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State of world aquaculture: 2006

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Cover photo:

Zhou Xiaowei.

Mandarin fish (*Siniperca* sp.) - Known from time immemorial in China, this fish became extremely popular in the Tang Dynasty (618-907 A.D.) and many poets eulogised about its colour and taste. However, the farming of mandarin fish did not begin until late in the 20th century. Experimental farming began in the 1950s when wild-caught seeds were used; farmers found that it was an excellent species for culture. Since 1975, the Suzhou Municipal Farm in Jiangsu Province managed to breed and raise them to 375 g in captivity, the farming of this species under controlled conditions has become more and more popular.

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Fishery Resources Division
Fisheries Department

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Preparation of this document

Status and trends analysis and reporting on aquaculture are regular activities of the FAO Fisheries Department. These are done by using official reports provided to FAO by the member countries as well as through organizing special activities for soliciting information from countries and opinion from experts. The *State of World Aquaculture: 2006* is the result of a most recent such effort by the FAO Fisheries Department.

The process of preparation of this document consisted of many sequential and parallel activities as outlined in Chapter 1 – Introduction. The process was organized by the Inland Water Resources and Aquaculture Service (FIRI) of the FAO Fisheries Department. This document, not only provides a synthesis of seven regional aquaculture development trends reviews (see Chapter 1 – Introduction), but also reflects an analysis of data and the opinion of a large number of experts worldwide.

The FAO Fisheries Department plans to update this document by publishing a supplement once every two years and a full-scale review once every five years.

Abstract

Aquaculture is developing, expanding and intensifying in almost all regions of the world, except in sub-Saharan Africa. Global population demand for aquatic food products is increasing, the production from capture fisheries has levelled off, and most of the main fishing areas have reached their maximum potential. Sustaining fish supplies from capture fisheries will, therefore, not be able to meet the growing global demand for aquatic food. Aquaculture appears to have the potential to make a significant contribution to this increasing demand for aquatic food in most regions of the world; however, in order to achieve this, the sector (and aquafarmers) will face significant challenges. The key development trends indicate that the sector continues to intensify and diversify and is continuing to use new species and modifying its systems and practices. Markets, trade and consumption preferences strongly influence the growth of the sector, with clear demands for production of safe and quality products. As a consequence, increasing emphasis is placed on enhanced enforcement of regulation and better governance of the sector. It is increasingly realized that this cannot be achieved without the participation of the producers in decision-making and regulation process, which has led to efforts to empower farmers and their associations and move towards increasing self-regulation. These factors are all contributing to improve management of the sector, typically through promotion of "better management" practices of producers.

This document analyses the past trends that have led the aquaculture sector to its current status and describes its current status globally.

Inland Water Resources and Aquaculture Service, Fishery Resources Division, Fisheries Department, FAO.
State of world aquaculture: 2006.
FAO Fisheries Technical Paper. No. 500. Rome, FAO. 2006. 134p.

Preface

The FAO Fisheries Department is pleased to present the *State of world aquaculture: 2006.*

The national and regional reviews and the resulting global synthesis, which provided the basis for this document, involved many people, including fish farmers, service providers, policy makers, scientists, researchers and intergovernmental and non-governmental organization (IGO and NGO) workers. This rigourous and iterative review process used has shaped this document. If some key information are lacking or inadequate, it is not a shortcoming on the part of the review process, they are simply unavailable; their absence has, in fact, been pointed out in the regional reviews, as opportunities for future assessments and information development.

While FAO has the ultimate responsibility for this review and indeed directed its development, the process has been widely owned and participated in by organizations, institutions, agencies and groups with a major stake in national, regional and global aquaculture development. This broad collaborative effort is a reflection of another positive trend that recently has characterized aquaculture development: global cooperation. This trend will probably have as much impact on the direction and speed of aquaculture development as the other trends revealed by the review, and alongside with the other desirable ones, it will be fanned and sustained.

Ichiro Nomura
Assistant Director-General
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Acknowledgements

This document is a result of the collaborative effort of many individuals and agencies worldwide through a process led by Dr Rohana Subasinghe, Senior Fishery Resources Officer (Aquaculture) of the Inland Water Resources and Aquaculture Service. The participants of the review workshop held in Guangzhou, People Republic of China, in March 2006 (see page 129) are acknowledged for providing advice and guidance. The following persons are specially recognized and commended for their valuable contributions which made this publication possible, in alphabetical order: Jose Aguilar-Manjarrez, Uwe Barg, Devin Bartley, Pedro Bueno, Valerio Crespi, Simon Funge-Smith, Matthias Halwart, Mohammad Hasan, Tom Hecht, Nathanael Hishamunda, Jia Jiansan, Audun Lem, Alessandro Lovatelli, Alan Lowther, Vielka V. Morales Quintero, Reinaldo Morales Rodriguez, John Moehl, Kalende Mulonda, Paul Olin, Michael Phillips, Sarah Poynton, Krishen Rana, Melba Reantaso, Doris Soto, Albert Tacon, Laszlo Varadi, Raymond VanAnrooy and Wilfredo Yap.

We thank Miss Hasini Wijesuriya for assistance in graphics, Ms. Jenny Rana for language editing and Mr. Jose Luis Castilla for layout design.

Contents

1. Introduction

Aquaculture, probably the fastest growing food-producing sector, now accounts for almost 50 percent of the world's food fish and is perceived as having the greatest potential to meet the growing demand for aquatic food. Given the projected population growth over the next two decades, it is estimated that at least an additional 40 million tonnes of aquatic food will be required by 2030 to maintain the current per capita consumption.

FAO regularly collects information on global aquaculture production, value and development through official reports from its member countries. These data are analysed, and the status and trends of the sector's development are regularly reported through two main publications of the FAO Fisheries Department: *The state of world fisheries and aquaculture* (SOFIA) and *Review of the state of world aquaculture*, as well as via occasional special publications such as *Aquaculture in the third millennium* (NACA/FAO, 2001).

In 1999, FAO conducted a series of regional aquaculture development trends reviews and made a comprehensive analysis of the status of the global aquaculture sector as part of the global Conference on Aquaculture in the Third Millennium that was jointly organized by the Network of Aquaculture Centres in Asia-Pacific (NACA), the Department of Fisheries Thailand and FAO, and held in Bangkok, Thailand, in February 2000.

In 2005, the FAO Fisheries Department, as one of its regular programme activities, again conducted a series of regional aquaculture development trends reviews, with the view to make a global appraisal of the status of aquaculture and the trends in its development. These regional reviews and the resulting global review or synthesis were conducted in parallel with and complementary to two other activities: (a) the development of National Aquaculture Sector Overviews (NASO)[1] and (b) the preparation of a Prospective Analysis of Future Aquaculture Development (PAFAD). Both were initiated in response to the recommendations of the Committee on Fisheries Sub-Committee on Aquaculture. During the process, over 100 NASOs were prepared and seven regional aquaculture development trends reviews were made.

This document is primarily a synthesis of seven regional reviews that have been previously published as FAO Fisheries Circulars[2]. Further information can be obtained by consulting the respective regional reviews as companion documents.

Initially, the intention was to cover all aquaculture-producing countries in the world, but this proved impossible due to some logistical and financial constraints. However, coverage includes all the countries with a significant aquaculture sector, however, are covered and all the regions, except the Central Asian Republics (although Georgia joined the review workshop of Asia and the Pacific region). For regional reviews, the following country groupings were used:

1. Asia and the Pacific region

East Asia – China (including Hong Kong Special Administrative Region, Macao Special Administrative Region and Taiwan Province of China), Japan, Democratic People's Republic of Korea and the Republic of Korea.

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[1] www.fao.org/figis/servlet/static?dom=root&xml=aquaculture/naso_search.xml

[2] FAO/Network of Aquaculture Centres in Central and Eastern Europe 2006; Hecht, 2006; Morales & Morales, 2006; Network of Aquaculture Centers in Asia-Pacific, 2006; Olin, 2006; Poynton, 2006; Rana, 2006

South Asia – Bangladesh, India, Nepal, Pakistan and Sri Lanka.
Southeast Asia – Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Thailand and Viet Nam.
West Asia – The Islamic Republic of Iran.
Oceania **–** Australia and the Pacific Island Nations.

2. Central and Eastern Europe
Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Russian Federation, Serbia and Montenegro, Slovakia, Slovenia and Ukraine.

3. Latin America and the Caribbean
Argentina, Belize, Bolivia, Brazil, Colombia,, Chile, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela.

4. The Near East and North Africa
Algeria, Bahrain, Egypt, the Islamic Republic of Iran, Iraq, Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Morocco, the Sultanate of Oman, Qatar, the Kingdom of Saudi Arabia, Syrian Arab Republic, Tunisia, the United Arab Emirates and Yemen.

5. North America
Canada and the United States of America.

6. Sub-Saharan Africa
Angola, Burkina Faso, Cameroon, Central African Republic, Congo Brazzaville, Congo DRC, Côte d'Ivoire, Ghana, Guinea, Kenya, Liberia, Madagascar, Malawi, Mozambique, Nigeria, Sierra Leone, South Africa, United Republic of Tanzania, Uganda and Zambia.

7. Western Europe
Austria, Belgium, the Channel Islands, Cyprus, Denmark, Faeroe Islands, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, Malta, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey and United Kingdom.

All chapters in this document, except Chapter 2, refer to the above regional country groupings. For aquaculture production in Chapter 2, FAO's latest official statistical data (2004) were utilized and the regional analyses were performed using available data from all countries in the regions. Most of the production analyses presented in other chapters are based on the FAO official statistical data up to 2003.

One of the major constraints encountered during the compilation of this review was the paucity of information on the behaviour of the aquaculture sector on a global basis. For example, reliable quantitative information on trends in intensification and aquaculture expansion; the contribution of aquaculture to employment, poverty reduction, health, nutrition and social development; and the impact of aquaculture on the environment are scarce. Therefore, when addressing these issues, it was necessary to discuss them in a qualitative manner. Information from a number of published studies was used to illustrate issues with specific cases or to complement materials in the regional reviews.

As the greatest proportion of global aquaculture production comes from Asia (currently over 90 percent, with about 74 percent originating from China alone), and as aquaculture is highly dynamic in the region, it is impossible to avoid bias towards Asia when discussing aquaculture globally. However, every endeavour has been made to cover all regions adequately.

Occasionally, issues do not draw on examples from all regions. This is due mainly to the unavailability of relevant information in the regional reviews. Also, in some cases, specific regional examples have been used to discuss specific issues.

As expected, the countries in any given region were not homogeneous in their state of aquaculture development. As a result, it was difficult to interpret information on a regional basis; however, this issue was addressed by demonstrating the differences among countries in the various regions.

In preparing this document, in addition to the use of United States dollar figures (US$), Euro figures have also been used, especially in the European review. It was not possible to collect unified information from all countries through the NASO process; for example, it was difficult to find information specific to the aquaculture sector on employment, social benefits, consumption, trade, etc., as most country data used were aggregated fisheries/aquaculture. In Chapter 4, which addresses food security and access to food, lack of consumption data for aquaculture alone compelled the use of aggregated fisheries data for analysis. The contribution of inland fisheries (culture-based fisheries) to world fish production has not been extensively reviewed in this document.

The national/regional review process and the resulting global synthesis involved many people, including fish farmers, service providers, policy-makers, scientists, researchers and non-governmental organization (NGO) workers.

A rigorous and iterative review process has shaped this report. If some key information, as mentioned above, are lacking or inadequate, it has not been the result of a shortcoming in the process, they are simply unavailable; their absence is in fact pointed out in the regional reviews as opportunities for future assessments and information development.

Another significant point is that, while FAO had the ultimate responsibility for this review and indeed directed its development, the process has been widely owned and participated in by organizations, institutions, agencies and groups with a major stake in national, regional and global aquaculture development. This broad collaborative effort is a reflection of another positive trend that recently has characterized aquaculture development: global cooperation. This trend will probably have as much impact on the direction and speed of aquaculture development as the other trends revealed by the review, and along with the other desirable ones, it should be fanned and sustained.

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2. Production: environments, species, quantities and values

INTRODUCTION

From an activity that was primarily Asian, aquaculture has now spread to all the continents. From an activity that was focused on freshwater fish, particularly the cyprinids, it now encompasses all aquatic environments and many aquatic species. Clearly, its Asian origin and its carp-focused beginnings are still evident in the present distribution and the dominance of cyprinids. The present situation in terms of natural resources, the environment, and population along with advances in biotechnology, marine engineering and in the movement of goods and services, bring with it greater potential as well as more complex challenges in the development of aquaculture.

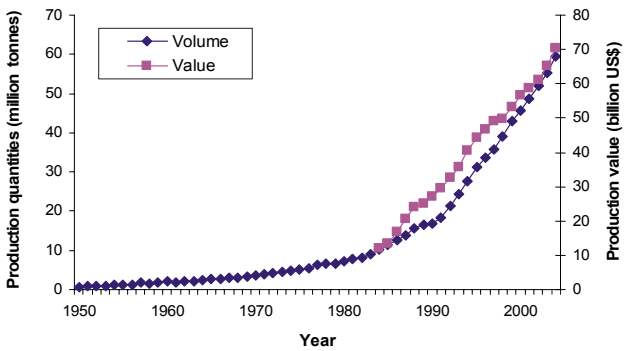
This chapter provides an overview of the current aquaculture production globally, using latest (2004) FAO aquaculture data and statistics from FISHSTAT Plus (FAO, 2006). Unless otherwise stated, the data and analysis provided refer to the situation in 2004.

PRODUCTION

World aquaculture has grown tremendously during the last fifty years from a production of less than a million tonnes in the early 1950s to 59.4 million tonnes by 2004 (Figure 1). This level of production had a value of US$70.3 billion. Of the production, 41.3 million tones, or 69.6 percent, was produced in the Peoples' Republic of China (hereafter referred to as China) and 21.9 percent from the rest of Asia and the Pacific region (Figure 2). The Western European region contributed 3.5 percent with 2.1 million tonnes (valued at US$5.4 billion), while the Central and Eastern Europe region contributed 250 000 tonnes, or 0.4 percent. Latin America and the Caribbean and North America contributed 2.3 percent and 1.3 percent, respectively. Finally, production from the Near East and North Africa region and sub-Saharan Africa accounted for 0.9 percent and 0.2 percent, respectively, of the global total for 2004 (Figure 3).

Production within each region is diverse. In Asia and the Pacific region aquaculture production from South Asia, China and most of Southeast Asia consists of cyprinids, while that from the rest of East Asia consist of high-value marine fish. In global terms, 99.8 percent of cultured aquatic plants, 97.5 percent of cyprinids, 87.4 percent of penaeids and 93.4 percent of oysters come from Asia and the Pacific region. Meanwhile, 55.6 percent of the world's farmed salmonids come from Western Europe, mainly from the northern region of the continent. Carps, however, dominate in the Central and Eastern Europe region, both in quantity and in value.

FIGURE 1
Trend in total world aquaculture production and value (including plants) between 1950 and 2004



In North America, channel catfish is the top aquaculture species in the United States of America, while Atlantic and Pacific salmon dominate in

FIGURE 2
World aquaculture production with China and rest of Asia and the Pacific region disaggregated from the rest of the world between 1950 and 2004

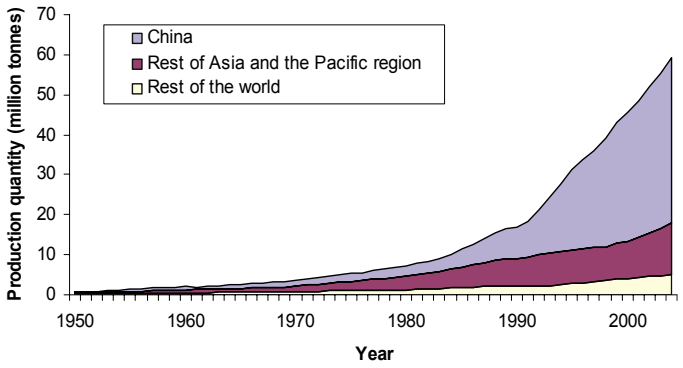
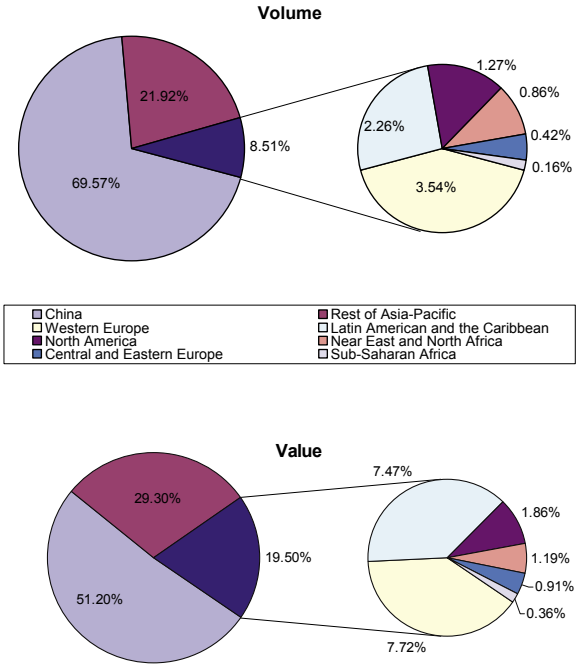


FIGURE 3
World aquaculture production by region with China disaggregated form the rest of Asia in 2004.



Canada. In the Latin America and Caribbean region, over the last decade salmonids have overtaken shrimp as the top aquaculture species group due to disease outbreaks in major shrimp producing areas and the rapid growth in salmon production in Chile (Figure 4).

The sub-Saharan Africa region continues to be a minor player in aquaculture despite its natural potentials. Even aquaculture of tilapia, which is native to the continent, has not developed to a large degree. Nigeria leads in the region with 44 000 tonnes of catfish, tilapia and other freshwater fishes reported. There are some isolated bright spots in the continent: black tiger shrimp (*Penaeus monodon*) in Madagascar and Eucheuma seaweed in the United Republic of Tanzania are thriving, and production of niche species like abalone (*Haliotis* spp.) in South Africa is increasing. In North Africa and the Near East, Egypt is by far the dominant producing country (92 percent of the total for the region) and, in fact, is now the second biggest tilapia producer after China and is the world's top producer of mullets (Box 1).

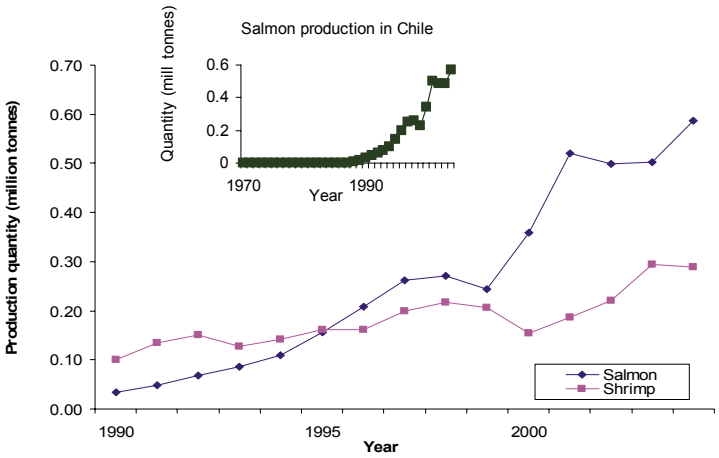
GROWTH IN PRODUCTION

The phenomenal growth in world aquaculture over the last fifty years has been most notable in Asia and the Pacific region and, in particular, in China. The aquaculture development in China has resulted in significant differences in the present magnitude and the rate of growth of aquaculture among continents. This makes it necessary for any assessment of global aquaculture development to be done on a region-by-region basis. Furthermore, due to the overwhelmingly large proportion of aquaculture production from China, for some analyses, China should be considered separately so that it does not distort the situation of Asia and the Pacific region in particular, and that of the rest of the world in general (see Figure 2).

World aquaculture has grown at an average annual rate of 8.8 percent from 1950 to 2004. Overall, Latin America and the Caribbean region had the highest average annual growth of 21.3 percent followed by and the Near East and North Africa and sub-Saharan

Africa, with 10.8 percent and 10.7 percent respectively. The average growth rate for the Asia and the Pacific region was 9.8 percent, while production in China, considered separately, has grown at a rate of 12.4 percent per year (Table 1).

FIGURE 4
Total production of Shrimp and Salmon in the Latin America and Caribbean Region



The high growth rate in the Latin America and Caribbean region is understandable since aquaculture was almost non-existent in the area from the 1950s to the early 1970s. South American aquaculture development is very much tied in with shrimp and salmon and is concentrated mainly in three countries; Ecuador, Chile and Brazil. The growth came in three distinct waves. The first wave came with the development of the world shrimp market and the resulting "shrimp fever" from the late 1970s through the 1980s that saw considerable investments in

BOX 1
Top ten producers of tilapia and mullet in 2004

Country	Tilapia (tonnes)	Country	Mullet (tonnes)
China	897 276	Egypt	132 651
Egypt	199 038	Indonesia	11 730
Philippines	145 869	Korea, Republic of	4 442
Indonesia	139 651	Taiwan Province of China	2 341
Thailand	97 653	Israel	1 792
Taiwan Province of China	89 275	China, Hong Kong SAR	577
Brazil	69 078	Greece	509
Lao People's Dem. Rep.	29 205	Tunisia	360
Colombia	27 953	Ukraine	243

TABLE 1
Average annual growth rate (%) of aquaculture production globally by continent and by decade, between 1950 and 2004

Region	1950-2004	1950-1960	1960-1970	1970-1980	1980-1990	1990-2000	2000-2004
China	12.4	27.6	4.0	7.5	11.6	15.1	6.2
Rest of Asia and the Pacific region	7.4	10.1	7.6	9.2	6.4	3.4	9.1
Western Europe	4.9	4.3	6.1	4.4	5.5	5.6	2.0
Latin America and the Caribbean	21.3	16.2	21.1	37.0	23.3	14.2	11.4
North America	4.7	5.2	4.8	0.0	7.6	5.0	6.5
Near East and North Africa	10.8	8.7	2.8	14.5	11.7	17.7	9.2
Central and Eastern Europe	2.4	3.8	4.5	5.3	6.5	-8.2	4.3
sub-Saharan Africa	10.7	19.8	5.9	5.2	10.2	13.1	9.9
Total	**8.8**	**12.3**	**5.7**	**7.6**	**8.6**	**10.5**	**6.8**

FIGURE 5
Aquaculture production in Brazil between 1980 and 2004

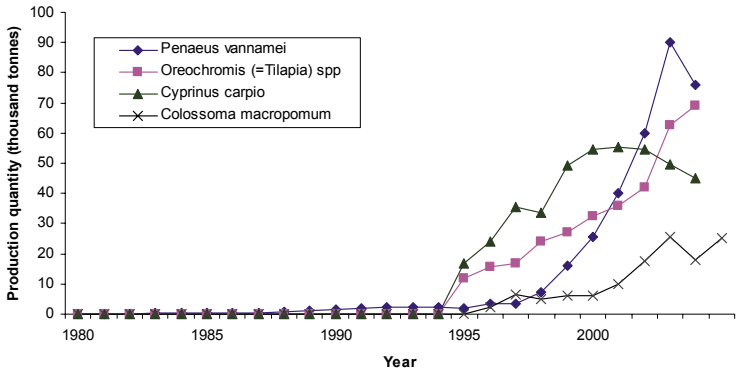
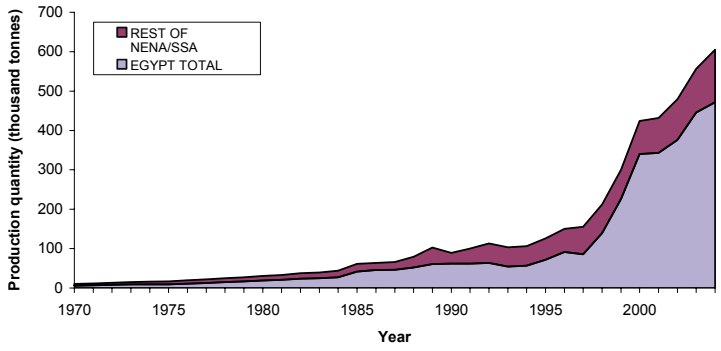


FIGURE 6
Total production of Nile tilapia, grey mullet and carps in Near East and North African and Sub-Saharan Africa region with Egypt disaggregated from the rest, between 1970 and 2004



shrimp production in Ecuador. The second wave started in the late 1980s with development of the Atlantic salmon industry in Chile. The third wave occurred only in the 1990s when Brazil made a deliberate plan to expand its aquaculture (shrimp) industry (Figure 5).

According to FAO statistics, in the case of the Near East and North Africa and sub-Saharan Africa regions, significant (sizeable) aquaculture development is concentrated in one country – Egypt – and in a few species: Nile tilapia (*Oreochromis niloticus*), flathead grey mullet (*Mugil cephalus*) and various carps (see Box 1). Production in Egypt makes up 78.0 percent of total aquaculture production in the combined regions (Figure 6). Substantial growth occurred in the 1990s with Nile tilapia, grey mullet and carp, production taking off at almost the same rate and at the same time although tilapia has been the dominant species. Towards the later half of the1990s, development of grey mullet outstripped that of the carps which continued to grow but at a lower rate.

Aquaculture in sub-Saharan Africa contributed only 1.6 percent (93 500 tonnes) of the total fish production from this region in 2004. In terms of volume and value Nigeria, followed by Madagascar, South Africa, the United Republic of Tanzania, Uganda and Zambia are the top six countries in the region, and the only ones with production above 5 000 tonnes. These countries produce over 80 percent of the total from the sub-Saharan Africa region.

Where aquaculture has long been an established industry the rate of growth has not been as high since the level of development was already high (relative to present production) at the time aquaculture statistics started to be compiled. This is true in Asia and the Pacific region without China, in Western Europe and in North America. As shown in Table 1, the ten-year average annual growth rate in these regions never reached double digits during all five decades between 1950 and 2000.

In the case of China, there was a spurt of development during the early 1950s soon after the country stabilized under the new government. For much of the five decades after 1950, annual growth rates were in the double-digit levels. Annual growth during the 1950s averaged 28 percent although production setbacks during some years in the 1960s to 1970s pulled down the ten-year averages to 4.1 percent and 7.5 percent, respectively. But massive and sustained growth came only in the 1980s and 1990s with ten-year averages of 11.6 percent and 15.1 percent, respectively, as the country shifted first to the production responsibility system and later to a market economy. No single species can be said to determine the growth of aquaculture in China. Growth is spread

over all cultured species but the top species (over million tonnes, in order of production volume) are Japanese kelp, Pacific cupped oyster, grass carp, silver carp, Japanese carpet shell, aquatic plants (various), common carp, wakame (*Undaria pinnatifida*), bighead carp and crucian carp.

In the rest of Asia and the Pacific region (without China), annual growth from 1950 to 2004 averaged 7.5 percent and the ten-year average annual growth ranged between 6.4 and 10.1 percent from the 1950s to the 1980s, but dropped to 3.4 percent in the 1990s. Between 2000 and 2004 the average annual growth rate increased to 9.2 percent. No single species or country can be said to determine the growth of the region as a whole. Eleven species items are above the half-million tonne production level including three species of aquatic plants, milkfish, giant tiger prawn, Pacific cupped oyster and four species of carp. India, mainly due to large increases in the production of cyprinids, is the world's second largest aquaculture producer with over two million tonnes. Five other countries exceed one million tonnes of production: the Philippines, Indonesia, Japan, Viet Nam and Thailand in that order. With China, these seven countries represent the top seven producing nations in the world. The Republic of Korea and Bangladesh follow in eighth and ninth place. Chile, in tenth place with almost 700 000 tonnes of production in 2004, is the only country outside of Asia and the Pacific region in the top ten (Box 2).

Aquaculture production in North America averaged a 4.7 percent growth during the 1950 to 2004 period. The pace of aquaculture development in North America is a function largely of the development in the United States of America, accounting for 80.7 percent of the continent's production in 2004, owing primarily to its channel catfish industry that makes up 47.1 percent of the total United States aquaculture production of 607 000 tonnes.

In the Western European region, the production of Atlantic salmon, primarily in Norway and secondarily in the United Kingdom, has led the growth of aquaculture. Two other species that have grown over the years are rainbow trout (*Oncorhynchus mykiss*) and blue mussel (*Mytilus edulis*) but their production growth rate is considerably lower than that of the Atlantic salmon. Norway is the top producer in the region. Its production share, however, is only 30.3 percent as aquaculture production is more spread throughout Europe. The blue mussels of Spain, and the cupped oysters of France are also produced in large quantities, but their production has already been stable for some time. The Mediterranean mussels of Italy have shown a steady increase over the years but the rate of growth and the magnitude of production are not substantial enough to influence the growth of aquaculture of the entire region.

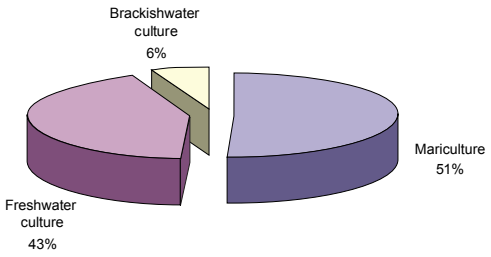
BOX 2

Top 10 aquaculture producers in the world in 2004

Country	Production volume (tonnes)	Global (%)	Production value (1 000 US$)	Global (%)
China	41 329 608	69.6	35 997 253	51.2
India	2 472 335	4.2	2 936 478	4.2
Philippines	1 717 028	2.9	794 711	1.1
Indonesia	1 468 612	2.5	2 162 849	3.1
Japan	1 260 810	2.1	4 241 820	6.0
Viet Nam	1 228 617	2.1	2 458 589	3.5
Thailand	1 172 866	2.0	1 586 625	2.3
Korea, Republic of	952 856	1.6	1 211741	1.7
Bangladesh	914 752	1.5	1 363 180	1.9
Chile	694 693	1.2	2 814 837	4.0

PRODUCTION BY ENVIRONMENTS

FIGURE 7
Aquaculture production by environment in 2004



In 2004, aquaculture production from mariculture was 30.2 million tonnes, representing 50.9 percent of the global total. Freshwater aquaculture contributed 25.8 million tonnes, or 43.4 percent. The remaining 3.4 million tonnes, or 5.7 percent, came from production in brackish environments (Figure 7). Some 63.1 percent of brackishwater production consists of penaeid shrimps. Fish comprised 34.0 percent, led by milkfish (*Chanos chanos*) and Nile tilapia culture in Egypt. Freshwater culture production consists largely of fish which accounts for over 94 percent. Molluscs and aquatic plants, on the other hand, almost evenly make up most of mariculture at 42.9 percent and 45.9 percent, respectively.

Caution should be used in making conclusions on the current importance of each environment. Only production from freshwater aquaculture can be considered distinctive. The same cannot be said for mariculture and brackishwater aquaculture, as there is no common standard used by countries in classifying an aquaculture area or in reporting production as either coming from brackishwater or marine environment. Thus, a species being cultured under the same conditions may be considered mariculture in one country and brackishwater aquaculture in another. This situation is best demonstrated in the case of penaeid shrimps, which are almost exclusively cultured in coastal ponds or tanks in all shrimp producing countries (with the exception perhaps of China and Thailand where culture in freshwater is also practised). Nearshore waters used to water coastal ponds are influenced greatly by surface runoffs so that technically, most of these waters can be considered brackish in nature. Yet in 2004, of the 51 countries reporting production of penaeid shrimp, 22 countries classified shrimp production exclusively under mariculture, 23 countries exclusively under brackishwater aquaculture while four countries reported production partly as brackishwater aquaculture and partly as mariculture. Iran classifies shrimp under brackishwater aquaculture and Saudi Arabia under mariculture although both countries operate their grow-out ponds under the same mostly hypersaline conditions (40 ppt or higher). Additionally, two countries reported penaeid culture in both brackishwater and freshwater environments.

DIVERSITY OF MAJOR SPECIES GROUPS AND SPECIES USED IN AQUACULTURE

By major groupings, fish is the top group whether by quantity or by value at 47.4 percent and 53.9 percent, respectively. Aquatic plants are second in quantity at 23.4 percent but only fourth in value at 9.7 percent, whereas crustaceans are fourth by quantity at 6.2 percent but second by value at 20.4 percent. Molluscs are the third most important group both by quantity and by value at 22.3 percent and 14.2 percent, respectively (Figure 8). It should be noted that the species listing found in the FAO FISHSTAT Plus database does not include production of cultured ornamental fish.

A total of 442 species items are listed in FAO FISHSTAT Plus database as being cultured or having been cultured at one time between 1950 to 2004. The actual number of distinct species under culture may be greater or less than this figure. Included among the 442 species items are many that are not defined to the species level – for example, "Penaeid shrimps nei" (where "nei" means "not elsewhere included"). Most likely, most of the production reported by countries in this way is made up of species for which there is some data at the species level. It is also possible, however, that new species could be included in these aggregated groupings. The wide diversity of aquaculture and the aggregated reporting make it unwieldy and potentially misleading to conduct

species by species analyses. It is common to group the species by taxonomic families since generally the species within each family have the same feeding habits, are cultured using the same basic protocols and have the same markets.

