EUROPEAN PARLIAMENT

DIRECTORATE-GENERAL FOR INTERNAL POLICIES

POLICY DEPARTMENT B
STRUCTURAL AND COHESION POLICIES

Agriculture and Rural Development

Culture and Education

Fisheries

Regional Development

Transport and Tourism

EUROPEAN AQUACULTURE COMPETITIVENESS: LIMITATIONS AND POSSIBLE STRATEGIES

STUDY

EN DE ES FR IT

2009

EUROPEAN PARLIAMENT

DIRECTORATE GENERAL FOR INTERNAL POLICIES

POLICY DEPARTMENT B: STRUCTURAL AND COHESION POLICIES

FISHERIES

EUROPEAN AQUACULTURE COMPETITIVENESS: LIMITATIONS AND POSSIBLE STRATEGIES

STUDY

This document was requested by the European Parliament's Committee on Fisheries.

AUTHOR(S)

John Bostock, University of Stirling Institute of Aquaculture (UoS).
Francis Murray, University of Stirling Institute of Aquaculture (UoS)
James Muir, University of Stirling Institute of Aquaculture (UoS)
Trevor Telfer, University of Stirling, Institute of Aquaculture (UoS)
Alistair Lane, European Aquaculture Society (EAS)
Nikos Papanikos, APC Advanced Planning – Consulting SA (APC S.A)
Philippos Papegeorgiou, APC Advanced Planning – Consulting SA (APC S.A)
Victoria Alday-Sanz

RESPONSIBLE ADMINISTRATOR

Jesús Iborra Martín
Policy Department Structural and Cohesion Policies
European Parliament
B-1047 Brussels
E-mail: ipoldepb@europarl.europa.eu

LINGUISTIC VERSIONS

Original: EN
Translation: DE, ES, FR, IT.

ABOUT THE EDITOR

To contact the Policy Department or to subscribe to its monthly newsletter please write to: ipoldepb@europarl.europa.eu

Manuscript completed in September 2009.

This document is available on the Internet at:
http://www.europarl.europa.eu/activities/expert/eStudies.do?language=N

DIRECTORATE GENERAL FOR INTERNAL POLICIES

POLICY DEPARTMENT B: STRUCTURAL AND COHESION POLICIES

FISHERIES

EUROPEAN AQUACULTURE COMPETITIVENESS: LIMITATIONS AND POSSIBLE STRATEGIES

STUDY

Abstract
This study examines the competitiveness of the EU aquaculture sector, as a contribution to the wider review of EU aquaculture policy being carried out by the European Community institutions. EU aquaculture competes with its international equivalents, with outputs from capture fisheries, and more fundamentally within global food markets. With small exceptions, the sector invests in production within the EU, and as little of its product is exported, competition is so far primarily defined within EU markets. Whilst EU aquatic food consumption has risen over the past 10 years, with stable or declining capture fisheries supply, most of this increase has come from imports rather than growth of EU aquaculture. To substantially increase aquaculture production at competitive prices for mainstream EU markets will require larger entities capable of scale economies, although small and micro-enterprises can also provide niche products and help sustain rural and coastal livelihoods. As spatial expansion is highly constrained by environmental regulation and conflicts with other resource users, productivity gains will be important in increasing output. Technological solutions are emerging, but are costly, so under current conditions, investments are more likely to be made in lower-cost production systems in third countries that export to the EU.

IP/B/PECH/IC/2008_177 December 2009

PE 431.569 EN

CONTENTS

GLOSSARY

Competition	Institutions, policies, and factors determining national productivity, which, in turn sets rates of returns to companies, growth rates and ultimately sustainable economic prosperity
Cost leadership	Efficiency driven competition strategy usually associated with economies of scale and low unit costs for commoditised products
Economies of scale	Reductions in unit-cost as the size of an enterprise increases
Future contract	A contract to buy or sell a specified commodity of standardized quality at a *future* date at an agreed (market-determined) price
Genetic Introgression	Movement of gene(s) from a hybrid or selectively-bred (farmed) species back into the parental (wild) gene pool by (escape and) backcrossing
Horizontal Integration	Acquisition or merger between firms in the same industry and stage of production
Recirculating Aquaculture System	Tank-based aquaculture system where the water flow is treated and re-used (as opposed to flow-through water supply which only passes through the farm once before discharge)
Product differentiation	Competition strategy based on development of distinctive product qualities, tangible and intangible often targeting narrower ‘niche’ premium markets
Vertical integration	Hierarchy of different market-specific production or service entities under common ownership combining to satisfy a common need

LIST OF ABBREVIATIONS

ACFA	Advisory Council on Fisheries and Aquaculture
AD	Anti-Dumping
APR	Annualised Percentage Rate (Growth)
ASC	Aquaculture Stewardship Council
B2B	Business to Business
B2C	Business to Consumer
BAP	Better Aquaculture Practices
BRIC	Brazil, India, Russia and China
CCRF	Code of Conduct for responsible Fisheries
CEE	Central and Eastern Europe (as aquaculture production region)
CFP	Common Fisheries Policy
CMO	Common Market Organisation
COP	Cost of Production
DoF	Department of Fisheries
EAS	European Aquaculture Society
EATIP	European Aquaculture Technology and Innovation Platform
ETP	European Technology Platform
ECA	European and Central Asian (region)
EEZ	Exclusive Economic Zone
EFF	European Fisheries Fund
EIA	Environmental Impact Assessment
EIFAC	European Inland Fisheries Advisory Commission
ERA	European Research Area
ESE	European Seafood Exposition
FAO	Food and Agriculture Organisation of the United Nations
FDA	Fisheries Dependent Areas
FEAP	Federation of European Aquaculture Producers
FIFG	Financial Instrument for Fisheries Guidance (now the EFF)
FTE	Full-Time Equivalent (employees)
FRS	Fisheries Research Services (Govt Directorate now Marine Scotland)
FTA	Free Trade Agreement
GAA	Global Aquaculture Alliance
GCI	Global Competitiveness Index
GDP	Gross Domestic Product
GMO	Genetically Modified Organism
GNI	Gross National Income

HABs	Harmful Algal Blooms
HACCP	Hazard Analysis and Critical Control Points
HSMI	Heart and Skeletal Muscle Inflammation
ICZM	Integrated Coastal Zone Management
IPN	Infectious Pancreatic Necrosis
ISA	Infectious Salmon Anaemia
LCA	Life Cycle Analysis
ISGA	Irish Salmon Growers Association
LDC	Least (or Less) Developed Countries
LWE	Live Weight Equivalent
MED	Mediterranean (as aquaculture production region)
MIP	Minimum Import Price
MSC	Marine Stewardship Council
MSFD	Marine Strategy Framework Directive
MSMEs	Micro, Small and Medium Sized Enterprises
NACA	Network of Aquaculture Centres in Asia
NE	Northern Europe (as aquaculture production region)
NOK	Norwegian Kroner
PD	Pancreas Disease
PGI	Protected Geographical Indication
POP	Persistent Organic Pollutants
PO's	Producer Organisations
PPP	Public Private Partnership
RAS	Recirculating Aquaculture System
RSPCA	Royal Society for the Prevention of Cruelty to Animals
RTD	Research and Technology Development
SME	Small and Medium Sized Enterprise
SPS	Sanitary and Phytosanitary measures (WTO agreement)
SWOT	Strengths, Weaknesses, Opportunities and Threats
TFP	Total Factor Productivity
UoS	University of Stirling (Institute of Aquaculture)
USPs	Unique Selling Points
WEF	World Economic Forum
WFD	Water Framework Directive
WFE	Whole Fish Equivalent (weight)
WITT	Water in the tariffs
WTO	World Trade Organisation
WWF	World Wildlife Fund

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Background

In April 2009, The European Commission issued a communication on "Building a sustainable future for aquaculture[1]", designed to provide "a new impetus for the Strategy for the Sustainable Development of European Aquaculture[2]" which was issued in 2002. This recognised the anticipated growth rate for aquaculture of 4% per year had proved highly unrealistic and in overall volume terms, the sector has stagnated since the turn of the century. This is in contrast to the overall market for fish and seafood which has continued to grow, mostly due to a growth in imports which now represent 60% of EU supplies.

With aquaculture viewed as the only responsible way of increasing global fish and seafood supplies to meet the needs and aspirations of growing populations, the Commission focused on the issue of competitiveness, and the identification of factors that might be inhibiting the European aquaculture sector from competing effectively with supplies from third countries. This is significant not only for the balance of trade, and for EU economic activity and employment, but could also potentially impact on employment, income and fish protein availability in less developed exporting countries.

The study examined European aquaculture sector competitiveness, it's limiting factors and means by which competitiveness may be enhanced. Inter alia, it examined nine potential areas of competition itemised in the table (under recommendations) below. It has drawn on secondary data (reports, statistics and scientific journals) and on interviews with a cross-section of stakeholders. The context of competitiveness can be recognised not just in the primary aspect of competition within the sector, and between the EU industry and external agents, but also in terms of access to primary resources, and in terms of the relationships and commercial impacts within the broader supply and value chain for aquatic foods.

Findings

The study commenced by defining the structure of the European aquaculture industry and then examined competitive indicators. The largest sub-sectors in EU aquaculture are salmon, trout, sea bass and bream, carp and mussels. Apart from very small quantities of specialised product, almost all output is consumed within the EU. The EU salmon sector competes with imported farmed salmon from Norway and wild Pacific salmon from Canada (although substitution between Atlantic and Pacific salmon is not perfect). The EU trout industry also has limited direct competition from Norway and there may be some substitution effects with salmon. The sea bass and sea bream sectors compete with similar product from Turkey and Croatia. The EU carp sector competes with imports from Ukraine and other Non-EU Eastern European states. The mussel sector has some direct competition from Norway and processed product from Chile and New Zealand. Within the broader EU seafood market, imports of frozen freshwater fillets, predominantly farmed pangasius, catfish (and tilapia) from SE Asia have surged over the last few years. Today pangasius competes as one of the lowest-cost substitutes for generic 'white-fish' products in processed form.

The majority of EU aquaculture produce is sold fresh. Value-addition is most common for salmon, though all species are involved to some extent. The broader context of competition can be defined as the EU market, with a wide range of fish and seafood products, mostly

[1] EC COM(2009) 162 final.
[2] EC COM(2002) 511 final.

from EU and external capture fisheries, but also including imported aquaculture species such as pangasius, shrimp and some tilapia. Consumers purchase some products regularly and others only occasionally for variety or for specific occasions. Purchasing decisions are based on a range of factors, but price is critical, as are basic characteristics such as taste, texture, and appearance. Aquaculture produce has to compete on this basis as well as on less tangible qualities such as consumer perceptions of the origin and production process.

A key factor to emerge was the importance of industry structure with respect to performance, and the existence of policy incoherence, in that some measures and regulations support consolidation while others retain fragmentation, EU Policy on seafood trade shows a similar tension between community preference and security of supply. A SWOT analysis of the major sub-sectors identified a number of recurring themes. Production technologies and markets are generally well established, although weaknesses in industry structure, uneven investment and lack of marketing frequently contribute to financial instability. Disease is an inherent threat to all fish sectors, as to any animal production systems but especially salmon, trout, bass and bream, the most mature industries. All sector stakeholders perceive opportunities if external competitive pressures could be reduced.

Aquaculture products need to be understood within the perspective of the whole market and value chain. Competition for factors of production, particularly site area, water and feeds can be critical. Competition as raw material for value-added products is different from that for whole fresh or live product as is the potential size and value of the markets involved. Further complexities are added for less tangible product attributes such as environmental and ethical provenance. These value-based ‘quality’ definers provide opportunities for niche product differentiation. However, cost leadership remains the basis of competition for much of the sector. In this context technical innovation becomes subordinate to productivity gains via basic efficiency factors/ scale economies etc. as the primary driver of competition.

Globally, aquaculture is set to meet a growing deficit for seafood associated with stagnating fisheries and rising demand. Whilst there is scope for further expansion of aquaculture in many areas of the EU, this is increasingly constrained. Major increases in capacity within the EU are likely to require technology development and investment, which may raise the cost base unacceptably. Demand will be greatest for lower value farmed products substituting for similarly priced marine capture products. Much of this will be exported in frozen form from Asian countries exploiting their low cost-base. Although there are serious sustainability questions for this production, this is not an area in which EU aquaculture is likely to compete. However, at enterprise/supply chain level for EU markets, aquaculture expansion could be conceived (potentially with European investment) in relatively under-exploited regions of Africa and Latin America. Norway’s domination of global (including EU) salmon production is a good example of this approach; the emergent EU sea bass and sea bream sector may be well placed to duplicate such a strategy with appropriate support. Within the EU greatest growth in demand is also likely to come from emerging economies undergoing demographic transition. Under these scenarios the EU should continue focus on production of fresh and value-added products while in the longer term basic food security may become a more fundamental issue for policy.

Conclusions

Overall, the study concludes that EU aquaculture policy must be more market based and that a greater level of information about markets and industry performance will be needed to facilitate quality analysis. The importance of consolidation for the production of commodity species or raw material is recognised and policies should not block this type of sector development. On the other hand, the importance of small and micro-scale enterprise in fragile rural and coastal communities in providing employment and stewardship of resources is also important and can be addressed through production of differentiated niche products with a variety of tangible and intangible value-additions. Future growth and competitiveness of the sector is likely to require difficult trade-offs against precautionary environmental regulatory regimes; failure to address this challenge is only likely to increase policy incoherence.

EU aquaculture produce competes with capture fisheries (both EU and imported) and imported aquaculture products. There is also greater potential for exports; particularly of value-added products. The important issue for EU aquaculture is whether this trade is a "level playing field" both with respect to the standards required of EU producers vs third country producers, and transparency in the market (e.g. concerns were raised over the positioning of defrosted Vietnamese catfish fillets with fresh EU aquaculture products).

From the perspective of sectoral analysis, innovation is a critical aspect of competitiveness and needs to be better supported and conducted throughout the industry. A more strategic approach to innovation support is recommended giving weight both to incremental technology development through close industry and research collaborations, and more radical technology innovations that often originate outside the sector. Support for business model and financial innovation should also be given greater emphasis together with lifelong learning initiatives to develop a more creative and innovative environment.

Recommendations

For policy-specific recommendations, the nine major competition issues specifically addressed in the review were grouped into three key themes, and an over-arching theme, as shown below. Recommendations concerning technology platforms, and a further set of cross-cutting recommendations were also developed.

Competition issue	Theme
1 Legal and administrative constraints	Over-arching; policy and regulation
2 Environmental aspects. 3 Availability of production sites.	Location and environment
4 Food safety and other aspects related to consumption 5 Animal health and welfare. 6 Third countries competition and market issues	Markets, competition and regulation
7 Fish oil and fishmeal availability 8 Technological issues 9 Production costs.	Technology development and cost

Over-arching; policy and regulation
1 Ensure aquaculture development is better embedded in CFP, MSFD, WFD and other policies (especially provision for offshore aquaculture) and is considered in indirect legislation

Location and environment
2 Adopt a broad, well defined ecosystem approach to environmental management; promote better spatial strategies including incorporation of aquaculture planning in ICZM planning, avoid unequal costs for EU producers

Markets, competition and regulation

3 Ensure the positive contribution of aquaculture to safe and high quality aquatic foods is reflected in policy and legislation; work to build EU lead on clear and coherent standards, and harmonise international equivalents

Technology development and cost

4 Support greater industry investment in well focused research and innovation to make full use of the ERA

Technology platform (EATIP)

5 Move to recognise EATIP as an approved ETP to give the sector greater influence; performance monitoring mechanisms

Cross-cutting recommendations

6 Aquaculture policy should be sufficiently nuanced to promote appropriate types of industry structure in relation to meeting economic and market objectives as well as regional social and environmental goals (e.g. issues of consolidation, size of sites, length of leases, social and environmental resilience)

7 Policy and regulations need to take account of the whole market and value chain structure, and where European competitiveness and economic result really lies (e.g. European aquaculture product occupies a smaller but higher value segment of the total fish market with greatest value from processing)

8 Trade regulations are a key factor shaping European aquaculture's competition with imports. A level playing field for industry subsidies, environmental controls, food safety, animal welfare and other ethical considerations would create a stronger foundation for investment and give greater transparency for informed consumer choice

1. INTRODUCTION

1.1. Background

The study was set against a context of increasing demand for seafood alongside stagnating fisheries and aquaculture production within the EU (Section 2.1) and the perceived failure of 2002 EU policy targets for the sustainable development of aquaculture

In 2002 the European Commission issued a strategy for the sustainable development of European aquaculture (*EC, 2002*), which recognised the increasing importance of aquaculture in meeting the expanding demand for seafood products within Europe, but also the challenges of meeting rising standards and aspirations for food safety and environmental sustainability. The strategy envisaged an increase in European aquaculture production of 4% per year to meet expected demand. However, over the past 6 years, European aquaculture production has stagnated, whilst import of seafood products have risen almost threefold (Ernst & Young *et al*, 2008) to fulfil 60% of demand. Europe consumes around 11% of global seafood (12 million tonnes per year), whilst producing less than 2% of global seafood through aquaculture (1.3 million tonnes). Nevertheless European aquaculture is significant, employing around 65,000 people with a turnover of around €3.5 billion and a leading role in global aquaculture technology (*Framian, 2009*).

In April 2009, the Commission issued a follow-up communication (*EC, 2009*) highlighting the need for a new impetus for the aquaculture strategy. This was developed through stakeholder consultation and the support of several strategic studies. It has since been endorsed by the European Agriculture and Fisheries Council Meeting (22-23 June 2009). One of the key elements of the renewed strategy is to "promote a competitive and diverse aquaculture industry".

The broader context for promoting competitiveness includes ensuring compatibility between aquaculture and the environment; securing animal health and welfare; provision of high quality and sustainable feed-stuffs for fish and ensuring consumer health protection whilst promoting the health benefit of aquatic food. Additionally the strategy calls for improving the sector's image and governance. It is the issue of competitiveness that is further examined in this study.

1.2. Aims

This study was commissioned by European Parliament to identify the issues hindering the development of the productive potential of European aquaculture. For this purpose, the study evaluated each of the following areas identified as having potential to influence competition (competition domains):

- Legal and administrative constraints.
- Environmental aspects.
- Availability of production sites.
- Food safety and other aspects related to consumption.
- Animal health and welfare.
- Third countries competition and market issues.
- Fish oil and fishmeal availability.
- Technological issues.
- Production costs.

The study goes on to describe the useful results of the research and technological developments with potential to compensate for the limitations identified around each of these areas. This includes an assessment of the effectiveness of European technological platforms. These outcomes are the basis for recommendations to policy makers on what might be the most effective means to overcome the identified limitations in order to develop the sectors productive potential and competitiveness.

1.3. Research approach

The study is based on the collation and analysis of relevant secondary data (e.g. EC and national government reports, published industry data and academic journals), and a series of key informant interviews to obtain perception and case-study data on which to develop further analysis. Key informant categories and numbers are summarised in Table1. All were interviewed on condition of individual anonymity. Most interviews were conducted during the European Seafood Exposition (ESE) with follow-up telephone calls where necessary. Interviews were constructed around a semi-structured checklist and sampling was randomised within the defined categories. The analysis was based on three key tools:

(1) Development of key indicators for competitiveness across the identified constraint areas and means of scoring/ranking. The role of competitiveness indicators is to support the broader analysis and contribute towards strategy options for improving the productive potential of the industry. It can be noted here that competitiveness can be considered at many levels. The order of priority (starting with most important), was taken as:

a. Between Europe and other world regions

b. Between European countries

c. Between aquaculture species/industries

d. Between companies within the same industry

e. Between large, medium and small sized companies

f. Between different production technologies for the same product

g. Between vertically integrated or specialist companies

h. Between aquaculture produce and fisheries produce

(2) SWOT analysis to highlight particular areas of competitive advantage and disadvantage and to inform forward projections. These were conducted for each of the competition categories listed in section 1.2, and for key sub-sectors.

Table 1: Stakeholder Groups contacted for the EP177 survey.

Stakeholder category	Subgroup	Number of interviewees
Aquaculture producers	Salmon farming companies	19
	Sea bass and bream farming companies	12
	Trout farming companies	2
	Shellfish farming companies	2
	Producers of "new" and minority species	2
Processing and marketing	Finfish sector	6
	Mollusc sector	2
Associations and representative organisations	European level	1
	National level (fish)	3
	National level (shellfish)	1
Policy agencies and regulators	EU level	1
	National level	1
Research organisations	Government research	3
	Academic research	9
Environmental NGOs	EU or global	1
	National level	1
TOTAL		66

1.4. Competitiveness concepts

The basic context for an examination of aquaculture sector competitiveness is the EC Lisbon agenda (2000) to make Europe the most competitive and dynamic knowledge-based economy in the world. This was relaunched in 2005 to put a stronger focus on growth and jobs following earlier analysis (*EC, 2003*) which identified a number of key issues for European competitiveness and made recommendations for action based around 3 main areas:

- Better analysis of competitiveness as a foundation for action
- Get the regulatory framework right, and
- Increase efforts to foster research, innovation and entrepreneurship

Competition was further embedded into the wider Lisbon strategy framework in 2007 with the launch of the new cycle (2008-2010) (*European Commission, 2008*). Further appreciation of competitiveness factors is given by the World Economic Forum Global Competitiveness Report (*WEF, 2009*). This defines competitiveness as:

"the set of institutions, policies, and factors that determine the level of productivity of a country. Which, in turn sets rates of returns to companies, growth rates and ultimately the sustainable level of prosperity that can be earned by an economy"

The report describes twelve pillars of competitiveness and three economic competitiveness classes – based on the relative importance of the pillars: (A) factor-driven (B) efficiency-driven (C) innovation-driven. Applying this classification - EU aquaculture can be characterised as an efficiency driven sector. 'Market size' is a particularly important factor in this designation i.e. growth in global value chains for seafood along with consumer demand. This is linked with the potential to exploit resources more efficiently through economies of scale, and the use of vertical and horizontal integration for efficiency gains. This is most clearly seen in consolidation trends in growing segments of the industry.

Whilst the WEF report sets out general principles, areas of particular focus tend to be industrial activity, the energy sector and advanced technology. More directly relevant to the aquaculture industry was a report by *Wijands et al*. *(2007)* on competitiveness of the European food industry. This concluded that the sector is weak compared to the US and Canada and approximately at the same level as the Australian and Brazilian industry. Nevertheless, the importance of the food industry in total manufacturing is growing. Of particular significance is the value-added by food manufacturing, which is higher than most other sub-sectors of manufacturing. Most recently, a report by *Ernst & Young et al. (2009)* commissioned by the European Commission, examined the economic performance and competitiveness of the European aquaculture sector.

The classic market competition model of Porter, 1980 envisages. companies relying on three generic strategies to maintain competitive advantage; product differentiation, cost leadership (efficiency focus) and market segmentation (niche market focus). The first two relate to core competencies of the firm and are considered most important as they have broadest market scope. Cost leadership can be resolved into low cost and best cost strategies. The latter indicates provision of best value for relatively low cost in order to reduce the likelihood of price wars with other 'cost leaders'. Companies following differentiation strategies risk being copied by competitors and have greater incentive to innovate and improve. These notions clearly correspond with the categories of efficiency and innovation driven competition described above. 'Niche' focus on a narrow market segment often occurs when a company can afford neither a differentiation nor cost leadership strategy with wide market scope. It is often adopted by smaller companies and may be combined with cost leadership or differentiation within the niche. The collective focus of many small Irish firms on organic salmon production for to supply the EU market is a good example. However niches disappear and over-reliance on a single small specialist niche may be a risky strategy in the longer term.

The costs incurred for value-added differentiation means that combining differentiation and cost (minimization) leadership strategies is rarely compatible at any market scale. Porter also observed that firms with intermediate market share are sometimes least profitable as they lack clear focus on a specific generic strategy.

2. European and Global Seafood Trends

KEY FINDINGS

- EU aquaculture stagnated in volume terms over the last decade; from 2001 to 2008 EU production growth averaged only 0.5% APR compared to 7.5% for all non-EU countries combined. Currently the EU accounts for only 2% of global aquaculture production. Aggregate figures conceal a 24% decrease in fresh and brackish water production and a 20% growth in marine production over the same period.

- Eight EU countries with annual production values over €100 million (France, UK, Italy, Greece, Spain, Denmark, Holland and Germany) account for 81% of Community production.

- The ongoing process of globalisation continues to drive rapid expansion of value chains across international boundaries. Nowhere has this been more marked than in the seafood sector where in value-terms, international transfers dwarf most other commodity sectors combined.

- SMEs dominate the bivalve and freshwater aquaculture sectors, including many family owned enterprises. By comparison, intensive marine cage-culture sectors have already seen more rapid consolidation as a result of more readily exploitable scale-economies (i.e. larger sites) and higher value products.

- Vertical integration is increasing, but specialisation is more important for high technology activities, especially selective breeding programmes and more advanced food processing.

2.1. EU and global seafood production and demand

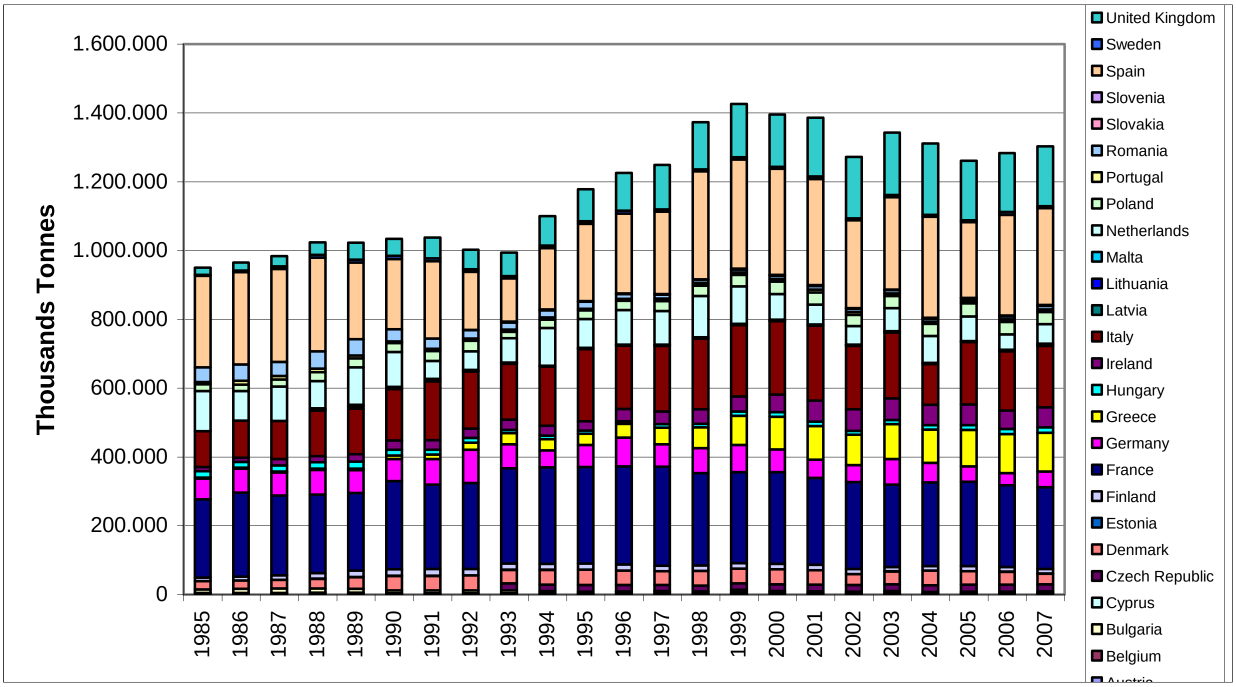
Worldwide aquaculture volume has grown by approximately 10–15% per year over the last decade. This is due to the combined effects of declining wild fisheries, increasing world population and changes in consumer preferences associated with increasing affluence and a positive health image associated with seafood (*Frankic and Hershner, 2003*). However, while consumer demand remains highest in developed countries, most of the production growth has occurred in low-income countries. In developed countries production grew by only 3.7%/yr from 1970 to 1999 (*FAO 2002*).

In the EU, farmed-production stagnated in volume terms over the last decade (Figure 1); between 2001 to 2008 European aquaculture averaged only 0.5% growth (APR) compared to 7.6% for all non-EU countries combined (*FEAP 2009*). Total EU production rose from 1,230,362 t in 1996, peaking at 1,431,738t in 1999 before declining to 1,283,969t in 2006 (*FAO 2007*). These aggregate figures conceal a 24% decrease in fresh and brackish water production (to 335,501t) and a 20% growth in marine production (948,468t) over the same period. Today, EU farmed production is equivalent to roughly 2% of global aquaculture production. Although declining, the EU retains proportionally greater reliance on its wild fisheries (which still accounted for some 6.1% of global capture production in 2005), most of which is consumed within the EU. In 2005 nearly 12 million tonnes worth some €3 billion were consumed in the EU. Aquaculture contributed only 18% of internal EU-27 seafood production (27% of total value) compared to a world average of 40% (*EUROSTAT*).

However, the latter figure declines to 20.5% with the exclusion of China, which alone accounts for 71% of global aquaculture production.

Poor resolution of available statistics makes it difficult to ascertain exactly what proportion of EU seafood imports are of farmed origin. However, imports of just two intensively cultured finfish species; pangasius (Vietnam) and salmon (Norway) were respectively equivalent to some 38% (*Paquotte 2009*) and 39% (*Catarci 2008*) of total EU-27 farmed production by volume in 2008. Although extremely important in value terms, imports of wild and farmed shrimp are particularly difficult to disaggregate. Other extensively 'farmed' species occupying the grey area in the continuum between aquaculture and fisheries present further difficulties e.g. Canadian Pacific salmon; a close substitute for Atlantic salmon relies to an indeterminate extent on stocking enhancements, with significant state support.

Figure 1: EU-27 country-wise aquaculture production excluding aquatic plants



Source: FAO Fishstat

2.2. EU supply characteristics: regions and sub-sectors

Production

The 27 member states of the European Union (EU-27) are grouped into three regions based on their main supply characteristics3 (Table 2):
1. CEE: Central and Eastern Europe (carp, rainbow trout, African catfish, sturgeon)
2. NE: North Europe (salmon, rainbow & sea trout, eels, mussels, oysters)
3. MED: Mediterranean (sea bass/ sea bream, oysters, turbot, mussels, oysters, clams)

A fourth group (Table 3) consists of five European countries which although non-EU (NEU) members, have significant aquaculture and fisheries sectors. Two of these countries, Norway and Iceland are part of the 'single-market' as EAA members, though their agriculture and fisheries (including aquaculture) remain subject to bilateral agreements.

[3] This broadly follows the scheme of Ernst & Young (2008).

Norway is by far the largest aquaculture producer in Europe (Table 3). The Faroes, as members of the Nordic passport Union (requiring no border checks with the rest of the Schengen area) effectively have free access to the European Market.

Table 2: Total Aquaculture production, mean price and value by country (EU-27) and Region 2006

Country	Tonnes	Mean €/kg	Value Mill €
1. Central and Eastern Europe (CEE)			
POLAND	35,867	2.08	74.6
CZECH REPUBLIK	20,431	1.74	35.5
HUNGARY	14,686	1.78	26.1
AUSTRIA	2,503	5.00	12.5
ROMANIA	8,088	1.15	9.3
BULGARIA	3,257	2.49	8.1
LITHUANIA	2,224	2.10	4.7
SLOVENIA	1,369	2.23	3.1
SLOVAKIA	1,263	1.71	2.2
LATVIA	565	2.10	1.2
ESTONIA	703	3.94	2.8
SUB-TOTAL (Weighted Mean)	**90,956**	**(1.98)**	**180**
2. Mediterranean (MED)			
FRANCE	238,905	2.20	525.6
ITALY	173,083	2.77	479.4
GREECE	113,384	3.28	371.9
SPAIN	293,288	0.98	287.4
PORTUGAL	6,778	4.93	33.4
CYPRUS	2,667	5.73	15.3
MALTA	1,126	5.61	6.3
SUB-TOTAL (Weighted Mean)	**829,231**	**(2.07)**	**1,719.3**
3. North Europe (NE)			
UTD. KINGDOM	171,848	3.56	611.8
GERMANY	35,379	3.50	123.8
DENMARK	37,188	2.79	103.8
IRELAND	53,122	2.24	119.0
FINLAND	12,891	3.28	42.3
NETHERLANDS	43,945	2.20	96.7
SWEDEN	7,549	2.94	22.2
BELGIUM	1,200	2.29	2.7
LUXEMBOURG	0	0	0
SUB-TOTAL (Weighted Mean)	**363,122**	**(3.98)**	**1,122.3**

Source FAO

Table 3: Finfish[4] production (t) by European country[5] and Region 2001-2008

COUNTRY	2001	2002	2003	2004	2005	2006	2007	2008
1. Central and Eastern Europe (CEE)								
POLAND	34,310	30,750	33,760	33,431	33,241	38,831	37,451	37,451
CZECH REPUBLIK	18,660	17,946	18,337	18,798	19,892	18,870	19,803	19,980
HUNGARY	17,733	18,408	17,735	17,735	17,837	17,697	15,114	15,114
AUSTRIA	2,308	2,229	2,148	2,410	2,543	2,632	2,632	2,632
SUB-TOTAL	**73,011**	**69,333**	**71,980**	**72,374**	**73,513**	**78,030**	**75,000**	**75,177**
2. Mediterranean (MED)								
GREECE	66,550	73,500	78,500	79,500	83,600	100,000	72,000	130,000
SPAIN	54,620	57,200	57,514	62,668	56,835	66,154	61,959	79,439
ITALY	62,900	60,100	56,900	59,100	59,845	60,705	59,700	60,925
FRANCE	59,155	55,300	49,470	51,010	48,770	50,655	49,194	48,435
PORTUGAL	4,940	5,040	6,040	6,040	6,040	5,040	5,040	5,040
CYPRUS	1,790	1,861	2,090	3,515	3,598	3,582	3,425	4,000
MALTA	1,235	1,116	1,000	913	931	931	931	931
SUB-TOTAL	**251,190**	**254,117**	**251,514**	**262,746**	**259,619**	**287,067**	**252,249**	**328,770**
3. North Europe (NE)								
UTD. KINGDOM	165,259	162,461	179,248	168,550	140,793	135,814	159,057	161,367
DENMARK	40,100	39,800	35,550	36,000	36,610	37,760	37,870	37,500
GERMANY	36,150	36,000	36,000	34,750	35,106	35,106	35,106	35,106
IRELAND	24,213	24,173	19,340	15,421	13,220	11,607	13,060	15,420
FINLAND	15,492	14,894	12,201	12,335	13,693	14,000	11,000	12,000
NETHERLANDS	6,700	6,400	8,275	8,475	9,650	9,300	8,640	8,640
SWEDEN	7,254	6,084	6,506	6,828	6,922	6,922	6,922	6,922
BELG.-LUXBG.	1,520	1,200	1,200	1,200	1,200	1,200	1,200	1,200
SUB-TOTAL	**296,688**	**291,012**	**298,320**	**283,559**	**257,194**	**251,709**	**272,855**	**278,155**
EU SUB-TOTAL	**620,889**	**614,462**	**621,814**	**618,679**	**590,326**	**616,806**	**600,104**	**682,102**
4. Non-EU (NEU)								
NORWAY	485,400	543,400	594,570	580,570	655,364	690,950	841,450	870,450
TURKEY	66,972	62,510	67,250	71,250	78,850	92,750	100,250	114,250
FAROE ISLANDS	49,138	55,000	62,746	37,518	22,677	14,846	25,173	33,800
CROATIA	9,840	9,605	8,456	9,350	9,950	9,550	10,430	10,930
ICELAND	8,070	3,467	6,147	8,917	8,355	8,478	6,852	6,852
SUB-TOTAL	**619,420**	**673,982**	**739,169**	**707,605**	**775,196**	**816,574**	**984,155**	**1,036,282**
Grand Total	**1,240,309**	**1,288,444**	**1,360,983**	**1,326,283**	**1,365,522**	**1,433,379**	**1,584,258**	**1,718,383**

Source: FEAP-Aquamedia

[4] Carps, catfish, eels, flatfish, other freshwater fish, other marine fish, salmon, sea basses, sea breams, sturgeon, tilapia, trout.

[5] The Federation of European Aquaculture Producers represents producer organisations in only 17 of the EU-27 states and 5 non-EU states. Sectors in the remaining EU states are generally too small to support such organisations.

As key competitors to EU aquaculture producers, Norway and Turkey are considered briefly in 0. Vietnam is also included in this section because of the phenomenal growth in its exports of fresh-water pangasius and catfish fillets to the EU over the last 5 years.

The NE and MED areas with their extensive coastlines dominate production (Table 2); respectively with annual production values of €1.7 billion and nearly €1.1 billion in 2006. An extensive shell-fish sector on France's Western coast accounts for much of the value difference between these areas. Production in the CEE region by contrast, is dominated by inland aquaculture and was worth less than €0.2 billion in 2006.

