EUROPEAN COMMISSION

FISHERIES DIRECTORATE GENERAL

FORWARD STUDY OF COMMUNITY AQUACULTURE

SUMMARY REPORT

BY

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INTRODUCTION TO THE STUDY

This study has been commissioned by the Fisheries Directorate General of the European Commission.

The aim of the study is to provide the Commission with a snapshot of European aquaculture in the late 1990s, the evolution of the sector over the last 10 years and prospects for the sector within the next 10 years.

The two issues of key policy interest to the Commission are the contribution of aquaculture to the provision of fisheries products in the Union and the generation of employment by the sector.

The Commission has supported the development of aquaculture in Member States in a concerted way since 1983. Since 1994, support has been provided through the Financial Instrument for Fisheries Guidance (FIFG). The next funding period for FIFG is 2000 to 2006 and, in preparation for this, the Commission is seeking to establish the current situation and prospects to enable planning of future assistance to the sector. Thus within the main policy framework mentioned above, this study aims to evaluate the evolution of the sector under previous aid arrangements as a guide to what might be achieved in the future. The study addresses such issues as the prospects for future expansion from the point of view of markets, production possibilities, (technical, economic and environmental), the location and nature of jobs that might be created, whether the production in the EU will be competitive in a global context and interaction of labour from the fishing sector.

This study has been conducted in parallel with a major investigation of the socio-economic importance of the fishery sector around Europe. The combination of studies will provide the Commission with information to make decisions on the future structural funding assistance to the fishery sector as a whole.

The study also follows a comparable exercise undertaken in 1990: 'Evaluation of the Effectiveness of the Aquaculture Support Policies of the Commission with Special Reference to Regulation EEC 4028/86' (Shaw and Bailly 1990). This study provided a detailed picture of the sector at the end of the 1980s and was a source for many useful comparisons, although care has been applied since the data sources and methodology have varied in some instances.

Methodology

The material contained in this study was researched primarily on a species group basis across the EU. Twelve specialists, each with particular expertise in a certain species group and/or the aquaculture sector of a particular Member State, researched information relating to the industry or MS with which they were the most familiar.

The team gathered data from a diverse range of sources. They also interviewed farmers, producer organisations, administrators and regulators to assemble the information required by the study.

Further details on methodologies used in forecasting are given in the body of the report.

DATA TREATMENT

Output and prices

Information from 1989 onwards has been researched. The team attempted to collect data as close to the production industries as possible. Sources of information were primarily producer organisations and Member State government surveys as well as the Federation of European Aquaculture Producers (FEAP), a grouping of most of the producer organisations involved in fish production across Europe (not just the EU). Some data was difficult to locate or did not appear to exist from any source close to the production industry, for example a full-time series of prices for mussels produced in the UK. Aquaculture production is sometimes combined with capture fisheries in official statistics, a feature that most commonly occurs for bivalves. In instances where data were either not available or apparently corrupted, the FAO Fishstat database was consulted. These data were gathered from reports to FAO from governments and, as there is the opportunity for corruption or estimation in this process, this source has been used to fill 'gaps' where it is apparently in harmony with the base data collected from closer to the production industries. Where the FAO data was apparently at odds with data from closer to production industry sources, then gaps have been left or estimations have been made by the specialist team, where confident estimates were possible.

For some species production data up to 1998 is available. This is discussed in the context of individual species but for comparative purposes 1997 is the most recent year with data uniformly available. 1997 is thus given as the 'current' position on an EU-wide basis.

Profitability

This is probably the most difficult statistic to collect for the aquaculture industry. Profitability is obviously sensitive. Some studies and producer organisations have relevant information which was taken into consideration. The team considered examining a sample of statutory accounts, which are in the public domain, for aquaculture companies but this approach was rejected in the majority of cases because of difficulties in interpretation of such factors as:

- Multi species or non aquaculture trading within a single company;
- Cash sales;
- Micro-enterprises not needing to file formal accounts;
- Returns not showing turnover nor volume; and
- Difficulty in selecting a representative sample.

Interviews with farmers and the team's own knowledge of the industry have therefore been used to comment in a semi-quantitative way as regards profitability and to highlight the main factors that have contributed to profitability, and will do so in future.

Employment

Employment data is readily available for some sectors; however for others no employment data are available.

Again, government surveys and producer organisations were the main sources of information and also some other relevant studies containing such data. Data has been expressed in full-time equivalents (FTEs) for production, upstream and downstream activities separately. Employment arising from upstream activities has not been recorded separately in publicly available statistics on aquaculture and the team has used various techniques appropriate to each situation to make the most meaningful estimate possible. Downstream activities that generate employment were considered to the level of primary processing only. In many cases these are inseparable from the primary production functions, particularly at the micro-enterprise level, and mostly concern carp, trout, rope/raft mussels and oysters.

Trade flows

The study has considered the distribution of aquaculture produce from the EU, within the EU itself and as exports to third countries. Official statistics on intra-EU trade are not considered to be uniformly reliable. This is thought to be so because shipments under a certain threshold value are not always recorded at border crossings. As an example, according to customs figures about 39% of oysters produced in Ireland are exported to other Member States. The industry and the Irish Government agency responsible for aquaculture development, BIM, estimate the export figure to be around 90% of production. Some producer organisations keep accurate records of distribution and such records were used where possible. In other cases, the team estimated the volume or proportion of domestic production that is exported to different Member States and to third countries according to discussions with industry and their own knowledge of the situation. These estimates are thought to be at least +/-20% of the actual situation, and in most cases considerably better.

Imports from third countries into the EU of the species groups produced by EU states are fairly minimal, the only exception being salmon. Eurostat import data was used to clarify the situation where possible.

Currency

The Euro symbol (€) has been used throughout the study and applies equally to ECU and the Euro, even though the Euro was not in existence for most of the period covered by the study. Raw data collected during the study was largely in national currencies. This has been converted to the ECU/Euro at the average annual conversion rate for the appropriate year(s).

1 STATE OF AQUACULTURE IN THE EUROPEAN UNION

1.1 INTRODUCTION

In 1997, EU-wide production from aquaculture of the main species considered in this study was 1,089,016 tonnes, worth € 1,904.6 million. In addition, there is a further 18,747 tonnes of aquaculture production, worth € 70.4 million, from minor species other than those included in this study. Hence the overall EU aquaculture production is 1,107,763 tonnes worth €1,975 million.

On a global scale, total aquaculture production in 1997 amounted to 36,050,168 tonnes worth €44,415.6 million (FAO Fishstat). The dominant producing countries are China, Thailand, Indonesia, and South American countries such as Ecuador. The EU produces 3% in volume and 4.3% in value of world-wide production of all species. However, table below demonstrates that for certain species the EU is a world leader.

Aquaculture production of the main species (tonnes in '97) in the EU as a percentage of global production

Species	EU15 Production	Global Production	%EU of global
Atlantic Salmon	115,749	523,213	22
Trout	235,541	436,592	54
Carp	18,264	8,006,325	<1
European Eel	8,053	8,134	99
Sea bass / Sea bream	46,136	67,968	68
Turbot	3,220	3,220	100
Mussels	514,507	732,928	70
Oysters	97,876	3,085,118	3
Clams	49,670	1,332,729	4
TOTALS	**1,089,016**	**14,196,227**	

Source: FAO

1997 EU Aquaculture Production

	Salmon		Trout		Carp		Eel		Seabass/bream		Turbot		Mussels		Oysters		Clams		Others		EU Totals	
Member State	**Volume** *(Tonnes)*	**Value** *(€,000)*	**Volume** *(Tonnes)*	**Value** *(€,000)*	**Volume** *(Tonnes)*	**Value** *(€,000)*	**Volume** *(Tonnes)*	**Value** *(€,000)*	**Volume** *(Tonnes)*	**Value** *(€,000)*	**Volume** *(Tonnes)*	**Value** *(€,000)*	**Volume** *(Tonnes)*	**Value** *(€,000)*	**Volume** *(Tonnes)*	**Value** *(€,000)*	**Volume** *(Tonnes)*	**Value** *(€,000)*	**Volume** *(Tonnes)*	**Value** *(€ '000)*	**Volume** *(Tonnes)*	**Value** *(€ '000)*
Austria	0	0	3,400	10,700	800	1,680	0	0	0	0	0	0	0	0	0	0	0	0	74	267	4,274	12,647
Belgium	0	0	820	2,360	300	567	150	946	0	0	0	0	0	0	0	0	0	0	201	819	1,471	4,692
Denmark	0	0	36,550	74,366	0	0	1,700	13,860	0	0	0	0	0	0	0	0	0	0	0	0	38,250	88,226
Finland	9	20	16,315	37,311	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41	91	16,365	37,422
France	0	0	51,660	101,954	5,500	11,550	160	1,696	3,485	27,138	980	7,448	53,604	66,444	87,103	138,952	618	4,215	8,095	27,668	211,205	387,065
Germany	0	0	25,000	63,655	11,514	23,030	150	1,290	0	0	0	0	22,330	10,819	75	662	0	0	0	0	59,069	99,456
Greece	2	16	2,322	5,805	50	120	312	2,761	25,500	154,687	0	0	25,434	8,006	0	0	0	0	1,327	6,659	54,947	178,054
Ireland	15,441	50,734	1,799	4,628	0	0	0	0	0	0	5	39	13,285	6,563	4,406	7,209	165	1,291	0	0	35,101	70,464
Italy	0	0	51,000	105,940	100	264	3,100	29,446	8,500	59,931	0	0	103,000	53,631	0	0	40,000	83,310	6,219	24,509	211,919	357,030
Netherlands	0	0	200	618	0	0	1,800	14,670	0	0	0	0	93,200	55,908	1,234	1,981	0	0	1,206	2,663	97,640	75,840
Portugal	0	0	1,500	4,504	0	0	200	1,678	2,611	20,884	105	840	445	432	618	1,200	3,260	23,897	42	286	8,781	53,722
Spain	1,100	3,289	25,000	41,358	0	0	266	2,036	6,040	38,419	2,055	16,440	188,793	59,528	3,387	7,893	5,591	36,071	1,461	6,955	233,693	211,989
Sweden	0	0	4,875	11,382	0	0	215	1,625	0	0	0	0	1,425	629	0	0	0	0	8	176	6,523	13,812
UK	99,197	339,469	15,100	33,574	0	0	0	0	0	0	75	591	12,991	7,711	1,053	2,801	36	115	73	262	128,525	384,522
Total	**115,749**	**393,528**	**235,541**	**498,157**	**18,264**	**37,211**	**8,053**	**70,007**	**46,136**	**301,059**	**3,220**	**25,358**	**514,507**	**269,672**	**97,876**	**160,699**	**49,670**	**148,899**	**18,747**	**70,354**	**1,107,763**	**1,974,944**

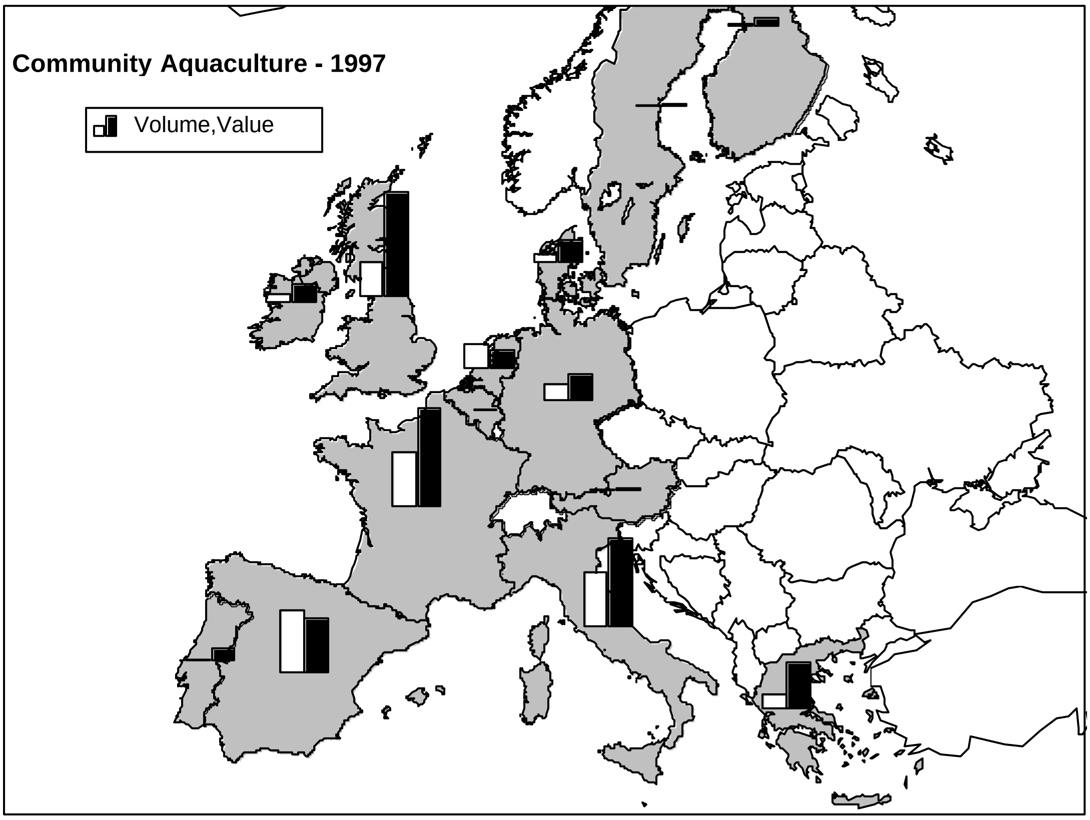
Aquaculture 1997	Volume (Tonnes)	Value (€ '000)	Employment (FTE = Full Time Equivalents)					
			Upstream (FTE)	*Production (FTE)*	*Production (Total Emp)*	*Downstream (FTE)*	*Total (FTE)*	*Overall (Total Emp)*
Austria	4,274	12,647	19	379	739	23	421	781
Belgium	1,471	4,692	6	112	226	8	126	240
Denmark	38,250	88,226	197	698	700	327	1222	1224
Finland	16,365	37,422	76	809	809	0	885	885
France	211,205	387,065	333	10342	14166	622	11297	15121
Germany	59,069	99,456	169	3193	7354	313	3675	7836
Greece	54,947	178,054	477	2711	2187	478	3666	3142
Ireland	35,101	70,464	196	1275	2092	301	1772	2589
Italy	211,919	357,030	357	4923	8376	1800	7080	10533
Netherlands	97,640	75,840	63	564	678	871	1498	1612
Portugal	8,781	53,722	30	1452	3312	43	1525	3385
Spain	233,693	211,989	1420	7851	18747	4238	13509	24405
Sweden	6,523	13,812	27	480	561	36	543	624
UK	128,525	384,522	1179	2705	3242	2926	6810	7347
EU Total	1,107,763	1,974,944	4549	37494	63189	11986	54029	79724

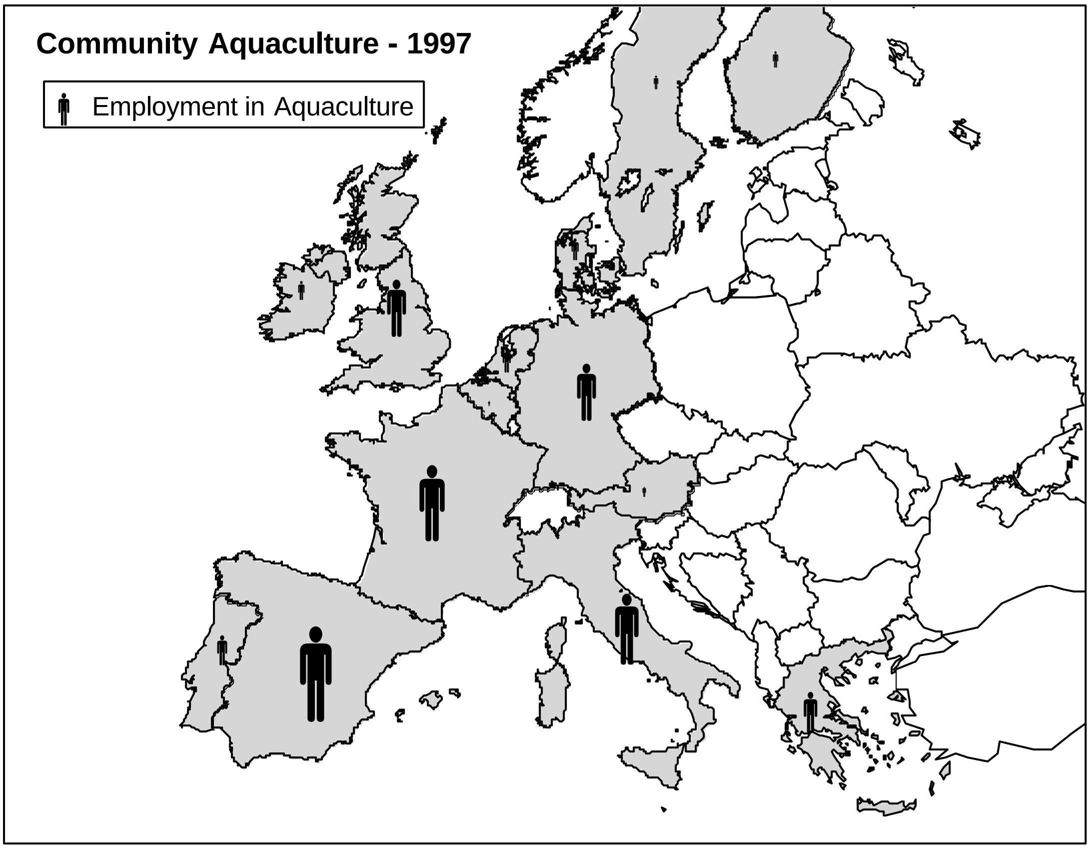
Employment in aquaculture in relation to total active population by Member State

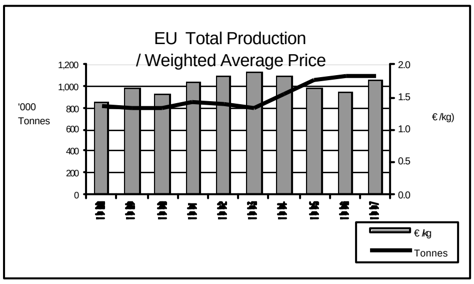
1997	*Employment in aquaculture*	*Active population (1995)*	*‰**
Austria	421	3.842.000	1,10
Belgium	126	4.183.000	0,30
Denmark	1.222	2.796.000	4,37
Finland	885	2.429.000	3,64
France	11.297	25.033.000	4,51
Germany	3.675	38.961.000	0,94
Greece	3.666	4.201.000	8,73
Ireland	1.772	1.434.000	12,36
Italy	7.080	22.607.000	3,13
Netherlands	1.498	7.304.000	2,05
Portugal	1.525	4.753.000	3,21
Spain	13.509	15.561.000	8,68
Sweden	543	4.498.000	1,21
UK	6.810	28.404.000	2,40
EU Total	54.029	166.006.000	3,25

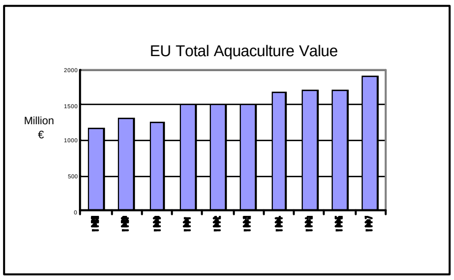
* Unit = Number of Full Time Equivalent employees in aquaculture per 10.000 total active population.

