ICTSD Project on Fisheries, Trade and Sustainable Development

Aquaculture: Issues and Opportunities for Sustainable Production and Trade

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ACRONYMS

ADM	Anti-Dumping Measures
EKC	Environmental Kuznets Curve
EL	Egyptian Lira
FAO	Food and Agriculture Organization of the United Nations
FCR	Feed Conversion Rate
GATT	General Agreement on Tariffs and Trade
GBP	Great British Pounds Sterling
HACCP	Hazard Analysis and Critical Control Point
LCA	Life Cycle Assessment
LDCs	Least Developed Countries
MMT	Million Metric Tonnes
MSY	Maximum Sustainable Yield
NAFTA	North American Free Trade Agreement
NOK	Norwegian Kroner
OECD	Organisation for Economic Co-operation and Development
PCBs	Polychlorinated Biphenyls
S&D	Special and Differential
SCM	Subsidies and Countervailing Measures
SPS	Sanitary and Phytosanitary
TAC	Total Allowable Catch
TBT	Technical barriers to trade
UNEP	United Nations Environment Programme
WTO	World Trade Organization

FOREWORD

Fish and fish products provide important trade and livelihoods opportunities in many coastal developing countries. Nearly 40 percent of fish output is traded internationally with an export value of US$58.2 billion, making seafood one of the most extensively traded commodities in the world. Exports of fish products from developing countries today comprise 20 percent of agricultural and food-processing exports – more than tropical beverages, nuts, spices, cotton, sugar and confectionery combined. These exports are likely to increase as demand for fish products continues to increase. In addition to providing a significant source of export revenue for developing countries, the fishing sector also constitutes a vital component of domestic food intake and an important provider of local livelihoods.

Meanwhile, fish stocks around the world are under significant pressure with some disappearing or becoming economically unviable. The UN Food and Agriculture Organization estimates that as much as 75 percent of global marine fish stocks are now fully exploited, over-exploited or depleted, confirming a consistent decrease since 1974 in marine fish stocks with little or no potential for further exploitation. Poor fisheries management and inappropriately designed subsidies to fishing industries have been widely recognised as the key drivers of over-exploitation of fisheries resources by contributing to significant overcapacities of fishing fleets, particularly in developed countries.

Aquaculture might provide one avenue to mitigate the threats to the world's fisheries by taking at least some of the pressure off wild fish stocks while supporting livelihoods and food production. Indeed, aquaculture production has increased tremendously over the past few decades and today accounts for almost a third of global production by weight while production from wild fisheries has largely slowed or stagnated. Over 80 percent of aquaculture is taking place in developing countries, highlighting the sector's growing importance as a source of revenue and food security.

However, significant market access barriers continue to pose serious obstacles for developing countries to expand their effective and sustainable participation in international trade. Of particular concern in aquaculture trade are stringent food safety requirements in the export markets, which many developing country exporters find difficult to meet. Anti-dumping measures, such as import duties, have also been used extensively against aquaculture products, such as shrimp, catfish and salmon, by countries seeking to protect their domestic industries from cheaper fisheries imports.

At the same, serious environmental concerns have been raised related to aquaculture production, such as water pollution, increased salinity and destruction of mangrove forests. Critics have also pointed to the sector's continued reliance on fish meal as feed produced from wild-caught fish, which is feared to further contribute to the depletion of fish stocks. Others have highlighted potential socio-economic implications, resulting for instance from increased market concentration at the expense of small-scale aquaculture producers and processors.

This issue paper – published in the context of the ICTSD project on *Fisheries, International Trade and Sustainable Development* – aims to contribute to these debates in an effort to develop fisheries and trade policies and rules that are supportive of both resource sustainability and livelihoods objectives. To this end, Frank Asche and Fahmida Khatun – fisheries experts from the University of Stavanger (Norway) and the Centre for Policy Dialogue (Bangladesh) respectively – assess current and future trends in global aquaculture production. Following an evaluation of trade in and market access constraints faced by aquaculture products, the authors explore the social and economic issues arising from the increased production and trade in aquaculture and how they could be addressed. They conclude by identifying a number of policy implications and options for sustainable aquaculture development.

We hope that you will find this paper to be stimulating and useful for your work.

Ricardo Meléndez-Ortiz
Executive Director, ICTSD

EXECUTIVE SUMMARY

Aquaculture can be described in general as the process of collecting fingerlings, fry or small individuals from wild stock and placing them into an environment where farmers have sufficient control to be able to harvest them. Aquaculture is an age-old production technology that has experienced something of a revolution in the last few decades, in both quantity and quality of production. The production process for many species has become closed so that producers no longer need to collect recruits from the wild. This gives a higher degree of control over the production process and allows for more innovation and productivity growth. This has caused a substantial increase in production and aquaculture now plays an important role in the global supply of food. Aquaculture's contribution to the global supply of seafood increased from five percent in 1970 to about 30 percent in 2003. However, this increased production has also led to a number of environmental challenges.

Seaweed and Japanese kelp are the most important species in aquaculture production in volume, followed by Pacific cupped oyster and several species of carp. Tilapia is the most extensively exported species and is the ninth largest in the total production. However in terms of value, whiteleg shrimp tops the list with Pacific cupped oyster in the second and tiger prawns in the third position. Shrimps and salmonides make up over 20 percent of total aquaculture production in terms of value.

Aquaculture is becoming a global production method with about 180 countries reporting some level of aquaculture production. Aquaculture activity is particularly high in Asia, which makes up to 91 percent of the production by volume and 82 percent by value. All the other regions have a higher value share than volume share, as they produce a higher-valued product. The top ten producers by value are Japan, India, Chile, Vietnam, Thailand, Indonesia, Norway, Bangladesh, South Korea and Brazil.

Higher productivity, made possible by technological changes, and the associated reduction in production costs have been the main drivers of growth in modern aquaculture production and trade. Aquaculture products are an increasingly important source of foreign exchange in many fish-producing countries, as well as a contributor to increased food production, employment and economic development in those countries. In poor countries, aquaculture contributes to poverty alleviation and food security through employment and income generation for several million people.

Fish trade flows mostly from less developed to developed countries. China is the major exporter of fish and aquaculture products, followed by Thailand. The fish exported from developing countries include tuna, small pelagic species, shrimps and prawns, molluscs, grouper, snapper, catfish, tilapia, rock lobsters and cephalopods. The species exported from developed countries include demersal species, herring, mackerel and salmon.

Globalisation and liberalisation have opened up opportunities for trade in this sector, but have also raised a number of issues related to safety and quality. Issues such as the introduction of a mandatory Hazard Analysis and Critical Control Point (HACCP) based strategy, risk assessment, consumer information and protection, labelling and traceability have turned out to be some of the serious challenges for aquaculture-trading countries.

Various studies have shown that complex requirements covered by Agreements on the Application of Sanitary and Phytosanitary (SPS) Measures and Technical Barriers to Trade (TBT) represent threats to existing exporters and barriers to new entrants. The stringent quality standards create a bias in favour of countries with improved infrastructure and greater resources. The case of the ban imposed by the EU on imports of shrimp from Bangladesh in 1997, the case of anti-dumping of Vietnamese catfish by the US in 2002 and the case of anti-dumping of Chilean salmon and shrimp products from various developing countries by the US are a few examples of protective measures. As the main trade

flows in the fisheries sector are from developing countries to developed countries dumping of fish products tends to be blamed on developing countries by developed countries. Aquaculture has been the main target of anti-dumping measures in fisheries. It is usually the more efficient countries that are targeted, when they threaten their northern competitors. As a result, the development of a strong competitive export-oriented sector suffers a set back, with negative impacts on all participants in the sector.

These restrictive trade measures highlight a range of critical issues that will need to be addressed if the multilateral trade regime is to be successful. These issues include trade-related domestic capacity building in least developed and developing countries, implementation of the special and differential (S&D) status for LDCs in the WTO, and the need for technical assistance at the firm and policy implementation levels.

Aquaculture production has also given rise to a number of environmental problems. The environmental impacts of shrimp culture, for example, include increased soil salinity, reduction in agricultural production, decrease in livestock production and destruction of mangrove forests. Shrimp cultivation has also negative impacts on biodiversity through the destruction of trees, grasses and crabs in the areas of operation. In addition to the environmental effects, health and social issues have also been raised as major concerns. The human health impacts of farmed salmon have received attention in recent years due to high fat levels, existence of various contaminants and use of antibiotics.

The 'fishmeal trap' is a hypothesis that claims that aquaculture is environmentally damaging because it leads to increased fishing effort to satisfy increased demand for feed. For this effect to occur, however, requires two conditions to be met: the major capture fisheries of the world need to be poorly managed and there needs to be little or no substitutes for fishmeal. While the former condition is unfortunately often met, the latter is not, since there are other protein meals available as substitutes for fishmeal.

While there is little doubt that aquaculture causes a number of environmental problems, there is also evidence that these problems can be solved and examples of where aquaculture provides an environmental 'win-win' situation. In addition, as increased supply tends to reduce prices, increased supply from aquaculture will reduce fishing pressure for competing wild species.

The social benefits of aquaculture trade have accrued to the fish farmers in various forms, such as gaining social acceptance of fisheries, increased affluence in the rural communities, improved quality of life and contact with the outside world. However, there are also a number of social costs associated with aquaculture production and trade. The income distribution is often skewed in favour of large-scale farmers and owners. Small farmers lack financial resources for investment in shrimp farming, processing or trading. The gender balance in the shrimp export industry in many countries is biased toward male workers. Women can participate only in a few types of activities at low wages, including fry collection and processing work.

Conclusions and Policy Recommendations

In many ways, aquaculture is still in its infancy, and for many species one has not even closed the production cycle yet. There is therefore significant potential for further growth in productivity and reduction of production costs. As lower production costs increase profitability, this will lead to increased production and lower prices. There will certainly be boom-and-bust cycles as production at times will increase faster than the productivity growth, but the underlying trend is clearly one of sustained growth. In a worst-case scenario, there may be import bans imposed by the EU and the US because of environmental concerns. However, it is unlikely that there will be import bans on most aquaculture species, and any environmentally-driven trade restrictions are likely to influence only a few species.

While most aquaculture production takes place in developing countries, the research seems more focused on species that are farmed in developed countries. Hence, there seems to be a further productivity growth potential if more research is focused on tropical and subtropical species. Such research has the potential to be very valuable with respect to food security and economic development.

An important question is whether this growth in aquaculture production will be sustainable. The evidence so far indicates that the answer depends on the surrounding environment. There is little doubt that most, if not all, species can be farmed on a sustainable basis. In particular, most species do not require feed based on marine inputs and closed systems do not need to have unsustainable impacts on the local environments. However, if they are profitable for the individual fish farmer, unsustainable practices may be observed in the absence of enforced regulations preventing them. Since profitability is the main driver in much of aquaculture development, this is also an area where trade measures can most likely be used to improve production practices.

It is also likely that aquaculture will become associated with several positive environmental effects. The most apparent is one is on wild fisheries. As aquaculture production increases, it will limit and possibly reduce the prices paid to fishermen for most species. As this reduces the profitability in fisheries, it will reduce fishing effort and the pressure on the fish stocks. another positive effect will be increased food production and, therefore, lower food prices. This will lead to increased availability of healthy and affordable food for more people, and to a reduction in land-based food production (as this becomes less profitable for farmers) and the environmental pressures associated with it.

1 INTRODUCTION

Aquaculture can be considered a recent success story in helping to feed the world's population. Production has increased from about 3.5 million tonnes in 1970 to more than 50 million tonnes in 2003, with most of this growth taking place in the developing world, which now accounts for more than 80 percent of global aquaculture production. This tremendous growth has provided a number of opportunities for greater food security, improved livelihoods and reduced poverty. However, it has also created challenges with respect to environmental issues and sustainability.

Aquaculture can be defined as the human cultivation of organisms in water (fresh, brackish or marine). It is distinguished from other aquatic production by the degree of human intervention and control that is possible. As such, it is in principle more similar to forestry and animal husbandry than to traditional capture fisheries. In other words, aquaculture is stock raising rather than hunting.

The production process in aquaculture is determined by biological, technological, economic and environmental factors. Many aspects of the production process can be brought under human control. Environmental conditions can be controlled to a large extent, breeding programmes undertaken, and harvesting timed to ensure continuous supplies of fresh product. This is in contrast to capture fisheries, which are controlled only through harvesting regulations, if at all. And while search for the resource is a very important part of the production process in capture fisheries, no such effort is required in aquaculture.

A number of criteria can be used to classify an aquaculture system. From an economic point of view the most significant criterion is intensity, i.e. the division into intensive, semi-intensive or extensive forms of culture. Measures of intensity include stocking density, production by area, feeding regimes and input costs, while the most interesting feature is the degree of control within the production process. In intensive salmon farming, fish are reared in pens and the farmer controls factors of production such as farm size, stocking and feeding of fish. For other species (e.g. turbot, shrimp) the pens can be replaced with land-based tanks, raceways or ponds. Traditional aquaculture varies between semi-intensive and extensive. Mussel farming is an example of an extensive method used around the globe, where the farmer primarily provides a rope or a stake for the mussel fry to fasten onto, but otherwise leaves the mussel to grow. The small ponds used in Chinese aquaculture were traditionally operated on an extensive basis, as the farmer did little to control growth and biomass. While this system is still common, many farmers have become semi-intensive as they actively feed their fish and maintain higher densities as well as adapting other production-enhancing technologies.

While the intensity of aquaculture production depends on the degree of control, in reality there is a continuum of operation modes. In fact, Anderson (2002) argues that the main difference between fisheries and aquaculture is the degree of control, and that the continuum of production modes stretches from a high degree of control in intensive aquaculture to basically no control in unregulated fisheries. The argument is persuasive as it is at times hard to draw the distinction between aquaculture and fisheries. For instance, how much effort must an oyster fisherman put into the maintenance of his oyster beds before it becomes aquaculture?

A relatively intensive production technology is necessary for aquaculture to become industrialised. While most of the world's aquaculture production cannot be characterised as intensive, this seems to be the direction in which it is heading. The higher degree of control over the production process allows technological innovation to a much larger extent than other operation modes. This allows large-scale production that can benefit from cost-saving economies of scale, which is necessary if aquaculture is to fulfil its promise as a major food-producing method with global benefits. It also allows market-oriented production and logistics, so that the fish can be sold in the markets that provide the producer with most added value.

The production process in aquaculture can be investigated in terms of the interactions between technological and biological factors and the culture environment together with the social interactions and economic development it creates. However, the nature of these interactions can vary substantially for different species, production locations and markets. The physical system for a cold water species like salmon will, for instance, differ from the physical system for a tropical species like tilapia or shrimp. Similarly, the culture environment can differ substantially on the production side as well as with respect to the market where the fish is consumed.

There are therefore some important issues in relation to the future of aquaculture:

- How much can productivity increase and production costs be reduced to make aquaculture products competitive?
- What are the social and economic issues arising from the increased production and trade in aquaculture, and how can these issues be addressed?
- Can increased aquaculture be environmentally sustainable?

Certainly the responses to these issues will differ depending on the species in question and the location of the farming. Moreover, there are a number of other issues related to whether the fish is consumed locally or exported, the influences on the local societies, the distribution of value added etc.

In this paper we will examine some of these issues. We will focus particularly on salmon and shrimp, since these are among the most valuable and intensively farmed species, where many of the above-mentioned challenges show up first. While the discussion of technological and environmental issues will focus mostly on salmon, because of data availability, this should still be instructive for other species, as most of the insights can be generalised.

The paper is organised as follows. Section 2 gives a brief overview of the aquaculture sector. Section 3 then discusses technological change in the aquaculture production process and looks at issues of quantity, price and productivity. Section 4 provides an overview of the trade flows of aquaculture products, and the emerging issues relating to market access. Section 5 elaborates some of these issues and discusses briefly how they affect the aquaculture trade. The associated environmental and socio-economic impacts of aquaculture are discussed in section 6, as well as the role of aquaculture in alleviating poverty and achieving food security. This section also examines the issue of the so-called 'fishmeal trap' in aquaculture production. Finally, section 7 draws some preliminary conclusions and presents policy recommendations for sustainable aquaculture production and trade.

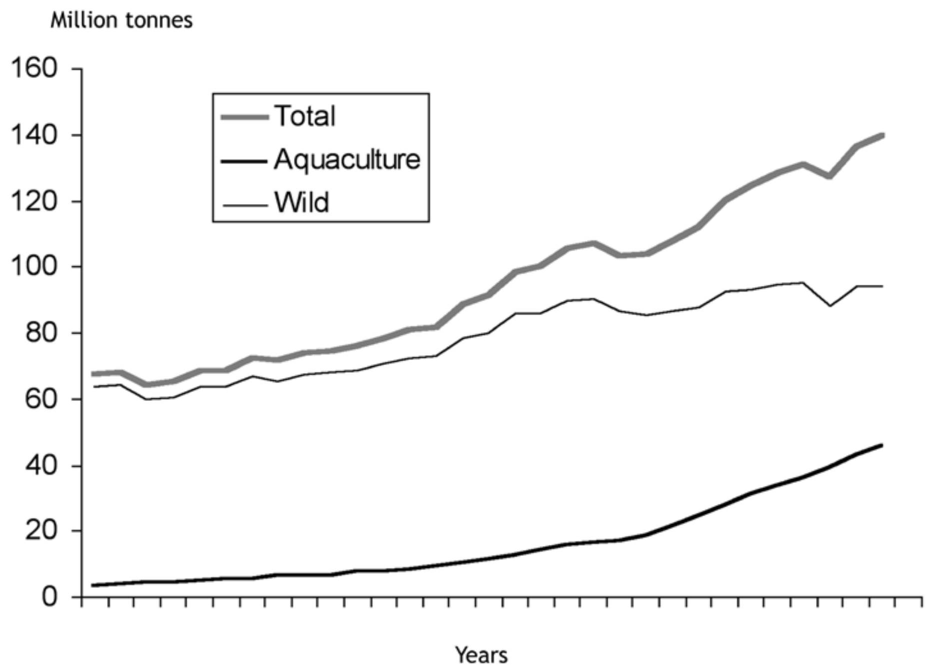
2 PRODUCTION OF AQUACULTURE

Aquaculture is a well-established production technology. It can be dated back at least two millennia in China and has been used in many other parts of the world for more than a century. Production techniques vary widely from region to region, depending on the different social and natural environments, and from species to species, depending on the different requirements. However, there are also several common features, particularly in the more extensive production technologies. In most cases, fingerlings, fries or small individuals are collected from wild stocks and placed in an environment where they can feed themselves, and where the farmer has sufficient control to be able to harvest them.

In recent decades a revolution has taken place in the production technology available for aquaculture, as semi-intensive and intensive production technologies have been invented. This has led to a substantial increase in production. Figure 1 shows the total global seafood production from 1970, together with wild and aquaculture production. As can be seen, aquaculture was relatively insignificant in 1970, making up only about 5 percent of total seafood production with a production volume of about 3.5 million tonnes. In 2003 aquaculture production had increased to about 55 million tonnes and constituted about one-third of the total seafood supply. While landings of wild fish have been stagnant since the late 1980s, aquaculture production has grown so much that it has maintained a rate of increase in seafood supply that exceeds global population growth. As a result, the global per capita supply of seafood has increased in all of the three previous decades. Hence, it is clear that aquaculture already plays a very important role in the global supply of food.

As can be seen from Table 1, Japanese kelp is currently the most important species in aquaculture production, in volume terms, making up 8.4 percent of the total volume. This is followed by Pacific cupped oyster and then several species of carp. Tilapia is the most important of the export-oriented species and the ninth most important overall, in volume terms. It is also clear that aquaculture produces large quantities of a substantial variety of

Figure 1: Global production of seafood



Source: FAO (n.d.)

Table 1: Aquaculture production in 1000 tonnes by species in 2003

Species	Volume	Percent
Japanese kelp	4614,4	8,4
Pacific cupped oyster	4376,8	8,0
Silver carp	3828,2	7,0
Grass carp	3683,0	6,7
Common carp	3239,7	5,9
Japanese carpet shell	2604,3	4,8
Bighead carp	1928,6	3,5
Crucian carp	1794,2	3,3
Nile tilapia	1367,7	2,5
Laver (Nori)	1258,5	2,3
Yesso scallop	1156,7	2,1
Atlantic salmon	1131,2	2,1
Zanzibar weed	879,6	1,6
Whiteleg shrimp	723,9	1,3
Roho labeo	713,3	1,3
Sea mussels nei	683,6	1,2
Constricted tagelus	672,4	1,2
Giant tiger prawn	666,1	1,2
Catla	566,1	1,0
Milkfish	552,0	1,0
Total	54785,8	

Source: FAO (n.d.)

