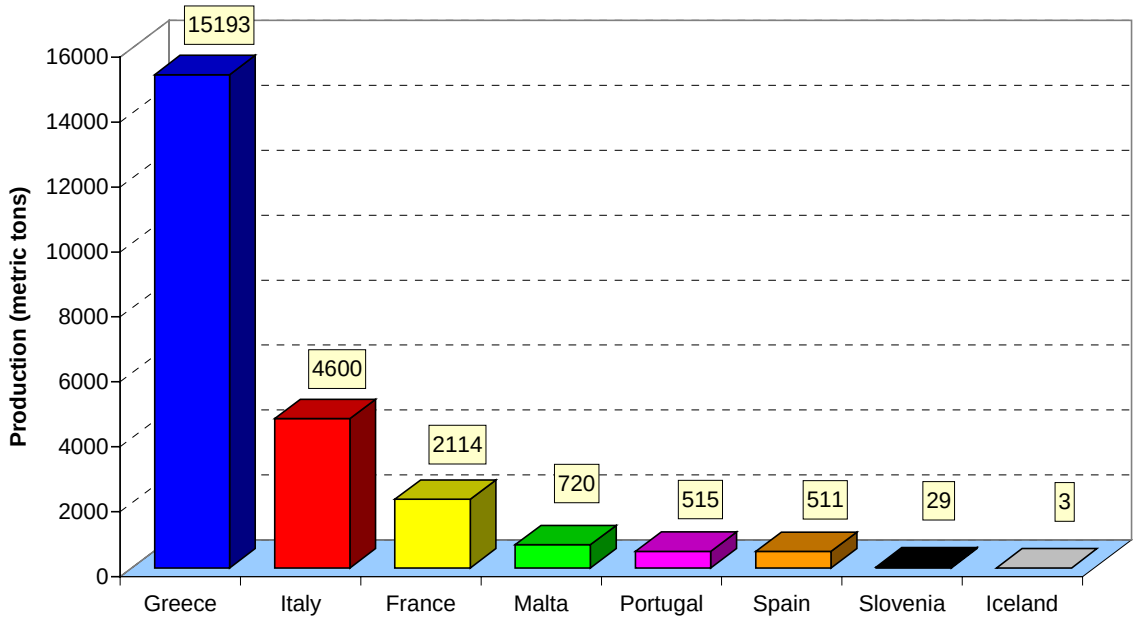


Figure 37 **Cultured European seabass production by countries in Europe (1997)**

Reference: FAO, FishStat Plus 1999

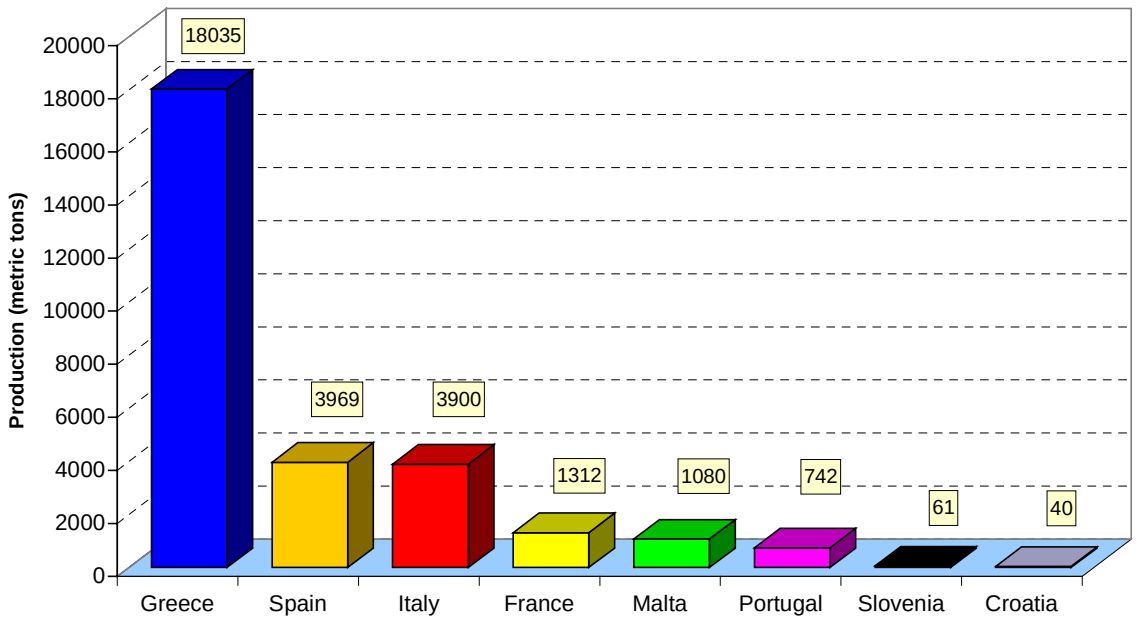


Figure 38 **Cultured gilthead seabream production by countries in Europe (1997)**

Reference: FAO, FishStat Plus 1999

In many countries seabass and seabream consumption is generally related to their local availability. Consumers do not always attach the same value to these species; consequently fishermen do not always catch them. In any case, most of the total production is internally consumed. Whenever quantities of sea bass and sea bream are large enough, each country tends to develop an export trade directed mainly towards Italy. Spain, France and Greece are also interesting markets for these species mainly during summer time. In many countries (except Greece), prices of imported seabass and seabream are lower than those of locally produced fish.

1.6.4. Potentials for future development

Capture fisheries currently dominate the European market for seabass and seabream, which is relatively small and limited to some countries. The market is performing well but special attention must be paid to the expansion of farming, as overproduction may occur because of the rapid increase in the volume of production due to the high number of farms under construction. Imports from non-European Mediterranean countries are also increasing. One may for see the same phenomenon happening in seabass and seabream production, as in salmon farming that is, a more significant increase in supply than in the demand. Thus, a general reduction in prices is expected. Therefore, it's urgent for producers to enforce all possible measures to contain and reduce production costs. The preservation of suitable sites for the development intensive rearing offers potentials for the future expansion of seabass and seabream aquaculture. Furthermore, special attention must be paid to avoid any polluting effect of the farms on their environments.

1.7. Flatfishes *(Psetta maxima, Hippoglossus hippoglossus, Scophthalmus rhombus)*

1.7.1. Natural distribution

Turbot *(Psetta maxima)* is a flatfish fished in the North Atlantic Ocean and the Mediterranean. It is considered a premium quality fish, which is marketed at high prices. Wild supplies, which are erratic, are estimated to be below 10 000 metric tons/year and come mainly from Denmark. The life cycle from egg to marketable size can be achieved in approximately 2 years at optimum water quality. Due to the static living habit of the fish on the seabed, high stocking densities can be achieved in artificial culture facilities. These advantageous characteristics make the turbot an ideal candidate for rearing. There are several other flatfish species *(dab, flounder, megrim, plaice, skate, lemon sole, dover sole, witch, etc.)* in the European markets but these come from capture marine fisheries not from aquaculture. However, Norwegian experts reported, culture of Atlantic halibut *(Hippoglossus hippoglossus)* reached its commercial phase in Norway, in 1998, 200 tons of production.