The following maps illustrate the volume and value of aquaculture production and employment generated for each of the EU Member States in 1997 for the main species groups in each Member State.


Community Aquaculture - 1997
Volume,Value


Community Aquaculture - 1997
Employment in Aquaculture





European aquaculture is a patchwork characterised by many different species, production zones and culture techniques. Because of its diverse nature, one has to be careful not to over generalise. Evolution of fish production has shown a very different trend over the last ten years compared to that of mollusc production.

However, as a whole, aquaculture production in the EU has grown by approximately 200,000 tonnes over the last 10 years and this growth has taken place in an environment of stagnant or falling prices in the majority of species. At the time of the first price collapse of salmon in the late 1980s, few observers would have predicted that salmon, or the aquaculture sector as a whole, would have grown as much over the ensuing decade.

A great deal has been achieved through innovative production technologies and economies of scale. Indeed for some industries the only survival strategy has been to grow in scale in an attempt to keep production costs falling ahead of market prices. Growth rates have been variable across the different industries but only carp is in recession. The following table sets out the overall increase by main species group. As an indication of how dramatic the growth has been a comparison is also made with predictions for 1995 from a study financed by the Commission in 1990. This is no way a criticism of that study, rather an illustration of how unforeseen some of the growth has been (growth was predicted for EU12 so is inherently underestimated, but only significantly so for trout).

Growth in aquaculture in the EU15 from 1988 to 1997

Species	Growth 1988 to 1997 (%)	Change in price 1988 to 1997 (%)	1995 predicted (tonnes)	1995 actual (tonnes)
Salmon	411	-35	52,265	83,193
Trout	57	-25	168,600	233,279
Carp	-30	0	10,420	18,965
Eels	33	24	7,770	7,546
Seabass [1]	1,531	-47	19,070	33,625
Seabream	1,983	-63		
Turbot	2,435	-8	5,200	2,564
Mussels	2	-3	537,500	511,093
Oysters [2]	6	6	133,250	161,740
Clam	284	-42	23,100	67,320

Notes: 1: Predicted seabass and seabream data for 1995 are combined predictions.

2: Oyster production recording method in France, the dominant producer, changed in 1996, growth is to 1995.

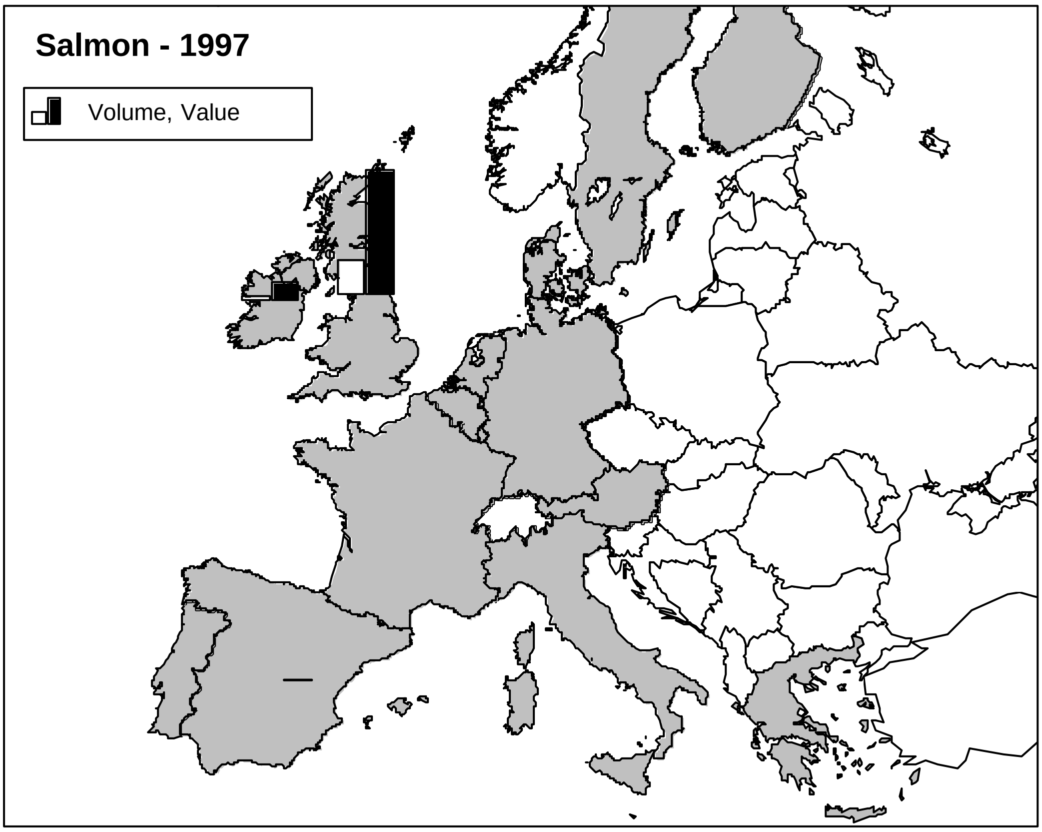
1.2 DESCRIPTION OF THE MAIN SUB SECTORS

1.2.1 SALMON

➢ **Main species farmed**

Atlantic salmon (*Salmo salar*).

➢ **Current output (volume and value)**



	Volume (Tonnes)	**Value** (€ '000)
Scotland	99,197	339,469
Ireland	15,441	50,734
Spain	1,100	3,289
Finland	9	20
Greece	2	16
Total:	**115,749**	**393,528**

- **Employment**

  Production 1,974

  Upstream 1,224

  Downstream 2,929

The above figures do not include employment data for minor producers of Spain, Finland and Greece.

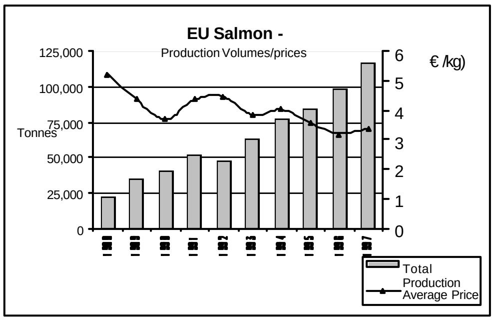
- **Market considerations**

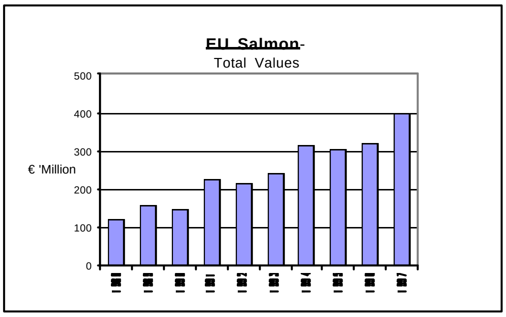
  The main product form is fresh, with lesser amounts processed by smoking and filleting. Minor amounts frozen and canned.

- **Trade flows (1997, tonnes)**

Total EU production	115,749
Total consumption in country of production	60,461
Total exported to EU Member States	45,983
Total exported to third countries	9,305
Total imported from third countries	236,645
EU balance	-227,340

- **Recent trends in output, prices and profitability**





The graphs above clearly show an increase in production volume over the decade. Overall value has also increased over the same period, although it is worth noting the decrease in value in 1995 when there was a corresponding increase in output. This is a function of prices, which have shown a net decline over the period.

Scotland

- Trend has been towards mergers in businesses with increasing overseas ownership to reduce costs and improve market position. Ten companies account for 90% of production in 1998.
- Production has continued to expand between 9% and 49% per year, mainly due to improved smolt production, expansion of sites, and successful application of disease control, new feeds and husbandry techniques.

- Productivity on some farms has risen to from 29 tonnes/employee in 1992 to an average of 77 tonnes/employee in 1997.
- Prices have declined by 35% over past seven years. 1993 saw profits near zero due to the price collapse that year, with a recovery in ’94 and ’95 due to higher survival arising from vaccine use. Profits fell again to an estimated 6% of turnover in ’97 and lower still in ’98 due to lower prices, particularly in Sterling terms.
- Norwegian producers remain the most significant competitors to Scottish production.
- General trend in middle-sized, vertically integrated farms to invest in value-added processing, product development and marketing.
- Profitability highly sensitive to feed costs, ISA and sea-lice related losses.

Ireland

- Production developed on a similar pattern to Scotland, but in the late ‘80s the level of environmental opposition resulted in a slowdown in the expansion of the sector. The ‘90s brought the successful application of means for disease control, husbandry, new feeds and on-growing technology.
- Prices have declined 45% during past ten years, but direct cost of production per tonne has declined 30% over the same period.
- Net profitability has been maintained at around 10%, due to major re-alignment of overall cost structure, increased efficiency and productivity.

Non-EU Producers

Norway

- Farming technology has evolved continuously since early 1980s, driven by year-round market demand, need for improved efficiency and impact of environmental and other regulations.
- World-leader in farming research, development and product development.
- Industry is highly intensive and efficient and, with a 331,367 tonne production in 1997, constitutes a dominant competitive force internationally.
- Heavy investment in research and development by feed companies and equipment manufacturers have helped the industry keep its competitive edge.

Chile

- Steep increase in production to 87,500 tonnes in 1997 coupled with trade barriers in US market and recession in Asia may result in increasing Chilean attention towards European market, especially for frozen/chilled fillets and convenience products.
- Industry characteristically dynamic and highly cost-efficient, capitalising on prompt introduction of imported new technologies.
- Trend in company mergers, with European group Marine Harvest McConnell now largest producer.
- Fish diseases and political stability appear to be main threats.

USA/Canada

- Not considered to be a serious threat to EU producers, since they target North American and Japanese markets, and not cost-competitive with European producers.

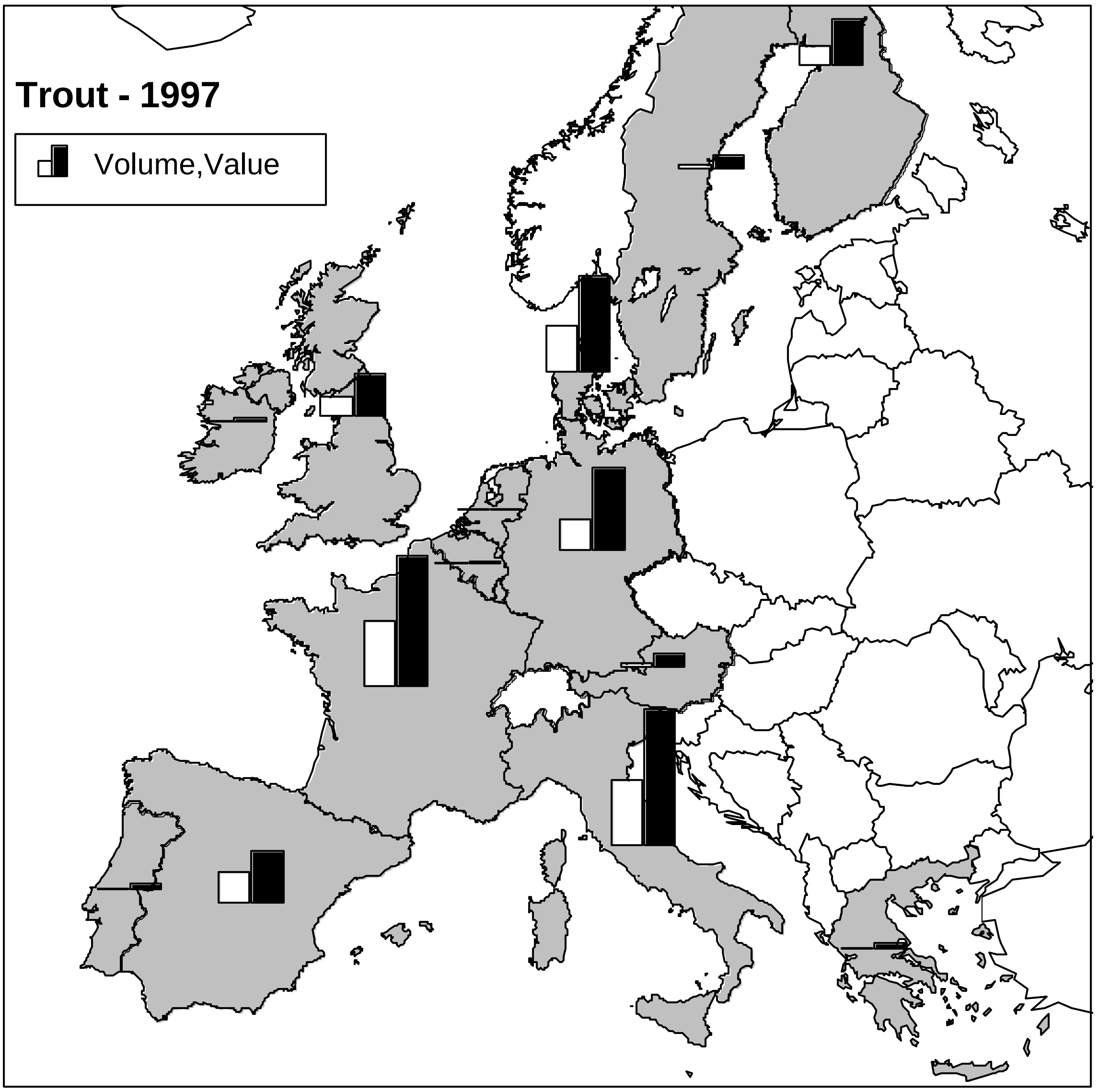
1.2.2 TROUT

- **Main species farmed**

Rainbow trout (*Oncorhynchus mykiss*).

Minor species; Sea/brown trout (*Salmo trutta*).

- **Current output (volume and value)**



Origin of farmed trout, 1997, by Member State

	Volume (tonnes)	Value (€ '000)
Austria	3,400	10,700
Belgium	820	2,360
Denmark	36,550	74,366
Finland	16,315	37,311
France	51,660	101,954
Germany	25,000	63,655
Greece	2,322	5,805
Ireland	1,799	4,628
Italy	51,000	105,940
Netherlands	200	618
Portugal	1,500	4,504
Spain	25,000	41,359
Sweden	4,875	11,382
UK	15,100	33,574
Total	**235,541**	**498,156**

➢ **Employment**

Production: 8,214

Upstream: 1,096

Downstream: 1,379

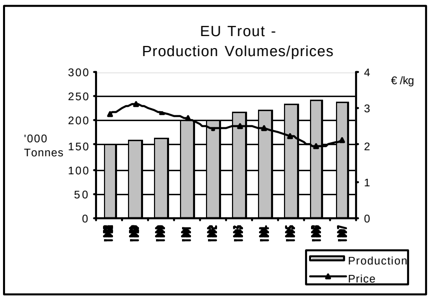
➢ **Market considerations**

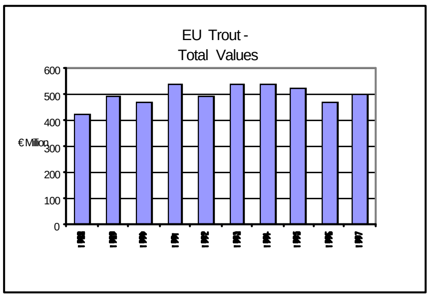
Most produced as fresh portion-sized trout (white or pigmented pink), Scandinavian countries preferring fresh large fish (1.5 to 3 kg). Some smoking, filleting, freezing whole, frozen fillets.

➢ **Trade flows (1997, tonnes)**

Total EU production	235,541
Total consumption in country of production	196,950
Total exported to EU Member States	33,199
Total exported to third countries	5,393
Total imported from third countries	4,878
EU balance	515

- **Recent trends in output, prices and profitability**





The graphs show a steady increase in volume over the last decade against a background of variable value and a net decrease in prices.

- EU production of portion size trout has increased 16% from 168,000 tonnes in 1990 to 194,000 in 1998. Large trout production has increased 56% from 29,500 tonnes to 46,000 tonnes over the same period.
- Demand in multiple stores with greater control on hygiene and adoption of HACCP procedures has had significant effect on structure of sector since late 1980s.
- In average, profitability has dropped largely across Europe, due to a fall in price of portion size trout by 26% from € 2.79/kg in 1988 to €2.05/kg in 1997. Comparable figures for large trout are a drop of 16% from €3.86/kg in 1988 to €3.24/kg in 1997. However, levels of profitability show considerable differences between regions, due to large variations in production costs.
- Atlantic salmon is a significant competitor in the market.
- Main areas of expenditure in past decade have been in production infrastructure (tanks, raceways), improved effluent water treatment and equipment (especially labour saving devices).

Non-EU Producers

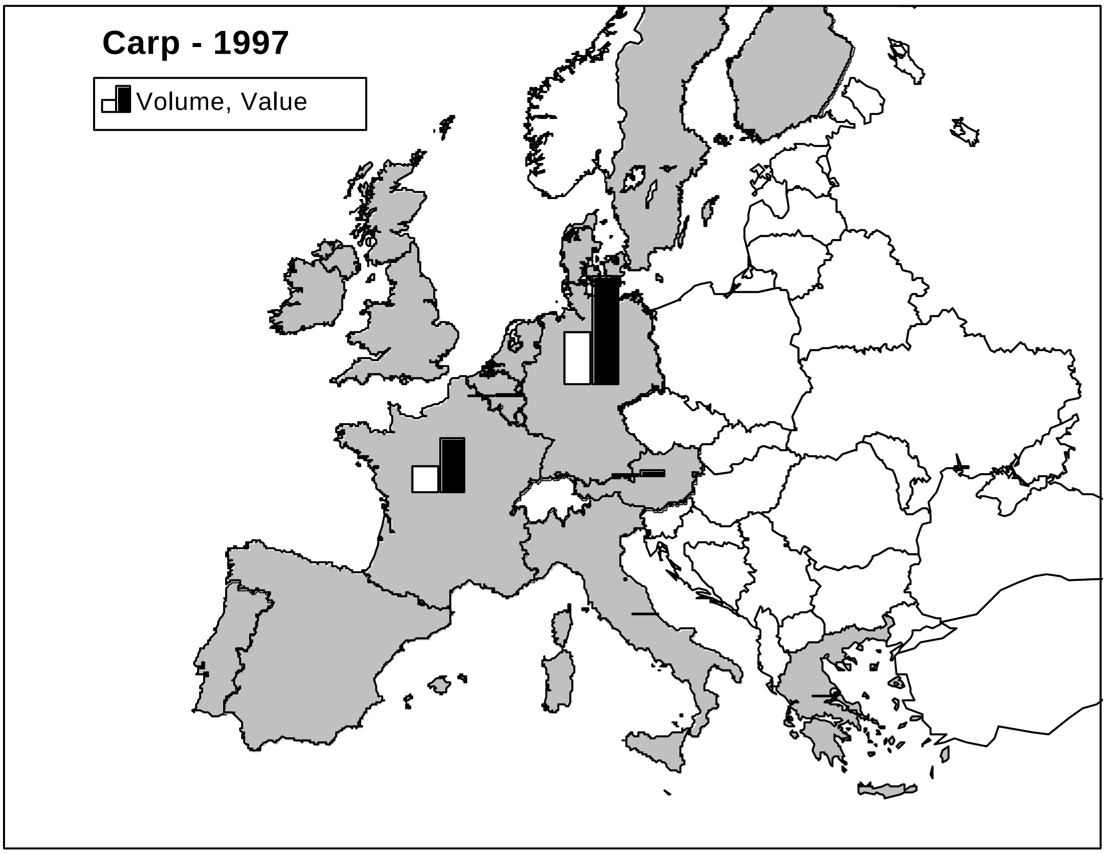
- Norway production is around 45,000 tonnes, of which only 5,000 tonnes is exported to the EU, the remainder going mostly to the South-east Asia market where demand for highly pigmented flesh is high. Other significant producers are Chile and USA with little market overlap with EU.