Table 2: Aquaculture production in million US$ by species in 2003

Species	Value	Percent
White leg shrimp	3839,3	5,7
Pacific cupped oyster	3688,0	5,5
Giant tiger prawn	3427,8	5,1
Atlantic salmon	3405,3	5,1
Silver carp	3195,2	4,7
Japanese carpet shell	3133,3	4,7
Common carp	3014,7	4,5
Grass carp	2992,1	4,4
Japanese kelp	2809,5	4,2
Chinese river crab	1840,7	2,7
Bighead carp	1658,6	2,5
Yesso scallop	1511,8	2,2
Rainbow trout	1447,0	2,1
Nile tilapia	1438,5	2,1
Japanese amberjack	1340,1	2,0
Crucian carp	1260,6	1,9
Mandarin fish	1229,1	1,8
Laver (Nori)	1200,5	1,8
Fleshy prawn	1192,7	1,8
Roho labeo	953,4	1,4
Total	67314,2	

Source: FAO (n.d.)

species with seaweeds, mussels, shrimps as well as finfish species on the top twenty list.

Quite a different picture emerges when we look at the ranking of species in value terms (see Table 2). Although fourteen of the species on the 'volume' list are still on the 'value' list, white leg shrimp has moved from fourteenth place to first, and giant tiger prawn from eighteenth place to third. Pacific cupped oyster remains at number two. Atlantic salmon has moved up from number twelve to number four and another salmonide, rainbow trout, has also made it onto the list. Shrimps (including prawns) and salmonides together make up over 20 percent of total aquaculture production value. Hence, the most intensively produced species are also among the most valuable. These are also some of the species with the highest export shares, with their major trade flows from Southeast Asia, Chile and Norway to the EU, Japan and the US. However, the production of these species is not increasing significantly faster than other species, indicating that production costs are not reduced to a larger extent.

Aquaculture is a truly global production technology, with close to 180 countries reporting some level of aquaculture production. However, as shown in Table 3, there are substantial regional differences in production volume. Asia makes up about 91 percent of the production measured by volume and 82 percent by value. All the other regions have a higher value share than volume share, as they produce a higher-value product. This is particularly true for South America. China is by far the largest production country with a value share of 53 percent and a volume share of 70 percent. Measured by value, Japan, India, Chile, Vietnam, Thailand, Indonesia, Norway, Bangladesh, South Korea and Brazil are the other top ten producing countries. Egypt is the largest producer in Africa and is number 16 on the list. Hence, aquaculture is clearly strongest in Southeast Asia, and is primarily conducted in developing countries.

Table 3: Aquaculture production by region in million US$ in 2003

Region	Volume	Value	Percent (volume)	Percent (value)
Asia	49975,9	55103,7	91,2	81,9
Europe	2203,8	5139,5	4,0	7,6
South America	1071,2	3889,3	2,0	5,8
North America	874,6	1836,9	1,6	2,7
Africa	530,9	831,1	1,0	1,2
Oceania	129,1	513,3	0,2	0,8

Source: FAO (n.d.)

3 PRODUCTIVITY AND TECHNOLOGICAL CHANGE IN THE PRODUCTION PROCESS

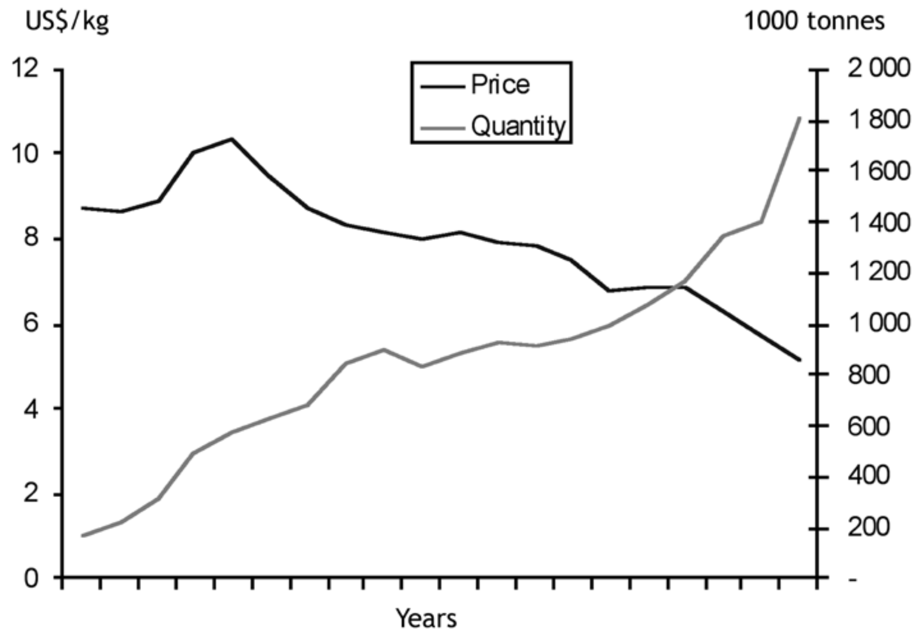
A substantial increase in the production of a particular aquaculture species usually results in a significant drop in the price of that species. For the production to be profitable, technological innovations must take place to increase productivity and reduce production cost. We will examine this process of change in this section, focusing particularly on salmon since this is the species on which most research has been conducted and for which most data are available. It is also the large-volume species with the most intensive production practice, giving it the largest potential for productivity improvements and the biggest challenges with respect to environmental sustainability. While conditions will vary in the production of other species, most of the trends and relationships described in this section can be generalised to other species.

3.1 Quantity increase and price reduction

Shrimp and salmon are good examples of species where production increases have been accompanied by price drops. Figure 2 shows the global production of farmed shrimp and the real price for the period 1984 to 2003. Production in this period increased from about 170 thousand tonnes to 1.8 million tonnes. Prices were at their highest in the late 1980s, at more than 10 US$/kg and then fell consistently, to about US$5/kg in 2003. A similar trend is seen for Atlantic salmon over the period 1981 to 2003 (Figure 3). Production of Atlantic salmon increased from about 20 thousand tonnes in 1981 to about 1.4 million tonnes in 2003 and prices declined from a high of over 7 GBP/kg in the mid-1980s to about 2 GBP/kg in 2003. The story is the same, on a more limited scale, for other salmonides like coho and salmon trout. It is also similar for sea bass, sea bream, catfish and tilapia, although the strength of the price decline varies (Asche, Bjørndal and Young 2001).

It is worth noting that the price reductions are not necessarily immediate. When the

Figure 2: Global aquaculture production of shrimp and real price (2003=1)



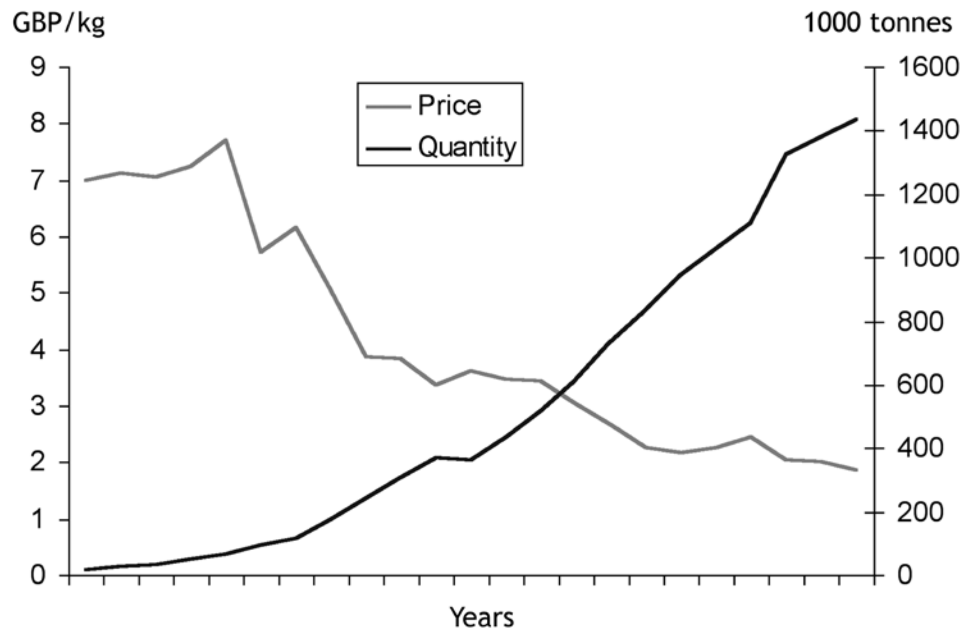
Source: FAO (n.d.); Anderson and Ass (2003).

aquaculture species is first introduced, there often seems to be an early period when demand is increasing faster than supply and prices are actually increasing. This can be explained by the fact that a stable supply of high-quality fish presents market opportunities that have not existed for the wild supply of similar fish. For instance, there is not going to be any price pressure if the farmed fish is sold in periods when there had previously been no supply of similar wild-caught fish, due to seasonality. Moreover, demand can increase when the logistical systems (such as transport and marketing) can operate with a stable and relatively predictable supply.

In simple terms, one can say that there are two main market structures that an aquaculture producer or country can face, following an increase in their production. If the market size is limited and there are few other species or products from which one can win market share, prices will decline rapidly. If, on the other hand, there is a large market where the producer or country in question only produces an insignificant share, there will not be any price effect. There is of course a continuum between these two structures, and the main reason for shrimp prices declining at a lower rate than salmon is that the global production of shrimp is substantially larger. If one looks closer at the shrimp producers, one will also observe that there have been substantial changes in the top 10 list of producing countries within short time periods (Anderson 2003), illustrating how little effect each of the large producer countries has on the price. The larger the market, the weaker the effect of any single country's production on the price and the more exposed that production will be to the impacts of changes in other parts of the world.

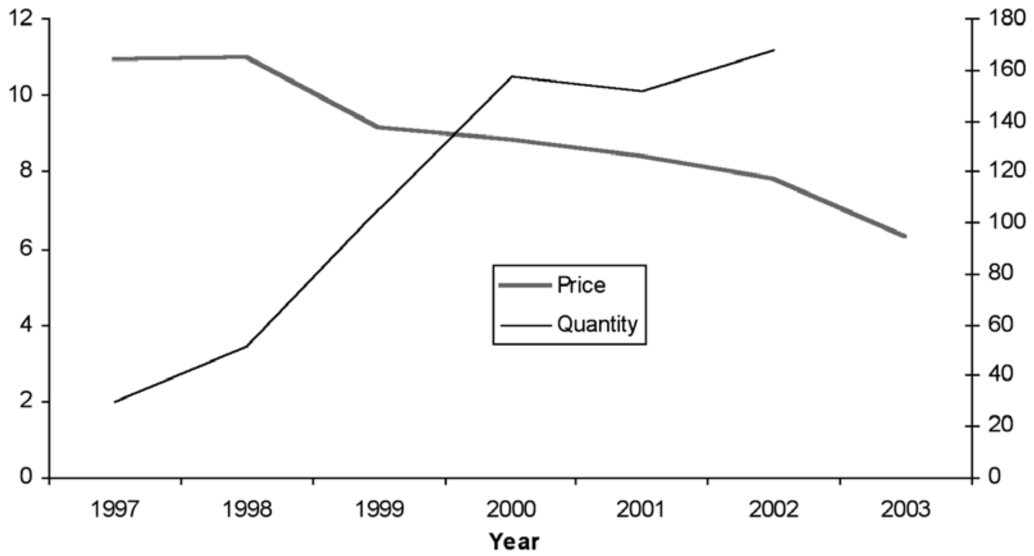
The production and price of Egyptian tilapia presents another interesting case. Egypt is the world's second largest producer of tilapia after China, but imports and exports very little. So one can say that tilapia producers in Egypt serve a market of limited size – the domestic Egyptian market. As shown in Figure 4, the period 1997-2002 saw an increase in production from about 40,000 tonnes to about 160,000 tonnes, and a halving of the nominal price of Egyptian tilapia. The observed price decline would be even stronger if adjusted for inflation. Hence, the same economic forces that influence the global market for salmon and shrimp, also work in the domestic market for tilapia in Egypt.

Figure 3: Global aquaculture production of Atlantic salmon and real price (2003=1)



Source: FAO (n.d.); Norwegian Directorate of Fisheries (various years).

Figure 4: Egyptian production and nominal price in EL for tilapia



Source: FAO (n.d.); Ana Norman (2005)

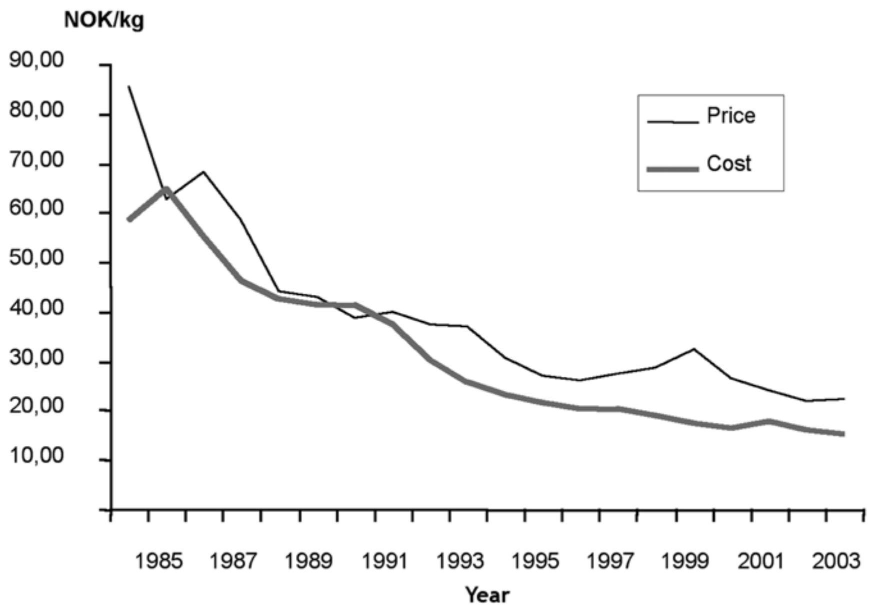
3.2 Productivity growth

So what causes this observed relationship between production levels and price? We will try to clarify this issue by looking more closely at salmon. For any product, its profitability determines the development of its production, with production tending to increase if it is very profitable. On the other hand, production will decrease if other uses of capital and labour are more profitable and if producers are losing money. The decline in the price of salmon has been necessary to induce greater consumption of the product. For this to be profitable, production costs must also have been substantially reduced. The main factors behind reduced production costs are productivity growth and technological change. In this section we will discuss the reduction in production costs for salmon aquaculture, focusing on Norway since this is the country for which data are most widely available. As the largest producer of farmed salmon, Norway can be considered fairly representative of other producers. However, at the end of the section we will also relate these results to other salmon-producing countries.

Determinants of the production-price relationship

Figure 5 shows real production cost and export price for salmon in Norway. Both variables have a clear downward trend and the gap between them is consistently small. The average price in 2003 was about a quarter of the price in 1985 and the reduction in production cost is of the same magnitude. The important message here is that there is a close relationship between the development of productivity and the falling export prices. Productivity gains are therefore able to explain a great deal of the decline in farmed salmon prices, as the price has been moving down with the production cost, keeping the profit margin relatively constant. This is also as expected in a competitive industry, since high profitability is the market's signal to increase production. As the cost reduction has been translated into lower prices, it is also clear that the productivity gains have been passed on to consumers. The main benefits to the producer are that they become larger and hence earn their profits on larger quantities produced.

Figure 5: Real production cost and producer price per kg in NOK 1985-2004 (2004=1)



Source: Norwegian Directorate of Fisheries (various dates).

The reduction in production costs has been due to two main factors. First, fish farmers have become more efficient so that they produce more salmon with the same inputs. This is what is normally referred to as the fish farmers' productivity growth. Second, improved input factors (such as better feed and feeding technology) make the production process less costly. This is due to technological change for the fish farmers, and productivity growth for the fish farm suppliers. This distinction is often missed and the productivity growth for the farmers as well as for their suppliers is somewhat imprecisely referred to as productivity growth for the whole industry. In addition, while the focus is on the production process, productivity gains in the distribution chain to the retail outlet are equally important. In the end, consumers are primarily interested in the final price for a product of any quality, and whether a price reduction is due to better feed or better logistics is of little importance.

The structure of production costs

We have seen that the production cost of salmon has been decreasing. To obtain further insight into this process it is necessary to break down the cost into different components, as illustrated in Table 4. The most important input in salmon farming is the salmon feed, which represented around 52 percent of operating costs during the period 1985-2004. Other inputs are smolts (15 percent cost share), capital (5 percent), labour (9 percent), insurance (2 percent) and materials (17 percent).

Smolts are a necessary input factor. When the smolts have been purchased, the remaining production process is determined by both the quantity and quality of smolt. The quality of the smolts influences the survival rate, the growth rate and the frequency of disease outbreaks. These are all factors related to breeding, which can have a marked impact on the cost structure. For example, there was a substantial mortality rate on Norwegian salmon farms in the 1980s, and fish that perished in the pen could not be marketed. These fish represented a direct loss as some feed and labour had been used to bring them up to the point at which they perished. Furthermore, a larger number of smolts were required to produce a given quantity of salmon. Today the survival rate is much higher (about 90 percent) because of better smolts, better husbandry practises and fewer diseases. This has contributed to reduced smolt costs. Smolts with a higher growth rate also give better exploitation of the other factors, as production and turnover rates are increased.

The production process has become more capital intensive over time, as the feeding and other processes have become automated. The cost share of capital is still decreasing substantially. This is because new equipment makes the process less costly to such an extent that it not only reduces labour cost but also the cost of capital itself. Higher turnover and growth rates for the salmon also give better exploitation of the capital equipment.

The cost of labour has also been reduced, although less than one would expect given that the production process has become more capital intensive. The use of labour has not increased at all since the late 1980s, even though total production in the industry has increased from 50,000 tonnes to almost 500,000 tonnes. This suggests that the remuneration to labour has become higher, and also that the skill level may have increased.

The share of feed has been increasing, making the production process more feed intensive. As feed is the factor most closely related to the production volume, this development indicates better exploitation of the capital and labour employed at each farm. This can be explained to a large extent by increased production on each farm. Several studies using data from the 1980s found that substitution was possible between feed, capital and labour. For instance, hand feeding was at the time more efficient than machine feeding. However, with the increased cost share of feed these substitution possibilities have been reduced. Guttormsen (2002) suggests that they have largely disappeared in the 1990s. This implies that salmon production now, after investments in capital equipment have been made, can be characterised as a technology with a close-to-fixed relative factor share in the production process. The production process then becomes one of converting a cheaper feed into a more desirable product for the consumers. So, even if the substitution possibilities between capital, labour and feed are limited, the farmers can substitute between different types of feed. Currently, about 35 percent of the feed is fishmeal which has been partly substituted with vegetable meals. About 40 percent of the feed is oil, of which fish oil currently makes up about two-thirds.

A cost share of one factor, feed, at over 50 percent may seem high, but not when compared to other comparable industries such as pork and poultry production. For example, the cost share for feed for the most efficient poultry producers is over 80 percent. This suggests that there is still a substantial efficiency potential for salmon and production costs can be further reduced if other factors are exploited even more efficiently.

The varying composition of the input use suggests that the production technology has been changing over time, and this is certainly an important factor in explaining the productivity growth. Tveterås and Heshmati (2002) found that technical progress at the farm level explains only about one-third of the reduction in production costs, with the remainder accounted for by reduced prices for input factors, or technological innovations amongst the suppliers of input factors. Tveterås and Heshmati also found that productivity growth was anything but smooth, indicating that technological progress at the farm level and among the suppliers comes in leaps and is unpredictable. With the long production time in salmon farming, this can create cycles in profitability as production costs decline, since lower production costs initially give higher profits, which induce farmers to expand production. The expanded production then drives the prices down, reducing profits.