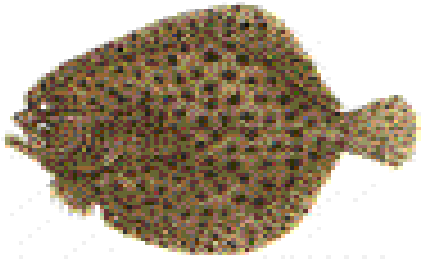
1.7.2. Culture techniques

For the farming of turbot, intensive land based systems with pumped seawater are used. Manipulation of environmental factors such as photoperiod and temperature induce the maturation process of the broodstock. This allows an egg supply distributed throughout the year. Larval rearing is done in indoor tanks, where live feed has to be supplied. When they are 10-12 days old, the larvae transform into fry. Both eyes "migrate" to the top of the fish in order to adapt to life on the seabed. After weaning to semi-moist diets, the fry or juveniles are is transferred outside to larger ongrowing tanks. Here, the fish has to be protected from excessive sunlight. The fish reach a weight of around 2 kg after about 2 years, and are ready for the market.

1.7.3. Production and markets

The infant turbot farming industry is developing fast in Spain and France. The actual production of 3 001 metric tons (1997) is concentrated in Spain (1800 metric tons), France (980 metric tons), Portugal (196 metric tons), and the Netherlands (25 metric tons). The United Kingdom and Germany are producers of juveniles, which are exported to other countries for ongrowing. France is also a net exporter of juveniles. The value of cultured turbot production in Europe was 26.9 million US$ in 1997. The quantities and values of

cultured turbot production in Europe are shown in *Table 12, 13* and *Figure 39.* Nowadays (1997) production of the brill *(Scophthalmus rhombus)* is 20-40 metric tons/year in Europe and this volume comes from Portugal only.



(Turbot)

Map 8 **Main turbot farming areas in Europe**

Table 12 **Cultured turbot production in Europe**

Quantity (metric tons), Value (Thousands US$)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Quantity	112	287	656	926	1 725	1 693	2 399	2 978	2 571	3 001
Value	1 132	4 966	10 253	12 632	17 750	14 446	20 875	26 804	25 112	26 925

Reference: FAO, FishStat Plus 1999

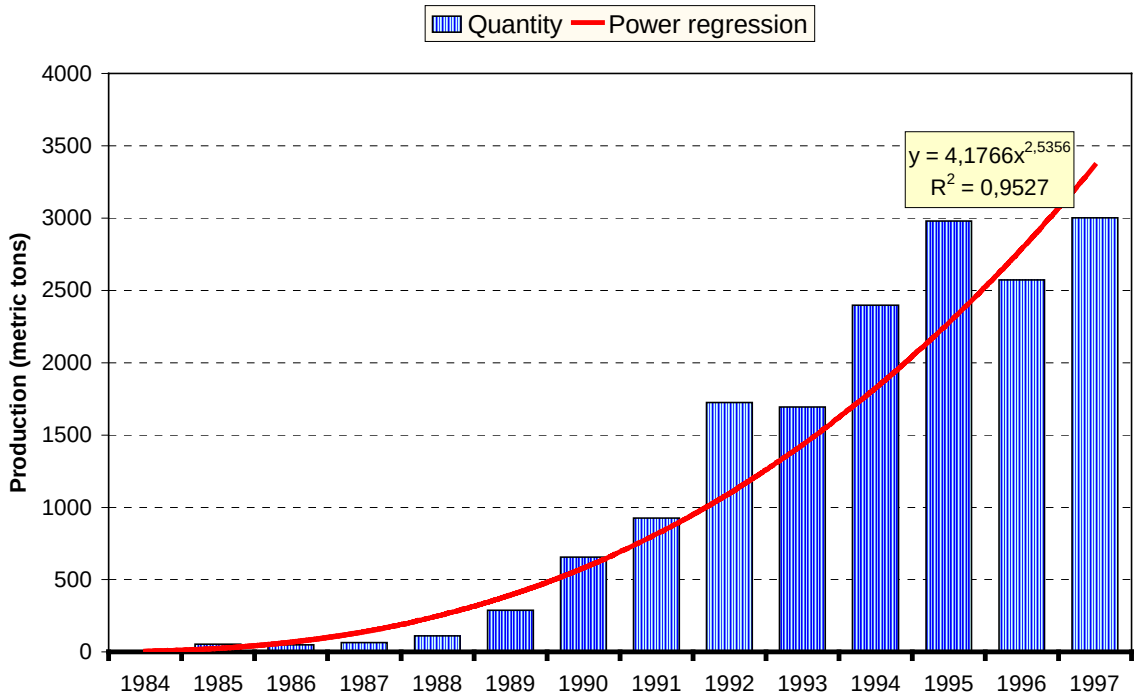


Figure 39 **Cultured turbot production in Europe**

Reference: FAO, FishStat Plus 1999

Table 13 **Distribution of cultured turbot production by countries**

Quantity (metric tons)

Country	Quantity (average of 1995-1996-1997) *(metric tons)*	Percentage *(%)*
Spain	2054.33	72.08
France	633.00	22.21
Portugal	126.67	4.44
The Netherlands	20.67	0.73
Ireland	15.00	0.53
Germany, Malta,	0.53	0.02
Total	**2850.20**	**100.00**

Reference: FAO, FishStat Plus 1999

1.7.4. Potentials for future development

There are no major constraints for the development of turbot farming. Challenges of this developing industry comprehend:

- improvement of live and artificial diets,
- achievement of higher yields of pigmented and non-deformed juveniles; and, in general terms,
- optimisation of the production process.

Large increases of production are forecasted in Spain and France. Marketing strategies have to be developed in order to maintain good market conditions in line with the rapidly increasing production.

1.8. Mussels *(Mytilus edulis, Mytilus galloprovincialis)*

1.8.1. Natural distribution

Mussels are widely distributed around the world, from the tropical to the polar regions. Two species are cultivated in Europe:

- Mediterranean mussel *(Mytilus galloprovincialis)* (on the coast of the Atlantic Ocean and Mediterranean Sea).
- Blue mussel *(Mytilus edulis)* (on the coast of the Atlantic Ocean and North and Baltic Seas).

After a free-swimming larval stage, the young mussel settles down in the intertidal range to a depth of 20 m. During its sedentary life, it feeds on microparticles by filtering seawater through its gills.

1.8.2. Culture techniques

Until the 19th century, the only known method to grow mussels was the upright wooden pole or "bouchots" technique, invented in France during the 13th century. The suspended rope culture appeared in Spain in 1846; finally a third technique called "bottom culture", was developed in the 1860's in the Netherlands.

Pole culture: A bouchot is made of a series of heavy wooden poles dug upright into the sea bottom. Mussel seeds collected around March either on poles, which are further out to sea or along hairy ropes, are transplanted onto growing poles ("boudinage") in July. Harvesting occurs after 15 months of growing and is repeated periodically with a special tool mounted on a hydraulic crane known as a "pêcheuse".

Suspended rope culture: For this technique, ropes covered with mussel seeds are suspended either from metallic frames or from floating structures, so that the young mussels stay under water all the time. Each frame is built of metallic poles dug upright into the ground, at water depths varying between 3 and 9 meters. Young mussels placed in nylon net bags are grown this way the whole year round and according to demand. Floating structures are either rafts ("bateas"), floating saucers or floating longlines.

Bottom culture: This technique rests upon the harvesting of naturally growth young mussels and their spreading out on specially prepared growing plots. It is widely practised in the Netherlands.