In the aquaculture production data for 1950, there were only 34 families represented, consisting of 72 species items. For 2004, production was reported for 115 families and 336 individual species items

FIGURE 8
World aquaculture production by major taxonomic grouping in 2004

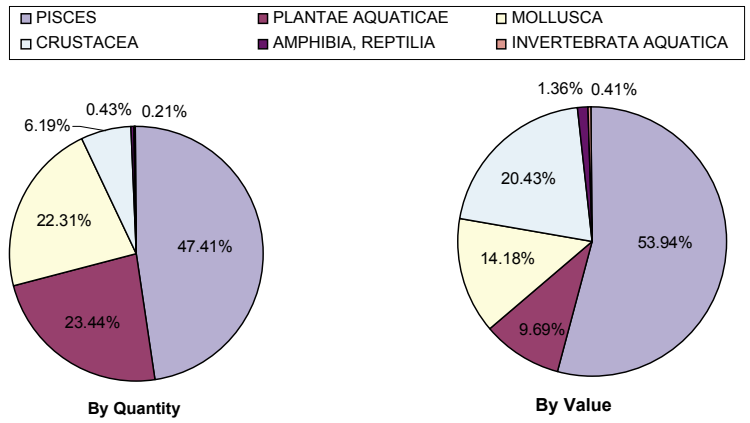
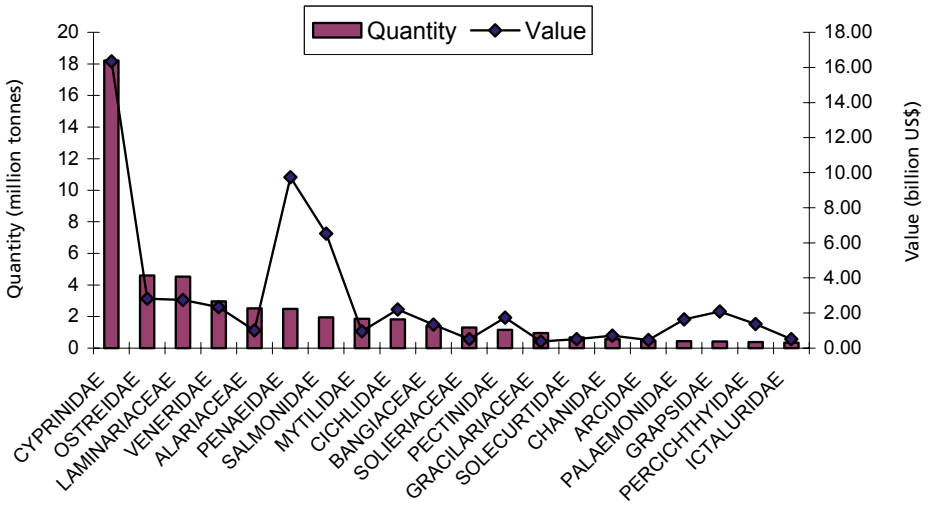


TABLE 2
Number of species in aquaculture with reported production in 2004 in FAO FishStat+ database by continent and major grouping

Continent	No. families	No. species
World	245	336
North America	22	38
Central and Eastern Europe	21	51
Western Europe	36	83
Latin America and the Caribbean	33	71
sub-Saharan Africa	26	46
Asia and the Pacific region	86	204
Near East and North Africa	21	36

FIGURE 9
Top taxonomic families used in global aquaculture (production of more than 250 000 tonnes) with corresponding values in 2004



(Table 2). Over the last 54 years, on average, 1.5 families and 5 species were added per year, although the most rapid growth in terms of number of species added per year occurred between 1980 to 1990 with 9.5 species per year, compared to only 0.3 species added between 1950 to 1960 and one species per year between 1960 and 1980. Asia and the Pacific region leads in the number of families cultured in 2004 (86) followed by Western Europe (36), Latin America and the Caribbean (33), sub-Saharan Africa (26), North America (22), Near East and North Africa (21) and Central and Eastern Europe (20) (Table 2).

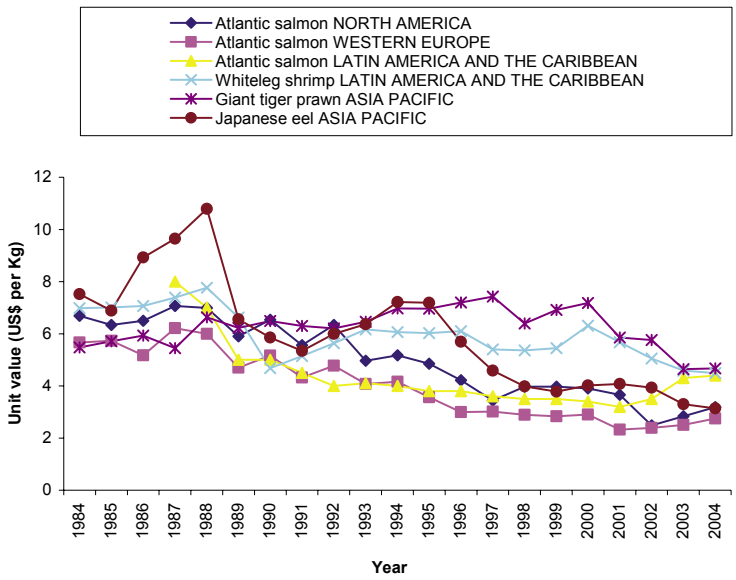
There are more species of fish cultured than other major taxonomic groups. The cyprinids, with 18.2 million tonnes valued at US$16.3 billion, emerge as the most important taxonomic family by quantity and by total value. By volume, Ostreidae (oysters) are a distant second at 4.6 million tonnes and are followed closely by Laminariaceae (kelps) at 4.5 million tonnes. As can be seen in Figure 9, crustaceans represented by penaeid shrimps and grapsid crabs have total values that are disproportionately high relative to their quantities. While the penaeid shrimps rank sixth by quantity, they rank second by value. Similarly, grapsid crabs are 18th by quantity but rank 8th by value.

VALUE OF PRODUCTION

Judging from their respective values it appears that many farmed fish species are raised for local consumption, as exemplified by the cyprinids, rather than for export. This highlights the important role of aquaculture in food security. Besides cyprinids, other important food fish species with total production over 200 000 tonnes in 2004 were the cichlids (tilapia), chanids (milkfish) and the clariids (catfish).

Thanks to aquaculture development, even species which used to be considered "luxury" species such as salmon and shrimps are now more affordable as the surge in volume through improved technology has brought down prices, as reflected in the value data. This has resulted in a downward trend in the unit values of Atlantic salmon, Pacific whiteleg shrimp, giant tiger shrimp and Japanese eels during the last 20 years (Figure 10). According to FISHSTAT Plus data, the unit value for Atlantic salmon in 2004 has dropped by 20 to 40 percent of the unit value in 1986–1987 in Western Europe, North America and Latin America and the Caribbean. The lowest values were recorded in 2001 but have rebounded somewhat in recent years. Japanese eels in Asia and the Pacific region showed a steep drop in unit value, with the 2004 unit value only 29 percent of the peak unit value in 1988. Also, it should be noted that these prices and comparisons are not adjusted for inflation. Thus, the actual decreases in real value are somewhat greater.

FIGURE 10
Trends in the unit value of selected high-value species in selected top producing regions between 1984 and 2004



This downward trend in unit value is also true for shrimps. The 2004 unit value for whiteleg shrimp produced in the Latin America and Caribbean region is only 58 percent of the unit value in the peak year of 1987.

In the case of the giant tiger shrimp, the unit value peaked in 1997, probably as the species gained greater market acceptance outside Japan. The unit value of the species in 2004 is only 63 percent of its peak value (Figure 11).

This trend towards decreasing unit value is also detectible in lower value fish, particularly the cyprinids in Asia and the Pacific region (Figure 12). The 2004 unit values for bighead carp, silver carp, and grass carp were only 84 percent, 83 percent and 64 percent, respectively, of those in 1984. Common carp showed the sharpest decline to only 60 percent of its unit value in 1984. Unit value of tilapias in 2004 is higher than that in 1984. When compared with 1992, however, when it rose to its highest value, presumably as it gained full consumer acceptance, the 2004 unit value is only 80 percent.

FIGURE 11
Trend in the unit value of shrimp in Latin America and Caribbean and Asia and the Pacific region between 1984 and 2004

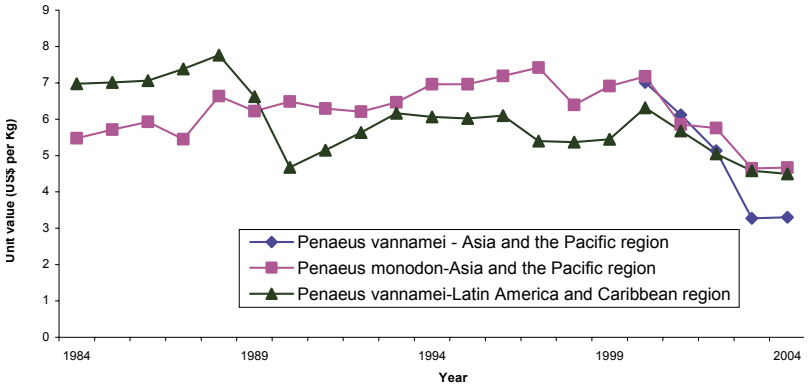
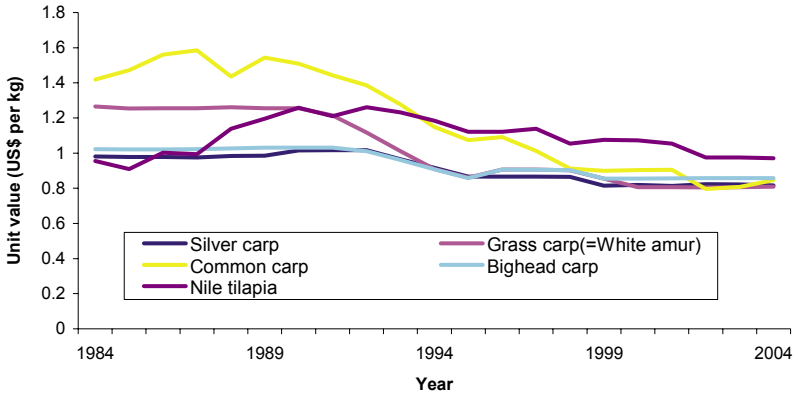


FIGURE 12
Trend in the unit values of selected lower-value species in Asia and the Pacific region between 1984 and 2004



USE OF INTRODUCED SPECIES

The use of introduced species in aquaculture is not new. There is no record as to when common carp, native to China, came to Indonesia. The same is true with Mozambique tilapia that is known more under its local name "mujair" in Indonesia than as tilapia. Similarly, rainbow trout had crossed the oceans even during the steamer days. But with air transport and increased global commerce, the rate of introductions has increased in recent years.

Two species stand out for the fact that production in the region where they have been introduced is now substantially more than in their native regions. These are Nile tilapia, *Oreochromis niloticus* and the whiteleg or Pacific white shrimp, *Penaeus vannamei*. Total production in Asia and the Pacific region of the Nile tilapia was 1.2 million tonnes in 2004 compared with 212 000 tonnes combined for the regions including Africa where it is native (see details in FAO, 2004). For whiteleg shrimp, production in Asia and the Pacific region was 1.1 million tonnes compared with 266 000 tonnes in Latin America and the Caribbean based on the FAO FISHSTAT Plus database. Actual production in Asia and the Pacific region of the whiteleg shrimp maybe more than that reported to FAO as many of the countries in the region are shifting production from *P. monodon* to *P. vannamei* but may be slower to change the reporting (see Figure 11).

PHOTO CURTSY MATT BRIGGS

Figure 13 - Penaeus vannamei, *the species contributing to the increase in shrimp production and decrease in unit price, globally.*

In Latin America and the Caribbean more than 65 percent of the aquaculture production was achieved solely with introduced species in 2004. This includes large production of salmon, trout, tilapia and carps. In addition, production of *P. vannamei* in non-Pacific countries can be considered as introduced. This would include the production of *P. vannamei* in Brazil (76 000 tonnes in 2004).

Another species that is now being produced more in regions other than in its native region is the European eel, *Anguilla anguilla*. Official statistics as reflected in the FAO FISHSTAT Plus database indicate that eel production in Asia (mainly Japan and China) consists primarily of the Japanese eel, *Anguilla japonica*. This is far from being the case, however, because over the last forty years Japanese glass eel catches have been falling in Asia. In 1965 the catch of Japanese glass eels reached 140 tonnes, by 2000 this had fallen to 40 tonnes (Klinkhardt, 2004). To make up for the shortfall Asian growers have been buying European glass eels. Japanese eel growers started this practice in 1973 after eel production in Japan fell (Japan Fisheries Association, 1975). In the 1980s, European eels amounted to only 3 percent of the glass eel stocks in Asia. But in the mid-1990s, Asian traders bought 75 percent of the European glass eel stock. By the end of the 1990s, with European glass eel imports ranging from 200 to 300 tonnes, it is believed that up to 80 percent of the eels in Asian eel farms consisted of European eels (Klinkhardt, 2004).

The growing paucity of seedstock of a local species as a reason for using an alien species is unique to eels. The most common reason for bringing in a foreign species is its perceived superiority in growth and yield over that of the local equivalent. In the case of the eel this is clearly not so. For the European eels, 3 to 4 kg of glass eels are required to produce 1 kg of eel, versus only 2.5 kg for the Japanese eel. In addition to

PHOTO CURTSY SENA DE SILVA

Figure 14 - *Tilapia* (Oreochromis niloticus) *farm in Malaysia. The current production of this introduced species in Asia is much higher than its native region, Africa.*

superiority in terms of growth, the use of an exotic species is always premised on either or any combination of the following reasons whether perceived or actual:

- more efficient feed conversion;
- resistance to disease;
- hardiness to handling and environmental fluctuations; and
- greater tolerance to crowding.

Alien species have been used successfully to generate increased income and social benefits in many parts of the world. They have, however, also been identified as a major threat to biodiversity and as a vector for pathogens. The domestication of native species also poses risks to biodiversity because of the potential for interbreeding with local species if related domesticated species escape. Alien species and the subsequent fishery/aquaculture development also pose risks to existing social and economic environments by changing access rights and local governance.

The growing of Atlantic salmon on the Pacific coast of the Americas is an on-going and unresolved controversy. Although confined to cages, the possibility of escape is real, having potential impacts on native species due to competition and predation. Escapes of Atlantic salmon are even more feared in Northern Europe because of possible mating with native stocks. Perhaps due to the fact that most aquaculture in the Asia and the Pacific region consists of exotic species, the issue of escaped stock has not received as much attention until recently. This interest came with the introduction and massive use of Pacific white shrimp, likely due to the strong opposition to its introduction by environmentalists afraid that it may bring exotic diseases or alter local biodiversity by displacing a local species in a particular ecological niche (FAO, 2005).

THE CULTURE OF ORNAMENTALS

The production of ornamental fish is often not regarded as part of what may be considered "mainstream aquaculture". Thus many countries do not keep statistics on its production in the same manner as food fish and these species are not included in the FAO FISHSTAT Plus database. Yet the production of ornamentals is as much an aquaculture activity as the production of salmon and shrimps, albeit on a much smaller scale. One difficulty in including ornamental fish in the regular reporting in aquaculture is the fact that the product is generally traded by the piece rather than by weight. Thus the best way to estimate the importance is through the value of ornamental production, which in 2000 was estimated at US$900 million at wholesale price and US$3.0 billion retail (FAO, 2001).

As with the culture of food fish, the ornamental fish industry is also strongest in the Asia and the Pacific region and focuses on freshwater species. While the culture of freshwater ornamentals can be considered mature, marine ornamental culture is still in its infancy and is limited to a very few species. Most trade in marine ornamentals comes from wild-caught stock. It is hoped that a detailed review of this sector will be conducted in time for the next global review.

Besides ornamental fish, the culture of pearl oysters is also an activity that can be categorized under aquaculture.

PHOTO CURTSY ZHOU XIAOWEI

Figure 15 - *Neon Tetras in an ornamental fish shop in Kunming, P.R. China – Ornamental fish industry is expanding globally, and is worth considering as an aquaculture activity.*

Many Pacific Island countries benefit from this activity and the industry appears to be expanding.

CULTURE SYSTEMS

An array of culture systems are used around the world. Various containment or holding facilities are common to freshwater, brackishwater, and marine ecosystems, including earthen ponds, concrete tanks, raceways, pens, cages, stakes, vertical or horizontal lines, afloat or bottom set, and racks, as well as the seabed for the direct broadcast of clams, cockles and similar species.

The current FAO reporting system for aquaculture classifies production only by environment, making it difficult to obtain the relative importance of each culture system in the respective regions. The dominant system, however, may be inferred for each region using the dominant species produced. Cyprinids are most likely to be produced in freshwater fishponds, salmons in sea cages, shrimps in brackishwater or marine ponds and channel catfish in raceways or freshwater ponds. On the other hand, marine bivalves are mostly produced using lines, racks and stakes and seaweeds are primarily produced using lines. This can imply that freshwater fishponds, sea cages, lines and racks are all important for aquaculture.

There are also developments on land-based, factory-type aquaculture production systems where temperature is controlled and where liquid oxygen may be used. These systems are energy intensive and are used only for very high value products intended for a niche market. For example, this system is used for abalone culture in Australia, for tilapia culture for the live market and for hybrid striped bass in the United States.

The commercial aquaculture of marine finfish is expanding and likely to take place in more offshore locations than have been used traditionally. Cages developed specifically for offshore culture have been put into commercial use in recent years. More development in this area is envisioned.

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3. Markets and trade

INTRODUCTION

Demand, market and marketing aspects have become an important set of driving forces in shaping the aquaculture sector, globally. Demand for aquaculture produce continues to grow but future growth will be driven largely by market requirements. Consumers are becoming more quality conscious and demanding. Issues such as socially and environmentally responsible aquaculture practices, food safety, traceability, certification and ecolabelling are becoming increasingly important. During the past five years, especially, market access and trade issues have dominated events in many parts of the world. The events are categorized into low international prices, trade barriers, non-tariff barriers, traceability issues, changing tastes according to demographics and consumer purchasing power and intense global competition, particularly for internationally traded commodities.

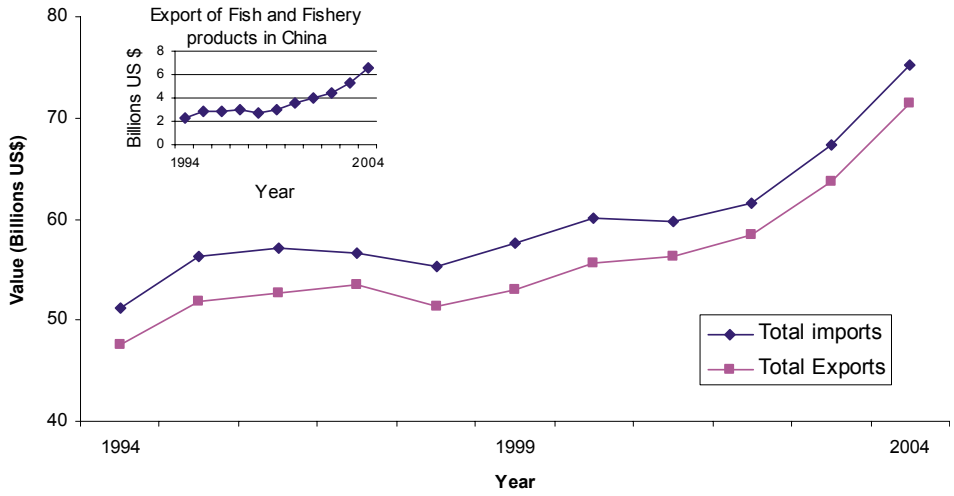
New markets are emerging worldwide. As high value species are increasingly exported (intra- or interregionally) and low-value products are imported (this is a particular trend in Asia), there is an increasing need by aquaculture farmers to improve and facilitate access to export markets. The choice of species produced may also increasingly be directed towards higher value strains that have export potential. With the more stringent demands of export markets, small-scale operators are facing increasing difficulties in producing aquaculture products for export and may leave the sector as they become uncompetitive. For some export commodities, exporting countries are beginning to look at quota systems or mutual agreements on production limits to avoid destabilizing market prices.

The regional aquaculture trends reviews indicate various responses by governments to market issues that have a significant impact on the aquaculture sector. They are mostly geared towards the small and poor farmers while generally they are aimed at improving the country's competitiveness in foreign markets. In some countries, the latter tends to bias support to the commercial, especially export-oriented farmers, but generally resulting in more efficient and, in many cases, responsibly managed production and processing of aquaculture food products. A study of China's fundamental and broad-ranging fisheries policy changes to align with World Trade Organization (WTO) rules shows how a country's broad-ranging adjustment to the WTO framework can have positive impacts on its fish farmers (Luping and Huang, 2005).

MARKETS, TRADE AND RURAL DEVELOPMENT

The global fish trade was worth US$63 billion in 2003 and Asia accounts for US$20 billion of this (Figure 1). Over 40 percent of fish production is traded across borders and exports exceed that of meat, dairy, cereals, sugar and coffee. Much of the traded fish and fish products are from aquaculture, which is practised almost entirely in rural areas and concentrated in developing countries. Thus trade presents an opportunity to help rural communities. Governments, however, do not appear to exploit fully the opportunity that this scenario presents for rural development (Gupta, 2005).

FIGURE 1
Global import and export of fish and fishery products from 1994 to 2004 (insert – Fish and fishery products expert from China P.R. during the same period)



Source: GLOBEFISH, 2006

Developing the local markets

The aquaculture status and trends review of sub-Saharan Africa is illustrative of some of the issues that contribute to market failure in nascent aquaculture sectors. Market failure is largely a consequence of poor governance, poverty, lack of resources and infrastructure and is one of the principal reasons for the failure of aquaculture to develop beyond the subsistence oriented scale. Bene and Heck (2005) consider market failure as the norm rather than the exception for the rural poor in Africa and efficient, redistributing trickle-down mechanisms are yet to be created in much of the sub-Saharan region. Farmers can be categorized into non-commercial[1] and commercial farmers. The market chain of commercial farmers in sub-Saharan Africa differs widely and depends entirely on the product, scale of operation and the target market. As elsewhere, the commercial aquaculture market chain is variably organized and ranges from selling fish via traders in urban markets (e.g. Ghana, Cameroon, Nigeria and Uganda) to sophisticated cold chain export of species such as live abalone. Because the non-commercial farmers internalize the bulk of their production and only sell fish to raise cash for immediate use, the market chain is correspondingly short. In most instances fish are sold at the pond or farm gate. Throughout the region there is an emerging small-scale commercial fish farming sector. It is crucial to promote the growth of this sector and to develop markets for these farmers. The most logical route, under current conditions, would be for emerging commercial farmers to link into the market chain of the established commercial fish farming sector. This underlines the key role that the larger commercial farmers can play in the overall development of the sector (Hecht, 2006).

The positive impact of market incentives on the scale and intensity of fish production is shown by a comparative analysis of two groups of fish producers

[1] The African overview referred to "non-commercial" aquaculture as small-scale subsistence, small-scale artisanal or integrated aquaculture and is normally practised by resource-poor farmers. Non-commercial producers may also purchase inputs, such as seed and feed, but rely chiefly on family labour and on-farm sale of produce. An additional feature of non-commercial aquaculture is that it is one of a variety of enterprises comprising the farming system; it is undertaken to diversify production and income, improve resource use and reduce risks of such events as crop or market failure.

differentiated by the location of their market, one in the peri-urban, the other in rural zones of southern Cameroon. In the peri-urban domain, prices were 48 percent higher, the number of buyers was three times greater and the average purchase per customer was nearly double that of the rural domain. Producers in the peri-urban domain sold 300 percent more fish per harvest, were 72 percent more productive per unit area and had 11 times the production scale of producers in the rural domain. This suggests an urgent need to connect rural producers to urban markets in order to foster the growth of aquaculture in sub-Saharan Africa. On the other hand, non-commercial fish farmers are widely distributed in most parts of the countries, where suitable conditions for aquaculture prevail. This does not provide the concentration and economies of scale for the market to become interested in the product. The Cameroon case suggests the potential advantage of zoning areas for aquaculture concentration, using bio-physical, demographic, marketing and socio-economic parameters. Such zones may provide platforms for the progressive development of aquaculture throughout the region. An example is the proposed Namaqwaland Mariculture Park in South Africa. In a related review of sub-Saharan Africa, the WorldFish Center (Bene and Heck, 2005) also recommends improving fish market chains through local small-scale entrepreneurs. The review points out that increasing demand of the urban population for higher quality fish products will drive small-scale enterprises in peri-urban areas.

A further constraint is that the infrastructure designed for agriculture, such as farm to market roads, may not be adequate to answer the needs of aquaculture. This is because aquaculture products are inherently much more perishable than for instance grains or other agricultural crops. Thus ice plants, cold storage and suitable transport facilities are even more critical in aquaculture. The provision of a cold-chain infrastructure on the other hand also raises its own problems related to cultural norms on the acceptability of frozen or even iced fish.

Another lesson relating to markets and market infrastructure and demand is the attempt of several countries (e.g. Angola, Liberia, Mozambique, Nigeria, United Republic of Tanzania, Kenya and Ghana) at shellfish culture. Such initiatives, for several economic, market and environmental related reasons, have not been successful. Mariculture is inherently more expensive than freshwater aquaculture and its success is strongly dependent on the market and the interest of the private sector and requires comprehensive business and environmental planning.

In the Near East and North Africa region, increased domestic demand has been stimulated by such factors as improved road access, improved cold chain facilities and effective marketing. Improved transportation of the aquaculture products means that inland communities that have not traditionally eaten much fish, can now include this protein in their diet.

North American producers, while they have to contend with lower-priced imports, have a decided advantage in their access to well-developed support services and close proximity to one of the world's largest seafood markets.

PHOTO CURTSY RIZAUL HASAN

Figure 2 - *A worker feeding fish in an African catfish* (Clarias gariepinus) *farm (Obasanjo Farm) in Ota, Nigeria. This livestock farm, which was established in late 70s, diversified into to fish in 2004. If all 12 concrete ponds of the farm are harvested twice annually, the farm should profit over 50 000 US$ a year.*

The United States of America alone imports US$11 billion in seafood products annually. The same advantage could probably be said of European Union (EU) aquafarmers.

Aquaculture production in North America contributes significantly to local economies in regions of the United States of America and Canada characterized by low levels of economic development and high rates of unemployment. In the southeastern United States, marginally profitable agricultural land coupled with available water and soils suitable for pond construction provide the foundation for development of the channel catfish industry. The US$480 million in farm-gate sales in 2004 generated an economic impact of billions of dollars through production, processing, feed manufacture and associated goods and services. From 1995 through 2002, the number of processors alone has ranged from 19 to 26. Localized impacts can be highly significant. For example, in 2004, catfish farming in Chicot County, Arkansas (United States) generates a total economic impact of US$359 million, providing US$20 million in tax revenues and 2 534 jobs, accounting for 46 percent of total employment in the county.

In Canada, Atlantic salmon aquaculture accounts for more than 90 percent of the total value of Canadian production and has developed in British Columbia and New Brunswick provinces where the resource extractive industries of timber harvesting and commercial fishing have declined significantly. In British Columbia, for example, salmon farming creates 1 800 direct year-round full-time jobs and over 2 000 indirect jobs. Ninety percent of salmon farming employment is in rural areas and the total economic activity attributed to the farmed salmon sector is worth US$523 million. Given that more than 85 percent of aquaculture production is exported, the value of this sector in generating outside revenue is amplified.

It is difficult to overemphasize the importance of a functioning market for small-scale aquaculture. Lessons from an Asian Development Bank (2004) evaluation of small-scale aquaculture in eight rural farming areas in Bangladesh, Philippines and Thailand include the following:

- Markets provide key channels for the exchange of goods and services to generate incomes.
- For producers, capital assets and factors of production have alternative uses and markets can provide important signals for producers to respond to demand.
- Functioning markets enable the flow of goods and services from producers to consumers, providing information on: (i) products and their features; (ii) prices of goods and services; (iii) places or locations of market transactions; (iv) promotion of sales; and (v) people, including producers, intermediaries and consumers, who are involved in these markets.

PHOTO CURTSY ALISTAIR STRUTHERS

Figure 3 - *Offshore salmon cage farm in Canada. The technological advancements in systems design and construction help in mitigating environmental impacts and improving production efficiency.*

In summary, the major factors that contribute to functioning markets include transportation and communications. Fish farming cannot succeed if pioneered and left to sustain itself in isolated areas where essential support services and markets are absent. Rural infrastructure makes access to and expansion of markets possible.

Role of the market chain

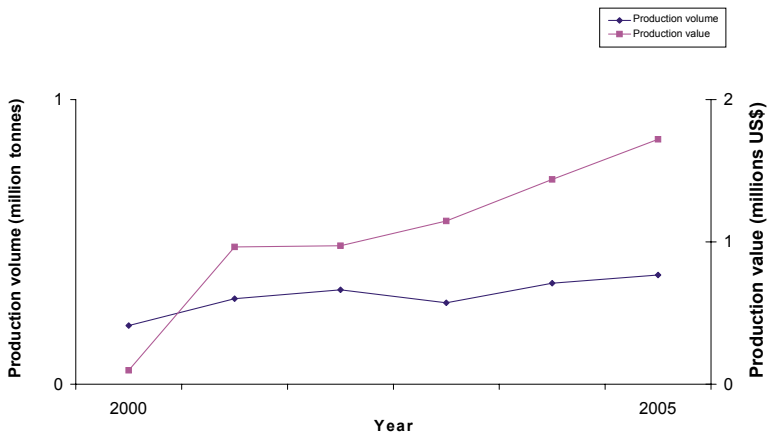
The efficiency and nature of the market chain impacts significantly on the margins of producers and the price and availability of fish to consumers. In many parts of Africa, post-harvest losses in capture fisheries exceeds 30 percent. This has a double impact on food security: it reduces income and the total supply of fish to consumers. Because of weak market infrastructures and facilities in rural areas, much of the captured fish is marketed as dried or smoked products. Local public and private investments are needed to support small-scale marketing initiatives in these areas leading to higher income and a greater supply of quality fish to consumers. This would stimulate rural development and provide economic opportunities for women traders (Bene and Heck, 2005).

As the Latin America and Caribbean review illustrates, the market chain for aquaculture products varies according to production volume and the distance between production centres and ports or export exit points. Small producers sell their products at the farm-gate or the nearest population centre. For the local market, rural sector supply chains are oriented from the producer to the selling point, while at the national level the processor and intermediaries are introduced. Larger enterprises often process their own products and transfer them to the "broker", even in the country of destination (as in salmon). For larger outputs, products are transported to the nearest cities that have cold storage facilities and processing plants. Prices are lower due to larger volumes handled. Large farms harvest and process their own products, placing them directly in the markets for their redistribution. The marketing of aquaculture products is carried out in supply centres, chain stores and supermarkets and in some instances in selling points that belong to the producers or the processing plants.

In this regard, a regional meeting in Panama in September 2005 convened by FAO/OSPESCA (Organización del Sector Pesquero y Acuícola del Istmo Centroamericano), attended by experts mostly from governments, noted the distinction between intermediaries operating in national markets and the chain of intermediaries active in export markets. Noting the significance of the aquaculture market and trade and the fact that market liberalization has no effect on intermediation and product prices, the meeting advised producers to group into associations and to form alliances with traders. They urged government support to producer associations and formulation of policies to reduce the chain in the trade of aquaculture products (Morales and Morales, 2006). Sub-Saharan Africa exhibits the same increasing marketing complexity and sophistication for traded products. The market chain for export products such as fish, prawns and abalone is more sophisticated and the chain may have the following links: producer, company marketing section to collective marketing companies, foreign agents or buyers, exporting companies to wholesale or direct to retail market (FAO, 2006a).

Three finfish and two shellfish species groups dominate trade in farmed aquatic products in the Western Europe region. In 2003 salmon, trout, seabass and seabream accounted for 92 percent of regional export and 90 percent import trade of farmed products. For

FIGURE 4
Salmon export (volume and value) from Chile from 2000-2005



Source: Revista Aqua. Fundacion Chile. No. 105. May 2006)

The production has almost doubled during the five year period. Atlantic salmon contributes more than 50 percent to the over all value of export.

finfish the most dominant product form was fresh chilled whole fish on ice. In the case of salmon and trout there was a significant market for fresh fillets and smoked products. Shellfish were mostly sold live on ice. Netherlands and Ireland show a net positive trade balance. Norway had the highest trade surplus of US$3.1 billion. Iceland and Denmark were in second and third with surpluses of US$1.43 and 1.04 billion, respectively. In contrast to these less populated countries, Italy, Spain, France, Germany and the United Kingdom reported trading deficits of US$3.11, 2.68, 2.46, 1.37 and 0.85 billion, respectively. The ability of aquaculture to contribute to this deficit in the Western European region will depend on farmed products being transformed from luxury products to mainstream commodities. In the case of salmon and trout this status is fast being achieved with falling prices and wider distribution through chains such as hyper- and supermarkets (Rana, 2006).

The role of super- and hypermarkets is not as pronounced in the Central and Eastern European countries as in Western Europe although their importance is gradually increasing. In some of the countries, these large outlet chains have already become important channels of distribution (e.g. in Estonia). Supply chains and distribution channels are diverse, from direct sales at the farm site to large supermarkets. In Poland, the sale of fish from aquaculture is handled directly by farms. From 90 to 95 percent of the production is sold wholesale, while 5–10 percent is sold retail through small outlets owned by the fish farms. Retail prices are approximately 20 percent higher than wholesale prices.

In Hungary and in Serbia and Montenegro, domestic production is mainly sold to the consumer in the form of live fish, through special fish shops and supermarket chains. Due to the lack of adequate numbers of such outlets, many consumers do not have access to live fish. The wholesale market for fish is very small in Romania, with the consequence that there are many short-link marketing chains, resulting in high transport and distribution costs. The markets for fish products in Russia have a three-tier system: local, regional and federal. In Moscow and Saint Petersburg regions fish farms sell 30 percent of their production themselves through their own shops and mobile aquarium booths. The rest of the production is supplied to the trading network at wholesale prices.