1.2.3 CARP

➢ **Main species farmed**

Common carp (*Cyprinus carpio*).

➢ **Current output (volume and value)**



	Volume (tonnes)	Value (€ '000)
Austria	800	1,680
Belgium	300	567
France	5,500	11,550
Germany	11,514	23,030
Greece	50	120
Italy	100	264
Total	**18,264**	**37,211**

- **Employment**

  Production: 2,699

  Upstream: 59

  Downstream: 67

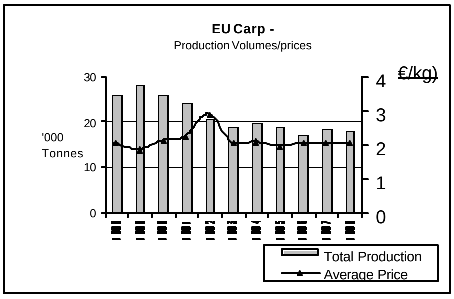
- **Market considerations:**

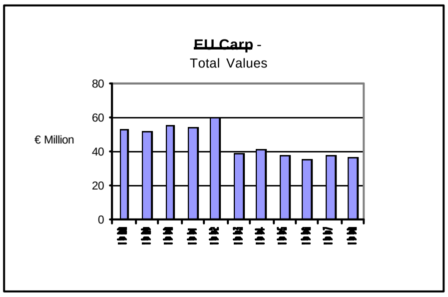
  Main product forms: live and fresh

- **Trade flows (1997, tonnes)**

Total EU production	18,264
Total consumption in country of production	17,574
Total exported to EU Member States	500
Total exported to third countries	190
Total imported from third countries	5,985
EU balance	- 5,795

- **Recent trends in output, prices and profitability**





Carp production has shown a decrease over the decade, although it seems to have levelled out over more recent years. Value has mirrored this pattern and prices have remained relatively constant over the whole period with the exception of a peak in 1992.

Germany

- Improved technology, feeds and use of warm water has raised production from 572 kg/ha in 1956 to 1,175 kg/ha in 1977. Since then, unit productivity has not increased.
- European carp production has virtually stagnated during the past 15 years, due to changing political and socio-economic conditions in Eastern Europe as well as weakened EU market demand.
- In 1998 less than 12% of farmers were full-time professionals using semi-intensive methods and account for 19% of production, the remainder use extensive rearing methods.
- Germany remains the main EU producer and consumer of carp, mainly sold live.

Non-EU producers

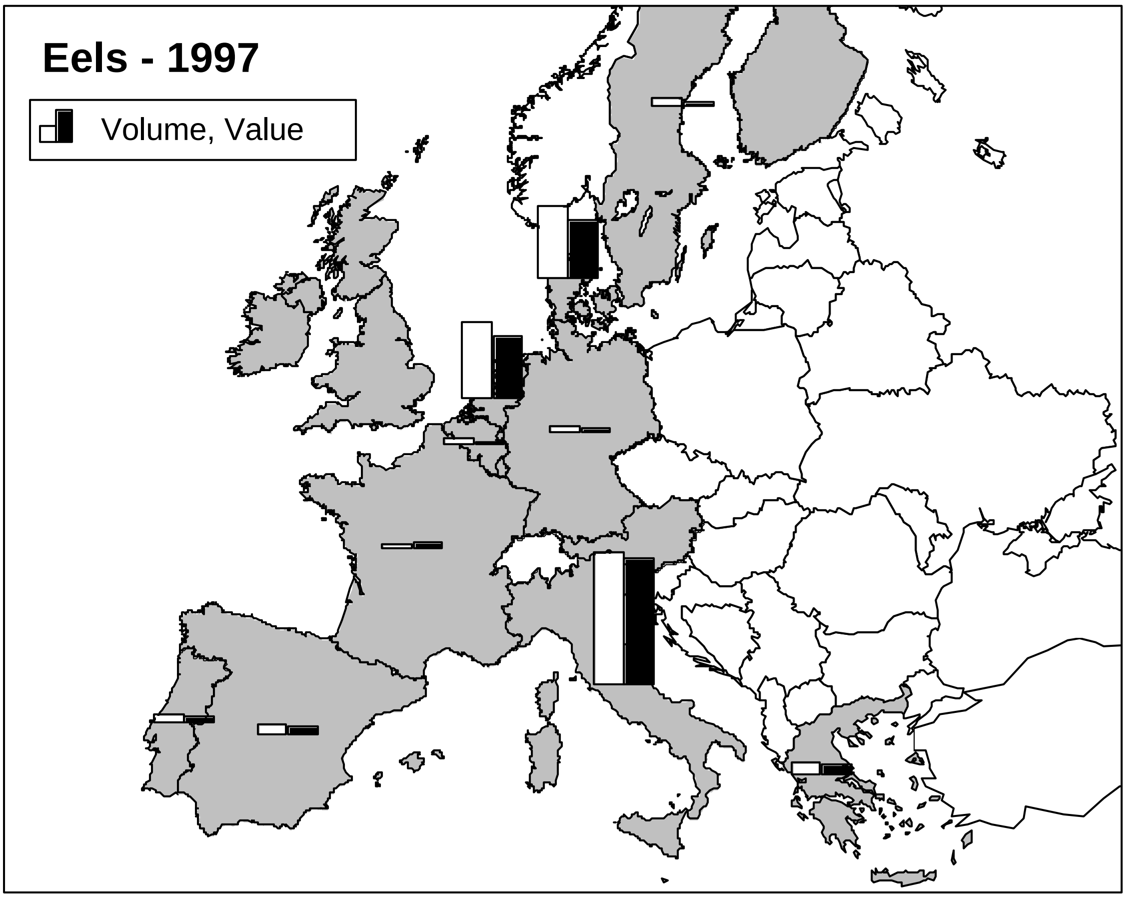
- Small, regular imports come from Czech Republic into northern Europe, Croatia supplies some carp to Italy and Turkey/Bulgaria has exported small amounts to Greece. Price competition has contributed to the decline of the traditional EU production sector.
- Former USSR and Russia production has fallen from 325,530 tonnes in 1985 to 33,400 tonnes in 1995.
- Carp is produced in enormous quantities in Asia using largely traditional methods with minimal international trade.

1.2.4 EELS

➢ **Main species farmed**

Common eel (*Anguilla anguilla*).

➢ **Current output (volume and value)**



	Volume (tonnes)	Value (€,000)
Belgium	150	950
Denmark	1,700	13,860
France	160	1,700
Germany	150	1,290
Greece	312	2,760
Netherlands	1,800	14,670
Italy	3,100	29,450
Portugal	200	1,680
Spain	266	2,040
Sweden	215	1,630
Total	**8,053**	**70,030**

- **Employment**

Production: 591
Upstream: 56
Downstream: 92

- **Market considerations**

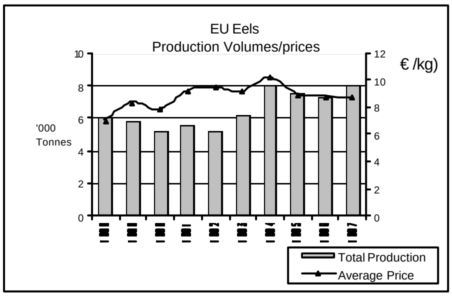
  Main product forms large and small eels, mainly for smoking.

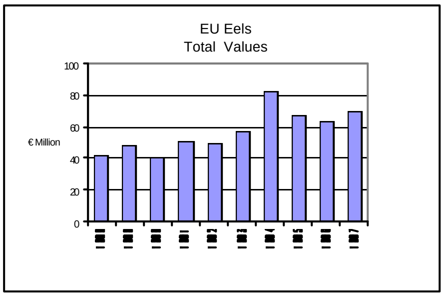
- **Trade flows (1997, tonnes)**

Total EU production	8,053
Total consumption in country of production	5,728
Total exported to EU Member States	2,325
Total exported to third countries	0
Total imported from third countries	3,476[1]
EU balance	- 3,476

Note 1: includes wild caught

- **Recent trends in output, prices and profitability**





Output of eels has fluctuated over the last decade although it has demonstrated a net increase. Value increased substantially in 1994 but decreased quite sharply and has remained fairly constant since. Price rose steadily until a peak in 1994, the price decreased the following year and has remained quite constant since.

- EU production has grown 50% from 5,300 tonnes to 8,000 tonnes over the past decade, with a projected 11,000-12,000 tonnes by year 2000.
- EU market average prices have fallen from €10.5/kg in 1994 to €8.6/kg in 1997.
- Eel farming has benefited from improved husbandry, increased management experience and improved feeds. Feed conversion rates have improved from 2.5-2.7:1 at the start of the decade to 1.8-2.0:1 in 1998, due entirely to feed quality improvements and extrusion techniques.

- Survival rates from glass eel to mature fish are calculated at around 80% today, compared with 20% in the 1980s.
- Non-EU import values for frozen product are on average €2 (or more) lower than live EU product.
- Continuing dependence on wild supplies of glass eels is causing concern for conservation of wild stocks.
- Filtration, water settlement, water-usage licensing and oxygenation are major cost considerations. Farms using re-circulation technology have an overall depreciation rate of 14-15% reflecting increased investment costs.
- Italy produces eels mostly in fresh, but also in brackish and marine water (95%, 4.5% and 0.5% respectively). Volumes have been maintained over the last decade, mostly because of market stagnation, and this despite a certain reduction in the availability of yellow eels (Italian farms mostly grow yellow instead of glass eels). Semi-intensive production systems are more common (densities of 10-20 kg fish / m³ water) and have shown proportional increases in output when compared to intensive units.
- Danish and Netherlands companies have specialised in manufacturing specific eel feeds, whereas German, Danish and Dutch companies lead in the market for specialist equipment (tanks, pumps, pipes and recirculation systems).
- Denmark and Netherlands, the two main Northern European producing Member States, achieve productivity rates of around 20-25 tonnes/employee; this is now comparable to the productivity achieved by Southern European producers. The largest investments have been made over the past decade in farms using re-circulation technology; this has seen production grow from 500 tonnes in 1988 to 4,468 tonnes in 1998, from the 80-90 farms concerned.

Non-EU Producers

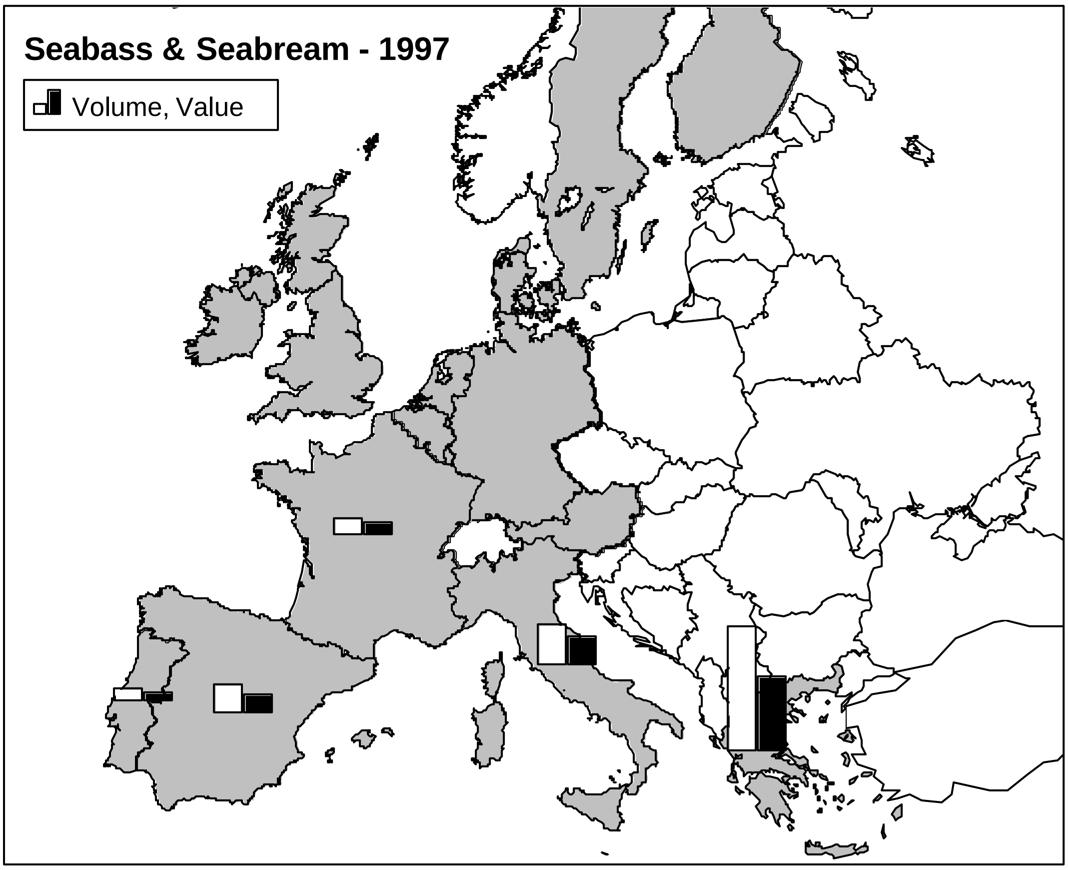
- Only significant European eel production outside EU is recorded in Tunisia, Macedonia and Morocco, with a combined total of 300 tonnes.
- Outside of Europe, major eel aquaculture activity is in the Far East where production of the Japanese eel, *Anguilla japonica* is well established. 1997 production figures indicate China produced 167,000 tonnes, Japan 24,000 tonnes, Taiwan 22,200 tonnes, Malaysia 6,600 tonnes, Korea 2,300 tonnes and Indonesia 2,200 tonnes.
- Increasing demand and higher prices offered by Far East producers for European glass eel supplies has given cause for concern for the conservation status of wild eel stocks in Europe, and the continuing affordability of glass eels to European farmers. Exports of glass eels to China have risen from 80 tonnes in 1994-95 to over 250 tonnes in 1997.

1.2.5 SEABASS AND SEABREAM

➢ **Main species farmed**

Common seabass (*Dicentrarchus labrax*) and Gilthead seabream (*Sparus auratus*).

➢ **Current output (volume and value)**



	Volume (tonnes)	**Value** (€ '000)
France	3,485	2,714
Greece	25,500	15,469
Italy	8,500	5,993
Portugal	2,611	2,088
Spain	6,040	3,842
Total	**46,136**	**30,106**

➢ **Employment**

Production	3,576
Upstream	656
Downstream	679

➢ **Market considerations**

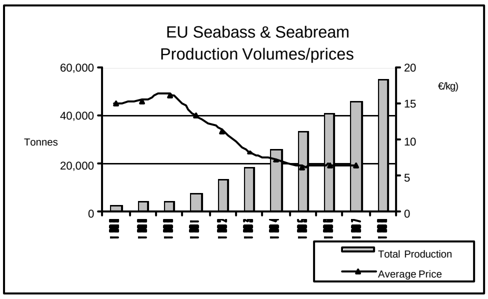
Almost all fish are sold at 300-400g portion size fresh. Some demand for larger fish (up to 1 kg).

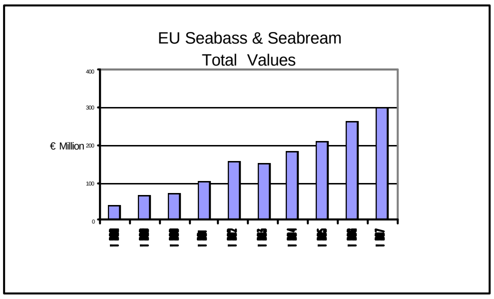
➢ **Trade flows (1997, tonnes)**

Total EU production	46,136
Total consumption in country of production	25,611
Total exported to EU Member States	20,525
Total exported to third countries	0
Total imported from third countries	12,953[1]
EU balance	-12,953

Note 1: This is predominantly farmed but includes wild caught fish as well

➢ **Recent trends in output, prices and profitability**





The graphs show a considerable and sustained increase in production output, against a backdrop of declining prices over the decade, although these have leveled off in recent years. Value has correspondingly increased over the period, but due to falling prices, to a lesser rate.

➢ Profitability pattern across Europe disrupted by differing age and size of producing industries.

Greece

➢ Largest producer, trends in the main drivers of profitability since 1990 include the following: survival improved from 75% to 90%; growth rate improved from 19 months to 15 months to market; feed conversion ratio improved from 2.8 to 2.1:1; productivity per person improved 10 to 27 tonnes per person on cages; average size of farm increased from 20 tonnes to 106 tonnes; reduction in capital costs per unit output.

- Prices less volatile in Drachma terms.
- Good profitability at the start of the 1990s eroded as prices fell faster than production costs. From the mid-1990s profitability improved and remained high.
- Production costs continue to be driven down.

France

- Production expansion rapid through land-based and cage systems.
- Production improvements progressed much faster than prices declined.
- Continually improving profitability from a heavily negative position in the early 1990s.
- Passed breakeven in 1995-6 to moderate profit in 1997.
- Pattern is due to the relative youth and small size of the industry.

Spain

- Rapid production expansion on Mediterranean coast using cages, tanks and salinas.
- Stable moderate profits in the later 1990s.

Italy

- Dramatic increase from combination of traditional 'vallicoltura' systems, pump-ashore farms and latterly marine cages.
- Profits eroding by late 1990s.