Cycles in profitability

Cost and price do not move in complete synchronicity (see Figure 5). In particular, the margins between price and cost were narrow in 1986, 1991, 1997 and 2001, and especially wide in the intervening years. In other words, some years were much more profitable than others. This structure is commonly seen in biological industries and other industries with a substantial time lag between the decision to increase production and the entry of the increased

Table 4: Costs in Norwegian salmon farming 1985-2004 per kg salmon produced
(values in NOK, percentage cost shares in parentheses)

Type of cost	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Feed	7,96	9,47	8,51	7,89	5,41	5,03	4,75	4,8	4,36	3,8	3,74	3,06	2,65	2,21	2,51	2,4	2,17	2,00	1,89
	(0,25)	(0,30)	(0,27)	(0,25)	(0,17)	(0,16)	(0,15)	(0,15)	(0,14)	(0,12)	(0,12)	(0,10)	(0,08)	(0,07)	(0,08)	(0,07)	(0,07)	(0,06)	(0,06)
Wages	4,79	5,51	5,04	3,65	3,35	3,39	3,24	3,25	2,62	2,25	1,86	1,71	1,6	1,6	1,48	1,54	1,44	1,30	1,26
	(0,15)	(0,17)	(0,16)	(0,11)	(0,10)	(0,11)	(0,10)	(0,10)	(0,08)	(0,07)	(0,06)	(0,05)	(0,05)	(0,05)	(0,05)	(0,05)	(0,04)	(0,04)	(0,04)
Net capital cost	2,43	3,49	3,24	2,63	3,13	3,31	3,27	2,79	1,88	1,19	0,96	0,89	0,73	0,76	0,86	0,5	0,49	0,82	1,15
	(0,08)	(0,11)	(0,10)	(0,08)	(0,10)	(0,10)	(0,10)	(0,09)	(0,06)	(0,04)	(0,03)	(0,03)	(0,02)	(0,02)	(0,03)	(0,02)	(0,02)	(0,03)	(0,04)
Insurance	1,14	1,65	1,42	1,04	1,09	1,11	0,93	0,82	0,62	0,49	0,4	0,36	0,24	0,25	0,28	0,26	0,35	0,29	0,27
	(0,04)	(0,05)	(0,04)	(0,03)	(0,03)	(0,03)	(0,03)	(0,03)	(0,02)	(0,02)	(0,01)	(0,01)	(0,01)	(0,01)	(0,01)	(0,01)	(0,01)	(0,01)	(0,01)
Other costs	3,55	4,95	4,85	3,8	3,09	3,3	6,3	4,67	3,57	2,62	2,57	2,76	2,56	2,59	2,82	2,89	2,63	2,72	2,34
	(0,11)	(015)	(0,15)	(0,12)	(0,10)	(0,10)	(0,20)	(0,15)	(0,11)	(0,08)	(0,08)	(0,09)	(0,08)	(0,08)	(0,09)	(0,09)	(0,08)	(0,09)	(0,07)
Operating costs per kg	32,01	39,09	36,17	32,32	31,03	31,14	32,28	30,25	25,07	21,50	19,78	18,66	17,86	18,20	17,65	16,62	16,28	17,01	16,73

Note: Due to changes in the definition of the different types of costs, there is some uncertainty associated with comparing these over time.Source: Norwegian Directorate of Fisheries (various dates) production into the market. A high profit margin gives a signal from the market to increase the supply, but due to the time lag in increasing the production, the signal can be quite persistent. This often leads to over-investment and excess production, with the result that prices may fall to production cost levels, or even lower, for a period. The low margins will then be a signal to reduce production, which again takes time, and production will often be reduced too much, giving rise to a new period with very good margins. In a stable world, one would expect producers to work out the production level that gives normal margins. Unfortunately, the world is anything but stable and the production volume that gives a normal margin is a moving target, because of productivity growth and other supply shocks as well as exchange rate movements, demand shocks and market growth. The delay in responses from the producers will therefore produce boom-and-bust cycles at irregular intervals and with different strengths in industries like salmon production.

Cycles in profitability are not a problem in themselves, as one usually retains a substantial portion of profits at the top of the cycle to cushion the bottom of the cycle. However, many owners do not retain earnings, with the result that more firms get into trouble at the bottom of every cycle than necessary – a feature the salmon industry shares with other primary industries. The cycles also make salmon and other aquaculture industries very susceptible to trade conflict, as a number of producers will lose money at the bottom of the cycles.

3.3 Productivity development in Norway relative to other producers

Norwegian salmon producers have been the main target of several studies on productivity. Bjørndal (2002) compares cost data for Norwegian and Chilean salmon farms and concludes that the cost level in Chile is similar or lower than that in Norway, although the cost composition is different since Chilean processing costs are lower, but transportation costs are higher. Industry sources normally indicate that average production costs in Scotland are between 0.1 and 0.3 euros/kg higher than in Norway.

While a lack of data prevents us from reporting on the specific productivity development among salmon producers, it is possible to make assumptions by investigating the development in production shares. In a free market, changes in production shares exist due to differences in productivity development or production costs. On the other hand, in markets with trade restrictions and regulations, the development in production shares will show the combined effect of trade restrictions, regulations, and the relative productivity growth.

In Figure 6, we see production shares of the four largest producers of salmon – Norway, Chile, the UK and Canada – which combined represent about 90 percent of the global production of farmed salmon. The Chilean figures are somewhat uncertain, as some sources report higher production than the figures used here, but that does not change the main picture.

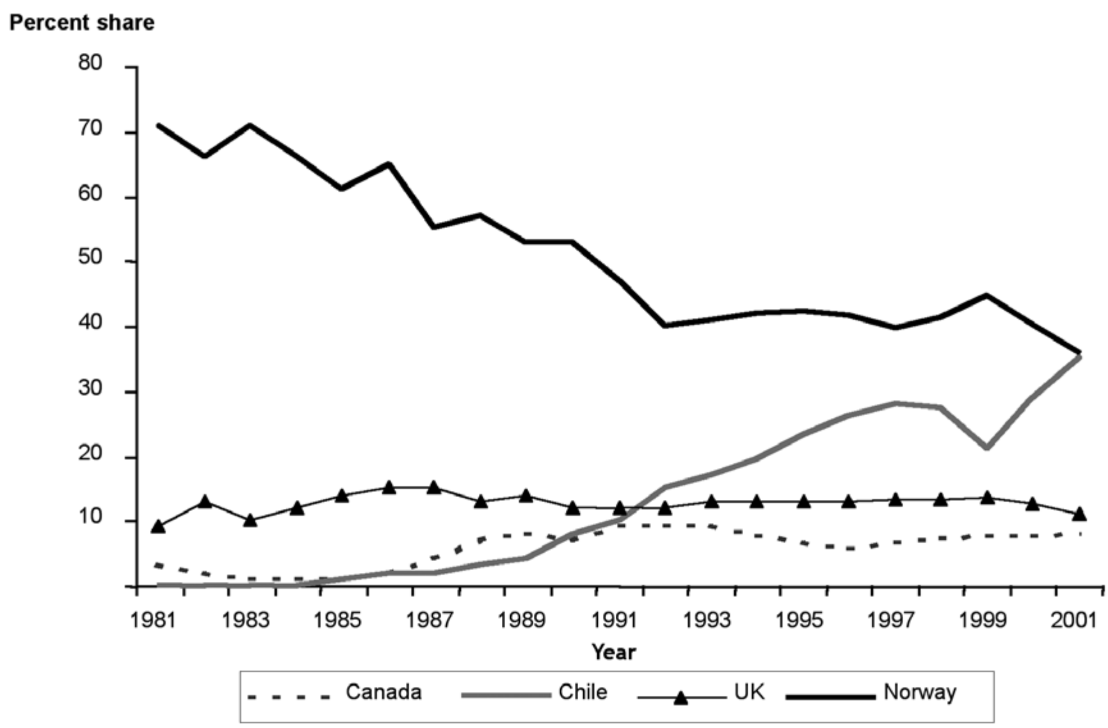
The dominating trend in Figure 6 is the development of Norwegian and Chilean shares, which decreased and increased respectively throughout the period. Norway's market share fell from 70 percent in 1981 to 40 percent in 1992. To some extent, this decline was probably bound to happen, as a result of the diffusion of best-practice production technologies from Norway to other countries. However, there is no doubt that it was accentuated by Norwegian entry and ownership regulations, as they represented incentives to invest in other countries. Since the second half of the 1980s, Norwegian capital has been involved in salmon farms in virtually all salmon-producing countries. The salmon market crisis around 1990 led to the abandoning of Norwegian ownership regulations. A restructuring process then started in Norway as firms merged and larger firms were created, actually increasing Norwegian market share from 1992 to 1995. Then, following anti-dumping allegations from the EU in 1996, new regulations were introduced, including feed quotas per farm that effectively limit production. Ever since, with the exception of 1999, Norway has been losing market share and ended at 36 percent in 2001.

In the 1990s, Chile became a major producer of farmed salmon. Currently, Chile is the second largest salmon producer, with about 34 percent of total production, and the country is expected to surpass Norway as the largest producer relatively soon. The large increase in the Chilean production has been possible due to few restrictions on salmon farming, a low cost level, and many foreign firms in the industry providing for the same knowledge base as the competitors. However, Chile also has some major disadvantages, including a lack of infrastructure in Region XI, where much of the future industry expansion may take place, and the long distance to the markets, that causes high transportation costs. Furthermore, its position as one of the major producers has led to anti-dumping complaints. The only setback in Chile's production share was in 1999, which can be attributed partly to the Asian crisis in 1997-98 influencing demand in key markets, and partly to the uncertainty following the US dumping complaint.

Canada and the UK both have access to major salmon markets: the US (through the North American Free Trade Agreement, NAFTA), and the EU. Norwegian regulations and trade problems and Chilean trade problems were expected to benefit the Canadian and British salmon producers, but both countries' production stagnated in the 1990s, and the British salmon production reached an historic low of about 11 percent in 2001. Both the Canadian and UK industries seem to have experienced a productivity growth close to industry average over the period, but neither producer has been able to benefit from the trade restrictions and regulations faced by Norway and Chile. Both these countries' industries have suffered from a lack of availability of sites, and the UK industry has also been hit by disease problems and a high value of the pound sterling that have reduced profitability levels for Scottish farmers. This is a concern for Chilean and Norwegian farmers, as it provides an incentive for anti-dumping complaints by UK producers.

The four main producers have increased their combined share of production during the last decade. The only smaller producer growing at a

Figure 6: Production shares for the four main salmon-producing countries, 1981-2001



Sources: FAO (n.d); Norwegian Seafood Exports Council (2005).

similar pace to the four major ones is the Faeroe Islands. Japan, however, the second largest producer in the world in the early 1980s, as well as the US, Australia, Ireland, and Iceland have fallen behind. It seems that regulations and problems with suitable locations have hindered growth to a large extent, even though production in most of these countries has been growing in absolute terms. It may also be that these industries, because of their small size, never realised the external scale effects associated with agglomeration and cluster effects that can be associated with a larger industry. Agglomeration effects have been revealed for Norway (Tveterås 2002), and are most likely present for the other three main producing countries as well.

Cost reductions in the supply chain

Productivity growth is most easily observed in the production process and in the main input factors but also stems from improvements in distribution and supply chain logistics. When looking at the growth of the salmon industry, it is important to keep in mind that improved logistics account for a substantial part of the productivity growth, as economies of scale and transportation methods that have not been used for other types of fish have reduced the cost of bringing the product to the consumer. To illustrate this, we can look at Norwegian and Icelandic exports of fresh cod to the UK. The fishermen's share of the retail value is about 10 to 15 percent, which is in the range observed for wild fish all over the world, and also for many farmed species. In contrast, salmon farmers receive about 50 percent of the retail value. If cod had the same efficient logistics as salmon, its price could be reduced by about 70 percent. We find a similar example in France, where the price of salmon in supermarkets is about 2 euros/kg lower than in fish markets and fishmongers' shops.

Salmon currently has the most efficient distribution and logistics system, and it is not obvious that all other species and producers will be able to achieve the same level of efficiency. This is largely down to the need for a high degree of organisation. Small-scale aquaculture producers in many developing countries will face supply chains with market clearing at each level, similar to what traditional fishermen face, and have a competitive disadvantage because of this. This is an issue that is difficult to overcome, as it is often related to how the society around the farm is organised. However, there are some examples, such as in Vietnam, where larger-scale operators invest not only in the production, but also in the whole supply chain to obtain cost savings and competitive advantage where they can be found.

3.4 An assessment of the aquaculture sector

Substantial increases in the production of species such as salmon and shrimp have led to price reductions. The speed with which price reductions follow the increased production depends on market growth and the extent to which the species in question can win market shares in existing markets rather than having to create new markets. Typically, prices will decrease faster in isolated markets, whether they are domestic or export-oriented.

With this structure, the only way for companies to survive and remain profitable in the face of decreasing prices is to reduce production costs through productivity growth. The fact that shrimp and other species continue to be farmed in increasing volumes despite reduced prices is evidence that they follow the same pattern as salmon, even though the specific elements contributing to the productivity growth can differ. For species, such as turbot, where the productivity growth is less rapid, the production increase is also substantially smaller.

For large-volume species such as salmon and shrimp, production takes place in different regions of the world. Relative productivity development (including the negative effects of diseases and trade issues) will determine where production takes place, both between and within regions. In the future, we are likely to see this kind of competition appear also between species; such inter-species competition already exists to some extent between small whitefish species such as tilapia and catfish and similar species in the same market segments. Hence, although technical progress is likely to contribute to an increase in the global aquaculture production, the production of specific countries, regions or species may be reduced.

This development is an opportunity as well as a challenge for many developing countries. Increased substitution gives more opportunities to gain market access and to win market shares. However, it also increases the potential competition. Different regions have different potential advantages. Seafood species grow faster in warmer waters, and tropical and subtropical regions therefore have a clear advantage. However, these environments suit different species than those found in colder climates, and it may be more difficult to gain consumer acceptance for these unfamiliar species. Infrastructure and production structures with many small producers can also present a challenge in gaining access to and fair treatment in global markets.

3.5 Aquaculture, trade and subsidies

It should be clear from this section that it is profitability driven by increased productivity that is the most important factor behind the growing aquaculture production. This is important with respect to the role that trade measures can have in the development of aquaculture. In many ways, control of the production process and the effect of trade measures in aquaculture is similar to that in the agricultural sector. Trade barriers will hinder trade because they reduce profitability, and will therefore influence what species and quantities are produced, and how the production process is carried out.

Subsidies are not a major phenomenon in aquaculture, particularly in developing countries (where most of the production takes place) but also in developed countries, where – in contrast to capture fisheries – few subsidies exist. Some subsidies are present, however, particularly in the start-up phase of the aquaculture industry in some countries. One can also question whether university research that benefits the sector is a subsidy. In developed countries, new aquaculture species are often supported by substantial university research and other publicly-funded research (Asche, Guttormsen and Tveterås 1999). Although this is not generally classified as a subsidy, there is little doubt that it is beneficial, particularly to developed countries. Since much of this research focuses on cold water species, it is less relevant for most developing countries and, as modern aquaculture is a knowledge-based industry, this makes it more difficult for aquaculture to develop in developing countries.

Another possible issue relating to subsidies is regional development schemes that can support the aquaculture industry. While these measures are not intended as aquaculture subsidies, they are beneficial for the industry. For instance, in the US dumping case against Norwegian salmon, it was found that interest support for industries in a remote region was a subsidy (Anderson, 1992). Similarly, in one of the dumping complaints filed against Southeast Asian shrimp farmers in the US, development aid that benefited the farmers was claimed to be a subsidy. However, while it is obvious that aquaculture benefits from any measure that supports economic activity in a region, one cannot claim that these measures are aquaculture subsidies.

Some authors also claim that externalities from aquaculture that are not accounted for as input factor costs must be regarded as subsidies, even if they are due to a lack of local management (van Mulekom et al. 2003). There are also claims that export earnings and activities, such as export-oriented aquaculture, that replace traditional activities are negative externalities. Traditionally, economics does not treat these issues as subsidies. The former issue should be treated as a lack of management, and the latter is an economic development issue, and redistribution of income is a political, not an economic issue. However, as these issues certainly influence aquaculture producers' profits, they can be influenced by trade measures.

4 TRADE IN AQUACULTURE

With the growth in aquaculture production during recent decades, international trade in aquaculture products has become an increasingly important source of foreign exchange in most fish-producing countries, as well as a contributor to food production, employment and economic development in those countries. Aquaculture products account for an increasing share of many countries' total international trade in fishery commodities. In 2002, exports of fish from countries such as Greenland, the Seychelles, Faeroe Islands and Iceland represented more than half of the total value of their exported commodities. Aquaculture trade has increased particularly in developing countries, where fish exports are now more important than exports of agricultural food products. This increase has been due to a number of factors, including the increased volume of commodities traded, a marginal decrease in the prices of major food products and a sharp decline in prices of feed. A sustained demand for fish products and improvements in technology, transportation and communication have also contributed to the increased production and trade of fish and fish products.

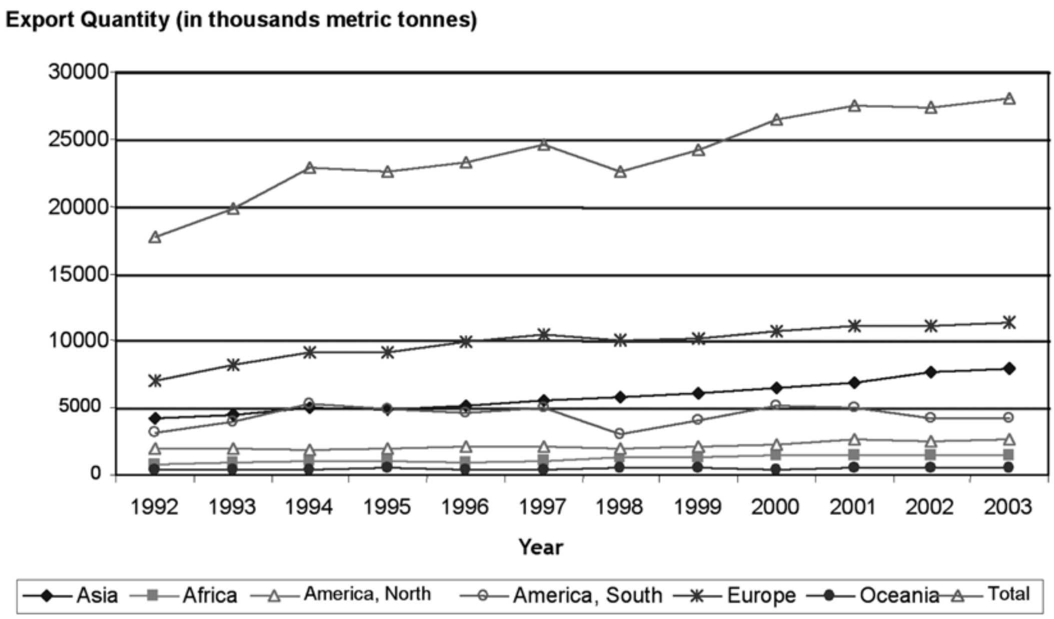
4.1 Volume and flow of fish trade

The value of world trade in fish registered a 45 percent increase during the period 1992 and 2002, from US$40.1 billion in 1992 to US$58.2 billion in 2002 (FAO 2004). The volume of fish exports increased by 40.7 percent during the same period. An initial estimate shows that total fish exports amounted to about US$63 billion in 2003 (Figure 7). On the other hand, net receipts of foreign exchange (total value of export less total value of import) derived from fish in developing countries increased from US$11.6 billion in 1992 to US$17.4 billion in 2002. Separate information on aquaculture export is not easily available.

Exports

Europe and Asia are the major exporters of fish and aquaculture products, with China and Thailand topping the list in 2002, accounting for 7.7 percent (US$4.5 billion) and 6.3 percent (US$3.7 billion) of the global fish exports, respectively. Other major exporters are the US (US$3.3 billion), Canada (US$3.0 billion),

Figure 7: Quantity of fish exported from different countries



Source: FAO 2004.

Denmark (US$2.9 billion) and Vietnam (US$2.0 billion). Chile and Norway also had net exports of more than US$1.5 billion while Iceland, India, Indonesia, Peru and Taiwan Province of China earned more than US$1 billion each in 2002 (FAO 2004). The increase in Chinese fish exports can be attributed to increased production and development of its fish processing industry, based on competitively priced labour and production costs. During 1992-2002, fish exports from China increased by an average of 11 percent per year, with a peak of 24 percent per year from 1999 to 2000 (FAO 2004). As mentioned in section 2, China is the world's largest aquaculture producer and has contributed significantly to global export growth.