The processing trend is towards direct purchase from farms as well as contract farming. Fully integrated companies (as those in Western Europe, North America, Asia and Latin America), control the production process and can assure traceability of their products. More and more feed companies are also becoming fully integrated to improve customer confidence in quality products through the production process. However, despite assurances of quality, occasional rejections by importers due to safety and quality issues are being continuously reported.

EXPORTS AND THEIR IMPACT ON THE ECONOMY

Impact of exports on local fish prices

Asia and the Pacific region has countries with the highest per capita consumption of fish. One forecast (Delgado *et al.,* 2003) sees consumption trends driving an increase in the demand for fishery products for food, partly due to changing food habits and the increasing purchasing power of several developing countries. In the Asian region, it is expected that there will be a shift from the region being a net exporter of fishery products to being a net importer. Developing Asian countries are expected to remain net exporters overall, but the percentage of their production exported could decrease due to rising domestic demand.

It seems logical to assume that the cost of fishery products will increase as, in most of the projections, supply cannot keep up with demand. Projected rises in prices between 1997 and 2020 are about 15 percent. Indeed the increase in the average price of fish to over US$2/kg in sub-Saharan Africa in the last five years has led to a resurgent interest in aquaculture throughout much of the region. On the other hand, analysis of recent

price trends seems to indicate the opposite trend, i.e. prices of fish are decreasing. This is in fact one scenario considered by Delgado *et al.* (2003); a rapid expansion of both scale and efficiency of aquaculture could lead to decreasing fish prices (this was the only scenario where fish price decreased). Herbivorous and omnivorous fishes are already being cultured very efficiently. However, current trends indicate that aquaculture is drifting towards higher value species, which present higher margins, allow investment in more intensive production systems and effluent treatments, may be easier to market and have greater export potential.

Regardless of price trend, but especially if it decreases over time, and given that the yield from capture fisheries is not expected to increase much, there would be a great emphasis on aquaculture's ability to provide increasing quantities of fish to satisfy the increasing demand in all regions.

Asia has a significant export orientation and focus on high value species, which has resulted in a shift in the balance of trade in fish commodities in favour of Asian developing countries. Despite being a significant net exporter, Asian developing countries' fish trade has been largely confined to a few developed country markets such as the EU, United States of America and Japan. In Asia, exports are relatively better documented than other aspects of aquaculture. Exports of individual countries range from a few hundred million to a few thousand million US dollars with China as the top exporter of aquaculture products (US$2 450 million in 2003). Thailand and Indonesia are viewed as the second largest aquaculture exporters in Asia with some US$1 600 million followed closely by Viet Nam with US$1 555 million.

Aquaculture export is focused on high value products, notably marine shrimps, but increasingly finfish including tilapia and catfish and seaweed. Almost all the South and Southeast Asian countries are shrimp exporters. The most notable success story in terms of non-shrimp export is that of the Pangasid catfish by Viet Nam which grew rapidly to reach almost 400 000 tonnes in 2005.

The principal aquaculture export products from countries in sub-Saharan Africa are mariculture products, mainly shrimps, abalone and seaweed. Shrimps are exported frozen (Madagascar and Mozambique), seaweeds are exported dry (United Republic of Tanzania, Madagascar and Mozambique) and 80–85 percent of abalone produced in South Africa is exported live and the remainder is canned. The value of marine products exported comprises 95 percent of the total mariculture revenue of the target countries and 33 percent of the total value of aquaculture products in the region. However, Uganda exports a small quantity of cold smoked *Clarias gariepinus* to the EU, showing the potential of freshwater fish for export.

In Latin America industrial aquaculture and some medium-scale operations are geared mainly to the export market. Leading the region's exports were Atlantic and coho salmon, with an exported volume of 375 000 tonnes and a value of US$1 500 million – normally marketed as whole fresh salmon and frozen fillets.

Next came marine shrimps with a production of 256 000 tonnes and a value of US$1.24 million. These were exported as fresh or frozen head-on shrimp and shrimp tails, and as processed shrimp tails. Tilapia exports amounted to 86 500 tonnes and a value of approximately US$266 million – mainly exported as whole frozen fish and fresh or frozen fillet. The main markets were North America and Asia, although Europe was becoming increasingly important. Intraregional trade (especially to Brazil and Colombia) was low in volume and value, but was on the increase. Exports played a significant role in certain national economies. Operations with the largest economic capacity, which were usually organized into trade associations, focused their investment on industrial culture for export. Many small and medium producers organized into cooperatives or other forms of association, concentrated on forms of culture that gave them access to local markets or markets in neighbouring countries, although shrimp and tilapia also targeted the export market.

The larger enterprises in the region gear their investments to fish, shrimp and mollusc culture towards international markets, organizing themselves into associations within or among countries, e.g. the Salmon Producers Association for the Americas. In general, the participation of the more powerful economic groups is reflected in the development of intensive aquaculture with a higher degree of technology and technological investment such as those in Chile, Brazil, Ecuador and Mexico. In Central America, associations enable the small- and medium-size producers to bring their products to local markets and, in cases such as shrimp, to external markets.

Fish produced in Central and Eastern Europe (CEE) are mainly exported live, frozen, quick-frozen, canned, salted and smoked. Exported fish are traded mainly within CEE countries and only in limited amounts in other European countries. Russia, despite its huge aquaculture production, only exports sturgeon and trout roe (caviar). Bulgaria also exports substantial amounts of aquaculture products (>5 600 tonnes annually), mainly molluscs (46 percent of the total exported quantity) and frozen fish, mainly to Romania, Serbia and Montenegro, Germany, Greece, Turkey and Japan. Croatian aquaculture production is focusing on export markets, which has resulted in a foreign trade surplus for several years now. In view of its export orientation, Croatia places strong emphasis on further trade liberalization, primarily with EU countries, and on increased export quotas.

Although production in the Near East and North Africa region has focused on domestic markets (led by Egypt, the dominant producer – which sells most of its product domestically due to high local demand), 11 of the 17 countries in the region export some or all of their production. Most exports are destined for other countries within the region, although some products are exported to more distant markets such as Europe, North America and Japan. A wide range of products is exported, principally market-size finfish and shellfish, but also fingerlings and seed, supplies (particularly fish feed) and non-food aquatics. Exports from this region are expected to increase both from established and new exporter countries.

Potential negative impacts of trade

A general conclusion about trade is that income from exports is good for the economy. But in a situation where the local demand has not been satisfied, exporting fish could undermine national or even regional food security. In this context, two issues are raised. First, while the fish removed from African markets can in principle be replaced by imports and the foreign exchange earnings from exports can stimulate national economies, the benefits of international trade versus the stimulus to local economies through increased processing, and national and regional trades have not been fully analyzed or demonstrated. Second, too strong a focus on international export could divert policy-makers' attention, research and management efforts and donor support away from the small-scale fisheries which supply local, provincial or national markets (FAO, 2003).

IMPACT OF COMPETITION FOR COMMON MARKETS ON AQUACULTURE DEVELOPMENT

Is competition for common markets good for national aquaculture sectors? Would it be good for all farmers in a country? Would it lead to a better global aquaculture order? Or would it favour stronger and better positioned countries at the expense of the poorer ones?

The regional reviews provide various general indications that competition had prompted governments, farmers, processors and exporters to adopt various measures to improve competitiveness. These have included improving technical efficiencies and reliability of supplies, diversifying products to cater to a wider range of specific market demands, improving capacities to comply with food safety requirements, promoting

the quality reputation and image of products and promoting the image of a socially and environmentally responsible farming and processing.

A study on shrimp farming in Latin America and the Caribbean provides an interesting perspective. It views the market-led development process as causing initially disruptive effects on aquaculture development in exporting countries, but with longer term beneficial outcomes (Wurmann, Madrid and Brugger, 2004).

The study focuses on two sources of competition: producers in importing countries, as with the United States shrimp fishing industry, and producers in other regions, particularly Asia. The study views the antidumping case in the light of its negative impacts on national shrimp industries. It takes the position that the antidumping accusation was in effect defending the probable structural incapacity of local shrimp fishers to compete on equal terms with a growing influx of cheaper shrimp imports whose costs and prices are lower than those of United States fishers. It notes that even if unfair competition by some countries was demonstrated and the corresponding producers face new tariffs, it will still be true that other farmers will be more cost efficient and competitive than the United States shrimp fishers. It predicted that after the completion of the exercise, things will go back more or less to where they were at the outset, but not before causing disruptions in producing countries, financial collapses of traders, importers and distributors and prompting less consumer demand (in the United States) because of higher priced shrimp products.

The study points out that China and other Asian countries have been producing whiteleg shrimp, *Penaeus vannamei*, in massive quantities.

It expects the production trend in Asia to continue with initial adverse impacts on the Latin America and Caribbean shrimp industry such as players leaving the industry altogether. It also predicts, however, that the competition will prompt the Latin American and Caribbean shrimp industry to develop innovative production methods and cost savings allowing farmed shrimp to become reasonably profitable and more competitive than in the past. This process will in turn enhance demand inviting more players to join or expand current capacity. It also pointed out an important strategic concern: balancing the support to small and medium producers with that of the big enterprises. The study contends that while the small producers are important for development and employment in poor rural areas, it is the big industry that leads the way in competitive and sustainable exports and increasing consumption in important local markets.

To mitigate the ruinous effect of competition between countries for the same product(s) and for the same market(s) the review of Asia and the Pacific region raised the prospect of adopting a form of "parts and product complementation" as practised in the manufacturing industry (automotive, electronics, etc.). One approach could be "national branding" whereby the production and marketing capability of each country will be put to a severe test in the open global market arena. In a related vein is the growing trend towards labelling or certification. For certification to be recognized and accepted, it is also essential to have an accreditation system for certifiers.

In Asia, a good case of a wide ranging government support to maintain market leadership in the face of growing competition from other producers is Taiwan, Province of China's promotion of tilapia as an export product. Taiwan POC exports tilapias mostly to the United States, Saudi Arabia and Korea (Rep. of), but Viet Nam is fast catching up, with cheaper prices, while China is now the biggest producer and also exporting significant quantities to some of the same markets. The Council of Agriculture (COA) strategy to boost tilapia's competitiveness includes upgrading its productivity, management systems and value addition. In short, they are turning tilapia aquaculture into a knowledge-based industry to stay ahead of competition.

One of the best models for an industry-initiated and industry-led marketing promotion which led to massive industry growth in aquaculture is that for the channel

PHOTO CURTSY MATT BRIGGS

Figure 5 - Penaeus vannamei *specific pathogen free (SPF) broodstock and postlarvae production hatchery in Thailand. Ability to produce SPF shrimp opened the door for P. vannamei to enter into Asia. As long as they remain free of major diseases such as Taura Syndrome and White Spot Syndrome Virus, the production will continue to grow.*

catfish in the United States. Farming of channel catfish was considered economically practical only in the 1950s and developed more rapidly only in the mid 1970s. Before then, catfish was still largely considered a regional food with little or no acceptance outside the southern United States. Acceleration in industry growth started during the 1980s which was attributed to the development of large feed mills and processing plants and an effective national advertising campaign launched by the combined effects of growers and feed millers. The expansion of the catfish market beyond southern United States of America made the industry grow from 15 000 ha pond area producing 35 000 tonnes in 1980 to 80 000 ha producing over 270 000 tonnes by year 2000 (Tucker, 2003). To finance the nationwide advertising, the growers agreed to pay a levy of a few cents for every kilogram of feed they purchase. The money collected by the feed mills was used for an advertising contract that covered all media as well as test-taste sessions in supermarkets. This cooperative and voluntary approach is worth emulating not just for market promotion but for other industry problems as well such as to finance research and development. On the other hand, in order to survive, the industry subsequently had to resort to anti-dumping legislation effectively applying a non-tariff barrier to protect it from foreign competition.

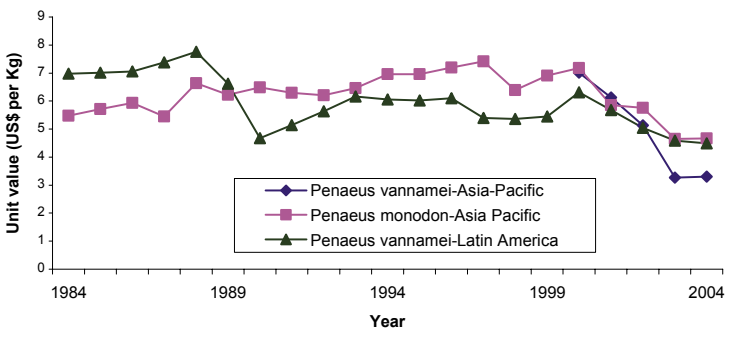
The above may be put in some perspective with a snapshot of the United States' seafood export and import status. The United States of America is one of the world's largest seafood exporters and the second largest seafood importer. While it is a significant exporter of seafood from the capture fisheries sector, aquaculture exports from the United States of America are small.

Oysters valued at US$17.2 million and clams worth US$10.9 million were exported in 2004, primarily to Canada. Ornamental fish worth US$8.7 million were shipped worldwide in 2004, with almost half going to Canada. During the same time the United States of America imported ornamental fish worth US$43.8 million primarily from producers in Asia. Tilapia imports to the United States of America have surged recently with imports in 2004 of 113 000 tonnes valued at US$297 million. Fillets comprise 50 percent of imported tilapia and 80 percent of total value. China provides more than 50 percent of the total and 77 percent of the frozen fillets. Total frozen fillet imports of 34 700 tonnes were valued at US$114 million with a unit value of US$3.28/kg. Honduras, Costa Rica and Ecuador provide 89 percent of the fresh fillet imports that command US$6.05/kg.

Salmon imports into the United States of America reached 179 000 tonnes with a value of US$871 million in 2004. Sixty-seven percent of imports are fillet products representing 70 percent of value. Average price is US$4.86/kg while fillets sold for US$5.06. Sixty percent of the total imports originate in Chile with the remainder coming primarily from Canada. Canada is the leading exporter of whole fresh fish to the United States of America with 78 percent of the market.

Shrimp is the most popular seafood in the United States of America with imports reaching 500 000 tonnes in 2004 with a value of US$3.7 billion. The average price of all products was US$7.11/kg. Thailand, China and Viet Nam are major suppliers, however imports from Bangladesh, Mexico and Indonesia have increased recently. Ironically the most significant aquaculture export of the United States of America also consist of shrimps, not the usual frozen shrimps for cooking, but live broodstock shrimps for hatcheries. The export of SPF (specific pathogen free) *Penaeus vannamei* and *P. stylirostris* broodstock may not be significant in terms of quantity or total value, but its impact is considerable both on the total quantity of shrimps produced and on global pricing. Without such exports, it is arguable if Asia's major shrimp producing countries could have recovered from disease outbreaks and severe shortage of healthy wild-caught broodstock of native penaeids, much less grown significantly to the present level of production.

FIGURE 6
Trends in price of shrimp



It is clear that the price of P. vannamei *in Asia is declining. This contributes to the declining global price of shrimp as* P. vannamei *now plays a major role in global shrimp production.*

PHOTO CURTSEY ROHANA SUBASINGHE

Figure 7 - *Surgeon hatchery in I.R. Iran. Besides aquaculture, culture based fisheries is a significant sector in Iran. Production of hatchery bred sturgeon fry for stock enhancement in the Caspian Sea is a regular activity of the Iranian Fisheries authorities.*

The majority of Canadian salmon production is exported to the United States of America and to a lesser degree Japan, Taiwan POC and France. Canada exported US$370 million in seafood products in 2004 with United States market accounting for almost 95 percent of the total. Canada holds 47 percent of the nearly US$1 billion United States salmon market, competing primarily with Chile which holds a similar market share.

In some countries in the Near East and North Africa, advertising and public education campaigns have been effective in stimulating demand for aquaculture products. Two examples are Iran (Islamic Republic of) and Saudi Arabia, countries with large interiors, where the inland populations are less familiar with buying, preparing and eating fish, than are the coastal populations. The inland populations thus represent potential new consumers for aquaculture products. Advertising and education for these groups enters into affect after the industry has reached a certain critical mass, in other words, there is enough supply to attract the market and it is reliable.

FOOD SAFETY, IMPORT REQUIREMENTS AND MARKETS

Competition aside, market access requirements that include non-tariff barriers to trade, technical barriers to trade and sanitary and phytosanitary (SPS) and food safety requirements have by themselves stimulated various responses from exporting

countries. In general, the responses can be seen as beneficial in the long run to the aquaculture sector, although apprehensions have been expressed on their impacts on the small and poor farmers, who do not have the economy of scale to comply cost-effectively with the requirements. Government and private sector institutions are also not well oriented towards supporting the large numbers of small-scale producers to address the complex issues surrounding food safety and traceability.

The global trade liberalization agenda has had a marked impact on Asia's seafood trade. Resolutions and agreements on market access issues, regulatory measures on health and food safety requirements and a host of other forms of technical barriers to trade are, in the coming years, expected to affect seafood exports from developing Asian countries. With the rising population and demand (including export demand), expansion of supplies to maintain food security has emerged as a priority concern. However, looming on the horizon are threats to fish supplies and fishery livelihoods due to resource degradation, weak public support and investment and potential worsening inequities in global trade (Dey and Ahmed, 2005).

A driving force has also been the need to comply with an ever increasing number and stringency of market requirements. The flashpoint may have been the rejection of shrimp exports by the EU but a combination of Technical Barriers to Trade Agreements (TBTs,) SPS, and Non-tariffs Trade Barriers (NTB) has prompted the broadening and hastening of initiatives that were already in place, such as Association of Southeast Asian Nations' (ASEAN) focus on competitiveness in trade, and the FAO, Network of Aquaculture Centres in Asia-Pacific (NACA), Worldwide Fund for Nature (WWF) and the World bank (WB) Consortium on Shrimp Farming and the Environment's work on international principles for responsible shrimp farming aimed at developing uniform certification standards and better management practices[2].

In most Latin American and Caribbean countries, plant certification programmes have been put in place by their health authorities in order to export fishery and aquaculture products. Some programmes are of particular note such as the SSOP (Standard Sanitary Operation Process) and the HACCP (Hazard Analysis and Critical Control Points), the application of which is required by the United States of America in order to approve importation and internal sale and by the European Union. Other institutions now carry out or implement studies for Residue Control Programmes in aquaculture operations and in plants, whose certification guarantees the quality of products, through tracing and traceability.

While developing countries have found it initially expensive, institutions are being built to support the tightened regulatory requirements for production and assurance of quality and safe aquaculture products. These include investment in capacity for the analysis of "contaminants" or "impurities" at the level of precision required by the importing countries. Most importantly, they have installed measures to prevent the appearance of residues and use of banned drugs in their products through good management practices employing such drastic measures such as confiscating drugs suspected of being diverted for livestock and aquaculture use. At present, most countries have the capability to apply HACCP to the production process which includes traceability, although practical implementation is still not widespread. There is a growing awareness of the need to adopt a uniform standard for aquaculture products whether for export or for domestic consumption, however, to date there is limited international progress on such standards.

In 2003, Thailand launched a comprehensive food safety and quality ("Farm to Plate") programme in order to maintain its competitiveness in the export market but also to assure local consumers and stimulate additional domestic consumption of seafood. The programme included product and process certification, promotion

[2] www.enaca.org/modules/tinyd2/index.php?id=2

of voluntary adoption of a package of good aquaculture practices aimed at food safety and quality as well as a more comprehensive code of conduct which includes environmental friendly practices, requirement of processors to install HACCP and other quality assurance protocols and strict policing of the use of banned chemicals and drugs.

Probably the most interesting case that depicts the success of an importing country, and future prospects, in dealing with competition and non-tariff trade barriers is that of Viet Nam by diversifying its market for the *Pangasius* catfish (Globefish, 2005).

During the first nine months of 2005, Viet Nam exported 89 300 tonnes of *Pangasius*, generating US$212.3 million, an increase of 58 percent in volume compared to the same period during the previous year. The catfish anti-dumping case, 2003, along with related bond requirements in 2005, has prevented Viet Nam from maintaining in recent years a stable growth rate on the United States market. The United States of America is no longer the biggest customer for Vietnamese *Pangasius*. The share of exports destined for the United States of America has decreased to 11.7 percent compared with 37.3 percent for the EU. This success story, however, raises the question of whether price competitiveness can be sustained and its long-term impact on the producers. The report (Globefish, 2005) points out that the competitive advantage of Vietnamese *Pangasius* has been based on lower prices, which may not be feasible in the long term. It implies a low marginal profit level which is unlikely to encourage production expansion. In addition, anti-dumping remains a potential threat with low price levels. In this regard, Vietnamese enterprises are currently intensifying efforts to meet strict EU requirements on quality, hygiene and safety. Exporters are examining approaches to value addition through product innovation.

Product labelling is applied in Madagascar, Mozambique, South Africa and Uganda, while the United Republic of Tanzania has developed legislation for labelling. On the other hand, however, Côte d'Ivoire and Ghana have implemented a ban on imports of aquaculture products in order to protect their emerging industries.

AQUATIC ANIMAL HEALTH, TRADE AND TRANSBOUNDARY ISSUES

Globally, aquaculture is expanding into new areas, intensifying and diversifying; as is trade in aquaculture species, products and services. Only through the trade of aquaculture commodities, live animals or products, can the primary producers earn their livelihoods and improve their economic well-being. Trade is always associated with economic benefits and hence will continue legally or illegally. On the other hand, trade in aquaculture commodities carries an inherent risk of moving and spreading aquatic animal pathogens.

A recent case of disease transmission through trade is the spread of koi herpes virus (KHV). Although known in other parts of the world since 1998, it was first reported in Indonesia in 2002. Since then it has spread to several countries in the region, in most cases associated with movement of live fish. KHV outbreaks in the region have significant trade implications for the high-value ornamental koi carp industry and the important food fish, the common carp. Active trade in ornamental fish poses a potential risk for the further spread of this disease in the region. Recognizing the significance and responding to confirmed outbreaks in Indonesia and Japan, "infection with koi herpes virus" was added in 2003 to the list of diseases prevalent in the region in the quarterly disease reports from Asian countries. Since its listing, several countries in the region have increased their surveillance, testing and quarantine programmes for KHV.

Infectious disease emergencies may arise within a country in a number of ways, for example: introduction of known exotic diseases; sudden changes in the pattern of existing endemic diseases; or the appearance of previously unrecognized diseases. Contingency planning, early warning and early response are critical to the effective management of such disease emergencies. Recognizing the importance

PHOTO CURTSY STUART MILLAR

Figure 8 - *Koi Herpese Virus (KHV) infected* Cyprinus carpio *(koi carp) in Indonesia. This outbreak of KHV, a highly pathogenic virus, caused unimaginable economic losses to the koi carp industry and common carp aquaculture in Indonesia. The disease is now found in several other countries and regions and is appeared to be moving through ornamental fish industry*

of aquatic animal health emergencies in the region, FAO, in partnership with Government of Indonesia, NACA and the WorldFish Center (WFC), organized a pioneering workshop on *Emergency preparedness and response to aquatic animal diseases in Asia* in Jakarta held in September 2004. The workshop reviewed the regional experiences in responding to disease emergencies and developed a set of recommendations to prevent, prepare for and respond to aquatic animal disease emergencies in the region (Subasinghe, McGladdery and Hill, 2004; Subasinghe and Arthur (eds.), 2005).

Various global instruments, codes of practice and guidelines (voluntary or obligatory) exist which provide certain levels of protection, all aimed at minimizing the risks due to pathogens/diseases associated with aquatic animal movement. One good example in Asia and the Pacific region is the development and adoption of regional guiding documents that take into full consideration the provisions of the WTO-SPS Agreement, the World Organisation for Animal Health (OIE) Aquatic Animal Health Standards, as well as the FAO Code of Conduct for Responsible Fisheries by 21 Asian governments. The Asia Regional Technical Guidelines provide the most comprehensive framework available for the development and implementation of national strategies to address aquatic animal health issues at national, provincial and local levels.

Risk analysis is increasingly being used as a decision making tool to determine risk associated with the movement of live aquatic animals and trade in aquatic products. International (e.g. OIE) and regional (e.g. NACA) disease reports provide regular and updated information on diseases of concern to facilitate risk analysis and minimize the introduction of pathogens as a result of trade. Towards training and capacity building, NACA in collaboration with Asia-Pacific Economic Cooperation (APEC), FAO, OIE and other partners, conducted two regional workshops on "Capacity and awareness building on import risk analysis for aquatic animals" in 2002. In addition, a risk analysis manual produced through this collaboration has provided a technical guide for implementing risk analysis.

From an aquatic animal health perspective, irresponsible practices (e.g. misuse of chemicals) adopted by farmers, with no access to technical knowledge, could lead to food safety problems in aquaculture products. This underlines the need to equip primary producers with necessary skills and knowledge so that the commodities they produce meet the requirements demanded by the market and consumers. As an example, a collaborative project in India between the Marine Product Expert Development Authority (MPEDA) and NACA supported by FAO has successfully brought together shrimp farmers (organized into aquaclubs) to collectively implement better management practices (BMP) to reduce disease-related losses, improve yields and produce quality and antibiotic-free shrimp. During 2005, the BMP implementation was carried out successfully at 15 villages in Andhra Pradesh and 5 villages in 4 other coastal states. In Andhra Pradesh and Gujarath, 635 and 88 farmers, respectively, participated in the demonstration programme.

The harvest results, from 930 demonstration ponds spread over 484 ha and 15 aquaclubs of Andhra Pradesh showed a two-fold increase in production, 34 percent increase in size of shrimp, 15 percent increase in crop duration, 68 percent improvement

BOX 1

Better management practices implemented by cluster shrimp farmers in Andhra Pradesh, India

Pond bottom preparation and water management

- Sludge removal and disposal away from pond site.
- Ploughing on wet soil if the sludge has not been removed completely.
- Water filtration using twin bag filters of 300 µ mesh size.
- Water depth of at least 80 cm at shallowest part of pond.
- Water conditioning for 10-15 days before stocking.

Seed selection and stocking practice

- Uniform size and colored PLs, actively swimming against the water current.
- Nested PCR negative PLs for WSSV (using batches of 59 PLs pooled together. If test turns negative it means that the prevalence of WSSV infected PLs is less than 5% in that population at 95% confidence).
- Weak PL elimination before stocking using formalin (100 ppm) stress for 15-20 minutes in continuously aerated water.
- On-farm nursery rearing of PLs for 15-20 days.
- Stocking during 1st week of February to 2nd week of March
- Seed transportation time of less than 6 hrs from hatchery to pond site.
- Stocking into green water and avoiding transparent water during stocking

Source: NACA/MPEDA/FAO cluster management in small-scale shrimp farming in Andhra Pradesh, India. www.enaca.org/shrimp

in survival and 65 percent reduction in disease prevalence when compared with surrounding non-demonstration ponds. As a result, for every 1 000 rupees (US$22) invested, demonstration farmers made a profit of 128 rupees (US$2.9), while non-demonstration farmers made a profit of only 38 rupees (US$0.86). This farmer-focused participatory project demonstrated that, through simple science-based, extension programmes, it is possible to bring about marked changes in the attitude of primary producers and equip them to pro-actively respond to market requirements (e.g. record keeping, traceability, chemical-free aquaculture) and stay in business.

In the Near East and North Africa, more than half of the 17 countries in the region report that their disease monitoring capabilities and programmes are inadequate. There is a scarcity of suitably qualified diagnostic laboratories, particularly for viral diseases, which are considered to be under-reported in the region. Hence, should an infectious disease emergency arise, the region is ill-equipped to respond. A regional alert system and a comprehensive regional centre of expertise in fish and shellfish health are urgently needed.

INTERNATIONAL TRADING AGREEMENTS, LAWS AND COMPLIANCE

Trade remains a potentially volatile area of tension between developed and developing countries and between the rich and the poor. The complexities of food safety and public health concerns in importing countries can dramatically affect access to markets particularly by small-scale farmers/traders in developing countries. Developing countries that can address the new hygiene and food-safety requirements, fair labour practices, and environmental needs will have the opportunity to capture the more lucrative export markets. An analysis of emerging trade patterns in fish products and the trade regime in which this is occurring indicate that food safety regulations, HACCP processes and technical barriers to trade have introduced high costs that tend to exclude the small producers and processors from the export supply chain (Dey *et al.*, 2005).

These authors point out that traditional market chains, usually long, may no longer be viable for the poor and in effect may make it too costly for many developing countries to compete on the world market. If the poor are to benefit from this potentially profitable trade, policymakers will need to find ways to include smaller scale operators (producers and processors) in those processes and to assist and support the adoption of improved management and technologies in order to minimize the costs of compliance. The study recommends identifying measures to reshape global trade arrangements and policies on production and post-harvest technology, marketing and resource use that are consistent with the efficiency, equity and sustainability of aquatic resources. These would aim to establish a trade environment that provides greater access to export markets and a fair share of the benefits of trade to poor people.

In Eastern Europe, major international standards (i.e. ISO 9001, HACCP) have already been established in almost all the countries of the region. Processing factories and also some fish farms apply these basic standards, however, specific labelling and certification schemes for aquaculture products are rare and existing schemes are largely undeveloped. Efforts have been made in some carp producing countries to promote their products through trademarks such as "Cesky Carp" or "Czech Carp". Standards for the production of organic fish have not been elaborated in these countries except for Hungary, where the certifying body is Biokontrol Hungaria, a non-profit organization, belonging to the Ministry of Agriculture and Rural Development.

Labelling programmes in these countries are underdeveloped, however, some efforts in establishing traceability are noticeable in EU member countries of this region. There is a growing interest in such programmes but no serious initiative has been taken so far. Most of the fish products are sold in local markets, where a large segment of the consumers look for cheap products and are less concerned about quality and traceability. Although various quality schemes are already available in most of the Eastern European countries such as EMAS (Eco Management and Auditing Scheme), fish farmers are either not familiar with such systems or refuse to pay for the certification which may not pay off for them.

For some countries in North Africa, namely Morocco and Tunisia, compliance with strict EU regulations for finfish and shellfish is the key to their existing export market. Egypt is in the process of adopting and applying EU regulations on safety and quality control, which will be essential for the emerging export sector. In the Near East, Saudi Arabia is also in compliance with EU standards, and can now export shrimp to this market (previously Saudi Arabia exported prime shrimp to Japan, Australia and United States).

PHOTO CURTSEY MATTHIAS HALWART

Figure 9 - *Aquaculture products with certified organic produce displayed in a supermarket in Germany. High value products such as salmon and shrimp are increasingly been subjected to labeling and certification to ensure consumer acceptance and market access. Certification of aquaculture products for safety, quality and environmental sustainability is a challenge for Asian shrimp as they mainly come from small-scale producers*

Although the countries within the Near East and North Africa exhibit a great heterogeneity in the extent of labelling (traceability), permits and certification that apply to their aquaculture products, this does not appear to be related to volume of aquaculture production, or to duration of establishment of commercial aquaculture. Regulation, via

permits and/or certification for export of market-sized fish and for export and import of fish eggs, juveniles and broodstock, is, however, in place in most of the countries in the region.

WTO/SPS AGREEMENT, RELATED ISSUES ON COMPLIANCE AND CHALLENGES FOR SMALL PRODUCERS

The more fundamental effects of WTO membership on policies are illustrated by the experience of China. In general, policy responses associated with WTO accession take one of two forms: to enable a country to keep its commitments to WTO accession and align existing domestic policies with WTO's; rules or to introduce new measures allowed under the new framework. In this regard, a study of China's policy adjustments in its fishery sector after its accession to the WTO gives a broad perspective of the effects of compliance with WTO regulations on a nation's aquaculture sector (Luping and Huang, 2005).

The government's response to WTO involved an entire shift of its policies, from directly intervening in the economy to playing an indirect, regulatory and fostering role. The specific policy and institutional adjustments have been on:

(i) Changes in laws and regulations. Essentially, the new regulations aim to transfer government functions to the market economy and direct the government to take a more indirect role in commerce and trade activities. They try to limit government intervention and emphasize that the role of government is primarily to provide social and public services. The regulations also seek to simplify administrative processes;

(ii) Encouragement of farmer organizations. The creation of farmer organizations used to be a politically sensitive issue. Recognizing that government investment in creating such farmer organizations as agricultural technology and marketing groups will not be counted as part of the nation's aggregate measurement of support (AMS), the government has now officially thrown its support behind self-organized farmer groups that focus on agricultural technology and marketing. Perhaps most importantly, the government is going to need these farmer organizations to lead the fight against the imposition of trade barriers on China's agricultural exports and to protect the interests of domestic agricultural exporters and producers;

(iii) Tax reform. To make the rural economy more competitive and to remove a set of institutions that has historically caused a lot of frustration among rural residents, the government has begun to experiment with rural tax reform. The boldest experiment to date is based on a movement that seeks to "convert fees into taxes". The earliest experiments began in Anhui Province in 2000. The reform was designed to reduce the burden of various fees imposed on farmers to a maximum level of 5 percent of the farmer's income.

Challenges for small-scale producers

The above case illustrates government's response to a new world trading regime by making adjustments and market-oriented reforms in a broad national context. However, notwithstanding WTO rules and regulations that are meant to level the international trading field, it has been the non-tariff trade barriers and other market access requirements, related to food safety, environmental, animal welfare and other issues such as bio-terrorism imposed by importing blocs that have driven reforms in production sectors. The other side of the coin is the same have been seen as threats to the continuing viability of small farmers simply because they raise the cost of farming. Apprehension has been expressed (NACA/FAO, 2004), that the increasing number and stringency of market requirements could drive the poor, small farmers – unable to comply with all these requirements – out of farming. Other studies have shown that poor access to capital and the high capital requirements for certain technologies and farming systems either make it difficult for the poor to enter or stay in farming (Ahmed, Rab and Bimbao, 1994).