1.8.3. Mussel production and markets

European production of mussel amounted to 469 120 metric tons in 1989, which represented about 50% of world production. This represented a value of 294 million ECU-s, of which Spanish production amounting to some 300 000 metric tons represented about a third. Most of this production is grown on suspended ropes, a technique, which can be extended further offshore. Although sensitive to planktonic blooms, it is the only technique which could still lead to a production increase, since both the "bouchot" and the bottom techniques are faced with growing coastal pollution, bird predation and land use constraints.

Mussel production in Europe decreased slowly until 1993, then increased again during the reported period *(Table 14).* In France and Italy the production showed a rising tendency. Ireland was also an important mussel producer with a relatively constant production level. Spain produced the highest volume of mussels in Europe in 1997 but a decreasing tendency was observed between 1988 and 1997. In the Netherlands, which was also an important mussel producer country, there was a decline in the production between 1991 and 1993. Although in Norway mussel production was not so important, there was also a decline between 1991 and 1993. In Germany the large-sized and quite variable mussel production touched bottom in 1994. Portugal has produced mussels only since 1990 but from then the production increased rapidly. In Greece and the United Kingdom the mussel production was expanded also rapidly. In Croatia the production was almost constant. Mussel production in Albania, Slovenia and the former Yugoslavia decreased from 1988 to 1997. In Bulgaria the production was in minimal level.

Table 14 **Cultured mussel[9] production in Europe**

Quantity (1000 metric tons), Value (million US$)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Quantity	506.76	469.12	464.59	440.04	412.58	368.01	424.04	469.72	518.69	509.38
Value	349.89	409.68	381.15	349.90	302.64	246.71	257.81	298.59	315.45	316.67

Reference: FAO, FishStat Plus 1999

[9] **Mussels:** blue mussel and Mediterranean mussel

The main producer countries of cultured mussel in Europe are Spain, Italy, the Netherlands France, Germany and Ireland *(Map 9).*

Blue mussel

Map 9 **Main mussel farming areas in Europe**

The quantities and values of cultured mussel production in Europe are shown in *Table 14* and *Figures 40, 41, 42 and 43.*