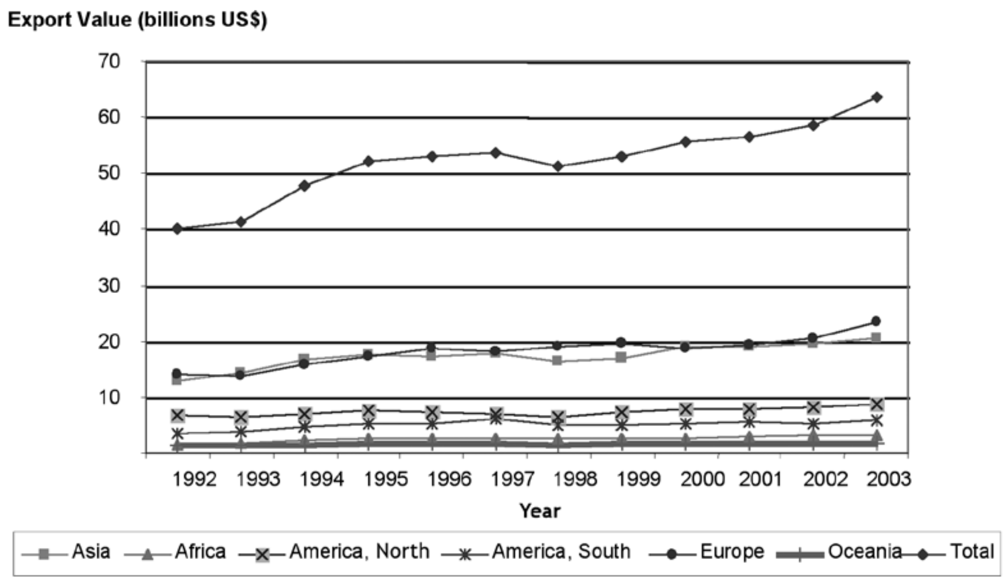
Another remarkable development has occurred in Vietnam where the export of fish and fish products increased from US$0.3 billion in 1992 to US$2.0 billion in 2002. The major share (48 percent) of Vietnam's fish exports comes from farmed shrimp (Tung, Thanh and Phillips 2004). Aquaculture has also emerged as India's most important seafood export, with a share of 60 percent of the country's total seafood exports in 2001 (Mathew 2003). In Bangladesh, shrimp exports increased from US$2.9 million in 1973 to US$297 million in 2003, some 4.5 percent of the country's total exports (Khatun 2004).

Developed countries export about 70 percent of their fish and aquaculture production (22 million tonnes of fish in 2002), while developing countries export 25 percent of their production. Developing countries' share in total fishery exports was 55 percent by quantity and 49 percent by value in 2002. These exports also included fishmeal. Developing countries export about 66 percent of total non-food fishery exports such as fishmeal.

Imports

In 2002, the value of world fish imports was about US$61 billion. Developed countries are the major importers, accounting for about 82 percent of the total value of fish imports in 2002. The largest fish-importing country is Japan (US$13.6 billion) followed by the US (US$10 billion), Spain (US$3.9 billion), France (US$3.2 billion), Italy (US$2.9 billion), Germany (US$2.4 billion) and the UK (US$2.3 billion) (all figures from 2002). Japan's fish imports in 2002 accounted for about 4 percent of its total merchandise trade and 22 percent of global fish imports. Other fish-importing countries include the Netherlands, Belgium, China, Hong Kong, Singapore and Thailand (FAO 2004). Imports by other countries are not significant. For example, India and Bangladesh import only

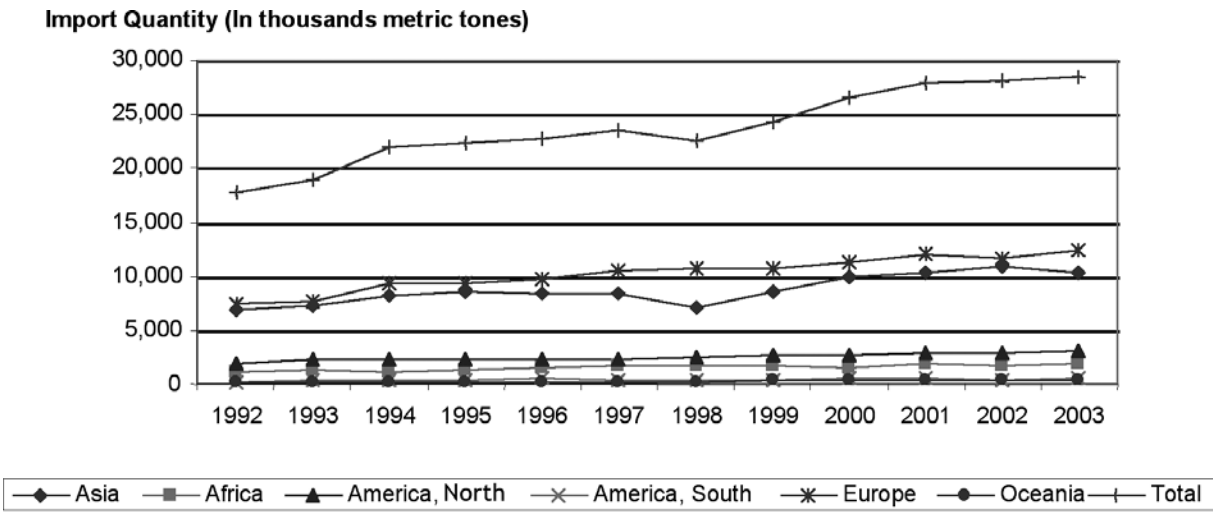
Figure 8: Export value of fisheries in different countries



Source: FAO 2004.

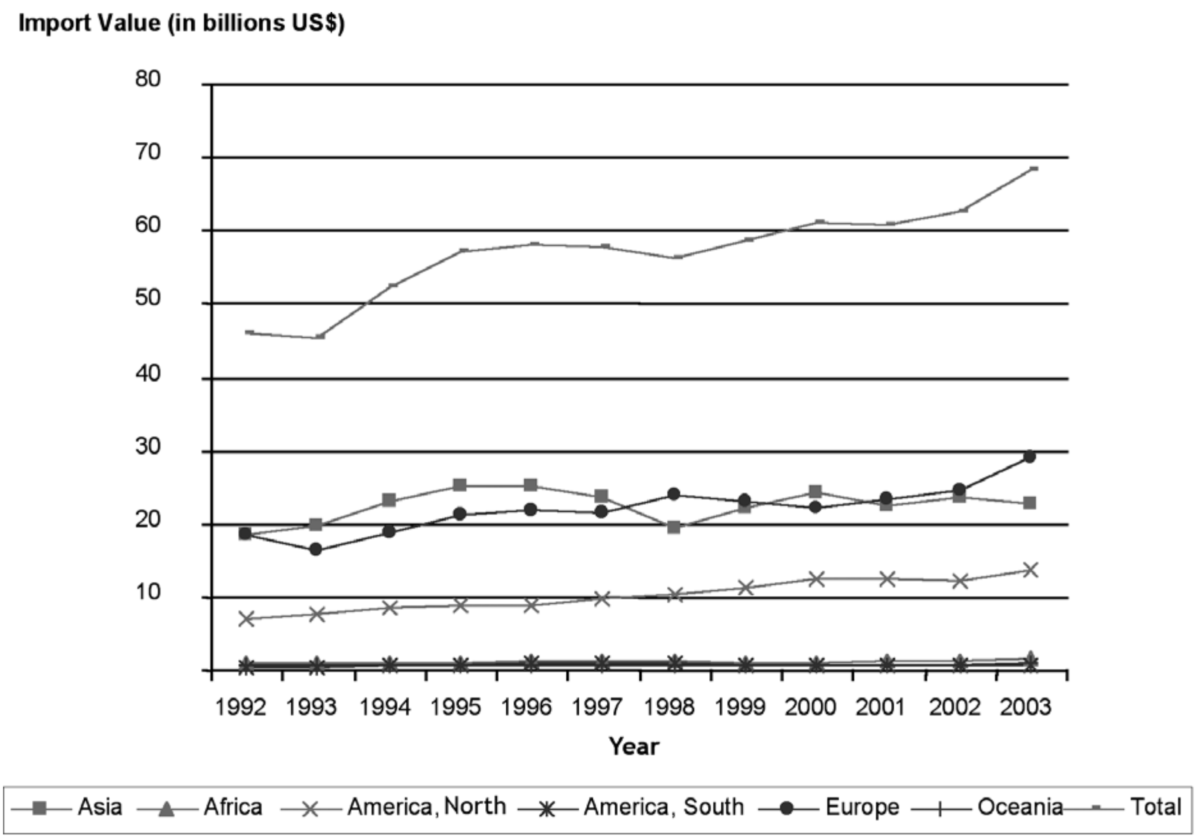
about 3 to 4 percent of its fisheries exports in value terms (FAO 2004). Figures 9 to 12 present the export and import trends of fisheries in some countries.

Figure 9: Quantity of imports by different continents



Source: FAO 2004.

Figure 10: Import value of fish in different continents

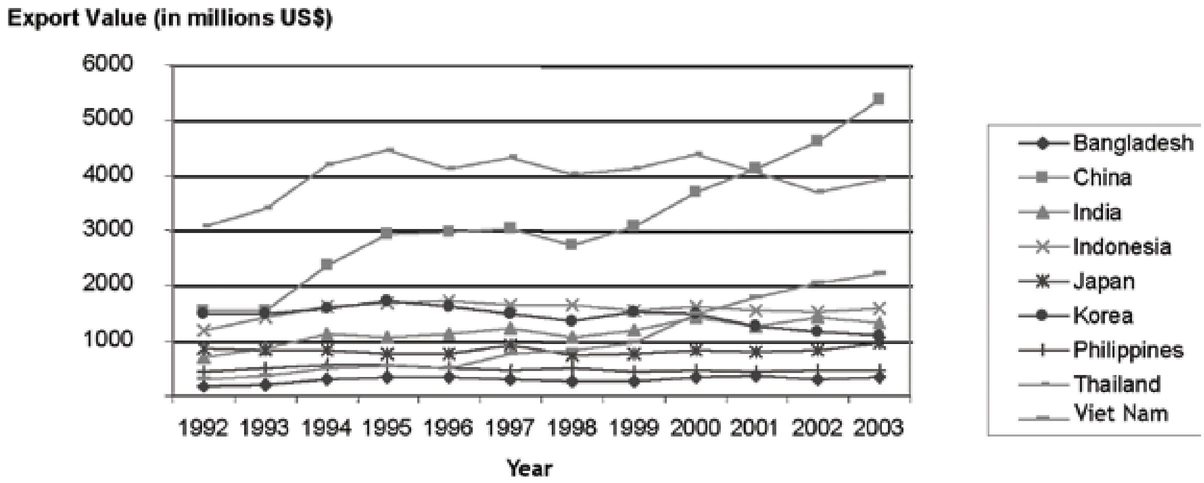


Source: FAO 2004.

Net receipts

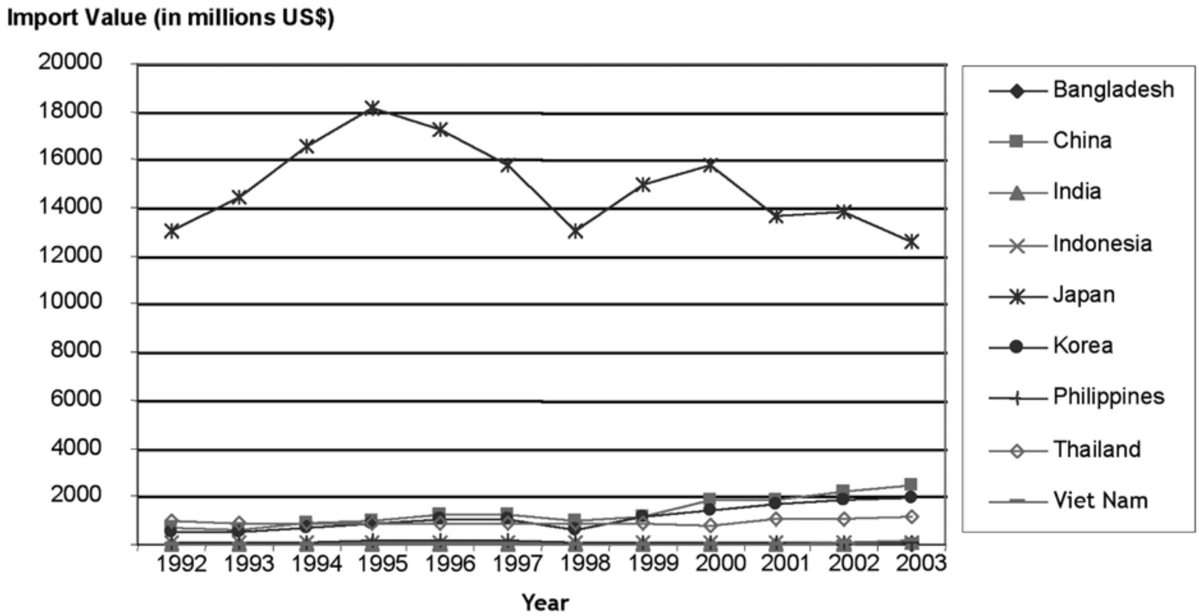
Developing countries have been able to gain positive net receipts, i.e. the difference between export and import value, through fish trade. These countries have been able to increase their foreign exchange from US$3.7 billion in 1980 to US$18.0 billion in 2000, representing a 2.5-fold increase in real terms. This increase was more than the net exports of other agricultural commodities. Canada, Chile, Norway, Thailand and Vietnam earned net exports of more than US$1.5 billion while Denmark, Iceland, India, Indonesia, Peru and Taiwan had net exports of more than US$1 billion each in 2002.

Figure 11: Country-wise export value of fisheries



Source: FAO 2004.

Figure 12: Country-wise import value of fisheries



Flow of trade

Fisheries trade flows mostly from less developed to developed countries. The list of fish exported from developing countries includes tuna, small pelagic, shrimps and prawns, molluscs, grouper, snapper, catfish, tilapia, rock lobsters and cephalopods. The fish traded between developed countries include mainly demersal species, herring, mackerel and salmon. The three import giants – Japan, the EU and the US – imported 32 million tonnes of fish and fish products in 2002, about 74 percent of the value of global fish imports. Most of the fish imported by these three countries was for human consumption (68 percent). Developing countries on the other hand imported 19 million tonnes in 2002, of which only 47 percent was for human consumption.

4.2 Traded products from aquaculture

Aquaculture production has contributed significantly to increased supply in the international fish product market. Various species of groundfish such as cod, haddock, Alaska Pollack, orange rugby and hoki, as well as shrimp, and farmed salmon, small pelagic fish, fishmeal and fish oil products are the important products traded. The following discussion on trade in aquaculture focuses only on important species such as shrimp, salmon, tilapia and catfish.

Shrimp is the most important aquaculture product in international trade. Aquaculture has been the main force behind increased shrimp trading during the past decade. Since the late 1980s, farmed shrimp has tended to act as a stabilising factor for the shrimp industry. Global shrimp production is dominated by developing countries. The major crop failures (i.e. periods of high mortality rates of shrimp due to disease outbreaks) in Asia and Latin America during the 1990s had an impact on overall supply, demand, prices and consumption trends of shrimp products. However, these problems now seem to have been largely overcome.

Shrimp trade has experienced strong growth over several decades. 2003 saw a particularly high increase in important shrimp markets, with the US (the largest importer of shrimp), importing 17 percent more (500,000 tonnes) in 2003 compared to 2002 (FAO 2004). In 2003, aquaculture production of shrimp exceeded 1.6 million metric tonnes, compared to 0.21 million tonnes in 1985 (Josupeit 2004). Moreover, prices remained low during most of 2003, and there are no indications of price increases in 2004 (FAO 2004).

Japan, the US and the EU are the major markets for shrimp. The largest exporters of farmed shrimp are Thailand, Ecuador, Indonesia, India, Mexico, Bangladesh and Vietnam. Asian markets such as China, the Republic of Korea, Thailand and Malaysia will increase their imports as their economies grow and consumer demand for seafood rises. This trend is already reducing the availability of shrimp to traditional importers, and will eventually put upward pressure on prices if supplies do not catch up with increased demand. Price increases will also encourage new entries into shrimp farming. It is expected that prices will be stabilised over time, through sustainable production (FAO 2002).

Salmon is also one of the most important aquaculture products traded. The trade volume of salmon doubled from 1.5 million tonnes in 1991 to 3.2 million tonnes in 2001. This was very much in line with the increase in salmon production (FAO 2004). Atlantic salmon is the major species traded, although a small amount of coho salmon is also traded. Norway is the largest exporter of Atlantic salmon while Chile is the main exporter of coho salmon and second largest exporter of Atlantic salmon. The main market for Norwegian salmon is the EU which accounts for about 70 percent of Norwegian salmon exports. Chile's main markets are Japan and the US, accounting for some 55 and 30 percent of Chilean salmon exports, respectively.

Farmed salmon prices showed a downward trend over the past decade, in response to increased world supply of both farmed and wild salmon. As production value has increased, costs and prices have been driven down, and at current prices salmon has become a relatively mid-priced product in the international seafood market. However, producers, particularly in Ireland and the UK, benefited from increased salmon prices in 2003.

Tilapia has taken an important position, with tremendous growth in production. International trade flows between a number of countries, including Costa Rica, Ecuador, Colombia, the US, Chinese Taipei, Indonesia, Thailand, Japan, Vietnam, Zimbabwe, Jamaica, the UK and other EU countries. In the US market, tilapia is the third most important aquaculture product in terms of quantity (56,300 tonnes in 2001), after shrimp and salmon. US imports of tilapia are expected to grow further in the future. In the long run, prices are expected to decrease with increased production. This will increase exports not only to the US, but also to underdeveloped markets for tilapia, such as Europe (FAO 2002).

American catfish is marketed mostly in the US where it is the fifth most consumed fish at present. In addition to domestic production (280,000 tonnes in 2000), the US imports catfish from Vietnam. Vietnam also supplies catfish to European markets. A strong consumer demand for white and easy-to-prepare fillets made catfish marketing successful. In 2002, Vietnam exported 21,000 tonnes of fillets to the US, which is 21 percent of the US catfish market. However, this market has now been closed to Vietnamese farmers due to anti-dumping measures.

5 MARKET ACCESS ISSUES IN AQUACULTURE

The expansion of international trade in fish and fish products has been an important manifestation of the globalisation and liberalisation process of world economies. Liberalisation through the General Agreement on Tariffs and Trade (GATT) negotiations and the establishment of the World Trade Organization (WTO) has created opportunities for developing and least-developed countries (LDCs) to have greater market access. There have been substantial improvements in terms of tariff reductions, quantitative restrictions and other trade barriers during the Uruguay Round negotiations (1986-94). However, with the liberalisation of trade through tariff reductions and quantitative restrictions, the Uruguay Round Agreement on the Application of Sanitary and Phytosanitary (SPS) Measures and the Agreement on Technical Barriers to Trade (TBT) have given rise to the possibility of introducing new measures such as food safety regulations, labelling requirements and standards. Similarly to tariff and quantitative restrictions, these trade-related technical measures can act as barriers to trade and restrict the trading opportunities available to countries (Delgado et al. 2003; Sykes 1995; Vogel 1995).[1]

Several issues have emerged as new challenges for aquaculture trading countries, particularly developing countries (Rahman 2002; Khatun 2004). These include the introduction of a mandatory Hazard Analysis and Critical Control Point (HACCP) based strategy, risk assessment, consumer information and protection, labelling and traceability.

This section discusses some of the important standards-related trade measures that may affect aquaculture trade, and includes a few case studies from developing countries to reveal the impact of such measures. A discussion on the ways to address market access issues related to these measures in the context of developing countries is also presented in this section.

5.1 Sanitary and phytosanitary measures

The SPS Agreement which entered into force in 1995 aims to reduce risk by protecting food safety and animal and plant health (WTO 1999). The Agreement covers all measures which aim to protect (i) human or animal health from food-borne risks arising from additives, contaminants, toxins or disease-causing organisms in their food; (ii) human health from animal- or plant-borne diseases; and (iii) animals and plants from pests, diseases or disease-causing organisms. SPS measures may include steps such as inspection of products, permission to use only certain additives in food, determination of maximum levels of pesticide residues, designation of disease-free areas, quarantine requirements and import bans (Zarrilli 1999). The spirit of these agreements is to ensure such measures without making any discriminatory trade restrictions. Member countries can apply different SPS measures on condition that the flexibility does not discriminate the foreign suppliers and favour the domestic producers.