Consequently, the high capital needed to adopt technologies and high cost of compliance with market requirements raise the spectre in Asia (where more than 80 percent of fish farmers are small scale) of hundreds of thousands of displaced and unemployed farmers, or farmers turned labourers in what used to be their farms being consolidated by some corporate giant.

The obvious impact of the increasing number and stringency of market requirements on developing country producers and exporters, many of which are small and mostly unorganized, will be higher costs of production and compliance. Not so immediate and not so evident, but a valid apprehension nevertheless, is that the high cost of compliance could become onerous to the small aquaculture producers or even large but unorganized producers with the result that they might eventually be pushed out of business. The challenge, therefore, is to enable the small farmers to take advantage of the economies of scale and thus be able to comply with market requirements by being well organized, while using the same market requirements to encourage responsible and sustainable practices. In the face of many barriers, meeting this challenge will also require much commitment from and cooperation among stakeholders (NACA/FAO, 2004).

In Asia, transparency and cooperation in information sharing and the need to strengthen information and intelligence capacities with information technology has been continuously emphasized. The forums have raised the prospects of developing countries moving into *e*-commerce and establishing mutual arrangements that facilitate and reduce cost of information flows, speed up the processing of "documents" and improve the efficiency of handling and moving products. Among trading partners, establishing common customs procedures and operations would reduce very high compliance costs, which had been estimated to be 7–10 percent of the value of global trade (UNESCAP, 2001). Applied to global trade in aquatic products, that is a cost of around US$4.3 to 6.0 billion.

In Latin America and the Caribbean, governments do not establish protection policies for small-scale producers. In general, only sanitary regulations are established and become obligatory for the safety of fisheries and aquaculture products for export. In certain cases aquaculture associations have undertaken efforts to establish support programmes to achieve quality, traceability, added value, biosecurity and promotion of exports (e.g. Brazil, Chile). On the other hand, countries such as Guatemala promote programmes to pledge banking warranties when producers apply for credit or loans. In Nicaragua, education is promoted among producers to fulfill national and international regulations. Guidance and direction is given in Paraguay through policies for new product incorporation to export lines. Associations for quality assurance policies and better practices are supported in Peru. In Venezuela, the exploitation of certain species is reserved solely to artisanal or subsistence fishermen or their community organizations. Costa Rica maintains a special tax policy as well as phyto- and zoo-sanitary measures for all aquatic species and products.

In Sub-Saharan Africa, there is very little evidence to suggest that there are any country specific strategies to safeguard small-scale producers from impacts of compliance to international trading standards, though at this stage there is hardly a need for this. However, Mozambique, Madagascar and South Africa have implemented strategies to safeguard larger producers of export commodities.

Trade in non-food aquatic products

There is an increasing trade in ornamental fish and plants (excluding seaweeds) and other products that are raised for non-food purposes. Interest from governments in promoting the culture and trade of non-food aquatic species, particularly ornamentals, has been spurred by their growing potential for increasing rural employment and generating income among small rural and even urban families. By 2000, the global total wholesale value of live ornamental fish both freshwater and marine (live animals

for aquarium only) was estimated at US$900 million with an estimated retail value of US$3 billion.

Asia provided more than 50 percent of the global total ornamental fish supply (FAO, 2000). Estimates place the annual value of the marine ornamental trade at US$200–330 million; the overall value of the marine fish trade accounts for about 10 percent of the international ornamental fish trade (marine and freshwater included)[3]. Ornamental fish are also produced for regional and international markets in Cameroon, Kenya, Uganda, Malawi, South Africa and Zambia, though no accurate figures are available, except for South Africa. The most important non-food aquaculture products exported from Sub-Saharan Africa are Nile crocodile skins[4]. Crocodiles are produced in several countries. The industry is growing particularly rapidly in South Africa, Zambia and Madagascar. Ornamental fish are also produced for the regional and international markets in Cameroon, Uganda, Kenya, Malawi, South Africa and Zambia, though no accurate figures are available, except for South Africa. Live bait fish are exported from Uganda and Kenya to the United Republic of Tanzania for the Nile perch long-line fishery on Lake Victoria. No figures are available for the volume of fingerlings exported. Except for the east coast seaweed industry, crocodile and ornamental fish farming, very little is known about non-food aquaculture in the region. The continent has an immense diversity of fishes and ornamental fish offer enormous potential in west and east Africa, particularly cichlids, cyprinids and catfishes. South Africa is the major producer of ornamental fish in the region and some 21 tonnes were exported in 2003. Except for Seychelles, there is no pearl farming in Sub-Saharan Africa, although some experimental work has begun in Kenya.

PHOTO CURTSEY ZHOU XIAOWEI

Figure 10 - *Ornamental fish stall in Thailand. This industry and trade has become an income generator and livelihoods supporter for many people in Asia. Even agricultural farmers are diversifying their livelihoods to raise ornamental fish through satellite farming systems in several; countries in Asia.*

Southeast Asia is the hub of the ornamental fish trade, supplying up to 85 percent of the aquarium trade[5].

The production of non-food aquatic species is very limited or non-existent in CEE countries, except ornamental fish, which are produced in a few food fish production farms as secondary species. The exception is the Czech Republic where ornamental fish production is an integral part of the aquaculture production; the total value of exported aquarium and ornamental fish was estimated to be US$120 million in 2003.

In the Near East and North Africa, the principal non-food aquatic species are also ornamental fish, which are raised in Algeria, Egypt, Iran (Islamic Republic of), Libyan Arab Jamahiriya, Morocco, Saudi Arabia and the Syrian Arab Republic. For Egypt, the export of locally bred, imported freshwater ornamentals is growing very fast.

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[3] These trade figures were calculated by the UNEP report from export value of the top ten producers. Unofficial figures place these values much higher. There is also significant intraregional trade which also adds value. www.unep-wcmc.org/index.html?
www.unep-wcmc.org/resources/publications/UNEP_WCMC_bio_series.htm~main

[4] In terms of value, crocodile skins are the most valuable export commodity, followed by ornamental fish, seaweeds and baitfish. This summary is based on South African export figures and the value of seaweeds produced in sub-Saharan Africa.

[5] Useful references to marine aquarium trade can be found at:
Global Marine Aquarium Database: www.unep-wcmc.org/marine/GMAD/; www.marine.wri.org/

In Latin America and the Caribbean, as well as ornamental fish which are farmed in almost half the countries., alligators are also raised and exported in a quarter of the countries. The annual contribution of ornamental fish exports to the national economies was estimated around US$3.5-4 million. In North America, ornamental fish are a significant industry in the State of Florida (United States) where 178 producers raise 700 species that generated US$47 million in farm-gate value in 2003. The overall value of the industry is estimated at US$175 million.

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4. Contribution to food security and access to food

INTRODUCTION

Food insecurity remains one of the most visible dimensions of poverty and is generally the first sign of extreme destitution. "Food security", defined by FAO as "a condition when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life", concerns not only food production and distribution but also has social, economic and institutional dimensions.

This chapter aims to elucidate and highlight the importance of fish and other seafoods in global food security using the information derived from regional aquaculture development trends reviews and FAO statistical data. While it would have been ideal to focus on the role of aquaculture in food security for the purpose of this synthesis, this was not possible since fish once traded are no longer disaggregated as to the source of production – aquaculture or capture fisheries – in the FAO statistical data. Therefore, in this chapter, fish[1] includes production both from capture fisheries and aquaculture and no attempt has been made to analyse the extent that only aquaculture production plays except where data and information were readily available. Considering the role that aquaculture currently plays in providing fish (aquatic food) to the world and the envisaged increasing role it will play over the coming decades, it is considered it appropriate to collectively discuss fish from capture and culture

CONTRIBUTION TO NATIONAL FOOD SELF SUFFICIENCY

Fish contributes to national food self-sufficiency through direct consumption and through trade and exports. In traditional fish eating countries in Asia and Oceania, annual per capita consumption is mostly above 25 kg. In some island countries in the Pacific the per capita consumption is above 50 kg per year or even as high as 190 kg as is the case in Maldives (see Table 1). In some countries in sub-Saharan Africa the balance in the export and import of fish more than adequately paid for the countries' import bill for rice and wheat in 2003 (Table 2). In this instance much of the fish originates form capture fisheries.

The extreme importance of fish to food security and nutrition may be illustrated by assessments on the situation in Africa. FAO estimates that fish provides 22 percent of the protein intake in sub-Saharan Africa. This share, however, can exceed 50 percent in the poorest countries (especially where other sources of animal protein are scarce or expensive). In West African coastal countries, for instance, where fish has been a central element in local economies for many centuries, the proportion of dietary protein that comes from fish is extremely high: 47 percent in Senegal, 62 percent, in Gambia, and 63 percent in Sierra Leone and Ghana (Table 3).

Contribution of fish to the daily dietary energy supply is also important. Where there is a lack of alternative locally produced protein and/or where a preference for fish has been developed and maintained, fish can contribute a substantial share of the dietary energy. In low-income countries, staples such as rice, wheat, maize and cassava make up the bulk of the food consumed by the people, and they supply the majority

[1] Fish includes finfish and shellfish

TABLE 1
Fish consumption in kilograms per capita, selected countries Asia and Oceania (original figures in grams per day from FAOSTAT 2006)

	1969-1971	1979-1981	1990-1992	1995-1997	2000-2002
Oceania					
Australia	15.0	15.7	19.3	20.8	22.3
Fiji Islands	23.4	36.9	33.6	25.5	33.2
French Polynesia	41.6	43.1	45.6	52.6	54.0
Kiribati	59.5	70.4	77.4	78.1	76.6
New Caledonia	4.75	23.4	25.9	25.2	28.8
New Zealand	16.4	15.7	20.4	23.4	26.3
Samoa	40.1	54.7	55.1	61.3	92.7
Solomon Islands	56.9	56.9	44.9	43.4	39.8
East Asia					
China	4.7	5.1	12.0	22.3	25.5
Japan	62.4	64.6	69.0	69.7	66.8
Korea, Dem. People's Rep. of	26.3	35.4	37.6	11.7	8.0
Korea, Republic of	20.4	42.0	46.0	49.6	54.4
South Asia					
Bangladesh	10.6	7.7	7.7	9.1	11.7
India	2.9	2.9	4.0	4.4	4.7
Maldives	90.9	87.9	110.9	152.9	190.5
Nepal	-	0.3	0.7	1.1	1.5
Pakistan	1.5	1.8	2.2	2.2	2.2
Sri Lanka	15.0	15.0	16.8	19.7	23.0
Southeast Asia					
Brunei Darussalam	29.6	47.1	29.9	44.2	29.2
Cambodia	8.8	5.1	10.2	8.0	25.9
Indonesia	9.9	11.7	15.3	18.2	20.8
Lao	7.3	7.3	6.9	9.1	15.3
Malaysia	25.9	42.0	50.0	57.7	58.4
Myanmar	13.9	14.6	15.3	13.9	19.0
Philippines	32.8	32.1	36.5	31.0	29.6
Thailand	23.7	19.0	24.1	32.8	31.0
Viet Nam	16.4	10.9	12.4	17.5	18.2

TABLE 2
Balance in the trade of fish and staple cereals, selected countries in sub-Saharan Africa, 2003, in thousand US dollars (FISHSTAT PLUS 2006, FAOSTAT 2006).

	Net Receipts from fish trade	Rice import	Wheat import	Balance
Madagascar	69 664	48 693	13 534	7 437
Mauritania	97 381	13 739	40 873	42 769
Namibia	323 689	2 201	7 282	314 206
Saint Helena	5 309	9	57	5 243
Senegal	282 186	217 386	59 061	5 739
Seychelles	143 400	4 359	1 641	137 400
Tanzania, United Rep. of	133 732	34 064	77 074	22 594

TABLE 3
African countries with per capita supply greater than 20 kg and/or a fish protein/animal protein ratio greater than 20 percent

Country	Per capita Fish supply (kg)	Fish protein/ animal protein (percent)
Angola	6.6	27.1
Benin	9.4	28.5
Burundi	3.2	29.6
Cape Verde	25.3	30.6
Comoros	20.2	61.8
Congo D.R.	5.7	31.0
Congo Rep. of	25.3	48.8
Cote d'Ivoire	11.1	36.9
Equatorial Guinea	22.6	61.9
Gabon	44.6	35.0
Gambia	23.7	61.7
Ghana	22.5	63.2
Guinea	16.0	60.2
Liberia	4.9	23.0
Malawi	5.7	37.7
Oman	24.1	21.5
Sao Tome and Principe	21.4	61.5
Senegal	36.3	47.4
Sierra Leone	13.4	63.0
Tanzania, United Rep. of	10.3	33.6
Togo	17.3	50.2
Uganda	9.8	30.0

of energy and nutrients. But some essential nutrients are not found in these staples, or are found only in small quantities, for example, iron, iodine, zinc, calcium, vitamin A and vitamin B. These nutrients must be supplied by other foods. Fish contribution in the supply of these elements and fatty acids that are necessary for the development can be particularly important.

There is also evidence suggesting that fish can play an important role in maternal, foetal and neonatal nutrition. An adequate amount of essential fatty acids (EFA) is important to health and is particularly important prior to and during pregnancy and lactation. EFAs, particularly DHA and EPA, are 10 to 100 times more concentrated in fats from marine sources such as fish than from terrestrial sources. Some studies show that fish and fish oil consumption significantly improves the outcome of pregnancy and infant development. Although other studies do not show any association between fish or fish oil consumption and infant development, eating fish two or three times a week is being encouraged as part of a healthy balanced diet both for child-bearing women and the family as a whole (Elvevoll and James, 2000; Halwart, 2006).

While fish as a subsistence product is an important source of direct food security for fishing households, incomes derived from wages in the fisheries sector or from fish trade is often even more important as an indirect contribution to food security. Inland and coastal fisheries and related fish processing and trading provide full- or part-time employment to between 6 and 9 million people in sub-Saharan Africa. Using a (conservative) ratio of 1 to 5 for household size, a total of some 30 to 45 million people (men, women and children) in Africa therefore depend indirectly on fish for their livelihoods.

The increasing contribution of aquaculture to regional food security is demonstrated clearly for the Near East and North Africa. In 1994, aquaculture contributed just 4.5 percent of fish production for the entire region, this rose to 18.7 percent in

PHOTO CURTESY MOHAMED HASAN

Figure 1 - *Fish market in rural Africa. Although very simple and small-scale, these rural fish markets play a significant role in distributing fish among the local communities.*

2003. On an individual country basis in 10 of 17 countries the contribution of aquaculture increased in the decade 1994–2003. Furthermore, for several emerging producer countries, aquaculture did not contribute to national food security in 1994, but did so in 2003. Within the region, the relative contribution of aquaculture in 2003 varied sharply from country to country, being highest in Jordan, Egypt and the Syrian Arab Republic (57, 50 and 44 percent, respectively).

Products from aquaculture are not a significant factor in providing food for the poorer segments of society in North America. In fact, seafood consumption is highest among older more affluent consumers (Johnson, 2004). In general, cultured products such as salmon and shrimp are some of the more expensive products, compared with catfish. One exception is frozen farmed tilapia which is imported at US$1.19/kg (Harvey, 2005). Most seafood products sell for 2–4 times their import value. The least expensive frozen tilapia fillets from China are imported at US$3.08/kg. With the availability of these inexpensive tilapia imports, virtually all of the tilapia cultured in North America is sold live to attract the premium price necessary to cover production costs.

Relative contribution of fish compared to other sources of protein

Countries with low per capita gross domestic product tend to have a higher proportion of fish protein in their animal protein consumption. Although less developed countries are not the biggest consumers of fish, they are the most dependent on it (Kent, 1997; Dey and Ahmed, 2005; FAO, 2003). The share of fish protein in total animal protein expenditure is higher for lower income groups, and poor people consume mostly low-price fish. This shows the importance of low-priced fish as a primary source of protein among poor households in developing countries, although in many cases this comes from inland capture fisheries or cheap imports of frozen fish. In countries such as Iran (Islamic Republic of), Philippines and Viet Nam where inland capture fisheries has declined, aquaculture increasingly makes up for the gap and even begins to fill the increasing demand of an expanding population.

In most countries of the Near East and North Africa, consumption of fish is lower than that of red meat and poultry. The exception is Egypt, where consumption of fish exceeds that of red meat and poultry. The relative contribution of fish to total animal protein varies greatly from country to country, being highest (15–25 percent) in Egypt, Morocco, Oman and Yemen.

Comparison of aquaculture with agriculture and meat production

In Western Europe, the value of aquaculture compared with that of agriculture or meat production is small at €4.9 billion in 2003. In the same period, the value of total agricultural and meat output at producer prices was €255 and 107 billion, respectively, representing a mean annual growth of only 0.7 percent for agriculture and a decline of 0.3 percent for the value meat since 1994. In contrast, aquaculture showed an annual increase of 4.5 percent. This stagnation in the former sectors resulted in aquaculture increasing its share from 1.4 to 1.9 percent of total agricultural value and from 3.1 percent to 4.6 percent between 1994 and 2003 (Figure 2).

In Western Europe fish has to compete with other animal proteins and food items and its consumption, therefore, is price sensitive. The cost and affordability of major food items has changed markedly in the region and in particular the rise in fish and seafood prices in the region is amongst the highest of key food types (Figure 3). Although the data used in Figure 3 are for the 25 EU countries it is indicative of Western Europe as the major consumer countries are common to both.

Between 1996 and 2003 (1996 = 100 percent) the relative cost of fish and sea fish food has risen by 30 points, almost by 2.5 times that of meat (112 percent). Also the relative price of meat has remained unchanged since 2000. These higher prices for fish and fish products are probably indicative of higher and rising demand and falling supplies of these products. Consequently, farmed fish is likely to remain a luxury commodity and its contribution as a food item to food security for poorer households within Western Europe is likely to decrease.

FIGURE 2
Recent changes in the relative value of aquaculture to agriculture and meat in Western Europe

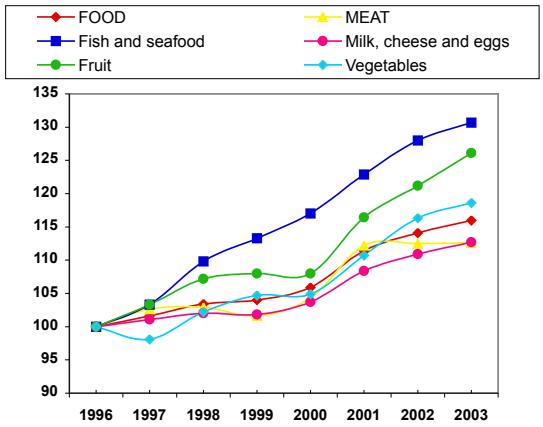
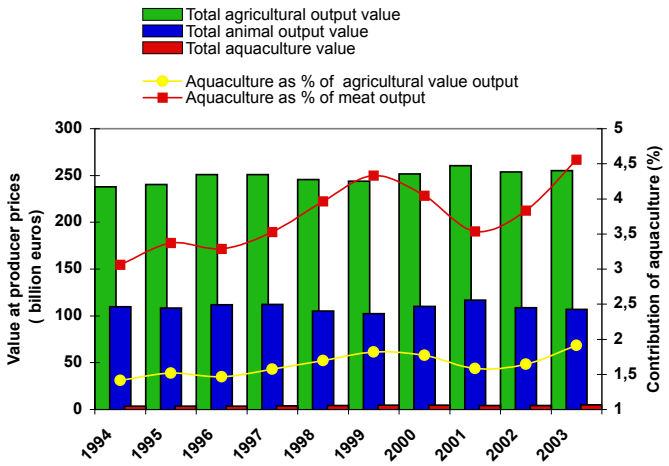


FIGURE 3
Comparison of recent changes in average price index of major food items in Major Western European markets



In Eastern Europe, however, consumption is increasing although slowly. One of the main factors which limit the consumption of fish and fish products is their relatively high price and the low income of the people, especially in rural areas. On the other hand, a large amount of chicken, pork, veal, beef and other meat products are imported into these countries which is not the case with fishery products. As supermarkets are spreading in the region, however, the import of fish and seafood products is increasing.

North Americans are also major consumers of beef. The per capita consumption of beef and veal was 42.8 kg in the United States and 31.28 kg in Canada, in 2003 (FAOSTAT 2005[2], Statistics Canada, 2005[3]). The per capita consumption of pork was 30.5 kg in the United States and 31.1 kg in Canada, while consumption of chicken broilers was 53.4 kg in the United States and 30.5 kg in Canada. Consumption trends for seafood products in 2004 were positive with increases in per capita consumption from 7.4 kg in 2003 to 7.5 kg in 2004, an increase of two percent. This is the third year in a row that United States per capita seafood consumption has increased. A record 1.9 kg of shrimp were consumed per person in 2004.

In Latin America as well, the value of aquaculture, which amounted to US$3.9 billion in 2003, is comparatively very small, only 7 percent of total animal land-based

[2] www.faostat.fao.org/faostat/collection s ?version=ext&hasbulk=0&subset=agriculture
[3] www.statcan.ca/english/freepub/23-222-XIE/23-222-XIE2004000.pdf

husbandry products (including meat, poultry and swine production)., The participation of aquaculture in the GDP (gross domestic product), however, is more significant for individual countries such as Chile, Belize, Honduras and Ecuador (Morales and Morales, 2006).

FAO statistical data demonstrate that the contribution of fish to the protein supply of the people is less than that of different meats (poultry, pig, beef, mutton and goat) in most of the Eastern European countries (Table 4).

TABLE 4
Fish and meat supply in Eastern European countries in 2002

	Fish, seafood supply cap/yr/kg	Meat supply cap/yr/kg	Fish, seafood as percent of total supply
Albania	4.1	39.3	9
Belarus	14.3	57.7	20
Bosnia and Herzegovina	4.4	22.6	16
Bulgaria	2.9	69.7	4
Croatia	11.9	31.5	27
Czech Republic	13.6	86.1	14
Estonia	21.2	64.7	25
Hungary	5.1	88.9	5
Latvia	11.1	45.9	19
Lithuania	59.8	50.9	54
Macedonia	4.1	40.7	9
Poland	13.1	73.3	15
Romania	3.4	54.1	6
Russian Federation	18.6	49.8	27
Serbia and Montenegro	2.0	77.9	3
Slovakia	7.3	66.3	10
Slovenia	7.7	88.3	8
Ukraine	15.4	32.0	48

Source: FAOSTAT Nutritional data, Food supply, 2005 (Last update 27 August 2004)

Market prices of wild fish versus cultured fish species

In Asian countries, the general situation is that wild-caught fish fetch higher prices than cultured fish (for the same species, especially the reef fish). This difference is usually attributed to the taste, texture and other quality preferences of consumers. On the other hand, aquaculture can also have a big impact on wild fish prices due to the higher volume and greater reliability of supply and the degree of inter-changeability between species. Cultured white shrimps from Asia are known to impact on the price of wild-caught shrimps in the United States to the extent that United States shrimp producers have levelled dumping charges against Asian exporters. Similarly, large volumes of *Pangasius* catfish from Viet Nam have affected the price not only of farmed channel catfish but also of any white fish in general since the fillet of *Pangasius* catfish can serve the same market.

A situation similar to Eastern Europe is evident in Albania, where the market price of wild fish can be twice as higher than that of farmed fish. On the other hand, in Estonia there is practically no "competition" between cultured and wild fish species on the domestic market. There is competition only between groups of fish of similar consumption profile.

In the largest producer countries in the Near East and North Africa, namely Egypt and Iran (Islamic Republic of), there are no clear price differentials between wild and cultured fish species. In other countries such as Libyan Arab Jamahiriya, Morocco

BOX 1
Viet Nam *Pangasious* catfish exports to European Union

Year	2000	2001	2002	2003	2004
			Value (US$)		
Spain			355 150	2 472 409	21 895 270
Germany		186 120	4 178 648	6 651 024	22 470 124
Belgium			2 418 319	4 929 643	12 763 527
Italy			67 791	1 094 029	3 396 972
Netherland		38 822	728 542	1 877 629	2 467 615
France				19 204	1 480 168
Others	0	0	406 744	710 946	2 623 322.600
Total	0	224 942	8 155 194	17 754 884	67 096 998.809
			Quantity (Tonnes)		
Spain		0	109	941	6903
Germany		60	1 296	2 494	7 396
Belgium		0	736	1 921	4 107
Italy		0	25	434	1 755
Netherland		10	216	631	763
France		0		9	544
Other	0	0	140	252	954
Total	0	70	2 521	6 680	22 422

Pangasious *catfish (basa) has now become readily available in the EU market.* Pangasious *used to be a significant export commodity to the USA. Information curtsey Viet Nam Customs.*

and Syrian Arab Republic, however, wild caught fish command a higher price than cultured fish. In Oman the opposite is true, with wild caught fish being less expensive than cultured fish.

FISH CONSUMPTION TRENDS

Asia and the Pacific region represents the most important region for aquaculture production, and also has countries with the highest per capita consumption of fish. It is generally agreed that aquaculture production will continue to increase and that it is expected that fish supplies from capture fisheries have little room for further expansion.

The likely global trends for fish supply, demand and consumption have been forecast by the International Food Policy Research Institute (IFPRI) in collaboration with the WorldFish Center (Delgado *et al*., 2003). The conclusions are that consumption trends show an increase in the demand for fishery products for food, partly due to changing food habits and the increasing purchasing power within several developing countries. In the Asian region, it is expected that there will be a shift from the region being a net exporter of fishery products to being a net importer. Developing countries are expected to remain net exporters overall, but the percentage of their production exported is expected to decrease due to rising domestic demand. While there is a trend of decreasing fish consumption in developed countries perhaps due to increased urbanization, this does not seem likely to offset the increased demand for fish in developing countries.

Per capita fish consumption figures for 2003 are available for Australia (10.9 kg), Indonesia (23.6 kg), Iran (Islamic Republic of) (5 kg), Myanmar (26.2 kg), Republic of Korea, (52 kg), Pakistan (2 kg) and the Philippines (36 kg for 1993). In the other countries, only the per capita fish supply or availability is reported (Table 5). With

the available figures from National Aquaculture Sector Overview (NASOs), and other sources, fish and other seafoods contribute 75 percent and 63 percent to animal protein intake in Cambodia and Bangladesh, respectively. In China fish contribute only 32 percent of total animal protein intake. In the Philippines, fish constitute 52 percent of animal protein intake (when milk and milk products are included).

TABLE 5
Per capita fish supply (kg), selected countries in Asia and Australia in 2003

	Per capita supply (kg)			
Country	**Capture**	**Culture**	**Total**	**Per capita Consumption (kg)**
Australia	10.5	1.9	12.4	10.9
Bangladesh	7.9	5.9	13.8	14.0
Cambodia	30.3	1.5	31.9	1.6
China	12.8	22.1	34.9	36.2
India	3.4	2.0	5.5	8
Indonesia	19.3	4.1	23.4	23.6
Iran (Islamic Rep. of)	5.1	1.3	6.5	5.0
Japan	36.1	6.7	42.8	
Korea, Rep. of	23.1	0.9	24.0	52.0
Myanmar	27.0	5.1	32.1	26.2
Nepal	0.7	0.6	1.3	
Pakistan	3.5	0.1	3.5	2
Philippines	24.7	5.2	29.9	36[a]
Sri Lanka	13.9	0.5	14.4	
Thailand	43.0	11.8	54.9	32 to 35
Viet Nam	19.9	11.2	31.2	

a) Food and Nutrition Research Institute (FNRI) Consumption Survey 1993.

TABLE 6
Fish consumption in kilograms per capita, Western Europe (original figures in grams per day from FAOSTAT 2006)

	1969-1971	1979-1981	1990-1992	1995-1997	2000-2002
Austria	9.5	7.3	12.0	13.5	14.2
Cyprus	8.8	9.5	22.3	25.2	28.5
Denmark	21.2	27.7	26.6	25.2	24.5
Finland	23.0	28.8	34.7	34.3	32.5
France	21.2	24.8	31.0	29.6	31.0
Germany	12.4	12.8	15.3	15.	14.6
Greece	18.2	16.8	20.8	24.5	23.0
Iceland	70.8	87.2	94.2	93.1	91.6
Ireland	11.7	16.1	17.2	17.2	16.8
Italy	15.0	16.1	23.7	23.0	25.5
Malta	13.1	27.7	25.5	37.2	46.4
Netherlands	13.5	11.3	11.3	16.8	23.7
Norway	40.5	43.1	45.3	52.2	53.6
Portugal	65.3	28.1	59.5	64.2	58.0
Spain	29.9	32.8	36.5	43.8	46.7
Sweden	28.8	30.7	29.9	29.2	32.1
Switzerland	13.5	10.6	16.8	17.5	20.1
United Kingdom	21.2	17.2	20.4	21.5	22.6

Since landings from capture fisheries are stagnant and population has increased the share of aquaculture per capita, supplies are likely to have risen. The importance of fish and shellfish within the region, however, is markedly varied ranging from 14-16 kg/capita in Austria, Germany and Ireland to over 50 kg per capita in Portugal and Norway. In all countries (except Portugal), however fish consumption has increased during the last 40 years (Table 6).

For Eastern Europe, based on available data and estimations, it can be said that there was a decrease in fish consumption in most of the Eastern European countries after the early nineties, when production decreased significantly in these countries. There has been a gradual increase in fish consumption in recent years and there are some countries where fish consumption increased rapidly.

Per capita fish consumption, measured as kg/person/year, is increasing in 10 of the 11 Near East and North African countries for which data is available. In some countries the increase is significant, for example Algeria (3.0 kg/person/year in 1993 to 5.1 kg/person/year in 2003) and Egypt (5.5 kg/person/year in 1982 to 14.9 kg/person/year in 2003).

In Latin America per capita fish consumption varies from 2 to 59 kg/year but only 10/kg/year in most countries. The contribution of aquaculture to this consumption is probably very small since the larger part of aquaculture products are exported.

Fish consumption in the Near East has been very low in the past (1969-1971) at less than 5 kg in most countries. There have been sharp increases in most counties during the succeeding decades with only Sudan and Syria with fish consumption remaining low at 1.83 and 2.56 kg per capita, respectively, even up to the 2000-2002 period. The most notable rise was shown by Egypt which is now at 15.0 kg and Lebanon at 11.3 kg (Table 7). Iran (The Islamic Republic of) has shown a steady increase also from less than 1 kg to almost 5 kg. In Saudi Arabia, fish consumption has almost doubled during the last 30 years and as of 2000-2002 reached 7.3 kg. For Egypt the major reason for such an increase must be a greater availability of fish due to aquaculture which has shown tremendous strides. In Iran (Islamic Republic of) there is a conscious effort by the government to encourage people to eat more fish (by emphasizing its healthy attributes). In Saudi Arabia and other countries, the increased consumption may be partly due to the large number of guest workers from the traditionally fish eating countries of Asia.

PHOTO CURTSEY SENA DE SILVA

Figure 4 - *Tilapia catch from reservoir in Myanmar. Tilapias are not only produced by aquaculture, but also a major commodity of culture-based fisheries in many countries, especially in Asia. In some countries like Sri Lanka, tilapias dominate the reservoir fisheries catch.*

TABLE 7
Fish consumption, countries of the Near East countries in kilograms per capita (original figures in grams per day from FAOSTAT 2006)

	1969-1971	1979-1981	1990-1992	1995-1997	2000-2002
Egypt	2.6	5.1	8.4	9.1	15.0
Iran, Islamic Rep. of	0.7	1.5	4.4	4.7	4.7
Jordan	1.8	3.6	3.6	5.8	5.1
Kuwait	9.5	12.4	5.8	12.4	8.0
Lebanon	4.0	0.7	2.9	7.7	11.3
Libyan Arab Jamahiriya	5.1	7.7	8.0	6.9	6.9
Palestine, Occupied Tr.	-	-	-	0.7	0.7
Saudi Arabia	4.0	9.9	5.8	6.6	7.3
Sudan	1.5	1.5	1.5	1.5	1.8
Syrian Arab Republic	1.5	2.6	0.7	1.5	2.6

Comparative consumption of fish versus terrestrial meat

More than 200 million Africans eat fish regularly (see Tables 2 and 3). Fresh but more often smoked, dried or even powdered fish is an important source of dietary protein and micronutrients for many isolated communities in rural areas. Fish may also be the sole accessible source of animal protein for poor households in urban and peri-urban areas.

In most countries of Eastern Europe, pork and poultry are dominant on the meat market. Fish and fish products are in 3rd or 4th place in the total consumption of meat in these countries. On the other hand, there are positive examples too, e.g. Latvia, Albania and Croatia where fishery products take 2nd place or lead the meat market. A recent study in Hungary revealed that fish consumption is higher in those areas where fisheries and aquaculture have long traditions irrespective of whether the market is in a rural or urban area.

Within some countries in the Near East and North Africa, there are marked local differences in relative consumption of fish versus meat, and this is often linked to proximity to the coast. For example, in coastal regions of Iran (Islamic Republic of), fish consumption exceeds that of meat, whereas in inland regions, the opposite pertains. There are also differences between rural and urban societies, for example, in Egyptian rural consumption of fish exceeds that of red meat and poultry, whereas in urban societies the reverse is the case. This contrast is mainly attributable to costs of the different types of protein and income levels in different regions of the country. In contrast, in Libyan Arab Jamahiriya rural societies, there is more meat and poultry consumed than fish and in urban societies more fish is consumed than meat and poultry.