Mean unit value was highest (€3.09) in the NE Region with its concentration of salmonid production and lowest in the MED region. Although the cost of the MED areas primary products; sea bass and sea bream were comparable to salmon, average value is depressed low market price for molluscs (mainly mussels) representing some 540,000 tonnes or 65% of total volume in 2006.

Eight countries with production values greater than €100 million in 2006 together produced 81% of the total aquaculture value that year[6]. All but one (Germany) were located in the NE and MED regions and five (UK, France, Italy, Greece and Spain) cultured produce worth from €280 to €600 to million in the same year (Table 2). With some 20% of total value, the UK is the largest producer, followed by France (17%) and Italy (16%). Poland's production at 37,451 t was also substantial though relatively low unit-value due to the high contribution of carp.

Species value and trends: In value-terms there are three main species groups: salmonids, sea bream/ sea bass and bivalve shellfish. Salmon and trout were the most important cultured species, each worth close to €480 million in 2005 (Table 4). Bream and Bass were worth €304 and €257 million respectively. The main shellfish group: mussels, oysters and clams ranged from €389 to €251 million. Carps were worth €152 million, Eels €71 million with other combined species worth approx. €127 million in the same year.

Table 5 reveals clear species-wise production trends for finfish species since 2001. Although still most important in value terms salmonid (salmon and trout) production has remained flat at approximately 400,000 t worth €1 billion/yr. Of the other high volume species only sea bass and sea bream production showed significant growth; sea bass almost doubling to 46,000 t and bream increasing some 20% to 52,000 t. It should be noted these are partial figures; based on data provided by FEAP members, they also reflect growing PO membership over the 2001-2007 period, The marked discrepancy between the FEAP (Table 5) bass/ bream Eurostat totals (Table 4) reflects the relative youth of this sector and relative lack of producer organisation compared to the salmon sector. Other Eurostat figures indicate that internal trade of sea bass and bream approximately doubled between 2005 and 2007 to €148 and €192 million.

6 Excluding value-added processing

Table 4: Value of EU-25[7] species in 2005

Species	Value €mill
Salmon	477.1
Rainbow trout	484.0
Mussel	388.6
Oysters	302.7
Clams	251.2
Sea bream	304.8
Sea bass	256.9
Carps	152.6
Eels	70.5
Tuna	46.1
Turbot	42.2
Catfish	10.8
Sturgeon	10.2
Meagre	4.2
Powan	3.2
Prawns	2.7
Brook trout	2.6
Charr	2.4
Tilapia	1.2
Cod	0.3
Other species	50.2
TOTAL	**2864.7**

Source: Eurostat (in *Ernst and Young 2008*)

[7] Prior to accession of Bulgaria and Romania.

Table 5: EU-18[8] finfish variety, production, price and value (*FEAP-Aquamedia*)

GROUP	Data	2001	2002	2003	2004	2005	2006	2007
Carps	Tonnes	77,664	72,743	73,265	73,004	73,308	72,666	70,341
	Mean €/Kg	1.52	1.68	1.57	1.74	1.56	1.97	2.11
	Value: Mill €	118	122	115.1	127.2	114	142.9	148.1
Catfish	Tonnes	4,071	3,756	5,458	5,512	6,436	6,857	7,788
	Mean €/Kg	1.79	1.74	1.09	1.07	1.24	1.58	1.59
	Value: Mill €	7.3	6.5	5.9	5.9	8	10.8	12.4
Eels	Tonnes	10,282	8,993	8,679	8,268	8,805	7,790	5,320
	Mean €/Kg	5.82	6.45	7	7.9	8.34	8.58	8.12
	Value: Mill €	59.9	58	60.7	65.3	73.4	66.9	43.2
Flatfish	Tonnes	5,029	5,730	6,004	7,035	7,464	9,020	8,903
	Mean €/Kg	7.99	7.6	7.72	7.79	8.3	8.55	7.4
	Value: Mill €	40.2	43.5	46.3	54.8	61.9	77.1	65.9
Other Freshwater fish	Tonnes	420	496	528	481	539	350	514
	Mean €/Kg	3.46	4.28	4.38	4.42	1.45		3.61
	Value: Mill €	1.5	2.1	2.3	2.1	0.8		1.9
Other Marine fish	Tonnes	10,103	9,071	9,655	15,203	16,781	18,725	17,400
	Mean €/Kg	5.4	2.92	3.8	4.31	5.28	4.71	1.44
	Value: Mill €	54.6	26.5	36.7	65.5	88.5	88.2	25.1
Salmon	Tonnes	160,346	138,742	169,274	161,781	141,175	130,859	152,966
	Mean €/Kg	2.57	2.42	2.34	2.67	2.95	3.54	2.86
	Value: Mill €	412.1	335.8	396.1	432.0	416.5	463.2	437.5
Sea Basses	Tonnes	24,645	31,676	30,412	35,149	42,599	53,688	46,247
	Mean €/Kg	4.89	4.68	6.08	5.21	4.72	4.8	4.16
	Value: Mill €	120.5	148.2	184.9	183.1	201.1	257.7	192.4
Sea Breams	Tonnes	43,548	46,674	52,738	51,202	52,029	70,397	52,025
	Mean €/Kg	4.1	4.1	4.88	4.66	4.52	4.31	3.57
	Value: Mill €	178.5	191.4	257.4	238.6	235.2	303.4	185.7
Sturgeon	Tonnes	595	600	630	675	2,142	2,597	2,077
	Mean €/Kg	6.64	6.49	5.29	5.31	30.63	25.26	31.59
	Value: Mill €	4	3.9	3.3	3.6	65.6	65.6	65.6
Tilapias	Tonnes	150	150	450	450	700	750	1,150
	Mean €/Kg			2	1.75	1.75	1.8	1.52
	Value: Mill €			0.9	0.8	1.2	1.4	1.8
Trout	Tonnes	295,876	305,436	273,177	269,269	248,298	252,657	245,803
	Mean €/Kg	2.22	2.14	2.11	2.16	2.37	2.57	2.48
	Value: Mill €	656.8	653.6	576.4	581.6	588.5	649.3	609.6
Total Production (Tonnes)		**632,729**	**624,067**	**630,270**	**628,029**	**600,276**	**626,356**	**610,534**
Mean Value €/Kg		**2.68**	**2.56**	**2.63**	**2.83**	**3.07**	**3.49**	**2.93**
Total Value in M€		**1,653**	**1,591**	**1,686**	**1,761**	**1,855**	**2,127**	**1,789**

Source: FEAP

[8] Corrected without NEU FEAP member states based on 2008 ratios of production.

Internal and External Trade

Internal Trade:

Denmark, Sweden and Greece are the biggest intra-community exporters. Denmark and Sweden import significant amounts of Norwegian (and Faeroese) salmon for processing and re-export while in 2007 Greece exported 76,000 tonnes of sea bream and bass as well as 18,000 tonnes of mussels. Most of the sea bass/ bream trade is to other Mediterranean countries where there is greater demand for fresh whole product. So far there has been relatively little penetration into northern European markets. Such demand as there is, is mainly for sea bass, perhaps because of its higher fillet yield (Section 0). France and Italy are the biggest net importers, mainly of salmon and mussels.

Imports:

Some 1.27 million tonnes of farmed seafood products were imported in 2007, four times the volume in 1999[9] and double the volume in 2004 (Ernst and Young 2008). This has been the main means of meeting the deficit in EU seafood demand and supply.

The most important groups were salmon in various mainly fresh forms equivalent to 714 thousand tonnes live weight (LWE), 56% of which was whole, 43% as fillets and 1% smoked. Most of the value-added processing therefore occurs within the EU with factory concentrations in Denmark and Sweden. A smaller though growing amount of salmon product, mainly frozen and canned, also originates from Chile and China (the latter importing raw material and re-exporting processed product). Although Chile is the largest global salmon producer its distance from Europe excludes it from the main market for fresh products. In value terms Norwegian salmon imports dwarfed all other sectors, at some €2,314 million, or 81% of a total of €2,851 million worth of farmed imports in 2007.

Imports of frozen fillets of fresh water species (mainly, pangasius catfish and some tilapia from Southeast Asia) have demonstrated the most remarkable growth, escalating rapidly from less than 10,000 tonnes (LWE) in 2002 to a total of 394,000 tonnes in 2007. However, growth rates in these sectors are unprecedented giving rise to serious sustainability concerns, particularly with respect to pangasius production in Vietnam

Mussels were the third largest import group equivalent to 134,000 tons (LWE), with some 90% originating from Chile in processed form. The only other group with significant volume were sea bass and bream with combined imports of around 18,000mt (LWE) in 2007, originating mainly from Turkey and Croatia.

Exports:

The EU area is globally the largest net importer of farmed seafood. Exports in 2007 totalled only 67,000 tonnes. These were mainly higher value processed products with a value of €278 million i.e. indicating a trade deficit of €2,573 million. In 2007 some 68% of exports were salmon products, worth 67% of total value. The USA and Russia were the two largest importing countries. Eels were 12% of exports by value, sea bass and sea bream 8%. Mussels were the next most significant sector after salmon, at 18% by volume, but only 6% by value although exports were showing rapid growth. Russia and Croatia were the main market for fresh mussels while processed mussels went to the USA. There has also been slow but steady growth in the export of oysters and trout, mainly to Russia.

[9] Only EU-25 countries included in this analysis to allow comparison over the time period.

2.3. Company characteristics and consolidation trends

Vertical and horizontal integration and consolidation trends

Table 6: Turnover of larger EU-27 aquaculture companies by size and country 2006

Turnover €mill	>20	10-20	5-10	1-5	<1	Total No.	Total turnover €mill	Mean turnover €mill
UK	4	3	6	5	6	24	489.7	20.4
Greece	7	6	5	56	39	113	625.4	5.5
Spain	2	1	4	32	55	94	180.2	1.9
France	1	2	7	46	99	155	239	1.5
Italy	1	4	2	43	109	159	222.8	1.4
Other EU-27	0	3	5	36	149	193	225.1	1.2
Total	15	19	29	218	457	738	1982.2	2.7

Source: Amadeus (After Ernst & Young 2008)

Table 7: EU-27 companies with annual turnover >€20 mill in 2006/7

	Company	Country	Main Species	Turnover €mill 2006/7
1	Pescanova	Spain	Salmon, prawns, turbot	270
2	Nireus	Greece	Sea bass / bream	198
3	Marine Harvest Scotland	UK	Salmon	154
4	Scottish Sea Farms	UK	Salmon	100
5	Selonda	Greece	Sea bass / bream	85
6	Hellenic Fish Farming	Greece	Sea bass / bream	64
7	Dias	Greece	Sea bass / bream	61
8	Grieg Seafood Hjatland UK	UK	Salmon	52
9	Stolt Sea Farms	Spain	Turbot	40
10	Mainstream Scotland	UK	Salmon	33
11	Culmarex	Spain	Sea bass / bream	32
12	Interfish	Greece	Sea bass / bream	31
13	Andromeda	Greece	Sea bass / bream	30
14	Agro Ittica Lombarda	Italy	Sturgeon (caviar)	24
15	Galaxidi	Greece	Sea bass / bream	22
16	Thaeron	France	Oysters	20
Total				1,216

Note: Turnover includes aquaculture, downstream processing and allied sectors
Source: Amadeus (After Ernst & Young 2008)

Large markets allow firms economies of scale, a key determinant of productivity and competition. The process of globalisation continues to drive rapid expansion of value chains across international boundaries, particularly in the seafood sector. For many countries, smaller ones in particular, these markets have now become more significant than domestic markets e.g. seafood producers including Norway, Iceland, the Faroes and Ireland. This was also noted by the *Ernst and Young (2008)* sector review, which suggested that the longer term viability of smaller companies, which are most susceptible to price fluctuations, would lie in premium niche markets. They also note the need at EU level for emphasis on consolidation of larger units capable of providing the major distribution chains with the volume and regularity of supply they require.

In terms of numbers (if not value), European aquaculture continues to be dominated by SMEs alongside a small number of larger vertically integrated companies. SMEs dominate the bivalve and freshwater sectors in particular, including many family owned enterprises. By comparison, more intensive marine cage-culture sectors have already seen more rapid consolidation as a result of more readily exploitable scale-economies (i.e. fewer larger sites) and higher value products. In this section we will first analyse horizontal consolidation at producer level, before looking at vertical integration trends.

Table 6 summarises turnover for 738 of the largest EU companies (financial data available up to 2006: Amadeus). Only 63 companies had turnover greater than €5 million, of which 38 were located in the UK and Greece, mainly in their salmon and sea bass/ sea bream sectors. These include eleven of the largest 16 European companies (turnover > €20 million: Table 7). Together, these 16 companies incorporate some 61% of the total value reported in Table 6, while the 457 companies generating under €1 million per year represented less than 10% of the total value. By comparison, 39 companies in Norway have annual turnover >20 million. The single largest European company Pescanova (Spain) generates 90% of its income outside the EU through its prawn (Nicaragua) and salmon (Chile) interests. Nireus, Selonda and Hellenic have also invested in sea bass/ bream ventures in Turkey and Andromeda in Albania. However, aside from Pescanova all the remaining businesses in Table 7 operate mainly or exclusively within the EU. Although all the top six Scottish salmon companies are majority Norwegian owned, they operate autonomously as UK listed companies.

The combined output of these six 'Scottish' companies represented over 85% of UK production in 2008 (*FRS, 2008*) making this the most consolidated production sector within the EU-27. It is also the longest established in the marine cage-sector, with consolidation driven by potentials for scale-economies and industry 'shake-outs' associated with over-production and episodic disease problems. It has in many ways provided the development model for younger growth sectors particularly the Mediterranean sea bass/ bream sector, which likewise however appears to have to go through its own painful changes.

Table 7 demonstrates the wider global consolidation of the salmon industry over the last decade. In 1997, 117 companies in Norway, Chile and Scotland were responsible for 80% of those countries' combined output (70 of them in Norway). Norwegian consolidation has been the most marked largely because of the greater number of players at the outset as a consequence of the government site-licensing restrictions. Subsequently the top 10 Norwegian companies have also been responsible for much of the international consolidation; MH group acquisitions are most significant in this respect (Annex 1, Table 20).

The same expansion and consolidation trends are occurring at an accelerated rate in the Greek sea bass/sea bream sector aided by a more open regulatory environment.

Vertical integration

From a broader value chain perspective, aquaculture can be viewed simply as a producer of raw materials for processing and retail presentation. This is where, for most species, greatest value-addition is concentrated. Thus the distribution of benefits along the value chain from small-producers of pangasius catfish in Vietnam to European retailers shows that of the final sales price of €7.00/kg, 10% goes to the farmer, 10% to the fish collector, 20% to the processor, 20% to the trader and 40% to the retailer (*Globefish 2009*). Vertical integration brings other opportunities for scale economies in distribution networks, enhanced production planning efficiency and generally greater protection against price fluctuation at different points in the production chain. In the following paragraphs we consider vertical integration starting at the bottom of the value chain.

Selective breeding programmes are one of the most costly research and development activities in fin-fish aquaculture. In Norway, production of salmon and trout eggs has been concentrated in the hands of just two specialist producers with global outreach: Salmobreed and Aquagen. Their successful growth is based on a history of effective public-private sector partnership (PPP) involving government financial support, research institutions and major industry players. For example over 90% of Aquagen's shares are held by three salmon producers and one feed company. These two companies exploit scale-economies unavailable to any companies within the EU. Consequently the Scottish salmon sector relies heavily on them for over 86% of its ova requirements. Ireland is more reliant on local production having prioritised organic salmon production as a niche strategy nationally.

In the absence of such PPP initiatives in the EU, there are very few independent 'stand-alone' hatchery operations of significant size incorporating broodstock programmes. Rare examples include the Spanish company Piscimar (sea bass), in France GrainOcean, France Naissain, Satmar (clams and oysters) and Ferme Marine Du Douhet (sea bream) and in Scotland Landcatch (salmon eggs and smolts).

Only two EU-27 Salmon companies retain fully vertically integrated egg to fork production: Marine Harvest Ireland for its organic stock requirements, and Norwegian-owned Marine Farms AS in Scotland, which operates a lower cost mass-selection programme through its subsidiary Lakeland Smolt. Marine Harvest UK, the largest Scottish company, abandoned its broodstock programme when it was first acquired by its Norwegian parent company which is also one of the major share holders of AquaGen.

In 2009 the world's leading poultry genetic holding company, Erich Wesjohann Group GmbH (EW Group) bought 50.2% of the shares in AquaGen AS. This may signal an attempt to exploit synergies between the salmonid sector and the highly successful poultry selection model noting the following caveat. Highly controlled broiler production environments permit use of highly in-bred lines selected for their marketable traits. This is far more complex in aquaculture because of the highly variable environmental conditions encountered in (predominantly) open-culture systems. Conversely this may provide future opportunities for an emergent recirculating aquaculture sector.

Due to disease risks and high transport costs, international smolt transfers are limited. Therefore more common than independent egg producers are independent or contract nursing operations (low-tech' by comparison) supplying parr or smolts to on-growers. Most of the larger Scottish producers have grown or acquired their own smolt production capacity. As the number of smaller salmon farmers has also dwindled, the 'spot' market has essentially ceased to exist. Much of the remaining market is for contract supply to two of the larger multi-nationals (Marine Harvest and Lighthouse Caledonian) and it is probable that these companies too will become increasingly self-reliant.

Few aquaculture companies have integrated fish feed production facilities. Exceptions include Cermaq, the Norwegian parent of Mainstream Salmon, and the global aquafeed group Ewos, both with Scottish operations. Ewos produced 902,000 t of feed in 2008, one third of global salmon and trout feed production. Due to the overproduction and high price competition, four of the larger Greek sea bass/bream producers (Nireus, Selonda, Hellenic, Dias and a group of smaller producers) are actively developing their own feed subsidiaries in an attempt to bolster their margins. Capacities ranged from 30,000 to 80,000t per year in 2007/8 with new-builds and factory acquisitions on-going. In Hungary, Szegedfish grows cereals to meet part of the feed requirements for its extensive carp operations.

The majority of larger aquaculture firms (with the exception of those involved in live-trade) also conduct their own slaughter, packing and transport of harvested product. However fewer, mainly larger firms have processing capacity for value-added products with smaller companies limited to filleting, freezing and boxing. The same Greek companies described above have also sought to develop their processing capacity to target northern new European markets where there is less demand for whole fish.

Some independent companies producing specialist products e.g. smoked salmon, eels, trout, sturgeon caviar rely mainly on third-party raw materials.

Very few companies have dedicated research and development departments, most being more likely to collaborate on an *ad hoc* basis with research institutions and universities as needs dictate. Again the largest UK producer Marine Harvest divested itself of its feed trial unit, juvenile/ new species experimental units and health laboratory after its Norwegian acquisition. The largest dedicated research capacity is focussed on genetic research: Landcatch in Scotland, Nireus, Selonda, and Andromeda in Greece. Once again this underscores the limited role of technical innovation in competition. The Norwegian strategy has been to supply the high volume commodity export markets through its Norwegian and Chilean farms while supplying more premium EU markets through its Scottish and Irish possessions. Norwegian companies are further consolidating their presence in Chile through acquisitions following the recent catastrophic disease losses faced by the industry.

In Europe such holdings as well as joint-ventures between aquaculture companies are very rare. However there are a few exceptions; the Greek company Nireus has slightly reversed the above trend by acquiring a 30% stake in the Norwegian Marine Farms AS. This has 100% ownership of its salmon operation in Scotland (incorporating Lakeland Smolt) and Culmarex, a Spanish producer of sea bass and sea bream. In turn Selonda owns 11.3% of Nireus, its main competitor.

Processing, distribution and consumption

EU aquaculture products bring many advantages to processers (and consumers) over and above those conferred by capture-fishery and third-party seafood-products. These include increased traceability and trust in local producers (i.e. compared to Asian and African aquaculture and fishery imports), regularity of supply and stable prices, greater freshness associated with shorter/ more responsive value chains, lower contaminant levels (mercury, parasites etc).

Throughout Europe there has been a trend toward concentrating distribution though large-scale retail chains, a trend most advanced in the NE region, but also gathering pace in the south. The regularity and volume of supply demanded by these chains has acted as a constraint on the development of new species. However the rapid rise of imported Pangasius catfish shows that new species can be adopted swiftly when these conditions are met. Significant scope also exists for development of new processed product forms using the available species and this is arguably a more profitable avenue for investment than species diversification.

2.4. Product differentiation, standards and certification

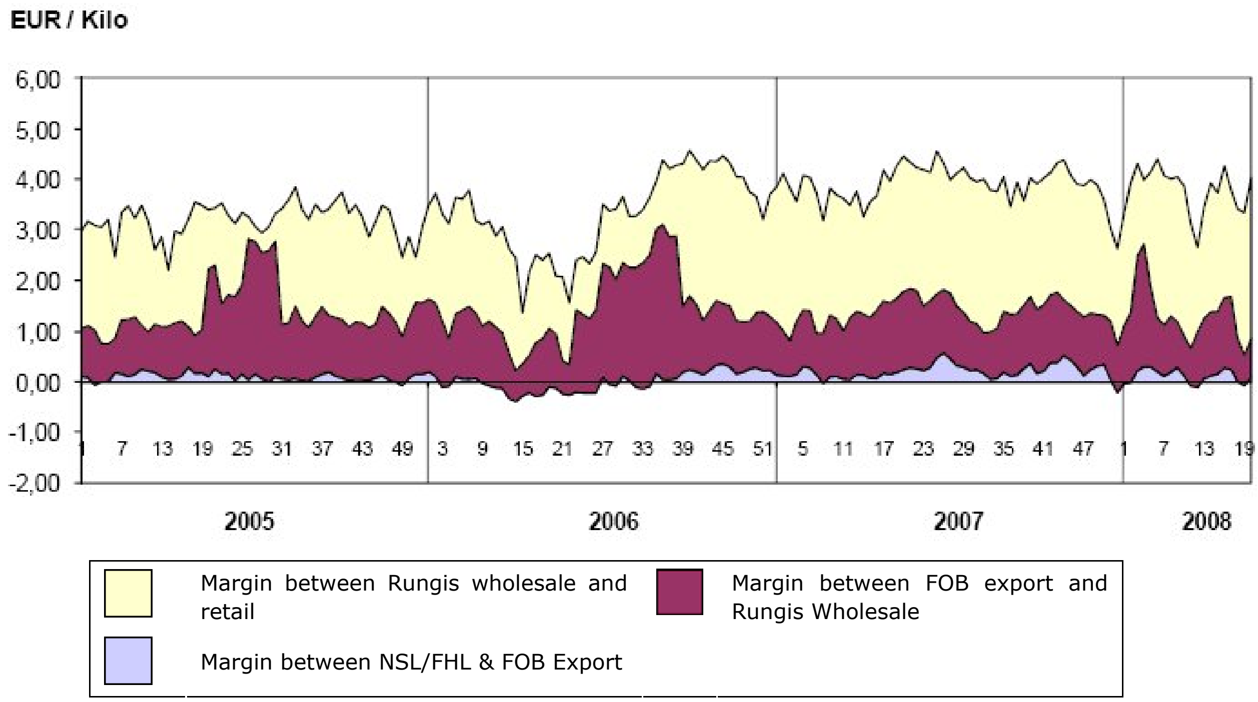
Product diversification and differentiation

Much aquaculture produce is sold whole and fresh (or live in the case of shellfish). Where product is relatively undifferentiated across producers, the industry will tend to be cost-led with internal competition based on lowest-cost production. The market can be expanded and further value obtained by producing additional (generally added-value) products from the basic raw material and/or by driving real prices down to widen competition with other food sources, and access a wider range of disposable income levels. These products may also increase the breadth of competition however; particularly in the case of white fish where the type of species may be less significant that the value-add format.

The salmon industry provides an interesting case study as rising production during the 1990s caused a fall in prices the industry responded by developing a wider range of processed products. In some cases, larger producers, through a range of expansion or merger strategies also made significant investment in vertical integration. This helped these producers expand their market reach, creating substantial additional turnover in the processing and marketing operations. Figure 2 shows the resulting relative improvement in retail margins over recent years.

The sea bass and bream sector has developed along somewhat similar lines to the salmon sector, and food sector companies might be expected to similarly invest in product diversification through value-added processing. However, in additional to cultural attachments to whole fish in the home markets, these species also have a lower fillet yield than salmon i.e. 64% (salmon) v 45% (sea bream), and 55% (sea bass). This would result in comparatively higher prices for fillets (or lower margins for producers), particularly for sea bream, which may be more difficult to recoup when exposed to the greater competition of other white-fish based products. Salmon again has an advantage here as there are fewer direct substitutes and it is relatively easy and inexpensive to grow to a size which provides wide versatility for diverse product forms.

Figure 2: Mean monthly margins between exporter purchase, export, wholesale and retail prices for Norwegian salmon



Source: Kontali 2008
Note: NSL/FHL refer to exporter purchase price, FOB to exporter sale price i.e. freight on board, Rungis is one the world's largest wholesale food markets, located in Paris.

Many aquaculture based products have some form of product diversification and value-addition e.g. fillets, smoked or ready-cooked etc. However, the barriers to developing this can be very high for individual producer companies, so some prior consolidation or the formation of producer cooperatives is often necessary as the investment costs for new product development and marketing are substantial. This investment is increasingly coming from value-addition specialists diversifying their input sourcing to develop ever wider ranges of products.

The other main strategy for value-addition is product differentiation, moving a product from competition based on price to non-price factors e.g. qualitative, ethical, promotional, distributional or other characteristics. By definition, successful differentiation requires something different from the majority of product and is therefore only feasible for a proportion of total production. For example UK organic salmon production at 5,500t in 2008 was around 4% of total production. Irish production at 7,000 was almost 50% of total production in the same year (*The Soil Association 2009*) but targeted at a much wider niche European market segment. This market has fared somewhat better than other organic sectors during the current economic downturn; however with Norway also planning to treble its production to around 3,000 t in 2009 (*The Fish Site, 2009*) this niche market may be oversupplied in which case price falls can be anticipated.

In the case of species variant or locality definition, the size of markets is clearly defined by potential production of this form meeting the required designation standards, the cost of developing differentiation and protecting identities.

Some aquaculture producers, including sea bass and bream farmers have suggested that previously frozen and defrosted pangasius and tilapia fillets are taking sales from their products. This is potentially a wider threat to all farmed whitefish products associated with their high substitutability particularly in processed form; for example cheaper variants are frequently substituted for both wild and farmed cod.

This highlights the need for a slightly different type of differentiation, based mainly on raising the awareness of consumers of the differences between the products, particularly with respect to tangible assets such as omega 3 fatty acid profiles, taste and texture qualities but also less tangible environmental, social and welfare factors. For example dietary sustainability criteria including the extent to which species are net contributors of marine proteins and oils as well as the sourcing of plant proteins increasingly used as fish meal substitutes.

Conversely differentiation in allied sectors can create a potential threat to aquaculture producers particularly if the benefits of their products are not as clearly articulated on a timely basis. For example some commentators perceived such a threat from the commercially successful Marine Stewardship Council (MSC) ecolabel for sustainably sourced capture-fisheries (*Stromsta, 2008*). This particular threat has subsequently diminished since, despite initial resistance, the MSC have chosen to extend their certification to aquaculture products; albeit those at the more extensive end of the production spectrum (e.g. fisheries based on stocking enhancements). These observations reflect one of the central problems of eco-labelling; the highly contested nature of hard and soft definitions of sustainability and therefore which aspects of sustainability should an eco-label represent? (*Ward and Phillips, 2008)*. From a marketing perspective consumer perceptions matter most and straightforward consistent messages have their advantage evidenced by the greater resilience of Fair Trade compared to more complex multiple-attribute organic products during the economic downturn.

Emerging standards and certification

High profile food scares have combined to create a renewed interest in provenance with transparent and verifiable systems of food traceability along the chain. Consumers have also sought greater reassurance in their food purchase decisions through additional attributes including fair trade, animal welfare, environmental impacts such as protection of overexploited fish stocks, food miles, and more locally sourced products.

Public standards

Governments at national, EU and inter-governmental level have responded to these concerns through their development of statutory quality standards, with particular emphasis on food safety. WTO signatories are accountable under the Agreement on the 'Application of Sanitary and Phytosanitary Measures' (SPS). A contentious feature of the SPS is its ability to override a country's use of the precautionary principle in favour of evidence-based arguments. The USA unsuccessfully challenged EU restrictions on the import of genetically modified organisms on this basis in 2003. It also offers scope for quarantine to be used as a 'technical trade barrier' to keep out foreign competitors. To date the welfare of farmed aquatic animals has been far less proscribed than terrestrial animals. Forthcoming EU legislation will also bring the sector under a statutory regime. This could either handicap EU producers or create a trade-barrier depending on how far foreign competitors can be practicably held accountable to the same standards.

Private standards

In a climate of political consumerism, markets have responded through an expanding array of voluntary certification and labelling schemes operated on a trans-national basis but often with different standards and sometimes conflicting interests. In addition to food safety assurance, environmental, social justice and animal welfare criteria have been a key area for these schemes, filling a gap left by public standards. Whilst some communications appear to have been effective, the proliferation has also caused confusion and precursors of renewed consumer distrust elsewhere.

Market-based standards can also be characterised in terms of their competitive strategy. Organically farmed and processed products are highly differentiated within a narrow market segment. Organic foods typically command a premium of 10-40% to compensate for reduced yields and accounted for 1-2% of EU food sales in 2008. Since the early 1990's up to 2008, the organic sector grew between 10-20% per year, far faster than the rest of the food industry. However, there is a lack or reliable statistics for organic aquaculture. One estimate put world production in 2004 at around 25,000 t; 14,000 t of this in Europe worth around €70m (*Globefish 2005*). Organic aquaculture standards are a relatively recent innovation, limited to relatively few countries and species, but achieving rapid growth. Globally there are around 30 non-governmental certifiers, 18 of them are in the EU with the market most developed in northern Europe. Extensively farmed, low-trophic status species such as shellfish and carp have obvious innate organic credentials. More contentious are species with predatory and/ or migratory characteristics e.g. salmon, trout sea bass/ bream, sturgeon. Ironically, relatively little shellfish is actually certified, sceptics arguing most production is already 'organic' and niche certification could have untoward effects on the larger 'non-organic' sector. Nevertheless, the use of certain production techniques such dredging, triploidy, disease treatment and predation protection measures clearly do offer scope for differentiation. Salmon and trout are the main organic species in the EU, salmon alone accounted for 12,500 t worth over €60 million in 2008. Premiums for organic seafood can be high; for salmon it can be over 100% and 30-40% for sea bass/sea bream. On the other hand, premiums for shellfish and organic carp (still perceived as a low cost product) are relatively low, though margins can still be good.

In the case of sea bass/sea bream organic development is still in its infancy, with just a few hundred tonnes production per year, most of it in the south of France. Poor differentiation and consumer confusion between organic and wild or conventionally farmed product has been cited as constraint in both the shellfish and the carp sectors. Organic salmon by contrast at over 4% of EU farmed production has surpassed the average market share of 1-2% for the organic sector, despite criticism of industrial-scale approaches conflicting with small-scale and other founding principles. Two of the largest EU salmon companies now produce organic salmon for example. Claims regarding the superiority of organic over conventional product have not always been scientifically substantiated. These factors present a threat to longer-term brand integrity.

Organic salmon has proved relatively resilient to past recession and in the UK is supported by favourable exchange rates during the current downturn, though there are some concerns regarding potential over-supply. UK production is relatively static with some smaller farmers ceasing production, conversely with State support Irish production is expected to rise from around 7,000 t in 2008 to 8,000 t in 2009. The availability of suitable sites meeting organic criteria may limit future growth (*Globefish 2009*).

As indicated above, contradictory and proliferating sets of competing private and international standards also represent a threat. The EU finally has just published its own detailed legislation on organic aquaculture (*EC 2009*), which may provide a baseline for standards harmonisation in the future. The FAO have also considered incorporating organic standards within their *Codex Alimentarius*; a collection of internationally recognised standards, recognised by the WTO (i.e. for trade-dispute resolution), with the intention of promoting food health and fair international trade practices.

As well organic certification, some UK salmon producers have adopted an animal welfare standard (*RSPCA Freedom Foods*) to differentiate their products. However, the prospect of mandatory EU welfare legislation for farmed aquatic animals has contributed to this scheme being rolled-out across the entire industry i.e. in order to capitalise on voluntary adoption. Smaller farmers who strategically adopted the standard to differentiate themselves from larger producers (previously more focussed on scale-economies) therefore face ongoing compliance costs while their price premium is eroded.

Some producer organisations have also developed farm management and geographic (e.g. protected geographical indication: PGI) accreditation with the aim of ensuring that a greater share of any value-add goes to producers. American POs appear to have greatest initiative here. For example the Global Aquaculture Alliance (GAA) has created a range of vertically integrated 'Better Aquaculture Practices' (BAP) standards for shrimp tilapia, channel catfish farms including hatcheries, processing plants with feed mills and other species to follow.

Benefits of certification extend through the value-chain and unsurprisingly retailers have not been slow to take advantage. Major chains are starting to collect around a smaller number of so called 'third-generation' private standards and 'own-labels' with the effect of further concentrating economic power at the top of value chain and away from processors, producers (and smaller retailers). They have also developed their own 'better farm-management' standards; the most significant, known as GLOBALGAP (formerly EUREPGAP) were originated by a consortium of European supermarkets but now have global aspirations. Under an integrated 'all farms base' there are separate standards for major crop and livestock commodities. An aquaculture sub-base covers salmonids, shrimp, pangasius and tilapia and like the BAP standards cover basic food safety, environmental, animal welfare and social responsibility criteria. The competition strategy here is to guarantee basic quality standards (i.e. less exacting than organic or other eco-labels) whilst maintaining relatively low prices to achieve the widest market penetration. This is business to business (B2B) rather than business to consumer (B2C), which is the requisite for a product differentiation strategy. Consumers do not see the label on specific goods instead the accreditation helps re-enforce the retailer's image with consumers as guarantors of generic food 'quality' along the whole food chain. Despite lower margins, high volumes point to high profits; the GLOBALGAP salmon standard now covers more than 60% of all farmed product, by far the greatest market share for any aquatic standard. Such standards also offer greatest appeal to larger producers wishing to secure long-term supply contracts allowing them to securely exploit scale-economies. Concerns over rising competition scrutiny in Western Europe are also driving the larger chains to scale-up their Eastern European penetration; for example Tesco increased total sales in the region by 75% between 2004 and 2005 (Millstone and Lang 2008).

The success of GLOBALGAP perhaps explains the lack of any EU producer initiative as ambitious as that of the GAA combined with the fragmented nature of European aquaculture and relative weakness of its producer organisations. Such schemes can therefore be viewed as drivers of consolidation operating potentially on a global scale. B2B schemes in particular may have intrinsic appeal to consumers wanting cheap food with a minimum assurance e.g. basic food safety and not much more. This appears to be a stronger push factor than provenance or other certification criteria since the economic downturn.

Following the success of the MSC capture fishery eco-label which they co-initiated, the WWF have also been sponsoring development of a range of farm management standards for twelve aquaculture species: salmon, shrimp, pangasius, tilapia, abalone, clams, trout, oysters, scallops, mussels, Seriola and cobia. Developed through 'stakeholder dialogues', the first set, for tilapia are close to completion and the rest scheduled for next year. An independent body the Aquaculture Stewardship Council (ASC) will be established in 2011 to provide certification under a B2C label. In the interim the WWF is offering non-exclusive partnerships with other suitably accredited certifying bodies. Interestingly such a partnership has reached with GLOBALGAP under their B2B model. As the WWF is a farm-only standard (i.e. unlike GLOBALGAP it lacks feed mill, hatchery, or processing factory components), this partnership is likely to endure in some form even when the ASC consumer label is finalised.

The 'Community Eco-label'

In an attempt to support greater equity and clarity to consumers efforts are being made to promote an EU-level 'Community Eco-label' based primarily on environmental sustainability criteria. This aims to drive standards harmonisation and reduce proliferation of private labels. To this end, The EU parliament and council recently passed a legislative resolution (*EC 2009b*) designed to improve the efficacy of an earlier initiative. The improved eco-label which covers aquaculture and fisheries products as well as other processed foods will attempt to capture the top performing 10% of products and services. A European Union Eco-labelling Board (EUEB) will be established to co-ordinate national accreditation bodies and to ensure balanced participation of interests across the value-chain (from feed suppliers to Environmental NGOs). As the label is restricted to EU members, this will further differentiate accredited products from Non-EU imports. The European Commission also plans to independently propose an eco-label regulation centred mainly on sustainable fishing criteria before the end of the year.