The SPS Agreement stresses that SPS measures should be based on good science and be preceded by a risk assessment to determine the appropriate levels of SPS measures. The Agreement encourages governments to establish national SPS measures consistent with international standards, guidelines and recommendations.[2] The Agreement gives status and legal force to the standards set by the Codex Alimentarius Commission for food safety, the International Office of Epizootics for animal health and the International Plant Protection Convention for plant protection.[3] However, Member countries may impose higher levels of protection than the prevailing international standards provided that the regulations are based on adequate risk assessment, and the approach is consistent, not arbitrary. They also have to make the risk assessment available to other member countries in the WTO to lend credibility and transparency to the standard-setting process.

These requirements are in place to avoid levels of standards that may result in obstacles to trade or discrimination between Members with similar prevailing conditions. The effectiveness of the Agreement depends on the transparency in the development and implementation of measures and the adoption of international standards. Member countries have to notify the WTO Secretariat well in advance of any new SPS requirement or proposed modifications of existing requirements if they differ from international standards.

Recognising the predicament of developing countries and LDCs in the implementation of the SPS measures, the SPS Agreement provides for special and differential (S&D) treatment for these countries. These include longer time-frames for compliance, time-limited exceptions from the obligations of the Agreement, facilitation of developing country participation in the work of the relevant international organisations and making resources available to enable developing countries and LDCs to comply with provisions of the SPS Agreement.

5.2 Technical barriers to trade

The issues of technical regulations and standards, including packaging, labelling requirements and procedures for assessment of conformity are covered by the Technical Barriers to Trade (TBT) Agreement.[4] The provisions of the Agreement cover all technical regulations and voluntary standards and the procedures to ensure that these are met, except when these are sanitary and phytosanitary measures as defined by the SPS Agreement (WTO 1999).

The guiding principles of the TBT Agreement are: (i) non-discrimination; (ii) harmonisation; (iii) least-trade restrictive measures; (iv) equivalence; and (v) transparency. The technical regulations are implemented by governments to attain certain objectives, such as: (a) prevention of deception practices; (b) protection of human and animal health; and (c) protection of the environment.

The TBT Agreement encourages countries to participate in various international standard-setting organisations and to develop their own national standards when there is an absence of standards or the existing standards are inappropriate. Under the TBT Agreement, governments are not bound to use international standards if it is deemed inappropriate due to, for instance, technological or geographical reasons.

The TBT Agreement is of particular importance for highly perishable products such as fish and fish products for which inspection, testing procedures and stringent import requirements are needed. The introduction of stricter import requirements by major international markets has increased the importance for an unbiased and correct application of rules, standards and procedures. The issue of eliminating hidden barriers is also enshrined in Article 11 on Post-Harvest Practices and Trade in the FAO Code of Conduct for Responsible Fisheries (FAO 1995).

On the face of it, SPS and TBT measures provide WTO Members an opportunity to safeguard their interests in crucial areas such as health and hygiene. However, there is a growing apprehension, particularly in LDCs, that certain provisions of the SPS and TBT Agreements can act as border protection instruments (see Box 1). They fear that the incremental benefits of trade liberalisation under the Agreement on Agriculture (AoA) could, in effect, be undermined by protectionist use of SPS and TBT measures. Such protections may not only be aimed at safeguarding the interests of domestic industries but also the interests of favoured trading partners. More specifically, it is feared that, if special safeguard clauses are not exercised, access for LDC products to developed country markets may be seriously constrained. As a result, the export potentials, including those for aquaculture, and development prospects of these countries will be compromised.

Box 1: Non-tariff barriers in aquaculture trade – The case of Bangladesh

Various studies have shown that complex requirements covered by SPS and TBT measures represent threats to existing exporters and barriers to new entrants. This is particularly true for exports from developing countries.[5] This affects trade in agriculture and food products (Digges et al. 1997; Hillman 1997; Jaffee 1999; National Research Council 1995; Sykes 1995; Thilmany and Barrett 1997; Unnevehr 1999). The stringent quality standards create a bias in favour of countries with improved infrastructure and greater resources (Greenhalgh 2004).[6] It has also been established in various studies that SPS measures have negative impacts on fisheries resources (ESCAP 1996; Josupeit 1997; Cato 1998). Differences in quality requirements mean that developing countries find it difficult to trade with developed countries (Murphy and Shleifer 1997). The SPS measures can impact a country's trade in three ways (Henson et al. 1999): (i) prohibiting trade by imposing an import or by prohibitively increasing production and marketing costs; (ii) diverting trade from one trading partner to another by imposing regulations that discriminate between potential suppliers; and (iii) reducing overall trade flows by increasing costs or raising barriers for all potential suppliers.

Such impacts have been seen in one form or another in the case of aquaculture trade. The case of the EU ban on imports of shrimp from Bangladesh in 1997, imposed on the grounds of health safety and hygiene, is a case in point. Cato and Lima dos Santos (1998) undertook an in-depth study of the negative impacts of the EU ban on shrimp imports from Bangladesh. Export of frozen shrimp from Bangladesh to the EU was zero during the banned period (August-December 1997). The aforementioned study estimated that the cost of the EU ban for Bangladesh was about US$65.1 million. Some of the plants did succeed in diverting a large part of their intended shipment to the US and Japan and, thereby, were able to cut down their losses. In spite of such efforts, the estimated net loss was equivalent to about US$14.7 million. These were evidently only the short-term losses; the medium and long-term losses stemming from the loss of the sector's momentum, market diversions, and erosion in price offered to exporters were much higher. A recent study shows that the qualitative impacts on the rural economy and livelihoods were also significant as the ban forced the closure of up to 78 smaller plants, with the loss of many jobs (Khatun 2004).

The government of Bangladesh and the shrimp entrepreneurs made substantial investments to ensure HACCP compliance in the export-oriented shrimp sector. Special credit programmes were designed and support was sought from a number of global organisations. Cato and Lima des Santos (1998) estimated that the total cost of upgrading the facilities and equipment, and training the staff and workers to enable the shrimp sector to achieve acceptable sanitary and technical standards was about US$18.0 million. The annual cost of maintaining the HACCP programme was estimated to be US$2.4 million. Initiatives included processing upgrade to match HACCP requirements, implementation of quality control measures, ensuring that HACCP compliance is monitored on a continuing basis and providing training to the GOB staff in the Department of Fisheries and at the firm level on HACCP compliance, with the support from the Food and Agriculture Organization (FAO).

When the ban was lifted and Bangladeshi plants were allowed to export to the EU market in a phased manner, exports of shrimp to the EU began to pick up. Shrimp exports to the EU market fell from US$128.9 million in FY1997 to US$48.2 million in FY1998 and then rose to US$89.3 million in FY1999 and US$124.9 million in FY2000. Evidently, the Bangladesh shrimp industry was able to address the emergency situation caused by the ban and did recover a large part of the lost ground. However, the momentum was lost and the risk of similar punitive measures continued to haunt Bangladesh (Rahman 2002).

5.3 Anti-dumping measures

Countries take Anti-Dumping Measures (ADMs) by imposing bans and/or compensating duties on certain products to protect their own industries. These measures are taken when a product is exported to another country at less-than-production cost, causing destruction of competitor industries in the importing country. As the main trade flows in the fisheries sector are from developing to developed countries, blame for the dumping of fish products tends to come from developed to developing countries. Aquaculture has been the main target in fisheries for anti-dumping measures and it is usually the more efficient countries that are targeted when they threaten their northern competitors. As a result, the development of a strong competitive export-oriented sector in the target country suffers a set-back, with negative impacts on all participants in the sector. At the same time, anti-dumping measures give less competitive countries an opportunity to prosper.

Anti-dumping cases are becoming an increasing concern for developing countries and LDCs. They have been part of the salmon trade since 1989 but have also surfaced in the trade of several other species in recent years. This is particularly true for exports to the US, where in addition to Chilean and Norwegian salmon and Vietnamese catfish, shrimp from a number of countries and crawfish from China have also faced dumping complaints.

The use of anti-dumping measures has increased tremendously after the GATT and WTO agreements restricted the use of normal tariffs. There is therefore a substantial suspicion that anti-dumping measures are being used largely as protective measures.

An example of this is Vietnam's experience in catfish exports to the US. Catfish farming is an important freshwater aquaculture activity in Vietnam. About half of the country's total catfish exports are directed to the US market. However, the anti-dumping policy of the US led a strong decline in catfish exports to the US market. This occurred when the Catfish Farmers Association and eight individual catfish processors in the US lodged a petition in June 2002 with the International Trade Commission under the US Department of Commerce (DOC). The petitioners demanded an anti-dumping investigation into the imports of certain Vietnamese frozen fish fillets. They complained that Vietnamese frozen fish fillets were sold in the US at less-than-production value and that they were damaging the US domestic catfish industry. In January 2003, following an investigation, the US DOC ruled in favour of the US catfish industry and levied a series of tariffs on Vietnamese catfish exporters from 37 to 53 percent.

This resulted in a decline in the farm-gate price of catfish and an estimated economic loss of US$24 million to catfish farming households in Vietnam. The policy also led to the loss of employment among small-scale fish farm households, labourers and people working in processing plants. About 8,000 people lost their jobs as labourers in catfish farms and 500 workers lost their jobs from export-processing enterprises. Women and poorer groups were among the worst affected (Tung, Thanh and Phillips 2004).

It is worth mentioning two other anti-dumping cases here. In 1997, US salmon producers claimed that Chilean government subsidies were allowing producers there to sell at below-true-production cost. The Chilean government proved that no such subsidies were provided and the ITC therefore rejected the allegation. In the process, the Chilean government had to bear the cost to fight the case which was as high as US$22 million. Another company-specific anti-dumping allegation was brought by the US and set tariffs at levels around 5 percent. In February 2003, a third US government review concluded that 90 percent of Chilean producers should not be subject to duties.

A similar allegation was brought by salmon farmers in Ireland and Scotland, that Chilean frozen salmon was being sold in the EU at below-production cost which resulted in a decline in the price of salmon. The investigation of this allegation was terminated in February 2003 by the Fisheries Commission of the European Parliament. Further discussion of several anti-dumping cases for aquaculture products can be found in Anderson and Fong (1997) and Asche (1997, 2001).

The success of farming low-cost shrimp in Southeast Asia, South Asia and South America has been blamed for a price collapse and the destruction of the domestic shrimp industry in the US. The 'Southern Shrimp Alliance', representing US Gulf of Mexico shrimp fishermen, challenged six developing countries (Brazil, China, Ecuador, India, Thailand and Vietnam) for dumping farmed shrimp in the US market. The US shrimp farmers proposed that duties should be levied on imports from these countries within a range of 30 to 267 percent. In January 2005, the US International Trade Commission concluded that imports of certain non-canned warmwater shrimp and prawn from these countries were materially injuring the domestic industry in the US (ITC 2005). In response, the Department of Commerce imposed anti-dumping duties on these countries ranging from 0.07 percent to 113 percent (ITA 2005).

5.4 Ecolabelling

The certificates of approval given to products deemed to have little environmental impacts, compared to functionally or competitively similar products, are termed 'ecolabels' (OECD 1991; West 1995). In the context of fisheries, ecolabels are used to identify fish caught using sustainable methods. In the case of aquaculture, the concern is whether the fish is produced through sustainably managed aquaculture. Ecolabels rely on a life cycle assessment (LCA) to determine the environmental impact of a product 'from cradle to grave' (Staffin 1996).

Ecolabelling can help support the conservation and sustainable use of natural resources, by rewarding the use of environmentally friendly production methods (Downes and Van Dyke 1998). In the case of fisheries, the rationale for labelling information at the point of sale is that it links fisheries products to their productions process. Ecolabels are used to support claims that, for example, the products come from stocks that have not been over-fished, have been harvested with no marine mammal by-catch, or in an ecosystem-friendly manner (Deere 1999). Interest in ecolabelling in the fisheries sector is increasing and there is potential for growth in the market share of ecolabelled products. If fisheries management improves, due to efforts undertaken to comply with certification criteria, the potential benefits to fisheries will be very significant.

Many national, international, industry-sponsored, NGO-led and consumer-supplier partnership certification and standards schemes already exist in the fisheries sector and several ecolabelling schemes are in operation. Schemes related to natural resources and fisheries/aquaculture can be divided into organic and non-organic schemes (Macfadyen 2004).

Organic schemes include those developed by the International Federation of Organic Agriculture Movements, Naturland Organic Standards, Soil Association for Sustainable Agriculture Australia, BioGro New Zealand Production Standards, KRAV Kontroll AB Organic Standards, and Debio Organic Aquaculture Standards.

Non-organic schemes include those of Fundacion Chile, Global Aquaculture Alliance, Marine Stewardship Council, Seafood Choices Alliance, Marine Aquarium Council, Industry Standards For The Live Reef Food Fish Trade, Federation of European Aquaculture Producers Code of Conduct for European Aquaculture, FAO Code of Conduct for Responsible Fisheries (CCRF), and national standards and codes such as the Thai Marine Shrimp Culture Codes of Conduct.

There are also a number of social and environmental initiatives which, while not specifically focused on natural resources, may be relevant for fisheries. These include: the International Social and Environmental

Accreditation and Labelling Alliance, ICFTU/ITS Basis Code of Labour Practice, The International Labour Organisation, Ethical Trade Initiative, Fair trade, EUREPGAP, ISO 14001 Environmental Management System and European Eco-Management and Audit Scheme, Social Accountability International, Dow Jones Sustainability Indices, and traceability requirements of retailers, which can include environmental and social information on their suppliers.

Ecolabelling can be mandatory or voluntary. Mandatory ecolabelling is proposed by governments to uphold minimum standards and enable customers to choose products on the basis of their environmental impacts (e.g. the energy ratings of refrigerators). These mandatory ecolabels can act as barriers to trade for products that do not comply with the minimum requirements. In the case of voluntary ecolabelling, trade is not restricted and it is up to the manufacturer to decide whether to seek certification for a product. It is also up to the consumer to decide whether to buy a product with or without an ecolabel.

The potential costs and benefits of ecolabelling have been under debate. Some argue that ecolabelling could provide much-needed incentives for better long-term stewardship and availability of natural resources, and are therefore important for safeguarding national economic welfare. Ecolabelling can also be a help countries to fulfil commitments made under international agreements on important environmental imperatives. It could also provide new opportunities for attracting capital investments and joint ventures in developing countries. Developing countries will therefore need to find strategic trade interests within this sector.

Ecolabelling schemes have been criticised on the basis of a number of issues raised by many governments and civil society. These criticisms include:

- A lack of transparency and opportunities for participation in the development of product standards, including those relating to sustainability issues.
- The possible discriminatory effects of ecolabelling. Labels may be based on domestic environmental priorities and technologies in the importing country and may overlook acceptable products and manufacturing processes in the country of production.
- The high financial cost of ecolabelling. There are two aspects to this: (i) the cost of adjusting production processes to ensure that the product will receive the relevant ecolabels; and (ii) the expense involved in subscribing to and maintaining participation in the ecolabelling programme.
- The impacts on trade, due to institutional factors in producing countries. Institutional factors could include difficulties faced by producers in some countries in obtaining adequate supplies of environmentally friendly technologies and other materials, which are acceptable for use in, or necessary to comply with standards for ecolabelled products.
- The potential for ecolabelling schemes to create a situation where both consumers and retailers prefer to buy and stock only ecolabelled products, and where some producers may have difficulty in finding buyers for their unlabelled products.

Keeping in mind the problems associated with ecolabelling, fish producers have taken initiatives to comply with environmental standards in order to be competitive in the international market. The ISO 14000 is currently the basis for such compliance on environmental standards for products including aquaculture. The issue of fisheries sustainability is a major concern particularly for developing countries and LDCs which find it difficult to achieve certifications due to resource constraints. It is also a concern in developed countries since they may be unsuccessful in achieving certification due to their over-fishing practices.

5.5 Traceability

Traceability is another major issue for fisheries trade. The EU introduced new legislation on traceability of food stuffs including fish and fishery products from 1 January 2002. This legislation requires that all fishery products traded in the EU be labelled with information on the type of the product (whether it is farmed or wild) and the country of origin or catch area. The advantage of traceability is that it can help ensure the quality of products and identify unsafe products.

As with ecolabelling, traceability can also be associated with higher costs of the products. This raises the question as to whether such schemes are cost effective and whether less developed countries will be able to afford to comply with such initiatives. The majority of stakeholders in the fisheries sector are unaware of this measure until now and are therefore not prepared to deal with the emerging issue which is known as 'farm-to-fork' principle.

6 ENVIRONMENTAL AND SOCIO-ECONOMIC ISSUES

Over-exploitation of resources, environmental degradation, and social issues such as distributive justice have added new dimensions to the analysis of sustainable aquaculture and international trade. Environmental issues have been receiving increasing attention in major importing markets and in international trade, partly because of the ecological and environmental effects of aquaculture in Southeast Asia and in some South Asian countries. Health and social issues have also been raised as major concerns.

6.1 Environmental impacts

Aquaculture clearly generates environmental and social costs, which vary with the scale, intensity and duration of farming operations. The environmental impacts of aquaculture are seen in, for example, increased soil salinity, reduced agricultural production, decreased livestock production and destruction of mangrove forests. Aquaculture has also caused negative impacts on biodiversity through the destruction of trees, grasses and crabs in the area of production (UNEP 1999). Environmental problems are also observed in terms of displacement of wild population, genetic impacts, parasites and diseases, effects on wild life, aquaculture wastes, chemicals and antibiotics, and feeds and feed conversion ratio (Weber 2003).

Salinity

Shrimp cultivating areas have experienced declines in agricultural production and destruction of grazing land due to high salinity levels in water.[7] This has often generated fodder crises and compelled farmers to sell off their cattle which in turn has decreased the supply of milk and left a negative impact on the nutritional status of the people in the region.

Water pollution

The feed used for salmon and other carnivorous fish enters the surrounding water as uneaten feed or faeces. Such wastes from aquaculture pollute the environment and may lead to a decline in those animal species that cannot tolerate polluted water. It has been observed that about 15 to 20 percent of feed used at salmon farms is left uneaten. Nonetheless, the waste effluents may be only 5 percent of the total feed in the best-run farms where fish oil is used in feed, and husbandry practices have been improved (Burd 1997; SAMS 2002).

Increased water salinity from shrimp cultivation may create severe shortages of drinking water, which can lead to various water-borne diseases among those employed in the industry.

Biodiversity loss

Shrimp cultivation causes deforestation and destruction of homestead vegetation. In Bangladesh, for example, at least 8,750 hectares of mangrove forests have been lost due to salinity and human intervention in the shrimp farming region, causing a serious ecological imbalance (UNEP 1999).

Similar impacts have been observed in Vietnam, where shrimp farming has caused significant coastal environmental problems and loss of mangrove forests. Mangrove forest cover in the country has fallen from 400,000 hectares in 1943 to about 110,000 hectares at present (Tung, Thanh and Phillips 2004).

The method used for shrimp fry collection is also harmful for other fish species. Shrimp fries are collected from open waters, and fries of other fish are destroyed during shrimp fry collection.

Aquaculture may also be responsible for the loss of genetic diversity. For example, farmed salmon escape in large numbers each year. When breeding occurs between wild salmon and escaped salmon, the genetic make-up of the two populations will converge, and overall genetic diversity is lost. Studies in Norway indicate that the difference in some genetic traits between escaped farmed salmon and wild salmon will be halved in little more than three generations (Fleming et al. 2000).