RURAL POOR AND AQUACULTURE; OPPORTUNITIES AND CHALLENGES

Growing demand and expanding markets are expected to push fish prices up, and there is a need to increase the supply of low-value food fish to keep the price within the reach of both rural and urban poor people. Semi-intensive and primary production-based aquaculture (that includes culture-based fisheries) of low-value food fish has the potential to be adopted by millions of smallholders in Asian developing countries and is well established in some countries (particularly China). It has emerged as an environmentally friendly production system that also supplies large quantities of low-value food fish. Small-scale integrated farming systems could, with improved infrastructure, availability of credit and greater assistance, provide many more economic opportunities for growing populations in rural areas, especially remote areas in Africa. In the increasingly competitive markets of today there are strong economic incentives for farmers to raise higher value fish crops that yield higher profit margins.

Polyculture or co-culture schemes involving both primary feeders and high value carnivores (confined in cages) in the same pond compartment, however, are possible and should be refined, disseminated and their application encouraged.

For women in particular, fish processing and trading provides a very important economic support. In West Africa and some southern African countries women dominate fish processing, retailing and local trading of fish. Many of the women are heads of households and fish trading provides the only source of income e.g. in western Zambia, where three quarters of the women in fish trading are from single headed households.

PHOTO CURTSEY MOHAMED HASAN

Figure 5 - *Integrated aquaculture facility in Zambia. Integrated aquaculture, the framing of fish with livestock and agriculture, is largely an Asian activity. However, it is also practiced in Africa. The focus on integrated farming is increasing worldwide.*

In several countries in southern Africa, over 30 percent of the adult labour force lives with HIV. The pandemic affects the livelihoods of others who were initially depending on its labour force for their livelihoods. This situation is causing an increase in food insecurity in the entire region by breaking the already fragile balance between labour, work and food entitlements. Fish – in particular cultured fish – can play a mitigating role in this crisis as the work (especially in small garden ponds) requires low physical labour, the product is nutritionally rich and it can generate cash to purchase other food items and medication.

Fish consumption in sub-Saharan Africa is the lowest in all regions and is the only part of the world where it is declining. The main reason is the levelling off of capture fisheries production and the growing population. To maintain the current level of per capita supply in sub-Saharan Africa of 6.6 kg per year up to the year 2015, capture fisheries and aquaculture must increase by 28 percent over this period.

Since capture fisheries cannot meet the demand for fish in the region, aquaculture will have to play a pivotal role. But in sub-Saharan Africa, aquaculture contributes less than 2 percent to total fish supply. The potential for growth, however, is extremely high although the task is enormous: based on 1997 levels, aquaculture would have to increase by 267 percent by 2020 to maintain the current consumption level in Africa. The sub-Saharan Africa regional aquaculture trends review (Hecht, 2006) recommended that fisheries be given support in five major areas:

a. support to small-scale labour intensive coastal and inland fisheries;
b. promotion of rural and peri-urban aquaculture entrepreneurship;
c. improvement of fish market chains through local investments;
d. favouring local, national and intraregional fish trade within Africa;
e. monitoring the above changes and feedback of information into decision-making processes.

The Pacific island nations have increasingly realized the role aquaculture can play in supplying fish protein, particularly for inland rural villages where access to fresh fish is limited and lack of electricity prevents storing food for a long time. Some parts of the Pacific, particularly the large Melanesian countries, are facing a food crisis situation from increasing population pressure, which is leading to poor nutrition and health. Generating another primary food source would help alleviate the reliance on imported processed, i.e. tinned foods. Aquaculture is also seen as a viable alternative source of

PHOTO CURTSEY ROHANA SUBASINGHE

Figure 6 - *Mangrove friendly crab culture in Palau. The government of Palau is promoting environmentally friendly aquaculture as a source of quality fish and shellfish. Crab culture is practiced in mangroves, with least impact to the environment. This pilot activity is proving its promise for future.*

essential cash needs (for school fees, social obligations and other expenditure items) and as a back-stop to declining fisheries revenues.

In Latin America and the Caribbean aquaculture carried out by poor households is oriented towards self-consumption and the local commerce of species such as tilapia, pacu, carps and catfish in freshwater and towards oysters in marine environments. In some countries, a certain degree of increase in fish consumption is recognized.

In many countries in the Near East and North Africa, aquaculture is seen as providing important opportunities to poor families; for employment and income and as a source of nutritionally healthy and affordable protein. Algeria's five-year plan for the development of fishery and aquaculture provides priority to the improvement of living standards in disadvantaged rural areas, through income and job opportunities from aquaculture. In the Syrian Arab Republic, aquaculture activities provide better income compared with agriculture and thus is economically advantageous in rural areas.

Rural poor, aquatic production and international markets

A general conclusion for trade is that income from exports is good for the economy. A different perspective however is raised by the WorldFish Center for Africa (Bene and Heck, 2005).

The situation is that sub Saharan-Africa has a trade deficit that is expected to worsen and exporting fish to other continents could undermine regional food security. In this context, two issues were raised. First, while the fish removed from African markets can, in principle, be replaced by imports and the foreign exchange earnings from exports can stimulate national economies, the benefits of international trade versus the stimulus to local economies through increased processing, and national and regional trades have not been fully analysed or demonstrated. Second, too strong a focus on international export can be detrimental to Africa's food security because it diverts policy-makers' attention, research and management effort, and donor support away from the small-scale fisheries which supply local, provincial or national markets and focuses these limited resources on the export-oriented industrial or semi-industrial fisheries.

Aquaculture currently competes with the livestock sector for fishmeal for feeds. If fish value increases, the "purchasing power" of aquaculture may draw this resource away from the livestock sector. There are calls for aquaculture to reduce its reliance on fishmeal and increase the efficiency of its utilization. Whilst more efficient use of fishmeal is possible, the reduced reliance may be more difficult. In the face of increasing purchasing power of aquaculture feeds, it may be the livestock sector which makes the greater progress towards reducing reliance on fish meals.

Low-income food-deficient countries (LIFDSs) or net food importing developing countries that are also significant fish producers are generating large foreign exchange earnings from fish exports that help pay for imports of low-value fish and non-fish food commodities. At the micro-level, fish and livestock are key sources of income and buffer against food insecurity during times of shortage. Aquaculture, however, can play a broader role in developing countries through poverty elimination and food security. (Dey and Ahmed, 2005).

PHOTO CURTSEY FLAVIO CORSIN

Figure 7 - *Fish market in Japan. It is interesting to note the diversity of fish and fish products displayed here.*

In Latin America, aquaculture enterprises tend to place priority on foreign currency and employment generation. Development of rural aquaculture is more directly related to food security and poverty alleviation. Unlike Asia, the historical development of rural aquaculture in Latin America has not emphasized food security. Indirectly, however, it has had a significant contribution to employment generation.

Aquaculture carried out by poor households is for self-consumption and the local market. Species are tilapia, pacu, carps and catfish in freshwater and oysters in marine environments.

An evaluation of freshwater rural aquaculture projects in Bangladesh, Philippines and Thailand by the Asian Development Bank provides good examples of the positive social impacts of aquaculture that include improvement in overall food and fish consumption and more employment and cash incomes from fish farming (Asian Development Bank, 2004).

In all sub-Saharan African countries, non-commercial fish farms are reported to play an important role in contributing towards food security, improved nutrition and rural employment. Estimates of employment by the non-commercial sector per country range between 18 000 and 30 000 jobs. Non-commercial aquaculture plays an important role in rural livelihoods; fish farming families in general are better nourished than non-fish-farming families. Cash income from fish ponds contributes to general household costs and living expenses and in most countries non-commercial farmers also use fish for barter and gifts. Given the current levels of production, however, the review suggests that non-commercial aquaculture is unlikely to make significant contributions to fish supply on a national basis in any of the countries in the short and medium term. Moreover, the contribution by the aquaculture sector to gross domestic production (GDP) in most sub-Saharan Africa countries is insignificant. Non-commercial fish farming in all countries is largely an on-farm diversification strategy, although all countries in sub-Saharan Africa consider it to have a positive effect on sustainable and improved livelihoods and poverty alleviation at the family level.

There is no doubt that Asian aquaculture is contributing to better nutrition, more food supply and employment. One issue, however, is whether fish is becoming a luxury item? The demand for fish in general and farmed fish in particular is likely to rise in the short and medium terms for the following reasons: in the countries that already have fairly high per capita fish consumption, the decline in capture fisheries has to be compensated for by increase in aquaculture production and where fish consumption is still very low, an increase in fish consumption under certain circumstances is a real possibility. Indonesia had a per capita fish consumption of only 12 kg as late as 1980. By 2002, fish consumption had doubled to 23 kg. The promotion of fish as health products (such as eel) has stimulated more consumption of fish, as has switching more to fish from red meat by the middle and more affluent segment of the population in the Republic of Korea (Bai 2006).

Thus far the trend in all major aquaculture species (cyprinids, tilapia, salmon, and shrimps) shows that the prices are declining over the years due to improved technology

and greater availability of seeds and feeds, all leading to higher and more efficient production. An increase in prices is likely if aquaculture production fails to keep up with demand and production efficiency does not improve. Ultimately, in all countries, the increased contribution of aquaculture to local food supply will be driven by local preference and acceptance of certain products and the economic cost of producing them, as well as a growing purchasing power.

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5. Resource use and the environment

INTRODUCTION

Similar to other food producing sectors in the world, aquaculture relies upon the use of natural resources such as land and water. In addition, aquaculture requires seed and feed resources, and more intensive forms of aquaculture depend upon ancillary resources such as energy (fossil fuels, electricity, etc.). However, aquaculture typically uses less land or water area per unit of production in comparison with other sectors. The use of natural resources for aquaculture production requires appropriate management of the interactions between aquaculture and the environment during planning and implementation of activities, and this is essential for the sector's sustainability. The aquaculture–environment interactions and the issues related to resource use have been well documented in numerous publications (FAO/NACA, 1995; FAO, 1997; NACA/FAO, 2001a). While in the past, the main emphasis was placed on environmental interactions, it is now clear that for competent management of aquaculture, issues relating to socio-economics, human health and the assurance of food safety must also be adequately addressed.

Aquaculture is a diverse sector spanning a range of aquatic environments spread across the world. It utilizes a variety of production systems and species. While the impact of aquaculture on the environment cannot be generalized, it is important to recognize problems where they occur and ensure that they are redressed or ameliorated. Identified cases of environmental and natural resources interactions that have been negatively associated with aquaculture include:

- discharge of aquaculture effluent leading to degraded water quality (eutrophication, concern over red tides, low dissolved oxygen, etc.) and organic matter rich sediment accumulation in farming areas;
- alteration or destruction of natural habitats and the related ecological consequences of conversion and changes in ecosystem functions;
- competition for the use of freshwater;
- competing demands with the livestock sector for the use of fish meal and fish oil for aquaculture diets;
- improper use of chemicals raising health and environmental concerns;
- introduction and transmission of aquatic animal diseases through poorly regulated translocations;
- impacts on wild fisheries resources through collection of wild seed and brood animals; and
- effects on wildlife through methods used to control predation of cultured fish.

Over the past five years, considerable progress has been made in the environmental management of aquaculture, addressing many of these key concerns. Public pressure as well as commercial pressure or common sense has led the aquaculture sector to improve management, and increasingly it is recognized that aquaculture has positive societal benefits when it is well planned and well managed. In terms of environment–aquaculture interactions these include:

- more efficient use of energy and other natural resources than many other forms of animal production;

- an alternative source of aquatic animal protein which can be less environmentally damaging than some fishing and over fishing practices; and
- improvements in water and environmental quality through aquaculture farming systems and practices such as: integrated farming, low intensity herbivorous fish culture, seaweed and mollusc farming.

During the past decade, global awareness and sensitivity to the environmental issues related to aquaculture has increased significantly. As a consequence, policy and regulation governing environmental sustainability have been put in place in many countries, requiring aquaculture producers to comply with more stringent environmental mitigation/protection measures. In some countries these changes were even initiated by the aquaculture sector itself, usually within the more organized private industry sector to ensure its sustainability and protect operations from poorly managed activities. The private sector has made tremendous advances in the management of its activities and there are many examples of better management of farming systems that have reduced environmental impacts and improved efficiency, including profitability, in all regions.

In several countries, aquaculture producers are introducing environmental certification, either individually or in a coordinated manner, in order to credibly demonstrate that their production practices are non-polluting, non-disease transmitting and/or non-ecologically threatening. Some countries have already introduced state-mediated certification procedures, to certify that aquaculture products are safe to consume and farmed in accordance with certain environmental standards.

This chapter provides more information on the major issues highlighted above with a regional and global perspective, including significant advances in management and mitigation plus lessons learned during recent years. Food safety, aquatic animal health and transboundary issues are considered in more detail in separate sections (Chapter 3, Markets and trade).

EFFLUENTS FROM AQUACULTURE

Aquaculture, like many other human activities, produces wastes which, if not managed properly, may negatively affect the environment. In intensive aquaculture, a considerable amount of organic wastes are produced in the form of particulate and/or soluble substances (mainly the uneaten food, faeces and excreta) which increase biochemical oxygen demand, nitrates and phosphates in receiving waters. This may not necessarily be a problem as natural breakdown processes or dilution in the receiving waters can assimilate this, provided that natural waters are not overloaded, and the increased fertility of oligotrophic waters may even bring positive effects on the local ecosystem, enriching food availability for wild species.

The risk of negative impacts of aquaculture wastes are greatest in enclosed waters with poor water exchange rates, where excessive development of intensive aquaculture can lead to eutrophication and other ecosystem changes (e.g. algal blooms and low dissolved oxygen levels). This is typically site specific and occurs in slow moving rivers, lakes and shallow bays, when the nutrient loading is far higher than the carrying capacity of the ecosystem, usually as a result of over-crowding or poor water exchange.

Farm density and intensification of operations - Although the number of individual business enterprises operating fish farms has sharply decreased in all major finfish producing countries in Western Europe over the past decade, the number of sites has remained largely unchanged or has decreased only marginally. For example, the two-and-a-half-fold increase in salmon production (298 000 to 730 000 tonnes) from 1994 to 2003 was attained largely from the use of more feed within the same number of sites thus increasing environmental pressure in these localities (Rana, 2006). Even though net loadings per tonne of production have declined significantly, such concentrated farming activity has resulted in an increase in organic and inorganic discharge of

nutrients, thus creating a major challenge in environmental monitoring to the European salmon industry. Norway has a monitoring system in place – the MOM or Modelling-On growing fish farms–Monitoring (Hansen *et al*., 2001). Other countries such as Scotland and Chile have strong environmental regulations in place for salmon aquaculture, which address such requirements.

PHOTO CURTSEY SHELLFISH HEALTH UNIT, DFO, MONCTON, CANADA

Figure 1 - *Oyster racks in Canadian waters. Culture of mollusks is considered highly environmentally friendly as they do not require any inputs for growth and utilizes nutrients from the surrounding waters. Integrated mariculture is increasingly practiced with fish, mollusks and seaweeds are cultured in close proximities.*

Impacts of dissolved nutrients - In general the total amounts of N and P loading are linked with aquaculture intensity and with feed conversion factors. In Norwegian and Scottish coastal waters, around 55 percent and 17 percent, respectively, of all coastal phosphorus discharge was attributable to mariculture. These discharges, although only indicative, also contribute to the overall load from inland and coastal environments in some locations, together with discharges from agriculture, forestry, industry and domestic waste. However, its impact on regional nutrient loading is unclear and is likely to be negligible (Rana, 2006). For example, it has been estimated that in the Mediterranean finfish aquaculture (UNEP/MAP/MED POL 2004) N and P loading did not increase as production increased over the past several years. According to Karakassis, Pita and Krom (2005), N and P loading from aquaculture would be less than 0.1 percent of the total loading originating from agriculture and sewage.

Clearly on a global perspective, more research and integrated monitoring is needed to offer reliable environmental carrying capacity estimates of inland water bodies and coastal zones/areas. Such information is still needed to refine effective strategies for sustaining aquaculture through integration with other coastal or aquatic uses (GESAMP, 2001).

Mitigation measures through improved management - Mitigation of any problems associated with aquaculture effluents and wastes from inland or coastal facilities can take a variety of forms. In fish or shrimp ponds, the use of different types of filters and sedimentation ponds can greatly reduce nutrients loads on receiving waters. There are new shrimp pond management regimes using recirculation and high aeration to enable reduced water exchange, in some cases to almost zero discharge.

Improved feed management - Innovations in automated feeding technology and feed form/composition have significantly reduced feed inputs and effluent loads per unit of production, whilst maintaining productivity. In salmon farming over the past decade, feed conversion ratio has been steadily decreasing, from 1.5 to near 1.0 (Larrain, Leyton and Almendras, 2005). Such reduction implies less organic matter and nutrients discharged to the environment. However, other types of aquaculture (sea bream and sea bass in the Mediterranean Sea) still need to improve their feed conversion ratios and strong regional efforts are being made to address this task (FAO/GFCM, 2006).

In open-water fish cages waste products cannot be contained although the impact of effluents can be greatly reduced because of good water circulation. Through the use of good quality and stable feeds and by practising good feed management, it is possible to significantly reduce the impact of wastes in such environments. Selection of suitable sites with good water circulation and currents, and proper spacing of cages limits impacts on the water column and prevents excessive sedimentation of the seabed.

PHOTO CURTSEY FLAVIO CORSIN

Figure 2 - *Farmer checking feeding tray in a shrimp pond. Feeding trays are increasingly used in shrimp farming to check feeding efficiency and health of animals under culture. These devices make feeding more efficient and reduce pollution from excess feeling.*

There are well documented impacts from the cage aquaculture of salmon in coastal fjords and lochs. There is considerable experience in mitigating impacts from aquaculture effluents in salmon farming. Smolt production in Chile is moving rapidly out of lakes, using fully re-circulated water systems, following similar techniques used in Norway and Denmark (Morales & Morales, 2006). There are also examples from sea bream and sea bass culture in the Mediterranean Sea and tilapia culture in freshwater lakes in Asia.

Most published studies concerning the impact of aquaculture wastes conclude the only significant impacts are localized effects from organic pollution on the sediments (Troell and Berg, 1997, Brooks *et al.,* 2003, Soto and Norambuena, 2004, Pitta *et al.,* 2005). Although eutrophication has been described as a potential impact, (Gowen, 1994) there are few studies that actually demonstrate this effect directly, may be due to the fact that most studies were done in large water bodies with high dilution effect where impacts are minimal (Aure and Stigebrandt, 1990). In highly loaded freshwater lakes, such as Lake Tal in the Philippines and reservoirs in West Java, eutrophication from cage culture and impacts on water have been documented (NACA/FAO, 2001b).

Use of extractive aquaculture to reduce nutrient loadings - Aquaculture also provides opportunities for improving the aquatic environment. The extensive low input mollusc or seaweed systems remove nutrients from the culture environment (Neori *et al*., 2004). Effective integration of combinations of fed aquaculture and such "extractive" aquaculture practices can result in net increase of productivity and could mitigate against nutrient build up in the environment. Mixed culture of fish, molluscs and seaweeds practiced in the coastal bays of China is a good example. However the techniques require further development and improvement. Economics of such integrated systems also require careful examination. If densely located, even extractive aquaculture systems can cause negative impacts on the environment, especially on sediments, as a result of faecal and pseudofaecal accumulation.

Managing the sector at an area level - Proper zoning accompanied by environmental impact assessments (EIA), including adequate evaluation of the carrying capacity of the environment as a prerequisite to establishing aquafarms are important tools in reducing environmental pollution in multiple use environments. Some countries are already applying these tools as requirements for aquaculture licensing, thus helping to reduce the negative environmental impacts of aquaculture and encourage establishing sites in suitable locations[1].

MODIFICATION OF COASTAL ECOSYSTEMS AND HABITATS

The issue of clearing mangroves for fish and shrimp ponds has largely abated over the years for many reasons. Foremost is the greater awareness on the importance of mangroves that has led many governments to impose either stricter regulations over their use or outright ban on further clearing although implementation may still be uneven among countries. Secondly, it has become increasingly clear that technically the mangrove is

[1] www.fao.org/figis/servlet/static?dom=root&xml=aquaculture/nalo_search.xml

not the best area for semi-intensive or intensive aquaculture and new farms are seeking areas behind the mangrove intertidal areas. Additionally, many countries are now attempting to implement the RAMSAR Resolution VIII.32 on "Conservation, integrated management, and sustainable use of mangrove ecosystems and their resources" (RAMSAR, 2002), which effectively protects fragile mangrove ecosystems worldwide. Finally, the attention given to mangroves and aquaculture had largely ignored the impacts of other uses such as agriculture, with various studies now showing that aquaculture globally accounts for less than 10 percent of the loss of this important coastal habitat.

PHOTO CURTSEY MOHAMED SHARIFF

Figure 3 - *Mangrove rehabilitation around shrimp ponds. Shrimp farming has been blamed for destruction of mangrove habitats. Many countries now ban mangrove clearance for aquaculture and in fact rehabilitate disturbed land.*

Using mangroves for aquaculture is a historical practice. In Southeast Asia, particularly Indonesia and the Philippines where the culture of milkfish has a long tradition, the mangrove area was considered an ideal site for brackishwater fish ponds because the ground elevation of such areas is low enough to be flooded naturally during high tide. Such attitude on mangroves was common throughout the world up to the 1970s, since "mangroves were generally considered as waste lands with little intrinsic value and their destruction was encouraged by government and planners" (Spalding, Blasco and Field, 1997). It was only during the 1980s at the height of widespread interest on shrimp farming that concern heightened over the destruction of mangroves. This appears to coincide with the development of large shrimp farms using mangrove areas in the western hemisphere, particularly in Latin America. So although most of the mangrove forests in Asia were originally cleared for fish and merely converted to shrimps much later, the destruction of mangrove forests is often still attributed largely to shrimp farming.

In most of Asia, not only has the further clearance of remaining mangrove areas for aquaculture been banned, but also many countries have embarked on replanting and restoration. Besides these, various attempts have been made to develop aquaculture in ways that do not cause damaged to mangroves (SEAFDEC, 2006; www.deh.gov.au/commitments/wssd/publications/mekong.html).

Africa, Madagascar, Mozambique and the United Republic of Tanzania have identified and zoned suitable areas for shrimp farming and Mozambique in particular has imposed strict environmental controls over these areas. Farms are required to treat effluent water and a large-scale and successful mangrove rehabilitation programme has been instituted for those areas where water supply canals have been built through mangrove swamps (Hecht, 2006).

In Latin America initially, the cultivation of shrimp affected mangrove areas in Colombia, Guatemala, Honduras, Nicaragua, Panama, Ecuador and Brazil. Nowadays, it is possible to see a degree of mangrove recovery thanks to better regulations for their protection, increasing awareness in the shrimp industry, and incentives for their restoration through replanting and maintenance measures. Some important initiatives that have taken place are the adoption of better management practices of shrimp farming (e.g. in Brazil) and the development of a mangrove atlas for the Brazilian north-east which provides information relevant for better management and use of the ecosystem (Parente Maia *et al.,* 2005).

Mangrove is not the only coastal ecosystem that may be affected by aquaculture. Untreated pond effluents can also potentially impact on coral reefs and sea grass communities, the latter has been well documented, here organic wastes from improperly located fish cages can rain down and smother such sensitive ecosystems. Freshwater marshes and wetlands that are often home or feeding grounds of birds are potential areas which might be improperly used for aquaculture without strict government controls. The awareness of the importance of conserving critical and fragile habitats has been growing. This has evidently reduced the deleterious use of critical habitats for aquaculture and led to the development of appropriate policies and regulatory measures in many producing countries, worldwide particularly in those were an environmental impact assessment is mandatory since fragile habitats are or should be clearly identified (GESAMP, 2001).

WATER AND LAND USE IN AQUACULTURE

Concerns regarding the use of land and water for aquaculture arise from problems of prioritization, as crops, especially staple crops such as rice, are often considered more important than fish, aquaculture development is perceived as a competition and/or a threat to agriculture. Urbanization and industrialization are starting to encroach on and reduce the area for aquaculture, particularly in places where there is no appropriate land-use zoning.

Challenges related to the utilization of water for aquaculture is often associated with the use of freshwater, which can also be used for crop irrigation and human use (consumption, bathing, etc.). Freshwater aquaculture can use significant volumes of freshwater, particularly in flow through systems, and this has led to speculation regarding whether aquaculture can afford to continue to use large volumes of freshwater for production purposes, in the face of increasing demands for water for human use. On the other hand, many freshwater ponds on Asian farms contribute to water conservation. This debate is rather complex, as in most cases aquaculture is not a significant consumptive user of water, since the water is returned to the system. However the quality of water may be modified in intensive operations. In some cases this has a positive benefit since this water can be used for irrigation of crops contributing to fertilization and production.

The risks of conflicts arise where freshwater is constrained (i.e. in arid countries or where freshwater is pumped from aquifers) and there is strong local competition for water. Again, aquaculture may not be a consumptive user and effective integration of the water uses can increase the net benefit for competing users (e.g. the use of good quality waste waters for aquaculture).

The use of marine waters for aquaculture (sea farming) also faces competition from other resource users; this is not typically competition for the water itself, but more for the use of marine or coastal areas for purposes other than aquaculture. Such competition comes from: fisheries, tourism, navigation, urban development, conservation of biodiversity, etc., and usually relates more to the spatial use of water by aquaculture than the quality or volume of water used. According to the FAO regional aquaculture trends reviews, some countries have started to restrict the use of land and water resources for aquaculture through effective land use planning and zoning (e.g. Chile, Mexico, China) (Morales and Morales, 2006 and NACA, 2006).

In terms of water use, there is a difference between the use of freshwater for aquaculture and the use of freshwater to manage salinity in brackishwater aquaculture, although the latter is highly discouraged and/or banned in many countries. However, multiple use of water for irrigation, agriculture and aquaculture is regaining attention. The productivity of integrated farms in many parts of Asia, particularly China, which takes advantage of the synergy between paddy and fish is a good example of such multiple uses.

In Egypt, only brackish and marine water and the lands that are deemed unsuitable for agriculture can be used for aquaculture, thus restricting the use of freshwater (El-Gayar and Leung, 2001). A rotating system utilizing a land portion for rice during the dry season and fish (or shrimp) during the wet season as practised in Asia can be considered an excellent way of optimizing land use based on "best use" as dictated by the season. A similar system exists in the southern United States where rice lands are used to produce crayfish during the winter months with the crayfish subsisting largely on the ratoon growth of the rice stalks (Olin, 2006).

PHOTO CURTSEY MATTHIAS HALWART

Figure 4 - *Rice-fish farming in Guyana. Rice-fish farming is mainly practiced in Asia. However, in the Caribbean countries the practice is now gaining momentum. Paddy farmers generate extra income by culturing fish in paddy fields and this integrated practice increases the water use efficiency.*

Integrated irrigated aquaculture (IIA) is a concept which has been developed to maximize water use efficiency, particularly in Africa. The IIA development has the potential to increase productivity of scarce freshwater resources and reduce pressure on natural resources, particularly in the drought-prone countries of West Africa. Irrigated systems, floodplains and inland valley bottoms are identified as the three main target environments for IIA in West Africa. In irrigated systems, aquaculture is a non-consumptive use of water that can increase water productivity (e.g. rice-fish farming in Asia). Continuity of water supply, the effect of aquaculture on water conveyance and the use of agrochemicals are the main points of attention for aquaculture in irrigation systems (NACA, 2006 and Poynton, 2006).

River floodplains and deltaic lowlands also offer opportunities for integration of aquaculture. Food production can be enhanced by enclosing parts of these flooded areas and stocking them with aquatic organisms. Examples of community-based rice-fish culture in Bangladesh and Viet Nam show that fish production can be increased by 0.6 to 1.5 tonnes per hectare annually. Another example is the use of seasonal ponds in the wetlands surrounding Lake Victoria (East Africa) which are stocked with water and fish by natural flooding and are managed using locally available resources such as animal manures and crop wastes. These are all good management strategies for better land and water use within an integrated framework.

In Saudi Arabia, irrigation water is used initially for tilapia farming to avoid contamination from the pesticides used in the agricultural crops. The situation is different when freshwater is used for brackishwater aquaculture. Once mixed with seawater, it cannot be used for other purposes. What makes the practice worse is when groundwater is extracted by pumping for aquaculture. Due to the large volumes required, this can cause saltwater intrusion to the aquifer rendering it unfit for agriculture and drinking (Poynton, 2006).

Over the years, these concerns on land and water use in aquaculture have been addressed carefully by many producing countries. Land-use planning, zoning, efficient use of water resources, multiple use of water, etc., have been practised in many countries at different scales. Some examples of partial or total recirculation of water for shrimp farming are now evident in some countries. Although expensive, recirculation or closed-water systems have proven their merit on improved biosecurity, thus reducing disease.

Aquaculture also offers opportunities for the alternative uses of land and waterbodies that suffer from salinization after irrigation or that are just not good enough for agriculture. For example in Eastern Europe most of the pond fish farms were built on areas that cannot be used for efficient agricultural production due to the low quality of the soil. There are also some large inland areas that are inundated regularly. Fish ponds or reservoirs have been constructed in some of these areas (FAO/NACEE, 2006).

In coastal areas, aquaculture can have conflicts with tourism and recreational activities; an example is in the Mediterranean and Adriatic seas. Although the fish-farming industry is now looking for more suitable space for relocation or expansion, the tourism and recreational industry is restricting this, creating a conflict of interest. Some countries in the region now implement good land-use planning and environmental impact assessment (EIA) procedures for development activities (including aquaculture) which avoids such conflicts, while improving the social impacts and economic revenue (Rana, 2006).

In other countries such as Chile and Mexico the main potential conflicts for water and space use particularly in fish farming are with small-scale fisheries, however, aquaculture zoning has been established to minimize or avoid such conflicts (Morales and Morales, 2006).

FEEDING FISH WITH FISH AND OTHER FEED ISSUES

One argument against aquaculture, which is often raised, is the use of low-cost fish species such as sardines, herrings or anchovies (low-value freshwater fish in some instances) as feed (fishmeal, fish oil and trash fish) to produce a higher-value carnivorous species such as tuna, grouper, crabs and shrimps. There are two major concerns. First, with this practice, carnivorous fish aquaculture does not contribute to global fish production, since every kilogram of farmed fish requires more than 1 kg of feed fish species depending upon whether raw fish is used as direct feed or in fishmeal form as a feed ingredient. Second, converting low-value species into a high-value species can make farmed fish prices beyond the reach of the poor and therefore has food security implications. However, despite such arguments, aquaculture production of fish low in the food chain, such as carps, is still greater than carnivorous species, and so aquaculture is clearly a net producer of aquatic products and a contributor to global food security. On the other hand, the production of high-value commodities such as salmon, while not providing food for the poor, in most cases are providing jobs and could have a large social impact (Morales and Morales, 2006).

In the ecological sense, converting several units of fish biomass to one unit of fish biomass is inefficient, although it is of course a perfectly natural phenomenon when shifting from one trophic level to another. Yet, aquaculture is an economic activity where efficiency is measured in monetary terms, not in terms of biomass or energy conversion, although such concepts should permeate more. Thus the use of fish in aquaculture, either in fresh or fishmeal form, will likely continue for as long as it is economically advantageous to do so.

Feed accounts for about 60-80 percent of operational costs in intensive aquaculture, while feed and fertilizers represent about 40-60 percent of the total cost of aquaculture production in semi-intensive aquaculture systems. Fertilizers and feed resources will, therefore, continue to dominate aquaculture needs. The importance of dietary input in aquaculture can further be emphasized by the fact that about 22.8 million tonnes or 41.6 percent of total global aquaculture production in 2003 was dependent upon direct use of feed either in the form of a single dietary ingredient, home-made aquafeed or by the use of industrially manufactured aquafeeds (FAO, 2005). In 2003, 19.5 million tonnes of compound aquafeed was estimated to be produced and the primary users of these aquafeed were non-filter-feeding carps, marine shrimp, salmon, marine finfish, tilapia, trout, catfish, freshwater crustaceans, milkfish and eels (FAO, 2006).

TABLE 5
Estimate of trash fish used to produce freshwater and marine species in Vietnam.

Species	Production (mt)	%using trash fish	FCR	Moist/wet feed (t)	Trashfish (t)	
					Min	Max
Pangasius catfish	180 000	80%	2.5	360 000	64 800	180 000
Shrimp (*Penaeus monodon*)	160 000	38%	4.75	287 280	71820	143 640
Marine fishes (grouper)	2 000	100%	5.9	11 800	11 800	11 800
Lobster (*P. ornatus*)	1 000	100%	28	28 000	28 000	28 000
Total				687 080	176 420	363 440

(Source: A Survey of Marine Trash Fish and Fish Meal as Aquaculture Feed Ingredients in Vietnam. P. Edwards, Le Anh Tuan & G L Allen. ACIAR. 2004).

Trash fish used for inland, coastal and overall aquaculture in Vietnam were estimated to be between 64 800 and 180 000 t; between 72 000 t and 144 000 t; and between 177 000 t and 364 000 t, respectively.

Although the feed-based aquaculture sector is highly dependent upon capture fisheries for sourcing feed inputs, either in the form of fishmeal, fish oil and so called "low-value trash fish", the major consumers of fishmeal and fish oil are carnivorous fish and crustaceans. It has been estimated that about 53 percent of global fishmeal and 87 percent of fish oil was consumed by salmonids, marine fish (in general) and marine shrimp in 2003.

There are three main types of raw materials used for producing fishmeal: (a) trimmings from fish processing plants, (b) bycatch from fishing, and (c) fish species, which occur in large volumes but do not have a demand as direct human food. The anchoveta caught in the upwelling area off the southern Pacific coast of South America is a good example of such species. Along with anchoveta as a major raw material for fishmeal are capelin, blue whiting, sandeel, sprats, menhaden and Alaskan pollack in the northern hemisphere. Since 1985, global production has stabilized at 6 to 7 million tonnes of fishmeal and one million tonnes of fish oil (IFFO, 2006).