2.5. International trade rules and market volatility

Intra-community and global import-export trends

The deficit between EU supply and demand has for the most part been met by rapidly growing farmed-seafood imports, mainly freshwater species from Asian countries, most notably Vietnam, Thailand, the Philippines, Indonesia, China and some South American countries. This reflects a wider trend whereby trade in farmed species is rapidly becoming a significant component of global levels of seafood supplies. In 2006 over 50% of fish production was internationally traded with net flows from developing to developed countries. Growth in production and export of fin and shellfish from Asia to European markets has accelerated over the last decade and this contributes a major share to what is, in value terms, now the most important internationally traded food commodity sector.

In certain 'hot-spots' in Asia, over the last few decades aquaculture has changed from a traditional small-scale practice to large commercial/industrial enterprises. Typically responding first to increased local urban demand, production has often been scaled-up dramatically to supply international markets. Consolidation of food commodity chains by fewer larger vertically integrated organisations is a growing trend, although SMEs still constitute the major proportion of the business.

Most of these imports arrive as highly commoditised bulk frozen products destined for, processing, wholesale distribution, supermarket retail and the refectory trade. Farmed EU-seafood products differentiated by USPs of local production and freshness occupy a smaller premium market segment. The main competition in this market sector comes from European capture fisheries and locally-farmed produce from third-parties outside the EU; notably Norway (salmon and trout) and Turkey (sea bass and sea bream) – section 0.

Effects of International Trade Rules

International trade is governed by a set of rules agreed by governments and overseen by the World Trade Organisation (WTO). Under WTO rules, levels of import tariffs for seafood are lower than most agricultural products. This probably reflects the dominant pattern of trade flows from less developed to developed countries with large seafood deficits; the EU alone takes 36% of all internationally traded products. The levels actually 'applied' within the EU are much lower than 'bound' WTO ceiling levels which range from 0 to 60%. This discrepancy is referred to as 'water in the tariffs' (WITT). *Melchior (2005)* calculated that a 40% cut in bound tariffs worldwide would only result in a 9% cut in applied tariffs as a result of the WITT.

Many developing countries including China, Vietnam and Turkey already benefit from full tariff elimination under various bilateral free-trade agreements. However, compliance costs for adhering to 'Rules of Origin' ensuring traceability still typically range from 2-5% of import value (*Estevadeordal and Suominen, 2004*).

The trade of greatest significance for EU competition originates from countries neighbouring the EU, especially Norway whose fresh products substitute directly for EU products. The UK and Irish Governments, citing unfair Norwegian State subsidy to the salmon sector, successfully lobbied for anti-dumping (AD) duties and quotas in 1997. These were replaced by a minimum import price (MIP) finally fixed at €2.80/kg in January 2006 (*Intrafish, 2007)*. This was not supported by Danish and other processors heavily reliant on Norwegian raw materials. However, it should be noted that members of this group already benefited from some protection in the form of 'tariff escalation' for processed goods c.f. a 13% tariff on smoked salmon compared to only 2% on whole salmon (5% averaged over all product lines). The MIP was revoked in July 2008 following a WTO ruling favouring the Norwegian case. The measure also had the unintended result of encouraging EU processors to source more wild Pacific salmon (mainly MSC certified). An earlier attempt to impose an MIP in 2004 was successfully opposed by Danish processors; a significant part of this sector has subsequently relocated to Eastern European EU states with lower labour costs.

As WTO regulated tariff barriers have been relaxed worldwide, anti-dumping (AD) measures of which the salmon MIP is an example, have become the most significant trade barrier for seafood entering developed country markets (*Zanardi, 2004*). AD duty, imposed on good sold at less than 'fair price' (technically below cost price in the exporting country) has been used more frequently, by more countries, and against more products (*Prusa, 2005*). The USA has been particularly zealous in protecting its farmers this way with wider spill-over effects. Duties were imposed on Norwegian salmon (1990), Chilean salmon (1997), Chinese crayfish (2003) and shrimp for six countries (2003). Earlier this year the anti-dumping duty (64%) first imposed on Vietnamese frozen catfish fillets in 2003 was renewed. This action initiated a drive by Vietnamese processors to penetrate alternative markets, notably the EU, which remains the main destination for these exports (Section 0). Vietnamese seafood businesses also find it difficult to penetrate the (second largest) Russian market due to its higher tariffs. As a result these commoditised imports effectively set the price floor for white-fish fillets in the EU. Powerful domestic farming lobbies have driven most, if not all of the US dumping cases referred to above. The trend has been less marked in the EU, due to a combination of weaker producer organisations, the spread of corporate equity beyond EU borders (e.g. for salmon production), and conflicts of interest between local producers and processors wishing to source low cost imported raw materials.

The discriminatory potential of mandatory food standards e.g. the sanitary and phytosanitary measures regulated by national/EU laws and WTO agreement and at EU-level new Hygiene Regulations (2004) in force since 2006 are undoubtedly the most significant class of non-tariff barrier for the seafood market. Over the last decade the EU has imposed bans on seafood (aquaculture and capture) on at least ten (mainly LDC) countries citing food safety concerns in production and processing (*Aksoy et al, 2005*). Costs of compliance (e.g. to HACCP systems) can be proportionately higher in developing countries with low factor productivity characteristics (infrastructure, human capital etc). The EU (1999) and the USA (2000) have banned a total of 16 antibiotic residues in foods for which scrutiny will become progressively more exacting as analytical techniques become standardised. Already detection of Chloramphenicol and nitrofurans has provided the justification for numerous temporary import bans. A ban on Vietnamese catfish imports by Russia and Egypt between January and May 2009 was imposed on this basis.

In summary, due to the high 'WITT', commitments to reduce seafood tariffs in the Doha round of WTO trade negotiations are likely to have limited consequence for EU producers. Processors benefiting to varying degree from tariff escalation and non-tariff barriers may feel greater impact. Overall the significance of these measures in the seafood sector may be more political than economic. *Péridy and Guillotreau (2000)* concluded that the transport distances and price factors (including exchange rates) remain far more influential for seafood import levels to the EU than artificial trade barriers.

Financial Instruments and price cycling

In most if not all aquaculture sectors, cyclical price and production trends are a key constraint to rational industry growth and efficient production planning. Comparisons with other agricultural commodity sectors reveal a lack of sophisticated financial instruments notably long-term contracts to hedge against future price and currency-rate changes. This is perhaps a consequence of the sectors' historic dependence on a longer established processing sector which handles capture products of much more erratic provenance. "Futures" one form of contract with potential to dampen price cycling are defined as 'a standardized, transferable, exchange-traded contracts requiring the delivery of a commodity at a specified price, on a specified future date, with an obligation to buy' (Valdez 2000)

The need for long-term contracting is most evident for temperate species; salmon can take from 25-35 months from egg to market, by which time the economic basis for planning decisions may have been entirely transformed. This sector, one of the most mature, regulated and intensive in the EU, therefore offers a useful case-study. Despite industry consolidation peaks and troughs in this market have not diminished (*Olsen, 2008*), as much of the product traded into Europe is still sold on the weekly spot market. Between 1998 and 2007 EU Atlantic salmon supplies fluctuated in a regular 'saw-tooth' profile, between extremes of 3% and 12% growth per year (*Kontali, 2008*). This masks regional variation; most of this trade is for Norwegian product for processing and whole fish sales. UK and Irish producers have increased their level of forward contracting with local and EU supermarkets which clearly does give them some competitive advantage. However the sheer volume of Norwegian (and to a lesser extent wild salmon imports) on the spot market continues to drive wider cyclical market trends. Better co-operation could benefit the whole industry. One Norwegian industry informant considered this likely to be the next key phase in the maturation of the salmon sector.

In Norway the main progress towards this goal has been establishment of two companies trading fish and seafood product futures and options (non-binding purchase rights) internationally: 'Fish Pool' and 'Fish Ex'. Although both are relatively small, producer membership shows steady growth. Fish Pool, the dominant player, claims to offer price predictability two years ahead. Inhibiting industry adoption is the intense competition which still exists between larger players and perceived positioning opportunities to make windfall profits on price fluctuations. The highly perishable nature of fresh premium seafood products also acts as a deterrent to speculators. For farmed-products where oversupply and associated price fluctuations are common, additional 'arbitrage' arrangements allow better approximation of profit to investor risk, for example by discounting futures prices at appropriate rates.

French industry informants (the main UK export market) also noted that quality labelled products e.g. Label Rouge are likely to become more price differentiated from mass market products in the longer term. This is likely to provide an additional impetus for processers and supermarket chains to enter into longer term contracts with EU producers. The differential is already marked with Norway providing 51% of total French salmon imports compared to only 43% of value in 2007 (*Catarci, 2008*).

3. INDICATORS OF COMPETITIVENESS

KEY FINDINGS

- To date, little systematic data has been collected on the structure and performance of the EU aquaculture sector. Potential indicators of competitiveness have been identified, but use is limited due to lack of consistent data.
- Key indicators used in this analysis are growth in output, growth in value, industry consolidation trends and development of certification schemes.
- Industry structure especially consolidation and vertical integration play an important role in growth, particularly when raw material can be further transformed to a variety of value-added products, although this opens up new areas of competition.
- Public aid has played an important role in stimulating aquaculture development, although at times this has caused market distortions due to increased production and unplanned supply of the markets in relation to marketing activity. In the sea bass/sea bream sector unplanned growth has contributed to the recent cycle of over-production, falling prices and business closures.

3.1. Availability of indicators

In preparation for the survey work the study identified 38 potential indicators, which were subsequently combined or prioritised to a list of 19 shown in Table 8. These cover the nine thematic issues requested in the study TOR although grouped somewhat differently.

Table 8: Candidate indicators for competitiveness

	Indicator	Issue cross ref	Measure	Notes	Data sources
1) Market segmentation					
1a	Industry concentration (scale-economies; inc. production and distribution)	6	% revenue accounted for by top four national companies - as % European totals (company accounts v FAO records) – but also fragmentation indicator linked with number of companies	Indicator of relative scale economies, area biosecurity management propensity etc.	FAO; Eurostat; large company accounts; Ernst & Young report
2) Farm sector conditions					
Barriers & incentives to growth					
2a	Biophysical capability	3	ratio of production to estimated carrying capacity (if established) or production per length coastline or area of freshwater (e.g. EIFAC)	national biomass limits assoc with carrying capacity estimates limited to a few countries (e.g. Norway)	National sources; FAO reports
2b	Site economic rent (i.e. consequential costs to regulation)	1,2,6	Site licensing, rent etc. e.g. as % of production cost or estimated sector earnings		National and industry sources
2c	Successful/ rejected site applications: new sites, enlargements and renewals	1,3	ratio of year on year license numbers/ biomass limits		National sources
2d	Government incentives/ subsidies	6	tax, grants, subsidies etc as percent of production costs or sector earnings	inc. EFF and FIFG structural funding	EU and National sources
2e	National regulatory or administrative obstacles	1,2,3, 4,5,6	non-tariff barriers, legal challenges (qualitative citation indices)	directives v regulation. Impacts of different aquaculture development strategies in Member States	EU National, PO & company Data
Operational inputs					
2f	Total factor productivity (TFP)	9	Derived from analysis of capital and labour input in relation to output	Powerful indicator - difficulty assessing capital costs for larger corporates	Company records; National data
2g	Economic Food Conversion ratio (eFCR)	7,8,9,5	total feed fed/ total live fish harvested	And/or protein efficiency ratio	Industry sources
2h	Feed Fish Efficiency Ratio (FFER)	2,7,9	(% fishmeal or oil in feed x eFCR)/(% yield fishmeal from wild fish)	Primarily an environmental indicator	Industry sources

	Indicator	Issue cross ref	Measure	Notes	Data sources
2i	Labour productivity growth	9	FTE per unit production	Indicator of technology (e.g. feed automation) adoption and resilience to contraction and expansion of production	OECD
2f	Labour force skills (management/ innovation capacity)	8	Graduate employment ratio or weighted salary	indicator of technological and innovation capacity	Industry sources
2j	R&D expenditure	8	ratio to revenue; private and public	from company accounts, EU FP6 and FP7 projects	OECD; company accounts, EU
Welfare					
2k	Adoption rate of (certified) welfare standards	6,5	Percent of companies or production certified	Voluntary market-based e.g. freedom foods for UK salmon v mandatory standards?	Certification schemes; Industry and national data
3) Wider value chain (inc. primary processing)					
3a	Market share	6	% of total market share for defined product segment	economies of scale - for product and perfect substitutes e.g. fisheries products	Apparent consumption calculations or retail survey data
3b	International-isation of demand	6	ratio of international to national market spread and share	resilience indicator	FAO; COMTRADE
3c	Mean added value	6	farm gate (and value chain) comparisons with overall consumer prices over time	value-addition, product differentiation - FAO register first sales point but little data on retail values	FAO; Eurostat; Retail surveys
4) Food safety and consumption					
4a	Traceability	4,6	extent of value chain penetration and size of traceable unit at key points		Industry data
4b	Adoption of voluntary producer and retailer certification schemes	4,6	percent volumes certified (at identified points in value chain)	Value-addition strategy focus on vertically integrated 'better practice' eco-labels commanding significant market share	Certification bodies; Retail surveys
5) External sensitivities					
5a	Credit availability and costs (interest rates)	6	Comparative national data		OECD; National data
5b	Trade flexibility: i.e. FTA agreements, tariffs and quotas	6	Comparative national data		OECD; National data

Key to cross-referenced thematic issues with TOR competition domains

1)	Legal and administrative issues	6)	Third countries competition and market issues
2)	Environmental aspects	7)	Fish oil and fishmeal availability
3)	Availability of production sites	8)	Technological issues
4)	Food safety and other aspects related to consumption	9)	Production costs
5)	Animal health and welfare	10)	Other

Note: coloured shading indicates indicators with best data availability

Research on the application of these indicators showed that relatively little economic and market data is available disaggregated to the level of aquaculture, or indeed individual species within aquaculture. Data on aquaculture production is collected by all countries in the EU, but collection of more detailed data on industry performance is patchy. The situation is improving significantly with the introduction of EC Regulation *762/2008* on national aquaculture statistics. This requires for the first time information on hatchery production and input from capture fishery. It also requires data on industry structure, although mainly the types of production system and their total size. This might yield useful data for indicator 2a above, but help little with the remainder.

A more comprehensive examination of the data collection needs for the aquaculture sector was recently undertaken for the European Commission by *Framian BV (2009a-c)*. This highlights many of the difficulties inherent in surveying such diverse production sector (55 segments identified plus the frequent problem of disaggregating aquaculture from capture fisheries production at market level) and draws a number of useful conclusions for future initiatives. More usefully the study conducted a pilot survey and the outputs provide new data on systems, employment and industry business and cost structures. This has allowed for some further indicators to be evaluated including:

- Turnover/FTE
- Gross value-added/FTE
- Output/FTE
- Turnover/Firm
- EBIT/Total assets
- Feed as % of operating costs
- Labour as % of operating costs
- Energy as % operating costs
- Debts as % of equity capital
- Assets/Company

The study identified 28 economic indicators with specific definitions under EC regulations (*2007/1998 and 1670/2003*) (*Framian, 2009c*). The following analysis utilises the quantitative data from the *Framian (2009)* and *Ernst & Young (2008)* reports where appropriate. For issues where quantitative indicator data is not available we have drawn on qualitative interviews with sector representatives in order to outline the perceived situation, trends and issues of importance.

3.2. Comparative economic performance

They key EU-27 species and their unit value, are summarised in Table 9, followed by value-addition (Table 10), and national and regional data tables (Table 11 and Table 12), which are discussed in the following sections.

Table 9: Composition of EU-27 aquaculture production by species

Species	2006 Value (€ mill)	Volume (1000 tonnes)	Average price (€/Kg)
Atlantic salmon	574.1	144.6	3,97
Rainbow trout	494.9	201.0	2,46
Gilthead sea bream	314.0	73.0	4,30
European sea bass	282.8	56.0	5,05
Pacific cupped oyster	278.0	125.4	2,22
Japanese carpet shell	218.9	58.7	3,73
Blue mussel	207.3	146.9	1,41
Common carp	134.9	66.1	2,04
Mediterranean mussel	80.0	105.6	0,76
European eel	74.6	8.3	8,99
Sea mussels nei	62.9	229.2	0,27
Turbot	45.8	7.6	6,03
Grooved carpet shell	40.8	8.2	4,98
Atlantic bluefin tuna	36.7	3.2	11,47
European flat oyster	13.7	4.7	2,91
North African catfish	10.2	6.6	1,55
Other species	201.9	57.4	3,52
Total	**3,071.4**	**1,302.6**	**2,36**

At the present time, processing of aquaculture produce is adding up to 43% value to basic production (*Ernst & Young, 2008* – Table 10). In terms of capital to earnings ratios, carp is highest at 63% and salmon is lowest at 21%

Table 10: Value-addition and growth for key EU farmed finfish species 2006

	Value €mill	Added value %	Turnover growth 2006 %
Sturgeon	27	43	18
Salmon	460	37	23
Bass, bream, turbot	789	25-28	14
Trout	143	25-28	6
Carp	30	25-28	13

3.3. National and Regional Comparisons

Table 11: Production (t) trends by country and region 2001-2006

		2001	2002	2003	2004	2005	2006	% Change 2001-2006
	Central & Eastern Europe CEE							
1	Poland	35,460	32,709	35,436	35,131	37,920	35,867	1.1
2	Czech republic	20,098	19,210	19,670	19,384	20,455	20,431	1.7
3	Hungary	13,056	11,574	11,870	12,744	13,661	14,686	12.5
4	Romania	10,818	9,248	9,042	8,137	7,284	8,088	-25.2
5	Bulgaria	2,938	2,308	4,465	2,489	3,145	3,257	10.9
6	Lithuania	2,001	1,750	2,356	2,697	2,013	2,224	11.1
7	Slovenia	1,262	1,289	1,353	1,571	1,346	1,369	8.5
8	Slovakia	999	829	881	1,180	955	1,263	26.4
9	Estonia	467	257	372	252	555	703	50.5
10	Latvia	463	430	637	545	542	565	22.0
	Sub-total	87,562	79,604	86,082	84,130	87,876	88,453	1.0
	Mediterranean (MED)							
1	Spain	309,351	255,189	268,609	293,779	219,800	293,288	-5.2
2	France	251,655	252,028	239,881	261,507	258,855	238,905	-5.1
3	Italy	218,369	184,482	192,022	118,486	181,383	173,083	-20.7
4	Greece	97,512	87,928	101,434	97,143	106,308	113,384	16.3
5	Portugal	8,209	8,288	8,033	6,700	6,696	6,778	-17.4
6	Cyprus	1,883	1,862	1,821	2,175	2,540	2,667	41.6
7	Malta	1,235	1,116	887	868	736	1,126	-8.8
	Sub-total	888,214	790,893	812,687	780,658	776,318	829,231	-6.6
	Northern Europe (NE)							
1	UK	170,516	179,036	181,838	207,203	172,813	171,848	0.8
2	Ireland	60,940	62,568	62,516	58,359	60,050	53,122	-12.8
3	Holland	57,042	54,429	66,540	78,598	71,370	43,945	-23.0
4	Denmark	41,573	32,026	37,772	42,814	39,012	37,188	-10.5
5	Germany	53,409	49,852	74,280	57,233	44,685	35,379	-33.8
6	Finland	15,739	15,132	12,558	12,821	14,355	12,891	-18.1
7	Sweden	6,773	5,618	6,334	5,989	5,880	7,549	11.5
8	Belgium	1,630	1,600	1,010	1,200	1,200	1,200	-26.4
	Sub-total	407,622	400,261	442,848	464,217	409,365	363,122	-10.9
	Grand-total	1,383,398	1,270,758	1,341,617	1,329,005	1,273,559	1,280,806	-7.4

Source FAO

Table 12: Regional volume, growth and main species comparisons 2001-2006

Region	Total volume 2006 mt	% total EU-27 volume 2006	% change 2001-2006	Total value 2006 €mill	%Total EU-27 value 2006	Main species	% volume 2006
CEE	88,453	6.9	1.0	306.6	10.1	Carp	72.3
						Trout	25.2
						Catfish	2.5
MED	829,231	64.7	-6.6	1,719.4	56.9	Mussels	44.7
						Bass/bream	21.9
						Oysters	17.3
NE	363,122	28.4	-10.9	995.7	33.0	Salmon	42.1
						Trout	24.0
						Mussels	23.2
Mean / total	1,280,806		-7.4	3,021.7			

Source FAO

EU-27 production fell by 7.4% between 2001 and 2006 (Table 11 and Table 12). The largest fall occurred in the NE region (-10.9%), followed by the MED region (-6.6%) while production remained fairly constant in the CEE region.

The Central and Eastern European Region (CEE)

Although containing the largest number of countries (10), the CEE region produced by far the lowest volume (7% of the EU-27 total) and value (10%). It also had the lowest species diversity, almost entirely reliant on freshwater aquaculture with carps constituting 72% of total volume and trout 25%. More than 75% of production occurred in just three countries: Hungary, Poland and the Czech Republic. Production has remained relatively stable over the last decade, with declining carp production compensated by increased rainbow trout production (up 24% from 2000-2006) with the highest growth in Poland. There has also been significant growth in the trout sector in Bulgaria and Estonia including development of more intensive (flow-through) systems. There has also been some growth of small-high value niche market enterprises e.g. sturgeon (Bulgaria, Slovenia, Baltic States), Barramundi (Bulgaria), Koi-carp (Czech Republic Hungary), crayfish (Estonia, Bulgaria).

Most carp production is extensive; even the larger companies in Hungary and the Czech Republic supplement only small amounts of cereal-based feeds. Feeds therefore only represent 8-20% of variable costs, elevating labour to 18-45%. The difference reflects wide variation in labour productivity correlating closely with operational scale. The Czech Republic has the highest average levels (€13,000-€19,000 per employee). At the other extreme Romania with many small companies with low levels of labour is likely to come under greatest pressure as average salaries continue to rise with economic development. Hungary also has a cost advantage on feed, as one of the largest cereal producers in Europe.

The Mediterranean Region (MED)

Production from the 7 countries of the Mediterranean region (Table 11) constituted the largest share of the total: 65% of total EU-27 production worth some 57% of total value in 2006. The MED region had by greatest reliance on bivalve shellfish, especially mussels (62% volume) followed by bass and bream (Table 12).

In the MED Region the greatest falls occurred within the more traditional mussel and trout sectors in Spain France and especially Italy and Portugal (Table 12). This was compensated for by substantial (20%) growth in Greece; sea bass rose by 28%, sea bream by 14% and mussels by 16%. Together sea bream, sea bass, oysters, clams and mussels generated 90.5% of total revenue in 2006, with individual contributions ranging from 18.5% (sea bream) to 11.5% (mussels). Turbot and tuna (fattening) each contributed less than 3%.

Most of the 129,000 t of sea bass and bream produced in the 2006 were raised in sea-cages (Greece, Spain and France). Some land-based systems in Italy have struggled to compete on price with their higher capital and operational costs and are also expanding into marine-cage sites. Total growth in both sea bass and sea bream production continued unabated with a year on year rise between 2007 and 2008 of 10.7 and 20.9% respectively (Table 13 and Table 14) especially in Greece and Turkey resulting in acute over-supply and serious price crash which is likely to drive further industry consolidation during 2009. (It should be noted that according to a recent study (*Papageorgiou 2009*), actual production if sea bass and sea bream in Greece for 2007 and 2008 was estimated at much higher volumes than officially reported, at 120,978 t and 145,176 t respectively). Traditionally, prices of the two have been closely inter-linked as the species are close substitutes in their core Mediterranean markets. However sea bass prices remained relatively stable suggesting the markets for the products are becoming more differentiated.

Table 13: Sea bream production (t) within EU-27 and Non-EU Mediterranean states 2003-2008

Year	2003	2004	2005	2006	2007	2008
EU-27 MED REGION						
Greece	49	46	44	60	43	60
Italy	12.4	13	15.6	20.2	23	25
France	7.8	8.5	8.5	8.9	9	10
Spain	3.8	3.8	5.7	3	4.1	4.1
Portugal	0.7	0.8	1.1	1	1.2	1.5
Others	2	2.2	2.6	2.8	3.1	3
Sub-total	**75.7**	**74.3**	**77.5**	**95.9**	**83.4**	**103.6**
Non-EU						
Turkey	12	13.9	17.5	22.5	24	27
Egypt	2.5	2.9	3.4	2.8	2.9	2.9
Croatia	2.5	2.5	2.5	1.6	1.6	2
Tunisia	1.1	1.6	1.9	2.2	1.5	1.7
Sub-total	**18.1**	**20.9**	**25.3**	**29.1**	**30**	**33.6**
Grand-total	**93.8**	**95.2**	**102.8**	**125**	**113.4**	**137.2**

Source FEAP Aquamedia

France Italy and Spain were responsible for 88,000 t of trout production, mainly in ponds. Turbot production mainly in land-based RAS and pump-through systems showed promising signs of growth in Spain and Portugal albeit from a low base. Small amounts of high value caviar were produced in Italy and there are also established sturgeon farms in Spain (Les in Lerida and Riofrio in Granada) and a third one in Huesca with 2-year old fish.

MED producers have also attempted to diversify into other species (e.g. meagre and various alternative bream varieties) – mainly using existing cage-facilities, although so far production is relatively limited. Spain is the main European producer of crayfish; *Procambarus clarkia* for consumption and *Pascifastacus leniusculus* for restocking in the wild.

Table 14: Sea bass production (t) within EU-27 and Non-EU Mediterranean states 2003-2008

Year	2003	2004	2005	2006	2007	2008
EU-27 MED Region						
Greece	25.4	30	36	40	29	35
Italy	8.9	9	8.6	9.1	9.2	9.8
France	3.7	4	4.3	5.6	4.6	4
Spain	4.5	4.7	5.5	8.9	10.6	11.8
Portugal	1.5	1.5	1.5	1.4	1.4	1.4
Others	5.5	0.7	0.7	0.6	0.6	0.5
Sub-total	**49.5**	**49.9**	**56.6**	**65.6**	**55.4**	**62.5**
Non-EU						
Turkey	15	17	21.1	30	35	38
Egypt	3.2	2.8	5.3	2.1	2.6	2.6
Croatia	1.8	1.6	1.9	1.6	1.8	2
Tunisia	0.5	0.5	0.6	0.5	0.8	0.8
Sub-total	**20.5**	**21.9**	**28.9**	**34.2**	**40.2**	**43.4**
Grand-total	**70**	**71.8**	**85.5**	**99.8**	**95.6**	**105.9**

Source FEAP Aquamedia

The Northern European Region (NE)

The NE region is the second largest of the three regions, accounting for some 28% of EU-27 volume and 33% of total value in 2006 (Table 12). It yields produce with some of the highest net worth due to the concentration of EU-27 salmon production in the region (42% of total volume).

Although production rose between 2001 and 2004, the region recorded a decline of 11.5% in total production from 161,831 t to 143,165 t from 2001 to 2006 (Table 11), mainly as a result of falling salmon production in the UK and Ireland and mussel production in Germany. This was a result of UK salmon farms being badly affected by the outbreaks of Infectious Salmon Anaemia (ISA), a viral disease in 2004, at the same time as production of the main competitors Norway and Chile grew rapidly. However, the disease problems gave to subsequent restructuring which has provided a firmer base for future industry stability, regulated growth and further development of the regions premium brand quality. This included further consolidation (despite an anti-competition check on one of the largest potential mergers in 2006) linked with ongoing implementation of tripartite loch management schemes (with private, public and recreational engagement). This has resulted in large mainland loch systems increasingly being farmed by single operators, thereby significantly enhancing overall disease management capabilities e.g. through synchronised treatments and site fallowing. Smaller producers have survived mainly through various niche-market product differentiation strategies, especially organic certification. These producers have become concentrated in remoter off-shore locations i.e. the Hebrides and Shetlands. Here, higher water flushing rates reduce risk of disease transmission and therefore requirement for prophylactic treatment measures heavily prescribed by organic standards.

Ireland, lacking the economies of scale offered by Scotland's extensive mainland loch resource has moved along the organic route as an entire industry strategy. Over 60% of production, the majority of it marketed with state support Irish Salmon Growers Association (ISGA) is now sold as organic.

The Scottish and Irish organic markets are themselves relatively differentiated: while Scotland has a large domestic market, Irish sales are mainly targeted at the mainland European sector. This means there is very little overlap between the standards systems adopted in the two countries. This has significantly reduced trade in ova and smolts which formally take place between UK and Ireland. For example the largest company Marine Harvest with significant market share in both countries is largely overwhelmingly reliant on Norwegian ova imports in Scotland. However, the company has retained Fannad, its subsidiary in Ireland to focus on production of organic ova and smolts for its local operations.

However, farmers relying on this differentiation strategy face an uncertain future. Sales of organic produce have suffered particularly badly during the recession, loosing 11% of market share in the UK over the last 12 months. This contrasts with the resilience of other eco-labels with less complex messages, especially Fair Trade.

Compared to salmon, rainbow trout production is spread more widely across the NE region, with some presence in all 8 countries. The sector has experienced a significant decline due to changing consumer habits and competition from a larger and more consolidated Norwegian sector, mainly farming in sea-cages. Total regional production fell by 12.3% from 99,781 t to 87,500 t between 2001 and 2006 (*FAO*).

With an annual production of 34,500 t in 2006, Denmark is the largest producer country in the whole EU-27. Tight environmental regulations have resulted in the sector developing efficient recirculation and intensive flow-through systems with good waste-management capabilities, along with an industry leading RAS service-sector. However, the land sector remains relatively unconsolidated, with the top 3 companies (T3) accounting for only 27% of production (Table 22 – Annex 1). The sea-cage sector which accounts for over 30% of production is much more consolidated (T3 = 90%) but limited in scope for growth. Despite this combination of factors, the country recorded an above average decline in the sector: 15% between 2001 and 2006. Germany lost 24% of its volume over the same period, with only the UK and Sweden registering significant growth.

Mussel production, the third most important NE sector in value terms fell sharply by 26.3% from 128,132 t to 94,375 t between 2000 and 2001. This was largely due to the collapse of the North Sea bottom-culture dredge-fisheries in Holland and Germany, where total production declined from 90,900 t to 35,000 t over the same period. This has been compensated for growth in more environmentally friendly raft and long-line production systems in the UK, Ireland and Sweden. These systems have seen rapid uptake in recent years with generous EU-subsidy support. Some 60% of UK production is now concentrated in the Shetland Islands, offering vital jobs in this remote area.

Oyster production (dominated by France in the MED region) has also shown encouraging growth, with production of the exotic pacific oyster (*Crassostrea gigas*) rising by 37% from 5,820 t to 7,973 t from 2001 to 2006, mainly in Ireland, the UK and Holland.

Eel production has remained relatively stable. The sector has seen much investment in recirculating aquaculture systems to accelerate grow-out (and protect valuable stocks), with capital and operational costs supported by consistently high market prices. Efficient juvenile production techniques have not been perfected; consequently grow-out is still reliant on wild sourced juveniles (glass eels). This is an international business with vigorous competition for supply from producers in China. This combined with dwindling global supplies has resulted in extremely volatile glass eel prices and this is the main constraint to sector growth. Over 90% of production is concentrated in Holland (66%) and Denmark with smaller amounts in Germany. The sector is highly concentrated, with Nijvis, a Dutch company, on-growing 3000 t annually - almost 50% of the entire production in NE region. Danish Royal Seafood account for another 1,000 t annual production cultured almost entirely in RAS systems.

The NE sector has been relatively progressive in its attempts to diversify into new species; in some cases such as turbot, much of the technology development occurred in this region, only for production to move to more promising market and resource conditions in the MED area. Several new species are either emerging or have maintained small market share over recent years. Tilapia, a warm/fresh-water species reliant on RAS for grow-out, holds some promise, combining generic (marine) whitefish eating qualities with herbivorous eating habits, a significant quality with potential for product differentiation. Two large-scale start-ups in Belgium (Vitafish[10]) and Holland FISHION (2-3 years old) have been joined more recently by several small to medium sized-companies (100-500t) in the UK; though not without problems. FISHION report production capacity of up to 2000t per year, however over 90% of this has been switched to production of much higher yielding African catfish hybrid (*Heterobranchus longifilis x Clarias gariepinus*). The hybrid also produces a higher value white-fillet, compared to the yellowish colour of the conventional *C. gariepinus* variety. A co-operative vertically-integrated (fry to fork) business-structure with franchise elements, experienced staff and proven technology is also key to their relatively enduring success. Vitafish declared plans to scale up to 5,000t before recently going into receivership due to technical problems and low-margins. The plant has been aquired by a high-value sturgeon/caviar producer. The more established catfish (mainly *C. gariepinus)* RAS sector produces around 5000t annually, with growth constrained by relatively low preference (and prices) amongst European consumers. Despite a promising start with a very successfully branded Shetland 'No Catch' operation, EU-27 cod production is again on hold following the companies collapse associated with high production costs. Contributing to this was a rise in the capture fisheries quota – which also stalled growth in the Norwegian sector, which had scaled up to over 11,000t annual capacity. Despite high hopes, halibut production has also stalled due to poor production economics as well as some persistent technical constraints. In Scotland, Marine Harvest have terminated their efforts at cage production and production is restricted to a few small-scale operations in Shetland and the West Coast (Norway continues to produce around 1,000 t annually). Artic Charr is being cultured in small quantities with limited success in Sweden, Denmark, UK and Ireland, with an economic model based on niche-marketing. Finland has recorded some success in its attempts to culture Powan (*Coreogonus lavaretus*) with production nearly 800 t in 2006, despite still having constraints to overcome in hatchery production. Attempts to kick-start warm-water production of other species in RAS systems have had mixed success; New Forrest Barramundi in the UK failed due to negative quality perceptions associated with off-flavours and perhaps the challenge of launching a new premium-price whole-fish product in a market dominated by fillets and value-added products. Blue-Water Farms have set up a sea-water RAS system in Wales targeting 1,000 t production of sea-bass for the UK market with promising early reports.

3.4. Aid to the sector

The primary source of state aid to the aquaculture sector is now the European Fisheries Fund (EFF)[11], formerly the Financial Instrument for Fisheries Guidance (FIFG)[12]. This requires a mix of EU, National government and company funding for mainly capital projects. Originally these supported capacity expansion, but latterly they have focused on

[10] Vitafish failed to raise necessary additional capital and the business has been acquired by sturgeon farmer as a going concern.

[11] Council Regulation (EC) No 1198/2006.

[12] Council Regulation (EC) No 2792/1999.

investments for diversification, environmental improvement and aspects of market development. The existence of state aid played an important role in expanding the marine aquaculture industry in Europe during the 1990s; however, it has also resulted in some distortions to industry development. For instance one reason for the 2008/9 price crash in sea bream was poorly targeted aid, especially in Greece and Italy, designed to attract new-entrants and championing out-sized projects without sound commercial underpinnings. These business were also first to dump product during the crisis accelerating the price fall, with highly negative effects on more mature businesses.

There is also a clear requirement for aid earmarked for technology development and particularly promotional activities to be used in a more co-ordinated and effective way. This will require trade-offs between national autonomy in the allocation of aid funds and central oversight at EU level to drive wider sectoral goals. Lastly, the relevant EU regulatory framework on the Common Organisation of the Markets[13], should be more supportive of the formation of effective aquaculture PO's.

3.5. External factors

Aquaculture businesses are exposed to a wide range of external factors likely to impact on the success of operations. These are summarised in Table 15 with many factors shared by other businesses.

Of particular note is the vulnerability of most sub-sectors to environmental factors. This is partly because of the location of aquaculture in often remote and exposed areas, but particularly due to the long culture periods (up to 3 years in some cases), during which time the stock are vulnerable. Also significant at the present time is the industry image as the general population are moved from an expectation that all fish come from the wild, to an acceptance that farmed fish are the responsible choice for ensuring food security and avoiding gross harm to ocean ecosystems. Mistrust of intensive farming is readily carried over from other sectors and applied to aquaculture. Some environmental campaign groups have also mounted public and sustained opposition, usually based on inaccurate information.

Table 15: Examples of external factors affecting the sector

Environment	Climate change, climatic events, emerging disease issues, changes in natural seed-stock availability, industrial or other pollution etc
Financial	Availability of investment funds, interest rates, exchange rates, taxation levels, insurance assessments and premiums etc.
Government policy	Regulatory framework and implementation mechanisms, changing rules and charges – inc. EU regulatory directives v national regulations and dispersion of competences across five different Commission Directorates General)
Trade	Changes to trade policy, tariffs, trade barriers and preferential access arrangements
Social and political	Activities of environmental pressure groups and others and impacts on markets and policy makers
Market	Changes in the supply of potential substitute products, changes in demand patterns, food scares etc.
Input supplies	In some cases wild seed-stock, fishmeal and oil supplies, prices of other feed inputs, price of fuel, cost of labour etc.