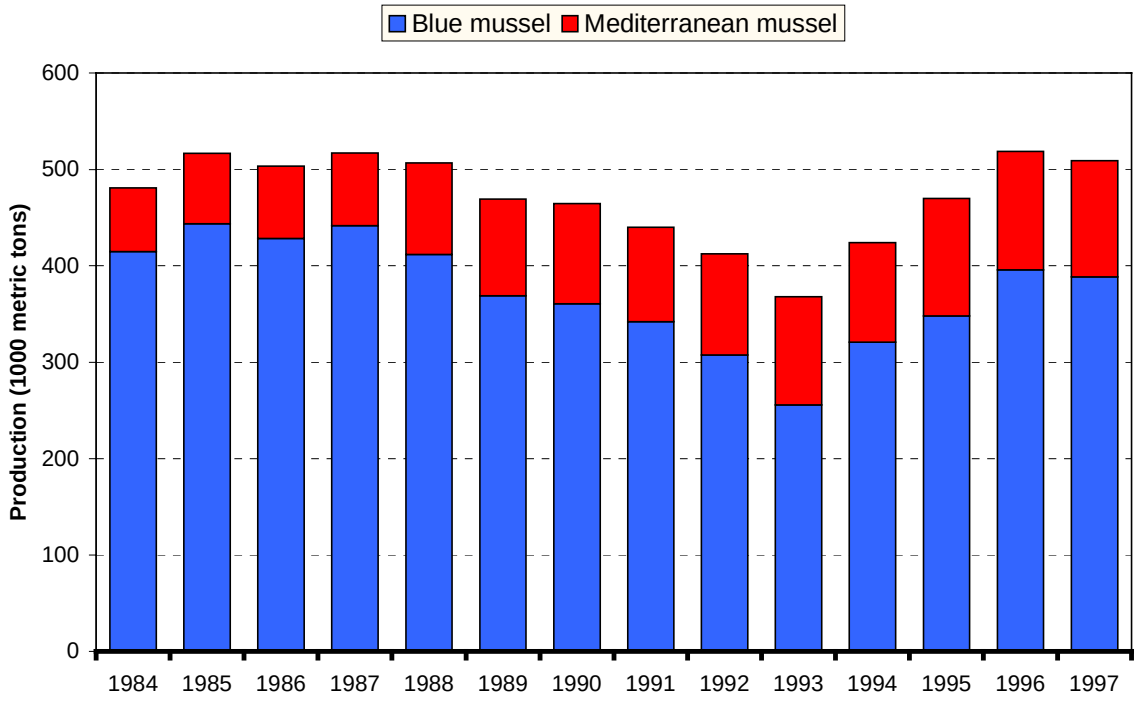


Figure 40 **Cultured mussel production by species in Europe**

Reference: FAO, FishStat Plus 1999

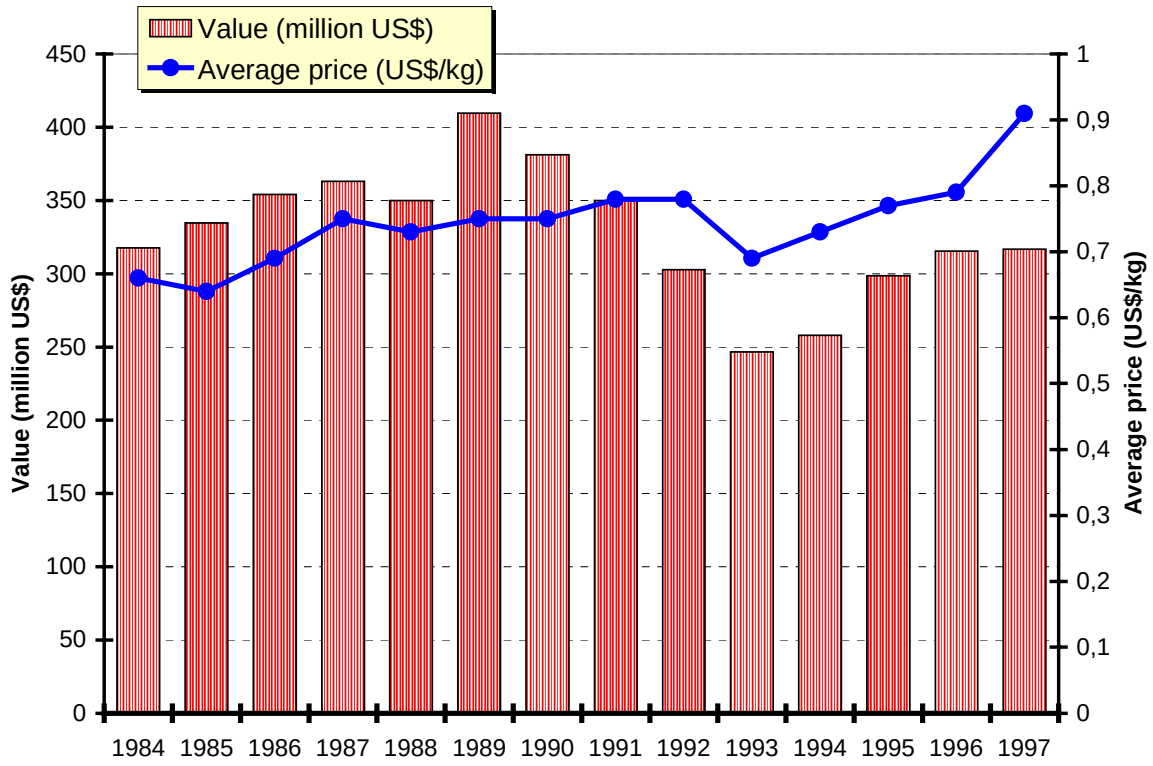


Figure 41 **Value of cultured mussel production in Europe**

Reference: FAO, FishStat Plus 1999

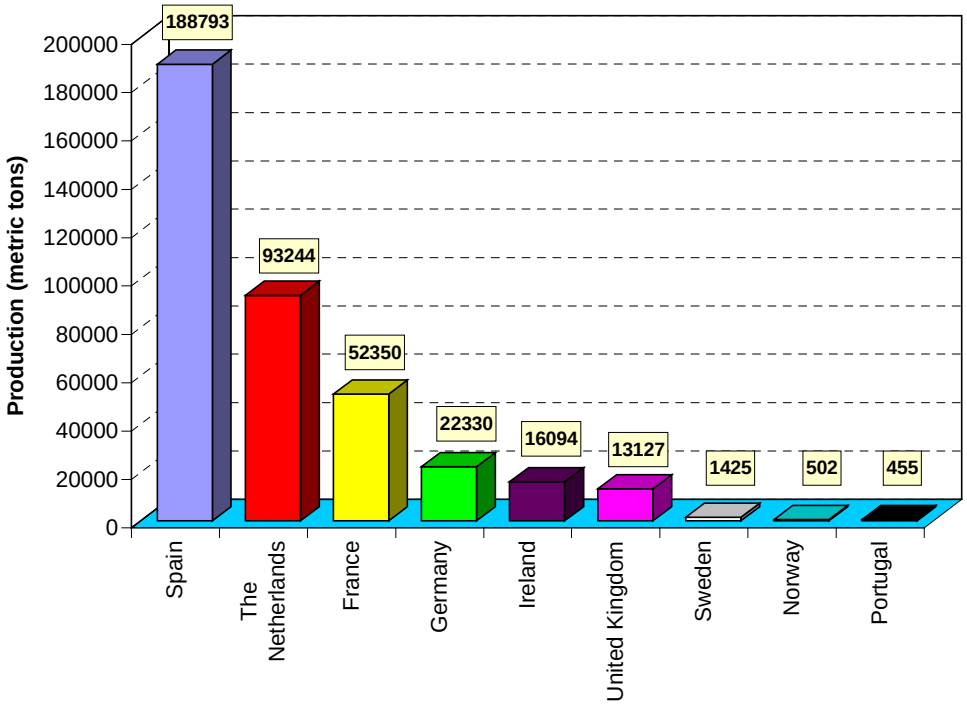


Figure 42 **Cultured blue mussel production by countries in Europe (1997)**

Reference: FAO, FishStat Plus 1999

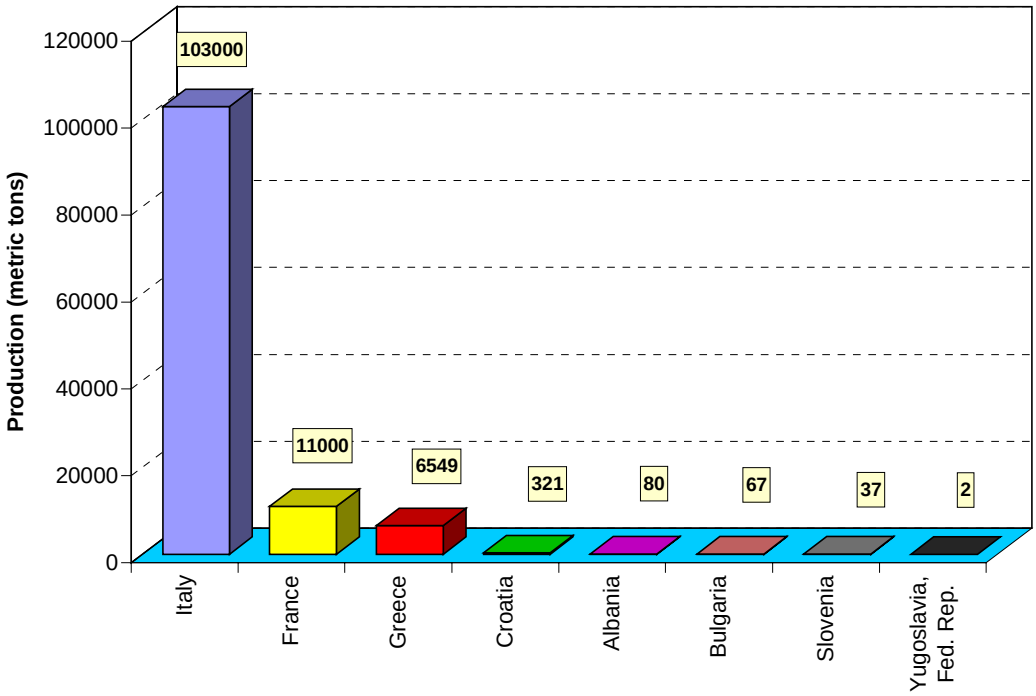


Figure 43 **Cultured Mediterranean mussel production by countries in Europe (1997)**

Reference: FAO, FishStat Plus 1999

1.8.4. Potentials for future development

The mussel market is doing quite well lately, especially when compared to the oyster market: in late 1990 for the first time ever in France, that the mussel prices were almost same with the oyster prices. Demand is stable and supplies seem to be under control thanks to the Spanish administration's ability to limit further expansion of raft production in Galicia. Mussel production has been developed recently on ropes suspended from longlines (Southern France and Italy) or from rafts (United Kingdom and Ireland) since hanging culture avoids a number of environmental problems linked to the use of the intertidal range. However, environmental concerns will remain a major constraint for mussel cultivation. The new EU directive regarding shellfish sanitary norms will lead to an improvement of mussel processing conditions, thus to a better marketing position for the mussel which has not always been perceived as safe.

1.9. Oysters *(Ostrea edulis, Crassostrea angulata, Crassostrea gigas)*

1.9.1. Natural distribution

The European flat oyster *(Ostrea edulis)* is found from Marocco to Norway and in the Mediterranean Sea. Two species of cupped oysters are cultivated in Europe but mostly in France, the Portuguese cupped oyster *(Crassostrea angulata)* (called "Japanese oyster" in Europe) and Pacific cupped oysters *(Crassostrea gigas)*, which comes from the Pacific Ocean

The larvae are free swimming until they settle down and turn into young oysters growing on a bed below the low tide mark *(Ostrea edulis)* or within the intertidal range *(Crassostrea gigas)*. The oyster feeds on dissolved substances and microparticles, which it filtrates through its gills. An inflow of freshwater improves its growth rate.

1.9.2. Culture techniques

Plinius the Old reported that the Romans knew how to collect oyster spat on wood faggots. Oyster culture developed in France during the 17th century, however, it was not until the mid 19th century that modern oyster culture appeared, using such a technique as chalk covered tile collectors and relying upon state allocation of growing plots in the intertidal range. Nowadays, European growing techniques are aimed at a market for fresh oysters delivered in their shells. Cultivation thus begins with the collection of small oysters on a support from which they can be removed easily ("détrocage") six to eight months later. During their second year oysters are spread in the intertidal range:

- either directly on the ground (bottom culture),
- or in bags on trestles,
- or suspended (Mediterranean shores).