This means that the expanding aquaculture and livestock sectors will be competing for a resource that is not increasing – a situation that has been referred to as the "fish meal trap" (FAO, 2002). Under a situation of apparently limited supply of fishmeal and fish oil, and assuming little or no improvement in the efficiency of use of fishmeal and fish oil, the expansion of some types of aquaculture could be constrained if not altogether stopped. Even with stable (neither increasing nor decreasing) supplies of raw fish for fishmeal production, it is also argued that the growing demand for fishmeal will continue to drive the price of fishmeal and fish oil upwards. Upon reaching a certain price level, the use of fishmeal and fish oil may no longer be financially viable. This highlights the need to reduce reliance on fishmeal and to improve the efficiency of use, and considerable research is currently underway in many producing countries. Along these lines, the livestock sector appears to have made the greatest advances, which it has been forced to do because of economic factors.

PHOTO CURTSEY FLAVIO CORSIN

Figure 5 - *Preparing trashfish for feeding cage cultured freshwater fish in Cambodia. Use of trashfish for aquaculture has become a point of discussion. It is more so when food grade fish are fed to culture high value marine species such as grouper.*

Natural phenomena affecting the environment and feeds availability/ quality - The El Niño is a disruption of the ocean-atmosphere system in the tropical Pacific having important

consequences for weather around the globe. The Peruvian anchovy fishery, a major fishmeal component (which represented over a quarter or 28.5 percent of the total estimated marine fisheries landings destined for reduction in 2003) is extremely vulnerable to the El Niño phenomenon. Over the past century the fishery for Peruvian anchoveta has undergone catastrophic declines after every strong El Niño event, with landings over the last 30 years ranging from a high of 13 million tonnes in 1970 to under 0.1 million tonnes following the 1982–1983 El Niño (the strongest this century), and landings declining drastically after every major event. However, the Peruvian anchovy populations have demonstrated to have a high capacity to recover from "El Niño" type of events provided these are followed by more favourable environmental conditions and proper fisheries management is in place. On the other hand other species have been incorporated into the fishmeal processing in the area (such as horse mackerel and sardines) which makes fishmeal production more resilient to these events and to the effects of single species' abundance variability. Also, the monitoring and forecasting capabilities of events such as el Niño have improved and, therefore, fisheries management finds or should find itself in a better position to respond and to cope with these changes.

Fishmeal can be replaced by vegetable protein, but results in increased costs in the form of enzymes to remove antinutritional factors and amino acids to improve the nutritional profile (Tacon, 2005). Nevertheless, fishmeal is still relatively available and its use will continue until availability becomes seriously constrained. The replacement of fish oils has been a more challenging task because of the difficulty in finding alternative sources of omega 3 molecules. However, the rising prices of both fishmeal and oil are driving research in the feed industry towards finding substitutes (FAO, 2006).

Global trends indicate that the high-value aquaculture sector is growing and this sector is the most reliant on feeds containing fishmeal and fish oil. Within the freshwater aquaculture sector, there are likely shifts in feeding and feed composition since it has a greater opportunity to use non-marine sourced feed ingredients (particularly slaughterhouse wastes, brewery wastes and agricultural milling by-products). The higher market price of marine cultured fish and crustaceans will enable this part of the sector to afford higher fishmeal prices as demand increases.

While some countries in the world produce adequate quality commercial fish feeds for aquaculture, many depend on imports from countries within or outside the region. The evolution and development in fish feed manufacturing in aquaculture has made good progress in all regions, perhaps except Africa. As mentioned above there are many ongoing studies aiming to reduce or substitute fishmeal with cheaper more available protein.

CONTAMINANTS AND RESIDUES IN AQUACULTURE

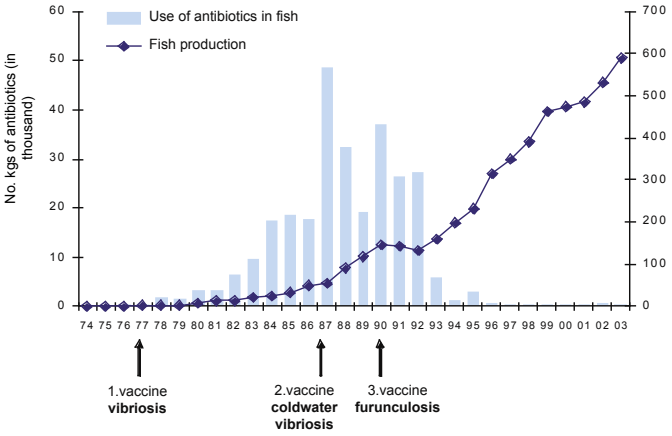
Aquaculture practices, particularly intensive forms, sometimes require the use of therapeutics (commonly referred to as drugs), for controlling diseases. Therapeutics include agents used for the effective treatment, and/or prevention of disease, and include antimicrobials (including antibiotics), antiparasitics, fungicides, biologics, hormones, chemicals, solutions, and compounds; not all of these may be used at any particular aquaculture site. Other treatments may be needed against hazards such as predators and fouling of marine cages.

Therapeutics are sometimes necessary for specific and identified uses in aquaculture. However, they should be used responsibly and under adequate control through appropriate regulation. While awareness building and education of farmers and processors on the responsible use of therapeutics is important, pharmaceutical manufacturers and dealers, feed manufacturers, and other relevant service providers should also fully cooperate in the efforts to regulate therapeutic use in aquaculture. Many

governments around the world have introduced changes or tightened national regulations on the use of therapeutics in general, and within the aquaculture sector in particular.

The use of therapeutics, especially antibiotics, is now strongly regulated in many countries, again due to the strict requirements of many nations, including importing markets. Antibiotic use has diminished significantly in some countries after the development of fish vaccines, as with salmon in Norway; the sharp decline took place after the vaccine against furunculosis caused by the bacteria *Aeromonas salmonicida* was developed (Midtlyng, 2000). Yet more efforts should be placed on research to develop better health management for finfish and crustaceans in aquaculture.

FIGURE 6
Effect of vaccination on the use of antibacterials in Norway 1974 – 2003



Source: Subasinghe and Arthur, (eds.), 2005

Use of antibacterials in aquaculture is a controversial issue. Many anitbacterials are banned from the use in aquaculture. However, if alternate health management procedures such as development of effective vaccines could significantly reduce the use of antibacterials and also increase production. The best example is Norway.

Excellent experiences were gained and positive results obtained by using the "cluster management" concept in bringing small-scale shrimp farmers together to manage their ponds using better management practices. This has reduced the use of antibiotics and completely removed the need to use banned antibacterial and veterinary drugs. (See Chapter 3, Markets and trade.)

The use of therapeutics can result in the presence of residues in the aquaculture products. Most of the presently permitted therapeutics are relatively safe and should not harm the environment outside the fishpond/fish cage as long as these are used properly. Better management practices, discussed at length in other chapters of this review, should significantly reduce the use of chemicals and other substances of any risk. In general, the use of these chemicals or pesticides has dwindled due to stricter regulation by governments and the stringent requirements of the export trade.

Although antibiotics have also been recommended and used as disinfectants in fish handling, this practice has proven to be non-hygienic, and is generally not approved by the fish inspection services. Antibiotics have not always been used in a responsible manner in aquaculture, and in a number of reported situations, the control of the use of antibiotics did not provide a proper assurance of the prevention of risks to humans. Organisations including FAO, WHO, the World Organisation for Animal Health (OIE) and a number of national governments are attempting to restrict use of antibiotics in all production sectors, as the potential risks to public health is a particular concern.

Contamination of aquaculture products - The other side of the coin is the contamination of aquaculture products due to other human activities. This has become an issue of public concern particularly after the publication of information referring to contamination of farmed salmon through fishmeal with dioxins, PCBs (polychlorinated biphenyls) and other chemicals, mostly pesticides (Hites *et al.*, 2004). Even though the overall benefits of eating salmon and other seafood products are overriding, consumers are now more aware and are increasingly demanding safer products. Many human activities can affect aquaculture, the most important being sewage outflows, which

can cause bacterial contamination and promote eutrophication, enhance algal blooms, etc., and industrial outflows, which may carry contaminants that affect aquaculture performance or may be picked up as residues in aquaculture products. The use of pesticides and fertilizers in agriculture can cause substantial damage to aquaculture. The deterioration of the aquatic environment by industrial effluents is seen as a major obstacle to further aquaculture development in certain coastal areas and is one of the reasons for pushing aquaculture offshore. Fishmeal contamination in industrialized regions of the world is also a major problem in the use of feed resources for aquaculture.

USE OF WILD-CAUGHT BROODSTOCK, POST-LARVAE AND FRY

Most freshwater species used in aquaculture are now hatchery bred, although wildcaught juveniles are still used in aquaculture in some parts of the world. Hatcheries in most countries are now capable of meeting demand for quality seed of freshwater species. The dependence of aquaculture on wild-caught seed is thus gradually diminishing and will most likely be limited to mature fish to be used in breeding programmes to improve the quality of broodstock. However, in the ornamental fish industry, there are a number of species that are still caught as juveniles for exports.

The situation is different in the marine and brackish environments where the culture of a range of species (grouper, mangrove crab, shrimp, tuna, eel, etc.) still depends on wild-caught broodstock or seed.

The use of wild-caught species in aquaculture is seen as causing negative impacts on aquatic biodiversity. One example is the black tiger prawn, *Penaeus monodon*. After years of culture in Asia and Latin America, almost all postlarvae are now hatchery produced. However, *P. monodon* aquaculture still almost fully depends on wild-caught breeders. The continued use of wild-caught broodstock as parent material makes the shrimp industry vulnerable to deterioration of seedstock quality, including susceptibility to pathogens. It is under such circumstances that many East and Southeast Asian producers have shifted to the Pacific white shrimp, *Penaeus vannamei*, due to the ready commercial availability of "specific pathogen free" (SPF) broodstock. It is worth noting here that the ability to produce SPF *P. vannamei*, has now sparked considerable interest giving way to research and development to produce SPF stocks of many other species and these are already starting to come into commercial production (e.g. *P. chinensis*). (Briggs, *et.al*. 2005)

In addition to its impact on biodiversity, massive exploitation of natural fry stock also results in inadvertent collection of the fry of non-target species and therefore has the potential of reducing recruitment to fisheries. This affects the catch and income of small-scale fishers dependent on the affected species. However, in certain instances an abrupt and complete ban on the gathering of natural fry stock is not without social cost. This again is true in *P. monodon* particularly in South Asia. In Bangladesh, hundreds of thousands of poor fishers, especially women, are dependent on the gathering of natural *P. monodon* postlarvae from the Sundarbans. The growth of the shrimp aquaculture industry has been a boon to these poor coastal families. A similar situation prevailed in Ecuador, however, the emergence of hatchery-bred clean postlarvae has resulted in the almost complete cessation of this activity as farms prefer the hatchery-raised postlarvae due to the more certain health status.

The culture of several marine finfish species and a few high-value crustacean and mollusc species are still reliant on wild-caught seedstock. In most cases this is due to the lack of reliable mass production of seed in hatcheries. Examples of this are the mangrove crab, (*Scylla* spp.), several grouper species (*Epinephelus* spp.) and the coral trout (*Plectropomus leopardus*).

As hatchery-produced milkfish (*Chanos chanos*) fry can now fully support industry needs, the only reason wild-caught fry are still being gathered is because it is a livelihood option of poor fishers. The technology for propagating mangrove crabs has been

developed and it is expected that, as the demand for crab juveniles outstrips the supply of natural stock, investment in crab hatcheries will become more and more attractive. The same situation is true for some grouper species; the humpback grouper, *Cromileptes altiveles,* is now produced commercially in Indonesia. A good example of a candidate for captive production is the Napoleon wrasse, *Cheilinus undulates,* which is now listed in CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), making the trade in wild-caught fish illegal. This commands a very high market price and can only be legally traded if demonstrated from aquaculture origin.

PHOTO CURTSEY MICHAEL PHILIPS

Figure 7 - *Napoleon wrasse* (Cheilinus undulates). *Although a popular expensive food fish species in South East Asia, this fish is now listed in CITES making the trade in wild caught fish illegal. Captive breeding of this species is now well established.*

In countries where wild-caught fish are used in aquaculture, in some instances, there is legislation governing the process. In Egypt, the government, through the General Authority for Fisheries Research and Development (GAFRD) of the Ministry of Agriculture and Land Reclamation, licences and controls fry fishing for aquaculture. It also operates official fry collection centres. However, while fry collection is controlled, the control over prices has given rise to a black market in fry. This has made management of the fry resources difficult as the amount of fry collected can be four to five times the official figures.

It is likely that the sector's dependence on wild-caught seed stocks and broodstocks is going to be reduced significantly. Equally, introduction of proper broodstock management in aquaculture will also contribute to enhance depleted wild stocks, thereby contributing to their conservation.

EFFECTS ON BIODIVERSITY

No development process or intensive food production activity can ignore its potential impacts on biodiversity and aquaculture is no exception in this regard. Yet aquaculture could use biodiversity from a biotechnological perspective and through the simple offer of new species for culture.

Aquaculture can affect local biodiversity in many ways. As mentioned earlier the use of wildcaught fry is still common for some particular marine species. Repeated fishing for the juveniles of certain species can drastically alter species composition by preventing some of them from bring recruited into the reproductive population.

The movement of seedstock within a country or between countries may significantly alter the genetic characteristics of local stocks of the same species due to inevitable escapes and/or stock enhancement practices such as those reported for salmonid stocks in North America, Europe and South America (Naylor *et al*., 2005). Likewise the escape of alien species such as salmon and tilapia can have deleterious effects on biodiversity. A recent review (Canonico *et al*., 2005) on the effects of tilapia indicates that, as alien species, they are highly invasive and exist under feral conditions in every region in which they have been cultured or introduced. On the other hand, a review on impacts on tilapias as alien species in Asia and the Pacific (FAO, 2004), based on experiences in continental Asia, points out that there is no objective evidence to show that tilapias have negatively impacted on biodiversity in this region. Furthermore, these authors argue that tilapias tend to occur in degraded habitats arising from other human activities either directly or indirectly, which thus makes them unsuitable for indigenous species. However, the situation in some Pacific and Micronesian islands is evidently different.

Nevertheless, concern is increasing over the use of alien species in aquaculture. There is often apprehension that these, if allowed to escape, can establish spawning

PHOTO CURTSEY SIMON FUNGE-SMITH

Figure 8 - *Tilapia nests in Kiribati. Tilapias are successful introduced species in many parts of the world. It has also caused limited environmental concerns, one of which is the prolific nesting and reproduction of the fish. This phenomenon has contributed to general rejection of this species as a candidate aquaculture species in the Pacific Micronesia.*

populations in the country of introduction and dislodge native species from established food niches or worse become a pest. Equally, exotic species that do not establish reproducible populations could create short-term impacts due to other interactions with native species and populations. Clearly, a precautionary approach needs to be adopted with regard to the use of alien species for aquaculture purposes, particularly regarding biodiversity conservation. As a response, many countries have adopted specific regulations to prevent and implement mitigation/control measures for escaped fish; this is particularly the case for salmon (Naylor *et al*., 2005).

Organic loading from cage or pen aquaculture is frequently cited as causing a decrease in bottom biodiversity. Although such effects are more local as there is usually a rapid recovery beyond the farms shade (Brooks *et al*., 2003), in some cases the impacts could have broader consequences; for example, when the affected habitat sustains high biodiversity and species refuge as is the case of seagrass beds (UNEP/MAP/MED POL, 2004; FAO, 2006g). Better planning, careful siting and improved construction and management practices can significantly reduce such negative impacts.

Impacts of aquaculture on biodiversity have been relatively exaggerated compared with effects of other productive sectors such as agriculture, and in most instances effects are linked to the escape of alien species or alien stocks, even though firm evidence is often not provided. Very often, habitat changes and degradation which have been brought about by non-aquaculture related activities that affect indigenous stocks and biodiversity precede those potentially connected to aquaculture and may even facilitate the latter. As aquaculture practices become increasingly responsible perceived impacts on biodiversity should decline.

There are a range of genetic improvement technologies available to aquaculturists from traditional animal breeding to genetic engineering. The use of genetically modified organisms (gene transfer technology) is controversial in most regions due to concerns about environmental and human health risks. There is much debate, even among scientists, on the degree of environmental risk associated with genetically modified organisms. However, most informed sources agree that, with the current set of genes that are being engineered for use in aquaculture, the risks to human health are minimal.

ENERGY AND RESOURCE USE EFFICIENCY

Aquaculture as an economic enterprise is sensitive to changing energy costs, particularly in more intensive systems. While energy use is typically for pumping, water circulation, aeration and lighting, transport and refrigeration are not minor uses. Fuel subsidies could improve economic viability of aquaculture, however, as a result of the rise in energy costs, aquaculture is driven to become more efficient and innovative. This is probably one of the largest challenges to intensive aquaculture, particularly to water recirculation systems which are more environmentally friendly as they

reduce nutrient outflows, disease risks and escapees, etc. but with higher energy costs. Research and technology development should focus on such challenges. There is also a need for addressing the global energy costs of aquaculture products along the full life cycle of the process (Troell *et al*., 2004) in order to put aquaculture within an ecosystem context and also to help decision making regarding alternative enterprises or activities in a local area. Often optimization procedures are the best approach and farmers on intensive production systems, particularly for high-value commodities such as shrimp and salmon, have been adopting such approaches. Nevertheless optimization on aquaculture production with an energy saving perspective should be widely adopted at all production scales and more training and organization for small farmers are potential ways to achieve it. It is a paradox that as aquaculture systems evolve to reduce the impact on the environments in which they are placed, there are corresponding increases in the energy requirements needed to deal with increased production intensity and effluent treatment.

PROGRESS IN ENVIRONMENTAL MANAGEMENT OF AQUACULTURE

Several initiatives and advances in aquaculture environmental management have been cited. These measures suggest that mitigating environmental problems requires concerted action among public and private sectors. Although considerable progress has been made in recent years, a lot more challenges remain for both sectors to improve the overall environmental performance of aquaculture. The demand to improve will continue, due to increased pressures on aquatic resources, and as consumers, governments and the international community focus on the environmental impacts of aquaculture. Some examples from Asia addressing shrimp farming are presented in Chapter 3.

Key farm-level indicators of environmental sustainability of marine fish farming have been the increased use of fallowing, improved cage design to minimize escapees and reduced usage of antibiotics. There is more effective enforcement of regulations throughout the world, although these measures are targeted at the farm level. Regulations appear to be stringent in those countries where the growth of aquaculture has been most rapid and producing high-value commodities. In many countries the industry has taken the lead to respond to the environmental pressures, mostly driven by market forces.

Coastal management tools are available with relevant case studies and strong scientific support and information (GESAMP, 2001). Yet the implementation of integrated coastal management has not been widely successful partly because of the lack of public/stakeholders involvement and interest, and limited resources. Within such an approach there is a wide range of possibilities to integrate aquaculture to other coastal uses as well as integrating different aquaculture practices in order to better use nutrients, improve productivity and decrease outflow impacts (Neori *et al*., 2004). The establishment of permanent monitoring programmes to evaluate external factors affecting aquaculture as well as the impacts of aquaculture on the environment would help to improve the management of the sector.

All regions of the world show keen interest in coordinated work amongst official institutions and farmer groups to address environmental issues, including integrating codes of conduct and regulations. The recent series of national reviews by FAO entitled National Aquaculture Legislation Overview (NALO)[2] showed that during the last decade a large number of countries have incorporated specific regulations to promote environmental management of aquaculture. Government reports on the progress of implementation of the Code of Conduct for Responsible Fisheries indicate that, worldwide, efforts are being taken to improve policy and regulatory

[2] http://www.fao.org/figis/servlet/static?xml=nalo.xml&dom=collection&xp_nav=1

frameworks supporting sustainable aquaculture development and reducing the sector's environmental impacts.

It is of critical importance that industry and research are effectively linked in those areas where environmental management and performance can be improved, for example research on better siting approaches, better diets and less expensive protein sources; technological innovations on feed manufacturing and efficient use of energy. More research is needed for the implementation of integrated aquaculture at larger production scales followed by training and extension so that the farmers are able to implement these approaches effectively. Capacity building is important particularly to develop and implement better management practices. Also more effective communication is needed at all levels both to share experiences in better management of the sector to all concerned and create dialogue and partnerships to improve understanding and find solutions to the pressing environmental issues affecting the development of this important food producing sector.

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6. Legal, institutional and management aspects

INTRODUCTION

This review is underpinned by the basic goal of sustainable development and two fundamental purposes of governance which are to ensure harmonious development and to deliver its benefits equitably. The review begins with a brief overview of fundamental concepts of governance to achieve the prime objective of sustainability, and then draws on examples of the application of these concepts from regional reviews and other sources.

Role of the public administration: Policy-making, planning and public administration for aquaculture development and management in any country should promote an economic and social environment that is optimal to fish farmers while ensuring that their activities do not cause undue costs for others. Thus, the public sector intervenes to promote efficient production, protect the environment including ensuring biodiversity and ensure that the evolution of the sector is socially acceptable (Wijkström, 2001).

Role of the government: Government can effectively foster sustainable development by playing three important implementation roles, namely: *cheerleader* or promoting particular developments; gatekeeper, or regulating and enforcing to require sustainability; and facilitator, or actively intervening to encourage sustainability (Corbin, 1997).

Sustainable aquaculture and the law: Although the moral force of the principle of sustainable development is readily apparent, morality by itself is not always sufficient to compel individuals to act wisely. Individual, corporate, national or international competitiveness may provide an incentive for short-term gains to be secured over longer-term cost. This requires balanced implementation of law to prevent "free riders" from benefiting at the expense of others who are prepared to behave responsibly towards the environment (Pillay, 1992).

The need for sustainable development to be supported by a legal framework should not be interpreted as an assertion that law is the only mechanism for realizing the objective of sustainability. Technical improvement and expansion of knowledge about good environmental practice are equally as important as the law. Likewise, markets and fiscal systems could function to reflect environmental preferences and policy objectives. Nevertheless, given the character of human nature, to pursue the range of approaches for the sustainable development of aquaculture without any legal basis is difficult to conceive (Howarth, 1998).

Legal and institutional domains of aquaculture management: Aquaculture, in common with other food production activities, interacts with the environment, as it is dependent on land, water and aquatic species, and thus causes environmental change. Production must also lead to a product safe for human consumption by domestic and foreign consumers. Therefore its development and management is likely to fall within the scope of various legislations and the expertise of various institutions (Van Houtte, 2001).

Market incentives: A market incentive works by the producer bearing the costs of polluting, or, not polluting the environment. In the first instance, a tax is imposed for pollution. The tax collected is then used to either clean up the pollution or compensate

BOX 1

Guidelines for the Ecolabelling of Fish and Fishery Products from Marine Capture Fisheries

These Guidelines were adopted by the twenty-sixth session of the Committee on Fisheries (COFI), Rome, 7 - 11 March 2005, with some observations and reservations. They can be found in paragraphs 64 to 67 of the COFI report (FAO Fisheries Report No. 780). These guidelines are applicable to ecolabelling schemes that are designed to certify and promote labels for products from well-managed marine capture fisheries and focus on issues related to the sustainable use of fisheries resources. The following principles should apply to ecolabelling schemes for marine capture fisheries:

- Be consistent with the 1982 United Nations Convention on the Law of the Sea and the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, the FAO Code of Conduct for Responsible Fisheries and the World Trade Organization (WTO) rules and other relevant international instruments.
- Recognize the sovereign rights of States and comply with all relevant laws and regulations.
- Be of a voluntary nature and market-driven.
- Be transparent, including balanced and fair participation by all interested parties.
- Be non-discriminatory, do not create unnecessary obstacles to trade and allow for fair trade and competition.
- Provide the opportunity to enter international markets.
- Establish clear accountability for the owners of schemes and the certification bodies in conformity with international standards.
- Incorporate reliable, independent auditing and verification procedures.
- Be considered equivalent if consistent with these guidelines.
- Be based on the best scientific evidence available, also taking into account traditional knowledge of the resources provided that its validity can be objectively verified.
- Be practical, viable and verifiable.
- Ensure that labels communicate truthful information.
- Provide for clarity.
- Be based, at a minimum, on the minimum substantive requirements, criteria and procedures outlined in these guidelines.

The principle of transparency should apply to all aspects of an ecolabelling scheme including its organizational structure and financial arrangements.

society for the damage caused by the pollution. In the second instance, the farmer pays for the cost of abatement of pollution so that no pollution is imposed on society. This underlies the polluter pays principle and since this affects personal cost and benefits, its purpose is to induce individuals or firms to change their behaviour to more socially desirable alternatives (Bailly and Willmann, 2001).

Another market instrument is ecolabelling, of which many voluntary schemes have been introduced in various sectors and for different objectives (Bailly and Willmann, 2001) by NGOs, government and industry. The common feature of such schemes is to take into account attributes of the products other than their price and quality and safety standards. These attributes can relate to economic and social objectives such as fair trade, support to small-scale farmers, discouragement of child labour and health related traits such as organic, environmental, and ecological ones. The purpose of

ecolabelling is to provide consumers the opportunity to express their environmental and ecological concerns through the choice of products. Such preference is expected to result in price gap or market share disparity between ecolabelled products and those products that do not qualify for ecolabelling or whose producers chose not to seek an ecolabel. The ecolabel is obtained through a certification process based on a set of criteria that define the desired standard. It is the potentially better price and/or increased market share that provides the incentive to seek certification.

Self-regulation and co-management: Faced with increasing difficulties with regulating aquaculture activity, increasing importance is given to voluntary arrangements and co-management practices. Their practical application is in the adoption of best management practices, codes of conduct and codes of practice by farmers and industry. Self-regulation and co-management imply divesting the government of some responsibilities. Usually these are in the operation and maintenance of systems in favour of the industry, although certain features of voluntary and co-management arrangements automatically remove the need for such usual government functions as monitoring of compliance with rules and regulations and imposition of penalties to violations (Van Houtte, 2001).

TRENDS AND DEVELOPMENTS IN SECTOR MANAGEMENT

An appropriate introduction to this topic might be the observations of a meeting of the Latin American and Caribbean aquaculture experts in Panama in September 2005 (FAO/OSPESCA, 2006). On the relationship between institutional capacity and aquaculture development, the meeting noted that the countries in which aquaculture had progressed the most normally had significant institutional support and was generally driven by the private sector. Development was often hampered by duplication of effort and an excess of rules and powers in the hands of the authorities.

Other outcomes of the meeting were also particularly relevant. An increasing trend in the management of aquaculture development is the gradual replacement of some of the command and control measures by economic incentives. A gradual transfer of more management responsibility from public administration to the private sector is occurring. This implies greater roles of producers, associations, and the private industry in managing the sector. Civil society groups, i.e. NGOs and People's Organizations, have also been demanding and playing a greater role, in most cases by advocating greater environmental and social responsibilities.

In a broad sense, this is co-management involving all the primary stakeholders, with the state itself as one stakeholder, in policy formulation, planning and management decisions at various levels. The ultimate application of the concept of co-management is the recent development model of stakeholder involvement in the management processes. This model seeks a different role for government that is based on consensus among all primary and legitimate stakeholders (Sen, 2001).

Sen (2001) described three ways by which stakeholders' participation can take place, namely: (i) Instructive, where the government is the decision maker but mechanisms exist only for limited exchange of information with other stakeholders (government informs stakeholders of the decisions they plan to make); (ii) consultative, where the government remains the decision maker although there are formal and informal mechanisms for consultation; and (iii) cooperative, by which all primary stakeholders work together as partners in decision-making and secondary stakeholders play a consultative role. These are not mutually exclusive, none is more desirable than the others, and they can be used in combination.

A democratic setting, good governance and transparent procedures are the contexts for involving stakeholders in policy. Such involvement is seen as critical to government and stakeholder partnerships, which is expected to yield two positive outcomes: (i) realistic and more effective policies and plans; and (ii) improved implementation.

The succeeding discussions provide specific examples of various strategies being adopted to manage the sector, which support the observation that there is a growing trend towards greater participation in sector management by the private sector, better complementation of *Command and Control* measures with economic instruments and assumption of more responsibilities for sector management by producers.

Some of the more significant developments in recent years include the promulgation of policies and programmes that are pro-poor, development or strengthening of legal and institutional support for environmentally and socially responsible aquaculture, implementation of strategies that engender wider participation in policy formulations, development planning and research, integration of aquaculture in rural development, and support or encouragement to farmer associations. The latter has been accompanied by the development of and encouragement to adopt voluntary codes of conduct, self-regulatory practices, and standards and certification schemes.

Globalization has made trade and market access increasingly the driver to aquaculture development. Its impact is two-fold: (a) strengthening of national, inter-provincial or inter-state, as well as regional and international biosecurity and food safety measures; and (b) enhancing ability, through legislation, codes of practice, certification, traceability schemes of governments and producers, to comply with trade and market access requirements. Countries are collectively harmonizing import and export standards and protocols. Direct subsidies are giving way to more market-friendly modes of technical assistance to the production sector.

The government continues to be the mainstay in the promotion of responsible aquaculture. However, the important roles of NGOs and farmers' associations are worth noting. The development and promotion of codes of practice, certification systems and standards have required the strengthening of farmers, through their being associated and thus better empowered, for their role in carrying out sustainable aquaculture. The desired status is that the various stakeholders participate and have co-ownership in the development of policies and research and development programmes to attain such objectives as equitable access to resources and share of the returns from aquaculture, environmentally and socially responsible farming, harmony and cooperation.

Banks and microfinance providers have widened their portfolio to include not only trading and processing but also for providing working capital to small-scale aquaculture ventures. Responsible aquaculture practise is now increasingly considered as one of the criteria used in loan approval.

Pilot studies and a number of in-country experiences are now providing concepts and methodologies that could be shared and adopted over wider areas. These include voluntary codes of conduct, as well as best practise, jointly developed and promoted by government, civil society and farmers associations. They are then promoted for adoption by farmers through their associations, with supporting evidence that productivity and profitability, as well as quality of produce, have improved.

As to sector management, it is well to distinguish between policy concerns, international trade and directions from the day-to-day activities of administration such as licensing, permitting and enforcement. Policy, international trade and directions are all national concerns. In some countries, these can be at the second level of government (directorate-general or bureau), or at the third level (directorate or division). Most of the Pacific islands manage aquaculture at the ministerial level within the same umbrella responsible for capture fisheries. Few countries have ministries specific for aquaculture, although in 2001, French Polynesia established a separate pearl ministry responsible to the president in recognition of the national importance of this industry.

In managing aquaculture the relevant national agency directly concerned with aquaculture often has to relate and work with other national agencies. This is unavoidable since aquaculture activities always require other non-fisheries services. For example, in Australia, the Department of Agriculture, Fisheries and Forestry

(DAFF) interacts at the highest level with the Primary Industries Ministerial Council (PIMC) on issues of national importance to better integrate Australia's conservation and sustainable production objectives. In Bangladesh, leasing of public water bodies is under the jurisdiction of the Land Administration and Land Reform Division (LALRD), while aquaculture, as part of rural development, is carried out through the Bangladesh Rural Development Board (BRDB). The use of mangrove forests in the Philippines is administered by the Bureau of Forestry under the Department of the Environment and Natural Resources (DENR), which also enforces environmental compliance of all aquaculture activities through its Environmental Management Bureau (EMB).

Exports and trade issues on aquaculture products are handled by the agency concerned with trade in general such as the Export Promotion Bureau (EPB) in Bangladesh and the Bureau of Export Trade Promotion (BETP) of the Department of Trade and Industry (DTI) in the Philippines. In India, a special body, the Marine Product Export Development Authority (MPEDA) under the Ministry of Commerce, was created exclusively to promote exports of shrimps and other fisheries products.

In all sub-Saharan African countries, except South Africa, aquaculture is promoted under the relevant Poverty Reduction Strategy papers. This indicates that governments throughout the region recognize the potential of the sector particularly for rural development. With the exception of Kenya and Uganda, the aquaculture specific legislation and regulatory frameworks in almost all countries are either non-existent or weak, though in concert with other legislation is adequate from an environmental management perspective. While all countries subscribe to the responsible development of the sector, very few have a specific Aquaculture Act (Namibia), a draft act (Zambia), or in the process of developing one (South Africa and Sierra Leone). Regulations specifically governing commercial aquaculture (i.e. mariculture exist only in Uganda, Madagascar, Mozambique, Congo Brazeville and South Africa. General regulations from other acts specifically those dealing with water, land and environmental and genetic conservation are used most often for managing the sector, while the Fisheries Acts provide the framework for issuing a licence or permit. It would further appear that current legislation in all countries pertains only or mainly to medium to large-scale commercial aquaculture.

While all countries have a policy for aquaculture development, most lack specific strategies to reach policy goals., Several countries, however, have recently developed national aquaculture development strategies or master plans (e.g. Angola, Cameroon, Madagascar, Malawi, Zambia) while plans are in preparation in the Democratic Republic of the Congo, Ghana and Mozambique. Nigeria has the preliminaries of a strategic plan though it has yet to be adopted by the federal government.