Non-EU Producers

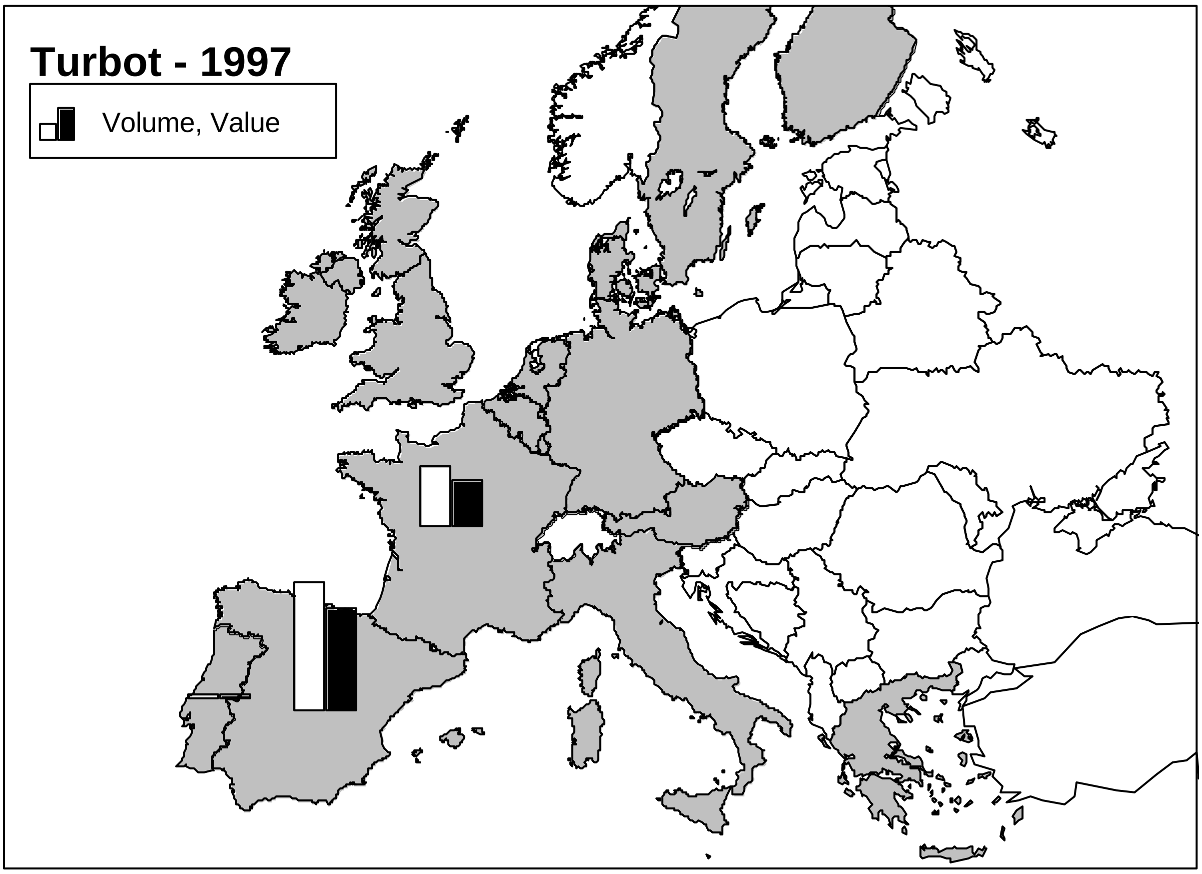
- Expansion from seven non-EU countries in Mediterranean also rapid from 11,799 tonnes in 1994 to 22,650 in 1998. Most target EU markets.

1.2.6 TURBOT

➢ **Main species farmed**

Common turbot (*Psetta maxima*).

➢ **Current output (volume and value)**



	Volume (tonnes)	**Value** (€ '000)
France	980	7,450
Portugal	105	840
Spain	2,055	16,440
UK	75	59
Ireland	5	4
Total	**3,220**	**24,793**

- **Employment**

Production:	380
Upstream	49
Downstream	36

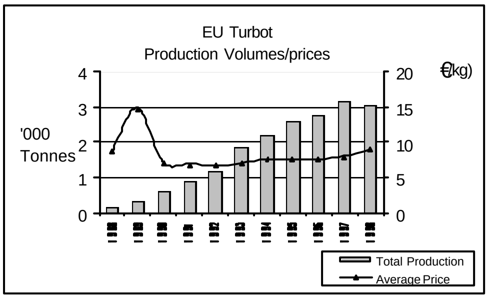
- **Market considerations**

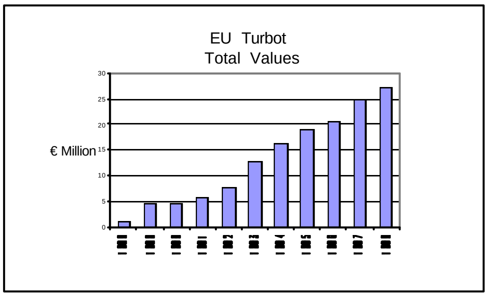
  Whole fresh fish

- **Trade flows (1997, tonnes)**

Total EU production	3,220
Total consumption in country of production	2,505
Total exported to EU Member States	625
Total exported to third countries	90
Total imported from third countries	200-250
EU balance	- 110 to -160

- **Recent trends in output, prices and profitability**





Turbot production has risen consistently until 1997 when there was a slight decrease. Correspondingly value has increased. Prices have seen a gentle gradual increase since 1992, after reaching a peak early on in the development of the sector.

Spain

- Steady increase in both price and production from the start of the industry in 1988, with price rising 42% and production 330%.
- 9 companies, one controlling 60% of production.
- All farms land-based, tank or raceway systems.

France

- The industry has grown each year to 980 tonnes in 1997, then dropped back slightly to 850 tonnes in 1988. Prices remained static at around €7.7/kg during 1994-1997, but increased to €9.5/kg in 1998.
- Production on Atlantic coast, one large company prominent, also supplies 75% of fingerling market.

Other EU Member States

- Portugal and UK have entered commercial production of this species. Relatively low production currently around 400 tonnes per annum, combined. Minor activity in Ireland, Denmark and Germany.

Non-EU Producers

- No significant production.

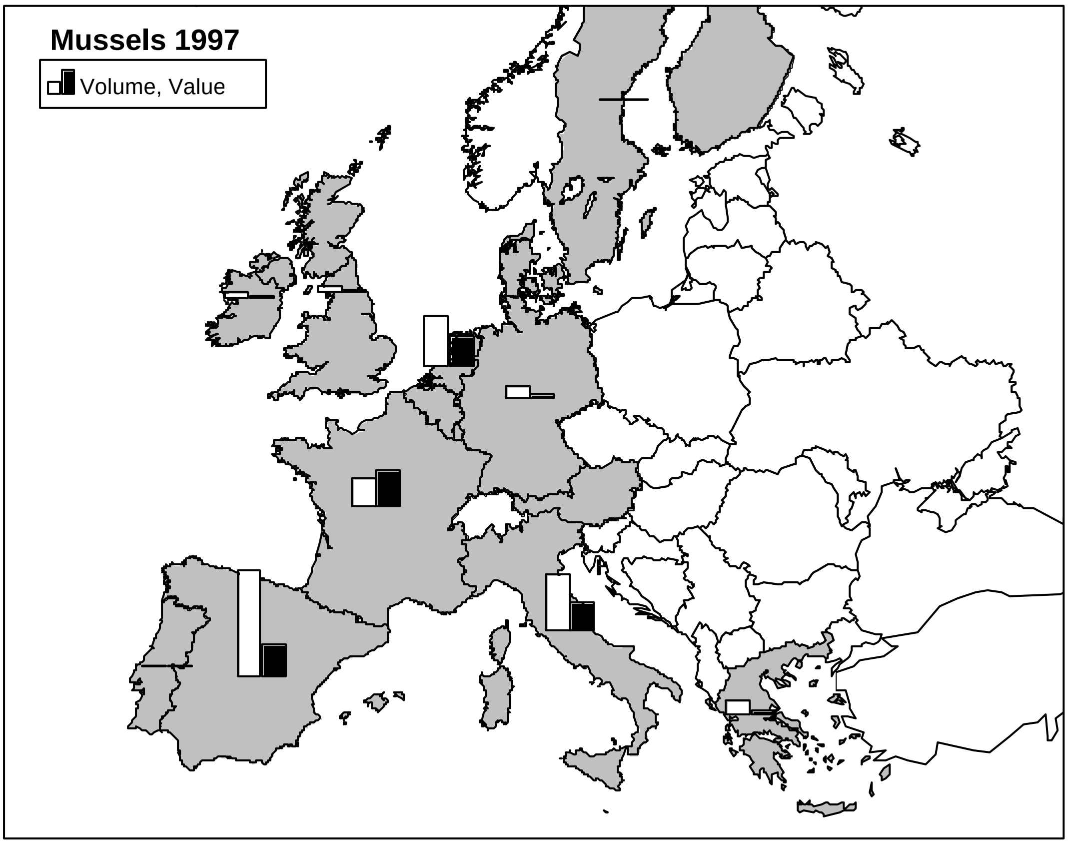
1.2.7 MUSSELS

- **Main species farmed**

Common mussel (*Mytilus edulis*).

Mediterranean mussel (*Mytilus galloprovincialis*).

- **Current output (volume and value)**



	Volume (tonnes)	Value (€ '000)
France	53,604	66,444
Germany	22,330	10,819
Greece	25,434	8,006
Ireland	13,285	6,563
Italy	103,000	53,631
Netherlands	93,200	55,908
Portugal	445	432
Spain	188,793	59,528
Sweden	1,425	629
UK	12,991	7,711
Total	**514,507**	**269,672**

- **Employment**

  Production: 11,114

  Upstream: 1,326

  Downstream: 6,919

- **Market considerations**

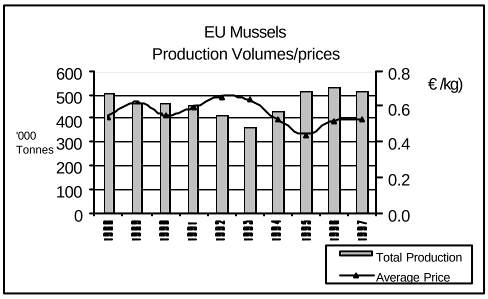
  Most mussels sold fresh, some canning in Spain and Netherlands, some freezing in Netherlands.

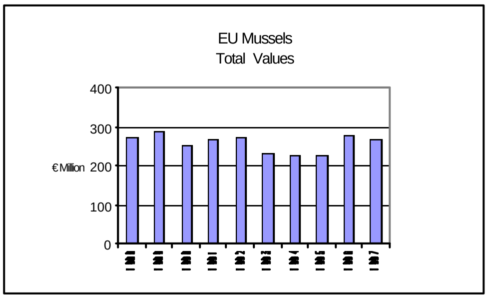
- **Trade flows (1997, tonnes)**

Total EU production	514,507
Total consumption in country of production	373,667
Total exported to EU Member States	135,651
Total exported to third countries	5,190
Total imported from third countries	6,346[1]
EU balance	-1,156

Note 1: may include wild caught.

- **Recent trends in output, prices and profitability**





Output has fluctuated slightly over the decade with a decrease in the early 1990s. Value has largely mirrored this. Prices have fluctuated and show a slight net decrease over the decade.

- On an EU-wide basis, production has remained static compared to other species, at 400,000-500,000 tonnes. The EU industry is dominated by Spain, France, Holland and Italy, where traditional industries are now mature.
- These large producers are largest consumers and have dominated market prices throughout the Union.
- Developing new industries in Greece, Ireland, UK and Sweden.
- Prices have risen with increasing production in some industries.
- Change in profits has been due to handling efficiency and quality gains, not biological advances.

- Profits static or slowly increased in traditional industries.
- Profit more variable in newer industries due to: spat supply, water quality, toxic blooms.

Non-EU Producers

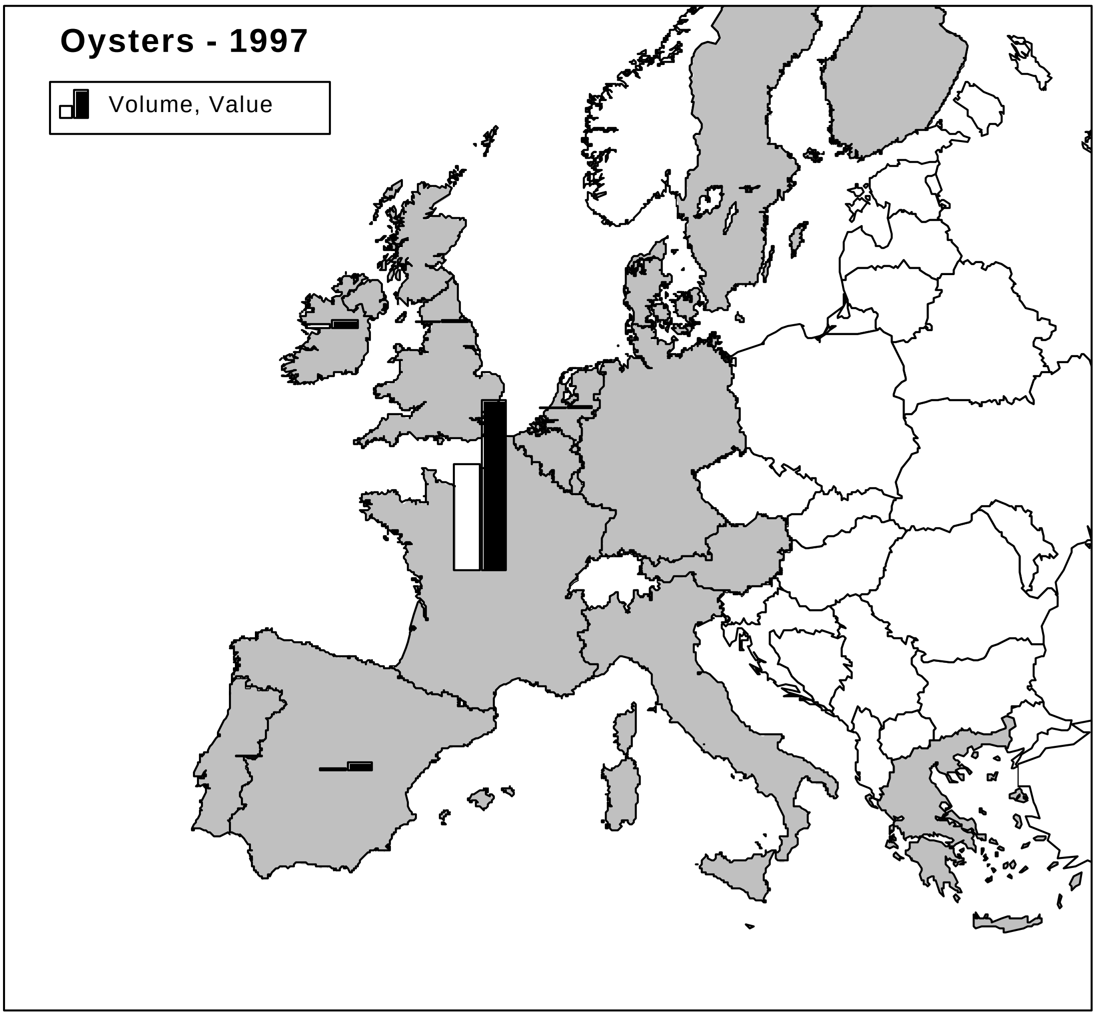
- High production in China, Korea, New Zealand.
- New Zealand currently minor competitor with large mussels produced in Spain.

1.2.8 OYSTERS AND CLAMS

➢ **Main species farmed**

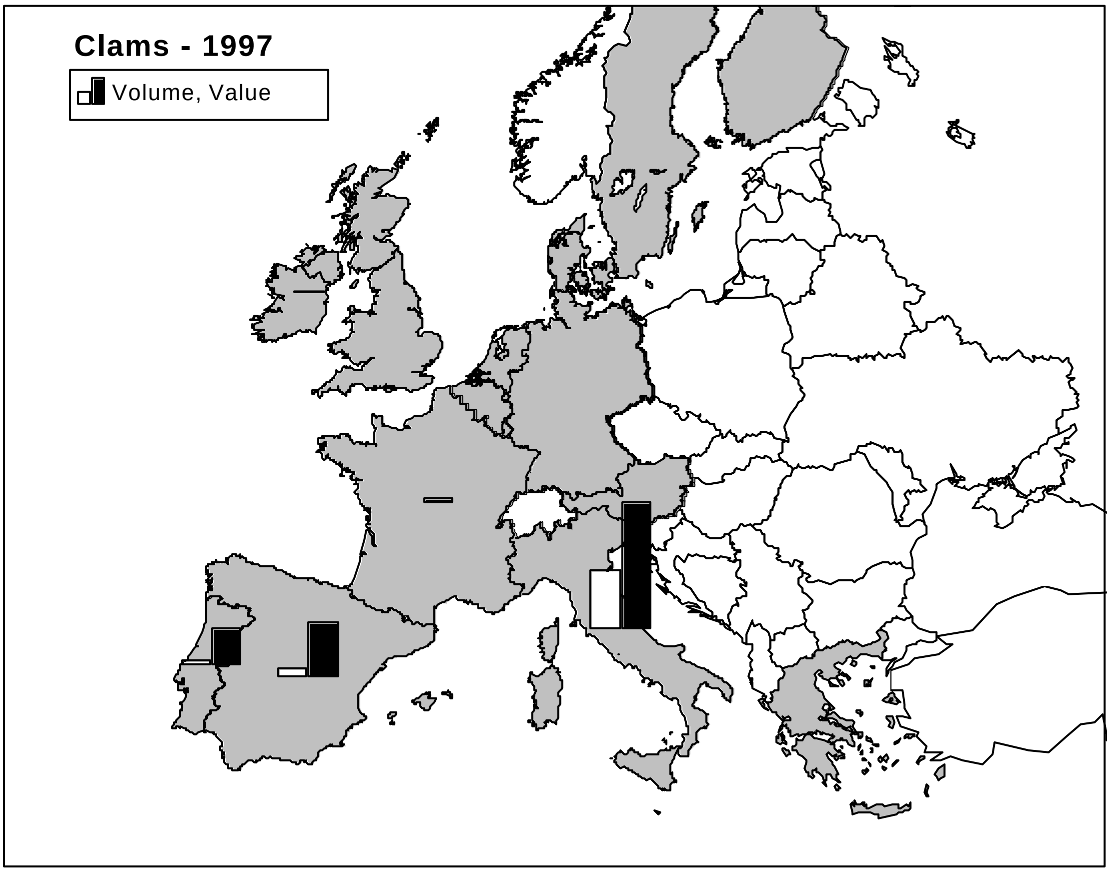
Pacific oyster (*Crassostrea gigas*), native oyster (*Ostrea edulis*), native clam (*Ruditapes decussatus)* and Manila clam (*Ruditapes philippinarium)*.