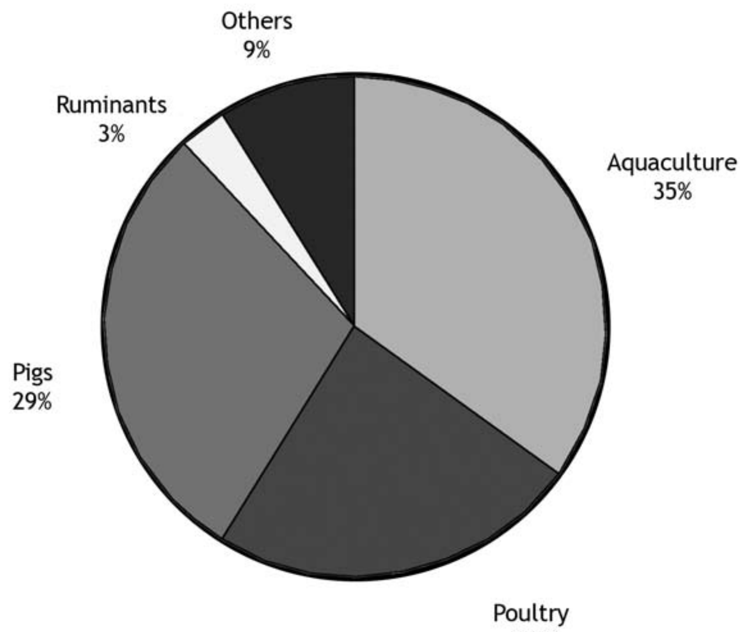
The use of pesticides and chemicals in salmon farming against outbreaks of disease and epidemics of parasites may be harmful to the environment. The use of pesticides to control sea lice has proved toxic to aquatic invertebrates and fish (Roth 2000). Salmon is treated for bacterial infections by using antibiotics and in many cases antibiotic residues in wild fish around salmon farms have been found to be higher than the recommended level (Weber 2003). Countries are now trying to minimise the use of antibiotics. Norway, for example, reduced the use of antibiotics in its salmon farming from 48,000 kg per year in 1987 to 680 kg per year in 1998 (Benbrook 2002).

Harmful fish feed

Fish feed includes metals such as zinc, copper, cadmium and mercury as supplements or as part of the meal on which the feed is based (SAMS 2002). Concentrations of some metals under salmon cages have the potential to cause damage to benthic invertebrates.

Most marine and diadromous fish species consume large amounts of fishmeal and fish oil. These carnivorous species are thus net consumers of fish. Fishmeal and fish oil are produced mostly from anchovies, sardines, capelin and sandeels. However, the opportunity for future increases in fish for the production of fishmeal and fish oil is limited. In 2002, aquaculture consumed 35 percent of the world's annual production of fishmeal and 57 percent of the fish oil. If aquaculture continues to consume fishmeal and fish oil at the current rate, it will account for 56 percent of the world's annual production of fishmeal and 98 percent of the fishmeal by 2010 (SAMS 2002). On the other hand, the efficiency of food production, as measured by the feed conversion rate (FCR) of salmon and other animals has been a matter of debate in recent years. FCR is defined as the amount of feed required to produce one unit of animal product. It takes nearly twice as much fish to produce a kilogramme of fish oil as it does to produce a kilogramme of fishmeal. So, even with an FCR of 1:1, the production of one kilogramme of farmed salmon requires two to five kilogrammes of wild fish (SAMS 2002).

Figure 13: Estimated total use of fishmeal



Source: Pike (2000).

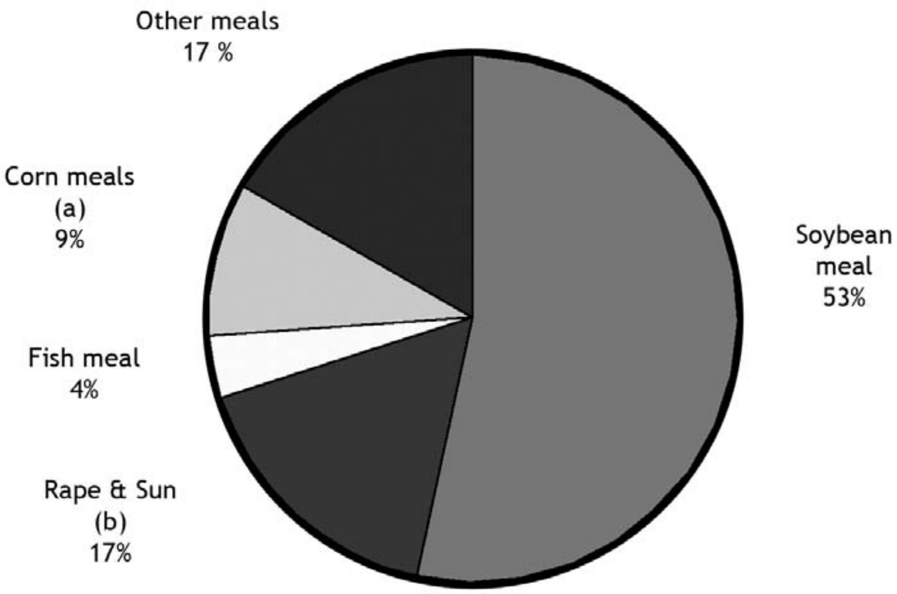
'Fish meal trap'

The 'fishmeal trap' is the name of a hypothesis that claims that aquaculture is damaging the environment by causing increased fishing effort to satisfy the increased demand for feed (Naylor et al 2000). It follows that the availability of marine feed will put a limit on how much the aquaculture sector can produce. While the fishmeal trap is mentioned in relation to aquaculture in general, it is clear that it is an issue only in some forms of finfish farming, and does not apply to farming of seaweeds and mussels. Furthermore, it will only apply to species that are fed with feed using marine inputs. This is a substantial part of the sector, as it includes not only carnivorous species like salmon and sea bass, but also omni- or herbivorous species, since the use of feed increases the growth rate. There are, however, some conditions that must be fulfilled for the fishmeal trap to occur. This section discusses these conditions, following Asche and Tveterås (2004).

The potential environmental problems associated with aquaculture's fishmeal trap can be broken down into two key issues, one pertaining to the regulation of capture fisheries and one pertaining to the market for protein meals. The extent to which increasing demand for fishmeal increases fishing effort is related to the management regime in operation for the fishery in question. Hence, whether growth of aquaculture production may lead to unsustainable capture fisheries is primarily a fisheries management issue. However, as the track record of many fisheries management systems is not too good, this can be a real problem. It does, however, require that aquaculture growth increases total demand for fishmeal.

The extent to which increasing aquaculture production increases fishing pressure depends on whether there are substitutes for fishmeal. There is little doubt that the markets for fishmeal are global. In fact, this is a main part of the criticism against the aquaculture industry, as it is the prime example that its negative environmental effects are global and not only local. The aquaculture industry is, however, far from the only consumer of fishmeal. Figure 13 shows the main sectors that use fishmeal As one can see, pig and poultry farming jointly consume 53 percent of the production, while the aquaculture share is 35 percent. Moreover, for most of the species that use fishmeal as feed, this is only one part of their diet. Other

Figure 14: World production of protein meals 1996/97



Source: OW (1999).Note: (a) Corn germ and corn gluten feed. (b) Rapeseed meal and sunflower seed meal.

protein meals, particularly soyameal, make up the major share of the diet. If one looks at the total market for protein meals in Figure 14, global fishmeal production is minor compared to total protein meal production.

When examining the development of fishmeal use, one can also question whether aquaculture's share really is increasing. In Table 5, we show total availability of fishmeal, which is relatively stable but cyclical, world aquaculture production of finfish and shrimp, their use of aquafeeds and the share of fishmeal going to aquafeed. It is clear that the quantity of fishmeal going to aquafeed was increasing strongly until 1997 and has since stabilised at between 2 and 2.5 million tonnes. Still, aquaculture production continues to increase. Hence, it is far from obvious that there is a close link between aquaculture production of the species that are thought to be most dependent on fishmeal, and fishmeal use.

Fisheries management

The different management forms in the world's fisheries can be categorised into three main groups: open access, sole-owner (or optimal management), and restricted open access (where the stock is protected with a quota and potentially additional measures). The extent to which the increased demand for feed for aquaculture will increase fishing pressure will depend on the management regime.

The world's reduction fisheries are mainly based on small pelagic species.[8] Pelagic fish are used both for human consumption and for reduction, i.e. production of fishmeal and fish oil, but

Table 5: World aquaculture production of finfish and shrimp in millions of metric tonnes (MMT), the production of fishmeal and the use of fishmeal in aquafeed

Year	Fishmeal				Reference
	World aquaculture production[1] (MMT)	World fishmeal production[2] (MMT)	Use in aquafeed		
			Use (MMT)	% of WP	
1988	8.20	6.85	0.69	10.1%	New, Shehadeh & Pedini (1995)
1992	10.90	6.25	0.96	15.4%	New and Wijkström (2002)
1994	14.06	7.48	1.27	17.0%	Pike (1998)
1995	16.10	6.85	1.73	25.2%	Tacon (1998)
1996	18.04	6.92	2.00	28.9%	Tacon (1999)
1997	19.97	6.54	2.32	35.5%	Tacon (1999)
1998	21.24	5.33	2.13	39.9%	IFOMA
1999	23.09	6.66	2.10	31.6%	IFOMA
2000	24.57	7.04	2.46	34.9%	Pike and Barlow (2002)
2001	26.36	6.22	2.49	40.0%	Pike and Barlow (2002)
2002	27.94	6.48	2.22	34.2%	Barlow (2003)
2003	29.83	5.58	2.00	35.8%	GAFTA – 2004

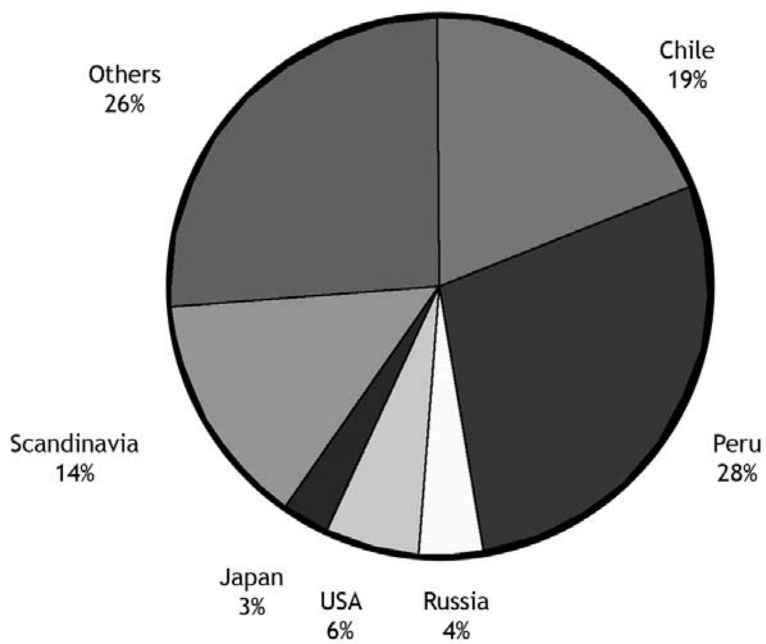
1 World production of finfish and crustaceans FISHSTAT, FAO 2004.
2 World production of fishmeal FISHSTAT, FAO 2004.

certain species are only fit for reduction due to their consistency, often being small, bony and oily. Annual catches in the 1990s with the main purpose of reduction to fishmeal usually amounted to approximately 30 million tonnes, giving an average of 6 to 7 million tonnes of fishmeal. The main reduction fisheries nations in 1997 and the percentage of the global fishmeal production are shown in Figure 15. Chile and Peru alone deliver over 50 percent of the global fishmeal production based on their rich fisheries of Peruvian anchoveta, Chilean jack mackerel, and South American pilchard. Other substantial producers are the Nordic countries Denmark, Iceland and Norway, whose fisheries combined provide 15 percent of the global fishmeal production.

One characteristic of pelagic fisheries is that while the quantity going directly to human consumption stays relatively stable, the 'surplus' that goes to reduction can vary dramatically (Hempel 1999). Thus, in years when the catches are low, such as in El Niño periods, there is little surplus and the fishmeal industry is hit hard. There are no indications that increased use of fishmeal in aquaculture has led to any increase in the share of the pelagic species that are used for fishmeal production. Moreover, as one can see from Figure 15, about three-quarters of the global fishmeal production takes place in South America or the OECD – regions where these species have never been important for human consumption. Hence, the extent to which fishmeal producers compete with humans for the resource is a local issue, not linked to the global fishmeal market or the aquaculture industry. The pelagic fisheries have also generally been described as fully exploited or over-exploited by the FAO (Grainger and Garcia 1996). A significant expansion of the global fishmeal production, beyond the 6 to 7 million tonnes that is normally produced, is therefore unlikely unless prices for fishmeal increase substantially.

In the case of sole-owner, or optimal management, the size of the landings responds to the increased prices. However, the biomass will always be higher than the biomass associated

Figure 15: World fishmeal production in 1997



Source: FAO (n.d.)

with Maximum Sustainable Yield (MSY). So one can hardly argue that the fishery poses a threat to the stock under optimal management. If the fishery is regulated by a quota that is set without regard to economic factors, the quota remains the same when demand changes, and the biomass remains the same, but the value of the catch increases. The obvious conclusion is that if the fishery is not allowed to respond to economic incentives, the increased demand for reduction species will not have much effect other than, for example, reducing the length of the fishing season.

The real problem is therefore in open access management, since increased demand for a species in this scenario might lead to serious depletion of the stock, and will increase the risk of extinction.

So what management system is used in industrial fisheries for the most important stocks? The stocks of Peruvian anchoveta and Chilean jack mackerel have shown vulnerability both to the weather phenomenon El Niño and to poor fisheries management. The fisheries management has, however, improved over the last decade, with increasingly stricter regulations on inputs. The most important tools used in Chile and Peru today are Total Allowable Catches (TACs), limited access, input factor regulations and closures that are imposed on the fisheries in certain periods and certain areas.

The industrial fisheries in the Nordic countries are regulated by TACs, often in combination with other restrictions. In the late 1960s and early 1970s, the herring stock collapsed, but the overall state of the fisheries for reduction in the Nordic countries has improved, and several of these stocks have been rebuilt to the pre-collapse levels. In the US, the menhaden fishery is the main industrial fishery, and here also the fishery is regulated with a TAC.

A first glance the management situations for the most important pelagic fisheries do not seem too bad, and do not appear to be ones of 'open access'. However, quotas tend to be high and one may often question whether the state of the fish stocks has the main priority when the quotas are set. Hence, it is not clear that the situation is very different from what it would be under open access. Whether increased demand for fishmeal from a growing aquaculture industry is harmful to the state of the fish stocks that are targeted in industrial fisheries will thus depend largely on the market structure for fishmeal.

Markets for oil meals

Given the poor management of fish stocks under current management practices, the extent to which increased demand from aquaculture will affect prices will be determined largely by the market structure for fishmeal. To determine the position of fishmeal in the protein meal market, Asche and Tveterås (2004) investigated its relationship to soy meal, since soy meal clearly is the most important vegetable meal. They analysed the relationship between fishmeal and soy meal prices from Europe and the US in the period from January 1981 to April 1999. The price trends for the two meals turned out to be very similar, and reacted in the same way to factors such as El Niño years and strong growth in intensive aquaculture production. The results suggest that the markets for fishmeal and soy meal are highly integrated and that the two products are strong substitutes. Total demand for fish and soy meal, possibly together with the demand for other protein meals, thus determines the price of these protein meals. If aquaculture is to influence the price of fishmeal with this market structure, the changes in demand or supply must be large enough to affect demand and supply for fishmeal and soy meal combined. It is, however, unlikely that increased demand for fishmeal from the aquaculture sector will lead to increased prices for fishmeal, since it has only a negligible share of the market. It is also unlikely that increased demand for fishmeal from the aquaculture sector will increase fishing pressure in industrial fisheries.

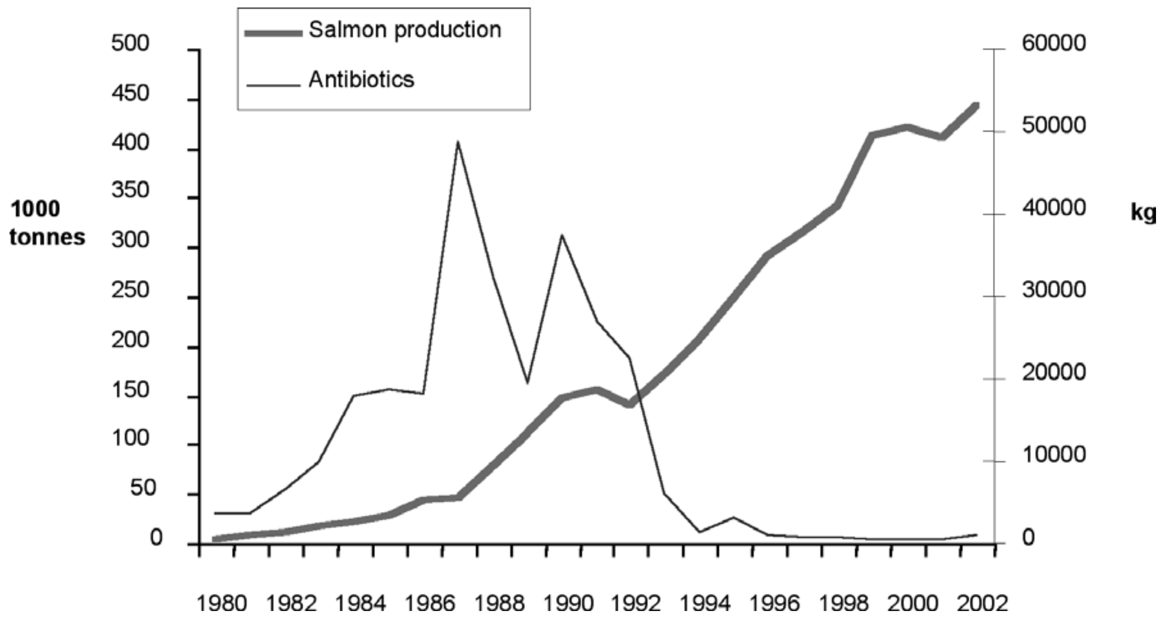
To conclude, increased demand for fishmeal from a growing aquaculture sector has the potential to increase fishing pressure in industrial fisheries. It does, however, require that the fisheries are poorly managed (or not managed at all) and that there are no close substitutes to fishmeal. The most important fish stocks in reduction fisheries can be described as regulated open access. If this management regime is efficient, increased demand from aquaculture does not pose a threat to the fish stocks. There are, however, many indications that quotas are set higher then biological recommendations and that stocks might be over-fished. With such a situation one might not be too far from open access. If so, increased demand for fishmeal may well increase fishing pressure.

Poor fisheries management alone does not cause increased fishing pressure – there must also be no close substitutes to fishmeal, since close substitutes would alleviate the pressure on the fishmeal market and consequently the fisheries. Asche and Tveterås (2004) indicate that fishmeal is part of the large protein meal market, and, in particular, that fishmeal is a close substitute to soyameal. With such a market structure, it is total supply and demand for protein meals, of which fishmeal makes up only 4 percent, which determines prices for fishmeal. One is then led to the conclusion that increased demand for fishmeal from aquaculture cannot have had any significant impact on fishmeal prices in the long run, and accordingly cannot have led to increased fishing pressure. However, demand for fishmeal from aquaculture has grown from basically nothing to 35 percent of total production in only twenty years. If demand for fishmeal from the aquaculture sector continues to grow, it is possible that the market structure may change. However, this does not have to be the case, since it is not clear that the demand for fishmeal from the aquaculture sector is mainly because of the unique characteristics of fishmeal. What is clear though is that the current market structure prevents increased demand for fishmeal to have a negative impact on industrial fish stocks. Moreover, as productivity increases and lower production costs have been the main drivers for the growth of the aquaculture sector, increased prices that would follow a shortage of fishmeal and oil will reduce demand. However, the only measure that can ensure that demand for fishmeal does not have a negative impact on these fish stocks due to increased fishing pressure is good fisheries management.

Solutions to environmental problems

While there is little doubt that aquaculture gives rise a number of environmental issues,

Figure 16: Norwegian salmon production and antibiotics use in Norwegian aquaculture



Sources: Norwegian Fisheries Directorate (2005); Norwegian Medicinal Department Database.

there is also evidence that these problems can be solved. Asche, Guttormsen and Tveteras (1999) argue that many of the problems cannot be discovered until large-scale production is taking place, and a problem must be discovered before it can be solved. In fact, many of the environmental problems are solved some time after they have been discovered, and Tverterås (2002) argues that, in the case of salmon, the relationships take the form of an Environmental Kuznets Curve (EKC) and provides evidence that this is the case for the use of antibiotics and chemicals in Norwegian salmon production.[9] This is clearly shown in Figure 16 for the case of antibiotics use.