There is also the case of well-defined policies for the poor but the implementation of which is blunted by many factors. In the Philippines, for instance, official policies for freshwater aquaculture are markedly pro-poor with numerous provisions that favour small-scale operations and community welfare, but these policies are not implemented effectively. They are hindered by vested interests and by complex and confusing legislation. The Asian Development Bank (ADB) noted that fish farmers (in Central Luzon) are aware of only the few administrative orders that relate to illegal fishing practices. Awareness of other regulations is limited and compliance poor. For instance, farmers with fishponds larger than 300 m^2 are required to secure an environmental compliance certificate from the Department of Environment and Natural Resources. Very few farmers are aware of this. It observed that limited budgets, the voluntary nature of a code of practice for aquaculture and weak enforcement capabilities of national and local governments constrain enforcement of environment-friendly regulations (ADB, 2004).

Within the European aquaculture sector there is an increasing trend towards creating partnerships between aquaculture producers and scientists, government and

other stakeholders. Producers are recognized as key players for establishing sustainable aquaculture development being direct users of resources in food production. The need is seen to promote better interaction and communication as well as coordination among producers and scientists (Hugh, New & Barg, 2004).

NATIONAL INSTITUTIONAL SUPPORT AND LEGAL AND POLICY FRAMEWORKS

Some examples of developing country government's support to promote as well as to ensure orderly aquaculture development with policy and institutional support are found in Asia.

Governments have the common role of promoting technology through any combination of the following activities:

- establishment of a hatchery and making seedstock available;
- establishment of a demonstration and training farm;
- training of farmers, selecting and giving full assistance to a key farmer to apply and showcase a specific culture system;
- fielding of extension workers;
- provision of special loan programme and sometimes marketing assistance;
- financial incentives for large-scale development.

To jumpstart development in an orderly and rational manner, some governments have set aside public lands for managed aquaculture development. The government, through the existing institutions or a quasi-governmental corporation, undertakes the physical planning and development before distributing farm lots or ready-to-operate farms to smallholders. In some cases, this may be left to a private investor under specific development guidelines. A common central facility to produce seedstock and feeds as well as to process and market the harvest often, but not always, comes with such development. Some examples are provided below.

In Indonesia, the government allows large-scale development only if provision (or consideration) is made for the participation of small-scale holders through a nucleus-estate type of development. Individuals or companies going into brackishwater aquaculture are limited to 30 ha within Java and 50 ha in the outer islands. Beyond such size, the development has to follow the nucleus-estate concept wherein the excess area is developed into viable farm units for distribution to qualified smallholders.

The Islamic Republic of Iran launched the development of its shrimp culture industry by pre-identifying thousands of hectares of coastal scrub land along the Persian Gulf and allocating these for shrimp farm development. The government undertook the design, engineering and construction of common facilities. Financing was provided for the recipients to develop their respective farms according to a prescribed design. The production of seed and feeds is left to private investors with the government providing financing. The marketing of shrimp is likewise left to private traders. The government provided technical support to both hatchery operators and growers in terms of laboratory analysis and allowed them to hire foreign technicians. Brunei Darussalam undertook a similar approach but invited individual investors to design and construct the farms.

Zoning and the establishment of mariculture parks are tools for encouraging investment and promoting orderly development of aquaculture. Malaysia set up the Aquaculture Investment Zones (AIZ). Investors participating in the AIZ are entitled to many financial incentives offered to large-scale agriculture development and production projects including seed and feed production.

In the Philippines, the government has taken the planned development concept to open waters through mariculture parks. Marine waters are identified and set aside for mariculture park development where infrastructure, in the form of mooring facilities, is provided. Fish cage operators pay an annual user fee, part of which goes to upkeep, security and technical assistance. For those who lack the capital to put up their own

BOX 2

The General Fisheries and Aquaculture Law (Ley General de Pesca y Acuicultura, 1991) of Chile

This is the main legislation regulating the conservation of living aquatic resources, the activities of capture fisheries, aquaculture, fisheries for research purposes and recreational fisheries, as well as the processing, storage, transportation and marketing activities. The Title VI is dedicated to aquaculture, although it only deals with the authorization system governing the establishment of aquaculture facilities.

The main institution responsible for the administration of fisheries is the Ministry of Economy, Promotion and Reconstruction (Ministerio de Economía, Fomento y Reconstrucción). It is also referred to as Ministry of Economy and Energy (Ministerio de Economía y Energía), which has the power to take action aiming at conservation of living aquatic resources, such as: the temporary prohibition of fishing in certain areas; the permanent or temporary prohibition of the capture of protected species; the establishment of marine parks; and the setting of the landing percentage of by-catch species. In the aquaculture sector, the Ministry has the power to take action to avoid the introduction of high risk diseases, prevent their spreading and ensure their eradication. Furthermore, environmental measures may be taken to ensure, among other things, that the development of aquaculture facilities does not exceed the carrying capacity limits of each water body.

The Under Secretariat for Fisheries (Subsecretaría de Pesca – SubPesca) also has a prominent role in the aquaculture sector, being the responsible authority for granting permits for practicing aquaculture and providing advice. Within the same administration, the National Service for Fisheries (Servicio Nacional de Pesca – SerNaPesca) is in charge of maintaining the national registers for fisheries and aquaculture and other minor administrative functions.

In addition, the Ministry of National Defense (Ministerio de Defensa Nacional) has the power to grant concessions over State property for aquaculture and shall establish, by decree, which areas are suitable for the development of aquaculture activities, as identified by the Under Secretariat for Fisheries (see § on access to land and water below).

Finally, the Under Secretariat also coordinates the preparation of plans for aquaculture and fisheries for research purposes.

Source: FAO National Aquaculture Legislation Overviews (www.fao/fi/figis).

cages, pre-installed cage frames are provided for a yearly fee so that the farmer needs to invest only in the net-cages, fingerlings and feed.

In India, the establishment of the Fish Farmers' Development Agency (FFDA) at district levels has been credited in popularizing freshwater and brackishwater aquaculture. As many as 442 such FFDAs had been set up. They organized farmers for more focused provision of extension and other technical services.

In Bangladesh, the effort of the government has been on culture-based fisheries rather than on aquaculture itself. Increased production of higher value fish species in oxbow lakes and the 68 000 ha man-made Kaptai Lake has been attributed to a regular stocking programme using major carps and exotic carps.

In Eastern Europe, the need for the establishment of aquaculture associations and societies as well as for specific legislation on aquaculture issues has also been expressed in order to get aquaculture recognized as a legitimate and equal-right user of resources that is eligible for institutional and financial support. There have been various responses to the above issues in different countries depending on the relevant political

and economical situation. Aquaculture is only a minor segment of the agricultural sector in most Eastern European countries; therefore relatively limited resources are available for aquaculture development. However, in those countries where the importance of aquaculture in rural development has been recognized, more resources are allocated for the aquaculture sector within the framework of agricultural and rural development policies. In many countries of the region, there is a continuous need for the development of appropriate legal and regulatory frameworks for aquaculture. Governments provide support for aquaculture research institutions and also for fisheries and aquaculture faculties at various universities.

In the European Union, member countries of Eastern Europe, the existence of the separate Common Fisheries Policy (and the Financial Instrument for Fisheries Guidance (FIFG) structural fund) helps to distinguish aquaculture from agriculture, which may have a positive effect regarding the recognition of special values of aquaculture. In countries where the status of the aquaculture sector is uncertain, however, further efforts are needed to get this sector accepted as an equal-right user of resources. National development strategies have a great importance with a view to providing and enabling policy frameworks, including institutional recognition and adequate financial measures in supporting aquaculture.

In Latin America and the Caribbean, a relevant trend is the policy of regional and sub-sector integration for the development of their fisheries and aquaculture sectors. The Central American countries have jointly collaborated to improve the management of fisheries and aquaculture according to their regional objectives and strategies, which reinforce their policy of integration.

Chile's modification of its 1991 Fishing and Aquaculture Law provides a good case of improving the legal framework to address abuses in acquisition of aquaculture space. It also encourages farmers by cutting the red tape and simplifying paperwork. More specifically, it establishes new reasons for cancelling licences together with more stringent regulations and fines for violation. To provide a legal remedy, the government of Chile created two kinds of regimes for aquaculture concessions and licences. The first regime occurs with the issue of the concession and its licence for which the holder pays 42 taxable units (US$2 500 per hectare or fraction of, with a maximum of 210 taxable units (US$7 600). In the second regime, it is not necessary to deposit cash for processing a concession request but the rights of the holder are limited. The cost of licence is proportional to the surface area of water occupied. These modifications are aimed at improving sanitary and environmental aspects of fish farming. It also allows a longer period to begin operations and therefore enough time to recover. As to seaweed farming, the law is favourable to individual native farmers with less than one hectare of total concession surface, because their licence debts are condoned.

Weaknesses in implementation

While most Asian countries already have adequate laws for the routine administration of aquaculture, they usually lack well-designed programmes to propel development towards a specific vision. Or, where there is a specific vision and programme, actual implementation is hampered by the lack of funding support at the institutional and farm levels. This is exacerbated by a lack of trained field personnel. The lack of personnel is particularly true in extension work.

The countries of the Near East and North Africa exhibit a broad diversity of strategies for aquaculture, ranging from government designation of aquaculture development as a high priority (often with a strong supporting legal, institutional and economic infrastructure) to an absence of economic development plans and no published policy. Countries in which aquaculture development is afforded a high priority include Egypt, Libyan Arab Jamahiriya, Oman, Saudi Arabia and the Syrian Arab Republic. Recognizing that the economic and social benefits of aquaculture

growth are not without their negative consequences, some countries in the Near East and North Africa have strategies that promote sustainable development and good stewardship of the environment. Examples are Bahrain, Iran (Islamic Republic of) and the Syrian Arab Republic.

Within the Near East and North Africa, while all countries have legislation and regulation pertaining to basic establishment and operation of aquaculture facilities, few countries have legislation and regulation pertaining to such aspects as use of chemicals and drugs in aquaculture, control of disease outbreaks, and emergency and contingency plans. A critical shortage of technical experts in some countries compromises their capacity and ability in such areas as development planning and policy, quality control and enforcement of existing regulations. Laws and regulation may be updated in cooperation with adjacent countries, as will likely be proposed for all countries that are members of RECOFI (Regional Commission for Fisheries, within the framework of FAO), namely Bahrain, Iran (Islamic Republic of), Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.

PARTICIPATION OF THE CIVIL SOCIETY AND THE PRIVATE SECTOR IN MANAGEMENT

In several sub-Saharan African countries, there have been major shifts in government policy with respect to the private sector. In Kenya, for example, government is gearing itself to play a purely supportive role for the private sector by:

- promoting self-regulation;
- providing basic infrastructure for aquaculture development (roads, electricity, improved telecommunications, schools, water and health services);
- providing conducive legal and investment frameworks;
- providing a research platform;
- monitoring and evaluation;
- zoning for aquaculture and provision of land;
- fostering participative policy formulation; and
- establishing public/private partnerships.

Kenya is now expecting private entities to be the engine for the growth of the sector. Several other countries (Uganda, Madagascar, Mozambique, Malawi, Côte d'Ivoire and Ghana) have adopted similar policy decisions. These shifts in government thinking should contribute to the rapid evolution of the commercial sector over the next decade. This approach has been part of the scene in Nigeria (the National Agenda for Fish Production) for a long time and, in conjunction with a vibrant private sector, has contributed to and underpinned the development of commercial aquaculture there.

PRIVATIZING RESEARCH FACILITIES

A call was made in 1999 (FAO, 2000) to privatize government facilities. There was some movement in this respect, particularly in Madagascar where significant progress has been made. Malawi has partially privatized one of its largest stations and some progress is being made in Ghana and Republic of Congo while Nigeria has now developed a policy for the privatization of its stations. The benefits of privatizing "research or demonstration" stations for the development of the sector are immense and include amongst others, income to government and enhanced extension services as part of the lease agreement. Privatized demonstration stations act as real demonstration units that encourage development, investment, generation of employment and enhanced rural fish supply.

The pitfalls of privatization

In Africa, the original purpose of fisheries stations serving as hubs for extension was clearly neither successful nor sustainable. The privatization of government stations,

such that they may serve as hatcheries and nurseries to address the shortage of fingerling throughout the region, should, however, be preceded by comprehensive economic feasibility studies to ensure sustainability and after establishing transparent privatization policies. Care should also be taken that the process of privatization does not lead to the dissipation and/or loss of research and development capacities.

Privatization has its merits, but the experience of Sri Lanka underlines the need for adopting the approach carefully; particularly in retaining essential state support that the private sector would find no incentive to undertake. In 1990, the government of Sri Lanka withdrew state patronage from inland fisheries and aquaculture. In effect, the whole bureaucracy involved in inland fisheries and aquaculture was disbanded and the implementation of the aquaculture component of the National Fisheries Development Plan was discontinued. Shrimp farming and ornamental fish breeding continued since these were completely in the hands of the private sector. With seed supply, extension and technical support terminated, production from inland fisheries and aquaculture declined from about 40 000 tonnes in 1990 to only 12 000 tonnes in 1994. Sri Lanka has since resumed its inland fisheries and aquaculture programmes with the establishment of the National Aquaculture Development Authority (NAQDA) in 1998.

In most Latin American countries, the participation of the private sector in governing and promoting aquaculture is achieved through National Consultative Commissions. These commissions work with government authorities in searching for solutions that may benefit this sector. The participation of various governmental entities in the licensing and granting of aquaculture permits and concessions tend to become an obstacle for the harmonious development of aquaculture. Similarly, a greater coordination between the different public and private research institutions becomes necessary because research priorities are not always clear or consistent, causing duplicity in the use of resources, and often failing to achieve solutions to the problems posed by the sector.

The Eastern European experience underlines the increasing role of the private sector, in general, and farmers associations, in particular, in a market economy. Privatization of individual fish farms has exposed the farmers to market conditions and to the sometimes difficult economic environment. In this new situation, fish farmers gradually realized that they needed a new type of cooperation that would allow them to protect their interests and achieve common objectives. Efficient industry representation in policy making has not been achieved yet in many Eastern European countries. Responsibility and mandate for sector management is often unclear. The status of the aquaculture sector has been, and still is, uncertain in some countries. In many cases, new producers' associations have been developed out of the previous cooperatives or state-owned associations. However, there have been significant changes in the structure and function of the old-type organizations while they have been converted into "real" producers' associations, which also resulted in conflicts in many cases.

Civil society groups, i.e. NGOs and People's Organizations have been playing greater roles in sector management. In most cases, the advocacy role has been focused on environmental and social responsibilities directly addressed at communities, governments and the farming sector. But it is now also expressed in consumer movements where awareness has been promoted among consumers on the attributes of products so that they can express their preference towards those that are reasonably priced, safe and wholesome but also towards how and under what conditions they were produced. Another important role of civil society groups has been their highlighting of inequitable arrangements in communities. This brought these otherwise ignored or tolerated inequities into public scrutiny, debate and study; and in many cases, are now being addressed in policy, regulations and stakeholder negotiations. A case in point is the ban on coastal shrimp culture imposed by India. This is further discussed in Chapter 7 of this document.

Several NGOs have also chosen to exercise their advocacy roles in the context of partnership with governments. This is exemplified by the Partnership in Development in Kampuchea (PADEK) in Cambodia, a civil society organization that, amongst other roles, worked with the government to improve national research and extension capacities, promoted the role of women in fisheries in Cambodia and the greater Indo-China region, and directly worked with farmers to improve technical efficiency and environmental sustainability of fish farming.

EXPERIENCE OF FARMER SOCIETIES

Following the adoption of FAO's Code of Conduct for Responsible Fisheries (CCRF), specific issues and challenges for attaining the long-term sustainability of aquaculture have been recognised. These include several areas, where associative professional structures have an important role to play, as follows (Hough and Bueno, 2003):

- comprehensive policies and corresponding legal and institutional frameworks that support sustainable development which cannot be developed without communication and consultation with the major stakeholders, the producers.
- enhanced participation and consultation of all stakeholders in the planning, development and management of aquaculture, including the promotion of codes of practice and best management practices.
- promotion of the appropriate and efficient use of resources, including water, sites, seed stock and other inputs.
- human resource development and capacity building, where training, technology transfer and the provision of and access to information are the most important components.
- voluntary self-regulatory mechanisms for attaining best practices.

The role of farmers' associations can vary but is generally one of uniting the views and actions of a profession for the common good. In fisheries or agriculture, in general, they provide support to the sustainable development and management of the sector. The roles of farmers' organizations as seen by different stakeholders, including the farmers themselves, include: (i) easier provision of government services to farmers; (ii) promoting and protecting farmers' interests; and (iii) more effective partnerships with other stakeholders.

In Latin America, the Salmon Producers Association (SOTA), which includes producers' associations from Chile, Canada and the United States, has recently achieved a regional certification system based on the Safe Quality Food (SQF) of the Food Marketing Institute (FMI) which includes the most important market chains and retailers in the United States and some in Europe and Asia.

A recent case study on 13 aquaculture farmer or producers' organizations in six Asian and one Latin American countries revealed that, while maintaining their economic viability is their primary concern, the associations also worked with government and other sectors of society to shape aquaculture policies and research and development agenda (Bueno and Hough, 2005). On the other hand, especially in developing countries, most of them remain dependent, to varying degrees, on government, which can compromise their effectiveness as a stakeholder in a country's aquaculture development. But they do possess the characteristics of being an effective partner to, but independent of, government. These include being legally established and legitimately representing their target constituents, establishing alliances with other institutions, sponsoring scientific and technical forums, bringing professional and scientific opinions and advice into public debates, and rendering a range of practical services to their members.

Professionalization of the association is seen as an essential measure that would lead to the development of an authoritative, credible, viable and independent association. In this regard, the Federation of European Aquaculture Producers' (FEAP) experiences

give valuable lessons in professionalizing a farmers' association (Hough and Bueno, 2003).

Establishing, operating and managing an association requires commitment, finance and results. For a regional federation such as the FEAP, its success can also be measured in terms of participation, encouraging the involvement of member associations and their representatives, without aspiring to be competitive to the function of the members. Maintaining a complementary balance between objectives and actions and providing the services anticipated are integral to successful operation.

SAFEGUARDING SMALL-SCALE PRODUCERS AND POOR FARMERS

Among the poor farmers and users and gatherers of aquatic resources, being organized into either a formal association or self-help group paved the way for collectively: (a) achieving a strong capacity to enter and stay in aquaculture; (b) effectively demanding and absorbing institutional services and technical assistance; (c) coping with natural hazards and economic risks; (d) addressing barriers to property and financial access; and (e) acquiring and using capital and operating assets (ADB, 2005). A number of cases can be cited here to illustrate the issue of protecting the small-scale producers from the impacts of compliance to international trading standards.

A good case of a much focused effort by an organization to market a single product, to benefit all its constituents, is the Seaweed Industry Association of the Philippines, a national association of carageenan processors, traders and farmer groups. (Carageenan is a colloid from the red seaweed *Eucheuma* spp., of which the Philippines is the world's top producer and exporter.) While its various activities included developing better technology for growing and processing better quality colloid, achieved in alliance with academic institutions and other international associations, a major effort had been the addressing of the non-tariff and technical trade barriers on carageenan. It successfully lobbied to have the Philippine Natural Grade (PNG) carageenan re-classified by the Codex Alimentarius Commission from non-food to food additive, thus effectively widening its market and raising its price. The Seaweed Industry Association, in 1964, included traders, exporters and growers most of them small-scale and poor and also engaged in artisanal fisheries.

In Eastern Europe, there are initiatives to assist the networking of small enterprises and the establishment of producers' organizations in order to meet new market challenges in several countries. Unfortunately, the process is slow and sometimes unsuccessful (e.g. in Hungary) due to the reluctance of individual farmers to collaborate and share market information. Some small farms could be victims of such a situation because bargaining power of individual farms (especially small ones) is very weak against the domineering supermarkets.

In some Latin American countries, the government offers credit or specific financial funds for aquaculture as well as support schemes for producers, but others do not offer such facilities because aquaculture is considered a high risk investment sector. The issues above are only part of a wider spectrum of associated trade and marketing issues that aquaculture producing countries need to address seriously. It has become essential to assume responsibility not only for the quality of the product but for the actions taken, or not taken, in its production (NACA/FAO, 2001). Environmental and social responsibilities are joining food safety and quality assurance as requisites to market access. In Asia, for instance, most farms are small and producers are generally not well-organized, which makes it difficult and costly for small or even large farmers, individually, to comply with international standards, adopt better aquaculture practices or codes of conduct and to ensure consistent product quality and delivery. Food safety and quality are no longer the only requirements to accessing markets. Even sanitary and phytosanitary (SPS) measures have been used as an excuse to raise non-tariff barriers to trade. Linkages to environmental responsibility, animal welfare, labour and human

rights and bio-terrorism have become part of the international trading landscape, along with anti-dumping and other barriers.

The obvious and immediate impact of the increasing number and stringency of market requirements on developing country producers and exporters, many of which are small and largely unorganized, are higher costs of production and compliance. Not as immediate and not so evident, but a valid apprehension nevertheless, is that the high cost of compliance could become so onerous to the small aquaculture producers or even large but unorganized producers that they might eventually be pushed out of the business.

The impediments to trade providing benefits to poor countries have mostly come in the form of non-tariff trade barriers. The future of fish exports from developing countries is seriously threatened by regulations, which are being progressively imposed by the major fish importing countries. Producing countries have launched measures – some rather expensive for a developing country – to prevent banned chemicals from getting into seafood products. But some of the better measures include adopting codes of practice and/or better management practices that reduce or eliminate the use of chemicals and drugs in culture systems.

A very recent issue is bio-terrorism. At the 2003 AquaMarkets conference[1], the Bio-Terrorism Act in the United States was mentioned as a possible non-tariff trade barrier. At the very least, it added more steps and therefore costs to export procedures. It should be said that none of the complaints objected to the United States' desire to ensure that goods, particularly food commodities, shipped into the country do not become a vehicle for terrorist acts against its citizens. Efforts were in fact made to comply with the requirements of the law; a case in point: Thailand and the United States inaugurated (during the APEC Summit in Bangkok in October 2003) a joint initiative to ensure the security of transported products originating from two ports in Thailand to the United States. The bottom line to exporters is, however, additional procedures and costs.

Protectionist movements have come in the form of anti-dumping cases, notably those that have been filed by the catfish and shrimp producers in the United States. While industry observers in Asia and the United States have pointed out that such trade actions, rather than solve the problems of the producers in the importing country, usually tend to create uncertainties in the market place, limit supplies and drive consumer prices up. Farmers in exporting countries must face up to the reality that anti-dumping measures will remain a threat, whatever their motivations.

These realities facing producers and exporters of seafood products are, at best, an annoyance to governments, at worst, a threat to the continuing ability of farmers and exporters in developing countries to stay in business. On the other hand, with the growing concern over food safety and the environmental and social issues linked to aquaculture production, producers not committed to adopting and implementing programmes that address these issues will find it more difficult to compete with those that do have responsible programmes.

As to the effect of trade liberalization on poverty, doubts linger among some developing countries on the impact of liberalization on the competitiveness of their aquaculture sector. These doubts are heightened by the fact that economies of scale are not readily achieved by their thousands of small farmers. Studies have found strong relations between trade and growth, although the point is stressed that "liberalization alone cannot be an answer but needs accompanying policies, such as market reforms, macro-economic stabilization, exchange rate adjustment and adequate safety nets"

[1] Regional Seminar and Consultation on Accessing Markets and Fulfilling Market Requirements, organized by NACA in Manila, 2–6 June 2003. It was hosted by the Agriculture and Trade and Industry Ministries of the Philippines and assisted by FAO and WTO.

(UNESCAP, 2001). Recent studies on the impact of trade liberalization on the reduction of poverty show that it can alleviate poverty but evidence is still not strong since findings vary between countries (UNESCAP, 2001).

These issues have prompted an increasing need to bring a trade dimension to work on aquaculture development. The responses that have been initiated and the broad and specific options that have been recommended by NACA and FAO initiatives on trade in aquatic products include: (i) strengthening capacities to comply with SPS standards; (ii) engaging more actively and effectively in the standard setting processes of international instruments such as the Codex Alimentarius Commission and OIE; (iii) certifying aquaculture products; (iv) finding ways to benefit fully from market chains; and (v) building the effective institutions.

AquaMarkets 2003 emphasized transparency and cooperation in information sharing and the need to strengthen knowledge and intelligence capacities with information technology. It also raised the prospects of developing countries moving into e-commerce and establishing mutual arrangements that facilitate and reduce the cost of information flows, which speed up the processing of "documents" and improve the efficiency of handling and moving products. Among trading partners, establishing common customs procedures and operations would reduce very high compliance costs, which had been estimated to be 7–10 percent of the value of global trade (UNESCAP, 2001). Applied to global trade in aquatic products, that is a cost of US$3.9 to 5.6 billion.

The growing awareness that environmentally sensitive aquaculture makes good business sense and helps poor and small-scale farmers, has spurred efforts to promote further the adoption of environmentally and socially responsible farming practices through appropriate standards or codes of conduct. In this regard, and following on from AquaMarkets 2003, the December 2003 Global Aquaculture Forum held in Dhaka (jointly hosted by the Government of Bangladesh, the Bangladesh Shrimp Foundation and NACA) brought together some 70 participants from seven countries representing various stakeholders in shrimp aquaculture to share experiences and ideas on trade in shrimp and to seek solutions to problems and constraints.

The specific responses to the various market access and trade issues were marked by a focus on people and their well-being, and cooperation among farmers, stakeholders and governments to maintain transparency and achieve competitiveness, but more especially, to ensure responsible aquaculture and trade[2] (NACA/FAO, 2004).

Better management practices

Promotion of aquaculture has largely met little problem in most countries. On the other hand, if a certain aquaculture venture turns out to be profitable, governments often found it difficult to control or stop runaway development until a catastrophic mass mortality and other related problems occurred. Viewed in this light, industry growth is self-limiting. The problem is not so much promotion as management. Beyond issuance of permits and licences, governments in Asia are increasingly realizing the need to protect the environment and manage aquaculture resources in a sustainable manner. In New Caledonia, a rigid system of self-regulation applying to all prawn farmers (*P. stylirostris*) has been put in place in order for the industry to meet the high quality standards demanded of its niche markets in Japan and France.

Thus, while maintaining policies to encourage the development or further development of the aquaculture industry through liberal land-use policies with long-term and low-cost lease options, liberal financing, technology development and other incentives, most countries are also trying to mitigate the negative consequences of runaway development by measures such as: (a) instituting rules and regulations on

[2] www.enaca.org/aquamarkets

environmental impact assessment; (b) banning of further clearance of mangrove forests for aquaculture development; (c) imposing a green belt along the shoreline and river banks; (d) licensing of all aquaculture operations including hatcheries with the licence often required by banks for loan applications; (e) implementing allowable size of fish cages and spacing between such cages; (f) banning the use of a specific list of chemicals and therapeutants; and (g) implementing inspection and imposition of quarantine procedures on movements of live fish.

In Latin America, Codes of Conduct for Responsible Fishing and good practices in shrimp culture are adopted as in Brazil, good practices in aquaculture production in Colombia, qualification in good practices on handling and quality assurance of aquatic products in Costa Rica and Nicaragua, and Environmental Regulation for Aquaculture (RAMA) in Chile. Unfortunately, information on verification processes of the fulfilment of such initiatives does not always exist. In some countries, governments have introduced quality betterment systems and better practices for aquaculture and have supported the implementation of Hazard Analysis and Critical Control Points (HACCP), qualification and training of Good Aquaculture Production Practices (BPPA), [International Organization for Standardization] ISO 9 000 certification (quality), ISO 14 000 certification (environment), rules and regulations and product chains schemes. Similarly, in other cases, independent companies and producers associations have established standards and regulations or codes of conduct under Clean Production Agreements (APL) for salmon, shrimp and tilapia production, postlarvae production, processing, etc. Steps are being taken to set up traceability systems for fisheries and aquaculture products.

A research-extension pilot project in India on developing and promoting best-health management practices among small shrimp farmers organized into self-help groups has highlighted the importance of farmers being organized to be able to adopt cost-effectively best practices that improve their yield and the quality of their produce. A project evaluation in 2004 found that the farmers increased yields by 33 percent, harvested shrimp were 1.5 times larger and were affected 20 percent less frequently by diseases than surrounding non-adopting farmers. Moreover, their produce became more attractive to buyers because the shrimp had no antibiotic residues as the farm management practices they adopted exclude the use of banned drugs and chemicals. The project was subsequently expanded and another evaluation of the 2005 crop, with results from 930 demonstration ponds spread over 484 ha in 15 villages, showed a two-fold increase in production, 34 percent increase in size of shrimp and 65 percent reduction in disease prevalence compared to surrounding non-adopting ponds. Another outcome is the "contract hatchery seed production system" in which the organized small farmers could procure high quality seeds at reasonable price, and even offering premium price to hatchery owners for quality and reliable seed supply.

A second case, from NACA's activities, to demonstrate the private and social benefits of adopting best management practices (BMPs) was a project in Viet Nam that supported coastal aquaculture. Support was given to the promotion of responsible development of the shrimp farming sector at all levels and for all links in the production chain. BMPs were developed for broodstock traders, hatcheries, seed traders and farmers. Focus was given on the development of simple and practical BMPs, which addressed the needs of less resourced small-scale farmers. Ten sets of extension material were developed and disseminated in close collaboration with the Ministry of Fisheries. The tangible outcomes included:

- implementation of BMP for hatcheries resulted in seed production up to 1.5 times higher and a price per unit seed of about 30-40 percent higher than non-BMP seed.
- BMP implementation in 7 pilot farming communities (655 direct beneficiaries) led to a remarkably lower risk of mortality, higher production and higher probability of making a profit.

- farming communes that introduced seed testing increased their chances of making a profit by over 7 times.
- BMP application led to average yields that were sometimes more than 4 times higher than in farms where BMP had not been adopted.
- the project BMPs were also incorporated into the draft standards for the production of organic seed.

Self-regulation

The need to develop aquaculture has to be accompanied by the assumption by the production sector of the responsibilities expected of it. To assure sustainable aquaculture, the production sector has to be organized efficiently for the implementation of, or compliance with, the requirements now in place or that are anticipated. The debate on the sustainability of aquaculture has broadened from technical and environmental questions to the inclusion of economic, marketing and social responsibility issues. To these purposes, the use of *associations*, at the national and regional levels, provides the basis and the practical means of communicating with the sector that will lead to improvements in the management of resources and the sector. These considerations are specifically reflected by a survey of national associations (in Asia, Latin America, Eastern Europe, Canada and Australia), a regional federation (FEAP) and a global alliance of producers and allied industries (GAA). The survey shows a range of motivations for organizing and organizational goals, a number of which highlight the increasing tendency towards self-regulation. From the 13 associations surveyed which includes 12 from Asia and one from Ecuador, a number of motivations for organizing relate to their assuming functions that relate to self-regulation.

The pathways for attaining competitiveness were basically similar: Unifying the industry players to address common problems cohesively; strengthening bargaining power with suppliers of materials and credit and buyers; improving production efficiency with better technology; and cooperating with government in conducting promotional activities, technology trials, shaping of regulations and policy; and developing and promoting codes of conduct, good aquaculture practices and better management practices.

For specific examples, the Thai Shrimp Farmers, Producers and Exporters Association and Sri Lanka's Professional Ornamental Fish Producers Association essentially have similar goals to rationalize and synchronize the efforts of the various sub-sectors of the industry. Individual players in the Thai shrimp industry, namely, hatchery operators, growers, cold-storage operators and exporters each had their own agenda and activities in addressing the common industry problems of safety and quality of product, especially the antibiotic residue problem, removal of Thailand's GSP (Generalized System of Preferences)[3] status with EU resulting in higher tariffs, price fluctuation and lack of raw materials for the processors, and the anti-dumping charges. The association was meant to unify and direct these separate efforts. The Sri Lankan ornamental fish producers association was meant to redress the inefficient operations of similar associations whose inefficiencies were exacerbated by declining export values and revenues that had caused members to drop out or apply for inactive status. The new association enlisted as members, players from the various subsectors (including wild fish collectors), which, in effect, unified the market chain.

The second motivation of coping with threats to viability and improving the industry's image, also leads to the associations adopting their own measures to deal with three major threats to the industry, namely: diseases, low prices and a bad image. The first and the last are linked, and found common solution in better water and effluent management. The Thai national shrimp association (that grew from a provincial shrimp

[3] This has recently been restored.

BOX 3

Shrimp Aquaculture Better Management Practices applied by small-scale farmers in India and Viet Nam

a. pond bottom and water preparation

1. Sludge removal and disposal away from pond site.
2. Ploughing on wet soil if the sludge has not been removed completely.
3. Water filtration using twin bag filters of 300 µ mesh size.
4. Water depth of at least 80cm at shallowest part of pond.
5. Water conditioning for 10-15 days before stocking.

b. seed selection and stocking practices

1. Uniform size and colored PLs, actively swimming against the water current.
2. Nested PCR negative PLs for WSSV (using batches of 59 PLs pooled together. If test turns negative it means that the prevalence of WSSV infected PLs is less than 5% in that population at 95% confidence).
3. Weak PL elimination before stocking using formalin (100 ppm) stress for 15-20 minutes in continuously aerated water.
4. On-farm nursery rearing of PLs for 15-20 days.
5. Stocking during 1st week of February to 2nd week of March.
6. Seed transportation time of less than 6 hrs from hatchery to pond site.
7. Stocking into green water and avoiding transparent water during stocking.

c. post-stocking / grow-out

1. Use of water reservoirs, and 10-15 days aging before use on grow out ponds.
2. Regular usage of agricultural lime, especially after water exchange and rain.
3. No use of any harmful/banned chemicals.
4. Using of feed check trays to ensure feeding based on shrimp demand.
5. Feeding across the pond using boat/floating device to avoid local waste accumulation.
6. Regular removal of benthic algae.
7. Water exchanges only during critical periods.
8. Weekly checking of pond bottom mud for blackish organic waste accumulation and bad smell.
9. Regular shrimp health checks, and weekly health and growth monitoring using a cast net
10. Removal and safe disposal of sick or dead shrimp.
11. Emergency harvesting after proper decision making.
12. No draining or abandoning of disease affected stocks but emergency harvesting.