[13] Council Regulation (EC) No 104/2000.

4. IDENTIFYING LIMITATIONS: SWOT ANALYSIS BY SECTOR AND THEME

KEY FINDINGS

- Overall growth of EU aquaculture production has stalled due to constraints to further reducing production costs to levels that would be competitive with the greater proportion of the primary fish and seafood market (or to successfully differentiating and marketing their products at a higher price than potential substitutes).
- The primary constraint to achieving greater economies of scale (and hence lower unit production costs) has been access to new sites (and expansion of existing sites) due to greater regulation of resource access (land, water, coastline etc) and limitations on waste discharges.
- The growth in sales of value-added products and greater differentiation, including based on production provenance, will provide new opportunities for aquaculture-based companies and help maintain smaller producers in rural and coastal communities.
- Appropriate policy support will allow continued technical innovation and up-scaling of production systems with reduced cost of production and hence larger market opportunities.

Table 15 lists the competition domains (section 1.2) which are evaluated in this section. The four following evaluations were conducted for each of the domains in turn, (1) potential competition issues and limitations (2) results of research and technical developments to address the limitations (key findings in the main text and others listed in numbered boxes) (3) a SWOT analysis (strengths, weaknesses, opportunities and threats) (4) recommendations for strategies to overcome the identified limitations.

The aim of the following SWOT analysis is to highlight particular areas of competitive advantage and disadvantage based on the previous review of sector performance and aiming to inform forward projections and policy options.

Table 16 Nine key areas for competiveness analysis and thematic groupings

9 Areas of competitiveness:	Thematic grouping	
1) Legal and administrative constraints	Over-arching; policy and regulation	**Policy and regulation**
2) Environmental aspects	**Location and environment**	
3) Availability of production sites		
4) Food safety and other aspects related to consumption	**Markets, competition and regulation**	
5) Animal health and welfare		
6) Third countries competition and market issues		
7) Fish oil and fishmeal availability	**Technology development and cost**	
8) Technological issues		
9) Production costs		

4.1. Legal and administrative constraints

Identified issues and limitations

Aquaculture comes within the Common Fisheries Policy, but was given little explicit attention there until the publication of the "Strategy for the Sustainable Development of European Aquaculture" by the Commission in September 2002. This has since been updated in the 2009 with the revised strategy "Building a Sustainable Future for European Aquaculture – A New Impetus for the Strategy for the Sustainable Development of European Aquaculture". These are welcome, but the industry has been disappointed that aquaculture has not been better integrated into other recent policy documents such as the Marine Strategy Framework Directive[14] and the Integrated Maritime Policy for the European Union[15]

At a practical level, the most significant constraint noted by the Industry has been the long and complex process for obtaining site licenses in the EU, which is often a significant deterrent for new entrants; environmental stipulations are of particular significance here. Once established, regulatory inertia can also constrain existing businesses; there is a need to recognise that as the industry develops, site requirements and regulatory criteria may also need to evolve. In other locations short lease durations can also be a deterrent to investment. Despite such concerns, one Scottish key informant in the salmon sector felt that there had been significant effort to address environmental problems by producers and there is corresponding evidence of more objective consideration by planners and politicians.

In many regions, there is an urgent need for greater investment and implementation of coastal-zone spatial planning that assigns priority in certain areas for aquaculture development, whilst seeking to minimise conflicts with alternative uses e.g. tourism and leisure (particularly in warmer southern coastal zones), renewable energy production etc. Guidance and reliable data from spatial planning also provides assurance to investors, and helps locate synergies between activities and environments contributing to sustainable development.

[14] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32008L0056:EN:NOT
[15] http://ec.europa.eu/maritimeaffairs/policy_documents_en.html

Off-shore development is also flagged as possible technical solution to limited inshore site availability (sections 4.3 and 4.8). However in some countries there is also a lack of proper legal protection for off-shore waters (and also a lack of regulatory frameworks for licensing such sites). Existing laws relating to the oil and gas sectors (>3nm offshore) will be less relevant to aquaculture than forthcoming WFD regulation or the Marine Bill in the UK. These initiatives may pose a heavier regulatory burden than many producers may have once envisaged by going off-shore. Food safety and welfare regulations also pose significant challenges. Hygiene regulations on slaughter and processing can be a bar to small farms engaging in any value-addition for local markets. More significantly, veterinary licensing costs deter the timely development of new therapeutants. The potential to incorporate additional species following successful trials on (related) species could save substantial additional investment and time (section 4.5). Wildlife protection regulations that result in excessively high numbers of predatory birds and animals can also be extremely costly to the industry (section 4.2). The level of such protection should require a rigorous evidence-base subject to periodic review, supported by public awareness campaigns to ensure greater acceptance and improved industry image.

Much of the animal welfare regulation currently applied was evolved from the terrestrial livestock sector. There is need to update these based on greater consideration of the needs of fish and shellfish. The new EU Animal Health Directive (2006) implemented in 2008 moves towards this as do new EU regulations on live-transports.

Results of research and technological developments that compensate for the identified limitations

The Commission is already promoting development of maritime spatial planning and Integrated Coastal Zone Management and encouraging Member States to develop marine spatial planning systems as well as ensuring that terrestrial land planning fully integrates the needs and values of freshwater aquaculture. GIS spatial management systems offer a proven tool for integrated coastal zone planning.

Box 1 Other relevant research projects

•Are aquaculture and coastal fishing sustainable? AQCESS
•Bridging the gap between Science and Industry AQUAFLOW
•Towards the sustainable development of European aquaculture CONSENSUS
•An ecosystem approach for sustainable aquaculture ECASA
•Investigating the genetic co-existence of fishing and aquaculture activities GENIMPACT
•Maximising the value of EU-funded research in fisheries, aquaculture and seafood processing IMPACTFISH
•Reducing the impact of alien fish species IMPASSE
•European Workshops on RTD Requirements for Professional Aquaculture PROFET
•Promoting extensive and semi-intensive aquaculture in southern Europe SEACASE
•Focussing on sustainable and healthy freshwater aquaculture SUSTAINAQUA
European research for Mediterranean seafood ERMES
•The future of European fisheries and aquaculture research FEUFAR
•Bringing together European fisheries and aquaculture research institutes MUTFISHARE
•Advanced laboratory training courses in aquaculture for early-stage researchers AQUALABS
•The aquaculture, fisheries and aquatic resources management thematic network in education and training AquaTNet
•Access to south European finfish aquaculture facilities ASEFAF
•Validation of working experience in aquaculture WAVE

SWOT analysis

SWOT	Coastal fish	Coastal bivalves	Freshwater ponds	Freshwater intensive
Strengths	Harmonization at EU level creates "level playing field" and reduces costs for international business	Existing designation of shellfish waters has provided useful framework	Flood control and landscape protection regulations can help protect traditional pond farms	Clear regulations generally in place for this type of aquaculture
Weaknesses	Lack of effective national strategies in most EU states Weak or ineffectual community strategy (e.g. EU 2002) Incompatibilities between producers needs and some publically funded research programmes Bureaucracy, especially with respect to site licensing, can deter potential investors	Traditional status of some activities may limit scope for policy	Slow development of regulatory frameworks; protection of wild birds has caused substantial losses in this sector.	Current controls are often based on limited factors which may not encourage best practice in all areas
Opportunities	Ensure aquaculture is firmly embedded in EU and national strategies	Incorporate positive benefits of bivalve culture into WFD and Marine policy	Incorporate positive role of freshwater fish ponds in environmental protection (e.g. WFD) where appropriate	Promote regulations for improved welfare and water treatment technology
Threats	Removes aquaculture from sensitive locations	Concern that re-classification of waters under the WFD may alter status for shellfish producers	The value of aquaculture will be lost if not properly considered in legislation aimed at wildlife conservation or other specific interests	Implementation of more stringent water quality criteria could close some farms if they do not have the financial resources to invest in new water treatment technologies

Recommendations for strategies to overcome the identified limitations

The issue of EU policy and legislation on aquaculture is covered in greater detail in the sister report to this study (176) "Regulatory and Legal Constraints for European Aquaculture". This recommends:

- The development of a best practice framework for aquaculture
- Exploration of the need and potential for an EU aquaculture licence
- Promotion of the role of aquaculture in Coastal Zone Planning and Marine Spatial Planning and specific guidance on the siting of aquaculture
- Integration of freshwater aquaculture into inland planning frameworks

- Better integration of aquaculture into the Water Framework Directive
- Clarification of regulations on protection of wild birds and habitats in relation to aquaculture
- Development of specific guidelines and frameworks for aquaculture environmental impact assessments
- Continue to assess and revise legislation on aquatic animal health and veterinary medicines
- Complete work on rules for organic aquaculture
- Continue to play a key role in the international trade agenda

Our key recommendation is to ensure that aquaculture development is better embedded in CFP, MSFD, WFD and other policies (especially provision for offshore aquaculture) and is considered in indirect legislation.

4.2. Environmental aspects

Identified issues and limitations

This includes bi-directional effects between aquaculture and the environment. As a relatively new industry, aquaculture is often subject to greater scrutiny and control than long-standing activities that are at least (if not more) environmentally damaging. Conversely the environmental benefits of some types of aquaculture may not be properly appreciated and taken into consideration; for example multi-trophic species combinations for nutrient recycling and effluent remediation. Studies on the impacts of salmon cages on sea-bed floors, to be highly localised and transient even in enclosed loch systems. Inconsistent implementation of EIA procedures between regions and authorities can create unnecessary barriers to entry or alternatively exacerbate problems.

Key wildlife interactions include predator control (section 4.1) and the impacts of escapees with their potential for genetic introgression, habitat / spawning displacement and disease transmission to (and from) native stocks. This has had highly negative impacts on industry image.

The needs of the aquaculture sector should also be considered in the implementation of the Water Framework Directive. Growing food security concerns will increase the pressure for pragmatic trade-offs between the precautionary underpinnings of the frame-work and the requirement for some degree of managed-development based on sound environmental monitoring.

Climate change will create new environmental challenges for aquaculture with consequences for species selection and loss or creation of new production sites, potential adjustments in carrying capacity limits as well as other environment/ wildlife interactions.

Results of research and technological developments that compensate for the identified limitations

The environmental aspects of aquaculture production in Europe are many and varied and there is considerable cross-over with other sub-sections of this study report, notably with the legal and administrative issues as well as those affecting animal health and welfare, feed issues, technologic and production costs.

However, one major EU project, financed under FP6 looked to develop an ecosystem approach for sustainable aquaculture. The key output of the **ECASA** project is a "**virtual toolbox**[16]", which contains various 'tools' to aid owners and operators aquaculture farms in selecting farm sites and operating farms, so as to minimize environmental impact and ensure the sustainability of sites and water bodies for aquaculture.

The toolbox is arranged into 5 categories providing background and theoretical information on the approach adopted; detailed descriptions on the use of a wide range of indicators of aquaculture related interactions as well as on the models developed and tested in the project. It also contains detailed reports on EIA's by species – where the models and indicators were tested in the framework of an Environmental Statement that can be used to inform the EIA process – and by country, providing another method of accessing the same study site reports. It therefore represents an important source of information for aquaculture producers, but also for policy makers and potential investors.

Box 2 Other relevant research projects

- Are aquaculture and coastal fishing sustainable? AQCESS
- How effective are biological filters in reducing the environmental impact of finfish cages? BIOFAQS
- An ecosystem approach for sustainable aquaculture ECASA
- Marine Protected Areas as a tool for fisheries management and ecosystem conservation EMPAFISH
- Reconciling fishermen and fish-eating vertebrates FRAP
- Sustainable integrated marine multi-trophic aquaculture in Europe GENESIS
- Investigating the genetic co-existence of fishing and aquaculture activities GenImpact
- Why local people should get involved in wetland management IMEW
- Do marine cages affect Mediterranean vegetation? MEDVEG
- A tool to monitor the environmental impact of marine fish cage farms in the Mediterranean MERAMED
- Reducing the conflict between Cormorants and fisheries on a pan-European Scale REDCAFE
- The impact of salmon farming on the genetic variation in wild populations of Atlantic salmon
  and brown trout through disease transmission SALIMPACT
- Trawling aquaculture-environment research to enhance accessibility SAMI

[16] http://www.ecasatoolbox.org.uk/

SWOT analysis

SWOT	Coastal fish	Coastal bivalves	Freshwater ponds	Freshwater intensive
Strengths	Most aquaculture practices depend on maintaining good environmental conditions	Contribute to ecosystem health and nutrient cycling	Contribute to ecosystem health and nutrient cycling	Technology options for reducing impacts are available with significant use in many areas
Weaknesses	Coastal fish aquaculture systems depend on environmental services for waste treatment	Negative environmental impact of dredging operations	Modest production potential, further reduced by control of nutrient levels	Discharge of nutrients, dissolved and solid waste if not captured and treated on-farm
Opportunities	Increasing demand for eco-labelled products – e.g. using LCA, footprint and food-miles criteria	Potential benefits of bivalve aquaculture for nutrient removal from coastal waters	Benefits to environment of sediment capture and wetland conservation	Potential for improved water utilisation efficiency with increased output
Threats	Strong environmental regulation in EU add costs and if not matched in other regions could make EU aquaculture uncompetitive	Spread of commercially unfavourable/ invasive species. Uncertain spat-fall under extensive production conditions	Aquaculture potentially impacted by pollution from agriculture, industry or other sources or toxic algal blooms	Strict environmental regulation without support for technology upgrade could close many farms

Recommendations for strategies to overcome the identified limitations

- Adopt a broad, well defined ecosystem approach to environmental management

4.3. Availability of production sites

Identified issues and limitations

Competition for space is a major challenge for growth or simply maintenance of all types of coastal (and fresh water aquaculture). Associated constraints include: conflicts between different uses, environmental limitations (e.g. carrying capacity, farmed/ wild stock interactions etc), disease risk and the associated regulatory constraints at national and EU-level (sections 4.2 and 4.1). The relative importance of these factors varies according to species and geographic sector.

When aquaculture development competes with other interests it often receives low priority whilst misleading information from objectors to aquaculture development is given too much weight. Conversely, resistance (by some parts of the industry) to recognise valid public concerns regarding visual and environmental protection can help create resistance to actions designed to help mitigate these concerns.

Environmental carrying capacity and regulation inevitably also limits scope for mass production of many species and thereby potential for scale-economies which underpin 'price-leadership' competition strategy. In Scotland salmon producers are consolidating to fewer larger inshore sites (>2,000t). Environmental limits on further consolidation are a contributory factor to the significant unused capacity at existing Scottish sites. However, (Rigby 2009) suggests access often has more to do with commercial territoriality than physical constraints. Tripartite disease-management agreements have increasingly restricted mainland freshwater and sea loch complexes to single business entities. Most niche-orientated SME's (<1,000t/yr) have relocated to remoter island sites with lower disease management constraints.

Off-shore production probably offers greatest potential for scaling up production of higher value marine species especially salmon, sea bass and sea bream, though is also subject to significant technical constraints (section 4.8) and has had a poor historic track-record. Development is probably most advanced for salmon, driven by its fast growth, high fillet yield and value and it is also grown in some of the most testing production environments in Europe. Food security concerns are stimulating renewed policy interest.

However commercial interest in going off-shore remains low due to higher costs and risks associated with unproven technology. There is however some movement to moderately exposed locations. Marine Harvest proposes to invest in £40 million developing self-contained farms with living quarters located in lee of the Outer-Hebrides. These will be double the size of their existing 'large' sites, each with a 4,000t annual production capacity.

Technological issues for land-based and large off-shore production alternatives to inshore systems are discussed in section 4.8.

Results of research and technological developments that compensate for the identified limitations

The principal research relevant to this area is essentially use of GIS to enhance maritime spatial planning.

The use of Integrated Coastal Zone Management for marine aquaculture development in Croatia (Katavic et al 2005)
Croatia currently produces some 11.000 tonnes of aquaculture production (FEAP, 2008) – mainly sea bass and sea bream, but also trout and tuna. It's extensive coastline of secluded and sheltered bays also make it one of Europe's top tourist destinations. The development of the aquaculture sector in Croatia therefore mirrors many of the challenges that Member States face - in terms of balancing the many 'claims' to coastal space.

The **Integrated Coastal Zone Management Plan** (ICZMP) for Croatia has a particular focus on aquaculture and sought to integrate the rational and sustainable mix of users of coastal and marine resources and protection of the Eastern Adriatic environment. With the assistance of ICZM specialists and using the tools of Integrated Coastal Zone Management (ICZM) and Environmental Impact Assessment (EIA), the Croatian Ministry of Agriculture, Forestry and Water Management, **in conjunction with** the Ministries of Environmental Protection and Physical Planning, Tourism, Sea Affairs, Transport and Telecommunication have produced the development plan. The plan proposes solutions to release the aquaculture development potential, while reducing negative impacts on the environment and potential conflicts of other coastal users. Education and knowledge transfer of the resulting guidelines have been major goals of the project.

IUCN-FEAP Guidelines on Site Selection and Site Management (IUCN 2009)
Resulting from its 2006 Memorandum of Understanding with the FEAP, The Mediterranean office of the World Conservation Union (IUCN-Med) with the support of the Spanish Ministry of Environment, Rural and Marine Affairs, is preparing a series of guidelines for the sustainable development of aquaculture in the Mediterranean. This year has seen the publication of the second in the series, on "Aquaculture Site Selection and Site Management" (IUCN, 2009).

The aim of this guide is to promote the sustainable development of Mediterranean aquaculture by providing basic guidelines for good practice in site selection and site management. More than 50 experts in different areas, including socio-economists, biologists, lawyers, aquaculture producers, and government and environmental organization representatives from most Mediterranean countries came together over a series of workshops to produce the guide and it is arguably the most comprehensive document to date for best practice derived by stakeholders representing multiple interests. It is available from www.iucn.org under the 'knowledge centre'.

SWOT analysis

SWOT	Coastal fish	Coastal bivalves	Freshwater ponds	Freshwater intensive
Strengths	Relatively flexible with respect to siting and scalability	Traditional practices in some regions provide priority for shellfish aquaculture	Ratio of suitable sites or freshwater resources to land area or population is higher in Europe than most other continents Low competition between aquaculture, fisheries and agriculture Hatchery availability	Good output to land area use Sometimes linked with fisheries enhancement and provision of fish for angling
Weaknesses	Availability of new sites is now heavily restricted on grounds of protecting the environment or visual seascape, or through competition with more economically attractive tourist development	Opportunities limited by water quality in some areas and potential conflicts with other resource users such as navigation and scenic value	Low growth associated with declining resource base	Waste output from flow-through fish farms likely to be further restricted in the future
Opportunities	Better coastal zone planning to reduce conflicts and optimise use of environmental services	New offshore technologies could enable expansion of production in less sensitive areas or in combination with other offshore projects	Currently under-managed resources could be made more productive	Technology upgrades to existing farms could raise output without development of new sites
Threats	Consolidation and internationalization of the aquaculture sector will lead to loss of support from local stakeholders for new site applications	Coastal pollution, especially pathogen release could reduce suitable sites	Pressure for development could reduce pond area Increased risk of flood and fish loss in some areas associated with climate change	High competition for sites and water from other potential users and constraints on development in rural areas

Recommendations for strategies to overcome the identified limitations

- Promote better spatial strategies for example by integrating aquaculture into all ICZM planning and avoid unequal costs for EU producers

4.4. Food safety and other aspects related to consumption

Identified issues and limitations

Restrictions on the use of animal by-products introduced in response to BSE have increased the cost of aquaculture feeds and contributed to reliance on fishmeal. However, relaxation of such rules should only be on the basis of clear scientific evidence of safety.

The Shellfish industry is particularly prone to contamination by human-pathogenic bacteria and viruses from inadequate sewage treatment, as well as biotoxin accumulation associated with algal blooms linked to paralytic shellfish syndrome in humans (these blooms may be due in part to increased nutrients from other activities such as forestry and intensive agriculture)

Contamination by industrial pollutants, especially dioxins, PCBs and flame retardants is not directly caused by aquaculture, so the industry needs more support to counter these issues where and if necessary.

Results of research and technological developments that compensate for the identified limitations

SEAFOODplus (www.seafoodplus.org) was one of the first of the major Integrated Projects developed by DG Research in FP6 to use the "fork to farm" approach. It brought together more than 70 partners in 16 countries to reduce health problems and increase well-being in European consumers by applying the benefits of consuming health promoting and high quality seafood products. It also took a full chain approach, with aquaculture being one of the inputs of 'raw material' to the seafood value chain. The seafood safety component of the project identified risk factors, avoiding risks caused by viral and bacterial contamination in seafood and undertook risk-benefit analysis. SEAFOODplus also developed consumer driven tailor-made, functional seafood products to improve health and to ensure nutritional quality and safety by full utilisation of raw materials from aquaculture and from traditional fisheries. The aquaculture component focused on the effects of dietary modulation, husbandry, fish physiology, genetics and pre-slaughter conditions.

Traceability

As in land farming, fish farming benefits from traceability technologies to monitor and follow the production cycle through its entirety. While traceability itself is not a guarantee of safety, it is essential in pinpointing problems, should they occur, throughout the whole production chain. This is not just limited to producers, but encompasses their suppliers, processors and distributors. Such "full chain traceability" is most effective when all links in the chain have the same principles and use the same (or at least compatible) tools.

In 2002, an EU-funded concerted action initiative called "**TraceFish**" (www.tracefish.org) produced three consensus-based standards for the recording and exchange of traceability information in the seafood chains. One of these is a standard for farmed fish. The basic element in the system is a unique identification number to be placed on each lot of products in such a way that traceability can be transmitted electronically. The system is voluntary.

Traceability tools are being continuously improved and are major monitoring components of various labelling and certification schemes for aquaculture products. An example of this is the **TRACE** initiative (www.trace.eu) that is using 5 case studies in food to improve traceability parameters and measure food authenticity. This last point has specific interest for fish products and TRACE is developing generic low cost analytical tools for use in the traceability infrastructure that verify geographical origin, production origin and species origin.

Box 3 Other relevant research projects

- Investigating the uptake of dioxins and dioxin-like PCBs by farmed salmon from feed DAPAFF
- Organotins in seafood: an issue for human health? OT-SAFE
- A new tool in the war against harmful toxin-producing algae ALGADEC
- Alternative methods for biotoxin detection and depuration in shellfish BIOTOX
- Socio-economic impacts of harmful algal blooms ECOHARM
- An accelerated detoxification system for live marine shellfish contaminated by algal PSP toxins SHELLFISH
- Towards an improved quality of smoked salmon for the European consumer EUROSALM
- Establishing standards for the traceability of seafood products TRACEFISH
- Seafood for a better life SEAFOODPLUS

SWOT analysis

SWOT	Coastal fish	Coastal bivalves	Freshwater ponds	Freshwater intensive
Strengths	Positive health image associated with seafood products and increasing concern over sustainability of capture-based fisheries	Protective sanitary legislation and screening for toxins	Robust environment copes with modest pollution issues etc.	Generally good control over environment and feed inputs, especially in recirculated aquaculture systems
Weaknesses	Quality of aquaculture product is frequently questioned by industry opponents, mostly linked with feed inputs	Most vulnerable to contamination via sewage effluent or accumulation of biotoxins	Relatively little control over water quality	Flow-though systems potentially at risk from water pollution and feed contamination
Opportunities	Growing collaboration between producers, market actors and NGO's on aquaculture standards	Offshore aquaculture could reduce risk from coastal pollution Better screening technologies	Improved screening technologies could provide greater re-assurance to consumers	Development and implementation of improved screening technologies
Threats	Risk of consumer confusion faced with a proliferation of labels	Environmental contamination, particular concern over pathogenic virus	Inadequate environmental protection and poor sewage treatment	Environmental pollution and feed contamination

Recommendations for strategies to overcome the identified limitations

- Regulations on the use of animal by-products in aquaculture feeds needs to be continually reviewed in light of scientific evidence and regulations applied to imported aquaculture products as well as those farmed in the EU.

- The Shellfish industry should be further supported by enabling and promoting the use of latest diagnostic surveillance tools for marine bio-toxins, pathogenic bacteria and especially pathogenic viruses.

- Practical support through research priorities and structural aid is required to address any remaining issues with persistent organic pollutants in feed materials and to ensure consumers are reassured as to the safety of farmed aquatic products.

4.5. Animal health and welfare

Identified issues and limitations

The new EU Animal Health Directive ("hygiene package" *Directive 2002/99/EC* [*adoption: consultation 2000/0181/CNS*]) implemented in 2006 harmonises and strengthens veterinary public health and food hygiene requirements previously covered in disparate pieces of legislation. It establishes more rigorous health rules and places limits on the marketing of animal products across the entire value chain (primary production, processing, transport, storage and sale) to prevent disease transmission. Significantly, it also increases ability to restrict imports from non-EU countries subject to animal health controls and stipulates the conditions non-EU countries must meet to be included on import accreditation lists. This entails compulsory audit and veterinary certification. Regulations under the package include: Reg. 852/2004/EC (primary production requirements inc. HACCP), Reg. 853/2004/EC (hygiene rules for live bivalves, fishery and processed products), Reg. 853/2004/EC (organisation of controls on animal products for human consumption) (Nazmul Alam and Pokrant 2009).

Other identified issues and limitations include:

- The lack of long-term view by industry and also government for strategic health plans including R&D
- The lack of enforcement of regulations in some parts undermines the regulations and therefore the need to develop new solutions within the regulations.
- The appropriateness of notifiable disease classification and regulations, particularly with respect to compensation issues

Results of research and technological developments that compensate for the identified limitations

Antimicrobials in cod

Despite the dramatic decrease seen in the use of antibiotics in Norwegian aquaculture, a minor increase in antimicrobial drug use occurred over the period 2000-2005, associated largely with the growth in Atlantic cod (*Gadus morhua)* production. While the number of prescriptions relative to the biomass of the cod produced actually declined from 2002-2005 (due to the introduction of more efficient vaccines after 2003 reflecting trends in the salmon sector), a considerable increase in the number of antimicrobial drug prescriptions issued for cod classified as fry (i.e. prior to vaccination by injection) was observed, especially in the period 2004–2005. *Grave et al*., (*2008*) conclude that if the production of farmed Atlantic cod were to increase strongly in the future and the antimicrobial drug usage in cod increases to the same extent as currently, this may pose a risk factor regarding the development of antimicrobial drug resistance in Norwegian cod farming. This example clearly shows that while the general trend of the use of medicines for established species in European aquaculture is on the decrease, there are risks in the industrial development of new species that may lead to critical disease situations.

Sea lice in Atlantic Salmon

Sea lice are often cited as a major problem in the intensive farming of Atlantic salmon, as well as a threat to wild salmon populations. Monitoring of sea lice infestation and new research initiatives are helping to address the issue.

Lusedata www.lusedata.no is a monitoring programme of sea lice in salmon farms around Norway. The website (in Norwegian) provides monthly data for all coastal areas on the water temperature, the numbers of adult female lice, the percentage of farms that treated for lice over the last month, the percentage of farms using cleaner fish and a long-term (3-year) graph of mobile lice and adult females - all as reported by fish farmers in those areas, under Norwegian legislation.

Chemical cues: *T*he most well-known semiochemicals are pheromones, often referred to as 'sex hormones', which regulate many essential aspects of behaviour, including mating. Sea lice use a combination of cues to locate and identify their fish hosts and then attach themselves and feed on the host before they can reproduce. These cues include kairomones – a semiochemical cue released by the host fish.

Researchers at Aberdeen University in the UK have identified chemicals produced by salmon that attract sea lice. "Unattractive chemicals", isolated from turbot, have also been identified and these are effective in repelling sea lice. If attractive and non-attractive semiochemicals can be successfully deployed in fish farms (in traps or other devices), they could reduce the rate of infections in farmed salmon.

Such techniques are well established in terrestrial agriculture and could form part of an integrated sea lice control programme, which would be less dependent on chemical treatments and more cost-effective to implement.

Enhanced immunity: Stimulating the immune system in fish significantly increases their ability to resist louse infection. New research being carried out at NOFIMA in Norway (www.akvaforsk.no/english) shows that the addition of β-1.3/1.6-glucan (a naturally derived polysaccharide or sugar) in fish feed decreases the number of lice per fish by 28 percent. One of the major global salmon producers, Marine Harvest, reported a 20 percent infection reduction when salmon were fed glucan-containing feed in the period prior to being treated (chemically) for lice. These new approaches have advantages compared to current medical treatments, which carry the potential for resistance and can have negative environmental effects.

Animal Welfare

The EU research Framework Programmes (especially FP6 2002-2006) put great emphasis on welfare issues and this was also reflected in national research programmes. The following initiatives brought together knowledge to look for application in the aquaculture sector and a support to the legislative process, notably through the Animal Health Directive.

Fish Welfare Net: Fish welfare net is a portal dedicated to research into fish welfare and serves as a source and reference point for information on fish welfare-related research initiatives. The site aims to increase awareness of emerging fish welfare concerns, and is able to rapidly disseminate new research findings. www.fishwelfare.net

WEALTH: The WEALTH initiative focussed on how different environmental factors and husbandry conditions in various farming systems result in physiological stress, and on the subsequent consequences for behaviour, growth performance, disease resistance and general welfare in fish farming. WEALTH has developed and tested new welfare indicators and applied these together with established indicators in various experiments in both tanks and sea cages. Recommendations for industry good practice are also provided. www.wealth.imr.no

Benefish: The EU project Benefish (Evaluation and Modelling of BENEfits and Costs of FISH Welfare Interventions in European Aquaculture) explores the benefits and costs of welfare measures in aquaculture production systems, having defined a widely-applicable set of operational welfare actions and indicators that can be connected to measurable consequences in production and extended to effects on value chain and changes in consumer perception. www.benefish.eu

Fish welfare was the central theme of the 2007 AQUA NOR FORUM, organised by the European Aquaculture Society in conjunction with the world's largest aquaculture exhibition. It brought together stakeholders from research and industry in a forum discussion, so as to maximise discussion of the issues. The event was the first of its kind and concluded that we still need better operating tools to measure stress, even if basic observation, such as fin integrity, feed intake, survival and growth, appear to provide fair indications.

Fish containment systems can be improved through multidisciplinary approaches where biological, operational and technical requirements for design are equally important. They resulted, for instance, in a new cage design to maintain an adequate swimming volume for fish, as well as new features of submersible cages, where fish can swim faster and adapt to being submerged. A pertinent choice of sites, sizing and placing of cages is necessary, together with elaborate husbandry practices, which are of importance to ensure good fish welfare.

Fish welfare can also be improved in optimizing handling operations, like transport (modification of the EU regulation on animal transport to apply for fish) or slaughtering. A new legislation known as "Slaughterhouse act" has been issued in Norway in 2007 (*Johansen et al, 2009*). The use of CO_2 as a sedative will be totally banned in Norway in 2010 and replaced by percussive stunning, which results in higher product quality and extended shelf-life because of the fact that an extremely long pre-rigor time can be achieved.

Box 4 Other relevant research projects

- Selective breeding to improve disease and stress resistance in fish and shellfish AQUAFIRST
- Learning more about the transfer of pathogens in the sea DIPNET
- Fighting epizootic diseases by improving excellence EPIZONE
- Increasing carp resistance to bacterial and viral infections EUROCARP
- Controlling infectious diseases by stimulating larval defence mechanisms FISHAID
- Technological knowledge-platform for a future improved immunity to infectious diseases in aquaculture IMAQUANIM
- Methods for the detection and the control of Infectious Salmon Anaemia ISA
- Controlling the dispersion of enteric myxosporosis in the Mediterranean MYXFISHCONTROL
- A permanent advisory network for diseases in aquaculture PANDA
- Identifying disease risk to native fish from ornamental fish species RANA
- How to avoid disease outbreaks: fight bacteria with bacteria RMBC
- Understanding the genetic basis for resistance to Gyrodactylus salaris in Atlantic salmon SALMOGYRO
- Sea lice resistance to chemotherapeutants SEARCH
- Sea lice: a salmonid's tale SUMBAWS
- Selective breeding to improve disease and stress resistance in fish and shellfish AQUAFIRST
- Evaluating the economic impact of maintaining the welfare of farmed fish BENEFISH
- Identifying quantifiable indicators of stress in farmed fish FASTFISH
- Reduction of malformations of juvenile fish in hatcheries FINEFISH
- Eliminating lordosis and improving musculoskeletal growth in sea bass ORCIS
- Improving the health and welfare of farmed fish WEALTH
- A network on fish welfare in European aquaculture WELLFISH

SWOT analysis

SWOT	Coastal fish	Coastal bivalves	Freshwater ponds	Freshwater intensive
Strengths	Relatively strong legislation to reduce the introduction and spread of fish diseases Harmonized legislation on pharmaceutical market authorisation provides larger market to encourage development Access to diagnosis	Welfare concerns generally lower	Protective sanitary legislation	Management and technology options more easily implemented to deal with disease and welfare issues
Weaknesses	Limited range of licensed medicines and vaccines Insufficient collation and analysis of aquatic animal disease data to allow real-time advisory or policy responses Lack of knowledge on pathogens and their transmission in new culture species	No possibility of treatment applications Risk from imported diseases e.g. via ballast water in ships	Poor health management by the industry	Intensive systems more likely to suffer major disease outbreak Welfare concerns higher
Opportunities	Improved health management and welfare conditions likely to boost production efficiency	Eco-labelling opportunities	Potential improvements through selective breeding and vaccines etc.	Improved systems based on welfare research
Threats	Risk of diseases/ parasites in absence of effective prevention or emergency management plans	Risk from imported diseases e.g. via ballast water in ships	Predation Koi carp herpes virus (KHV)	Emergence of new disease problems

Recommendations for strategies to overcome the identified limitations

- Ensure the positive contribution of aquaculture to safe and high quality aquatic foods is reflected in policy and legislation;
- Licensing of aquaculture drugs could be made more flexible to make their development a more attractive proposition for animal health companies.
- Welfare regulations should have special provisions for fish and shellfish (separately).

4.6. Third countries competition and market issues

Identified issues and limitations

Key 'third country' competitors are discussed below; 'other competition and market issues' including product standards, trade rules and market volatility are dealt with extensively in sections 2.4 and 2.5 and a few key points summarised below.

There are serious concerns whether third countries products are being adequately checked for therapeutant contaminants; the scope and depth of "hygiene package" (section 0) is likely to result in increased levels of retentions on importing countries – particularly those in Asia with weaker regulatory regimes. The prospect of EU bans has recently driven the governments of Bangladesh and Malaysia to implement self-imposed bans on seafood exports in order to address these quality control and traceability issues. Conversely it is doubtful how far 'third countries' can be held accountable to stricter EU-rules on animal welfare (maximum stocking density levels etc), environment and social justice – in order to ensure a level playing field with EU farmers. There is also a major concern over the lack of requirement to label previously frozen products (section 0), again favouring low-cost imports over predominantly fresh EU produce.

Aquaculture also competes with capture-fishery products. Given an even-playing field most aquaculture is likely to profitable only when capture stocks become over-exploited; in which case it can relieve pressure on the fisheries. However whereas fisheries and agriculture both enjoy access to capital grant support from EFF structural funds; EU aquaculture benefits little in the way of the direct and indirect production subsidies that remain available to the fisheries e.g. fuel subsidies and EU payments for fishing access to third country waters (*IEEP 2002*). This helps to maintain artificially low prices for fishery in relation to aquaculture products. The problem is compounded by a lack of clarity over what government actions or inaction actually constitutes a subsidy (*FAO 2009*). For example, in Norway government investment in to prevent bankruptcy could be interpreted as state aid.

Third country competition

Norway and Turkey are the two most important aquaculture producers outside the EU, but producing species in common with EU producers and marketing fresh products largely into the EU. Turkey consumes most of its trout production but exports some 75% of sea bass/ sea bream production to the EU (FAO). In 2007 Norwegian salmon accounted for 85% of EU imports, 4% of USA imports, 78% of imports to Eastern European nations (non-EU) and 58% of exports to Asia. In Asia 46% of the market is for fresh salmon, of which Norway supplies 84% (*Aandahl, 2007*). Whilst Chile has the natural resource base to grow its salmon production well beyond that of Norway, its distance makes it much less of a threat to EU producers. EU demand for frozen salmon, their main export to the EU, fell dramatically in the early 1990's. Today Chile accounts for around 11% of total salmon imports.

Globally nearly 60% of aquaculture is of freshwater species giving countries with abundant freshwater resources a competitive advantage; Vietnam has capitalised on this with its unprecedented rate of up-scaling for pangasius and catfish production. It is also considered here as the EU is its main trading partner.