Harvesting usually takes place during the third year. A special treatment known as "affinage" may be carried out for top quality oysters, which are brought into former salt marshes turned into ponds. By feeding on blue algae growing there *(Navicule)* the oyster turns into a "fine de claire" or a "special" characterised by a green colour.

1.9.3. Production and market

European production of oysters amounted to 137 838 metric tons in 1989, which represented about 13.5% of world production. France accounted for some 96% of European production.

Nowadays (1997) cultured oysters production is 160 223 metric tons with a value of 279.8 million US$ in Europe. Actually, most oyster culture is concentrated between Caen and Arcachon, an area within, which about 80 000 metric tons of *Crassostrea* are grown. This concentration suggests that the density of growing plots could account for the parasitosis and viral outbreaks, which have repeatedly plagued oyster culture for decades: the Portuguese oyster was wiped out after an epidemic of gill disease in 1965, the flat oyster suffered an outbreak of *Martelia* then of *Bonamia* in 1968, and the Japanese oyster was successively infested by an iridiovirus and *Mytilicola* in 1977.

Oyster production increased slowly in Europe in the reported period *(Table 15).* In the main oyster producer countries (France, Ireland, Spain and the United Kingdom) production expanded slowly. Aquaculture production of the Channel Islands is composed mainly of oyster production. Production increased rapidly, here and in Portugal too. Oyster production of Croatia, Germany and the Netherlands was not too important but it increased slowly between 1988 and 1997. Oyster production collapsed suddenly, in Italy in 1990, and in Norway in 1991. In the former Yugoslavia oyster production was rather variable. In Greece oyster production started only in 1994 with insignificant values.

Table 15 **Cultured oyster[10] production in Europe**

Quantity (1000 metric tons), Value (million US$)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Quantity	143.27	137.84	149.71	136.89	142.24	154.57	157.45	156.31	163.57	160.22
Value	313.77	284.94	310.32	284.47	329.67	313.74	349.97	378.59	304.71	279.84

Reference: FAO, FishStat Plus 1999

The main oyster producer countries in Europe are: France, Spain, the Netherlands, Ireland and United Kingdom *(Map 10).*

(European flat oyster)

Map 10 **Main oyster farming areas in Europe**

[10] **Oysters:** Pacific cupped oyster, European flat oyster, Portuguese cupped oyster, cupped oyster nei.

The quantities and values of cultured oyster production in Europe are shown in *Table 15* and *Figures 44, 45, 46.*