There are two main reasons why the aquaculture producers will correct the environmental problems that aquaculture can cause. For some problems, such as disease and antibiotics, which directly influence the producers' production costs, it is beneficial for the producers to solve them. In other cases, the aquaculture producers can be regulated so that they do not impose the negative externalities of environmental impacts on the society.

Whether aquaculture is sustainable is primarily a function of the regulatory environment under which it operates. For instance, it is not accidental that the 'pond' in turbot farming in Spain is isolated from its surrounding environment with watertight material and discharges are pumped out and given special treatment, while such practices are much laxer in other countries, such as Bangladesh. Furthermore, it is not a requirement that shrimp farming in Bangladesh has to take place in mangroves, and it has indeed been moving away from these areas. Rather, aquaculture producers, like any other producers, will tend to use the most profitable production practice. Environmental issues that affect their profitability through their production cost will be corrected if it is profitable to do so, or if one is forced to do so by regulations. Environmentally unsustainable practices will be used only when they are most profitable and when there is nothing to prevent someone from using them. One of the main reasons for destroying mangrove forest to make room for aquaculture was that this was cheap land as nobody else used it, not because it was especially suitable for shrimp farming.

Though it is clear that very extensive aquaculture technologies will have very little environmental impact, it is surprising that very intensive systems in most cases will be the best

Box 2: Aquaculture production in India

The extent of the environmental impacts of aquaculture depends on the size of the farm, the density of fish per pen, the duration of the farm at a particular site, the physical and oceanographic conditions at the site, the biota of the area, and the capacity of the environment to absorb the wastes (Weber 2003). In India, aquaculture provides an environmental 'win-win' situation in coastal Kerala region where rice and shrimp crops can be rotated on the same land (Kaushik and Saqib 2003). Aquaculture cannot be practised during the monsoon season but rice can be grown during this period. In the Indian context the concern that shrimp farming causes degradation of coastal zones, has proved baseless. Rather, the shrimp farms protect coastal zones against sea-erosion during the monsoon season. Aquaculture units are set up in fallow areas where land is inundated with saline or brackish water and the units do not encroach upon the traditional fishing or farming zones. A study by the National Environmental Engineering Research Institute (NEERI) of India found that there is no seepage of drinking water wells because of shrimp farms, and deterioration of ground water quality was not observed around the pond sides. The cost of aquaculture in India is also much lower than the return. Capital costs per unit of 180 hectares of shrimp farms amount to Rupees 180,000 whereas the return from shrimp farms is Rupees 280,000 per 180 hectares, making it a profitable business.

alternative. Shrimps serve well to illustrate this. Semi-intensive shrimp farming typically includes digging a pond with no firm isolation between the water in the pond and the soil, and the pond is densely stocked. Fingerling is then captured from wild stocks using nets with very fine meshes, killing substantial biomass of other species in the process. A pond that is less densely stocked, with good isolation between the soil around the pond and the pond and with water cleaning and discharge systems does not have to lead to soil degradation. In addition if one has control of the full production cycle so that the fingerlings are produced in specific plants rather being captured from the wild, this environmental impact disappears.

However, though the economic benefit of aquaculture may be high and the environmental problems can be dealt with, the environmental impact may persist in the long run, and some of the negative impacts may be irreversible, as in the case of biodiversity loss or human health impacts.

6.2 Health impacts

The human health impacts of farmed salmon have caught public attention in recent years due to high fat levels, existence of various contaminants and use of antibiotics. It was found that the flesh of farmed salmon had more fat than did wild salmon (Bell and Paone 2001). While this provides positive health effects as it increase the content of Omega 3, it also raises health concerns as it increases the levels of dioxin, polychlorinated biphenyls (PCBs) and other chemicals in fish oil. Dioxin and PCBs are considered among the most toxic man-made chemicals and are thought to cause cancer, disrupt the endocrine system, cause developmental and reproductive problems and other health problems (Huwe 2002). Fatty fish like salmon accumulate these chemicals in their fat (Jacobs et al 2002).

Environmental problems such as water pollution due to salinity can also have serious health impacts in terms of increased morbidity and mortality. The economic value of the health impacts of polluted water due to shrimp cultivation in Bangladesh has been estimated to be as high as US$23 million (UNEP 1999).

6.3 Socio-economic impacts

Social benefits of aquaculture trade can accrue to fish farmers in various forms, such as gaining social acceptance of fisheries, increased affluence in the rural communities, improved quality of life and contact with the outside world. However, there are also a number of adverse social impacts associated with aquaculture production and trade. The income distribution is highly skewed in favour of big farmers and owners of the business. The small farmers lack financial resources for investment in shrimp farming, processing or trading. The gender balance in the shrimp export industry in countries such as Bangladesh and India is also biased toward male workers. Women can participate in only a few types of activities at low wages. Lack of resources limits their choice of activities in shrimp aquaculture only to fry collection and processing work at the shrimp depots and processing centres. Women are also vulnerable to harassment and torture by the male co-workers and the owner of shrimp farms.

The positive impact of the sector is not equal across the whole production and export chain. Recent studies in Bangladesh, Guinea, India, Uganda and Vietnam show that fry collectors, aquaculture labourers in depots, hatcheries and processing factories, basket weavers, maintenance workers, porters and fish smokers are still in the category of 'very poor' (Khatun 2004; N'Dia 2004; Salagrama 2004; Blackie 2004; Tung, Thanh and Phillips 2004). These groups of workers do not have any production assets. Regular employment is also seasonal, making their income levels highly variable. They can afford very little food for their families during periods when little or no job opportunities are available. Small-scale aquaculture farmers, local fish processors and traders, hatchery workers, owners of fish ponds and procurement staff of processing plants and auctioneers earn a moderate income. In terms of wealth status, they sometimes own some agricultural land and a small capital.

The large-scale aquaculture producers and owners of hatcheries, depots, processing factories, ice plants, trading and export business are well-off and contribute to economic development in the region. They also contribute to economic activity in the societies in general through their higher demand in the production process as well as through their private consumption. The severe socio-economic impacts of the closing of the European market for shrimp also indicate that while the majority of the stakeholders in the industry are poor, they are better off than with no aquaculture.

Notwithstanding the fact that the benefits of aquaculture development are not distributed equally among the stakeholders, the sector is one of the fastest growing food-producing sectors which contribute to poverty alleviation, food security and income generation (Subasinghe 2003). It is an important source of income opportunities for those who have very limited choice of livelihood opportunities in poor economies. Aquaculture is an important source of employment, particularly in developing countries which are the major producers of aquaculture and where the majority of the poor live in rural areas. The increase in aquaculture production over the last few decades has also continued to increase employment in the sector. Thus in poor countries, aquaculture contributes to poverty alleviation through employment and income generation for several million people which in turn helps achieve food security.

The number of fishers and fish farmers in the world has been growing rapidly. In 2002, fishery and aquaculture production activities provided direct employment and revenue to an estimated 38 million people (FAO 2004). In the same year, fishers and aquaculture workers constituted 2.8 percent of the 1.33 billion people economically active in agriculture worldwide, compared to 2.3 percent in 1990 (FAO 2004). A significant number of people are involved exclusively in aquaculture. Marine and inland water fishing accounted for 75 percent of total employment while aquaculture provided employment to 25 percent of the fishers and fish workers (FAO 2004). These figures are only indicative, as complete data on the number of aquaculture workers worldwide are not available. Some countries do not collect employment data separately for the two sectors while other countries' national systems do not account for fish farming. Table 6

Table 6: World fish farmers
(in thousands)

Region	1990	1995	2000	2001	2002
Asia	3698	6003	8503	8720	9502
Africa	-	105	112	115	111
Europe	11	36	37	39	39
North and Central America	53	74	74	69	65
Oceania	negligible	1	5	5	5
South America	16	88	92	92	93
World					
Fishing	*-*	*-*	*26,974*	*27,494*	*27,980*
Aquaculture	*3778*	*6307*	*8823*	*9040*	*9815*

Source: FAO 2004.

presents aggregate information on the number of people engaged in aquaculture in different continents of the world.

The partial statistics that are available indicate that the number of fishers and fish farmers has increased by about 8 percent per year since 1990. However, in many developed countries a levelling-off has started to occur since 2000. This may be due to a decline in the rate of growth of farmed fish and shellfish production (FAO 2002).

Developing countries are the source of about 70 percent of the global fish for human consumption. The fisheries sector is particularly important for 44 countries, including 15 small island developing states, 3 transition economies, 12 African, 12 Asian and 2 Latin American countries. In these countries, the sector contributes to both foreign exchange earnings and domestic nutritional intake. Developing countries contribute over 90 percent of the total global aquaculture fisheries production (Subasinghe 2003).

In developing and poor countries, the spouses and families of fishers are also involved in artisanal fisheries and associated activities. Though these part-time and unpaid family workers do not show up in the national accounting system, their contributions to the national economies and the family welfare are immense. Aquaculture involves hatchery owners, operators, workers, daily wage labourers for the preparation packers, handlers, ice makers and sellers, technicians, transporters and carriers. Therefore, a large group of people are directly or indirectly dependent on the sector.

Aquaculture has also been a source of high-quality protein for poor households and vulnerable groups in developing countries which otherwise could not afford fish for their own consumption.

Finally, aquaculture is also considered to be a contributor to rural development and poverty reduction as it forms an important component within agriculture and farming systems development (Halwart *et al*. 2003; Dixon *et al*. 2001; Edwards 1999; Tacon 2001; Edwards and Demaine 1997; Haylor and Bland 2001; Demaine 2001; FAO 2000; FAO/NACA 1999). Therefore, aquaculture has been suggested to be an important component of a holistic approach to development (APFIC 2000; Martinez-Espinosa 1996).

7 CONCLUSIONS AND POLICY RECOMMENDATIONS

Although aquaculture is an age-old food-producing technology, its development only really picked up pace in the 1970s. A revolution then occurred with the introduction of semi-intensive and intensive farming practices, as producers started to actively influence the growing conditions of the fish with feeding, breeding etc. The control of the production process that was obtained also allowed a number of productivity-enhancing innovations to take place.

Aquaculture production primarily takes place in the developing world, and particularly in Southeast Asia. It is a source of economic growth as well as increased food production in many countries of this region. Although there are challenges with respect to environmental sustainability, it is clear that aquaculture is, when measured in volume produced, a recent success story when it comes to providing more food to the world's population. A global aquaculture production of about 3.5 million tonnes in 1970 increased to more than 50 million tonnes in 2003. This tremendous growth has provided a number of opportunities with respect to greater food security, improved livelihoods and reduced poverty.

It is clear that a lower production cost due to productivity growth is the main engine for growth in aquaculture production. Lower production cost makes aquaculture production of different species profitable in a large number of countries. This also makes aquaculture products competitive in the markets where they are sold, whether these be export or domestic. This productivity growth is possible because of the higher degree of control over the production that is present in aquaculture relative to traditional fisheries. To obtain this control, one also needs to move towards relatively intensive production techniques. Unfortunately, while this is what has made it possible for aquaculture to become an important source of food, it has also been responsible for creating some major environmental challenges. However, the environmental issues can generally be addressed if the farmers operate under a reasonable regulatory system. Moreover, because productivity growth and profitability are the driving forces for aquaculture growth, trade measures have a much larger potential to introduce sustainable practices in aquaculture than in traditional fisheries.

In many ways, aquaculture development is still in its infancy. For many species one has not even closed the production cycle yet, i.e. one still depends on the harvesting of wild fingerlings rather then producing them from a domesticated stock. Hence, there is a substantial potential for further productivity growth, and for aquaculture production to become less costly. As lower production costs increase profitability, this will lead to increased production and lower prices. There will certainly be boom-and-bust cycles as production at times increases faster then the productivity growth, but the underlying trend is clearly one of sustained growth. In a worst-case scenario, there may be import bans from the EU and the US because of environmental concerns. However, continued productivity growth will ensure that aquaculture becomes an increasingly important food supplier locally because it is profitable and produces an easily traded commodity. It is also unlikely that there will be import bans on most aquaculture species, and any trade limitations stemming from environmental concerns are likely to affect only a few species. On the other hand, trade restrictions, if they are not targeted at achieving sustainable practices, can limit economic development and local food supply. Many dumping cases indicate that this is a problem.

It is also worth noting that while most aquaculture production takes place in developing countries, the research seems more focused on species that are farmed in developed countries. Hence, there seems to be a further productivity growth potential if more research is focused on tropical and subtropical species. Such research has the potential to be very valuable with respect to food security and economic development.

The control of the production process in aquaculture in many ways makes aquaculture similar to any other growing industry. Accordingly, the growth in other industries should hold a number of lessons and perspectives for the future growth of aquaculture. Although it is not perceived as equally dynamic in many parts of the world today, agriculture is in many ways the industry that is closest to aquaculture. By becoming increasingly intensive, agriculture has enabled humanity to increase global food production capacity tremendously. Certainly, it is not equally intensive everywhere, and hunting, gathering or very extensive farming practices are still used as food-producing technologies in many areas. However, since these production techniques are not very efficient, their share of the world's food production is relatively small.

However, agriculture has certainly had its own problems. Unsustainable practices have led to tremendous environmental impacts as landscapes are transformed and forests cleared. Erosion or overuse of the soil has also made agricultural land unproductive in some parts of the world. Nonetheless, the general experience from the last two millennia in trying to make agriculture sustainable has been positive.

Aquaculture faces many of the same opportunities and challenges as agriculture. An important question is whether the growth in aquaculture production will be sustainable. The evidence so far indicates that the answer depends on the surrounding environment. There is little doubt that most, if not all, species can be farmed on a sustainable basis. Closed system aquaculture production, which is possible for most species, does not need to be environmentally unsustainable. However, unsustainable practices will prevail if they are profitable for the individual fish farmers and if the enforcement of regulations does not prevent them. At this stage, it is impossible to claim that most aquaculture will follow environmentally sustainable practices, but the evidence from other industries indicates that this is likely.

It is also likely that there will be several positive environmental effects associated with aquaculture. The most apparent is one is on wild fisheries. As aquaculture production increases, this will limit and possibly reduce the prices paid to fishermen for most species. As this reduces the profitability in the fisheries, it will reduce fishing effort and pressure on the fish stocks. Another likely positive effect will be that of increased food production and, therefore, lower prices. This will not only make healthy and affordable food available to more people, but will also reduce land-based food production as this becomes less profitable for farmers. The end result may therefore be a reduced pressure on soils and forests.

To conclude, it is clear that since aquaculture is an industry in its infancy, there is tremendous potential for productivity growth. As this leads to aquaculture production becoming profitable and competitive, aquaculture products will win market share from other foods. There are some local environmental challenges to make this production growth sustainable, but the fact that aquaculture growth is caused by productivity growth and profitability means that there is much more scope to use trade measures to promote sustainable practices in aquaculture than in traditional fisheries. Finally, by reducing the prices of other foods, aquaculture will reduce their production and the pressure on other natural resources.

The restrictive trade measures which affect aquaculture highlight a range of critical issues that will need to be addressed if the multilateral trade regime is to be successful. These include the issue of trade-related domestic capacity building in LDCs and developing countries, implementation of the S&D status for LDCs in the WTO and the need for technical assistance at the firm and policy implementation levels.

In the case of SPS and TBT Agreements, the issues which are important for market access are related to: (i) design of trade-related standards; (ii) global support for the implementation of trade-related standards; and (iii) mechanisms for monitoring compliance. In order for all WTO Members to benefit equally from the agreements and to ensure that such measures are not used as market access barriers, it is important to undertake concerted efforts on a global scale. SPS and TBT provisions should be formulated in a transparent and accountable manner, with LDCs having equal opportunities to participate. If standards are to be harmonised these should take into consideration regional socio-economic conditions. The implementation of SPS measures should be sensitive to the trade-disruptive and trade-restrictive nature of these measures for exports from LDCs. Adequate preparatory measures must be ensured in the exporting countries prior to the imposition of any penalty on their exports. This is important in view of the fact that the implementation of trade measures is a highly dynamic field with frequent changes taking place and often at short notice.

There are also new requirements to consumer information. There is a need for understanding of emerging issues as part of SPS and TBT requirements. Access to scientific and technical information on food safety standards by the stakeholders in the whole supply chain is a prerequisite to ensuring compliance. Adequate financial and technical assistance should be given to least-developed and developing countries to facilitate conformity with SPS requirements. Legal assistance is also needed to participate in dispute settlement. There is a need for detailed empirical study on the impact of environmental and social certification and labelling. Given the fact that developing countries are constrained by resources, they will need to be supported in their efforts to strengthen their fisheries management in order to achieve certification. They should also be provided with support to cover certification costs.

Similar measures are needed to deal with anti-dumping policies. Anti-dumping measures have a negative impact on the aquaculture of least-developed and developing countries. These impacts can be inequitable and counter-productive. Stakeholder knowledge on anti-dumping measures is often limited and can be improved by developing practical manuals and other relevant dissemination materials. Assistance may be provided to countries affected by anti-dumping measures to provide advisory services and help them identify alternative markets.

This leads us to the following recommendations:

Encourage expansion of aquaculture.

Aquaculture is primarily an industry in developing countries. While there are socio-economic and environmental issues to be addressed, in most communities aquaculture provides economic development and improved livelihoods. Further expansion of aquaculture should therefore be encouraged. The negative side effects must be addressed, but not in such a way that stops the development of an important food-producing industry.

Apply trade measures carefully:

Aquaculture is, in contrast to fisheries, an industry where productivity growth and profitability is the main engine of growth. This makes aquaculture an industry where trade measures can be very effective. However, one must be careful when recommending the use of trade measures. Although there are many issues where one would like to see improved practices, the application of overly stringent trade measures may have undesirable effects. For instance, trade barriers that prevent market access or make access too costly will lead producers to look for a new market. If they find this market and can access it with the unwanted practices, they will continue on that path.

Improve the transparency of trade measures:

Access to international markets increases the income potential for aquaculture producers, and promotes economic development. Transparent criteria and stable market access will promote growth. Non-technical trade barriers and anti-dumping measures are often not very transparent and predictable. Improved rules for when such measures can be used would benefit developing countries and the aquaculture industry in these countries.

Address aquaculture's environmental problems:

Issues of environmental unsustainability should be addressed, and the application of trade measures is one means of doing so when the country in question is not able to address the problem itself.

Improve management practices:

The international community must aim at improving management practices as sustainable productivity depends on the way the resource is managed.

De-politicise domestic policy decisions:

One criticism levied against aquaculture is the involvement of political motivations behind some domestic policy decisions. These issues must not be allowed to take a central part when creating policy objectives. In particular, a number of the environmental and socio-economic 'costs' attributed to aquaculture are not externalities from an economic perspective, but only from some authors' political perspectives.

Invest in research:

Research and transfer of knowledge are important elements in obtaining a successful sustainable aquaculture industry. The international community has a positive role to play here. In this arena, investment support, development aid and subsidies can all have a role to play, and their use must not be hindered by anti-dumping regulations.

ENDNOTES

1 A study conducted by the United Nations Conference on Trade and Development (UNCTAD) on the Indian shrimp industry showed that standards such as Hazard Analysis and Critical Control Point (HACCP) may be totally inappropriate for India and may even have serious social consequences. It was also mentioed that out of about 400 shrimp farms, only 80 could comply with the standards (cited in Jha 2003).

2 This is referred to as 'harmonisation'.

3 The Codex Alimentarius Standards, Guidelines and Recommendations created by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) in 1963 is the preferred standard for food quality requirements.

4 The Agreement on Technical Barriers to Trade was negotiated in the Tokyo Round of multilateral trade negotiations (197401979) and was adopted in 1979 as the TBT Agreement (also named as 'Standards Code').

5 SPS measures are far more serious for developing than developed countries (UNCTAD 1998, 1997; UNCTAD/Commonwealth Secretariat 1996; FAO 1999; Singh 1994).

6 The impact of technical barriers has also been quite high in developed countries. For example, it has been estimated that the impact of food safety standards on US exports was equivalent to US$2.28 billion (Thornsbury et al. 1997).

7 A moderate degree of land degradation may result in an agricultural production loss of 45 percent (UNEP 1999).

8 Pelagic fish are free migrating fish species that inhabit the surface waters, as opposed to demersal fish that inhabit the sea floor.

9 The EKC hypothesis was developed to reflect findings that some environmental problems actually decrease with increasing incomes and consumption levels. In the Norwegian aquaculture case, the EKC shows that the use of antibiotics reached a turning point around 1990 and then decreased during the period of strong growth of the aquaculture sector.