Norway

Norwegian salmon farmers have maintained margin despite volatile prices by steadily driving down costs of production (COP). Although EU producers frequently claim Norwegian farmer costs are lower due to state subsidy, lack of data in the public domain makes this difficult to substantiate. More apparent is that the UK and Ireland increasingly compete with Norway by offering a less commoditised product with judicious use of quality labelling schemes (RSPCA, Organic, PGI etc: see Section 0), supported by some of Europe's more effective producer organisations. The UK market is also one of the largest for salmon giving further advantage to local producers. Salmonid production in Norway rose to a world-leading 800,000 t in 2007; consisting of 736,000 t of salmon (almost 5 times total EU-27 salmon volume) and 78,000 of trout (83% of EU-27 production). This makes it the second largest exporter of seafood in the world after China with a value also around five times the entire EU-27 aquaculture production. It is also taking a lead in the scaling-up of two high potential temperate marine candidate aquaculture species: cod and halibut (Section 0). Shellfish culture is less advanced, except for mussel production rising from 425,000 t to 630,000 t between 2001 and 2006.

Despite supportive government policy over many decades, the country's competitive advantages are first and foremost its extensive sea-board (25,148 km of mainland coast, 58,133 km of island coast and nearly 2 million km^2 of EEZ) with deep, sheltered inshore conditions, good flushing rates and stable salinity ideal for inshore aquaculture. Secondly, salmon have extremely favourable traits of as a culture species: grow-out potential in simple low cost-cage systems, a simple and robust hatchery phase with low losses (contrasted with other marine species with planktonic larval phases e.g. cod, bream and bass), and ability to feed immediately on formulated feeds, as well as one of the highest fillet yields (around 64%) of any cultured species.

The three largest global animal feed producers are also Norwegian: Skretting, Ewos and Biomar. They benefit from sizeable R&D budgets, monopoly positions in the European Salmon sector, 80% of the South American market and 45% of the EU-27 market for bass, bream, trout and carp. Ewos parent company Cermaq also owns Mainstream salmon, a major international producer with production sites in Norway, UK, Chile, Canada and the USA. With consolidation and technical advances (automated feeding, development of low grilsing stocks), productivity in the salmon sector grew 10-fold from 30t/ FTE to 307t/ FTE in 2001. Since then it has grown by a further 25% to 392t/ FTE (DoF). Costs of production fell from NOK16.14 to NOK14.75 from 2001 to 2006 due to falling costs of feed, smolt production, generous financing from local banks as well as productivity gains. Thereafter they rose again to NOK15.81 in 2007 due increasing salary and feed costs.

Government strategy has focussed heavily on licensing arrangements for limited inshore sites. Currently this is limited to 870 in number (salmon and trout) with a statutory limit of 760 t per licence, though with derogations up to 1,000 t. Limits on individual ownership were also increased from a maximum of 15% to 25% of licences; today the largest producer Marine Harvest owns nearly 21%. Clearly this regulation prescribes opportunities for additional growth with the inshore area as well as significant additional consolidation. The government is also encouraging steps to reduce escapees, which it considers as the most serious environmental consequences associated with the salmon/ marine trout sectors as well as the most serious threat to the industry image.

The recent crash in Chilean production due to Infectious Salmon Anemia (ISA) and other existing pathologies that allowed the wide spread of this virus due to the poor health condition of the stocks (sealice and *Piscirickettsia salmonis*) has resulted in much speculation about possible benefits to EU producers. Although world prices have increased, the Chilean and European markets are very different and any windfall is likely to last at most 2-3 years until the Chilean sector becomes re-established. Despite a strong Kroner Norway is benefiting from record sales (up 12% on 2008) and higher prices with growth in exports to the USA (up 100% on 2008 following removal of fillet import restrictions) and EU (Berglund, N. 2009).

Potential for significant future world growth rests in further exploitation of largely undeveloped remote southern regions and/or emergence of economic conditions which would justify off-shore cage developments elsewhere. The government is also actively involved in consolidation, reselling its 51% stake of the conglomerate Norsk Hydro with global farming interests to Nutreco in 2000.

Unfortunately, Norwegian consolidation of the salmon sector in the EU also means that the greatest shares of the benefits of these companies overseas expansion are likely to repatriated to tax regimes (if not necessarily shareholders) out with the EU. This contrasts with the growth sea-bass / sea-bream sector where overseas technology transfer and investment is dominated by EU head quartered companies.

Turkey

Turkey is today the fifth largest aquaculture producer in Europe; the third largest excluding shellfish. In terms of EU-27 competition focus is almost entirely on predatory finfish, as the second largest producer of bass (38,400 t in 2006; 29.8% of national production) and bream (28,400 t; 22.1%) after Greece, and the second largest producer of trout (56,000 t; 44.7%) after Norway. Focus here is on the former two species as the trout sector, despite significant recent growth, remains highly unconsolidated (most farms <10 t/yr) with production of portion sized fish from inland ponds destined mainly for local consumption. Local seafood demand is driven by increasing per capita consumption (6.6 to 8.2 kg/capita between 1995 and 2006) and population growth. This created a demand for an additional 120,000 t of fish per year. Aquaculture production rose to around 130,000 t over the same period though it still accounts for only 13% of total seafood production and capture fisheries have been able to meet much of this additional demand. The aquaculture sector has grown by about 25% per year since 2006 following the end of a year long economic crisis in 2002, with recovery buoyed by the start of EU Accession talks and devaluation of the Turkish Lira in 2005. Many of the smaller bass and bream farms also cater to local needs, however recent acquisitions by Greek producers (especially Nireus and Selonda) have targeted export markets, especially in Spain and Italy, taking advantage of generous government subsidies. The primary value of farmed-fish, traded into the EU was around 360 million Euros last year. This was mainly for bass and bream for which the EU is the primary market and Italy the main buyer.

Bream and bass volumes have increased by 240% and 260% respectively since 2002. Of a total of 276 registered companies engaged in marine cage production, 264 culture these species. Sites are located in the Sea of Marmara, the Mediterranean Sea and especially the Aegean (92% of farms), where sheltered inshore areas are highly suited for cage-culture. Much of the production equipment (cages, chemotherapeutants, vaccines and live feeds) are still imported while feeds are locally produced.

Competitive advantages include the extensive and only partially tapped nature of the marine resource (8,333 km of coast line and 151,000 km^2 of EEZ), very low manual labour costs, and high levels of Government support including capital grants and subsidised loans for operational inputs (including energy and feed) over extended terms. Government policy encourages productivity growth and quality improvement, though regulatory polices for planned growth corresponding with market demand is notably lacking. Growth has also been supported through technology development and transfer, notably from Norway.

Despite the extensive marine resource, production conditions along much of the coastline are sub-optimal and this is likely to become a limiting factor for future growth. Temperatures in the southwest can fall too low for sea bass/sea bream, while the Black Sea coast experiences extreme temperature fluctuations, such that even for rainbow trout farming possibilities are highly seasonal. The main potential for growth therefore exists along the more exposed Mediterranean coast.

Some attempt has been made to improve the regulatory framework with an Environmental Law amendment in 2006. This forbid location of fish-farms in closed bays and gulfs considered sensitive on the basis of their natural or cultural (archaeological) characteristics. The stipulation that farms had to be relocated off-shore or closed within a year affected some 85% of existing farms. Strict implementation is expected to cause more than 5000 job losses and serious socio-economic hardship. Delays have been mainly due to the protracted definition of 'sensitive' areas. However some operators have been unable to renew leases and bank loans are not available to unlicensed farms. This is driving consolidation with many smaller farms closing down or changing hands (*Deniz, 2009*). Higher capital requirements for development of larger farms on the exposed Mediterranean coast will be a further driver of consolidation.

These factors are contributing to development of larger farms; the biggest with larger individual net-pens produce around 2,400t/yr; still half the size of the largest Norwegian salmon farms. Automated feeding utilising centralised storage is increasingly replacing simple boat-based feed spreading methods. However, mean feed conversion rates remain high: 1.6-2 for sea bream and 2.2 for sea bass, perhaps also reflecting feed quality issues. Successful vaccination regimes and relatively low stocking density (10-13 kg/m^3) have contributed to good survival rates averaging 85-95% for bass and bream respectively.

Marketing is complicated by the intrinsic seasonality of bass and bream production, which naturally tends to result in the largest volumes being harvested in the autumn when demand is falling. Stocks can be overwintered to meet rising consumer demand in spring, but this can add significantly to production costs. Southern producer countries with warmer winter temperatures (i.e. Cyprus, Malta and the Canaries) are less subject to such problems, thereby simplifying production planning. Turkey's development of its southern Mediterranean coast will confer similar advantage in this respect.

Many farms also continue to rely on wild-caught fish as broodstock while nearly 90% of sea bass and sea bream production is marketed as whole fish with no post-harvest processing or value-addition.

In general, there is lack of reliable data collection on the sector, essential to effectively counter negative environmental perceptions. These deficits in the public sector are also matched by a lack of any effective producer organisation[17]. Consequently, there is also looming potential for conflicts with other important economic sectors, notably tourism.

Other development initiatives offer significant scope for future freshwater aquaculture and fishery development; the Southeast Anatolian (GAP) irrigation Project has added 123,000ha to the inland fresh water capacity of Turkey. However, it is likely that this will cater mainly to a growing local population.

In contrast to Norway, Turkey offers at least three forms of direct (horizontal) aid to the sector worth nearly 24 million in 2006. Firstly, an export refund for 'prepared and preserved fish', worth $200/t aims to encourage value-added marketing. Second are state-subsidised 'soft' loans (capital and operational) available to fish farmers (and fishermen) at 30% below market interest rates for loans up to $150,000/ farmer. Finally and most significant is the Government's 'Aquaculture Support Scheme' offering grants to certified farmers belonging to the National Farmers Registration Scheme (NFRS). Worth $0.48 cents/kg sea bass or bream (new species $0.68/kg) this amounted to $22.5 million in

[17] EU POs regulation does not recognise third countries POs.

2006. Although relatively small in total, this could have significant competitive impact if benefits were concentrated a few larger exporters.

Vietnam

Whitefish products of marine origin constitute the most important sector of the European seafood by volume, particularly in the West. However, over the last decade several freshwater substitutes have increasingly filled the growing deficit between supply and demand for such products, especially low-cost processed items. The trade largely consists of three farmed species (pangasius, tilapia, African catfish) and one capture species (Nile Perch). Most of this is imported. However, combined consumption and imports of the last three species are dwarfed by pangasius, almost all of it cage-farmed under the highly favourable conditions of the Vietnamese southern Mekong Delta.

Even as an imperfect substitute for European farmed products, the volume, market growth and low price of pangasius imports position it as a competitor which should not be ignored. Pangasius currently accounts for 12% of the EU market for whitefish and 5% of all finfish. The USA with its own (channel) catfish sector (and where inland fish has traditionally met over 70% of finfish demand) imposed protectionist measures in 2003. This contributed to the surge in EU imports from 2004 onwards as Vietnamese exporters redirected their focus. The sector's rate of growth is un-paralleled in aquaculture: Vietnamese production has risen from hundreds to over a million tonnes (*WFE*) in just a decade. By comparison it took more than two decades for the Norwegian salmon and EU sea bass/ sea bream sectors to grow to around 800,000 t and 350,000 t respectively.

In 2008 Vietnam exported over 600,000 t of frozen fillets, 35% to the EU, the largest and most affluent market. Other key markets include Russian and Ukraine (33%), SE Asia and China (12%), USA/Mexico (8%) and Egypt (5%). In Europe three countries: Spain, Poland and Holland take almost 60% of imports; Germany and Italy take another 15%. Penetration has been slower in France (6%) and the UK (3%), both major markets for farmed salmon.

As imports of frozen fillets doubled from 2006 to 2008, already low prices fell a further 25% from €2.1 - 2.8/kg to €1.6 to €2.4/kg over the same period. The spreads also reflect regional variations with Poland consistently importing at the lowest price. Here pangasius has become the closest substitute for a locally farmed species: low cost carp. Pangasius currently accounts for nearly 25% of an annual Polish fish consumption of 11.6 kg/yr/caput. The same values for the largest pangasius importer, Spain, are 8% against consumption of 35 kg/yr/caput.

Vietnamese competitive advantages include: an abundant, highly regulated fresh water resource with high flushing rates, rapid growth potential in (<1yr to harvest) in a sub-tropical flood plain environment, low labour costs and a highly consolidated processing sector accredited to international standards. Compared to the main temperate species, pangasius has relatively unselective dietary requirements and can be cultured at more than ten times the cage stocking densities of salmon, sea bass and sea bream (i.e. >250-300 kg/m^3). However, the meteoric rise has not been without controversy and there are serious sustainability concerns. A predominance of small-scale farmers combined with a weak regulatory environment has resulted in growing water quality and disease problems. Mean survival rates can be as low as 60% from fingerling to harvest. Antibiotic residues and traceability issues in turn create downstream marketing problems. Associated health scares have resulted in a growing number of import bans, most recently by Russia and Egypt.
However, weak industry structure appears to be the most significant constraint in the short term at least. Profit sharing is highly skewed towards a few powerful processors who take 78.5% of total profit (to point of export) compared to farmers 19.4% (MRDDRI 2009).

Consequently an estimated 70-80% of farmers have been made losses following a hike in feed prices in the first quarter of 2008 and some 20-30% of farming households face bankruptcy as credit availability also shrinks. Although processors frequently blame tariffs and technical barriers imposed by importing countries, the situation clearly reflects poor production development strategy by the processors. Around 100 factories in the region are operating at just 50% of their designed capacity (VietnamNet 2009).

These factors have finally arrested the primary growth of the sector. It is estimated that production will shrink by 20% in 2009 compared to 2008. In the EU import volumes fell by 30% between in the first quarter of 2009 compared to the last of 2008 accompanied by a 10% price increase (Paquotte, 2009). On the other hand these trends mirror the development of more mature aquaculture sectors including salmon, in scope if not degree. Predictably the first major shake-out and consolidation of the production sector is underway. Many of the smaller house-hold levels producers have ceased production though, and there are indications that some processors are pursing strategic vertical integration to improve stability of supply. Some international food processors are evaluating potential for contract farming if adequate quality safeguards can be imposed.

Frozen blocks of fillets have become a raw material for value-added European processing. The food service/canteen sector in particular has embraced the product. Yet some European processors of retail seafood products remain more circumspect due to adverse quality perceptions associated with adverse media coverage in key consumer nations.

Fillet yields slightly above 40% are comparable to sea beam though significantly lower than sea bass and only two thirds of salmon yields. Currently these losses are effectively passed onto Vietnamese farmers. Compliance with new farm management standards will inevitably impose additional transaction costs on producers likely to drive further consolidation unless a producer price premium is secured. These include standards being facilitated by the World Wildlife Fund (targeting 20% of production), NACA (an Asian inter-governmental aquaculture association championing ‘better management practices’) and GLOBALGAP (a business to business model initiated by a consortium of mostly European Supermarkets). A more mature and sustainable sector will only be possible through more equitable distribution of benefits along the value chain. The attendant benefits of on-going consolidation (improved diagnostic capacity driving development and adoption of low-cost vaccines, traceability and quality certification systems etc) are likely to translate into improved efficiency and stability in a production sector with fewer direct stakeholders. While Europe is likely to remain a premium market, these factors will inevitably erode some of pangasius’ competitive advantage. As a low cost white-fish substitute demand is especially price elastic as recent declines in the key European markets in Spain, Poland, The Netherlands and Italy following a 10% price increase demonstrates. Although the extreme growth levels of the last decade are unlikely to be repeated, further cycles perhaps of lower amplitude are probably inevitable. Vietnamese processors and export authorities have proven themselves to be extremely adaptable in the past and their position in Europe is likely to endure if quality concerns are addressed.

It is also worth considering how this freshwater model may translate into other areas with similarly favourable freshwater resources. Flood plain areas in China and Thailand are already heavily exploited and exporting sizeable surpluses, particularly to the USA. Despite growing population levels, Bangladesh and Cambodia also have significant potential to produce export surpluses if they can harness their flood plains effectively. To give an idea of the scale of this potential, Bangladesh - a country the size of the UK - has more fresh-water flowing through it per year than the entire EU.

Results of research and technological developments that compensate for the identified limitations

Box 5 Other relevant research projects

•Prices and margins along the European seafood value chain SALMAR

SWOT analysis

SWOT	Coastal fish	Coastal bivalves	Freshwater ponds	Freshwater intensive
Strengths	Proximity to the worlds largest seafood market Proximity to largest market for value-added qualities Purchasing power of wholesale distribution networks	Increasing demand Live product, less competition from distant markets	Large variety of species	Potentially close to market
Weaknesses	Traceability requirements not as stringent for imported products Lack of market and industry studies	Over production resulting in low prices e.g. mussels Fragmented production base e.g. oysters	High price fluctuations assoc. with independent fishing activity Limited export potential	Limited options for economies of scale in most current systems
Opportunities	Declining wild fishery resources Increasing transport costs for external producers Growth of value-added processed products	Promotion of live product	Local consumer demand Organic culture & certification	Potential for marketing as local production
Threats	Competition from 3rd country aquaculture producers (Norway, Turkey, Vietnam) Lack of centrally coordinated transnational promotion campaigns	Competition from imported products (mostly processed) from lower-cost regions	Lack of differentiation makes product liable to competition from lower-cost imported substitutes	Vulnerable to competition on price from third countries

Recommendations for strategies to overcome the identified limitations

- Work to build EU lead on clear and coherent standards, and harmonise international equivalents

4.7. Fish oil and fishmeal availability

Identified issues and limitations

European aquaculture developed to meet demand primarily from consumers in developed countries of Europe, North America and Japan. The species produced in Europe are generally representative of those fish that are locally fished and historically consumed in these markets. These are mostly carnivorous (or better piscivirous) fish, which, due to their physiological specificity, require feeds composed of mainly marine feed ingredients, high in protein and fats (lipids). The use of fishmeal and fish oil is therefore a necessity to provide essential dietary omega-3 fatty acids, which have been shown to be beneficial to human health. As a consequence, European fin fish aquaculture is more feed-based compared to other world regions and as the production has grown uses more of the world supply of fish meal and fish oils.

Given that feed costs can represent 40% or more of the total production cost in these species, considerable efforts have been made by producers and suppliers to use feed more efficiently (the number of kilograms of feed used to produce 1 Kg of fish), with its concomitant effects on the level of wasted feed that is not consumed and can contribute to the environmental impact of aquaculture activities.

A landmark paper published in Nature (Naylor et al., 2000) and based upon 1997 data from the world fishery and estimations of its use by the aquaculture industry, raised considerable controversy among the industry as well as within the scientific community. It put forward the hypothesis that the captures for non food fish will not increase and the availability of fishmeal and oil, if remaining at the same level, would not allow alone the projected increase of the world aquaculture production. Much more recently, new arguments such as those put forward by Tacon and Metian (2008) stress the point, arguing in detail that a large part of the fish captured to produce fishmeal and oil could (and should) be better used for direct human consumption, to maintain the per capita ratio of wild fish in the diet. They goe on to predict that aquaculture usage will be increasingly restricted to high value starter, finisher and broodstock diets.

Other identified issues and limitations are as follows:

- Finite supplies are likely to be fully utilised for aquaculture in the future
- Food safety regulations could possibly reduce availability of fish processing wastes
- For the salmon industry, limitations on fish oil supply are more critical than on fishmeal (though globally this balances out with higher requirements for fishmeal in other aquaculture and feed lot sectors; Jackson 2007).
- There are possible implications for reduced fish oil use for human health i.e. one of the key drivers of increased seafood consumption.
- There are less well recognised welfare and environmental issues with respect to higher use of terrestrial feed components e.g. GMO soya and maize.

Results of research and technological developments that compensate for the identified limitations

Over at least the last decade, research efforts (at the EU level and though national programmes), as well as research carried out by the main fish feed suppliers to the sector, have focused on the reduction of fish meal and oil in fish feeds and their replacement by terrestrial plants, as protein and oil sources, without affecting the growth and quality of aquaculture produce and maintaining the considerable health benefits that are one of the principal reasons for fish consumption in developed countries.

During the 6th Framework Programme of European Community research and development (2002-2006), 11.9 million euro of Community contribution was spent on feed and nutrition research, representing some 13% of the total EU contribution to aquaculture research during that period. Key research projects such as PEPPA[18], RAFOA[19] or AQUAMAX, looked at the replacement of fishmeal and fish oil and the potential to 'tailor' aquaculture feeds to maximise feed efficiency and of course the health benefit to consumers.

The AQUAMAX Integrated research project[20] started in March 2006 and runs for four years. It starts from the premise that fish play a unique role in human nutrition and wellbeing, that aquaculture has thus far managed to make up the fisheries deficit, but that its growth is becoming increasingly constrained by the limited industrial supply of fish on which aquaculture feeds are so heavily dependent. The strategic goal of the AQUAMAX project is to replace as much as possible of the fish meal and fish oil currently used in fish feeds with sustainable, alternative feed resources. The project involves 32 partners from throughout Europe with partners also from China and India. To date, AQUAMAX has made significant headway in 'tailoring' aquaculture feeds to produce high-quality fish with significantly reduced use of fishmeal and fish oil.

Hence, over the last decade, cooperation between the research community, the fish feed manufacturers and the production sector has resulted in a reduction in the share of fishmeal in fish feeds by almost half and similar efforts are reducing the use of total fish oil use through phase-feeding practices, using appropriate mixtures of plant oils for part of the production cycle, then switching to finishing feeds rich in fish oil to raise the levels of long-chain w3 polyunsaturated fatty acids to ensure the nutritional value of fish to the consumers.

Recent arguments ((Jackson, 2008), as put forward by the International Fish Meal and Fish Oil Association (IFFO) show that the increased use of fishery by products to produce fish meal and oil, and the changes in formulation of fish feeds for aquaculture species that represent the majority of global production (carps, shrimp and salmon) the so-called "Fish in to Fish out" ratio actually shows that global aquaculture is actually a net producer of protein and that the frequently posed question of "how many Kg of wild fish does it take to produce 1 Kg of salmon?", is currently actually less than 2, rather than the 4 or more Kg that are often quoted.

Box 6 Other relevant research projects

AQUAMAX – Formulating fish diets to maximise human health benefits
FORM – Thematic network on fish meal and oil replacement
GITINTEGRITY – Are appetite, intestinal structure and function of salmonids adversely affected by feeds containing vegetable lipids?
PUFAFEED – Substituting fish oil with marine microalgae in fish feed production
RAFOA – Using vegetable oils as alternatives to fish oils in aquaculture
SELFISH – Optimising feeding efficiency by analysing the fish's need for macronutrients

[18] http://ec.europa.eu/research/agriculture/projects/qlrt_1999_30068_en.htm,

[19] http://www.rafoa.stir.ac.uk/

[20] AQUAMAX: Sustainable Aquafeeds to Maximise the Health Benefits of Farmed Fish for Consumers. www.aquamaxip.eu

SWOT analysis

SWOT	Coastal fish	Coastal bivalves	Freshwater ponds	Freshwater intensive
Strengths	Advances in diet formulation is reducing the quantity of fishmeal and fish oil required per unit of production	No dependence on fishmeal or fish oil	Little if any reliance on fishmeal and oil	Opportunities for close control over feed composition and use
Weaknesses	For aquaculture, fairly high dependency on imported fishmeal and oil due to higher levels of POP contamination in European supplies	Not applicable	Can be some reliance on fishmeal and oil at some stages in production	Variable, but generally significant reliance on fish meal and oil at present
Opportunities	Development of alternative protein and oil sources, or improvements in utilisation likely to have positive impact of aquaculture sector economics and potentially other export opportunities Reduction of use of fishmeal and fish oil in land animal husbandry Exploitation of fishery by-catch and discards by the fish-feed industry	Market opportunities based on high quality seafood without dependence on fishmeal and oil	Market opportunities based on no or very limited dependence on fishmeal and oil	Potential for significant reductions in fishmeal and oil use per unit of production through diet development
Threats	Rising demand for fishmeal and oil from China and other countries may increase prices as availability is limited Competition for fishmeal and fish oil from land animal husbandry or other users	Not applicable	Not applicable	Rising prices could impact on output if production becomes unprofitable due to high essential feed ingredients (if substitutes not found)

Recommendations for strategies to overcome the identified limitations

- Continued research inputs are required to identify new or adapted feed materials for aquaculture, or other solutions to fish meal and oil constraints.

- In the interim, further attention can be given to regulations on the the of fish and other animal wastes in aquaculture feeds

4.8. Technological issues

Identified issues and limitations

A review of emerging aquaculture technologies is provided in *Sturrock et al (2008)*. Space limitation and conflict with other users is one of the key constraints facing European Aquaculture (section 4.3). Much of the marine industry is concentrated in coastal areas with high amenity value and environmental sensitivity. Several approaches have been developed to differing degrees of commercial viability (Table 17), which address the key issues to varying extents. At present, most of these approaches are more expensive and hence have limited uptake.

Table 17: Emerging aquaculture systems

System	Space / location	Local environmental impacts	Conservation of resources	Energy use
Integrated multi-trophic systems	Requires aquaculture to be in concentrated zones	Reduced environmental impacts due to nutrient cycling	Increased ecological efficiency	Potential for economies of scale may be limited
Closed containment systems	Requires relatively sheltered sites	Solids wastes captured and removed for treatment elsewhere; risk of escapes reduced	Potential for alternative uses of solids wastes	Increased energy over cage farming due to pumping requirements
Off-shore cages	Removes aquaculture from most sensitive inshore zones	Localised impacts reduced due to superior dispersion	Conserves valuable inshore resource for other stakeholders	Possibly increased energy use, but could be reduced through scale efficiencies
Onshore sites using RAS technology	Removes aquaculture from sensitive locations	Eliminates most local environmental impacts	Conserves water resources and nutrients if additional processes added	Slightly higher energy requirements

Competition also exists for freshwater resources and associated land, so similar approaches can also be relevant here.

While the necessary automated feeding and monitoring systems for off-shore cage systems are well developed; engineering containment structures to withstand extreme physical forces is highly challenging. Wave height and current speed are key constraints both physically and in with respect to animal welfare. Costs remain the biggest barrier to off-shore production: e.g. for 10,000t/yr salmon farm costing around £24 million to construct, IRR of 15% - 30% are required to attract venture investors, industrial investors may accept 15%, but only if technology is well proven and it is not. IRR calculations also demonstrate high price sensitivity indicating optimal marketing strategies will be required to secure a premium above inshore sites. Currently there is insufficient incentives and support to give offshore cage-aquaculture technology development the impetus it requires.

Submergible cages are an option in highly exposed sites but this brings significant additional technical difficulties; monitoring complexity (including detection of escapes), fouling and increased drag, pressure-related (barotrauma) welfare problems and reduction in waste dispersion benefits.

Shellfish culture using submerged and semi-submerged long line are more technically suited to off-shore production, but constrained by their lower value. Pilot scale systems have been successfully tested under moderately severe conditions (*Holmyard 2008*). Synergies may also exist through co-location with off-shore renewables.

More generally, there are inadequate systems for the prevention of escapes from cage aquaculture and the protection of stock from predatory wildlife in both fresh and marine aquaculture.

Shore-based systems provide another alternative to inshore-cage production. Previous attempts at pump-ashore systems indicate this is unlikely to be profitable where tidal ranges are high corresponding with high pumping costs. Recirculating Aquaculture Systems offer greater scope, including more flexible / strategic location options. As closed systems they confer ability to manage concentrated effluents and high bio-security; resulting in attempts by the environmental lobby to promote their wider adoption. However, low margins for grow-out, lack of system standardisation and proven systems for water recirculation have caused many start-up failures. Limited examples of longer-term adoption are associated with high value-products (e.g. sturgeon caviar, eels and salmon smolts) and lower value species capable of production at high stocking densities (e.g. African catfish). Strict anti-pollution legislation has also encouraged adoption in the Netherlands.

In addition to engineered system advances, bio-technology can also provide useful enhancements. To date this involves the development of new vaccines and therapeutants, and improvements to stock through selective breeding programmes. Gains from selective breeding are likely to be most significant under controlled production environments (c.f. the poultry sector) which could be provided by closed-containment and especially recirculating systems. These would also help to contain the fish more securely and prevent genetic pollution of wild stocks. However the productivity gains would have to be substantially greater to offset the greater capital and operating costs of these more sophisticated intensive systems.

New species

Potential for culture of new species is also included under the technology banner. A wide variety of marine fish species have been explored for commercial aquaculture. The status varies from mainly research to fully commercialised, albeit at modest volumes. Examples include Cod (*Gadus morhuna*), Arctic char (*Salvelinus alpinus*), sole (*Solea spp*), Black Sea turbot (*Scophthalmus maeoticus*), several bream varieties; *Pagrus pagrus Diplodus puntazzo*, *Sparus erythrinus*, *Dentex dentex*, *Diplodus puntazzo*, groupers (*Epinephelus spp.*) amberjack (*Seriola dumerili*) and meagre (*Argyrosomus regius*). Of these, cod has developed most strongly in Norway and meagre most strongly in the Mediterranean. Also notable has been the emergence of Northern bluefin tuna (*Thunnus thynnus thynnus*) fattening, which started at the turn of the millennium. So far, this is more an extension of the bluefin tuna fishery than full aquaculture, but development of the infrastructure for holding the fish is significant, and research is underway on breeding and nutrition.

Numerous technical difficulties are encountered in developing new species, i.e. knowledge of reproductive biology under intensive production conditions, cannibalism during juvenile phases, disease and mortality at different life-stages, nutrition, colour quality (red bream varieties) etc. However, arguably more important is correctly identifying the market opportunities and positioning and marketing the product effectively. High value and high cost species will be in niche positions in terms of the overall fish and seafood market, so must be differentiated on quality and related criteria. There is also the well-noted risk that a wider variety of niche species will simply crowd a specialised market, with very significant price reductions in inelastic conditions. If specialised low volume techniques mean higher production costs, profit margins could be very sensitive and difficult to maintain. Lower value species have greater production and sales potential, but require low-cost production to compete.

Results of research and technological developments that compensate for the identified limitations

In order to reinforce the innovation processes that are required within a modern and developing Europe, the European Commission introduced and promoted the development of Technology Platforms. The basic concept of these Platforms is to provide a framework for stakeholders, led by industry, to define RTD priorities and action plans on a number of strategically important issues where achieving Europe's future growth, competitiveness and sustainability objectives is dependent upon major research and technological advances in the medium to long term. These RTD priorities form a Strategic Research Agenda and the platforms also have a role in implementing results through effective dissemination and technology transfer mechanisms. 35 European Technology Platforms are listed and which cover a wide range of industrial sectors (see http://cordis.europa.eu/technology-platforms/individual_en.html), such as forestry, food, fuels, communications, steel, nanotechnology.

The European Aquaculture Technology & Innovation Platform (EATIP)

The impetus to create a separate technology platform for aquaculture came from the recognition of the sector as a complete value chain, which provides highly nutritious and desirable products for the consumer and which depends on research, technology and innovation for its continuing development. The European Aquaculture Technology and Innovation Platform was thus created in 2007. It comprises a Board of Directors made up of senior industry representatives and seven Thematic Areas of interest, each of which has a chairperson from industry and a facilitator from the research sector and which cover important sectoral areas of importance within the aquaculture value chain. These are:

1. Product quality and human safety and health
2. Technology and systems
3. Managing the biological lifecycle
4. Sustainable feed production
5. Integration with the environment
6. Aquatic animal health and welfare
7. Knowledge management

The immediate task of each Thematic Area is to prepare an individual draft Strategic Research Agenda on its subject matter, using expertise drawn from industry, RTD and other relevant stakeholders. Working Groups cover specialized topics that are contained within the overall scope of the Thematic Area in question. For example, the biological lifecycle includes marine and freshwater fish, shellfish, hatchery, juvenile and on-growing phases and thus requires multiple specialist inputs.

These Strategic Research Agendas have to relate to the medium to long term Vision that the stakeholders agree on with respect to aquaculture as an activity – in other words, these Agendas must have a view to the achievement of the Vision set out for European aquaculture in the future, through successful and innovative RTD on the acknowledged challenges. An important consideration is the identification of the best means of managing the knowledge generated from RTD, particularly in assuring the transfer of new knowledge into the appropriate sector – an absolute requirement for improving the competitiveness of the European aquaculture sector.

Within the EATIP, the following actions are foreseen:

- To establish a basis for applying good governance principles between the different stakeholders, using a participatory process, so as to facilitate the creation and development of vision documents and strategic research agendas for the main thematic areas within the aquaculture value chain;
- To provide dedicated fora to facilitate the dialogue between National and European policy makers, researchers and stakeholders;
- To assure the promotion of the communication, dissemination and exploitation of Community funded RTD projects.
- To create the conditions for managing knowledge by identifying needs, challenges and methodologies for knowledge application and utilisation

Assessment of ETPs

In August 2008, DG BUDG published an evaluation of European Technology Platforms. (http://cordis.europa.eu/technology-platforms/home_en.html) Its main recommendations for policy makers were to:

- Position the platforms as "flagships" for open innovation, with stronger support by the Commission and also at the political level, by making the ETP label a 'privilege' and using the ETP's as dialogue partners during policy preparation phases;
- Have Member States (In the context of the ERA and the Lisbon Objectives) support the operations of the platforms by stimulating the creation of national counterparts and consider extension to regional levels;
- Fine-tune the ETP concept and the underlying ETP objectives - notably in view of the expectations between the Commission, the ETPs and the various stakeholders and how the Commission deals with the Vision Documents and Strategic Research Agendas developed by the platforms in future Framework Programmes and general policy development;
- Involve ETPs in policy preparation processes that move them beyond 'technology' and link to other mainstream policies such as education, labour, competition, the ERA, etc.

The main recommendations for the platforms themselves were to move further towards implementation to facilitate innovation, to pay more attention to fund raising and bringing in financial providers and to internationalise the ETP activities to outside the EU.

Box 7 Other relevant research projects

- Improving stock rearing in aquaculture through applied genetics knowledge AQUABREEDING
- Selective breeding to improve disease and stress resistance in fish and shellfish AQUAFIRST
- Integrated knowledge on functional genomics in sustainable aquaculture AQUAFUNC
- Genomics in fish and shellfish: from research to aquaculture AQUAGENOME
- Building a roadmap of the European sea bass's genes BASSMAP
- Understanding and communicating fish reproduction research REPROFISH
- Farming out waste to help the environment AQUAETREAT
- Towards European Best Practice in marine aquaculture biofouling CRAB
- A network to support innovation in European aquaculture CSN-INTRAN
- Facing the unmet needs in European aquaculture DESIGNACT
- An escape-proof net for cod, bass and bream fish farming ESCAPEPROOFNET
- Improving water quality in recirculation systems by means of electro-coagulation FISHTANKRECIRC
- Development of an "intelligent fish tank" for cost-effective aquaculture production INTELFISHTANK
- Bio-economic feasibility of intensive pikeperch culture LUCIOPERCA
- Improving pikeperch larval quality and production LUCIOPERCIMPROVE
- Securing the production of Eurasian perch juveniles PERCATECH
- Intensive and sustainable culture of the freshwater fish species tench PROTENCH
- Reproduction of the Bluefin Tuna in captivity REPRO-DOTT
- Using seaweed to purify effluents from aquaculture farms - and lots more! SEAPURA
- Addressing the constraints for commercial sea urchin aquaculture SPIINES2
- Doubling European production of the great scallop SCALQUAL
- Improving productivity on turbot farms TURPRO

SWOT analysis

SWOT	Coastal fish	Coastal bivalves	Freshwater ponds	Freshwater intensive
Strengths	Technological competence at all value chain levels – notably reproduction High levels of research capacity	Reasonably strong innovation in the mussel sector and some development in oyster and scallop etc.	Established technology and increased research on ecological role	Focus of much R&D over last 10-20 years
Weaknesses	Narrow range of culture species Fragmented and high-risk nature of industry can deter technology developers and investors	Limited investment funding for innovation	Whilst traditional practices provide a strength, they can also hold back innovation	Limited investment funding for innovation
Opportunities	RAS technology applications to bring production closer to markets Off-shore aquaculture to reduce environmental impacts and provide new scale economies Bio-tech applications for improved stock, nutrition and disease control	New technologies for offshore culture and integration with other types of project	Greater understanding of ecological systems could improve management strategies	Improved technologies to address environmental issues and improve efficiency and robustness
Threats	Lack of investment in research and innovation could allow other regions (e.g. US) to take technology lead	Lack of investment in innovation	Limited returns fail to attract investment and innovation	Lack of technology development could lead to many of these farms breaching tightening environmental regulations

Recommendations for strategies to overcome the identified limitations

- Support greater industry investment in well focused research and innovation to make full use of the ERA

4.9. Production costs

Identified issues and limitations

The RTD inputs here overlap significantly with all the previous sections; additional key points are as follows:

- Constraints on companies achieving economies of scale
- Conflicting priorities over economic development – for job creation or competitive industry
- Limitations on use of feed ingredients not necessarily imposed on imported products?
- Welfare and social legislation not imposed on imported products

Results of research and technological developments that compensate for the identified limitations

Data collection

Data on European production volumes and values has been compiled for some years and for all species groups in Europe by the FEAP and is regularly updated on the FEAP web site http://www.aquamedia.org/production/default_en.asp. In 2008, The European Commission launched a tender to identify the data required to assess the economic trends and performance of the EU-27 aquaculture sector, and the best mechanisms for collecting this data. The resulting report (*Framian, 2009*) provided recommendations on the financial indicators that could be collected, the organisations that are best-placed to enact them, and their potential annual cost (estimated at 2.5 m euro with 1 m euro start-up cost).