➢ **Current output (volume and value) - Oysters:**



	Volume (tonnes)	**Value** (€ '000)
France	87,103	138,952
Germany	75	662
Netherlands	1,234	1,981
Ireland	4,406	7,209
Portugal	618	1,200
Spain	3,387	7,893
UK	1,053	2,801
Total	**97,876**	**160,699**

Clams:



	Volume (tonnes)	**Value** (€'000)
France	618	4,215
Ireland	165	1,291
Italy	40,000	83,310
Portugal	3,260	23,897
Spain	5,591	36,071
UK	36	115
Total	**49,670**	**148,899**

- **Employment**

Total employment: 8,946

- **Market considerations**

  Marketed live and unprocessed

- **Trade flows (1997, tonnes)**

  Oysters:

Total EU production	97,876
Total consumption in country of production	88,809
Total exported to EU Member States	8,897
Total exported to third countries	170
Total imported from third countries	283[1]
EU balance	-113

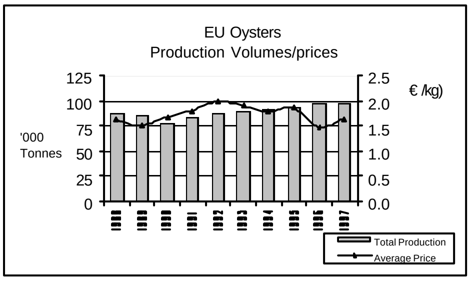
Note 1: Includes wild caught oysters

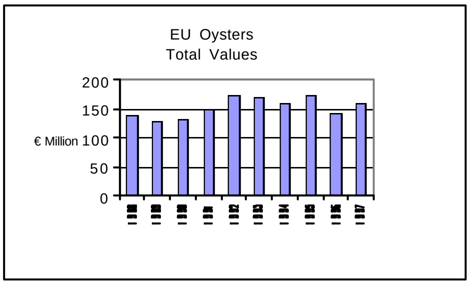
Clams:

Total EU production	49,670
Total consumption in country of production	29,522
Total exported to EU Member States	20,148
Total exported to third countries	0
Total imported from third countries	not available
EU balance	-

- **Recent trends in output, prices and profitability**

Oysters





Output and value have fluctuated slightly over the decade, whilst prices rose up to the early 1990s after which they declined. Prices made a recovery in 1997.

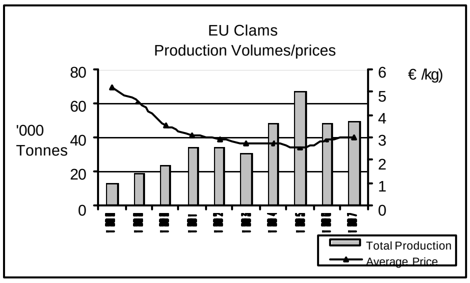
- Output near stable over last 10 years.
- Prices move gradually in relation to supply and demand in main market of France.
- Price movements can be more abrupt for smaller producers.

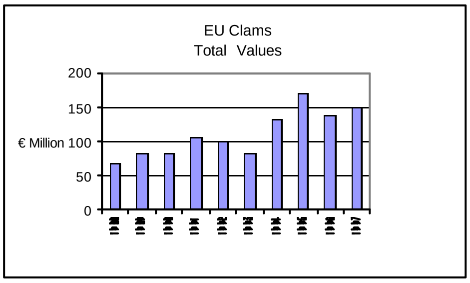
- Profitability for farms selling to public became negative in mid-1990's due to investment burden to comply with hygiene regulations.
- Profitability in Ireland has declined but still positive.
- Profitability in UK has been near neutral throughout last 10 years.
- Major production in Asia but little overlap with EU.

Non-EU producers

- China produces huge amount of Pacific oysters (over 2 million tonnes annually), Korea and Japan each produce over 200,000 tonnes, USA 75,000 tonnes and Mexico 35,000 tonnes. All production goes to local or regional markets, and transport costs make penetration to the live EU market unlikely.

Clams





- The Manila clam is preferred for aquaculture, as it is easier to produce seed in hatcheries, grows faster and is more parasite resistant. However in some Member States regional governments (Galicia, Spain) have banned the use of Manila clam seed for semi-extensive use on beaches and are actively promoting the use of the native clam.
- Manila clam easier and cheaper to produce but lower value.
- Clam production has expanded rapidly, introduced Manila clam in Italy now sustains a wild fishery representing 95% of production in Italy.
- Italy dominant, Portugal and Spain also significant.
- Spain struggling to compete with cost of production in Italy.

Non-EU producers

- China produces over 1 million tonnes of clams and Korea 18,000 tonnes. Imported to EU as frozen meats, often through Holland. Not considered a threat to European producers, who specialise in live product

1.3 ANALYSIS OF HEALTH AND ENVIRONMENTAL CONSTRAINTS OVER THE LAST TEN YEARS

Diseases:

- Many disease challenges in the salmon industry have been overcome but Infectious Salmon Anaemia (ISA) outbreaks in the salmon industry are a major threat in the late 1990s.
- Concerns in the EU over possible negative effects on the environment caused by the use of veterinary medicines to treat parasites have given Norway a competitive advantage over EU salmon producing countries (veterinary medicines for aquaculture have generally been made legally available at a much earlier stage in Norway). Sea-lice mortalities have cost the EU industry an estimated € 14 million *per annum*. The Norwegian industry is coming under increasing environmental scrutiny.
- Increased mortalities due to parasitic infection on seabass and seabream farms, arising as farm sizes increase and management practices generally fail to use fallowing and rotation. In many Member States there are currently no legal requirements to do so.
- Production of the Pacific oyster and mussels continues without major disease threats but European oyster production levels have remained low due to the presence of *Bonamia*.
- Increase awareness of disease problems has resulted in survival levels of 95% Europe wide on well managed freshwater trout farms; mainly due to improved husbandry techniques and use of vaccines. Hatchery survival rates have remained at 70-80% for the last decade.

Health and hygiene:

- Cage farming sector has not been seriously constrained by Health and Hygiene issues, apart from legislation concerning minimum residue levels of some theraputants. Slow licensing of chemical treatments gives competitors an advantage.
- Microbial water quality has been a major constraint in the shellfish industry throughout much of the EU. The cost of depuration measures set out in Directive 91/492 EEC are very significant to producers. Interpretation of the Directive varies between Member States. The Commission's Food and Veterinary Office have analysed and confirmed this to be the case. The Directive is likely to be updated and clarified.
- Harmful Algal Blooms (HAB). Closures due to Diarrhetic Shellfish Poisoning (DSP) and Paralytic Shellfish Poisoning (PSP) have threatened the economic viability of many bivalve mollusc farms. In '97 and '98 levels of domoic and isodomoic acid, the ASP (Amnesic Shellfish Poisoning) toxins, were found to be above the threshold level in scallops on the West-coast of Scotland and Voluntary Closure Agreements (VCAs) were instigated.
- Biotoxin levels are monitored by individual Member States. The national biotoxin laboratories are supported by the designated Community reference laboratory located in Vigo, Spain.
- Integrated farms undertaking processing and packaging have experienced capital burden and operating costs of complying with hygiene directives covering post-harvest operations.

Interactions with the biological and physical environment:

- Discharges from cages have become a significant issue in the last ten years constraining use of sites and biomass levels.
- Most cage sites require Environment Impact Assessments (EIA). Under Environmental Impact Assessment Directive 97/11/EC the size or nature of projects requiring EIAs are determined by Member States. Typically a threshold used in the UK and Greece is more than 100 tonnes capacity, more than 0.1 ha in area or locations in sensitive areas. EIAs can lead to € 50,000 to 100,000 costs to the farmer. Issues primarily relate to the discharge of waste

- Use of sites by cage aquaculture systems can cause conflicts with other forms of aquaculture, navigation, tourism, recreational boating, military activities, wildlife, and waste dispersal. This has extended application procedures and limited availability of new sites.
- Compliance with regulations has lead to offshore cage technology being developed and implemented, notably in Ireland and the Mediterranean, leading to increased start-up costs, but lower unit production costs.
- Limited availability of land bases have constrained development of cage farms in some areas.
- The use of high value species in cage aquaculture systems has lead to increased incidences of theft, leading to a degree of reluctance to use unattended cage systems.
- Eel farming is becoming constrained by the availability of wild elvers for stocking purposes.
- Freshwater farms have faced tighter control over water use and discharge in the last ten years, adding to costs and reducing site availability. Regulations vary considerably between Member States.
- EU-wide legislation regarding treatment of freshwater is currently under review.
- Waste discharge from shellfish farms is usually not regarded as damaging to the environment, but there is a possibility that highly productive large scale operations may exacerbate algal blooms (red tides) through nutrient enrichment.
- Shellfish farms have been constrained by the following considerations at their planning or operational phase over the last ten years:
    - Competition for feed;
    - Predator control;
    - Sharing of seed resources with other wild life;
    - Historic or new discharges, to coastal waters especially sewage;
    - Aesthetic view of long-lines/mussel rafts;
    - Navigational restrictions, especially objection to longlines;
    - Loss of public fishery grounds to private concessions;
    - Conflict with fishery interests for mussel seed;
    - Space for yacht moorings; and
    - Competition for shore-side land and facilities.

Broader constraints:

- Many other factors which have had an impact on the aquaculture industry development can be summarised as being related to competition for use of the water resource and aesthetic problems relating to the presence of aquaculture systems in areas of natural beauty.
- The availability of affordable coastal land for pumped-ashore farms is a major constraint.
- Increases in the cost of fishmeal due to lower production levels during El Niño years, affecting Peru and Chile, have had a negative effect on profitability of fin-fish farming. Fishmeal prices are currently dropping after reaching highs of US$700 per tonne in ’98.
- Public awareness of the aquaculture industry, and its use of aquatic resources, has increased considerably in the last ten years. This has inevitably filtered through to tighter environmental legislation concerning availability and operation of sites in many instances.

2 OUTLOOK FOR FUTURE DEVELOPMENT

2.1 INTRODUCTION

The future development of aquaculture depends not only upon future supply potential but also upon the future market for aquaculture products. The economic sustainability of aquaculture requires a balance between expansion of production and market development. The development of aquaculture cannot be separated from the development of the fisheries sector generally, although the market and resource use links between the two are not always clear. The impossibility of meeting growing demand for fish from capture fisheries is widely seen as the context for aquaculture development. Total EU capture fisheries production has remained static at 12-13 million tonnes; the continued growth of aquaculture has resulted in its contribution towards total fisheries landings being close to ten per cent. Aquaculture can also create a market for particular products by increasing availability and lowering prices, as the cases of farmed salmon and seabass and bream illustrate. The product cycle for farmed salmon has been similar to that of broiler chicken in this respect. However, aquaculture brings with it new problems – not least it raises new food safety issues because of the human interference in the food production cycle. In the following sections, those demand and supply factors which will shape the development of the sector over the next decade are reviewed. This review then forms the basis for a simple projection methodology to explore alternative development scenarios and their implications on a species by species basis.

2.2 FUTURE DEMAND FOR FISH AND FISH PRODUCTS

Changes in eating habits with an increase in 'casual vegetarianism' (non-red-meat-eating) as well as trends towards greater consumption of convenience food and processed fish have improved the market position of fish, although it remains a relatively expensive source of protein. With the shortfall in supply of landed fish, aquaculture, while producing a differentiated product, has been able to capitalise on the demand for fish and fish products. There is inevitably generalised competition between capture and farmed supplies in consumption, but the extent to which farmed and capture supplies are regarded as direct substitutes varies from one species to another. For the species considered here, except for turbot, bass and bream, there is little, if any, wild caught fish available in most markets. Given the rather blurred distinction between aquaculture and capture products, much of the discussion of demand and markets applies equally to products from both sources. With the exception of salmon, demand and markets for farmed fish *per se* have been little investigated mainly due to the lack of sufficiently specific data which distinguish between farmed and wild caught fish. The major influences on fish consumption are discussed below, drawing particular inferences for aquaculture as appropriate.

Underlying growth in consumption can be attributed to income and population growth. Relative price movements result from the reconciliation of movements in demand and supply. These effects can all be quantified and projected given assumptions concerning the relevant elasticities. However, much of the change in the level and structure of fish consumption reflects more subtle and complex demographic and attitudinal variables. Ageing populations, changing gender roles, smaller household sizes, dietary concerns, food safety issues and ethical concerns are evident throughout Europe. Fish consumption has benefited from these trends. Quantifying these trends is difficult, not least because there may be offsetting influences – a positive effect due to increasing interest in healthy-eating, but a negative effect because of food safety concerns.

2.2.1 Relative price movements and price elasticities

- The own- and cross-price elasticities of demand for farmed fish are of vital strategic importance in the development of aquaculture.
- Numerous econometric studies of the demand for salmon, and to a much lesser extent other fish, have provided some estimates of these key economic parameters. However, these vary significantly from one study to another: from virtually zero to nearly minus three. Studies of the

demand for fish more generally have shown similar wide variability but own-price elasticities for most species appear to average around –1.0. This is probably an appropriate value for most farmed species. Elasticities for less popular, cheaper fish such as herrings and mackerel would be expected to be lower: perhaps around –0.5. A value such as this would seem appropriate for the less popular farmed fish such as carp and, perhaps, eel.

- The own-price elasticity of demand, or more precisely its inverse the price flexibility (a measurements of the responsiveness of price to changes in the quantity marketed), is the key determinant of how much price will fall for any given increase in quantity.
- For the purposes of projections some broad consensus values need to be taken. An assumption of –1.0 for the price elasticity of demand for all species except trout, carp, eels and mussels is plausible and not too far out of line with the available empirical estimates. For trout, carp, eels and mussels a value of –0.5 is plausible.

2.2.2 Income growth and income elasticities

- As consumers become more affluent their consumption of fish and fish products tends to increase.
- An income elasticity of 1.0, implying that growth in salmon consumption will match growth in incomes, is probably a realistic assumption since there is some evidence that farmed salmon is losing its luxury market image and may be perceived as ‘the broiler chicken of fish’.
- Income elasticities show the percentage increase in demand as income grows. Income growth assumptions for the EU15 used in the projections are taken from the latest OECD *Agricultural Outlook* (OECD, 1999) for the period up to 2004. These assume a 2.2 per cent growth in 1999, and a steady 2.5 per cent growth thereafter.

2.2.3 Influence of demographic factors

- In general, one would expect the total demand for any commodity to grow in proportion to the growth of population, since the latter determines the overall size of the market.
- The population projections employed in this study are those employed in the most recent OECD *Agricultural Outlook*: a steady 0.3 per cent growth per annum.
- The projections of fish demand made here assume demand to grow in line with population, but these broad movements in the total population mask significant changes in its structure which may have important implications for the structure of food demand. The main features are: more single person households, decreased fertility, decline in marriage, a greater incidence of divorce, an ageing population due to increasing longevity. These factors have led to a decline in the nuclear family mealtime. Changing trends in eating habits have benefited the snackfood, processed and ready cooked convenience food sectors.

2.2.4 Influence of social factors

- Consumption also varies with socio- economic group. Changing lifestyles throughout the EU will continue to have an impact not only on the quantity of fish consumed but also the ways in which it is consumed.
- Longer working hours and increased female participation in the full time workforce have led to a decline in the preparation of food from basic ingredients. Lack of knowledge in how to prepare and cook fresh fish and a dislike of bones has led to a decline in the consumption of fresh whole fish among younger people in particular. Convenience and frozen foods have increased in popularity as consumers of all ages, but especially the young, devote less time to food preparation.
- The move towards more convenient presentations of fish has been accompanied by the expansion of the supermarkets as major sources of fish purchases. The consequence has been the relative decline of the small independent specialist fishmonger. This decline has been most pronounced in

Northern Europe: multiple retailers now have up to 60% of the fresh/chilled market for fish and up to 70% for frozen in UK, Germany and the Netherlands; in France the multiples' market share is around 50%.

2.2.5 Shifts in consumer attitudes

- Shifts in consumer attitudes and preferences have been an important factor influencing the demand for fish in general. Fish has been seen as a 'healthy' product and has benefited from the trend towards reducing meat consumption.
- Besides price and quality consumers are increasingly concerned with how their food is produced. Farmed fish may arouse concerns for animal welfare as any intensive livestock production system, for example. The environmental effects of intensive fish farming may also provoke a negative consumer response.

The demand for added value products

- With static consumption levels of food in general, there is competitive pressure in the food industry to create added value and to innovate.
- The demand for fresh fish is limited or declining whereas demand for frozen and value-added products is expanding.
- Value-added products are well-suited to the multiple retailers. Such products might be chilled or frozen, coated, smoked, or even complete recipe dishes. The value added fish products sector is forecast for growth. Aquaculture production methods allow continuity of supply, size and quality assurance of the raw ingredients. These features are particularly attractive to the food processing industries.

Dietary trends

- Healthy eating trends have undoubtedly had a positive effect on fish consumption. Fish is a high quality source of protein with lower fat and cholesterol levels than meat products .

Food scares

- Consumers are increasingly concerned and aware of what they eat and this influences their purchasing decisions accordingly. Fish consumption may have benefited from food scares associated with alternative sources of protein, especially meat and BSE. Recently fish farmers have reported increases in their salmon sales to Belgium in response to the dioxin scare in pork.
- Fish and shellfish are generally considered to be healthy foods and hence a 'safer' alternative to intensively-reared livestock products.
- Possible food safety hazards in aquaculture products are listed in Table below.

Possible food safety hazards in aquaculture products

Biological		**Chemical**	
Parasites	Parasite of public health significance: Trematodes, Nematodes, Cestodes Clonorchis, Opisthorcis, Paragonimus	Agrochemicals	Disinfectants, pesticides, herbicides, algaecides, fungicides, anti-oxidants (added in feeds)
Pathogenic Bacteria	Salmonella, Shigella, E. Coli 0157, Vibrio cholerae, Vibrio parahaemolyticus, Vibrio vulnificus, Listeria monocytogenes, Clostridium botulinum	Veterinary drug residues	Antibiotics, growth promoters, (hormones), other feed additives, from animal manure

Biological toxins	Scrombrotoxin, Ciguatoxin PSP: Saxitoxins DSP: Okadaic acid ASP: Domoic acid Isodomoic acid	Heavy metals	Metals leached from soil, from industrial wastes, from sewage or animal manure

From FAO aquaculture newsletter No 19, August 1998

- There will be increasing interest in the development of regulatory frameworks for aquaculture to protect the industry, the consumer and the environment. The question arises as to the effect on costs and the rate of aquaculture development where new investment is needed.