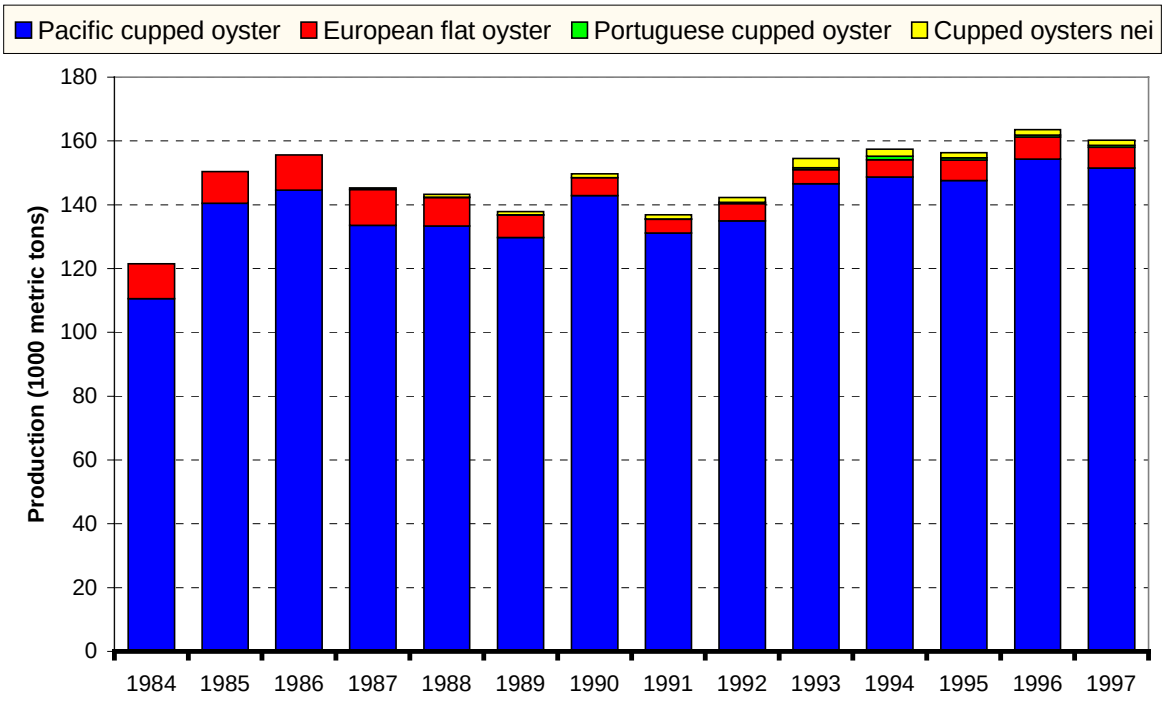


Figure 44 **Cultured oyster production by species in Europe**

Reference: FAO, FishStat Plus 1999

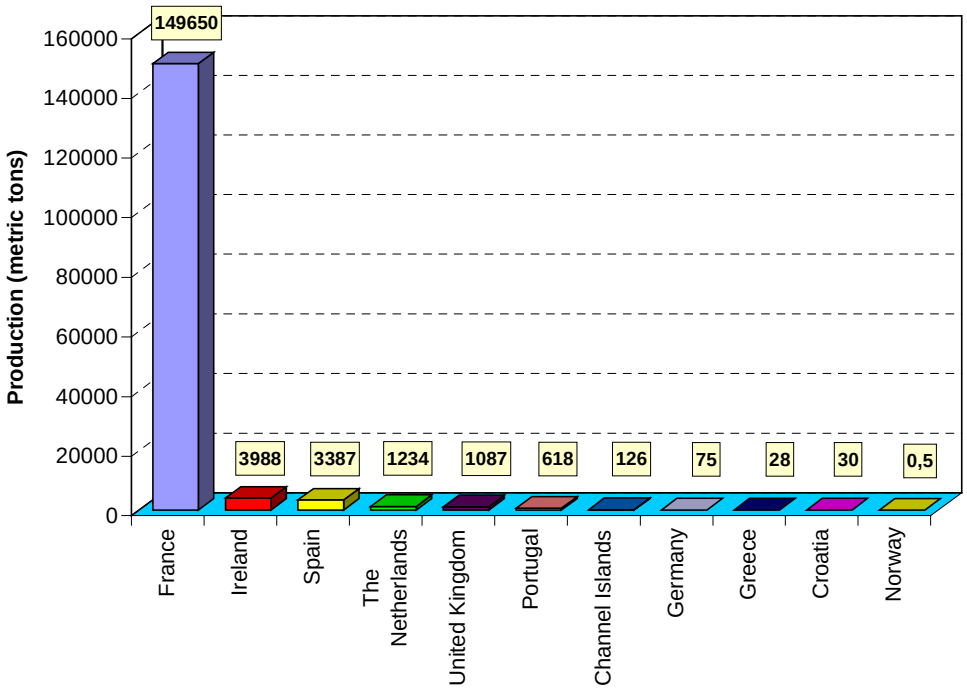


Figure 45 **Cultured oyster production by countries in Europe (1997)**

Reference: FAO, FishStat Plus 1999

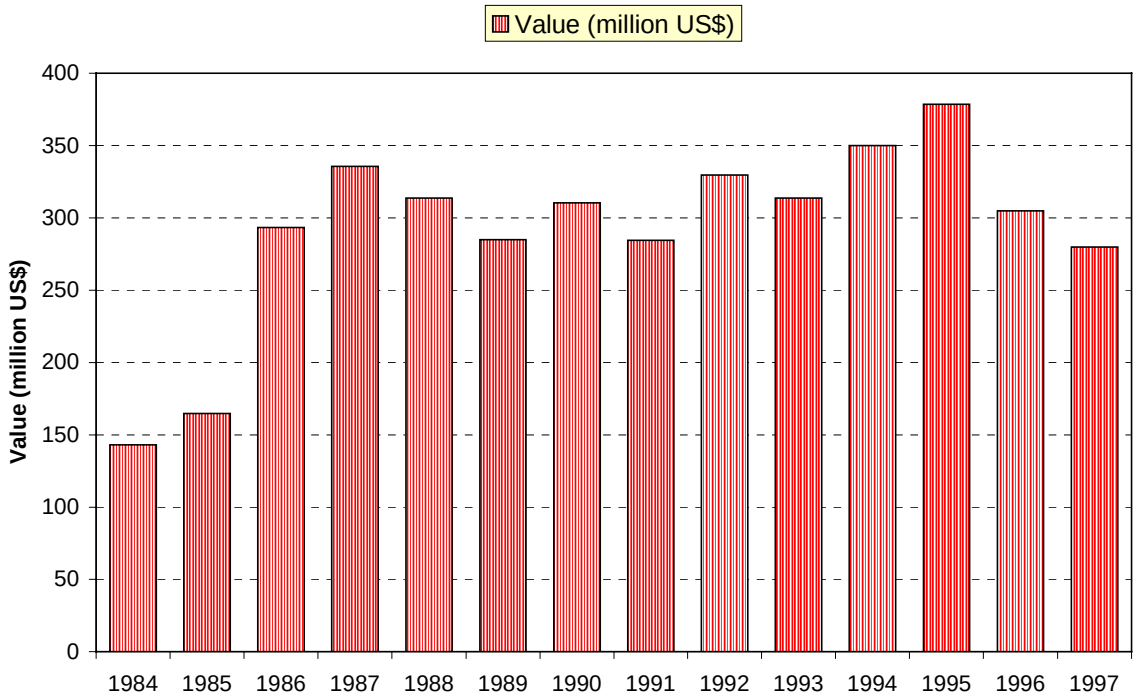


Figure 46 **Value of cultured oyster production in Europe**

Reference: FAO, FishStat Plus 1999

1.9.4. Potentials for future development

Following a series of disease outbreaks, which ruined production areas, French oyster growers are now faced with serious marketing problems. By the end of 1990 for the first time in France oyster prices were barely higher than those of mussels! This price collapse is likely to discourage other EC countries, like Ireland, United-Kingdom or Germany, which are trying to promote this culture. Its consequences are likely to be dramatic for a sector comprised of small enterprises with reduced financial capacities. There is a clear need for growing areas to be reorganised so as to adapt densities to carrying capacities and to avoid catastrophic disease outbreaks. This necessity and that of adapting thousands of small scale oyster farms to sanitary standards are likely to lead, in the medium term, to a concentration of production.

1.10. Clams *(Ruditapes decussatus, Ruditapes philippinarum, Tapes pullastra)*

1.10.1. Natural distribution

The Japanese carpet shell, also known as Manila clam *(Ruditapes philippinarum)* is replacing the European species, the grooved carpet shell *(Ruditapes decussatus)* for farming purposes all over Europe, due to its faster growth and higher resistance to pathogens, temperature and salinity variations. Both species are eurythermic and euryhaline, living in mixed sand-mud bottoms in coastal areas and lagoons. Grooved carpet shell is distributed in coastal areas of the Mediterranean and Eastern Atlantic from Norway to the Congo; the original distribution of Japanese carpet shell covered a vast area from Pakistan to the Kuril Islands, including Japan, the Philippines and Indonesia, but due to farming this species is now widely spread throughout the world. In Japan aquaculture production of this species largely exceeds wild catches. The success of Japanese carpet shell is also due to the possibility of its artificial breeding. In Europe, hatcheries are located in Portugal, Spain, the United Kingdom, Germany and France.

1.10.2. Culture techniques

The farming of this species is based on artificial reproduction. The nursery phase is carried out in tanks, little ponds or boxes, T6-T8 juveniles are released in controlled areas (lagoons, salt-pans, large ponds or “parks” in the open sea) often with different sorts of protection (the commonest system is to cover the area where the clams are settled with nets of little mesh size, to avoid predation and escapement). A culture-based fishery method of this species is also developing: the natural reproduction of animals originally released for farming creates wild populations in areas that where they were not present previously, which are being exploited then with traditional fishing methods. This creates a growing concern over the competition of the introduced species with the autochthonous and the potential risk of diseases being spread must also be taken into account. An application by the Member States of the recently published Council Directive concerning animal health conditions and regulating the placing on the market of aquacultured animals and their products (91/67/EEC) is desirable.

1.10.3. Production and market

Clam farming is rapidly developing all over Southern Europe: total production of farmed clams in 1997 was 9 303 metric tons. Main clam producers are Portugal, Spain and France *(Map 11).*

(Clams)

Map 11 **Main clam farming areas in Europe**

The quantities and values of cultured clam production in Europe are shown in *Tables 16, 17* and *Figures 47, 48.* Grooved carpet shell production is very fluctuate year by year, and it is decreasing in 1990's.

Table 16 **Cultured clam[11] production in Europe**

Quantity (metric tons), Value (million US$)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Quantity	10 991	11 169	6 676	7 259	6 938	6 683	7 713	8 724	5 795	9 303
Value	74.67	95.93	53.65	67.58	65.69	60.60	69.90	68.83	50.29	79.64

Reference: FAO, FishStat Plus 1999

[11] **Clams:** grooved carpet shell, Japanese carpet shell, pullet carpet shell, clams nei.