The main recommendations arising from the Framian report can be summarised as being:

- That maximum efficiency and effectiveness of an on-going data collection scheme can be only achieved if the future intended data use is well defined, which will also allow a precise ***formulation of the objectives*** of the scheme as well as prioritization of the indicators to be collected or estimated.
- A significant level of heterogeneity still exists within the defined segments of aquaculture firms (based on species and on-growing technology), caused by differences in size and by the level of vertical integration, e.g. own production or acquisition of juveniles. Therefore it is recommended to define the ***'field of observation'***, including suitable thresholds and focus the on-going data collection on it. Additional criteria could be also applied, e.g. with focus on species or size. Data on segments which fall outside the field of observation can be collected in ad hoc surveys to be carried out according to specific needs less frequently. Average segment data should be based on at least five firms, none of which should represent more than a specified percentage of the total production value.
- In addition to the definition of the field of observation it is recommended to ***prioritize the indicators*** to be collected. Data on high priority indicators (turnover, personnel costs, total operational costs, employment) should be collected annually. Data on lower priority indicators (details on composition to operational costs and capital costs) could be collected only once in several years in ad hoc surveys, whilst estimation procedures should be developed to generate this data information whenever needed.
- ***Co-operation of the aquaculture industry*** is indispensable for several reasons: a/ to obtain access to the data, b/ to justify the additional administrative costs which the data collection will imply for the surveyed firms and c/ to promote the legitimacy of analysis based on that data, so that the results are not disputed or

discredited as being based on biased information. Therefore the objective of the data collection scheme as well as certain details of the implementation (prioritization of indicators) should be developed in dialogue with the industry.

- As the number of firms in new areas of aquaculture in individual countries is very low, it is recommended to pool the data of the anonymous individual companies from several Member States to ***calculate averages at EU level***. This approach is likely to produce a lower relative standard error and data confidentiality will be easier to guarantee.
- Collection of the aquaculture data should be executed by ***organizations already involved in compilation of statistical data scientific analysis in comparable areas***, such as agriculture or fishing. This approach will have several important advantages: a/ proximity of data collection and analysis allows a better interpretation of the quantitative results due to precise knowledge of strengths and weaknesses of the data, b/ the link between analysis and data collection will be beneficial for prioritization and implementation of ad hoc studies on specific new aquaculture activities and/or detailed indicators as proposed above, including various estimation procedures.

EU research has generally focused on understanding the technological and biological functions of **Recirculating Aquaculture Systems** (RAS). Projects have looked at the optimisation of tank design (INTELFISHTANK: Development of an intelligent fish tank for cost effective aquaculture through control of water quality in each different fish tank and FISHTANKRECIRC: Development of electro-coagulation technique for optimal cleaning efficiency and maximum reuse of water in land based fish farming) effluent treatment (AQUAETREAT: Improvement and innovation of aquaculture effluent treatment Technology) and the growth of fish in such systems (GRRAS: Towards Elimination of Growth Retardation in Marine Recirculating Aquaculture Systems for Turbot).

A notable project that looked more at the financial aspects of operating RAS systems and also diversifying the species (not just fish) produced in them was SUSTAINAQUA. The project www.sustainaqua.org targeted making the European freshwater aquaculture sector industry more competitive by helping farmers diversify their production, increase product quality, and improve production methods. The project revolved around five case studies made in Denmark, Hungary, the Netherlands, Poland and Switzerland, where the project consortium developed different options for diversifying the product range (including fruit and vegetables) next to the fish production.

A substantial output from the project has been a practical guide for aquaculture farmers, which is available in 12 languages, including of course those mostly spoken in the main freshwater producing countries. It describes how the methods developed in the case study to achieve specific results can be scaled up to actual farm proportions.

SWOT analysis

SWOT	Coastal fish	Coastal bivalves	Freshwater ponds	Freshwater intensive
Strengths	Economies of scale improving as investment is made in developing appropriate technology	Relatively robust with respect to industrial input costs	Relatively robust with respect to industrial input costs	Relatively robust with respect to labour costs
Weaknesses	Generally high production costs in relation to capture-based fisheries and some other animal protein sources	High labour requirement of traditional systems	Low yields due to environmental controls and predation	Environmental limits on scale economies for flow-though systems
Opportunities	Scope for reducing production costs through improved technical performance and economies of scale	Further technology innovation could allow reductions in cost of production	Integration with leisure activities and eco-landscape services may provide new opportunities	Further development of recirculated aquaculture systems to reduce costs
Threats	High costs of transport for some production zones (Greece, Shetlands etc) Increasing cost of fuel and feed materials	Additional costs imposed through regulatory requirements	Narrow environmental agenda could raise costs for this type of aquaculture	Rising feed costs and tighter environmental regulations

Recommendations for strategies to overcome the identified limitations

The Commission has recognised the need for improved data on industry cost structures for different aquaculture production systems to better inform policy formulation. Some of this data will be challenging to collect and there are likely to be serious objections to some elements on the basis of commercial confidentiality and maintenance of competition. It is therefore essential that the Commission also indicate how the data will be usefully employed for the benefit of the industry.

5. CONCLUSIONS & RECOMMENDATIONS

5.1. Introduction

Table 18 Recommendations cross-cutting individual competition domains

Cross-cutting recommendations
Aquaculture policy should be sufficiently nuanced to promote appropriate types of industry structure in relation to meeting economic and market objectves as well as regional social and enviromental goals (e.g. issues of consolidation, size of sities, length of leases, social and enviromental resilience)
Policy and regulations need to take account of the whole market and value chain stucture, and where European competitiveness and economic result really lies (e.g. European aquaculture product occupies a smaller but higher value segment of the total fish market with greatest value from processing)
Trade regulations are the key factor shaping European aquaculture's competition with imports. A level playing field for industry subsidies, environmental controls, food safety, animal welfare and other ethical considerations would create a stronger foundation for investment and give greater transparency for informed consumer choice

As noted in the introduction, the context of competitiveness for EU aquaculture has to be recognised not just in the primary aspect of competition (within the sector and between the EU industry and external agents), but also in terms of access to primary resources, and of relationships and commercial impacts within the broader supply and value chain for aquatic foods. The report addresses fundamental strategic questions for the EU aquaculture sector:

- How effectively does the industry meet EU and other demands, and what are the factors that define its strengths and development prospects?
- Given a substantial shortfall in EU aquatic food supply, is it feasible to expand the sector, and if so, in what directions, recognising resource and other forms of competition?
- Within a much more developed supply and value chain for aquatic products (i.e. with substantial investment and internationally competitive strengths in value-added and retail sectors), what role does EU aquaculture production play, and how are future structural developments likely to affect this role?
- Within this context, what are the areas where development and policy support are likely to have the strongest and most effective impact?

In the following sections, we consider these questions using a generalised SWOT analysis and within conclusions drawn across five major competitiveness themes:

- Market orientation
- Sustainability and access to resources
- Industry structure
- Innovation and industry support
- Industry image

5.2. General SWOT analysis for European aquaculture

Whilst it is difficult to generalise across such a diverse sector as aquaculture, a number of themes occur to varying degrees in many sub-sectors. These are summarised in Table 19.

Table 19: General SWOT analysis for European Aquaculture

Factors	Strengths	Weaknesses	Opportunities	Threats
1) Legal and administrative	Harmonization at EU level creates "level playing field" and reduces costs for international business	Lack of effective national strategies in most EU states Weak or ineffectual community strategy (e.g. EU 2002) Incompatibilities between producers needs and some publically funded research programmes Bureaucracy, especially with respect to site licensing, can deter potential investors	Ensure aquaculture is firmly embedded in EU and national strategies	Risk of public budgets being preferentially focussed on management of the fisheries crisis Loose and decentralised coordination of R&D and marketing and promotion actions thus increasing the risk similar project financing, and/or inefficient use of financial resources
2) Environmental aspects	Most aquaculture practices depend on maintaining good environmental conditions so industry has incentive to be responsible Regulations to control aquaculture discharges are in place in most countries	Most aquaculture systems depend on environmental services, but regulation is often narrowly focused on pollution	Increasing demand for eco-labelled products should encourage focus by the industry. Aquaculture should be given priority within Integrated Maritime Policy	Strong environmental regulation in EU (e.g. Water Framework Directive and Nature 2000 Directive) if not matched in other regions could make EU aquaculture uncompetitive
3) Availability of production sites	Ratio of suitable sites or freshwater resources to land area or population is higher in Europe than most other continents	Availability of new sites is now heavily restricted on grounds of protecting the environment or visual seascape, or through competition with more economically attractive tourist development	Higher priority for aquaculture in emerging coastal zone planning measures to reduce conflicts and optimise use of environmental services	Consolidation and international-isation of the aquaculture sector will lead to loss of support from local stakeholders for new site applications
4) Food safety and other aspects related to consumption	Positive health image associated with seafood products and increasing concern over sustainability of capture-based fisheries	Quality of aquaculture product is frequently questioned by industry opponents	Growing collaboration between producers, market actors and NGO's on aquaculture standards	Risk of consumer confusion faced with a proliferation of labels

Factors	Strengths	Weaknesses	Opportunities	Threats
5) Animal health and welfare	Relatively strong legislation to reduce the introduction and spread of fish diseases Harmonized legislation on pharmaceutical market authorisation provides larger market to encourage development Access to diagnosis	Limited range of licensed medicines and vaccines Insufficient collation and analysis of aquatic animal disease data to allow real-time advisory or policy responses Lack of knowledge on pathogens and their transmission in new culture species	Improved health management and welfare conditions likely to boost production efficiency	Risk of diseases/ parasites in absence of effective prevention or emergency management plans
6) Third countries competition and market issues	Proximity to the worlds largest seafood market Proximity to largest market for value-added qualities Purchasing power of wholesale distribution networks	Traceability requirements not as stringent for imported products Lack of market and industry studies	Declining wild fishery resources Increasing transport costs for external producers Growth of value-added processed products	Competition from 3rd country aquaculture producers (Norway, Turkey, Vietnam) Lack of centrally coordinated transnational promotion campaigns
7) Fish oil and fishmeal availability	Advances in diet formulation is reducing the quantity of fishmeal and fish oil required per unit of production	For aquaculture, fairly high dependency on imported fishmeal and oil due to higher levels of POP contamination in European supplies Excessive use of fishmeal and fish oil in land animal husbandry	Development of alternative protein and oil sources, or improvements in utilisation likely to have positive impact of aquaculture sector economics and potentially other export opportunities Reduction of use of fishmeal and fish oil in land animal husbandry Exploitation of fishery by-catch and discards by the fish-feed industry	Rising demand for fishmeal and oil from China and other countries may increase prices as availability is limited
8) Technological issues	Technological competence at all value chain levels – notably reproduction High levels of research capacity	Narrow range of culture species Fragmented and high-risk nature of industry can deter technology developers and investors	RAS technology applications to bring production closer to markets Off-shore aquaculture to reduce environmental impacts and provide new scale economies Bio-tech applications for improved stock, nutrition and disease control	Lack of investment in research and innovation could allow other regions (e.g. US) to take technology lead

Factors	Strengths	Weaknesses	Opportunities	Threats
9) Production costs	Economies of scale improving as investment is made in developing appropriate technology	Generally high production costs (principally due to limited economies of scale) in relation to capture-based fisheries or other animal protein sources	Scope for reducing production costs through improved technical performance and economies of scale	High costs of transport for some production zones (Greece, Shetlands etc) Increasing cost of fuel and feed materials
10) Public image of aquaculture	High quality protein supply Substitutes the over exploited marine resources	Perception of negative environmental and social impact The industry is not effectively organized to respond to NGO's attacks	Create a new image of nutritional quality, health promotion, environmental care etc	Loss of customers due to the negative campaigns organized by NGOs
11) Other	Aquaculture is becoming a better recognised commercial sector, increasing possibilities for investment finance	Limited access to credit and often insurance for many SMEs due to risk factors Lack of innovation in some sub-sectors Lack of timely and updated industry and market information	Opportunities for better linking industry, research, education and policy practitioners through advances in Internet technologies	Potential impact of climate change on many production factors

Source: Based on Ernst & Young et al (2008) with additional analysis by Stirling Aquaculture

Further perspectives and analysis of SWOT by country are provided in *Framian (2009c)*. The following sections examine the major sub-sectors with the SWOT analysis being a summary combination of perception interviews carried out for this study and those reported by *Ernst and Young et al (2008)*.

5.3. Market orientation

European aquaculture producers operate in a globalised market place for aquatic food products and must compete with capture fisheries and farmed imports. Furthermore an increasing proportion of aquatic product is subject to further value-addition through processing and as a sub-sector, this may be more economically valuable to Europe than primary production, and must to taken into consideration when considering policy options for primary production. However, sustainability also demands regard for environmental issues (environmental legislation of country of origin of raw material) and societal needs of certain regions of the EU which depend on fisheries and aquaculture.

In volume terms, the major markets are for commodity products where prices are mainly set globally and products from different producers are readily interchangeable. The majority of European aquaculture falls into this category. The other major category is differentiated (or niche) products where markets recognise the uniqueness of a particular supplier (or group of suppliers) e.g. through branding and special certification. There are also numerous examples of this in aquaculture. In comparison with commodity products, volumes of niche products are expected to remain relatively small.

For commodity markets, economic forces tend to favour low-cost producers, usually achieved through scale efficiencies and industry consolidation. Niche products are best addressed by small and medium scale enterprises with specialist focus. Whilst there are opportunities for European niche producers to market product globally and achieve significant economic success, the commodity sector is much larger, especially when value-addition is taken into account.

With the exception of the salmon industry, aquaculture production is quite fragmented, but with discernable trends towards consolidation in many sub-sectors. Encouraging that consolidation will in the long-term increase the competitiveness of those sub-sectors and allow for market expansion and better availability of aquatic produce for European consumers. However, this may be at substantial social cost in many rural and coastal communities where job opportunities would be reduced and local ownership lost. Regional social policy may therefore prefer to promote niche production at the expense of volume.

There should be no fundamental contradiction in promoting both commodity production and niche production to meet different policy objectives (healthy food supplies, consumer choice, employment, environment etc). However, as far as possible competition between commodity and niche producers (e.g. over site access) should be reduced. This may be achieved though zonal planning and licensing arrangements, or more fundamentally (as discussed in the next sub-section) through new technologies or further internationalisation.

A further consideration is the existence of trade barriers and regulations that in some way distort free or fair trade. This is a complex area as the EU is accused of market protectionism by many third countries for implementing stricter hygiene standards on aquatic imports, whilst EU producers complain they have to produce to higher standards than third countries with no recognition of that in the marketplace. In addition to reviewing relevant legislation, ensuring greater transparency and public information may help.

KEY RECOMMENDATIONS – Market orientation

- Aquaculture policy should primarily draw on market analysis and incorporate support for both commodity and niche production whilst limiting direct competition between them, e.g. for space and other resources.

- Commodity aquaculture production is most compatible with objectives for improving population health, economic growth and food security. Niche aquaculture production is most compatible with regional social and community development, local enterprise and the provision of consumer choice.

- Support for individual species needs to take account of its market prospects and potential for new products through value-added processing.

- Trade regulations are a key factor in whether the European aquaculture industry can effectively compete with imports. A level playing field with respect to rules on industry subsidies, environmental controls, food safety, animal welfare and other ethical considerations would benefit the European industry, or at least greater transparency for informed consumer choice.

5.4. Sustainability and access to resources

Society is increasingly concerned about the impacts of production activities on the environment and implications for global warming and biodiversity. There is also growing concern about primary resource constraints, notably fuel, freshwater, and in the case of aquaculture, fishmeal and oil. Policymakers are responding by increasing restrictions on activities that impact on the environment or have high demands on limited resources. This clearly includes aquaculture, which in most forms, relies to a large extent on environmental supplies and services.

More scientific work is needed to help define the degree of aquaculture activities that are sustainable in any given area, particularly when there are mixed activities that may have synergy. However, any substantial increase in aquaculture production must address the issue of its demand on natural and environmental resources. Options include:

- More efficient use of existing resources, e.g. through integrated multi-trophic aquaculture[21] etc.
- Development of new and economically viable technologies with reduced direct environmental impacts and enhanced utilisation of resources, e.g. through offshore aquaculture, recirculated aquaculture and perhaps biological advances using GM etc.)
- Sustainable exploitation of currently underutilized inland and coastal natural resources, most likely in Africa and South America

In the present economic and regulatory climate, investment in lower-cost third countries for import to European markets appears the most likely prospect for volume production. However, the long-term environmental, economic and political implications for this should be considered.

The reliance of some sub-sectors of aquaculture on finite supplies of fishmeal and fish oil from the capture fishery as a primary feed input places a significant limit on future growth. The industry has already made substantial progress in optimising the use of these ingredients, but further work is needed, particularly as competition for these supplies may emerge as marine aquaculture develops more strongly in Asia and the Americas.

KEY RECOMMENDATIONS – Sustainability and access to resources

- Greater scientific work is needed to optimise the use of natural and environmental resources by aquaculture and hence allow an increased output with reduced impact.

- Substantial increases in aquatic food production will require either the exploitation of new areas, mainly in third countries who then export to European markets, or further development of new technologies to the point where they are economically viable and can compete with third country imports.

- Further work to develop feed technologies that reduce reliance on industrial fisheries is a high priority.

[21] The farming of several species at one site, where the second species (e.g. algae), 'mops up' nutrients in the seawater arising from the primary culture (e.g. salmon).

5.5. Industry structure

As a whole, the aquaculture sector is highly fragmented, but this varies substantially between sub-sectors, with salmon being the most consolidated. Whilst it is undesirable to eliminate competition, consolidation has many advantages. Larger companies are able to achieve greater economies of scale and efficiencies of product distribution which benefits consumers. Arguably, higher production standards (with respect to health and safety, fish welfare and environmental controls) can be more easily implemented by larger companies with corporate structures. A fragmented industry supplying commodity products results in high internal competition, poor profitability and greater likelihood of costs being cut in areas of health and safety and respect for environmental impacts etc.

Consolidation implies horizontal and often vertical integration. Both introduce greater robustness into the business, horizontal integration by spreading risk and overhead costs, and vertical integration by reducing the impact of cost changes at individual points in the production and market chain, elimination of contribution to third party profits, and usually further reductions in overhead costs.

Large corporations with high labour productivity, whilst good for wider society, are less able to meet the needs of local communities for varied local employment and local stewardship of resources. This has a better fit with small and micro-enterprises (or part-time crafting activities). As indicated earlier, promotion of both types of structure is possible, and is probably best achieved by focusing on different market segments (commodity and niche). In some circumstances, production and market chains that are not vertically integrated can be more efficient. This is particularly the case where high degrees of expertise and specialist facilities are required and where the cost of these would be disproportionate in relation to the other activities of the company, or where greater business agility is required. This may be the case with selective breeding programmes and specialist feed suppliers.

As the industry is structured at present, it is widely believed that the EU aquaculture industry has reached a critical point due to the increased 'buying power' of the wholesalers and large retailers. Producers have been pushed into a vicious circle of competing with each other, primarily through damaging price competition, whilst the many cost reductions have not been passed on to the final consumer, mainly serving to increase the profits for the retailers. Many producers therefore believe that the only way for producers to be able to defend their position, and for the industry to remain economically viable in the long run, is through effective and efficient Producer Organisation (PO) schemes. These appear as options that could impose effective governance on production planning and control – moving to improve the balance of supply with demand. Such POs would need to be more collective and with a much wider geographic coverage than was initially envisaged under the legislation in force (*min 25% of the production of a given area, according to Art.1, Par.5.of Reg (EC) 2318/2001*). In practice, companies, or groups of companies, from different geographic regions produce the same product and target the same buyers, both at national and international level. In this respect the notion of 'regionality' can no longer be applied in the same sense as in the capture-fishing industry (landing ports) nor as it was initially intended for the aquaculture industry.

The objective of POs should not only be to organise and stabilise production, but also to concentrate the offer in fewer hands. This is necessary so as to match the concentration of the buying capacity of retailers. Thus, aquaculture PO's need to be representative of the industry at a regional or national level so as to effectively fulfil the objectives set out in Article 5, Par.1 of Reg (EC) 104/2000. Practically this means that a PO should account for at least 50% of the production at national level or significantly higher if recognition is to be granted at a regional level. Similarly, the concept of *Extension of Rules* could be further supported and be put in place practically for non-members who produced in the same area of the PO (as the target market is in all cases the same). More specifically it is recommended that *Extension of Rules* to non members (producers of the same area of the PO) should be automatically obligatory if the respective PO has more than 2/3 of the production of the area, and at the discretion of the Member State's Competent Authority if the PO accounts between 51% to 66% of the area's production.

Given the pan-European nature of the market for many of the products of European aquaculture, the concept of Associations of POs – acting to reduce the fragmentation that is typical within the sector – should be encouraged and their creation supported by financial assistance, in a similar manner to that foreseen for National/Regional POs. Revisions to the Common Market Organisation (CMO) for fishery and aquaculture products should be aimed at helping to stabilise the market and supporting EU production.

KEY RECOMMENDATIONS – Industry structure

- Consolidated and vertically integrated companies are most efficient for the supply of commodity aquaculture produce for the needs of society so the processes of consolidation should not be unduly impeded providing competition is maintained.
- Small and micro enterprises are best for delivering local and community objectives for employment, self-sufficiency and stewardship of local resources and should be supported in areas of low-population or otherwise fragile social and economic conditions.
- Aquaculture policy should be sufficiently nuanced to promote appropriate types of industry structure in relation to meeting economic and market objectives as well as regional social and environmental goals.
- The new common market organisation (CMO) should constitute, through revision of the structures and mechanisms described, a framework that supports stability and good governance – notably for planning, growth and control - within the professional European aquaculture sector.

5.6. Innovation and industry support

Aquaculture producers are in the main, the marketplace for sector technical innovation, which is directly provided by sector suppliers with the support of research organisations. A primary consideration is therefore an assessment of the market demand from producers for innovation. In many sub-sectors this may be perceived as low. At a small scale, aquaculture activities are often as much of a lifestyle and location choice, rather than an entrepreneurial activity. Participants in this sector often have high regard for traditional methods of production and relatively low desire for radical innovation, unless it also enables them to maintain valued elements whilst improving other aspects. They also usually have very limited means to invest in new equipment and systems. Policies and support measures which aim to stimulate sector growth by directly targeting such producers with the expectation that they will be a source of innovation are rarely successful. Medium and large-scale companies that are more business focused provide the main market for technology innovation. This can vary from company to company, but the most entrepreneurial will be continually seeking ways to improve their competitiveness and exploit new market opportunities. It is mainly from dialogues between these companies in technology suppliers that problems are identified, which the suppliers then address through new products and services. Policies and measures which support this kind of bottom-up innovation and which foster close links between producers, technology suppliers and supporting research organisations are most effective in facilitating incremental innovation.

Radical innovation most often comes from outside the existing producer base. This is probably partly due to the different characteristics of highly entrepreneurial people and those who run successful established companies. It may also be that radical innovation upsets existing business models and therefore would not be perceived as in the interests of the established companies. Radical innovation is normally high-risk, but often supported through state aid and more easily attracts venture capital finance. Policies on innovation support should therefore ensure space for entrepreneurial entrants to the sector along side that of internal sector innovation.

Interviews with the production sector demonstrated a generally low priority for innovation, and little recognition that innovation is central to competitiveness. Greater support for lifelong learning which fosters better understanding of sector dynamics as well as technical issues may help to change this.

State aid is currently most universally available to the aquaculture sector through the European Fisheries Fund (EFF) (and some support for innovation through 7th Framework RTD programme). Support may also be available through other targeted structural funds and national business support measures. The EFF is a substantial revision of the previous FIFG (Financial Instrument for Fisheries Guidance) scheme, but will require timely evaluation and periodic adjustment to meet policy objectives. Whilst there are inevitable complaints about the funding schemes and their limitations in both scope and resources, a more significant constraint may be a shortage of private and bank finance for aquaculture development and particularly innovation. Much of this may be due to the patchy business record of the majority of small and medium enterprise companies operating in volatile markets, which has given the sector a high risk rating. Additionally, new entrants frequently underestimate the technical problems that they will face and do not reach production targets on time. Insurance is often only available (at realistic cost) after some production record is established. Greater availability of sector performance information would assist investors to make more realistic projections and financial institutions to better evaluate specific company prospects

KEY RECOMMENDATIONS – Innovation and industry support

- The importance of innovation appears to be underestimated by many in the aquaculture sector, so stimulus measures, including support for lifelong learning are recommended.
- Support for innovation should be separately targeted for (1) incremental technological development in existing growing sectors with strong links between producers, technology suppliers and research organisations and (2) new industry entrants with more radical technological innovations. Attention should be given to avoid funding innovation projects that aggravate problems of industry fragmentation.
- Much of the industry has very limited scope for investment in innovation and especially R&D, indeed access to finance for basic investment and working capital are often difficult to obtain. The role of EU structural and framework RTD programmes funding is very important, but more detailed information about industry performance would enable both public and private financial organisations to better judge loan and investment decisions.
- Timely evaluation and periodic adjustment of the EFF in order to meet policy objectives.

5.7. Industry image

Communication is an important challenge for aquaculture. It needs to convey its message to the consumers to be able to compete with fisheries products. There is a major opportunity to educate the consumer, the community and the general public as to the health, community development and sustainability benefits of aquaculture. Aquaculture should be looked at with enough perspective and compared to other animal producing industries to realize the enormous positive influence and the relatively low environmental or social cost it has had. The learning curve has been and still is so fast that the inevitable negative consequences have been minimized. The experience of the past 20 years has shown that aquaculture serves as a vital tool for fisheries management and as a viable and sustainable industry.

In terms of promoting aquaculture products the industry will naturally wish to communicate messages such they are good to eat, easy to prepare, healthy, good value and environmentally and ethically sustainable. However, the industry would benefit from institutional support to counteract some of the misinformation from campaign groups and help with further sector innovation. This could be done through better publicised scientific research on three key topics.

The first of these would target the health benefits and product quality. It would require further research on understanding species nutritional diversity, optimizing the nutritional content of aquaculture products, products targeted to segments perceived to benefit the most (e.g. children or elderly), evaluation of health effect of seafood intake against nutritional supplements or further documentation on the benefits for diseases of particular interest in Europe such as Alzheimer disease.

The second would target the identification and proper description of the hazards, including a risk assessment of residues and epidemiological studies on antimicrobial resistance due to drug use in aquaculture. A proactive attitude to deeply evaluate the hazards would allow counteracting NGOs falsehood and generalizations, overturning prejudices and raising confidence in European aquaculture.

The third line of research and communication should address the quality of the aquaculture products compared with fishery products, its main competitor and the perception of food safety. This would require research on the organoleptic properties of the different products, consumer sensory studies and the development of new products based on farmed products.

KEY RECOMMENDATIONS – Industry image

- The image of aquaculture has been degraded by irresponsibility both within some parts of the industry and on the part of anti-aquaculture campaign groups. It has been further undermined by the promotion of sustainably caught capture fisheries in opposition to responsibly farmed product.

- The industry needs to focus on meeting the wants and needs of consumers and ensuring that their products meet expectations.

- Governments and other institutions should support research that helps to address questions about human health benefits and risks associated with farmed seafood consumption and actual environmental impacts and welfare effects.

REFERENCES

- Aandahl, P. T. 2007. Steady rise in volume and value. Article in Fish Farming Xpert No.1 pp56. www.fishfarmingxpert.com
- Aksoy, M.A., Beghin, J.C. 2005 Global agricultural trade and developing countries, World Bank Publications, 329pp.
- Berglund, N. 2009 Seafood exports climb to new record, Views and News from Norway; Business news in brief, Oct 5th 2009 http://newsinenglish.no/News/businessbriefs.html.
- Catarci, C. 2008 Salmon Market Report - EU. February 2008. FAO Globefish http://www.thefishsite.com/articles/399/salmon-market-report-eu-february-2008.
- Chapman, A 2005 Michael Porter's Five Forces of Competitive Position Model. www.businessballs.com
- Courtney Hough, General Secretary, Federation of European Aquaculture Producers (FEAP). http://www.fhl.no/getfile.php/DOKUMENTER/No%205%20-%20Courtney%20Hough%20-%20EU%20Aquaculture%20Policy.pdf
- Davila A, Epstein MJ, & Shelton R (2006) Making innovation work: How to manage it, measure it, and profit from it. Wharton School Publishing, New Jersey.
- Del-Polo Gonzalez, J (2009) A study of the aetiology and control of rainbow trout gastroenteritis. PhD thesis, University of Stirling. http://hdl.handle.net/1893/1081.
- Deniz H (2009) Support to the GFCM working group on Marketing on Aquaculture Products: Development of a strategy for marketing and promotion of Mediterranenean aquaculture. National Aquaculture market report for Turkey. GFCM – CAQ.
- Earnst_&_Young, AND_I, Eurofish, & Indemar. (2008). Etude des performances économiques et de la compétitivité de l'aquaculture de l'Union Européenne. Young (pp. 1-198). Brussels: European Commission DG MARE. http://ec.europa.eu/fisheries/publications/studies/aquaculture_2008_fr.pdf
- EC 2003 Commission Regulation No 1670/2003 of 1 September 2003 implementing Council Regulation (EC, Euratom) No 58/97 with regard to the definitions of characteristics for structural business statistics and amending Regulation (EC) No 2700/98 concerning the definitions of characteristics for structural business statistics. http://www.legaltext.ee/text/en/U71184.htm
- EC 2006 Enlargement Screening reports Turkey, Chapter 13 Fisheries agenda item 7: State Aid, Country session: the republic of Turkey 31 march 2006 http://www.abgs.gov.tr/tarama/tarama_files/13/SC13DET_State%20aid%20in%20fisheries.pdf
- EC 2008 Commission Regulation No *762/2008* of the European Parliament and of the Council of 9 July 2008 on the submission by Member States of statistics on aquaculture and repealing Council Regulation (EC) No 788/96. http://eur-lex.europa.eu/JOHtml.do?uri=OJ:L:2008:218:SOM:en:HTML
- EC 2009 Commission Regulation (EC) No 710/2009 of 5 August 2009 amending Regulation (EC) No 889/2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007, as regards laying down detailed rules on organic aquaculture animal and seaweed production. Official Journal of the European Union, L204, Vol 52, 6 Aug. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:204:0015:0034:EN:PDF
- EC 2009b European Parliament legislative resolution of 2 April 2009 on the proposal for a regulation of the European Parliament and of the Council on a Community Ecolabel scheme (COM(2008)0401 – C6-0279/2008 – 2008/0152(COD)). http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P6-TA-2009-0209+0+DOC+XML+V0//EN

- Ernst & Young, ANDI-COGEA & Eurofish (2008) Évaluation de l'Organisation Commune de Marché des produits de la pêche et de l'aquaculture. Report for the European Commission. http://ec.europa.eu/fisheries/publications/studies/evaluation_markets_report_fr.pdf
- Ernst & Young, ANDI-COGEA & Eurofish (2008) Evaluation of the Common Organisation of the Markets in Fishery and Aquaculture Products. Executive Summary. EC Directorate-General for Maritime Affairs and Fisheries (DG MARE) http://ec.europa.eu/fisheries/publications/studies/evaluation_markets_summary_en.pdf
- Estevadeordal, A. and K. Suominen, 2004, Rules of Origin in FTAs in Europe and in the Americas: Issues and Implications for the EUMercosur Inter-Regional Association Agreement, Washington DC: Inter-American Development Bank, INTAL-ITD Working paper No. 15.
- European Commission (2003) Communication from the Commission to the European Parliament and the Council: Some Key Issues in Europe's Competitiveness – Towards and Integrated Approach. COM(2003) 704 final, Brussels. http://ec.europa.eu/enterprise/enterprise_policy/industry/doc/com704_en.pdf
- European Commission (2003) Communication from the Commission to the Spring European Council: Integrated guidelines for growth and jobs (2008-2010). COM(2007) 803 final, Part V, Brussels. http://ec.europa.eu/growthandjobs/pdf/european-dimension-200712-annual-progress-report/200712-annual-report-integrated-guidelines_en.pdf
- European Commission (2007) Communication from the Commission to the European Council: Strategic report on the renewed Lisbon strategy for growth and jobs: launching the new cycle (2008–2010) Keeping up the pace of change Part I (COM(2007) 803 final.
- European Commission (2008) Report on Competition Policy 2007. Office for Official Publications of the European Communities, Luxembourg. DOI 10.2763/9849 http://ec.europa.eu/competition/annual_reports/2007/en.pdf
- European Commission (2009) Communication from the Commission to the European Parliament and the Council: Building a sustainable future for aquaculture. A new impetus for the Strategy for the Sustainable Development of European Aquaculture. COM(2009) 162 Final, Brussels.
- Evans A (2009) The Feeding of the Nine Billion: Global Food Security for the 21st Century. Chatham House (Royal Institute of International Affairs) London, 61pp. http://www.cic.nyu.edu/Lead%20Page%20PDF/Evans_food.pdf
- FAO (2008) The State of World Fisheries and Aquaculture 2008. Food and Agriculture Organisation, United Nations, Rome, 196pp. http://www.fao.org/docrep/011/i0250e/i0250e00.htm
- FAO (2009). Fishstat Plus Database. Aquaculture production 1950-2007. Food and Agriculture Organisation of the United Nations. http://www.fao.org/fishery/statistics/software/fishstat/en
- FAO 2009 Subsidies in Fisheries, Fisheries and Aquaculture Department of the FAO http://www.fao.org/fishery/topic/13333/en
- FEAP (2008) Production and price reports of member associations of the F.E.A.P. 2001-2008. Federation of European Aquaculture Producers. http://www.aquamedia.org/production/euproduction/productionreport_en.asp
- FEAP 2009 EU Aquaculture Policy Where are we and where are we heading?
- Feenstra, J.F. 1998 Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies United Nations Environment Programme. http://hdl.handle.net/1871/10440
- Ferguson, H. W., Girons, A., Rizgalla, G., LaPatra, S., Branson, E. J., MacKenzie, K., et al. (2006). Strawberry disease in rainbow trout in Scotland: pathology and association with Flavobacterium psychrophilum. The Veterinary record, 158(18), 630-2. http://veterinaryrecord.bvapublications.com/cgi/reprint/158/18/630

- Food safety, human health and quality. 3rd EATIP Stakeholders' Meeting- Ghent February 3rd February 2009.
- Framian BV (2009a) Definition of data collection needs for aquaculture, Vol 1: Review of the EU aquaculture sector and results of costs and earnings survey. Final Report for the European Commission, Ref: FISH/2006/15-Lot 6. http://ec.europa.eu/fisheries/publications/studies/aquadata_part1_en.pdf
- Framian BV (2009b) Definition of data collection needs for aquaculture, Vol 2: Feasibility assessment of an on-going data collection scheme for aquaculture. Final Report for the European Commission, Ref: FISH/2006/15-Lot 6. http://ec.europa.eu/fisheries/publications/studies/aquadata_part2_en.pdf
- Framian BV (2009c) Definition of data collection needs for aquaculture, Vol 3: Annexes. Final Report for the European Commission, Ref: FISH/2006/15-Lot 6. http://ec.europa.eu/fisheries/publications/studies/aquadata_part3_en.pdf
- Frankic, A., Hershner, C., 2003 Sustainable aquaculture: developing the promise of aquaculture Aquaculture International 11: 517–530.
- FRS 2008 Scottish Fish Farms Annual Production Survey, 2007, Fisheries Research Service http://www.marlab.ac.uk/FRS.Web/Uploads/Documents/surveytext2007final.pdf
- Globefish (2009) Sea bass and sea bream market report – June 2009. http://www.globefish.org/dynamisk.php4?id=4737
- Globefish 2005 Organic Aquaculture in the European Union Current Status and Prospects for the Future Note of Thematic Conference, Brussels, 12/13 December 2005. http://www.globefish.org/files/Meeting%20note%20Bruxelles%20GB-001_308.pdf
- Globefish 2009 UK Organic Aquaculture Market Report 2009. http://www.thefishsite.com/articles/674/uk-organic-aquaculture-market-report-2009
- Graham, D. A., Jewhurst, H. L., Mcloughlin, M. F., Branson, E. J., Mckenzie, K., Rowley, H. M., et al. (2007). Serological, virological and histopathological study of an outbreak of sleeping disease in farmed rainbow trout Oncorhynchus mykiss. Diseases Of Aquatic Organisms, 74, 191-197. doi: 10.3354/dao074191.
- Grave, K., Hansen, M.K., Kruse, H., Bangen, M., Kristoffersen, A.B. 2008 Prescription of antimicrobial drugs in Norwegian aquaculture with an emphasis on "new" fish species Preventative Veterinary Medicine, 83,2, 156-169.
- Holmyard, J. 2008 Potential for Offshore Mussel Culture. Offshore Shellfish Ltd. Published in Shellfish News 25 Spring Summer http://www.thefishsite.com/articles/466/potential-for-offshore-mussel-culture.
- http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0162:FIN:EN:PDF.
- IEEP 2002 Subsidies to the European union fisheries sector Paper commissioned by WWF European Fisheries Campaign. Institute for European Environmental Policy (IEEP) http://assets.panda.org/downloads/subsidiesreport.pdf
- Intrafish 2007 FAO Fisheries Circular No. 1016: Tariffs in World Seafood Trade Seafood Trade Report Dec 2007 Intrafishhttp://www.intrafish.no/multimedia/archive/00021/pdf20071225_21717a.pdf
- IUCN 2009 Guide for the Sustainable Development of Mediterranean Aquaculture 2. Aquaculture site selection and site management, IUCN, Gland, Switzerland and Malaga, Spain. VIII + 303 pages. http://www.iucn.org/about/union/secretariat/offices/iucnmed/?4026/Aquaculture-site-selection-and-site-management
- Jackson, A. 2007 Challenges and opportunities for the fishmeal and fish oil industry. Feed Technology Update, 2 (1) 9pp.