2.3 OUTLOOK FOR PRODUCTION COSTS AND ENVIRONMENTAL CONSTRAINTS

2.3.1 Future trends in production costs

The cost base of aquaculture is focussed on:

- feed
- repairs
- fuel
- staff
- insurance
- marketing
- capital expenditure
- veterinary services
- rentals
- juveniles
- water costs

In a cross sector analysis, trends are exhibiting the following characteristics:

Feed: The production of fish meal has been fairly stable over the last decade at 6-7m tonnes and is likely to remain so over the next decade, El Niño events permitting. Estimates for use of fish meal by aquaculture for the year 2000 are 2.11m tonnes, or some 32% of supply. This has risen from 17% in 1994. The estimate for 2010 has recently been revised upwards to 2.83m tonnes or some 44% of likely supply. It seems likely that the underlying trend will be for fish meal prices to drift, rather than accelerate, upwards over the next decade from a realistic starting point at pre-El Niño levels. However events in 1998-9 have shown how volatile this market can be and further disruptions are likely.

It would be a mistake to abandon the significance of fish oils as subservient to that of fish meal. There is a risk that quality fish oils could prove to be the more finite commodity in the next decade as aquaculture is projected to use 87% of world supply in 2010. This has obvious implications for the salmon sector and others where much of the dietary energy is provided as oil at present.

For the purpose of projections of feed prices, it is assumed that reduction in fishmeal dependency in aquaculture diets will neutralise the upward drift of fishmeal prices foreseen

Staff: Costs will tend to reduce with stabilisation of wage increases and improvements in productivity.

Capital expenditure: This area is particularly aligned to investment in technology which provides an early return via improved productivity. Such items include sea pens, tanks, pumping systems, computerised feeding mechanisms, work boats and automated vaccinating equipment. Costs in investment per unit output should decline as industries grow as they have in the past. However if further expansion depends on more expensive engineering solutions to environmental constraints then unit costs will rise.

Juveniles: With increases in productivity, and vertical integration or power of bulk purchase, the price of juveniles continues to be driven down, and will become stable during the next decade.

Repairs: With a tendency to core technology being composed of steel, fibreglass or polyethylene, fish and shellfish farmers in the Community have learned to extend life of product through repair and refurbishment by the original manufacturer. Repairs costs will increase while capital expenditure decreases in times of low profitability.

Insurance: Through risk management applied by insurers in partnership with producers, generally insurance costs promise to decline slightly per unit output.

Veterinary services and medication: Professional services from vets remain a stable cost. Fish are typically inoculated in the hatchery phase. Vaccines have been subscribed to increase in productivity in key sectors. However, due to their typically becoming multivalent (a number of diseases covered in one dose), costs are rising against reduction in sale price of juveniles to ongrowers.

Water costs: The costs of access to water will probably increase. This is expected to be felt in fresh water in particular through either direct increase in charges per unit volume or through stricter environmental standards on discharge. The overall result will be the same: higher investment and operating costs to the producer to either increase production per unit volume (re-circulation, oxygen injection etc) or to treat effluent waters.

Fuel: The inflationary trends of these commodities will be alleviated by continuing improvements in productivity.

Marketing: The trend in all EU Member States is for the bulk of seafood to be sold through multiples (supermarkets). Multiples, as policy, impose their own criteria and protocols on growers, typically at the cost to the latter. Whilst long term contracting eases costs for producers and buyers, this favours large producers, not SMEs. To participate in these benefits, SMEs need to demonstrate strength of organisation, typically through producer co-operatives. Hence, SME's will bear a larger increase in costs of marketing during the next ten years but with the benefit of some stability in price.

Rentals: Rental cost of land, buildings, access roads etc for farms and shorebases will vary according to location. Inland in non-scenic areas they can be expected to follow the general trend for agricultural or light industrial rents and are assumed so stay neutral in forecasts. For coastal areas, particularly scenic or tourist the trend will be upwards with continuing increases in pressure on the coastal zone with many users. Sea area rentals for cages, longlines etc will probably stay neutral. In some Member States these are geared to tonnage and it seems unlikely that states will increase these given the marginal profitability of salmon in particular.

Increased technical and economic efficiency

For the future, the main efficiency gains will be based on
Nutrition: Conversion ratios for gross protein consumers such as salmon and trout will be lowered to best ever levels of 1:1.1, and 1:1.5 for bass and bream. If other protein sources are substituted for fishmeal then conversion may suffer.
Equipment: A substantial segment of EU aquaculture still has the technical opportunity to invest in larger holding facilities to enhance productivity and profitability. Much equipment is increasingly computerised. Hatchery equipment is more and more aimed at manipulation of life cycles.
Health: The last decade has seen a swing towards provision of very effective, specialised fish vaccines and antibiotics.
Genetics: Genetic mapping will significantly increase the efficiency of selective breeding programmes. Improvements to growth in seabass, for example, are reported to be in the region of 10% per generation. In the shellfish sector, those industries relying on hatchery seed (some oyster, some clam) stand to benefit from selective breeding.

2.3.2 Environmental constraints

The purpose of this section is to identify the main environmental constraints limiting the further development of aquaculture and examine options for their mitigation.

Water Quality

Freshwater aquaculture: aquatic farming in freshwater, and in particular those operations depending upon surface water flows, is particularly vulnerable to upstream changes in water quality.
Mariculture: coastal aquaculture has traditionally been limited to shallow, inshore waters, due to cost-related logistical reasons (cost of moorings, feed transfer, personnel deployment etc.) and the need to locate aquaculture in sheltered locations. These locations are commonly shared with other coastal users, and often experience water quality problems and resource user conflicts.
The main constraints to the expansion of coastal mariculture due to water quality problems are summarised in Table below:

Water Quality Related Constraints to Coastal Aquaculture

Pollution Type (and Source)	**Effects**	
	General Environmental Effects	**Constraints on Aquaculture Production**
Organic (sewerage, agriculture, industry)	Increased biological oxygen demand, algal blooms, formation of anoxic sediments, change in ecosystem structure	Stress-related disease and stock mortality, phycotoxic effects, reduced site carrying capacity; increased net fouling
Inorganic (heavy metals, pesticides, PCB's, dioxins, etc)	Chronic sub-lethal effects on flora and fauna, genetic distortion and biodiversity impacts	Possible bio-accumulation that may affect consumability; sub-lethal growth impacts, lowered resistance to disease
Suspended solids (river catchments, coastal engineering, seabed mining activities)	Reduced productivity, smothering of benthos, change in ecosystem structure, benthic habitat loss.	Gill irritation; siltation of water supply system, reduced bivalve growth and contamination of stock
Pathogens (sewerage)	Includes hepatitis A & B viruses, gastro-enteritis and cholera	Accumulation and human exposure through shellfish
Thermal (power generation, industry)	Localised change in ecosystem structure	Impact on fish growth (may be positive)
Oil spills	Oiling of sediments	Tainting of flesh
Desalination	Increased salinity	Osmotic stress effects on growth

Feed waste: the hypernutrification generated by farmed fish faeces can affect quality of downstream water. The use of 'high energy' (that result in reduced ammonia-N loading) and 'low pollution' (high digestibility, low P) diets, together with the development of improved feeding management, have reduced the production of polluting wastes (this allows more production in areas subject to effluent consent requirements, such as Scotland).

Site Availability and Carrying Capacity

Site availability: Many of the best and most obvious sites have been filled, with increasing competition for the remaining suitable areas. This has resulted in a number of effects:

- Production intensity at existing sites may increase until productivity is affected - in many cases this only becomes obvious after the ecological damage has been caused; the mitigation response has been the development of fallowing strategies and single bay management techniques;
- As the better sites are already occupied, compromises might be made on new site selection;
- Farm operations are moving offshore.

Carrying capacity: it is now recognised that particular sites and semi-enclosed ecosystems (i.e. lakes or bays) have a finite environmental carrying capacity i.e. the upper limit of the site to assimilate human-induced impacts without unacceptable long-term ecological change. Predictive modelling of carrying capacity of individual bays for aquaculture have been carried out (including two EU projects on trophic capacity of estuarine ecosystems and a recently funded EC programme looking at aquaculture capacity in the enclosed bays of the East China Sea). These models are currently complex, data intensive exercises, but offer a useful means of identifying the nutrient assimilative capacity of receiving waters and thus a way of planning the strategic development of aquaculture.

Resource Allocation Conflicts

Water: With water becoming an increasingly scarce and economically valued commodity, land-based aquaculture is subject to growing constraints, and in restrictions and costs for access.

Space: aquaculture production units take up space. In many cases this is valuable, since aquaculture tends to occupy areas such as river corridors, the coastal supralittoral or inshore waters. As a result, conflicts may develop with other coastal resource users (see Table below).

Resource User Conflicts of Aquaculture

Culture System	**Resource Utilisation / Impacts of Aquaculture**				**Other Resource Users and Level of Conflict**							
	Space occupation	Visual impact	Water consumption	Effluent levels	Urban development	Industrial development	Tourist development	Recreation	Water navigation	Land transport	Capture fisheries	Conservation interests
Intensive freshwater cage culture (finfish)	+	+++	-	++	-	-	++	+++	+++	-	+++	++
Intensive freshwater tank / raceway culture (finfish and crustacea)	++	++	+++	+++	+	+	++	++	-	++	++	++
Semi-extensive freshwater pond culture (finfish)	+++	++	++	++	++	++	++	++	-	++	+	++
Marine land-based pond/raceway culture (finfish and crustacea)	++	++	++	+++	+++	+++	+++	++	+	++	+	+++
Marine inter-tidal culture (shellfish)	+++	+++	+	+	+	+	++	+++	+	-	+++	+++
Marine cage culture (finfish and shellfish)	+	+++	+	++	-	-	++	++	+++	-	++	++

High (+++), Medium (++), Low (+) & None (-)

2.4 PROJECTION METHODOLOGY

This section describes the simple methodology employed to generate ten-year projection scenarios for EU aquaculture on a species by species basis. This methodology attempts to capture the major influences on the supply and demand for aquaculture products and therefore on prices and profitability. These are summarised in the figure below. Clearly ten years is a substantial time horizon, so the analysis presented here must be regarded as a projection of possible broad future developments given various stated assumptions rather than a precise forecast.

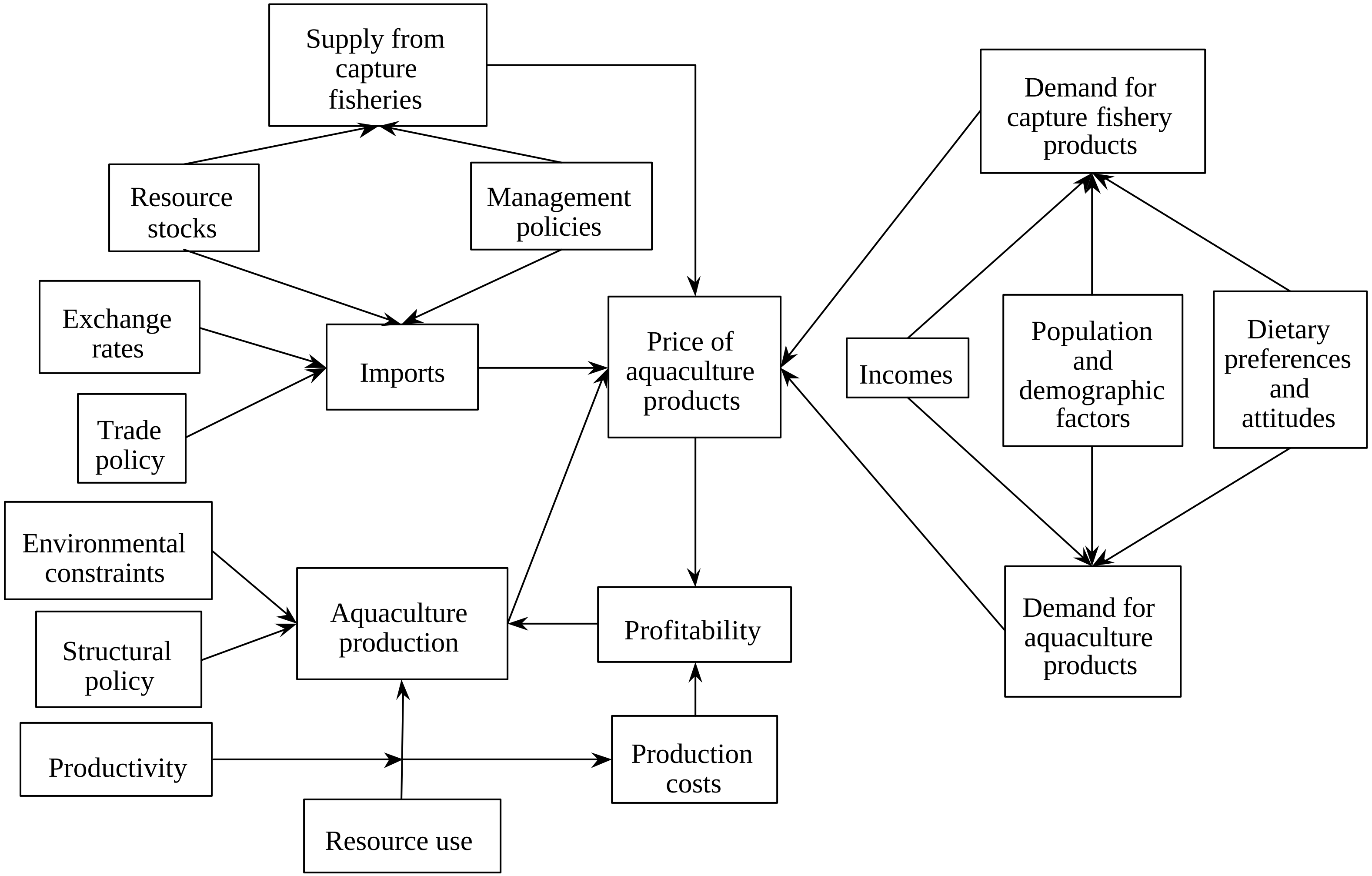
The methodology emphasises the importance of demand in driving aquaculture development. It begins from a perspective of the EU demand for products from all sources – captured and farmed. For some farmed species there is little if any capture production, and even where there is, farmed and capture supplies may not compete due to product differentiation. Where there is supply from capture fisheries (mainly bass and bream), the potential supply from this source, both domestic and imported, can be set against overall demand to estimate the potential market for aquaculture products. However, there is no guarantee that aquaculture can entirely fulfil that potential. A variety of economic, technical and environmental constraints will limit production potential. Price movements are projected on the basis of a comparison of market potential with production potential. These price projections together with projected changes in costs of production allow a projection of future profitability and hence the sustainability of EU aquaculture in the medium to long-term. Resource use by aquaculture, notably employment, can be projected from the production level through the application of simple input-output coefficients.

The demand for aquaculture products will follow the same trends as the demand for fish and fish products in general and be driven by the same basic economic and marketing variables - consumers incomes, relative prices, population growth, consumer preferences and attitudes. In general, continuing income growth and population growth will add to the demand for fish. More importantly, preference shifts may also encourage greater fish consumption. Evidence from other food markets indicates that as consumers' incomes rise, price considerations become less important. Attitudinal variables become more important drivers of market growth. Measurement of attitudinal effects is problematic, and projection work typically employs "trend extrapolation" to pick up these influences. These trends are established from historic demand data after eliminating the effects of real price, real income and population changes.

It appears to be generally accepted that current catch levels world-wide will not significantly increase so aquaculture production is unlikely to face growing competition from capture supplies. EU waters in particular cannot be expected to yield higher catches. The potential for aquaculture is therefore clear. However, this should not be taken to imply that any farmed fish will find a ready market. Carp, for example, is unlikely to enjoy any significant market growth. At the same time, product development may open up new markets for certain species as in the case of salmon. Aquaculture development will only materialise if the economic, technical and environmental conditions are right. The legislative framework concerning environmental and other external effects can only be expected to become stricter. Assumptions in the projections concerning the supply potential of aquaculture for different species are based on the extrapolation of trends presented earlier and the study team's assessment of the future outlook.

The externalities of aquaculture may also prove important determinants of consumption growth. Concerns over sustainablity, environmental degradation and food safety can only become more pronounced. It appears, therefore, that many of the constraints on expansion of fish farming are likely to become more binding over the next decade.

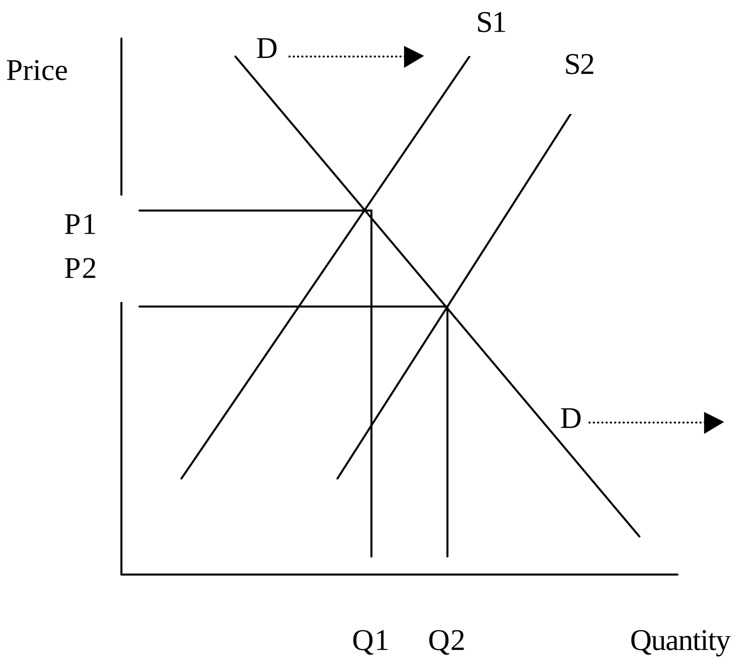
Aquaculture Projection Methodology



Management of capture fisheries involves a major structural adjustment problem in EU fishing regions, so the employment potential of aquaculture is of great interest. The idea that aquaculture might provide employment to those displaced from employment in capture fisheries has been a feature of EU structural policy. However, the extent to which this is possible is probably quite limited since the necessary skills are quite different and aquaculture is often not practised in traditional fishing areas. Employment coefficients for farming of each species covered are used later to derive projections of employment for projected levels of aquaculture production.

Bringing together the projections of the demand for farmed fish with those of the supply projections allows one to project the extent of any excess demand or excess supply given the assumptions upon which the projections are based. Market balance is the key determinant of price movements in aquaculture product markets. The figure below illustrates this problem.

Production expansion and market development



The vertical axis measures the price of a species, while the horizontal axis measures the quantity. The demand curve, D, shows the quantity which will be demanded at each price. The supply curve, S1, shows the quantity supplied at each price. The intersection of the two curves shows where the market is in balance with demand equal to supply at quantity Q1 and price P1. The demand and supply curves show the relationship between quantity and price. Any changes in other factors will shift their position. So, as incomes rise consumers may demand more at any given price and the demand curve will shift to the right. Similarly, as productivity increases more can be supplied at any given price and the supply curve will shift to the right.