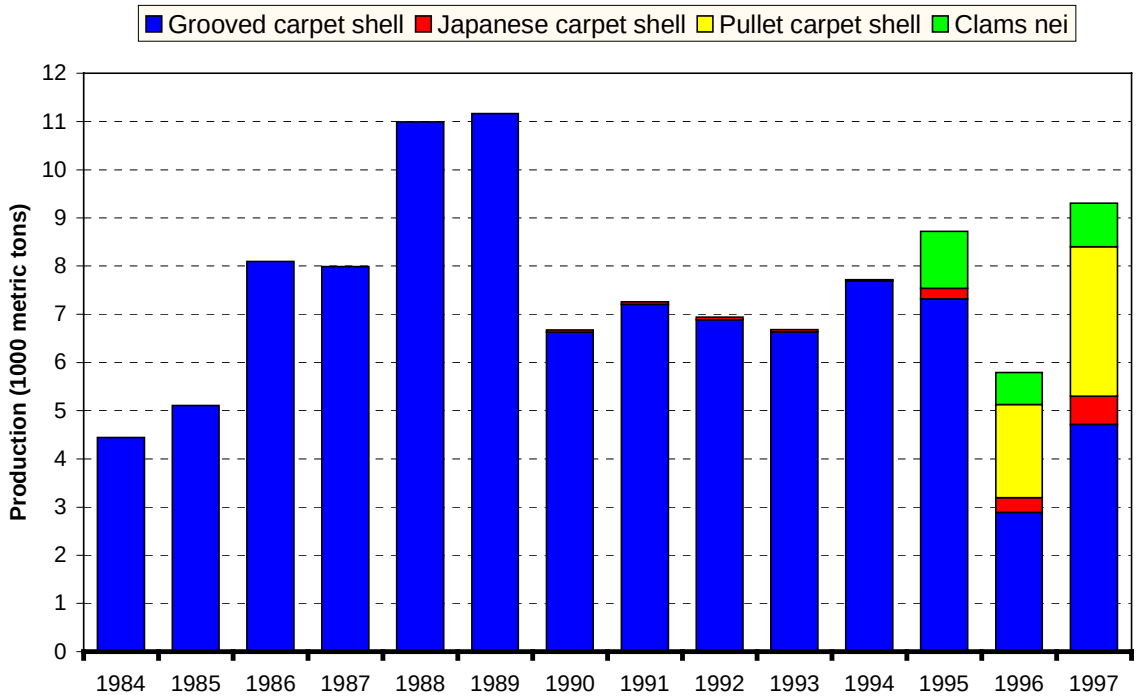


Figure 47 **Cultured clam production by species in Europe**

Reference: FAO, FishStat Plus 1999

Table 17 **Distribution of the cultured clam production by countries**

Quantity (metric tons)

Country	**Quantity** (average of 1995-1996-1997) *(metric tons)*	**Percentage** *(%)*
Spain	4626.33	58.26
Portugal	2296.50	28.92
France	481.33	6.06
Germany	433.67	5.46
Ireland	76.00	0.96
United Kingdom	24.67	0.31
Channel Islands	2.33	0.03
Total	**7940.83**	**100.00**

Reference: FAO, FishStat Plus 1999

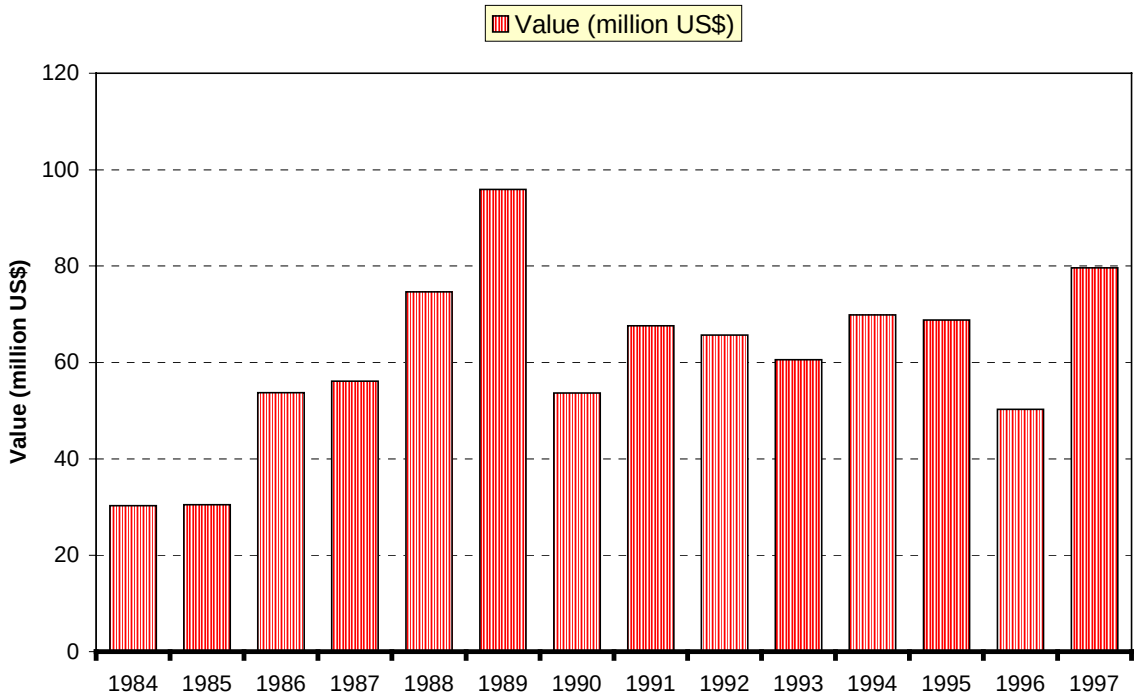


Figure 48 **Value of cultured clam production in Europe**

Reference: FAO, FishStat Plus 1999

1.10.4. Potentials for future development

Perspectives of development are very good, because there is a demand for these species and the wild catches are decreasing. Availability of suitable culture sites is, however, a cause for concern as sanitary and environmental controls are necessary.

1.11. Scallops *(Pecten maximus, Chlamys opercularis, Chlamys veria)*

1.11.1. Natural distribution and culture techniques

The scallop commonly seen in fishmongers is the great Atlantic scallop *(Pecten maximus)* known also as the king scallop. Another species, smaller than the king scallop, known as queen scallop *(Chlamys opercularis)* is also available. King scallop lives in groups on sandy seabeds from 5 m tot 50 m depth and is found in Europe from the North Sea to Portugal. The king scallop is normally fished, but can be also cultivated through methods imported form Japan. Scallop culture developed in Japan during the 1950' with the production of another species *(Pecten yessoensis).* The cultivation of king scallop is based upon spat collection on specific materials chosen for this purpose. Then the young shells are distributed on seabeds for fishing at a marketable size, or put in suspended cages called lantern nets. Anticipating poor spat collection among natural conditions, the development of hatcheries and nurseries appears to be a worthy cause but unresolved problems still remain.

1.11.2. Production and markets

This culture, however, is developing in Spain where production is estimated to reach 150 metric tons, in Ireland as well as in West Scotland where the production cycle, based on Japanese techniques, is just starting. In France, the efforts undertaken to increase production are focused more on spat collection for re-seeding the natural seabed for fishing purposes.

The main scallop producers in Europe are The United Kingdom, Spain and France *(Map 12).*

(King scallop)

Map 12 **Main scallop farming areas in Europe**

Table 18 **Cultured scallop[12] production in Europe**

Quantity (metric tons), Value (1000 US$)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Quantity	331	261	187	219	241	231	202	232	485	431
Value	1 242.5	1 305.0	1 096.9	1 280.2	1 473.6	1 234.4	1 028.0	1 064.9	2 146.5	1 964.7

Reference: FAO, FishStat Plus 1999

Between 1988 and 1995 more or less same volume of cultured scallops was produced in Europe. In 1996 production app. doubled.

The scallop market is supplied by products imported from the Pacific Ocean as well as by European capture fisheries production. Aquaculture must, therefore, produce at costs that are competitive with fishing. The environmental constraints for this type of culture seem to be minor given their small scale as well as extensive nature. The availability of spat for each rearing cycle is still not guaranteed.

1.11.4. Potentials for future development

Despite being an important marine resource for certain fishing zones in Europe, king scallop cultivation is in its early stage and culturing other two native species are still under development.

[12] **Scallops:** king scallop, queen scallop.