- Johansen R., Bornø R., Olsen A.B., Ørpetveit I., Hansen H., Garseth A.H., Hjeltnes B., 2009. "The health situation in farmed salmonids in 2008". In "The health situation in Norwegian aquaculture 2008"; *Annual report from the National Veterinary Institute of Norway. PO Box 750 Sentrum · N-0106 Oslo, Norway. P 3-20.*
- Kaiser, M., Stead, S.M., 2004 Uncertainties and values in European aquaculture: communication, management and policy issues in times of "changing public perceptions" Aquaculture International 10: 469–490.
- Katavic, I.*, Herstad, T-J, Skakelja, N, Kryvi, H., White, P.,Franicevic., V. 2005 Integrated coastal zone management for croatia with particular focus on marine aquacultureMinistry of Agriculture, Forestry and Water Management (MAFWM) Ul. Grada Vukovara 78, P.P. 1034, 10000 Zagreb, Croatia. ivan.katavic@mps.hr
- Kontali 2008 Atlantic salmon market fundamentals presentation. http://www.fishpool.eu/docs/Presentation_Salmon_Markets.pdf
- Melchior, A. 2005 The Fishy Story About Tariffs in World Seafood Trade, 29 November 2005. Paper written for FAO (Food and Agriculture Organization of the United Nations). http://www.bing.com/search?q=Melchior+2005+tariff&src=IE-SearchBox
- Mendrinos, A & Bostock J (2009) Study of the competition in Scottish salmon and Greek sea bass and sea bream industries. MSc thesis, University of Stirling.
- Millstone, E., Lang, T. 2008 The atlas of food; who eats what, where and why Earthscan Publications.
- MRAG & DFID (2008) Fisheries and International Trade. Policy Brief 7. Marine Resources Assessment Group and NRI for the UK Department for International Development. 4pp. http://www.mrag.co.uk/Documents/PolicyBrief7_International_Trade.pdf
- MRDDRI 2009 Profit Sharing from Vietnamese Seafood Exoprts. Mekong River Delta Development Research Institute and Can Tho University. Unpublished report.
- Naylor R.L, Goldburg R.J, Primavera J.H, Kautsky N, Beveridge M.C.M, Clay J, Folke C, Lubchenco J, Mooney H and Troell M. Effect of aquaculture on world fish supplies, Nature 405 (2000), pp. 1017–1024.
- Nazmul Alam, S.M., Pokrant, B. 2009 Re-organising the shrimp supply chain: Aftermath of the 1997 European Union import ban on the Bangladesh shrimp. Aquaculture Economics and Management, 13:53-69.
- OECD/FAO (2009) OECD-FAO Agricultural Outlook 2009-2018. 95pp. http://www.agri-outlook.org/dataoecd/2/31/43040036.pdf
- Olsen, K. 2008 Price cycles can be avoided. Intrafish, Feb 12 2008 http://www.intrafish.no/global/news/article162899.ece
- Papageorgiou P (2009) Support to the GFCM working group on Marketing on Aquaculture Products: Development of a strategy for marketing and promotion of Mediterranenean aquaculture. National Aquaculture market report for Greece. GFCM – CAQ.
- Paquotte, P 2009 The place of pangasius in the European seafood market ACFA Working Group Aquaculture – 3 June 2009. DG Maritime affairs and fisheries http://ec.europa.eu/fisheries/dialog/acfa030609_annex1_en.pdf
- Péridy, N., Guillotreau, P. 2000 Trade barriers and European imports of seafood products: a quantitative assessment*1 Marine Policy Volume 24, Issue 5, September 2000, Pages 431-437.
- Porter, M.E. (1980) Competitive Strategy, Free Press, New York, 1980.
- Prusa, Thomas J.,Anti-dumping: A Growing Problem in International Trade. The World Economy, Vol. 28, No. 5, pp. 683-700, May 2005.

- Richards R (2006) Current Disease Issues. Presentation given at the 10th Aquaculture Insurance and Risk Management Conference, Vigo, Spain, 6-7 April 2006. http://conference2006.aquacultureinsurance.com/imgCache/06pdf/Randolph_Richards.pdf
- Rigby, M. 2009 Off-shore aquaculture presentation CEFAS sustainable aquaculture workshop, Weymouth 13-14 Oct 2009 http://www.slideshare.net/Cefas/presentations
- Schnick RA (1996) Cooperative Fish Therapeutic Funding Initiative: States in partnership with federal agencies to ensure the future of public fish culture. Transactions of the North American Wildlife and Natural Resources Conference. pp. 553-55 NAL Call No. 412.9 N814
- Soil Association 2009 Soil Association Organic Market Report 2009, The Soil Association. http://www.soilassociation.org/Businesses/Marketinformation/tabid/116/Default.aspx
- Stromsta, K. 2008 Does farmed salmon have an eco-label problem. Intrafish, 1 Oct 2008. http://www.intrafish.no/global/news/article229285.ece
- Tacon, G.J., Metian, M. 2008 Global overview on the use of fishmeal and fish oil in industrially compounded aquafeeds: Trends and future prospects, Aquaculture 285, 146-158.
- Telfer TC, Atkin H & Corner RA. (2008) EIA and monitoring in aquaculture – Regional case study for Europe and North America. FAO Technical Workshop on Environmental Impact Assessment and Monitoring in Aquaculture, 15-17 September 2008. (in press).
- The EU and Global Trade: http://ec.europa.eu/trade/issues/global/index_en.htm
- The Fish Site 2009 UK Organic Aquaculture Market Report 2009, The Fish Site http://www.thefishsite.com/articles/674/uk-organic-aquaculture-market-report-2009
- Valdez, S. 2000 An introduction to global financial markets (3rd ed.). Basingstoke, Hampshire: Macmillan Press. ISBN 0333764471
- Verner-Jeffreys, D., Pond, M., Peeler, E., Rimmer, G., Oidtmann, B., Way, K., et al. (2008). Emergence of cold water strawberry disease of rainbow trout Oncorynchus mykiss in England and Wales: outbreak investigations and transmission studies. Diseases of Aquatic Organisms, 79, 207-218. doi: 10.3354/dao01916.
- VietNamNet 2009 Tra fish crisis watch VietNamNet Bridge 18/09/2009 http://english.vietnamnet.vn/biz/2009/09/869274/
- Vukasovic T (2008) World poultry market faces accelerated change. Agri-& HortiWorld. http://www.agriworld.nl/public/file/pdf/20090330-18_ppm_world.pdf
- Ward, T., Phillips, B. 2008 Seafood ecolabelling, principles and practice. Blackwell Publishing limited.
- WEF GCI 2009 The Global Competitiveness Report 2009-2010 http://www.weforum.org/en/initiatives/gcp/Global%20Competitiveness%20Report/index.htm
- Wijnands JHM, Van der Meulen BMJ and Poppe KJ (eds) (2007) Competitiveness of the European food industry: An economic and legal assessment. European Commission, DG Enterprise and Industry. Reference No. ENTR/05/75 Project Number 30777 Service contract 432403, The Hague.
- Zanardi, M. (2004). Antidumping laws as a collusive device. Canadian Journal of Economics, 37 (1), 95-122.

ANNEX 1: INDUSTRY STRUCTURE STATISTICS

Table 20: Top ten Salmon companies by region and production volumes in 2006 ('000s tons - wfe)

Norway	Vol.	Chile	Vol.	UK	Vol.	Canada	Vol.
Marine Harvest	155	Marine Harvest	99	Marine Harvest	67	Marine Harvest	38
Leroy Seafood	60	Aquachile	52	Scottish Seafarms	23	Cooke Aqua	35
Salmar (Senja)	38	Camanchaca	36	Hjatland Seafarms	13	Mainstream	30
Nordlaks Hlg	30	Salmones Mainstream	28	Marine Seafarms	10	Grieg Seafood BC	4
Nova Sea	21	Salmones Multi-export	26	Mainstream	8	Target	4
Mainstream	17	Pesquera Los Floridos	19				
Grieg Seafood	17	Cultivos Marinos Chiloe	15				
Sjotroll	14	Invertec pesquera	14				
Veststar	13	Yadran	13				
Alsaker	13	Pesca Chile	13				
Total Top 10	**377**		**314**		**121**		**110**
Others	220		54		7		5
Grand Total	**597**		**368**		**128**		**115**
Top 10 share	**63%**		**85%**		**95%**		**95%**
MH Share	**26%**		**27%**		**53%**		**33%**

Note: The top 5 companies globally, in order of 2006 production volumes are ('000s tons wfe - in parentheses:): Marine Harvest (292), Salmar and Leroy inc.. jointly owned Scottish Seafarms (121) Main stream (83), Aquachile (52), Nordlaks Holdings (30).

Table 21: Principal aquaculture companies by country

Ref. No.	Name(s)	Region	Country	Species
1	Przedsiebiorstwo	CEE	Poland	Carps
2	KCJ Hodowli	CEE	Poland	Carps
3	Slodkowwodnych	CEE	Poland	Carps
4	Gospodastwo	CEE	Poland	Carps
5	Rybartsvi Trebon	CEE	Czech Republic	Carps
6	R. Kardasova	CEE	Czech Republic	Carps
7	Recice	CEE	Czech Republic	Carps
8	R. Hluboka	CEE	Czech Republic	Carps
9	Szegedfish	CEE	Hungary	Carps
10	Hortobagy	CEE	Hungary	Carps
11	Togazda	CEE	Hungary	Carps
12	Szarvafish	CEE	Hungary	Catfish
13	Forus	CEE	Hungary	Sturgeon
14	Pescoliv	CEE	Romania	Carps
15	Rompescaris	CEE	Romania	Carps
16	Eurofish SRL	CEE	Romania	Carps
17	Blapis SA	CEE	Romania	Trout
18	Tinamenore	MED	Spain	Sea bass
19	Culmarex	MED	Spain	Sea bass
20	Cupimar	MED	Spain	Sea bass
21	Niordseas	MED	Spain	Sea bass
22	Piszolla	MED	Spain	Trout
23	Isidro Cal. Grp Tresmares	MED	Spain	Trout
24	Stolt sea farm	MED	Spain	Turbot
25	Pescanova	MED	Spain	Turbot
26	Thaeron	MED	France	Oysters
27	Cadoret	MED	France	Oysters
28	Medithau Maree	MED	France	Oysters
29	AquaNord	MED	France	Sea bass
30	Aquavar	MED	France	Sea bass
31	Cannes Aqua	MED	France	Sea bass
32	Campomoro	MED	France	Sea bass
33	Acqua Azzurra	MED	Italy	Bass/Bream
34	Coopam	MED	Italy	Bass/Bream
35	Medfish	MED	Italy	Bass/Bream
36	AIT	MED	Italy	Bass/Bream
37	Copego	MED	Italy	Clams
38	Scardovari	MED	Italy	Clams
39	Agro Ittica Lombarda	MED	Italy	Sturgeon
40	Nireus	MED	Greece	Bass/Bream
41	Selonda	MED	Greece	Bass/Bream
42	Andromeda	MED	Greece	Bass/Bream
43	Dias	MED	Greece	Bass/Bream
44	Hellenic	MED	Greece	Bass/Bream
45	Diomudis	MED	Greece	Mussels

Ref. No.	Name(s)	Region	Country	Species
46	Marine Harvest	NE	UK	Salmon
47	Scottish Seafarms	NE	UK	Salmon
48	Grieg Hjatland UK	NE	UK	Salmon
49	Mainstream UK	NE	UK	Salmon
50	Lakeland Marine	NE	UK	Salmon
51	Lighthouse	NE	UK	Salmon
52	Dawnfresh	NE	UK	Trout/mussels
53	Scottish Shellfish Marketing Grp	NE	UK	Mussels
54	Marine Harvest	NE	Ireland	Salmon
55	Irish Salmon Producers Grp (ISPG)	NE	Ireland	Salmon
56	Irish Shellfish Growers Assoc (ISGA)	NE		Mussels/Oysters
57	FISHION	NE	Holland	Tilapia/catfish
58	Nijvis	NE	Holland	Eels
59	Dingemans	NE	Holland	Mussels
60	Kongeaens Damburg	NE	Denmark	FW Trout
61	Aquapri	NE	Denmark	FW&SW Trout
62	Ejstrupholm			
63	Musholm Lax	NE	Denmark	SW Trout
64	Hjarne Havbrug	NE	Denmark	SW Trout
65	Royal Danish Seafood	NE	Denmark	Eels
66	Peitzer	NE	Germany	Carp
67	Westerwalder	NE	Germany	Carp
68	Fischzucht Stahler	NE	Germany	Carp
69	Abel	NE	Germany	Trout/ Eels
70	Hofer	NE	Germany	Trout
71	Herman Rameil	NE	Germany	Trout
72	Emsland	NE	Germany	Eels
73	Alands Fiskforadling	NE	Finland	Trout/Powan
74	Brando Lax	NE	Finland	Trout/Powan
75	Savon Taimen	NE	Finland	Trout
76	Euro-forell	NE	Finland	Powan
77	Arvokala	NE	Finland	Trout/Artic Charr
78	Carelian Caviar	NE	Finland	Sturgeon

Source: Ernst and Young 2008, FAO Aquamedia

Table 22: Industry structure by country and species (countries producing >10,000mt of aquaculture products per year)

			Consolidation					Main companies	
	Region / country	Species	No companies	2006/7 Vol (mt)	% Volume top 3	Vertical integration	Production system(s)	Company Ref.[22]	Mean Production (mt)
	Central & Eastern Europe CEE								
1	Poland	Carps	300	15,500	Very low	Low	Extensive ponds	1,2,3,4	
		Trout	160	17,000	Low	Med-high	Ponds		
2	Czech republic	Carps	78	16,019	37	Leaders med	Ponds	5,6,7,8	1,964
		Trout	15-20	1,362	70	Leaders med	Ponds		
3	Hungary	Carps	220-230	13,878	28	Low	Trad. polycultures; 80% live sale	9,10,11	1,317
		Catfish	5	1,911	>70	High	RAS	12	1,400
		Trout	3-4	42	High	High	Ponds		
		Sturgeon	2	22	High	High	RAS	13	
		Ornamentals	2	na	High	na	Ponds		
4	Romania	Carps	400	9,938	12	Low	Extensive ponds	14,15,16	397
		Trout		855	Low		Ponds	17	130
	Mediterranean (MED)								
1	Spain	Bass	100	18,000	57	High	Sea-cages	18,19,20,21	3,050
		Trout	120	25,000	47	Leaders high	Intensive ponds	22,23	3,900
		Mussels		300,000	Low	Low	Mainly rafts		
		Turbot	23	6,000	>82	High	Tank-based flow-through and RAS	24,25	2,450
2	France	Oysters	3,400	127,000	Low	Low	Mainly small family coastal farms	26,27,28	(€12mill)
		Trout	400	32,000	40	Low-med	Ponds		
		Bass	13	3,900	64	Low	Sea-cages	29,30,31,32	725
3	Italy	Bass	<50	9,300	23	Med	Sea-cages, some land flow-through	33,34,35,36	5300
		Bream		9,500					
		Clams	>150 coops	54,700	35	Leaders med	Coastal flats (75%)	37,38	4,800
		Sturgeon	4	27	99	High	RAS	39	24

[22] See Table 21.

			Consolidation					Main companies	
	Region / country	**Species**	**No companies**	**2006/7 Vol (mt)**	**% Volume top 3**	**Vertical integration**	**Production system(s)**	**Company Ref.[22]**	**Mean Production (mt)**
		(caviar)							
4	Greece	Bass/ Bream	120	120,000	50 (hatcheries=75)	Leaders high	Sea-cages	40,41,42,43,44	20,000
		Mussels	500	28,000	>70	Leader only	Mainly rafts	45	19,600
	Northern Europe (NE)								
1	UK	Salmon	50	132,000	50	High	FW & Sea-cages	46,47,48,49,50,51	18,920
		Trout	25	13,000	Med	High	Intensive flow-through pond, sea-cages	52	5,000
		Mussels	110	14,700	Low	High	Mainly longline and raft	53	
2	Ireland	Salmon		11,000	80	Med-high	FW & Sea-cages	54,55	
		Mussels	200 licences	34,000	Med	Med	70% dreging, 30% longline	56	750
		Oysters		6,500		Med			100
3	Holland	Catfish	35	6,000	80 (1=75%)	High	RAS	57	2,000
		Tilapia		2,000		High			4,000
		Eels	50	4,500	>68	Low	Mainly family RAS <30mt	58	3,000
		Mussels	90 licences	30,000		Med-high	Mainly dredging	59	
4	Denmark	Trout (fresh water)	294	26,813	27	High	RAS, intensive ponds	60,61,62	2,414
		Trout (sea water)	24	7,668	90	High	Sea-cages	63,61,64	2,283
		Eels	11	1,729	>60	High	RAS	65	1,000
5	Germany	Carp	192	14,000	Low-Med	Low	Ponds	66,67,68	
		Trout	440	22,000	Low	Low	Ponds	69,70,71	900
		Eels	7	567	Med	None	RAS	69,72	
6	Finland	Trout	50-60	12,047	40	Med	Ponds	73,74,75	1,500
		European whitefish	15-20	795	Low	Low	Tank-based	73,74,76	
		Sturgeon	3-4	26	Med	Low	RAS	77	
		Brown trout/ Artic charr		23	Low	Low	Ponds/tanks	78	

Source: Ernst and Young 2008, FAO Aquamedia

ANNEX 2: SWOT ANALYSIS FOR MAIN INDUSTRIES

A2.1 Salmon SWOT

For the salmon sector (Table 23), the predominant issue appears to be the market, reflecting a reasonably mature technology and consolidated industry structure. Production costs and consumer issues are also highlighted as issues for this sector. The growing importance of labelling and certification schemes is noted in this sector mainly as a strength, but also as a threat if a proliferation of schemes leads to consumer confusion.

Although fish meal and fish oil availability potentially impacts most on the salmon sector, this was not an issue raised by the stakeholders, presumably indicating that it is not seen as an immediate constraint. Likewise, no environmental concerns were raised other than in as much as they impact on site availability and licensing issues. Both of these issues are major concerns for environmental lobby groups who in turn are perceived as a threat to the industry. This suggests the judgement of many in the salmon industry is that the environmental lobby groups represent a minority concern relying on distorted information and that most consumers are happy to leave sourcing issues to the retail chain and focus mainly on price and quality attributes. Whilst this suggests a fair degree of polarisation between the environmental lobby groups and the industry, the reality is that the lobby groups represent at least some consumers and most likely have some influence on many others. The whole market chain is therefore responding to such market signals by continually improving performance with respect to efficiency of natural resource utilisation and reduction in environmental impacts. In some instances, companies are specifically addressing the "green consumer" with farmed salmon products differentiated through branding or organic certification.

The industry has suffered from endemic disease problems, especially sea lice and viral problems. It is not surprising therefore to see disease and parasites listed as a threat to the industry. The salmon industry in Chile has been very hard hit (2008-09) by the emergence of the ISA virus requiring the concerted fallow of the main producing areas. At present, only 60% of the sites have stocked the cages. A recent outbreak in Scotland, although quickly contained, was a warning against complacency in Europe. Diseases reported to be increasing in the salmon sector include Infectious Pancreatic Necrosis (IPN), Pancreas Disease (PD), and the emerging problems of Cardiomyopathy and Heart and Skeletal Muscle Inflammation (HSMI) (*Richards, 20*06).

Fish farmers, like all livestock producers, must have access to a range of medicines to safeguard animal health and welfare. Public concerns about human food safety, human health and environmental impacts have resulted in increasingly strict interpretation and enforcement of regulations. Such actions have drastically curtailed the availability and use of drugs essential to maintain fish health in hatcheries. Lack of approved drugs and chemicals has dramatically reduced the effectiveness and increased the cost of fish production. To make therapeutants available, EU legislation is requiring an range of specialized laboratory research studies and clinical field trials. Generating all the data necessary for approval may take 5 to 10 years. Pharmaceutical manufacturers are reluctant to undertake any major efforts to gain approval of aquaculture drugs because each (i.e., use on one species for one purpose) is estimated to cost a minimum of $3.5 million (*Schnick RA (1996)*). Hence, the expenditure is not warranted by the apparent market potential. This applies to all aquaculture species.

EU Council Directive 2006/88/EC has the objective to provide sanitary protection to the European aquaculture production and minimize disease impact in wild aquatic animals by developing standards that are consistent with World Trade Organization and World Organization for Animal Health (OIE) guidelines and ensuring the availability of diagnostic capacity.

Table 23: Generalised SWOT analysis for European salmon aquaculture

Strengths	Weaknesses
Positive image for salmon (4) Successful/ advanced eco-labelling/ PGI schemes (4) Diversity of salmon based products (6) Large local UK market (6) Technical know-how (8) High quality research available to producers (8) Restructuring of the sector accomplished (9) Vertical integration – hatchery to processing (9) Relative stability in relations between producers and distributors etc (e.g. credit lines extended by feed producers) (10) Knowledge available on the pathogens affecting production, pathogen transmission and diagnostic methods (5) Successful biosecurity measures to mitigate disease risk have been identified and are widely implemented (5) Protective sanitary legislation (5)	Heavy regulatory burden for obtaining site licenses (1) (3) Marginal sector relative to national economy compared to main competitors (1) High production costs (labour, feed, economies of scale) (9) Limited access to credit (10) Consolidation of feed suppliers (10) Limited authorised chemicals and chemotherapeutants for prevention and treatment of diseases (5) Lack of some effective vaccines to prevent major diseases (5)
Opportunities	**Threats**
Novel vaccine research (5) Growing consumption (6) Development of consumption opportunities(6) Development of niche markets (labelling) (6) New export markets e.g. Russia, Ukraine (6) Some distributors favouring local production (e.g. Sainsbury, UK) (6) Competitive advantage for local markets for fresh product (6)	Adverse NGO campaigns against farming practice (4) Confusing proliferation of labels (4) Diseases and parasites affecting production and sustainability (5) Competition with external countries: Norway, Chile (6) Growing relative transport costs (esp. Shetland) (9)

Key and issue score

1) Legal and administrative issues (2)	6) Third countries competition and market issues (9)
2) Environmental aspects (0)	7) Fish oil and fishmeal availability (0)
3) Availability of production sites (1)	8) Technological issues (2)
4) Food safety and other aspects related to consumption (4)	9) Production costs (4)
5) Animal health and welfare (7)	10) Other (3)

(number in brackets is the number of times this issue is reflected in the SWOT analysis)

A2.2 Trout SWOT

As with salmon, the predominant issues for the trout sector relate to markets and consumers (Table 24). There is greater concern about competition from other products, mainly salmon and large trout from Norway, although pangasius from Vietnam was also mentioned. Environmental constraints are more pressing for the trout sector and this is reflected mainly in the identified weaknesses and threats, although the development of recirculated and water reuse systems is seen as an opportunity. Access to sites is mostly a background issue as the industry is not expanding and most focus is on productivity at existing sites given market and environmental constraints. However, short leases appear to be an issue of concern in Finland.

Fish diseases are seen as a weakness and threat, reflecting chronic problems and the emergence of new disease issues over the last 5-10 years such as streptocotocis caused by *Lactococus garvieae* and *Vagococcus salmoninarum*. These include Rainbow Trout Gastroenteritis (*Del-Polo Gonzalez, 2009*), Sleeping Disease (*Graham et al., 2007*), Red Mark Syndrome (*Verner-Jeffreys et al, 2008*) and the closely related Warm Water Strawberry Disease (*Ferguson et al., 2006*), which add to the already substantial list of disease problems affecting the European trout industry.

The trout sector is in many ways more closely aligned with rural smallholder farming and has not generally seen the levels of industrialisation and consolidation experienced in the salmon sector. Much of this is due to the limited production capacity per site, which makes it difficult to achieve substantial economies of scale. However, modernisation and some consolidation is evident in the sector, so future expansion may be observed.

Table 24: Generalised SWOT analysis for European trout aquaculture

Strengths	Weaknesses
Advanced culture techniques (8) Vertical integration (hatchery to processing) (9) Good relations with downstream actors: distribution, wholesalers etc. (6) Protective sanitary legislation (5)	Disease related mortalities (5) Strict biosecurity measures are not widely spread within the industry (5) Limited authorised chemicals and chemotherapeutants for prevention and treatment of diseases (5) Lack of effective vaccines to prevent disease losses (5) Decline over last decade assoc. with investment uncertainty (10) Licensing transaction costs (1) Short term-licensing (Finland) limiting long-term planning/ investment (1) Overlap between fisheries and environmental governance sectors (1) Environmental constraints (2) Some negative quality and environmental perceptions (continental culture) (4) Sector fragmentation (9) (10) Poor consumption trends (4) Competition with salmon (6) Poor alignment of research centres with producer needs (8) (10) Certification difficulties associated with recirculation system production intensities (6)
Opportunities	**Threats**
RAS: economies of scale and environmental benefits (2) (8) (9) Utilisation of safe but media sensitive feed ingredients e.g. blood meal (1) (4) (9) Development of markets for certified produce (6)	Diseases and parasites (5) Competition with external countries: Norway & Chile (6) Domination by Norway for 'large trout'? (6) Competition by new substitutes e.g. pangasius (6) NGO environmental campaigns (2) (4) Conflicts with recreational fishers (3) (10)

Key and issue score

1) Legal and administrative issues (4)	6) Third countries competition and market issues (7)
2) Environmental aspects (3)	7) Fish oil and fishmeal availability (0)
3) Availability of production sites (1)	8) Technological issues (3)
4) Food safety and other aspects related to consumption (4)	9) Production costs (4)
5) Animal health and welfare (2)	10) Other (4)

(number in brackets is the number of times this issue is reflected in the SWOT analysis)

A2.3 Sea bass and sea bream SWOT

Market issues continue to be a leading concern of the Mediterranean sea bass and bream industry (Table 25). The market appears to be most influenced by the actions of the Greek industry, which accounts for around 34% of Mediterranean sea bass and 46% of sea bream (including Turkish production)[23]. Between 70 and 80% of Greek production is exported, mainly to other EU countries (*Mendrinos & Bostock, 2009, Papageorgiou, 2009*), and increases in supply are thought to have been responsible for a long period of (historically) low sea bream prices during 2007-09 which resulted in several company failures and consequent consolidation. There are signs that lessons have been learned although most emphasis has been on cooperation to restrain output (control of fry production by the leading companies) rather than development of the market, although there are indications that this is also receiving greater attention (*Globefish 2009*). Unlike salmon, which now has a wide range of value-added products, most sea bass and sea bream are sold fresh and whole, mainly in Southern Europe. Sea bass in particular has become more popular as a restaurant dish, although the current global recession has impacted on this outlet. However, as processed whitefish, sea bass and bream are in a more competitive market which generally remains price sensitive. Substantial investment will therefore be required to differentiate and promote aquaculture produced sea bass and bream products if the market is to be substantially expanded in this direction. There is probably some scope for further cost reduction in the sector through consolidation, economies of scale, and improvements in production efficiency, which could also expand the market somewhat, if supported by timely marketing actions.

The issue of shortage of sites does not feature substantially in the above SWOT analysis. This could be due, especially in Greece, to current opportunities for expansion through the takeover of weaker competitors, but also due to recent efforts of the national administration to legally resolve the issues of site availability through improved spatial planning and minimisation of conflicts with other users. However, it is a major constraint in some areas. The development of new sites in Spain appears to be difficult with complex bureaucracy cited as a major factor (stakeholder interviews). In Spain marine aquaculture sites come under two federal laws (Law of Marine Farming 23/1984 and Law of Coastal Zones 22/1988). However, each of the 17 autonomous regions in Spain also regulate applications for aquaculture installations. Authorities involved in granting approvals therefore include regional councils, local councils, navigation authorities, National Fisheries General Directorate and Ministry of the Environment. Other consulted organisations with influence include the regional Tourism Office, Service of Public Health and Fishermen Associations (*Telfer et al, 2008*). At best, permissions take between 1 and 2 years.

Access to credit appears to be an increasing constraint, certainly for Greek farmers, due the high debt ratio and the liquidity problems they have faced over the last 2 years. In this

[23] Calculated from data presented in FEAP, 2008.

context, feed and fry suppliers have also greatly reduced their credit period to 0-2 months, in contrast to the 12 or more months of the recent past. It should be noted that the extended credit period of the past seems to have been a contributory factor to continued increase in production without corresponding investment in marketing. (*Mendrinos & Bostock 2009*). There may also be significant differences in drivers for private and public companies. Larger companies quoted on the Athens stock market may have been driven by targets for revenue growth to increase share value rather than a focus on annual profits which tend to characterise private enterprises.

Emerging diseases such the Viral Encephalopathy and Retinopathy caused by Nodavirus might may result in significant future looses to the industry.

Table 25: Generalised SWOT analysis for European sea bass and sea bream aquaculture

Strengths	Weaknesses
Short production cycle (8) (9) High demand in Mediterranean market (6) Market share 63-68% of global production (6) Several large companies exploiting significant scale-economies (9) Vertical integration (9) (10) Consistent quality and year round production (4) (6) Protective sanitary legislation (5)	Licensing bureaucracy (1) Credit limits (10) Large number of small-subsidised operations in Greece with limited market access (6) (10) Absence of production controls or strategic planning by Greek authorities (1) Low consumer familiarity (esp. bream) in Northern Europe (6) Absence of zoning (1) (3) Lack of industry and market studies relating to potential export markets (6) Absence of timely updated EU industry and market information (10) Limited authorised chemicals and chemotherapeutants for prevention and treatment of disease Lack of effective vaccines to prevent some disease losses
Opportunities	**Threats**
Increasing demand for farmed produce (4) (6) Emerging markets for processed products in N. Europe (6) Emerging quality labels (4) (6)	Increased-production and price competition (6) (9) (10) Third party competition (Turkey) (6) NGO campaigns against poor farming practices (4) (6) (10) Inability to launch centrally coordinated transnational promotion campaigns (6) Emerging diseases (5)

Key and issue score

1) Legal and administrative issues (3)	6) Third countries competition and market issues (13)
2) Environmental aspects (0)	7) Fish oil and fishmeal availability (0)
3) Availability of production sites (1)	8) Technological issues (1)
4) Food safety and other aspects related to consumption (4)	9) Production costs (4)
5) Animal health and welfare (4)	10) Other (6)

(number in brackets is the number of times this issue is reflected in the SWOT analysis)

A2.4 Carp SWOT

The carp sector (Table 26) is in most respects, completely different to the salmon or sea bass and bream sectors. It shares some features with the trout sector as a rural freshwater activity, but with many differences. Nevertheless, market issues are again highlighted in the SWOT analysis. Carp have traditionally had a relatively low value and seasonal market, linked with Central European cultural traditions of eating carp at Christmas. This market is declining as increased trade is introducing new and competing products. Elsewhere carp is not well accepted; particularly in the MED region. On the other hand, the sector, especially in the Czech Republic, appreciate the strong green credentials of traditional carp and are seeking ways to exploit these and develop new products for European markets. Organic certification, e.g. by the German organisation Naturland, and in the UK the Soil Association are examples of this approach.

Most carp farming in Czech Republic is in large ponds that are an important part of the landscape, valuable for flood protection and highly significant for biodiversity and conservation. The strategy of raising value rather than output has good logic here. Hungary, Poland, Germany, Austria etc have smaller ponds that are often managed as semi-intensive production systems which are perhaps more readily adaptable to different production and marketing strategies.

The availability of production sites is raised more frequently as an issue for freshwater aquaculture (either directly or indirectly) indicating the greater pressure on these resources and likelihood for conflicts if aquaculture expands. Technological approaches, e.g. through the increased use of recirculated water systems would facilitate higher outputs whilst using no more land or water resources. However, such approaches can also be used for other potentially more valuable species, so production strategy must be principally guided by market opportunities.

The issue of knowledge sharing, dissemination and sector cooperation is particularly raised as an area of weakness for carp aquaculture. These issues are not unique to the carp sector, but reflect the history of carp farming as a rural labour intensive rather than knowledge intensive activity. The sector has also had a localised focus on markets and competition; indeed much of the fairly recent history of carp farming has been under socialist systems with no specific regard to competition. For these reasons the carp sector appears to have lower rates of innovation than in the case with some other species.

Table 26: Generalised SWOT analysis for European carp aquaculture

Strengths	Weaknesses
Long tradition of aquaculture (6) Low competition between aquaculture and agriculture (3) Low competition between aquaculture and fisheries (3) Large variety of species (6) (8) Polyculture options (8) Nutrient availability/ recycling in ponds (2) (9) Hatchery availability (3) (8) Low disease problems in extensive aquaculture (5) Gender opportunity – for women involved in production (10) Sustainability implications: environmental & social (2) (10) Protective sanitary legislation (5)	Low growth associated with declining resource base (3) Low development of intensive production (8) High unit production costs (9) Low market value species (6) Processing sector poorly developed (6) Limited credit access (10) Limited export potential (6) Poorly trained/ adapted human resources (10) Limited access to certification schemes (6) (10) Limited contribution to labour market (10) High price fluctuations assoc. with independent fishing activity (6) Slow development of regulatory frameworks (1) Poor knowledge and extension base (10) Weak professional/ producer organisation (10) Low quality product image Poor health management by the industry (5)
Opportunities	**Threats**
Intensification potential (8) (2) (3) (9) Organic culture & certification (4) (6) Local consumer demand (6) Training development (10) Rural development potential (10) Exploitation of green/ sustainability credentials (2) (4) (6)	Koi carp herpes virus (KHV) (5) Predation (2) (5) Illegal fishing (10) Quality and cost for fresh water (2) (8) (9)

Key and issue score

1)	Legal and administrative issues (1)	6)	Third countries competition and market issues (9)
2)	Environmental aspects (6)	7)	Fish oil and fishmeal availability (7)
3)	Availability of production sites (5)	8)	Technological issues (6)
4)	Food safety and other aspects related to consumption (2)	9)	Production costs (4)
5)	Animal health and welfare (3)	10)	Other (12)

(number in brackets is the number of times this issue is reflected in the SWOT analysis)

A2.5 Shellfish SWOT

The shellfish sector (Table 27) has a much greater focus on environmental issues. Much of this is positive as the industry seeks to promote its green production credentials. However, environmental variability and long-term climate change represent potential threats. Market issues have not been of high concern for the shellfish sector, although this may be changing with recent falls in price for mussels. The predominant product is live, so competition from third countries is modest, mostly in value-added products where distance from market is less of an issue. There is growing appreciation in some parts of the mussel industry that expansion of output should be possible with further investment in value-added product and marketing efforts that capitalise on the product's health and environmental benefits.

The issue of site availability is significant, but not reflected in the above SWOT analysis. New developments are limited to areas designated as shellfish waters under EC Directive 79/293/EEC, and in many areas there are restrictions due to navigational or visual impact considerations, or guidelines concerning allowable distance from finfish farms. Shellfish farming is not without environmental and ecological impacts although these are considered relatively benign compared with intensive fish production.

Most shellfish farming is highly fragmented; carried out by owner-operator businesses, often at artisanal scale. However the size of some farms, especially in the mussel sector, is growing, and the emergence of larger businesses with some consolidation is possible, particularly with developments in deeper-water mussel long-line technology. Alternatively several cooperatives have emerged, especially for processing and marketing shellfish products.