The trend in prices for aquaculture depends on the balance between the rightward shifts in the supply function, S1, and the demand function, D. The supply curve shifts from S1 to S2, for example, as production expands and as productivity improves through technical progress. It can also shift as volumes of imports increase. This can be slowed by trade policy measures of the kind applied in the case of Norwegian salmon. The demand curve shifts to the right as a result of, for example, income growth, population growth and favourable shifts in consumer preferences that may be engineered in part by sales promotion. It is only if the rightward shift in demand matches the rightward shift in supply that price levels will be maintained. If the demand curve remains unchanged or shifts right at a slower pace, the price will fall, and the extent of that fall will be measured by the price flexibility.

Excess supplies (relative to market growth) of bass and bream led to sharp falls in prices of 53% between 1989 and 1994. The recurrent problems of market balance for farmed salmon are well-known. These further illustrate the fact that it is not just EU supplies which enter into the sometimes fragile market balance. In the salmon case it is variations in Norwegian supplies which have been the main determinant of international salmon prices. Projections of market balance and the consequent price adjustments therefore need to take into account the EU's external trade position. As noted above, this is particularly important for salmon, but also, to a lesser extent, for bass and bream.

Whether aquaculture can operate profitably at the projected prices depends upon the costs of production. These are projected on the basis of likely future costs of inputs and productivity improvements.

Analysis has been undertaken on the influence of grant aid on the sector over the last ten years. The data available was inadequate to reach a statistically significant conclusion. In any event grant aid is unlikely to alter profitability trends to a great extent. Therefore the scenarios discussed below exclude consideration of the role of grant aid.

The methodology outlined above is used to explore alternative development scenarios. Here, four basic scenarios are explored. These are selected to throw some light on the importance of the issue of market balance between increasing production and consumption.

- Scenario 1. Production grows at its maximum potential, with demand rising according to its historical relationship with incomes, population and trend effects
- Scenario 2. More plausibly, production grows at half its potential (for example as a result of increasing environmental constraints), with demand rising according to its historical relationship with incomes, population and trend effects
- Scenario 3. Production grows at its maximum potential, but trend effects on demand are halved as a result of an adverse consumer reaction to food safety concerns for aquaculture products, etc..
- Scenario 4. Possibly the most plausible, production grows at half its potential and trend effects on demand are halved.

In each case, the effects on production, consumption, prices and profitability are examined. For some species, not all of these scenarios are relevant: some already face a negative demand trend, for example. In such cases alternative scenarios are explored.

The assumptions concerning income and population growth are as specified earlier. OECD projections of EU15 inflation rates are also used. Assumptions concerning production potential and costs are discussed in the next section for each species. Assumed price and income elasticities are as discussed earlier.

2.5 ANALYSIS FOR INDIVIDUAL SPECIES

2.5.1 Salmon

- Consumption has enjoyed a variable but strong upward trend during the 1990s, increasing by 10% or more in some years. This is largely due to positive shifts in consumer preferences towards greater consumption levels. This is turn reflects the concerns with healthy eating mentioned earlier and also the increasing availability of salmon and salmon products through the multiple retailers. Excluding the influence of price changes and income and population growth, these positive trend effects account for around 6% per year growth.
- On an EU basis the maximum feasible production growth is probably around 4% per year. Growth potential is likely to be constrained by a number of factors: the tightening of environmental policy; a shortage of new sites; prohibitive cost of truly offshore technology for Atlantic conditions; and continuing ISA problems. Survival rates should be maintained, apart from the ISA factor that could keep the average down.

- Production costs will fall slightly with further growth, mostly due to further increases in efficiency in labour. Feed costs per tonne are assumed as stable at 1996 levels. Capital expenditure per unit output has a natural tendency to fall with growth but it is estimated this will be neutralised by more expensive engineering solutions. Unit cost of eggs and smolt will continue to fall through increased stock performance. Licensing of new sea-lice compounds will result in better overall productivity in the short term and sea lice vaccines may improve the situation further later in the next decade. Cost changes are therefore likely to be in the range of -2 to –5% per year.
- Exports to the EU from all sources are assumed to increase by 6% per year. This implicitly further assumes that Norway and Chile will be successful in their attempts at export diversification, and that the current volume limitations on Norway will remain in place. It is also assumed that EU export volumes remain at their current levels.
- The strong growth in demand due to the positive trend effects mentioned earlier and the growth in income means that even the assumed maximum potential production growth can be accommodated with improving profitability. However, this is sensitive to variations in import volumes: price and profitability increases are wiped out by even slightly higher levels of imports in most scenarios.

Salmon Scenarios % change

Scenario	*Production*	*Costs*	*Demand*	*Profitability*
1	4	-3	9	+ to 2002; ++ to 2006; +++ to 2010
2	2	-3	9	+ to 2000; ++ to 2004; +++ to 2010
3	4	-3	6	+
4	2	-3	6	+

Notes
Profitability increase: +++ high; ++ medium; +low
Profitability decrease: --- high; -- medium; -low

2.5.2 Trout

- Trout consumption has followed an erratic but generally upward trend during the 1990s, with the exception of the most recent year for which data is available, 1997. Prices have followed a similarly erratic course. In both cases these movements reflect the underlying variations in production levels. Excluding the influence of population growth, income and real price movements, a trend effect (reflecting shifts in consumer attitudes) of around +1% per year is apparent.
- Production growth will be constrained by the increasing price of water and cost of treatment of effluent. Industry estimates suggest that expansion of the trout sector is possible with more active growth such as in Spain, through investment in modern technology, but this will be cancelled out by reductions where environmental controls are increasingly restrictive, such as in Denmark. Overall, maximum EU production growth could reach 2% per year.
- Production costs may be reduced by gains from better growth through genetic selection and survival through disease control. However there will have to be further investment in water treatment and associated running costs. Feed has the possibility to fall in terms of costs per unit output as development of fishmeal substitutes is more advanced than for salmon. Overall production costs should remain approximately neutral on an EU wide basis.
- The results of the scenario analysis illustrate the crucial importance of balance between expanding production and increasing consumption. With the maximum production growth rate in line with demand growth, modest improvements in profitability result (scenario 1), with greater improvements where production remains unchanged (scenario 2). However, where production overtakes demand (scenario 3) consequent falls in price with unchanged costs turn a small profit into a small loss.

Trout Scenarios % change

Scenario	*Production*	*Costs*	*Demand*	*Profitability*
1	2	0	2.4	+
2	0	0	2.4	+ to 2001; ++ to 2006; +++ to 2010
3	2	0	1.5	+ to 2003; - to 2010
4	0	0	1.5	+ to 2003; ++ to 2010

Notes
Profitability increase: +++ high; ++ medium; + low
Profitability decrease: --- high; -- medium; -low

2.5.3 Carp

- Demand for carp has shown little sign of expansion during the 1990s. The trend effects on demand after the exclusion of the effects of price, income and population changes are strongly negative at more than 4% per annum.
- The potential for expansion of carp farming is large through intensification – up to 10% per year. The sector has contracted in the last ten years for economic reasons but the production capacity still exists, provided the bird predation problem can be overcome. A lot could be done with intensification to exceed historic levels. However, intensification will raise costs by up to 10% per year.
- Under any realistic scenario excess supplies and price reductions are inevitable. Further contraction of the industry seems likely. Even with more modest growth rates, production far exceeds demand and prices fall quite catastrophically. Removing the negative trend effects on demand allows maintenance of prices and profitability in the short-run, but counteracting the negative image of carp for consumers would be a major task.

Carp Scenarios % change

Scenario	*Production*	*Costs*	*Demand*	*Profitability*
1	10	10	-3	- to 2001; -- to 2002; --- to 2010
2	5	10	-3	+ to 2001; -- to 2004; --- to 2010
3	10	10	0	-- to 2001; --- to 2010
4	5	10	0	+ to 2001; -- to 2006; --- to 2010

Notes
Profitability increase: +++ high; ++ medium; + low
Profitability decrease: --- high; -- medium; -low

2.5.4 Seabass and Seabream

- Despite periodic oversupply and price falls, demand for these species has seen a strong upward trend. After excluding the effects of price, income and population effects this has been 13% per year for bass and even slightly higher for bream.
- All the signs are that recent rapid growth will continue. The bass and bream industries have considerable advantage in following technological developments of salmon farming. Further moves offshore are feasible in the Mediterranean at reasonable cost, and could give a cost benefit. There are, however, some constraints on pump-ashore sites and land-bases for cage farms in France and Spain. In Greece existing hatcheries are below production capacity. Better quality juveniles should arise from the mesocosm semi intensive techniques at lower costs, although there are some reliability hurdles to overcome. Genetic mapping techniques should see improvements in growth of up to 10% per generation. Unlike in the more mature salmon-farming sector, there is not yet systematic vaccination. Marketing of bass and bream remains also immature. Therefore

this sector has potential for expansion with a maximum potential production growth of up to 20% per year.

- Production costs seem likely to follow the trend of recent years. Feed per unit output will probably remain stable as is the case for salmon. Capital expenditure will decrease per unit output as scale grows. Labour productivity will increase with scale. The price of eggs and juveniles will decrease per unit output with increased growth and survival. The outlook is estimated to be slightly better than for salmon and average –5% per year.
- The strong upward trend in demand means that prices and profitability can improve in spite of relatively high growth rates. However, scenarios 1 and 3 illustrate the vulnerability of the market to production outstripping demand. Bream fare better than bass in each scenario.

Seabass and Seabream Scenarios % change

Scenario	*Production*	*Costs*	*Demand*	*Profitability*
1	20	-5	16	+ to 2000; - to 2006; -- to 2010
2	10	-5	16	++ to 2001; +++ to 2010
3	20	-5	10	- to 2001; -- to 2005; --- to 2010
4	10	-5	10	++

Notes
Profitability increase: +++ high; ++ medium; + low
Profitability decrease: --- high; -- medium; - low

2.5.5 Eel

- Demand for eel has been static during the 1990s, with negative trend effects due to consumer attitude changes offsetting the effects of rising incomes and population. After excluding the effects of price, income and population effects, a negative demand trend of around 2.9% per year is apparent.
- Production potential through intensive techniques is very large. However, production has been growing slowly, partly reflecting demand and partly the dependence on wild caught glass eels and elvers. No hatchery techniques have yet been developed for eels. There is increasing environmental restriction on extraction of wild juveniles from rivers, for farming elsewhere, and farmers from the Far East compete to purchase this resource. Capital and operational cost impacts of difficulties associated with use of freshwater resources are as described for trout. The maximum growth potential is perhaps 2% per year, discounting the possibility of restriction on elver fishing.
- Feed costs are expected to stay steady. Capital spending will probably increase per unit output to comply with environmental regulations. There is no scope for growth rate improvement due to dependence on wild caught juveniles. Staffing costs may fall if the industry grows. The major uncertainty is the cost of juveniles. Apart from these, production costs will probably increase by 2% per year.
- The four scenarios indicate optimistic prospects for the eel market, especially where demand is assumed stronger. However, even modest increases in the production growth rate is enough to eventually depress prices. Increased cheaper imports from China would undermine market balance.

Eel Scenarios % change

Scenario	*Production*	*Costs*	*Demand*	*Profitability*
1	2	2	-1	++ to 2001; ++ to 2005; + to 2007; - to 2010
2	1	2	-1	+++ to 2003; ++ to 2008; + to 2010
3	2	2	0	+++ to 2004; ++ to 2010
4	1	2	0	+++

Notes
Profitability increase: +++ high; ++ medium; + low
Profitability decrease: --- high; -- medium; - low

2.5.6 Turbot

- The product itself has value in its appearance as a whole, being one of the few farmed species to be not instantly recognisable from wild fish. However, whole fish do not sell easily in a mass market and product development is required for fillet and portion versions. Turbot is an expensive but sought-after fish so it is not surprising that there is a strong positive demand trend remaining after the exclusion of price, income and population effects. This trend effect is of the order of 8% growth per year.
- EU production is small but growth prospects are good. However access to suitable, affordable coastal frontages in Atlantic France and Spain is going to hold the potential back. UK temperatures are below the optimum. Attempts to grow turbot in cages have not been successful. Effluent treatment would need to be built into any new pump-ashore farms.
- Hatcheries are increasingly proficient and are producing juveniles throughout the year. Production efficiencies are likely to come from many of the areas described for bass and bream. However, the smaller size of the industry and the limitations on its expansion will make it a less attractive proposition for R&D investment in such areas as feed improvements, vaccine development, or genetic mapping. These benefits will thus be slower than in other sectors. Efficiencies stemming from water re-use and productivity per unit labour will also help to lower costs. However use of tank systems on land is probably not so amenable to bulk handling and economies of scale as has been the case for bass, bream and salmon, so capital expenditure per unit output will not fall as fast as for those species. Production growth rates of 10% per year seen recently will probably be continued through expansion of existing farms with modest new development.
- Production costs are expected to move in the range –3 to –6% for the reasons set out above.
- Under scenario 1, strong demand growth keeps pace with maximum production potential. Modest price increases with falling costs improve profitability. Under scenario 2, production growth is lower at 5% per year, and with the same strong demand growth prices and profitability rise significantly. Under scenario 3, the demand trend is halved, and excess supply develops. Prices fall, more than offsetting the falling costs and so profitability declines. However, this scenario seems the least plausible for this fish. Scenario 4 restores the favourable balance between demand and production growth leading to rising prices and profitability.

Turbot Scenarios		% change		
Scenario	*Production*	*Costs*	*Demand*	*Profitability*
1	10	-3	11	+
2	5	-3	11	++ to 2002; +++ to 2010
3	10	-3	7	--
4	5	-3	7	+ to 2004; ++ to 2010

Notes
Profitability increase: +++ high; ++ medium; + low
Profitability decrease: --- high; -- medium; - low

2.5.7 Mussels

- The mussel market has been rather static. Consumption is not expected to increase by more than 1% per year. After excluding the effects of price, income and population effects, a slight negative trend remains in demand of around 0.7% per year.
- Dependence on wild spat and competition for sheltered areas for production means this sector will be somewhat limited in production potential in the coming years. There is potential to develop longline technology in more exposed locations in the Mediterranean and in Scotland, Ireland and Sweden. More could be produced from dredged wild seed if environmental and management pressures eased, which seems unlikely. Production in the large, traditional mussel industries of

the EU has been more or less static and lack of further space and seed means they will remain in this state. Production could expand at about 2% allowing for growth in the newer industries.

- Production costs are likely to remain near stable in the large, traditional producing countries. There will be economies of scale in those industries that are still growing. Taking the EU as a whole, costs are assumed to remain unchanged for the outlook period.
- All scenarios indicate a relatively static future given the underlying assumptions. In scenario 1, production growth is assumed to reach its maximum potential of just 2% per year. Consumption rises by only some 0.8% per year so there is some deterioration in prices and profits. Scenario 3 assumes a zero rather than a negative demand trend, so demand growth is rather stronger at around 1.5% per year, market balance, prices and profitability are maintained. In scenario 4, reduced production growth and higher demand growth lead to modest increases in profitability.

Mussel Scenarios % change

Scenario	*Production*	*Costs*	*Demand*	*Profitability*
1	2	0	1	- to 2008; -- to 2010
2	1	0	1	+ / -
3	2	0	2	-
4	1	0	2	+

Notes
Profitability increase: +++ high; ++ medium; + low
Profitability decrease: --- high; -- medium; - low

2.5.8 Oysters

- An exogenous negative trend in demand of around 5% per year seems to exist after excluding the effects of price, income and population effects.
- There is limited production potential to expand. Availability of sheltered foreshore areas outside the traditional growing area of France is likely to meet opposition on conservation or resource user grounds. Suspended culture could be developed further. This would compete with mussels for production space. As with mussels, the newer, smaller industries in Ireland and UK have capacity to grow but their contribution will not greatly alter the EU position. A maximum of 2% can be expected.
- Oyster farming is a labour intensive process with limited scope for greater mechanisation. Production costs will probably fall modestly in the expanding industries, only very slightly overall in the region of 2%.
- In scenario 1, production increases by the maximum assumed value of 2% per year. The strong negative demand trend outweighs income and population growth effects to lead to a declining demand by around 2.2% per year. Price and profitability fall at an increasing rate as the market becomes more and more unbalanced. In scenario 2, the situation is slightly less extreme since the production growth is assumed to be half that in scenario 1. However, weak demand still means significant falls in prices and profits. Scenario 3 again presents a rather pessimistic picture, although the decline in demand is moderated by the assumption that the negative trend is halved. This gives a reduction in demand of about 0.2% per year. However, prices are still weak and profitability declining. Scenario 4 reduces the production growth rate maintaining prices and profitability in the short-run.

Oyster Scenarios % change

Scenario	*Production*	*Costs*	*Demand*	*Profitability*
1	2	-2	-2	- to 2001; -- to 2005; --- to 2010
2	1	-2	-2	- to 2002; -- to 2008; --- to 2010
3	2	-2	0	- to 2006; -- to 2010
4	1	-2	0	+ / - to 2002; - to 2010

Notes
Profitability increase: +++ high; ++ medium; + low
Profitability decrease: --- high; -- medium; - low

2.5.9 Clams

- Production and consumption of clams have been very variable in the 1990s with annual increases as much as 55% and decreases as much as 29%. Overall demand is strong, with a trend effect of around 7.5% on top of demand growth due to income and population growth. However, the clam market is diverse with quite different trends evident in different EU states.
- Industry estimates of potential production in Italy are around the 100,000 tonnes by 2010, above which space could be a constraint. In Galicia and Portugal there is production expansion forecast using semi-extensive techniques. 6% maximum growth is estimated overall for the EU, much the same as historically.
- Improvements in efficiencies are possible with volume as this is less labour intensive than other shellfish farming, at least in Italy where it is harvested by fishing. Inter-tidal culture is very labour intensive in Spain and Portugal and seems set to remain so. Overall there is scope for minor cost reductions due to efficiencies up to 2%.
- Scenario 1 shows that even at maximum growth in production the increase in demand can still not be satisfied giving strong upward pressure on prices. As expected, with half the annual production increase (scenario 2) excess demand is exacerbated and pressure on prices increased. Scenario 3 halves the trend effect on demand which now grows at about 6% per year on average, leaving the market closer to balance. Upward pressure on prices remains. Reducing production growth in scenario 4 leads to the re-emergence of significant excess demand.

Clam Scenarios		% change		
Scenario	*Production*	*Costs*	*Demand*	*Profitability*
1	6	-2	10	+ to 2000; ++ to 2003; +++ to 2010
2	3	-2	10	++ to 2001; +++ to 2010
3	6	-2	6	+
4	3	-2	6	+ to 2001; ++ to 2005; +++ to 2010

Notes
Profitability increase: +++ high; ++ medium; + low
Profitability decrease: --- high; -- medium; - low

2.5.10 Minor and new species

In addition to the main species groups discussed above there are a large number of other species in small-scale commercial production, and others at the pilot-scale or research/development stage. Their status and outlook are briefly discussed by climatic region.