REFERENCES

Anderson, J. L. (1992) "Salmon Market Dynamics." *Marine Resource Economics* 7. 87-88.

Anderson, J.L. (2002) "Aquaculture and the Future." *Marine Resource Economics* 17: 133-152.

Anderson, J.L. (2003) *The International Seafood Trade*. Woodhead Publishing: Cambridge.

Anderson, J.L. and Fong, Q.S.W. (1997) "Aquaculture and International Trade." *Aquaculture Economics and Management* 1: 29-44.

Norman, A. (2005) Personally collected figures from the Obour market.

APFIC (2000). Report of the Ad Hoc Working Group of Experts in Rural Aquaculture, Asia Pacific Fisheries Commission, Bangkok, Thailand, 20-22 October 1999, FAO Fish, Report No. 610, pp 22.

Asche, F., Bjørndal, T. and Young, J. A. (2001) "Market Interactions for Aquaculture Products." *Aquaculture Economics and Management* 5. 303-318.

Asche, F., Guttormsen, A.G. and Tveterås, R. (1999). "Environmental Problems, Productivity and Innovations in Norwegian Salmon Aquaculture." *Aquaculture Economics and Management* 3: 19-30.

Asche, F. (2001) "Testing the Effect of an Anti-Dumping Duty: The US Salmon Market." *Empirical Economics* 26: 343-355.

Asche, F. (1997) "Trade Disputes and Productivity Gains: The Curse of Farmed Salmon Production?" *Marine Resource Economics* 12: 67-73.

Asche, F. and Tveterås, S. (2004) "On the Relationship between Aquaculture and Reduction Fisheries." *Journal of Agricultural Economics* 55(2): 245-265.

Barlow, S.M. (2002). *The World Market Overview of Fish Meal and Fish Oi*l. Paper presented to the 2nd Seafood By-Products Conference, Alaska in November 2002

Bell, W. and Paone, S. (2001). "Human Health Risks Associated with Salmon Farming" *Presentation to the Leggatt Inquiry*, Vancouver, British Columbia, October 9 2001.

Bjørndal, T. (2002) "The Competitiveness of the Chilean Salmon Aquaculture Industry." *Aquaculture Economics and Management* 6. 97-116.

Blackie, K. (2004). *Policy Research - Implications for liberalisation of Fish Trade for Developing Countries - A Case Study of Uganda*. FAO, Rome, Italy.

Burd, B. (1997). *B C Salmon Aquaculture Review,* Interim Draft Report: Key Issues C: Waste Discharges, B C Environmental Assessment Office, British Columbia, Canada.

Cato, J.C. (1998). *Economic Issues Associated with Seafood Safety and Implementation of Seafood HACCP Programmes*. FAO, Rome, Italy.

Cato, J.C. and Lima dos Santos, C.A. (1998). "European Union 1997 Seafood-Safety Ban: The Economic Impact on Bangladesh Shrimp Processing", *Marine Resource Economics* 13: 215 -227.

Deere, C. (1999). *Eco-Labelling and Sustainable Fisheries*, IUCN, Washington, D.C., USA and FAO, Rome, Italy.

Delgado, C.L., Wada, N., Rosegrant, M.W., Meijer, J. and Ahmed, M. (2003) *Fish to 2020, Supply and Demand in Changing Global Markets,* International Food Policy Research Institute, Washington D.C., USA.

Demaine, H. (2001).*The role of small scale aquaculture in rural development,* In Utilizing Different Aquatic Resources for Livelihoods in Asia: A Resource Book, International Institute of Rural Reconstruction, International Development Centre, Food and Agriculture Organization, Network of Aquaculture Centres in Asia-Pacific and International Centres in Asia-Pacific and International Centre for Living Aquatic Resources Management.

Digges, P., Gordon, A. and Marter, A. (1997). *International Markets for African Agricultural Exports: Agricultural Policy Reform and Agricultural Exports*. Natural Resources Institute (NRI), Greenwich, UK.

Dixon, J., Gulliver, A. and Gibbon, D. (2001). *Global Farming Systems Study: Challenges and Priorities to 2030, Synthesis and Global Overview*, FAO, Rome, Italy and the World Bank, Washington, D.C., USA.

Downes, D. and van Dyke, B. (1998) *Fisheries Conservation and Trade Rules: Ensuring that Trade Law Promotes Sustainable Fisheries*, Centre for International Environmental Law, and Greenpeace, Washington D.C., USA.

Edwards, P. (1999). *Aquaculture and Poverty: Past, Present and Future Prospects of Impact*, A Discussion Paper, prepared for the Fifth Fisheries Development Donor Consultation, Rome, Italy, 22-24 February 1999.

Edwards, P., and Demaine, H. (1997). *Rural Aquaculture: Overview and Framework for Country Reviews*, FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, RAP Publications, 1997/3, pp 61.

ESCAP (1996). *Promoting Exports of Fish and Fishery Products in Selected Island Developing Countries of the ESCAP Region*. Economic and Social Commission for Asia and the Pacific, United Nations, New York.

FAO (n.d.) *Fishstat database*, Food and Agriculture Organization, Rome, Italy.

FAO (2005). *Commodity Production and Trade 1976-2003,* Fishstat Plus, Food and Agriculture Organization, Rome, Italy.

FAO (2004). *World Review of Fisheries and Aquaculture 2004*. Fisheries Department, Food and Agriculture Organization, Rome, Italy.

FAO (2002). *The State of World Fisheries and Aquaculture 2002,* Fisheries Department, Food and Agriculture Organization, Rome, Italy.

FAO (2000). Report of the Workshop on Participatory Approaches in Aquaculture, Bangkok, Thailand, 28 February-1 March 2000, FAO Fish Report No. 630, pp 48.

FAO (1999). *Importance of Food Quality and Safety for Developing Countries,* Committee on World Food Security, 25th Session, FAO, Rome, Italy.

FAO/NACA (1999). Report of the FAO/NACA Consultation on Aquaculture for Sustainable Rural Development, Chiang Mai, Thailand, 29-30 March 1999, FAO Fish Report No. 611, pp 34.

FAO (1995) *Code of Conduct for Responsible Fisheries*, Food and Agricultural Organisation, Rome, Italy.

Fleming, I.A., Hinder, K., Mjolnerod, I.B., Jonson, B., Balstad, T. and Lamberg, A. (2000). "Lifetime Success and Interaction of Farm Salmon Invading a Native Population", *Proceedings of Royal Society of London*, 267: 1517-1523.

Grainger, R. J. R. and Garcia, S. M. (1996). Chronicles of Marine Fishery Landings (1950-1994): Trend Analysis and Fisheries Potential. FAO Fisheries Technical Paper No. 359. Rome.

Greenhalgh, P. (2004). "*Trade Issues Background Paper: Sanitary and Phytosanitary Measures and Technical Business to Trade*", prepared under the study on Policy Research – Implications of Liberalisation of Fish Trade for Developing Countries. FAO, Rome, Italy.

Guttormsen, A.G. (2002) "Input Factor Substitutability in Salmon Aquaculture." *Marine Resource Economics* 17: 91-102.

Halwart, M., Funge-Smith, S. and Moekl, J. (2003). The Role of Aquaculture in Rural Development. In: *Review of the State of World Aquaculture*, Food and Agriculture Organization, Rome, Italy.

Haylore, G. and Bland, S. (2001). Integrating Aquaculture into Rural Development in Coastal and Inland Areas, In R.P. Subasinghe, P.B Bueno, M.J. Phillips, C. Hough, S.E. McGladdery and J.R. Arthur (eds.) *Aquaculture in the Third Millennium*, Bangkok, Thailand, 20-25 February 2000, Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand and FAO, Rome, Italy, pp 73-81.

Hempel, E. (1999). Fishmeal: Not as gloomy as it looks. Seafood International, April 99:79-82.

Henson, S.J., Loader, R.J., Swinbank, A., Bredahl, M. and Lux, N. (1999). *Impact of Sanitary and Phytosanitary Measures on Developing Countries*. Department for International Development, London, UK.

Hillman, J. (1997). Non-Tariff Agricultural Trade Barriers Revisited. In: Orden, D. and Roberts, D. (eds). *Understanding Technical Barriers to Agricultural Trade*. International Agricultural Trade Research Consortium, University of Minnesota.

Huwe, J.K. (2002). "Dioxins in Food: A Modern Agricultural Perspective" *Journal of Agriculture Food Chemistry* 50:1739-1750.

IFOMA 2001. Sustainability of Fish Meal and Oil Supply. Paper presented at Scottish-Norwegian. Conference on Sustainable Futures for Marine Fish Farming (June 2001)

ITA (2005) *Amended Final Determinations and Issuance of Antidumping Duty Orders: Imports of Certain Frozen Warmwater Shrimp from Brazil, Ecuador, India, Thailand, the People's Republic of China, and the Socialist Republic of Vietnam*, Fact Sheet, International Trade Administration.

ITC (2005a) *Certain Frozen or Canned Warmwater Shrimp and Pawns From Brazil, China, Ecuador, India, Thailand, and Vietnam*, US International Trade Commission, Investigations Nos. 731-TA-1063--1068 (Final).

Jacobs, M.N., Covaci, A. and Schepens, P. (2002). "Investigation of Selected Persistent Organic Pollutants in Farmed Atlantic Salmon (Salmo salar), Salmon Aquaculture Feed, and Fish Oil Components of the Feed. *Environmental Science and Technology* 36(13): 2797-2805.

Jaffee, S. (ed.) (1999). *Southern African Agribusiness: Gaining Through Regional Collaboration*. World Bank, Washington, D.C., USA.

Jha, V. (2003). "Trade and Environment: Doha and Beyond", in A. Mattoo and R. M. Stern (eds.) *India and the WTO*, World Bank and Oxford University Publication.

Josupeit, H. (2004). "An Overview on the World Shrimp Market", GlobeFish, World Shrimp Markets, Madrid, Spain.

Josupeit, H. (1997). *Trade Opportunities for Processed Fish*. UNCTAD, Geneva, Switzerland.

Kaushik, A and Saqib, M. (2003). "Market Access Issues: A Study of the Impacts of Environmental Requirements on India's Export Performance and a Scoping Study for Environment Friendly Products" in Jha, V. (ed.) (2003). *Trade and Environment: Issues and Options for India*, UNCTAD, Geneva, Switzerland.

Khatun, F. (2004). *Fish Trade Liberalisation in Bangladesh: Implications of SPS Measures and Eco-Labelling for the Export-Oriented Shrimp Sector*, Study on Policy Research – Implications of Liberalisation of Fish Trade for Developing Countries, Food and Agriculture Organization, Rome, Italy.

Macfadyen, G. (2004). Use of Ethical/Social/Eco-Certification, Labelling and Guidelines, Trade Issues Background Paper for the Study on Policy Research – Implications of Liberalisation of Fish Trade for Developing Countries, Food and Agriculture Organization Rome, Italy.

Mathew, S. (2003). "Trade in Fisheries and Human Development: Country Case Study – India", for Asia and Pacific Regional Initiative on Trade, Economic Governance and Human Development, United Nations Development Programme.

Martinez-Espinosa, M. (1996). Report of the Expert Consultation on Small Scale Rural Aquaculture, FAO Fish Report No 548, pp 182.

Milazzo, M. (1998). *"Subsidies in World Fisheries: A re-examination"*, World Bank Technical Paper, No 406, World Bank, Washington, D.C., USA.

Murphy, K.M. and Shleifer, A. (1997). "Quality and Trade". *Journal of Development Economics* 53(1):1-15.

N 'dia, Y. (2004). *Policy Research - Implications for liberalisation of Fish Trade for Developing Countries - A Case Study of Guinea*, Food and Agriculture Organization, Rome, Italy.

National Research Council (1995). *Standards, Conformity Assessment and Trade*. National Research Council, Washington, D.C., USA.

Naylor, R.L., Goldburg, R.J., Primavera, J.H., Kautsky, N., Beveridge, M.C.M., Clay Folke, C., Lubchenco, J., Mooney, H. and Troell, M. (2000) "Effects of Aquaculture on World Fish Supplies." *Nature* 405: 1017-1024.

New, M. B. and Wijkström, U.N. (2002). *Use of Fishmeal and Fish Oil in Aquafeeds: Further Thoughts on the Fishmeal Trap*. FAO Fisheries Circular No. 975 Food and Agriculture Organization of the United Nations, Rome.

New, M.B., Shehadeh, Z. and Pedini, M. (1995). Status and Trends in Food Production Through Aquaculture. *FAO Aquaculture Newsletter* (FAN), 9:12-18.

Norwegian Directorate of Fisheries (Various Years), Økonomiske Analyser av Fiskeopdrett (In Norwegian, Economic analysis of fish farming), Bergen.

Norwegian Seafood Export Council (2005) Salmon Database, Tromsø.

OECD (1991). Environmental Labelling in OECD Countries, OECD Report 12, by J. Salzman, OECD Paris.

OW (1999). The Weekly Forecasting and Information Service for Oilseeds, Oils, Fats and Oil meals. Oil World ISTA Mielke Gmbh. Hamburg.

Pike, I. (1998). "Future Supplies of Fishmeal and Fish Oil: Quality Requirements for Aquaculture with Particular Reference to Shrimp". In *International Aquafeed Directory & Buyers' Guide 1998*. pp. 39-49. Uxbridge, United Kingdom, Turret RAI plc.

Pike, I. (2000). Personal email communication with Dr. Pike of International Fishmeal and Fish Oil Organisation, Hertfordshire, UK.

Pike, I.H. and Barlow, S.M. (2002). *Impact of Fish Farming on Fish Stocks*. Paper presented at Bordeaux Aquaculture and Environment Symposium - September 2002

Rahman, M. (2002). *Market Access Implications of SPS and TBT: Bangladesh Perspective*, Research Report, CUTS Centre for International Trade, Economics and Environment, Jaipur, India.

Roth, M. (2000). "The Availability and Use of Chemotherapeutic Sea Lice Control Products", *Contributions of Zoology* 69 (1-2): 109-118.

Salagrama, V. (2004). *Policy Research - Implications for Liberalisation of Fish Trade for Developing Countries - A Case Study of India*, Integrated Coastal Management, India, Food and Agriculture Organization, Rome, Italy.

SAMS (2002). *Review and Synthesis of the Environmental Impacts of Aquaculture*, Scottish Executive Research Unit, Scottish Association for Marine Science and Napier University, www.scotland.gov.uk/cru/kd01/ green/reia-00.asp.

Schrank, W.E. (2003). *Introducing Fisheries Subsidies*, FAO Technical Paper 437, FAO, Rome, Italy.

Singh, K. (1994). GATT (WTO): "Implications for Indian Agriculture with Special Reference to Panjab". *Indian Journal of Quantitative Economics* 9 (2), 85-107.

Staffin, E.B. (1996) "Trade Barrier or Trade Boon? A Critical Evaluation of Environmental Labelling and its Role in the 'Greening' of World Trade", *Columbia Journal of International Environmental Law* 21(2): 205-286.

Subasinghe, R.P. (2003). An Outlook for Aquaculture Development: Major

Issues, Opportunities and Challenges. In: *Review of the State of World Aquaculture*, Food and Agriculture Organization, Rome, Italy.

Sykes, A.O. (1995). *Product Standards for Internationally Integrated Goods Markets*. Brookings Institution, Washington, D.C., USA.

Tacon, A.G.J. (1998). Global Trends in Aquaculture and Aquafeed Production 1984-1995. In *International Aquafeed Directory & Buyers' Guide 199*8. pp. 5-37. Uxbridge, United Kingdom, Turret RAI plc.

Tacon, A.G.J. (1999). *Overview of World Aquaculture and Aquafeed Productio*n. Data precented at World Aquaculture '99. Sidney April 27- May 2. 1999.

Tacon, A.G.J. (2001). Increasing the Contribution of Aquaculture for Food Security and Poverty Alleviation, In R.P. Subasinghe, P.B Bueno, M.J. Phillips, C Hough, S.E. McGladdery and J.R. Arthur (eds.) *Aquaculture in the Third Millennium*, Bangkok, Thailand, 20-25 February 2000, Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand and FAO, Rome, Italy, pp 63-72.

Thilmany, D.D. and Barrett, C.B. (1997). "Regulatory Barriers in an Integrating World Food Market". *Review of Agricultural Economics* 19 (1): 91-107.

Thornsbury, S., Roberts, D., Deremer, K. and Orden, D. (1997). *A First Step in Understanding Technical Barriers to Agricultural Trade*. Paper presented at the conference of the International Association of Agricultural Economists, Sacramento, August 1997.

Tung, N.T., Thanh, N.V. and Phillips, M. (2004). *Policy Research – Implications of Liberalisation of Fish Trade for Developing Countries: A Case Study of Vietnam*, Food and Agriculture Organization, Rome, Italy.

Tveterås, S. (2002) "Norwegian Salmon Aquaculture and Sustainability: The Relationship between Environmental Quality and Industry Growth." *Marine Resource Economics* 17: 121-132.

Tveterås, R. and Heshmati, A. (2002) "Patterns of productivity growth in the Norwegian salmon farming industry." *International Review of Economics and* Business 49. 367-393.

UNCTAD/Commonwealth Secretariat (1996). *The Global Spice Trade and the Uruguay Round Agreements*. UNCTAD, Geneva, Switzerland and Commonwealth Secretariat, London, UK.

UNCTAD (1998). *Elements of the Positive Agenda on the SPS Agreement*, United Nations Conference on Trade and Development, Geneva, Switzerland.

UNCTAD (1997). *Opportunities for Vertical Diversification in the Food Processing Sector in Developing Countries*. UNCTAD Geneva, Switzerland.

UNEP (2004). *Fisheries Subsidies and Marine Resource Management: Lessons from Bangladesh*, by F. Khatun, M. Rahman and D. Bhattacharya, United Nations Environment Programme, Geneva, Switzerland.

UNEP (2002). *Fisheries Subsidies and Marine Resource Management: Lessons from Studies in Argentina and Senegal*, United Nations Environment Programme, Geneva, Switzerland.

UNEP (1999). *Environmental Impacts for Trade Liberalisation and Policies for Sustainable Management of Natural Resources: A Case Study on Bangladesh's Shrimp Farming Industry*, Prepared for United Nations Environment Programme by A.D. Bhattacharya, M. Rahman and F. Khatun, United Nations, New York, USA and Geneva, Switzerland.

Unnevehr, L.J. (1999). *Food Safety Issues and Fresh Food Product Exports from LDCs*. Paper presented at the conference: Agro-Industrialisation, Globalisation and Development. Nashville, August 1999.

Van Mulekom, L., Axelsson, A., Batungbacal, E.P., Baxter, D., Siregar, R. and de la Torre, I. (2003) *Trade and Export Orientation of Fisheries in Southeast Asia: Underpriced export at the expense of domestic food security and local economies*. Paper presented at PEMSA 2003, Malaysia.

Vogel, D. (1995). *Trading Up: Consumer and Environmental Regulations in a Global Economy*. Harvard University Press, Cambridge, MA, USA.

Weber, M.L. (2003). *What Price Farmed Fish: A Review of the Environmental and Social Costs of Farming Carnivorous Fish*, SeaWeb Aquaculture Clearinghouse.

West, K. (1995). "Eco-labels: The Industrialisation of Environmental Standards", *The Ecologist*, 25(1): 16-20.

Westlund, L. (2003). *Draft Guide for Identifying, Assessing and Reporting on Subsidies in the Fisheries Sector*, in FAO (2003). Report on the Expert Consultation on Identifying, Assessing and Reporting on Subsidies in the Fishing Industry, Rome, 3-6 December 2002, FAO Fisheries Report No. 698, FIPP/R698 (En), Rome, Italy.

WTO (2005). Contribution to the Discussion on the Framework for Disciplines on Fisheries Subsidies – Aquaculture, TN/RL/GEN/54, Negotiating Group on Rules, World Trade Organisation, 1 July 2005.

WTO (2001). Doha Ministerial Declaration, Ministerial Conference, Fourth Session, Doha 9-14, November 2001, WTO, WT/MIN/(01)/DEC/W/1

WTO (1999). Understanding the WTO Agreement on Sanitary and Phytosanitary Measures, World Trade Organisation, Geneva, Switzerland.

Zarrilli, S. (1999) WTO *Sanitary and Phyto Sanitary Agreement: Issues For Developing Countries*, Trade Related Agenda, Development and Equity (T.R.A.D.E) Working Papers No. 3, July 1999, South Centre, Geneva, Switzerland.

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