Table 27: Generalised SWOT analysis for European shellfish aquaculture

Strengths	Weaknesses
Low input production systems (labour and feeds) (2) (8) (9) Increasing demand (4) (6) Protective sanitary legislation (5)	Over production resulting in low prices e.g. mussels (6) (9) (10) Fragmented production base e.g. oysters (6) (9) (10) Negative environmental impact of dredging operations (2) (8) No possibility of treatment applications (5) No vaccines available (5)
Opportunities	**Threats**
Development of new environmental friendly production systems (2) (8) Eco-labelling opportunities (2) (4) (6)	Diseases and parasites (5) Environmental contamination (5) Uncertain spat-fall under extensive production conditions (2) (8) (9) Spread of commercially unfavourable/ invasive species (2) (10)

Key and issue score

1)	Legal and administrative issues (0)	6)	Third countries competition and market issues (4)
2)	Environmental aspects (6)	7)	Fish oil and fishmeal availability (0)
3)	Availability of production sites (0)	8)	Technological issues (4)
4)	Food safety and other aspects related to consumption (2)	9)	Production costs (4)
5)	Animal health and welfare (1)	10)	Other (3)

(number in brackets is the number of times this issue is reflected in the SWOT analysis)

A2.6 Other species SWOT

A2.6.1 Other high value marine species e.g. halibut, turbot and sole

The most successful higher-value marine fish industry to date is for turbot (Table 28) with over 9000 tonnes produced in 2008 (*FEAP, 2008*). This is mostly from land-based systems in Spain, France and Portugal. The technology is reasonably mature and growth has been gradual allowing market prices to be maintained. Sole is still at pilot stage, but produced in similar systems. Despite a long history of development, there are still very few halibut farms. Most of the 1,200 tonnes production in 2008 was from Norway (*FEAP, 2008*). Farms also exist in Iceland and UK.

Potentially in this category is bluefin tuna. However, the capture and fattening operations that currently exist have questionable sustainability, and development of commercial hatchery and nursery operations are still at the research stage.

Table 28 Generalised SWOT analysis for other high-value marine species

Strengths/Opportunities	Weaknesses/Threats
Technology reasonably established at commercial scale High value products with good market image Protective sanitary legislation	High cost of production limits market Products from aquaculture, when differentiated, may not be valued as highly as wild product Threat of disease Limited range of effective vaccines Limited authorised chemicals and chemotherapeutant for prevention and treatment of diseases Lack of knowledge of major pathogens and their mode of transmission

A2.6.2 Mid and lower value marine species e.g. cod, meagre, bream species

More promising examples include cod, meagre and various bream species (Table 29). Cod farming appeared to be emerging over the last 5 years with around 10,000 tonnes produced in Norway in 2008 (plus small quantities in Iceland, UK and Ireland). However, recent increases in supplies from the capture fishery and reduced demand due to substitution has led to a fall in cod prices and the collapse of several cod farming companies. Short-term prospects therefore appear quite poor.

In the Mediterranean, there has been some modest species diversification, mostly based on alternate sea bream species (e.g. *Puntazzo puntazzo*, *Pagrus pagrus*, *Dentex dentex*, *Diplodus sargus*, *Pagellus erythrinus*, *Oblada melanura*, *Diplodus cervinus* etc. *Sturrock et al*, *2008*). The most significant development is perhaps the emergence of meagre (*Argyrosomus regius*) with farms in France, Italy and Spain producing around 2,235 tonnes in 2008 (*FEAP*, *2008*). With a faster growth rate than sea bass and (currently) better prices, more farms are looking to produce this species. Other species under development include amberjack (closely related to yellowtail/kingfish which are cultured in Japan and Australia). Overall the lesson that must be learned from recent history is the need to be market rather than production led.

Table 29 Generalised SWOT analysis for other mid and low value marine species

Strengths/Opportunities	Weaknesses/Threats
Technology mostly established Product diversification for aquaculture based on existing production systems	Cost of production may be above sales price but markets mostly proven at right price Threat of disease

A2.6.3 Other high value freshwater species e.g. eel, sturgeon, zander, Arctic charr

This is a very diverse range of species (Table 30), but with small to modest production volumes. Eel production is constrained by the availability of wild glass eels and elvers, However, research is underway (for instance in Denmark) to close the breeding cycle and if this is achieved, some expansion of the sector is likely. Were this to be achieved prices would certainly be negatively impacted unless advantage can be taken of potentially strong markets in the Far East.

Sturgeon culture is gradually expanding in Europe, mostly for caviar production, although males are commonly harvested and sold for meat (approximately 2,730 tonnes in 2008 (*FEAP*, *2008*). Farmed caviar prices range from €650-1,200 per kg and production was around 63 tonnes in 2008 (*FEAP*, *2008*). This was mostly from Italy and France, although farms can also be found in Germany, Belgium, Bulgaria, Hungary, Poland, Romania and Spain. Further modest expansion is anticipated, but prices would be vulnerable to a major increase in supply. Competition may also come from developments in Russia, China and elsewhere.

Zander (pike-perch) are being farmed in Hungary and Czech Republic, in pond systems but only in small quantities. There is also a recirculated water production system in Denmark (*Framian*, *2009a*). It is a reasonably well known fish in Eastern and Central Europe with good value. Most supplies currently come from the wild. There is probably good scope for market expansion if production can be intensified. However, price and other market attributes will be critical for financial viability.

The market for Arctic charr is quite small, it being a relatively unknown fish throughout most of the EU. Commercial production has been most successful in Iceland and parts of Scandinavia. Projects in the UK and Ireland have mostly failed through combinations of technical and market factors. For the present it appears likely to remain a niche species.

Table 30 Generalised SWOT analysis for other high-value fresh-water species

Strengths/Opportunities	Weaknesses/Threats
Successful commercial systems in operation Diversification and integration options Protective sanitary legislation	Limited markets (especially arctic charr) Limited supply of eels from wild and fishery conservation issues Long lifecycle (sturgeon) Limited range of effective vaccines Limited authorised chemicals and chemotherapeutant for prevention and treatment of diseases Lack of knowledge of major pathogens and their mode of transmission

A2.6.4 Other mid & lower value freshwater species e.g. tilapia, catfish, perch, tench

Tilapia culture (Table 31) has attracted a good deal of attention and some significant recent investment, in part due to strong growth in the USA. Global production is around 2.5 million tonnes (*FAO, 2009*), although the bulk of this is low value produced in China and other Asian and Central American countries. If imported into Europe, it is usually in frozen fillet form sold into ethnic markets. An increasing quantity of fresh product is being air freighted into Europe, and this is encouraging domestic production using recirculated water aquaculture systems due to the need for high temperatures (28°C is optimal). Such systems are relatively expensive to build and operate, so cannot compete on price with most imports. This may restrict development to niche markets with an emphasis on freshness, local provenance and green credentials of low fish meal and oil requirements. A lower cost of production could substantially grow the market as tilapia fillets are potentially suitable for a range of value-added whitefish based products.

Perch and tench are valued by many Central European markets (perch is particularly popular in Switzerland) and fish farming of these species is starting to increase. However, volumes are still very low and unlikely to grow rapidly. Around 7,000 tonnes of African catfish are produced in recirculated aquaculture systems. Growth has been very modest over the past 5 years, indicating limited opportunities for market expansion. European catfish is even more niche with around 700 tones produced in 2008 (*FEAP, 2008*).

Table 31 Generalised SWOT analysis for other low-value fresh-water species

Strengths/Opportunities	Weaknesses/Threats
Currently niche species, but with potential for expansion at lower prices Tilapia and catfish especially are robust species with less demanding water quality requirements Highly resistant to disease and poor health management for tilapia and catfish Protective sanitary legislation	For catfish and tilapia – low cost production in tropical countries is providing cheap imported material which may undermine market image and product value For perch and tench – vulnerability to disease Lack of knowledge of major pathogens and their mode of transmission Limited range of effective vaccines Limited authorised chemicals and chemotherapeutant for prevention and treatment of diseases

ANNEX 3: POTENTIAL STRATEGIES: SCENARIO ANALYSIS

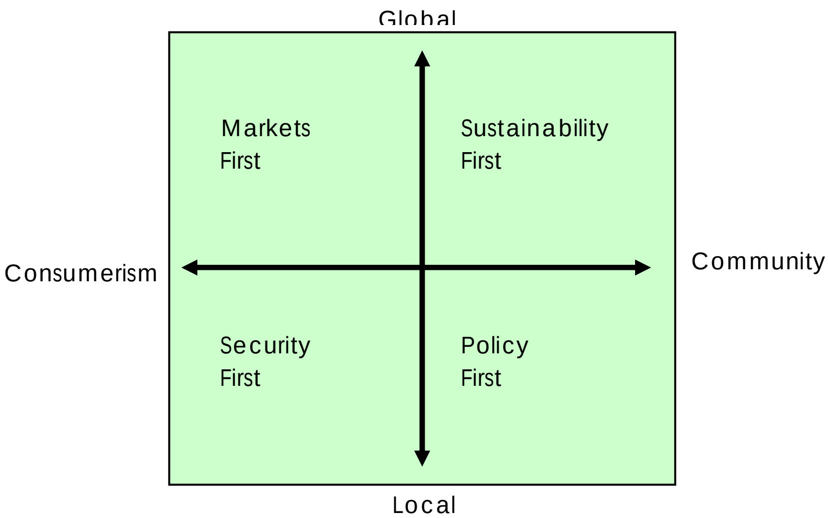
KEY FINDINGS

- Aquaculture policy must reconcile the wants of consumers and the wider interests of society. It must also find a path between satisfying local (community) interests and those at the EU and global levels
- Meeting the forward needs of society for safe fish and seafood of high quality and sustainability will require increased production – either through the exploitation of underutilised resources in third countries (directly participating or simply by purchasing product) or through technological innovation that overcomes current environmental and economic constraints
- Aquaculture, as an industry in the EU, must locate itself as an equal resource user, promptly dealing with spatial planning issues and conflicting of uses of other natural and biological resources (i.e. water, fish feed, fish oil)

A3.1 Approaches

Two outline scenario analyses are used. **Scenario one** draws on the work of the EC FEUFAR project (*EC, 2007*), although adopts simpler approaches based on the work of the United Nations Environment Programme (*UNEP, 1998*). Two main (linear) dimensions are considered (Figure 3). The first is the range from individual consumerism to collective social responsibility. The second is the spread between local and global interests and governance. These can be seen as opposing poles, but more realistically as a framework for recognising and/or developing preferences and policy options.

Figure 3: Two-dimension scenario scheme



Source: UNEP, 1999

The four rather idealised sectors which this generates provide the following contexts:

1. A 'world markets' scenario, within which people aspire to personal independence, material wealth and greater mobility, to the detriment of wider societal and environmental goals. The market is 'all powerful' and unrestrained (global + consumerism)
2. A 'global stewardship' scenario which assumes that people aspire to high levels of welfare and a sound environment. There is a belief that these objectives are best achieved through cooperation at an international level (global + community).
3. A 'nationalistic' scenario which assumes that people aspire to personal independence and material wealth within a nationally rooted cultural identity. Conservation and sustainable development are not a main priority whereas security of indigenous supplies is very important (local + consumerism).
4. A 'local stewardship' scenario which assumes that people aspire to sustainable levels of welfare in local communities. Public policy supports economic activities that are small-scale and regional in scope, and constrains large-scale markets and technologies. Pressure continues to protect but also to exploit indigenous aquatic resources, and this results in a diverse range of impacts with some aquatic areas becoming degraded due to free-rider effects, while others see great improvements. Local action fails to address large-scale global environmental concerns (local + community).

The **second scenario** approach explores one of the more fundamental aspects of the modern aquaculture sector, the major dynamic of **supply and value chain development**, and the extent to which its features might influence industry structure, scale and competitiveness.

A3.2 Developing the market and stewardship scenarios

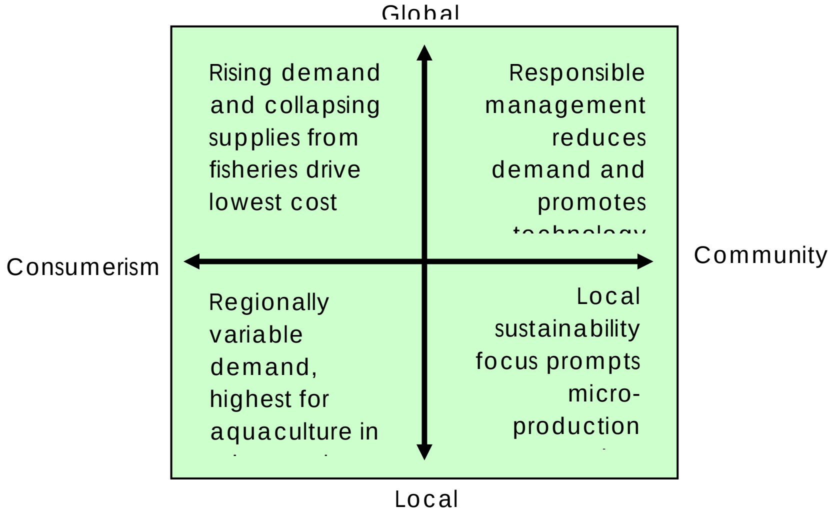
A3.2.1 Introduction

At the EU level it is immediately evident that wider socio-political and economic drivers will determine a position within the four quadrants, and that a series of movements might be definable as the populace and its social and political processes responds to different arrays of inputs. As a developed society it is clearly not possible to operate at any of the extremes of this system, and indeed the position of the EU would be defined by both internal and external vectors. At a sectoral level, the issues and approaches are likewise definable by the interactions between these elements. For a food-related product, in which localised and personal decisions are increasingly being overtaken by the role of the food industry and multiple retailers, socio-political context is increasingly mediated by market and product presentational features.

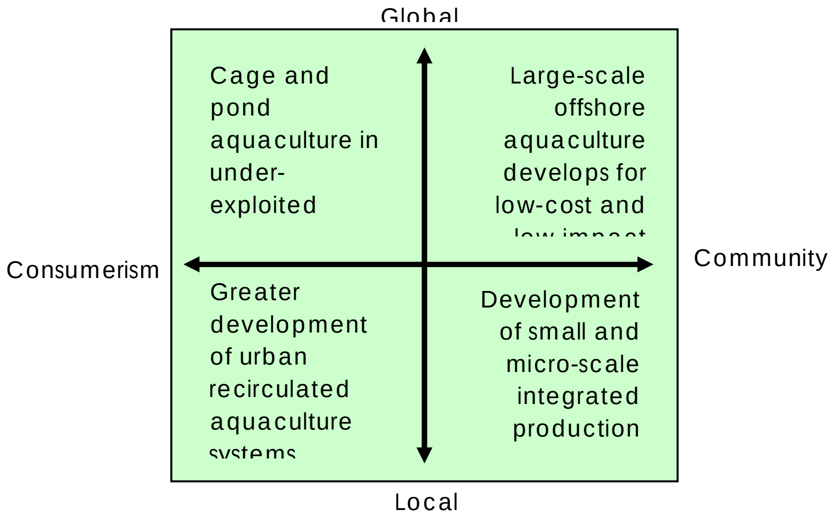
A3.2.2 Addressing scenario options

Which scenario will define the future of the sector will depend to a great extent on the perceived source of the problems, hence encouraging a move in the opposite direction. Figure 4A shows the major directions and Figure 4B the corresponding farming system outcomes.

Figure 4 A and B: Aquaculture development trends based on defined scenario schemes



A ***Drivers for aquaculture output***



B ***Possible aquaculture enterprise features***

In the context of aquaculture, the tensions between consumerism and community, and between global and local can be outlined as follows:

Consumerism	Community
• Consumers want access to cheaper food – implies support for lowest-cost production methods, most likely through economies of scale, consolidation, or increased impacts on the environment • Consumers want choice and variety – implies promoting a mix of suppliers and products • Consumers want safe food with guaranteed provenance – implies strict control systems which can be costly for governments or external bodies to provide; self regulation more cost effective, but most effective in a consolidated industry	• Cheap fish and seafood is good for population health – low-cost production systems should be encouraged to allow for greater output • Aquaculture sector should employ as many people as possible – implies productivity of aquaculture enterprises should be limited – e.g. resist consolidation (unless growth in output compensates) • Aquaculture should not have adverse impacts on the environment – implies limiting scale or increasing expenditure on mitigation measures, both of which will increase production price and hence restrict output
Global	**Local**
• Global free trade is usually promoted – this implies aquaculture production will move to areas of lowest cost production • Global action on sustainability and climate change may restrict aquaculture production options in countries or regions that might otherwise wish to expand – hence restricting supplies and increasing prices unless technical innovation compensates • An agenda for fair trade and global economic and social development will reduce the opportunities for "low cost production" based on low cost labour – this could impact on some segments of the aquaculture industry, especially shellfish and shrimp – rising costs and hence reducing output	• Desire to protect local jobs – implies protection against loss of industry to lower cost areas – may reduce output and increase prices overall • A focus on local control and measures to protect the environment will restrict aquaculture – either reducing output and hence increasing prices, or driving greater technical innovation • A focus on food miles as a key parameter for judging sustainability could promote local production at the detriment of poorer societies overseas, or even peripheral communities within nations, potentially restricting supplies and increasing prices

A path through these conflicting aims needs to be found that best fits overall social and policy objectives.

A3.2.3 Scenario implications

Some of the key features likely to be seen in the emerging EU aquaculture/aquatic food context are shown in Table 32. As shown, a mix of scenario elements might be expected, with a significant spatial variability defined by local context and its interaction with EU level market, economic and policy features. A diversified sectoral approach could be envisaged, rather than a single set of outcomes.

Table 32: Summary of outcomes based on defined market and stewardship scenarios

From the 'world market' scenario
• Price is the predominant factor for competition for commodity food items (e.g. white fish, salmon, prawns, tuna), encouraging production to move to lowest-cost locations and consolidation to increase economies of scale and strengthen control of markets
• Aquaculture will develop most rapidly where abundant natural resources (particularly space, water and environmental services for waste disposal) are available at lowest cost and allow large-scale developments. Most likely to be found in parts of Africa, Asia and Latin America
• Less efficient aquaculture in many EU rural and coastal communities will move towards supplying niche high value products, best supplied by smaller more agile companies
• Increasing wealth in South, East and South-East Asia could increase market opportunities for exports of EU aquaculture produce such as salmon and trout
From the global stewardship scenario
• Ethical provenance will become more important in some markets, including adherence to criteria for fair trade, environmental sustainability, climate change indicators (carbon footprint or LCA) and impacts on biodiversity
• Better management (and rising costs of fishing) will help stabilise fish stocks and may moderate potential demand for aquaculture produce; the use of fishmeal and oil for aquaculture feeds will come under greater scrutiny, promoting alternatives
• More aquaculture may be moved to large scale offshore aquaculture projects, recirculated units (if LCA and other aspects are acceptable), multi-trophic aquaculture, and other more ecologically efficient systems, with low environmental impact yet high social value with respect to the supply of good quality food.
From the nationalistic scenario
• EU countries will push to reduce aquatic food trade deficits by boosting cost-effective domestic aquaculture production, within inshore and inland water areas. Highly urbanised countries could use large-scale recirculated systems if resource-efficient
• Culture of a greater variety of regional species could be more strongly promoted
From the local stewardship scenario
• Capture fisheries access will vary widely; high priority will be placed on local production and minimisation of imports, including feed ingredients and energy supplies. Low food chain and/or integrated production might become more favoured
• A greater emphasis on local employment and value-addition will act against large international corporations, with less vertical and horizontal integration; small and micro-scale integrated systems e.g. linking other economic/environmental functions will be favoured

A3.3 Supply chain scenarios

A3.3.1 Introduction

One of the most important vectors for change in the aquatic food sector, as indeed for the wider food industry, has been the extent to which products have been taken up into modern distribution and retail chains, bypassing and substantially overtaking the traditional fishery sector market and supply routes. The growing urbanisation of EU societies, coupled with technical innovation in product development, and a greater willingness to pay for a wider range of product attributes has brought about significant structural change, market and consumer responses, and steadily evolving and differentiating ranges of products. A significant aspect in this is that businesses engaged in the 'downstream' end of the supply chain commonly hold the greatest share in added value, and have increasing market power, better returns on investment, and steadily better opportunities to invest and gain greater turnover and profitability. In competition terms, focus is less on species and more on brands and products.

Possible evolution could direct towards:

- Regulated and disaggregated supply chains

In this scenario, various policy and market changes may result in a supply system which is less concentrated than it has recently become, with smaller average size of enterprise. Trends towards "local" produce could reduce the opportunities for international companies to source widely, or utilise offshore processing, diminishing their costs advantages in comparison with smaller national enterprises.

- Evolution of current mix

Here, the recent and present features of the sector are expected to continue more or less unchanged into the future, with no higher levels of industry aggregation, and a reasonably active and profitable smaller scale sector.

- Highly concentrated and integrated supply chains

Global trade drives further consolidation nationally and internationally around major market players. The rise of supermarkets as dominant suppliers of food will continue globally with increasingly concentrated supply chains geared to the volumes and mix of products required for the supermarket trade. Branding and the use of market-based standards could make it increasingly difficult for smaller enterprises to find a market.

A3.3.2 Conclusions

The overall perspective of market and value chain development is important for the more fundamental features of EU competitiveness on a number of fronts. At present, there is greater economic value in fish and seafood processing than in production. This encourages international sourcing of raw materials and potentially discourages investment in higher-cost local production. The sophistication of processing and modern distribution mean that it is exceedingly difficult for smaller enterprises to invest in substantial value-addition and they are left to compete more or less on global spot markets with products that often have substitutes from either lower-value aquaculture species or capture fisheries. Schemes to assist SME producers enhance production may have little impact if downstream market chain factors are not properly considered.

A3.4 Implications for policy

A3.4.1 Global policy context

The future of the European aquaculture sector has to be seen within the overall context of likely future directions in macro economic conditions and regulatory frameworks. These in turn will be driven by events, social trends and political responses. The situation in Europe will also depend substantially on global factors. However, several key considerations are already well defined (e.g. *OECD/FAO, 2009*; *Evans, 2009*) as:

- Potential impact of climate change and the need to move to a lower-carbon economy with potentially higher energy costs

- Food security in the context of rising populations, increased pressures on land and freshwater resources and impact of climate change on agriculture and fisheries productivity
- The ability of national and international bodies to manage capture fisheries at sustainable levels during a likely period of ecological change
- Increasing demands by consumers for food that is good value, high quality, safe and with ethically sound provenance (i.e. social and environmental sustainability)
- The need to maintain positive economic activity and growth for social stability

A failure to respond to these challenges will undoubtedly lead to social and political stress and danger of serious conflict over access to resources or distribution of benefits. Under these circumstances development might be pushed towards one of the more extreme positions defined in the first set of scenarios.

A3.4.2 Markets and competition

A fundamental issue for policy development is that aquaculture product is in most cases not well differentiated from capture fisheries product at the point of sale to consumers. This is gradually changing due to EU labelling regulations and increasing awareness by the population of aquaculture. However, in broad terms aquaculture product is competing with capture fisheries product. This has been illustrated most recently by developments in the cod farming sector which has suffered a severe setback after substantial investment and reasonable technical success. The reasons for this can be analysed in relatively simple economic terms. At the present time the cost of farming cod is higher than the cost of catching them from the wild. This would change if cod stocks reduce substantially, or if there are changes in energy, feed or licensing costs etc (the latter potentially under greater political control). The market price is set by supply and demand. The cod farming industry invested on the projections that capture supplies would be gradually depleted due to overfishing, whilst demand would continue to rise. With increased production it was hoped that the cost of production could be reduced whilst prices might rise further, so long as the cod farming sector did not over-produce. However, at least for the present, stocks appear to have recovered whilst demand appears to have fallen due to major processors switching to pollack as raw material. Prices are therefore below the cost of production for farmers and the industry has largely collapsed, particularly in the EU. Some efforts have been made to differentiate farmed from wild cod such that there would be little substitution between them by consumers. At the present this would require positioning the farmed cod as the premium product – the converse of salmon, where wild fish occupy the premium position. This is clearly a major challenge, although arguably the only way for aquaculture companies to address competitive pressures from capture fisheries.

A further consideration is that a substantial proportion of aquaculture output is sold with some form of value-added processing and packing, and this is expected to increase. To some extent, value-added processing provides increased opportunities for substitution of raw material (e.g. the whitefish in fish fingers). More importantly, it provides a range of very different products that appeal to people who might not purchase whole fish, or even fresh fillets. Processing can therefore make a major difference to the appeal of the raw material and hence potential size of the market, and indeed the economic value of processing is often greater than that of production. The primary signals for policy should therefore come from assessment of market demand rather than production potential.

Looking just at aquaculture products, an assessment of competition can potentially provide a basis for distinguishing between sub-sectors and addressing these through different policy measures. All aquaculture ventures compete across a range of factors, including price, quality, service and other intangibles. The importance of each of these varies and that could be significant when designing a policy framework.

Table 33: Basis for competition between similar aquaculture products

Competitive factor	Characteristics of aquaculture producers
Price	Most common parameter of competition for medium sized companies – particularly for commodity products including fresh whole, and sales to processors
Quality	Niche producers competing on tangible quality parameters including freshness or differences in meat texture and taste. Products usually identified in the market through some form of branding
Service	Can become an important parameter of competition between commodity suppliers where longer-term contracts are more common, or in local markets
Location	Occasional opportunities for regional producers to differentiate on the basis of farm location – usually linked with sales to local markets
Ethical	Differentiation on the basis of higher ethical standards such as environmental responsibility, fair trade, fish welfare etc. Successful pioneers of this approach have often found commodity producers following and reducing their competitive advantage

By definition, the bulk of the market will be for commodity product, with any differentiation being provided by downstream processing and branding rather than differentiation on the basis of raw material (other than generic factors such as adherence to sustainability standards). Such raw material is most economically and effectively supplied by a consolidated industry with economies of scale and employing the most advanced technologies. To be competitive in this sector, the EU must adopt policies that allow for such businesses to develop through access to suitable sites, investment in research and innovation, and streamlined international regulations. Furthermore EU producers can be competitive with third country imports if common standards of production are required. So far, only the salmon sector is substantially consolidated.

Several aquaculture species currently supply basically commodity markets with large numbers of producers struggling to compete mainly on price. This, for instance includes trout and mussels. Smaller producers are easily pushed out of business when prices fall, and struggle to meet rising environmental and food hygiene standards as they have little resources for investment. It might therefore be argued that policies that artificially sustain small and medium producers of commodity products are counter-productive and do not promote competitiveness in the context of the global marketplace.

Many aquaculture producers however, fall into the “niche” category. Products with modest production levels (for instance less than 10,000 tonnes) are niche products in relation to aquaculture, and even more so in the context of all fisheries products. Producers that differentiate their product from other similar products through unique attributes, be they quality, service or ethical, are also niche. At a global level, niche markets are not necessarily small in absolute volume terms, but are a small proportion of the total market for a category of products.

It may be a beneficial strategy to put in place policies that support niche sector producers, providing the limits of this market segment are appreciated. For instance, it may be sensible to support the development of a new species that successfully opens a new niche market. However, there may be much less value in continuing to support growth in production until is it struggling to compete with commodity product. Some smaller commodity producers might be encouraged and supported to move into niche markets through differentiation. But this is not an option for all producers within a sizable industry (such as sea bass and sea bream). Support for differentiation might therefore be best targeted where it would have maximum social or environmental impact.

A3.4.3 Access to resources

At a global level, it is clear that aquaculture competitiveness is directly linked to access to environmental resources – land or water area, water supplies, and environmental services, which may include natural food supplies and waste removal and processing. In a globalised marketplace, if all else were equal, aquaculture production will be most successful where these resources are most available at lowest cost. The issue of further environmental capacity in Europe is debatable, but indications are that regulatory agencies are increasingly restricting access. Further development of aquaculture is therefore most likely in Africa and Latin America, where resource utilisation is much lower than that in Europe and Asia. The question for policy makers is whether to support this development and encourage the involvement of European companies and technologies, or to compete with it by promoting technological solutions to current environmental constraints (such as recirculated aquaculture systems, fully offshore aquaculture and perhaps genetically adapted stock). This will also be linked to trade policy and broader social and environmental policy.

A3.4.4 Innovation

It was notable that few producers cited research and innovation as key issues for competitiveness. This suggests a focus on day to day business survival and tight margins that allow little scope for acting and investing for long-term strategic interests, especially where there are many uncertainties. This is also characterised by a certain conservatism towards substantive change promoted by policy organisations since it is likely to upset their existing business model, increase competition and require substantial new investment which can be hard to secure. Indeed access to finance was an important factor and is a particular issue for aquaculture due to the relatively long production cycles and significant risks of losses due to disease and sometimes predators, mechanical failure or climatic events etc.

Innovation policy needs to take greater account of the different components of innovation and the main actors and different sub-sectors. One view on industrial innovation is provided by Davila et al. (2006) (Figure 5). This differentiates between business model innovation and technology innovation.

Figure 5: The six levers of innovation (*Davila et al, 2006*)

	Value proposition	Product and services	
Business model innovation	Supply chain	Process technologies	Technology innovation
	Target customer	Enabling technologies	

For business model innovation the *value proposition* represents **what** is sold and delivered to the market; the *supply chain* represents how it is created and delivered to the market; and the *target customer* represents to **whom** it is delivered. Business model innovation is almost entirely ignored in innovation support programmes which tend to focus on technology innovation, although there are of course some crossovers.

Technology innovation concerns:

- *Products (or services) offered* – for aquaculture producers this concerns the species and the product forms (including value-added products)
- *Process technologies* – for aquaculture this primarily concerns the production technologies employed and potential to improve performance and efficiency (equipment, feeds, vaccines etc)
- *Enabling technologies* – for aquaculture these may include information technologies with speed up business processes and enable better responses to changing market requirements

Innovation can also be classed as incremental, semi-radical or radical depending on whether it is making small improvements to existing technology and business models, or resulting in entirely new products or means of producing them.

Larger and vertically integrated corporations have greater scope for business innovation than smaller companies with limited internal resources, production and market options. Some of the innovation may be externally driven however, e.g. changes required to meet the needs of major multiple retailers.

For all aquaculture production companies, technology innovation is largely externally sourced (Table 34).

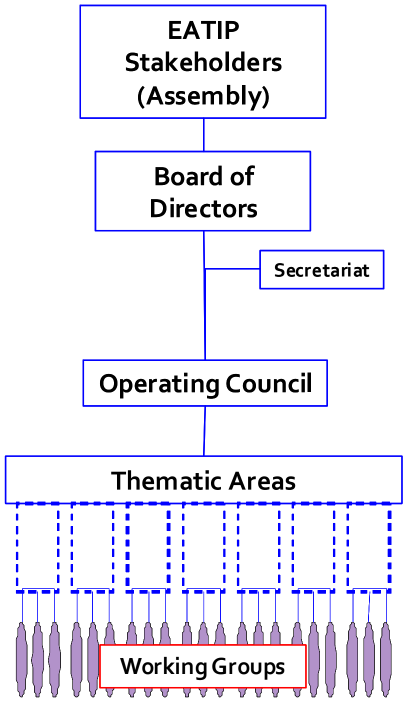
Table 34: Technology innovation in relation to sub-sectors and main actors

Type of innovation	Sub-sector and actors
Incremental technological process - engineering	Delivered by aquaculture supply companies responding to the needs of the market – examples are the developments in cage and nets, feeding systems and well boats. Sometimes supported by academic and government research institutions to help provide fundamental understanding of key factors (stresses on marine structures, physiological responses of fish to lighting systems etc)
Incremental technological process - biological	Improvements in fish nutrition and feeds, the development of fish vaccines and new therapeutants, and improved stock through selective breeding. Delivered by major pharmaceutical and feed manufacturing companies or genetics companies with both in-house R&D and substantial use of academic, government and other private research institutions
Radical technological product - new species	Usually developed by small companies with pioneering focus and support from public funds etc. Additional inputs by research organisations
Radical technological Process - new systems	Usually developed by start-up companies with intellectual property and venture capital finance. Often also relies on some public funds and inputs from research organisations
Radical (or semi-radical) technological - new value-added product	Developed by downstream processing companies usually with own and loan financing. Inputs from food science and marketing organisations
Technological enabling	Usually adapted from allied sectors with customisation for aquaculture (e.g. IT systems)
Business model innovation	May include development and promotion of new certification standards, involving non-government and non-profit organisations, or catering and retail organisations that present product in a new format and with new associations

In general, the established aquaculture producers are not a significant source of technology innovation, although as primary users, especially of incremental technology innovation, they need to be key stakeholders in the innovation process. An important development in this respect is the establishment of the European Aquaculture Technology and Innovation Platform[24] (EATiP). This is aiming to become recognised as an official European Technology Platform[25], and as such, play a key role in helping to define research priorities for funding and influence sector policy. The organisation is now established as a legal entity, registered in Belgium with FEAP (Federation of European Aquaculture Producers) providing the secretariat. Most of the work of the EATiP is being conducted through seven thematic working groups which draw together industry, research and other stakeholders. These are:

1. Product Quality & human safety & health
2. Technology & Systems
3. Managing the biological lifecycle
4. Sustainable feed production
5. Integration with the environment
6. Aquatic animal health & welfare
7. Knowledge management
8. Socio-economics and marketing

[24] http://www.eatip.eu/
[25] http://cordis.europa.eu/technology-platforms/home_en.html



Overall strategic development is the responsibility of the EATiP board (comprising 8 members from industry, 2 from research and 2 representing other consumer and societal stakeholder groups). The overall initiative has so far been guided by three open stakeholder meetings. The initiative has attracted the interest and support of most of the major companies and institutions in the aquaculture sector, and is starting to play a formal role in some EC funded projects.

Since participation in EATiP is largely self-funded, there is a tendency for it to be dominated by the larger organisations with SMEs in particular somewhat under-represented. This however is common issue across the ETPs, and could be addressed through financial support measures. The clear benefit of the EATiP should be that it will identify and help to rank research priorities within the aquaculture sector, especially the major segments that are involved in innovation, and help to optimise research effort through improved coordination and knowledge sharing. Due to the interests of the stakeholders, this is likely to focus more on incremental innovation and building a core of longer term and more productive research collaborations and programmes rather than a large number of short-cycle research initiatives, which will certainly be supported by those involved. The potential danger is that more radical innovations that might compete with the established industry could be suppressed by such a body. However, as these often arise through new entrants to the sector, it would be difficult for the EATiP to involve them in a representative way. It is also in the nature of more radical innovations that failure rates are much higher, so separate support mechanisms are probably more appropriate.

A3.4.5 Global investment

Aquaculture production in EU is increasingly part of a highly internationally competitive food industry. In this context several major trends are observable:

- Large food supply companies with major relationships with retail and food service outlets, integrating backwards to link with producers, in the EU and elsewhere, to supply EU and international markets; this is less common, as profitability is higher in the downstream subsector, and so investment in supply is less attractive, but is being considered strategically. Long-term supply contracts can also be relevant, effectively providing investment backing for aquaculture producers

- Large aquaculture sector producers of stock or feeds, integrating forwards to added-value production to link with food supply sectors, primarily based on their main production species
- Large fishing industry entities seeking to diversify and expand output, acquiring aquaculture capacity to link in supplies for national and global markets, building on product and market chain knowledge, reducing supply risk and widening market presence

Most of these have been very significant in defining the larger scale competitive characteristics of the EU industry. There may be other future linkages e.g. energy supply companies, agro-industrial and/or biofuel companies. The role of sovereign wealth funds in developing food production capacity has so far been confined to terrestrial production, but might also be extended to aquaculture. In the broad context of EU geopolitical and economic interests, and allowing for relative freedom of capital movement, and primary area of policy, concern relates to the extent to which value can be built around aquaculture production so that advantage accrues to EU based business entities. The broader issues of investment and capital policy, fiscal conditions, risk environment and trade policy will all be critical in defining the shape and context of the macro scale sector.

The role of smaller scale niche producers will be less influenced by policy themes at this level, though this may depend on the extent to which marketing links are established between specialist products and more generic aquaculture output. An area which links the two however is the skill and knowledge base, and the role of specialised skills and services. The competitiveness of EU interests in these areas is recognised to be high, based on the diversity of skills and the internationalisation of experience; this will also need to be further strengthened.

NOTES

EUROPEAN PARLIAMENT

DIRECTORATE-GENERAL FOR INTERNAL POLICIES

POLICY DEPARTMENT B
STRUCTURAL AND COHESION POLICIES

Role

The Policy Departments are research units that provide specialised advice to committees, inter-parliamentary delegations and other parliamentary bodies.

Policy Areas

- Agriculture and Rural Development
- Culture and Education
- Fisheries
- Regional Development
- Transport and Tourism

Documents

Visit the European Parliament website: **http://www.europarl.europa.eu/studies**

PHOTO CREDIT: iStock International Inc., Photodisk, Phovoir

ISBN 978-92-823-3079-1