Mediterranean region (Greece, France, Italy, Portugal, Spain)

Sturgeons *(Acipenseridae);* Sturgeon farming operations are relatively new in Europe and are centred in France and Italy. Output in 1998 is 134 tonnes of fish sold in France and 400 tonnes in Italy. There are a number of sturgeon farming activities in France, the principal activities are located in the south west in the Bordeaux region using the siberian sturgeon *(A. baeri).*

Native Cyprinids; tench *(Tinca tinca)*, roach *(Rutilus rutilus)* are being farmed in France with production levels of 1,400t pa and 2,700 t pa respectively.

Other native species include; pike *(Esox lucius)* and perch *(Perca fluviatilis)*.

Catfish *(Ictalurus spp, Clarias spp, Silurus spp).* All species require warm water. Sold to niche markets.

Italy – *Ictalurus* Channel catfish 2,000 tonnes.
France – *Silurus* Wels 300 tonnes.
Holland – *Clarias*, African catfish 1,000 tonnes.

Marine Breams *(Sparidae)*. A number of species lend themselves to the processes developed for the Gilthead Seabream. Some of the new species command a higher price at present. Species include; Sheepshead Bream (*Diplodus puntazzo)*, Red Porgy *(Pagrus pagrus),* Japanese Red Seabream, *(Pagrus major)*.

Corb *(Umbrina cirrosa),* Meagre *(Argyrosomus regius)* and Brown Meagre *(Sciaena umbra)* are in pilot production Italy.

Mullets *(Mugilidae).* Commercially produced by 'vallicultura' in Italy.

Common Sole *(Solea solea),* is now farmed in small quantities in Portugal.

Octopus *(Octopus vulgari*s) at trial stage in Spain.

Temperate and northern regions (Belgium, Denmark, Northern France, Finland, Germany, Ireland, Netherlands, Sweden, UK)

Charr *(Salvelinus alpinus)*. Small quantities have been farmed in Scandinavia, including in sea pens. Less than 1,000 tonnes reach world markets each year.

Tilapia *(Oreochromis spp*) is in minor production using power station waste heat.

Halibut *(Hippoglossus hippoglossus).* Subject to much R+D effort in Northern Europe, now at pilot production stage. Reliable production of juveniles is the main constraint.

Atlantic Cod *(Gadus morhua).* Semi-commercial trials are now underway in Scotland and Norway, commercial success depends on economics of scale and possibly market differentiation of farmed product.

Wolf-fish *(Anarhichas lupus).* This is a better fish, from a culinary viewpoint, than it looks, yielding long, meaty fillets. R+D stage only.

Lumpfish *(Cyclopterus lumpus)*. The meat of this commercially netted fish is not normally consumed but the fish are valued for the caviar-like eggs. Lumpish roe production from chiefly a northern Atlantic fishery, now exceeds 6,000 tons annually. R+D stage only.

Monkfish *(Lophius piscatorius).* Scottish researchers have studied this fish. Taking into account its nature of being a slow moving, bottom dweller, there is merit in considering the fish as a candidate for polyculture within pens or tanks holding midwater fish, such as salmon. No activity currently.

Plaice *(Pleuronectes platessa),* was the subject of successful trials in the UK in the sixties. Rejected because of its low value and plentiful wild catch at the time. No activity currently.

Brill *(Scophthalmus rhombus)*, is a turbot like fish, subject of a small commercial fishery. Its ability to hybridise with turbot is of commercial interest. No activity at present.

The Great *(Pecten maximus)* and Queen Scallop *(Chlamys opercularis)*, of the Northern Atlantic, have lent themselves to ongrowing in lantern nets hung from mussel-type long lines in north-western areas of the Union at small scale. The process remains based on capture of wild spat. This year wild scallops in Scotland have been contaminated with ASP (Amnesic Shellfish Poisoning) toxins and may continue to cause problems to further expansion.

Lobster *(Homarus gammarus).* Potentially of very great interest, culture techniques of this high value crustacean have been clearly demonstrated. The high cost of growing to market size in captivity makes this a non-viable proposition. At present juveniles are being produced in hatcheries for wild fishery re-stocking in UK and Ireland.

Abalone. *(Haliotis tubercolata)*. Trial production in Ireland and Channel Islands.

Sea Urchins, North Atlantic *(Stronglyocentrus droebachiensis)* and Mediterranean *(Paracentrotus lividus)*. Most species of the animal around the world are valued for their roe. The animal is relatively easily confined and feeds on certain marine algae. R+D stage in Scotland.

Re-laid Cockles *(Cerastoderma edule)*. There is recent interest in relaying juveniles, which are a by-product of automated harvesting of wild stocks, in a more favourable growing site, so in effect becoming an extensive culture process.

2.5.11 Non-Food Species

There is minor production in the EU of groups of aquatic animals for non–food use. Their status and outlook is as follows:

Aquarium and pond fish

Europe is a substantial importer of live, exotic fish from the tropics both freshwater and marine. Ornamental koi carp are being reared in the EU and there is considerable potential for import substitution. Culture of marine ornamentals is also starting.

Restocking

Salmonids. Atlantic salmon, sea / brown trout, rainbow trout, and brook trout are reared in hatcheries through farms in the EU to enhance the native stocks or restock sports fisheries. Both of these are linked to recreational fishing.

Coarse fish. This term refers to those species, other than salmonids, which offer sporting value. They include carp, bream, tench, roach, rudd, pike and perch, and are reared in UK, France and Austria principally.

Other

Marine worms. The ragworm, *(Nereis virens)*, is highly regarded by anglers as one of the best baits for catching sea fish. A British company developed a process to spawn, hatch and rear juvenile ragworm for ongrowing in shallow ponds. Pilot scale production is underway. Demand is significant.

The estimated contribution of non-food species to EU aquaculture as a whole is under 1% of volume, value and employment. Although growth will occur, this proportion is not expected to change in the next ten years.

2.6 GENERAL CONCLUSIONS ON FUTURE PRICES AND PROFITABILITY OF AQUACULTURE

- Profitability of aquaculture requires a balance between demand expansion and supply growth. The farmed salmon market in particular has suffered from periodic excess supply and illustrates the dangers of rapid supply growth. The supply situation in major producing countries outside the EU is just as important as domestic supplies in this balance, especially in view of diminishing barriers to trade under multilateral and bilateral trade agreements.
- In spite of generally rising demand for fish, not all aquaculture species will enjoy increasing prices and profitability. For some species with otherwise strong demand prospects, short-term market imbalances will continue to be a problem given the scope for rapid expansion of output and the fragmented and uncoordinated nature of much aquacultural production. Trade associations and other industry bodies rather than government should take the responsibility to enhance market stability, through market information provision, for example.
- For some species, the market prospects in terms of increasing consumer demand are simply not good. Carp is the prime example, and there seems no alternative but further contraction in this industry. Eel, mussel and oyster appear to have little scope for expansion of demand due to consumer preferences on an EU wide basis, though specialised niches exist.
- For salmon, seabass, seabream, turbot and, to a lesser extent, trout, continuing strong demand growth is likely to be able to absorb plausible increases in domestic production. These species also have the most potential for product development to meet growing consumer demands for

processed and convenience products. Nevertheless, the scenario results illustrate the sensitivity of prices to supply increases, including from imports.

- For some species market prospects are good and producers should be able to generate sufficient funds from the market to meet their investment needs. At the same time there is no case for market price support policies for these species. For other species, which are simply not in demand, market price support measures are only likely to generate supplies of unwanted products, misallocating resources and imposing a burden on public funds.
- The industry itself can do much to improve its average level of returns, through generic promotion aimed at expanding demand, for example. EU aquacultural production will be increasingly exposed to international competition as trade liberalisation proceeds. It is essential that EU production should be competitive. Price support measures would simply hinder the development of true competitiveness. Open international competition and trade will encourage it.
- In the cases of most of the species considered, there is no wild production, and hence any impact of aquaculture on capture fisheries can only be generalised. It is perhaps only in the cases of bass and bream and turbot that direct competition may result. However, for all these cases demand growth is strong and farmed production can be absorbed without adversely affecting price levels.

2.7 FUTURE ENVIRONMENTAL IMPACT OF AQUACULTURE

2.7.1 Introduction

As the aquaculture industry has developed and has incorporated technological advances, it has moved from extensive to intensive systems. This intensification of production methods has been accompanied by an increase in the potential threat to the already precarious ecological equilibrium in our streams, reservoirs and oceans. This is especially true if the intensification involved a switch from the use of natural to artificial food supplies in order to sustain reasonable fish growth.

In intensive aquaculture units, due to the high fish densities and the very high water flows in the self-cleaning tanks, pollutants are eliminated from the unit and therefore the effects are felt outside. This may lead to conflicts with other users of aquatic resources. Recently, this intensification of aquaculture production has led to the industry being regarded as one of the leading polluters of the aquatic environment. Due to these actual or perceived negative impacts, greater restrictions have been imposed on the establishment of new aquaculture units and environmental impact studies are now commonly required for licensing.

2.7.2 Mechanisms for Reducing Constraints

There are various strategies and mechanisms for increasing aquaculture production whilst reducing the constraints described above. These are examined below.

Farm Operational Strategies

While productivity gains can be achieved through improved technical development, it is worth noting that many EU Member States regulate effluent quality through mechanisms such as pollution consent limits. It is therefore possible to increase the productivity of aquaculture per unit area through reducing pollution (principally N and P). Effluent nutrient levels can be significantly reduced using the following approaches:

- Feeding methods - method and timing of presentation (restricted demand feeding showing significantly improved FCRs) and devices to collect and remove uneaten feed from the bottom of the cage
- Water quality - oxygen levels are critical in metabolising modern high energy diets for salmonids (low oxygen conditions can give impaired growth and increased N excretion)
- Feed type - (i) fish meal types can be optimised to reduce the level and availability of P and (ii) lower protein diets with a high lipid content can significantly increase the production of fish per unit of nitrogen discharged.

- Waste treatment – by means of physical settlement, biofiltration, BOD reduction and ammonia removal
- Polyculture - change from current monoculture to combine finfish, shellfish and algal culture to (i) reduced net effluent levels and (ii) improve spatial productivity per unit area

Integrated strategic aquaculture development planning

As river corridors and coastal areas attract ever greater numbers of different users, there is an increasing need for integrated development planning, resource allocation and environmental management. Integrated catchment and coastal management have received considerable attention over the past few years, and aquaculture has featured to varying degrees in both. Many technical advances have been made, particularly towards the use of geographical information systems and ecosystem modelling as planning tools. However, poor cross-sectoral institutional co-ordination and management remains the greatest constraint to integrated planning. The following areas are particularly weak and hinder the development of aquaculture within the overall framework of sustainable development:

- There is a need for regional environmental carrying capacity studies, particularly for coastal aquaculture development in semi-enclosed areas or inshore waters with restricted water exchange. This could be combined with the formulation of nutrient budgets and quotas for discharges.
- Few countries have a strategic approach to aquaculture within the overall development framework. The EU would benefit from a framework for national aquaculture development, including the inclusion of aquaculture in national zoning plans. This would take account for national and EU priorities for different development options and conservation needs, especially that of Habitat and Birds Directive.
- Institutional appraisal of the roles of national planners, aquaculture interests and regulators (both national and EC) allocating finite coastal and terrestrial resources (space, water, human, etc) to aquaculture. The aim would be to optimise the industry's development potential with the demands from other development interests, including that of conservation.

Applied Research

A number of the technical constraints to sustainable aquaculture development are common across the EU Member States and would benefit from EU supported research. These include:

- Investigations into the technical constraints to, and economic viability of offshore aquaculture;
- Improved waste water treatment techniques, including research on integrating wetland bioremediation technology;
- Further support to developing alternative protein sources to fish meal and oils, with lower ecological costs, subject to having equivalent or better nutritional performance and lower waste production;
- Support the development of polyculture options for intensive and semi-intensive aquaculture in order to optimise productivity per unit area, integrate non-aquaculture waste products into potential aquaculture inputs and to minimise net waste production.

2.8 FUTURE IMPACT OF AQUACULTURE ON EMPLOYMENT

2.8.1 Employment creation

Estimates of future employment have been made for the main species groups. These have been made on the basis of the most likely development scenario, scenario 4, that is growth of production at half of its potential and change in consumer attitudes at half the rate seen previously. For carp, where scenario 4 shows consistent decrease in profitability in future, employment is assumed to remain at current levels in this analysis. Also, no reduction calculation has been assumed for economies of scale expected, most notably in seabass, seabream and turbot. Employment projections have been calculated to 2005, not 2010 as with profitability, as numerical rather than trend projections are less safe over a ten-year span. Multipliers are derived from the main study and apply to immediate upstream activities and downstream activities as far as primary processing.

2.8.2 Geographical distribution of aquaculture production and regional impacts

The distribution of aquaculture largely reflects the suitability of sites and environmental conditions. The extent to which it might be promoted in certain areas specifically to generate employment is limited. It is fortuitous that much aquaculture development has occurred in areas of relatively high structural unemployment.

2.8.3 Potential contribution of aquaculture in fishing regions in structural decline

With the decline in employment numbers in the capture fishing sector due to falling fish stocks and the restructuring of the EU fishing fleet, levels of unemployment in some of the traditionally fishing dependent areas has been considerable. Some of these fishing dependent communities have little access to other employment prospects.

However the potential contribution of aquaculture to generate employment in place of capture fishing jobs remains limited.

Firstly there would appear to be limited overlap of skills (apart from boat handling and handling of the harvested crop). Secondly if the geographic characteristics of fishing ports are compared to those of aquaculture sites, then considering the UK as an example, the major fishing fleets operate out of deep-water harbours on the East Coast of the country. The majority of the aquaculture sites tend to be on the more sheltered West Coast of Scotland or inland.

The sectors where the skills might be more transferable, i.e. using smaller boats in the shellfish sector, are already mature industries in the major producing countries with production and demand not expected to experience strong growth. There would be reasonable scope for shellfish related employment to expand in the emerging shellfish industries such as in Ireland, UK, Sweden (mussels) and Spain and Portugal (clams).

Current and projected total employment. Full Time Equivalents.

	Austria	Belgium	Denmark	France	Germany	Greece	Nether-lands	Italy	Ireland	Portugal	Spain	Sweden	UK	Finland	TOTAL Current EU Direct Employment	Projected Direct Employment 2005	Multi-pliers	Total Employment
Salmon									351				1,623		1,974	2,349	2.40	5,637
Trout	267	63	613	1,445	1,450	256	5	1,133	193	59	699	420	802	809	8,214	8,214	1.18	9,693
Carp	112	41		836	1,670	7	19	14							2,699	2,699	1.05	2,834
Sea-bass/bream				320		1617		766		223	650				3,576	7,553	1.41	10,650
Eel		8	85	5	8	31	90	310		20	27	7			591	636	1.26	801
Turbot				116						40	215		9		380	561	1.22	678
Mussels				2,400	50	800	350	2,650	343	10	4,290	53	168		11,114	12,025	2.08	25,012
Oysters/Clam				5,220	15		100	50	388	1,100	1,970		103		8,946	10,153	1.16	11,778
Totals	379	112	698	10,342	3,193	2,711	564	4,923	1,275	1,452	7,851	480	2,705	809	37,494	44,190		67,084

2.9 THE ROLE OF EU FINANCIAL ASSISTANCE IN THE FUTURE

2.9.1 Policies for aquaculture development

Assistance to EU aquaculture in the period 1989-99 has been provided via Regulation 4028/86 and via FIFG since 1994. Support to aquaculture reflects the declared policy objective that EU aquaculture should be developed to help meet the shortfall in fish supplies from capture sources. However, expansion also needs to take account of the technical and economic viability of the industry, environmental impact, quality, hygiene conditions, human and animal health including food safety.

Besides direct assistance to aquaculture itself, the EU also provides for environmental, health and food safety legislation and general support to R&D.

2.9.2 Aquaculture development under alternative levels of public support

The issue of whether public aid has had any positive effect on aquaculture development was addressed. The analysis was inconclusive, possibly due to the limited range of information available. An earlier study of the impact of support under Regulation EEC 4028/86 (European Association of Fisheries Economists, 1990) was also not strongly conclusive.

Whether aid can promote the development of aquaculture depends to a large extent on whether it is access to investment funds which is constraining development. This does not appear to be always the case.

2.9.3 Priorities for financial support.

It is apparent from the scenario analysis that not all areas of aquaculture are in need of financial support. Furthermore, where public funds are limited there is a need to set priorities. These priorities should reflect the needs of the market in terms of products, while also assisting the improvement of aquaculture’s environmental performance. The latter needs to be addressed if future production is not to be constrained by an increasing range of legislation and control.

- The first criterion for support is that the project concerned should be viable. This involves market possibilities as well as technical production possibilities. On this basis, certain species would be unlikely to be desirable targets for support. Carp farming for example, at least for food purposes, does not enjoy an expanding market and further investment, other than perhaps for angling and restocking, is not likely to be viable. At the same time emphasis should be given to ‘new’ products and species still in development stages rather than established production lines. This has happened in the allocation of funds to date with relatively little going to salmon and more going to turbot, for example, and in the eighties to seabass and seabream.
- More generally, the scenario results illustrated the importance of market expansion. Support needs to emphasise marketing projects such as generic promotion, marketing group formation, and market development. Such projects are particularly important given the fragmented nature of much of aquaculture production.
- The importance of environmental constraints on aquaculture development has been noted. Compliance with such measures will involve businesses in investments – in waste water treatment for example. These may lead to structural changes in the industry if only larger enterprises are able to afford them. Obviously, the environmental aspects of any project need to be considered before funding is granted.
- Transition to more environmentally benign and ‘organic’ production systems might be supported as in agriculture.
- There is an argument for further supporting development of ‘new’ species in the transition from R&D to commercial-scale. The benefits of such support would be diversification for existing farmers in marginal operations, possible encouragement of more environmentally benign

production methods, and import substitution. However, comments above about only supporting projects with good market potential for their output and long term viability apply equally here.

- Future growth in any fish business may depend upon allaying consumer concerns over food risks. Investments to assure food safety might be suitable targets for support.
- The market increasingly emphasises processing and product development, and these activities should be regarded as equally deserving of support as production *per se*.
- Investment in integrated development planning, resource allocation and environmental management deserve support. Many technical advances have been made, but there is still a need for investment in regional environmental carrying capacity studies, nutrient budgets, further improvement of the use and quality of geographical information systems and ecosystem modelling.
- The EU should support research in the field of sustainable aquaculture, including: technical constraints to, and economic viability of offshore aquaculture, waste water treatment techniques, alternative protein sources to fish meal and oils, and development of polyculture options.