1.12. Crustaceans *(Astacus sp., Cambarus sp., Macrobrachium rosenbergii, Penaeus japonicus, Palaemon serratus, Penaeus monodon, Maja spinado, P. kerathurus)*

1.12.1. Natural distribution and culture techniques

A wide variety of crustaceans is marketed and consumed in Europe in all of the climatic zones from Norway to Greece. Unlike in several tropical countries crustaceans in Europe are still considered luxury food. Natural stocks of the most preferred species are either fully utilised or over-harvested, therefore culturing them received increased attention over the past decade.

Crustaceans cultured in Europe may be divided into the following main groups:

- freshwater crayfishes;
- freshwater prawns;
- marine shrimps and
- marine crabs and lobsters.

Freshwater crayfishes *(Astacus, Cambarus sp.)* are traditionally consumed all over Europe, however, since the introduction of the crayfish plague, which almost completely eradicated wild populations, their availability declined dramatically. Despite an unsupplied demand culturing the native European species is not yet fully commercialised, although France reported successful culture of the Danube crayfish *(Astacus leptodactylus)* and several other countries are working on the culture of the noble crayfish *(Astacus astacus).* The introduced signal crayfish *(Astacus leniusculus)* and the red swamp crawfish *(Procambarus clarkii)* seem to be better adapted to culture conditions, the former is grown in commercial quantities in France and the United Kingdom, the latter is cultured successfully in Spain. Total European production of freshwater crayfishes without red swamp crawfish was 242 tons in 1997. The estimated volume of red swamp crawfish production is 2 300 tons in 1997.

Freshwater prawns are not native in Europe, however, the giant river prawn *(Macrobrachium rosenbergii)* imported from tropical Southeast Asian countries is marketed long since with good success. This species and its culture techniques were introduced to Europe from the tropical/subtropical French overseas territories (French Guinea, French Polynesia, Martinique, Reunion), where successful culture commenced already in the early 1980's. European experiences in France and Portugal with the culture of the giant river prawn are contradictory.

Because of suboptimal climatic conditions volume of production did not exceed 75 tons in 1997, economy of production is also in question because of competing cheap imports from tropical developing countries.

Marine shrimps are extensively harvested by capture fisheries of European countries from the cooler waters of the North Atlantic to the Mediterranean Sea. The outstanding success of marine shrimp farming in Asia and Latin America induced efforts in Europe too to adapt culture techniques especially for the native common prawn *(Palaemon serratus)* and for the Kuruma prawn *(Penaeus japonicus)*, which is an Indo-Pacific species, but may have entered the Mediterranean Sea through the Suez Canal via natural migration. These two species were commercially cultured in 1997 in France, Portugal, Spain, Greece, Italy and Albania in a total volume of 353 tons, respectively, while the culture of the introduced giant tiger prawn *(Penaeus monodon)* produce only moderate results to date.

Marie crabs and lobsters are still supplied by capture fisheries in Europe, despite efforts to culture spinous spider crab *(Maja spinado)* and Palinurid spiny lobsters *(Palinurus spp.)* in Spain in the late 1980's.

1.12.2. Production and markets

The production of crustaceans in Europe hardly exceeded 2 970 tons in Europe in 1997 *(Table 19, Figure 49)*. The principal producers were Spain and France, with promising results also in Italy, Sweden and the United Kingdom. In spite of very important crustacean markets in Europe, European farmers have not had a great success to date with these species, neither in intensive culture nor in stock enhancement efforts (e.g. with lobster in France and shrimp in Greece). Strong competition by Asian and Latin American tropical countries makes the economy of culture operations in Europe doubtful, despite the fact that demand is strong and prices high. One have to be careful, however, when assessing the magnitude of market niches for various crustaceans because of their image as luxury items.

Table 19 **Cultured crustacean[13] production in Europe**

Quantity (metric tons), Value (million US$)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Quantity	2 859	2 874	2 775	2 394	2 525	2 644	2 640	2 692	2 721	2 970
Value	34.59	48.59	45.29	41.18	39.47	41.33	41.27	42.08	42.53	46.43

Reference: FAO, FishStat Plus 1999

The main crustacean producer countries in Europe are: Spain, France, Italy Sweden, and United Kingdom *(Map 13).*

(Common prawn)

Map 13 **Main farming areas of crustaceans in Europe**

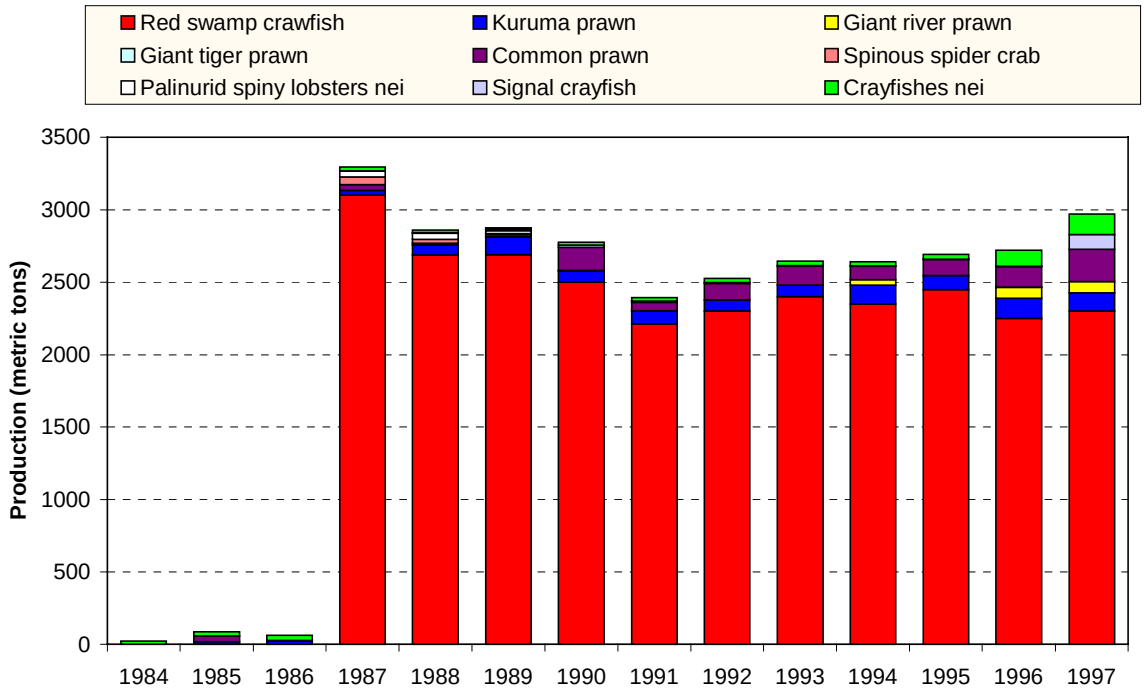


Figure 49 **Cultured crustacean production by species in Europe[14]**

Reference: FAO, FishStat Plus 1999

[13] **Crustaceans:** kuruma prawn, red swamp crawfish, giant river prawn, giant tiger prawn, common prawn, spinous spider crab, palinurid spiny lobsters nei, signal crayfish, crayfishes nei.

[14] The red swamp crawfish production is estimated only between 1992-1997.

1.12.3. Potentials for future development

Potentials for culturing crustaceans in Europe seem to be limited because of the strong competition of tropical developing countries in freshwater prawns, marine shrimps and marine crabs and lobsters. Production costs in Europe, where climate is sub-optimal and labour much more expensive, can not compete with cheap import prices. However, crayfish markets may be supplied even on a long range with European production and speciality products (e.g. live shrimp, crab, lobster sold directly to high class restaurants) offer additional market niches for domestic producers.