Source: NACA/MPEDA/FAO cluster management in small-scale shrimp farming in Andhra Pradesh, India. www.enaca.org/shrimp

farmers' association) enhanced its image further with successful and visible efforts at planting mangroves or rehabilitating them. To improve the industry's image, the Sri Lankan ornamental fish farmers association, the membership of which includes gatherers of ornamental fish and as yet depends to some extent on wild sources, has promoted the breeding of endangered species.

To promote a unified governance of the sector, the Vietnamese Fishery Society unified the Vietnamese Aquaculture and Vietnamese Fishery Associations. Two of their aquaculture products are major export items: shrimp and catfish. As such, while the society's activities do not include exporting, it does have a great interest in having the products and their farming and processing practices adhere to safety, quality and environmental requirements.

As with Viet Nam, the Ecuadorian association, which is in fact a national "chamber", consists of the entire range of industry stakeholders, but unlike Viet Nam, does not include government services. Its membership of nearly one thousand indicates the broad scope of representation in the association. In Chile, the "salmon cluster" involves not only the salmon farmers but also feed, nets and equipment producers as well as certain services such as processing, transport and cold chains. This cluster has been involved in a Clean Production Agreement with the government.

Self-regulation is enhanced by having a voice in policy and plans. At the local level, this is exemplified in India by the formation of associations of poor tribal farmers and scheduled castes, which was initiated by development agencies, government and an NGO in three eastern states to provide the environment and institutional support for poor farmers and aquatic resource users to enable them to demand the institutional support necessary and recommend policies and approaches needed to bring it about. To be even stronger, the small village associations have formed a network among themselves, albeit with assistance from the state governments and an NGO.

In Eastern Europe, the older and more organized associations have memberships that include producers, processors, traders and even independent experts. Their objectives are also more varied and organizational structures more sophisticated. Their goals, for instance, include protecting the rights of members and of the fisheries and aquaculture sectors, improving the national fishery and aquaculture legislations and adapting it to the EU Common Fisheries Policy, strengthening the position of the producers in the domestic and international markets and establishing links and cooperative activities with international organizations. A special mention was made of the producers' associations in the Czech Republic, Hungary and Poland which are described as more advanced than those in the other countries surveyed. The producers' associations of these three countries are also members of the FEAP.

The presence and extent of farmer associations in the Near East and North Africa typically parallel the state of development of the aquaculture industry. For example, in Egypt, the largest regional producer and long established, there are seven aquaculture cooperatives. In Iran (Islamic Republic. of) the second largest regional producer, there are three cooperative unions, one each for coldwater, warmwater and shrimp production; the unions have been formed to lead aquaculture development, to collaborate in decision-making and to support farmers. In Saudi Arabia, the third largest regional producer, there are currently no producer associations, although the government plans to facilitate the development of such associations in cooperation with the Chamber of Commerce.

Two farmers' associations, in Australia and Canada, illustrate the purposes, services to members and the role of the associations in the advancement of the aquaculture industry, in developed economies. The emphasis on scientific and manpower development is strong, and the focus on having a stronger representation in government policy-making is very evident.

The objectives of the Aquaculture Association of Canada (Association aquacole du Canada)[4] are to: (a) foster an aquaculture industry in Canada, to promote the study of aquaculture and related science in Canada to gather and disseminate information relating to aquaculture and to create public awareness and understanding of aquaculture; (b) promote, support and encourage educational, scientific and technological development and advancement of aquaculture in Canada; (c) gather and disseminate technical and scientific information on aquaculture development; (d) conduct seminars for the presentation, exchange and discussion of information, findings and experiences on all subjects and techniques related to aquaculture; (e) encourage the teaching of all phases of aquaculture and the training of aquaculturists in accredited colleges and

[4] www.apfa.com.au

universities; and (f) encourage private industry and government agencies to support education, research and development.

The Australian Prawn Farmer's Association (APFA)[5] aims to represent the interests and foster the development of the Australian prawn farming industry. The APFA has close to 100 percent coverage of growers across Australia, which means that it has a strong voice at all levels of government.

The APFA, in collaboration with the Fisheries Research and Development Corporation, helps direct funding to a number of core areas described in the APFA Research and Development Plan 2000–2005. The APFA has prepared a Five Year Research and Development Plan, the priorities of which are determined annually by members in a series of workshops and surveys.

The activities and purposes that relate to promoting sustainable aquaculture and better management of the sector, of two kinds of associations, a regional federation and a global alliance, are provided by the FEAP[6] and GAA[7].

The FEAP had 34 associations from 24 countries in 2005. Its primary goal is to provide a forum for the debate of issues (concerning European aquaculture primarily) common to its members and to communicate the results of such discussion to the appropriate authorities. One of the key objectives is the effective communication of these opinions to the authorities, which vary according to the topic, and cover all aspects of aquaculture operation. In Europe, many countries have adopted much of the harmonized legislation.

There has been a significant increase in the requirement for consultation with the professional aquaculture sector in recent years, reflecting changes in government policies where the higher involvement of stakeholders and the move towards self-regulation are important issues. When issues such as international trade and market stability, sustainability, development of standards (including organic farming and ecolabelling issues), governance and self-regulation have to be debated, with the professional point of view in mind, this cannot be done in a vacuum. The FEAP provides apolitical positions, based on science and/or good sense, which support the sector and its development.

The FEAP and GAA have been active in promoting Codes of Conduct and Good Practice and, since each has direct access to producers, this activity has been quite successful in transposing the desires of government into practical actions at farm level. The development of internationally-acceptable standards may also be seen as an activity that could be developed through regional cooperation between such bodies.

The GAA focuses on tropical shrimp production and its membership covers associations, private production companies and product importers. Its goal is to advocate aquaculture as an answer to global food needs and to educate producers, consumers and the media in regard of this, while furthering environmentally responsible aquaculture. Under its Responsible Aquaculture Programme, it has initiated the development of standards of good practice or codes of conduct. It also provides advice for monitoring and certifying adherence to standards or codes and has initiated the development and use of marks or logos designating adherence to such codes or standards.

Co-management

Co-management is an emerging trend and the concept has mostly been described through its application in the management of common resources and mostly at the community level. A review of co-management is included here to shed some light onto the existing and potential ways by which it is applied to the aquaculture sector (Carlsson and Berkes, 2005).

[5] www.apfa.com.au
[6] www.feap.info
[7] www.gaalliance.org

BOX 4

International Principles for Responsible Shrimp Farming

Farm Siting: Locate shrimp farms according to national planning and legal frameworks in environmentally suitable locations, making efficient use of land and water resources and in ways that conserve biodiversity, ecologically sensitive habitats and ecosystem functions, recognizing other land uses, and that other people and species depend upon these same ecosystems.

Farm Design: Design and construct shrimp farms in ways that minimize environmental damage.

Water Use: Minimize the impact of water use for shrimp farming on water resources.

Broodstock and Postlarvae: Where possible, use domesticated selected stocks of disease free and/or resistant shrimp broodstock and post-larvae to enhance biosecurity, reduce disease incidence and increase production, whilst reducing the demand for wild stocks.

Feed Management: Utilize feeds and feed management practices that make efficient use of available feed resources, promote efficient shrimp growth, minimize production and discharge of wastes.

Health Management: Health management plans should be adopted that aim to reduce stress, minimize the risks of disease affecting both the cultured and wild stocks, and increase food safety.

Food Safety: Ensure food safety and the quality of shrimp products, whilst reducing the risks to ecosystems and human health from chemical use.

Social Responsibility: Develop and operate farms in a socially responsible manner that benefits the farm, the local communities and the country, and that contributes effectively to rural development, and particularly poverty alleviation in coastal areas, without compromising the environment.

Source FAO/NACA/UNEP/WB/WWF. 2006.

What is co-management? In relation to natural resources, the term management can be understood as the "right to regulate internal use patterns and transform the resource by making improvement". These activities can be performed by single actors or jointly by groups of individuals or as a result of cooperation among different groups. Collaborative management, or co-management, has been defined as "the sharing of power and responsibility between the government and local resource users" (Carlsson and Berkes, 2005).

The World Bank has defined co-management as "the sharing of responsibilities, rights and duties between the primary stakeholders, in particular, local communities and the nation state; a decentralized approach to decision making that involves the local users in the decision-making process as equals with the nation-state" (Carlsson and Berkes, 2005). The same definition was adopted by the World Conservation Congress: "a partnership in which government agencies, local communities and resource users, nongovernmental organizations and other stakeholders negotiate, as appropriate to each context, the authority and responsibility for the management of a specific area or set of resources". This latter regards the state as only one among a set of stakeholders (Van Houtte, 2001).

Two different models try to conceptualize co-management between "folk-managed" systems and state-managed systems. On the one hand, there is a horizontal continuum from nearly total self-management to nearly total state management. On the other, there

is a vertical contracting out model of state-management powers which is characterized by devolution of rights. Although these models are not mutually exclusive, they are based on an implicit dichotomy comprised by the state and local resource users. Co-management can be looked upon as a continuum from the simple exchange of information to formal partnership

The above definitions and conceptualizations of co-management have some common underpinnings: (i) they explicitly associate the concept of co-management with natural resources management; (ii) they regard co-management as some kind of partnership between public and private actors; and (iii) they stress that co-management is not a fixed state but a process that takes place along a continuum.

What is co-management good for?

Allocation of tasks: Many existing management systems need to operate at both small-scale and large-scale levels requiring different kinds of skills and knowledge to do so. This is possible because co-management brings together a variety of different capacities and comparative advantages. For example, marginalized producer groups in remote areas of the world need external markets for the realization of the value of the goods they produce; but they need links to the market through persons who know the structure of the demand, or have access to different types of commercial networks. This is only one example of allocation of tasks, but the principle is something that permeates all types of co-management systems. Division of labour enables specialization to increase efficiency.

Exchange of resources: Local groups may have a need for certain types of resources that they are themselves unable to provide, such as technology, scientific expertise and a diversity of information.; but they may possess resources needed at the centre, such as information about harvesting volumes or status of the resource. A basic assumption about network relations is that one party is dependent on resources controlled by another, and that there are gains to be had by the pooling of resources.

Linking different types and levels of organization: Co-management is a means of linking different types of organization. In a bureaucracy, different layers of organization are linked to one another within a framework of coherent hierarchy. Co-management, by contrast, is a process by which representatives from different levels of organizations and types of organizations coordinate their activities in relation to a specific area or resource system. In practice, it means that, for instance, state-employed experts might work in concert with the board of a local community of resource users. In comparison with hierarchic ways of organizing management, the latter is more responsive to local circumstances. It is also likely that the flow of information is faster and more effective and that problems are addressed at a more appropriate level within the organization. In short, co-management agreements serve the purpose of constituting linkages among organizational groups that might not be otherwise connected.

Reduction of transaction costs: Transaction costs are the costs of measuring what is being changed and enforcing of agreements. These costs can be divided into long-term and short-term costs, although it is not easy to distinguish between activities aimed at a long-term reduction of transactions costs or for more immediate purposes. Although it may be the case that the initial phases of the establishment of co-management increase transaction costs, one positive, but often neglected, effect is the possibility that well-tailored systems help reduce transaction costs. If most instances of co-management consist of fairly rich webs of relations, these networks have certainly evolved over time. The function of individual links in these networks usually has to do with information, legal relations and monitoring, features that are usually associated with the exercising of property rights. If (as a result of an agreement) representatives of state authorities are entrusted the right to monitor the access to or appropriation of a resource, this will reduce conflict among members of the community. Consequently, users do not have to dedicate time and resources for solving these conflicts, thus reducing transaction costs.

Risk sharing: Many agriculture-based communities tend to diversify their crops. If one crop fails, they would still have a resource base for their subsistence living. In short, they do not put 'all eggs in one basket'. The same type of reasoning can be applied to institutions and governance systems. Systems that are composed by single administrative units and practise monolithic decision systems are more vulnerable than are polycentric arrangements and redundancy. This logic can also be applied to co-management networks. Webs of relations that have evolved over time make up diversified management arrangements. These webs serve the purpose of spreading the risk among involved parties. For example, it is less risky to share some management tasks among a number of actors, as compared to relying on one actor for their accomplishment.

Conflict resolution mechanisms and power sharing: The establishment of co-management systems may function as a means of conflict resolution between communities of local resource users and the state. The processes of negotiation, bargaining and setting up co-management agreements that codify the rights and responsibilities of involved parties (local groups, the state, commercial actors, etc.) reduce conflicts and might even function as a more long-term problem-solving mechanism. Successful reduction of conflicts is essential for long-term planning and for the willingness among individuals to invest in creating appropriate institutions.

Three examples, on culture-based fisheries (De Silva *et al.*, 2004), on community-based aquaculture (ADB, 2004), and on stock enhancement of low-trophic organisms in a coastal bed (Fjalland *et al.*, 2005), of the application of co-management in aquaculture are described below.

A good example of the application of co-management is in culture-based fisheries, a form of aquaculture practised communally in small water bodies in rural areas. It is increasingly popular with governments and communities in their attempts to increase rural fish supplies with minimal input of resources; it is also a good example of effective secondary use of water resources, which are primarily targeted for downstream agricultural activities. Culture-based fisheries are being practised effectively in countries such as Sri Lanka, Viet Nam and Bangladesh (in oxbow lakes) and involve the participation of the agricultural community that essentially manages, and are the beneficiaries of, the water resource. The community structure that has been organized previously for managing the water resource for agricultural activities (often a community organization formed through the existing legislative structures for agricultural activities, which is the only direct government intervention) are incorporated, encouraged and stimulated to take part in culture-based fisheries in the water body, without compromising the downstream agricultural activities. The operational activities of the individual culture-based fisheries practices are totally determined by the community (such as species to stock, time of stocking, time of harvesting, caring for the stock), on the technical advice of relevant authorities (De Silva, Amarasinghe and Nguyen, 2006).

Another example is provided by the community-based aquaculture programme in Northeast Thailand. The study does not describe the arrangements and processes but only the reasons for both good and unsuccessful outcomes (ADB, 2004). The evaluation found that the programme had contributed to the development of self-help initiatives, local ownership and decision-making in the communities. The main factors that influenced the success of community-based aquaculture were: (i) the demand for and the extent of interest in fish farming; (ii) social capital, including organizational arrangements that contribute to strong community participation, sharing access to resources and conflict resolution; and (iii) government assistance and partnerships with the communities. On the other hand, constraints to rural aquaculture have included water shortages, unfavourable biophysical conditions, low natural productivity and such farm management issues as stocking density, pond management, access to

feed and harvesting methods. Fish farming has also been affected by environmental degradation, limited financial and human resources, inappropriate links between extension and research and external shocks (such as the effects of the Asian financial crisis of 1997).

A third is one of field projects of a DANIDA-assisted project for mariculture and brackishwater aquaculture in Viet Nam (Fjalland *et al.*, 2005). Van Thang Commune is an island fishing community dependent on a combination of over-fished benthic resources (gastropod and bivalve molluscs) and unsustainable aquaculture practices (lobster grow-out in cages). A study identified a suitable area for a marine benthic resource management programme referred to as a 'seabed resource management'. The 30 ha area was demarcated and restocked with a range of species low in the food chain but economically valuable, including topshell (*Trochus niloticus*), abalone (*Haliotis asinina*) and sea cucumber (*Holothuria scabra*). The aim was to ensure that local communities would manage the area and continue to hold the legal rights for the sustainable use of their resources.

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7. Social impacts, employment and poverty reduction

INTRODUCTION

A global review of aquaculture would be incomplete without dealing with the social dimensions. First, the objectives of governments of producing more food, earning higher incomes and improving economies have expanded to ensuring that enough food is produced and made accessible to the masses and that the poorer participants in the aquaculture sector gain a better livelihood. Second, as with other economic activities, the impacts of aquaculture range from those benefiting individuals to those benefiting entire communities. Third, the practice of aquaculture may also have its unintended and negative consequences which, if not dealt with, may outweigh its positive impacts.

The purpose of this chapter is not to balance, as in an accounting ledger, the positive impacts of aquaculture against the negative, the beneficial effects against the harmful. Rather, using the regional aquaculture trends reviews as source materials, this chapter is meant to enable an understanding of why and how these impacts are caused so that the positive are enhanced and the negative mitigated or avoided. One difficulty in dealing with social dimensions in a global review is that, more so than with bio-technical aspects, social norms, traditions and cultures vary from one region to another so that generalizations are not only difficult but also need to go beyond the social and political and delve into the ethical aspects. Regional examples therefore are provided to illustrate or highlight certain points or serve as lessons but are by no means intended to be applicable globally.

The positive livelihood impacts of aquaculture are well known and include provision of rural livelihoods, better income and new or alternative employment, additional income from rice farming systems or subsistence staple cropping systems, food security and better nutrition, and development of rural areas, the latter is also seen as a means to arrest urban migration. Another would be the opportunity for diversion and leisure to stressed citizens offered by angling.

Negative impacts of aquaculture arise due to the constant need to produce more by expanding the production area or by increasing the unit productivity. Under such circumstances conflicts arise which may be classified into three types, two of which are social in nature and the third related to the wider environment within which aquaculture operates:

(i) Conflicts among people or social groups that stem from competition for common resources as well as denial to some groups of access to resources.

(ii) Social inequities that are caused when benefits from aquaculture are not equitably shared or when some people or groups reap the benefits while others bear the cost.

(iii) Social impacts or conflict arising from the use of common resources by aquaculture operations, or damage caused to the ecosystem by aquaculture and the cost of mitigating the damage or restoring the ecosystem. In the short term, it is society that usually bears the cost of abatement or restoration although in the long term the benefit accrues to everyone, including the exploiters of the ecosystem.

HOW AQUACULTURE IS DELIVERING SOCIAL BENEFITS

To feed the growing population, there has to be a corresponding increase in food production whether from agriculture or aquaculture. There are basically two options to increase production in agriculture: (a) expansion of production area and (b) intensifying production. With increasing global population, the first option becomes less likely on land. However, aquaculture still has an advantage over agriculture as there are still the open waters of the sea to expand into. But as FAO (2004) has noted, "given the present and anticipated increases in world population, not to mention current and projected environmental problems and ecological stress from agriculture, further agricultural intensification will be needed." This applies as well to aquaculture. Intensification implies improved technology, improved strains but does not always mean increased amount of inputs. "For practical purposes, intensification occurs when there is an increase in the total volume of agricultural production that results from a higher productivity of inputs, or agricultural production is maintained while certain inputs are decreased" (FAO, 2004). How to enable farmers to intensify and enjoy the benefits of aquaculture and how to minimize and mitigate environmental problems are policy issues that need to be addressed.

Fish for the poor at an affordable price

Fish has always been recognized as a cheap source of animal protein. Countries with low per capita gross domestic product tend to have a higher proportion of fish protein in their animal protein consumption. Although less developed countries are not the biggest consumers of fish, they are the most dependent on it (FAO, 1993; Kent, 1997). The share of fish protein as a proportion of total expenditure on animal protein is higher for lower income groups, and poor people consume mostly low-priced fish. This shows the importance of low-priced fish as a primary source of protein among poor households in developing countries – although in many cases this low-cost fish is derived from inland capture fisheries. When inland capture fisheries decline, aquaculture increasingly makes up for the gap and even starts to fill the increasing demands from increasing populations. This suggests that freshwater aquaculture plays a significant role in the growth in per capita fish consumption and in keeping fish prices stable and at least as likely to be on the table as meat from livestock and poultry.

Growing demand and expanding markets are expected to push fish prices up, hence the need to increase the supply of low-value food fish to keep the price within the reach of the rural and urban poor. Semi-intensive and primary production-based aquaculture (includes culture-based fisheries) of low-value food fish has the potential to be adopted by millions of smallholders in Asian developing countries and is well established in several countries in Asia. It has emerged as an environmentally friendly production system that also supplies large quantities of low-value food fish. However, in the increasingly competitive markets of today, there are strong economic incentives for farmers to shift to higher value fish crops that yield higher profit margins.

As described in Chapter 4, low-income food-deficient countries or net food-importing developing countries that are also significant fish producers are generating large foreign exchange earnings from fish exports that help pay for imports of low-value fish and non-fish food commodities. Thus aquaculture can play a broader role in developing countries, through poverty reduction and food security. In sub-Saharan Africa, for instance, the non-commercial sector in many countries is recognized for its important contribution to household or community livelihoods, while on the other hand, countries such as Madagascar and Mozambique earn substantial foreign exchange from the export of premium quality shrimps.

This multilevel benefit is also recognized in Latin America and the Caribbean region; the countries have identified six main objectives for aquaculture, namely: (a) increase in export-derived income; (b) generation of employment; (c) increase in protein

consumption; (d) better food security; (e) poverty alleviation; and (f) stemming of rural migration. Due to the social and economic conditions in Latin America, aquaculture enterprises tend to place priority on foreign currency and employment generation; however, development of rural aquaculture is more directly related to food security and poverty alleviation. Unlike Asia, the historical development of rural aquaculture in Latin America has not adequately emphasized food security. Indirectly, however, it has had a significant contribution to employment generation (Morales and Morales, 2006).

PHOTO CURTSEY DORIS SOTO

Figure 1 - *Rural aquaculture in Brazil. Culture of introduced tilapia and native tambaqui (Colossoma macropomum) is common in rural areas of northern Brazil. The families working ion sugar cane industry receive additional income through this rural fish farming activity. This small-scale rural aquaculture practice is now expanding.*

In Latin America, extensive and semi-extensive aquaculture and culture-based fisheries contribute to fish consumption in rural areas, and to small-scale local trading. The establishment of intensive or industrial-scale fish, shrimp and mollusc farming in rural and coastal areas has a positive impact in the creation of jobs. Furthermore, the communities' participation through cooperatives and aquaculture associations allow for the development of these areas, guaranteeing the resources that ensure greater food security to their populations. Aquaculture carried out by poor households is for self-consumption and the local market and the species used are tilapia, tambaqui or cachama (*Colossoma macropomum*), carps and catfish (*Ictalurus* spp.) in freshwater and oysters in marine environments.

The Latin America and Caribbean regional review noted the lack of reliable data to enable more definitive conclusions on the contribution of aquaculture in the region's social and economic development. There is a consensus that the activity has generated rural and urban jobs as well as export products, creating income for the countries and maintaining domestic fish supplies, but the degree of investments created by this activity is not well defined, except for countries such as Chile, where precise numbers exist, for example, in jobs created. However, one clear indication of the importance of aquaculture in the coastal rural economy is the fact that, when shrimp farming crashed in Ecuador due to the white spot virus, some half a million jobs were lost and, in 2000, the government had to declare a State of Emergency in the shrimp producing region in order to extend assistance to the workers as well as the growers.

Wealth creation

Fish farming has evidently supported the creation of wealth in many countries. Commercial, industrial aquaculture of course operates as a business with maximizing profits in mind. This scenario is worldwide. There are documented examples of wealth creation or income generation through small-scale aquaculture in developing countries.

An evaluation of freshwater rural aquaculture projects in Bangladesh, Philippines and Thailand by the Asian Development Bank provides good examples of the positive social impacts of aquaculture that include accumulation of capital. Fish farming households in a large district of

PHOTO CURTSEY ROHANA SUBASINGHE

Figure 2 - *Trout farm in Iran. Iran is known for trout and sturgeon aquaculture. Trout farms are located in hilly areas and are fed with running water. The industry is expanding and the number farms are increasing.*

2.5 million people in Bangladesh "overwhelmingly perceived" that: (i) their overall food and fish consumption had improved, (ii) they had gained from employment and cash incomes from fish farming; (iii) the natural resource conditions for fish farming had improved; (iv) they had acquired means to finance fish farming; (v) their housing conditions had improved; (vi) they had gained access to fish farming technology; (vii) there had been an increase in the adoption of fish farming technology; and (viii) their access to credit had improved (ADB, 2004a).

On a national perspective, the last two decades have seen a dramatic increase in inland freshwater aquaculture production in Bangladesh: fish pond production increased from 123 800 tonnes in 1986 to 561 000 tonnes in 2000, and average national yields rose from 840 kg/ha to 2 440 kg/ha. With farmgate prices of farmed fish at about US$0.80/kg (Tk45–50/kg), freshwater aquaculture production contributes to the rural economy about US$700 million/year at farmgate value, or more than US$1 billion annually when post-harvest handling and marketing are included.

Diversification of livelihoods

Aquaculture offers opportunities for diversification of sources of livelihoods and farm enterprises. In sub-Saharan Africa aquaculture, particularly the so-called non-commercial or small-scale subsistence type is one of a variety of enterprises comprising the farming system undertaken to diversify production and income, improve resource use and reduce risks of such events as crop or market failure. It was also pointed out that the underlying motivation of "non-commercial" farmers is often similar to that of commercial farmers: earning income from sale of fish rather than producing fish for own consumption. Examples of aquaculture systems that offer diversification are seaweed culture to supplement artisanal fisheries and even crop farming, culture-based fisheries and integrated farming.

PHOTO CURTSEY SIMON FUNGE-SMITH

Figure 3 - *Kelp farmer in DPR Korea. Kelp is the largest produced seaweed in the world. It is farmed in many countries. Farming seaweeds like kelp is easy and requires little resources, however, generates good income.*

Seaweed is a crop that small-scale and poor coastal fisherfolk in the Philippines can grow as a supplementary or alternative source of income when the catch is poor. The rapid growth of the carageenan refining industry in China with its high demand for *Eucheuma* is fuelling further expansion in seaweed farming in the subregion. The buying price for *Eucheuma* has been going up in the Philippines, and the fisheries bureau has been promoting seaweed farming in more rural fishing communities. Outside Asia, the United Republic of Tanzania provides an example of successful diversification of aquaculture into seaweed.

Another form of aquaculture with a number of positive social impacts is culture-based fisheries. It has been enjoying renewed attention from governments and development agencies for several reasons (NACA/FAO, 2004a). It is mostly a rural artisanal activity catering to rural people, providing an affordable source of protein, employment opportunities and household income. Its added advantage is in being less resource-intensive and less environmentally perturbing. Furthermore, it does not allocate public resources to a few individuals and is therefore more equitable. Culture-based fisheries

can, however, succeed only with the proper institutional framework that recognizes territorial use rights for local inhabitants. One of the major concerns of stock enhancement of inland waters, however, is the possible effects of enhancement on biodiversity. There are two main reasons for this concern: (a) most nations depend wholly or partially on exotic species for stock enhancement; and (b) freshwater fishes are known to be among the most threatened vertebrates. Culture-based fisheries in sub-Saharan Africa offer an enormous potential to enhance fish supply. However, where they do exist they appear to be non-sustainable as governments do not have the resources for regular restocking.

The case for integrated farming draws support from evidence showing that the technological yield frontier has been stagnating with signs of a long-term decline (Sununtar, 1997a). There are also concerns of unforeseen high costs of intensifying aquaculture production in terms of adverse side effects on soil and water quality, human health, food safety and biological diversity. In this regard, attention has been renewed in integrated farming. Integrated aquaculture-agriculture is usually seen as a system to add value to water, recycle energy and farm waste in the system to produce more farm products, intensify the use of land and as an environmentally friendly practice. From the socio-economic, environmental and cultural standpoint it does provide much more benefit than conventional agriculture practices. A study by the Asian Institute of Technology (AIT) (Sununtar, 1997b) in rain-fed ecosystems in Northeast Thailand shows that fish farming integrated with livestock and crops has a highly significant impact on the welfare of farm families.

An economic analysis of a model 5-ha integrated farm carried over a 15-year time frame suggests that if the farmer opted to stay in agriculture, he would be much better off with an integrated farming system. The outcome of the analysis of this model has empirical support from an AIT survey that showed significant improvement in the quality of life of integrated farming households (Sununtar, 1997b).

In many sub-Saharan African countries, aquaculture was introduced at the turn of the century, mainly to satisfy colonial angling needs. Aquaculture for social objectives, such as improved nutrition in rural areas, generation of supplementary income, diversification of activities to reduce risk of crop failures and the creation of employment in rural areas, was introduced mainly during the 1950s, when many of the government fish farming stations were built. Today, in almost all countries, aquaculture is promoted under the relevant Poverty Reduction Strategy papers. This shows that governments throughout the region recognize the potential of the sector for development, in particular for rural development. The regional aquaculture trends review indicated that, in 10 countries of sub-Saharan Africa, there are nearly 110 000 non-commercial farmers[1] (Hecht, 2006).

Around 90 percent of aquaculture operations in these sub-Saharan African countries are rural based and generally referred to as small-scale or subsistence. Most fish farms are owned by individual families. Throughout the region, less than ten percent of ponds are owned by communities or farmer groups, although these are generally poorly managed. The only community-based operations that have worked in general are those where the community collectively develops the basic infrastructure such as roads and canals, but production systems are individually owned and managed.

[1] The African overview referred to "non-commercial" aquaculture as small-scale subsistence, small-scale artisanal or integrated aquaculture and is normally practised by resource poor farmers. Non-commercial producers may also purchase inputs, such as seed and feed, but rely chiefly on family labour and on-farm sale of produce. An additional feature of non-commercial aquaculture is that it is one of a variety of enterprises comprising the farming system; it is undertaken to diversify production and income, improve resource use and reduce risks of such events as crop or market failure. In reality, however, the underlying motivation of "non-commercial" farmers is often similar to that of commercial farmers, i.e. profit is more important than food security

PHOTO CURTSEY MOHAMED HASAN

Figure 4 - *Catch from culture-based fishery in Bangladesh. Stocking in floodplains and harvesting when the water recedes is a common practice in Bangladesh. Generally Indian carps are stocked and the harvest brings substantial income. However, as the land (floodplain) owners and fishers are generally not the same, there is an issue of equity.*

Employment and gender

Employment figures in aquaculture are hard to come by. Most countries do not disaggregate aquaculture from agriculture or from fisheries. But estimates on the total number of workers involved in aquaculture are as high as more than 4.3 million in China and 4.36 million in Bangladesh (if the estimated 1.28 million post-larval and fry collectors are included) (NASO, 2006) and 2.38 million in Indonesia. Most of the other countries in Asia estimate the number of workers directly employed in aquaculture to be at the hundred thousand level of magnitude. The lack of accurate figures implies a lack of appreciation in most countries of the distinct nature of aquaculture as an industry, and this ought to be rectified.

Bangladesh provides a good picture of the diverse employment opportunities from freshwater aquaculture (ADB, 2004b). Apart from direct self-employment opportunities from fish farming, freshwater aquaculture offers diverse livelihood opportunities for operators and employees of hatcheries and seed nurseries, and for seed traders and other intermediaries. Labour is needed for pond construction, repairs and fish harvesting. The total number of people benefiting from direct employment in aquaculture is difficult to estimate because households are rarely engaged full time in fish farming. With as much as 400 000 ha under fish farming, direct, full-time employment may reach more than 800 000 people, assuming a minimum requirement of 2 persons/ha. Most of the work is part time, however, the number of people directly involved is probably much more than 2 million. When related services are included, freshwater aquaculture may benefit 3 million or more people and many more if their dependents were included as indirect household beneficiaries. Much of the employment benefits accrue in rural areas and include the poor. Thus, the contribution of freshwater aquaculture to rural livelihoods is far-reaching in Bangladesh (ADB, 2004b).

Several sub-Saharan African countries provided information on the role of women in fish farming and the data show that women play a minor role in fish production and own or manage approximately 16 percent of the farms (Hecht, 2006). The highest proportion of women fish farmers (30 percent) is in Zambia. All countries commented, though not quantified, on the important role of women in post-harvest activities, and particularly in marketing of the product.

In all countries, non-commercial fish farms are reported to play an important role in contributing towards food security, improved nutrition and rural employment. It was estimated that the non-commercial sector provides between 18 000 to 30 000 occasional jobs per country. Non-commercial aquaculture plays an important role in rural livelihoods, and fish farming families in general are better nourished than non-fish farming families. Cash income from fish ponds contributes to general household costs and living expenses and in most countries non-commercial farmers also use fish for barter and gifts.

Seaweed farming has given many families opportunity for entrepreneurship while commercial shrimp farms offer substantial opportunity for employment. For example, seaweed farms in the United Republic of Tanzania, Mozambique and Madagascar are family-owned businesses and more than 80 percent are owned and/or managed by females. In Mozambique, these farms provide some 2 000 jobs and in the United Republic of Tanzania the industry employs 3 000. Seaweed farmers are reported to earn around US$60 per month. Commercial fish farms in the region are owned by companies and individuals. In several countries, e.g. Zambia, Nigeria, Kenya and Uganda many

of the fish farms are part of larger commercial farming operations. Shrimp farms in Mozambique employ abut 1 500 people and in Madagascar the farms provide 4 325 direct and 30 000 indirect jobs. In the directly employed labour force on shrimp farms, approximately 30 percent are women, whose jobs are in the post-harvest operations or in administration. Some 60 000 people gain temporary employment from aquaculture in Madagascar.

PHOTO CURTSEY DORIS SOTO

Figure 5 - *Salmon farming in large cages in the Reloncavi Estuary, Southern Chile. Chile is the second largest producer of salmon in the world. This industry which is largely based on an introduced species now provides significant income and employment to rural communities in Southern Chile. By 2001, the regional workforce in this region employed by salmon the industry reached 11%, significantly impacting rural employment.*

In Latin America, aquaculture directly employs an estimated 221 500 workers. These include professionals, mid-level technicians, administrative personnel, field labourers, small-scale producers, lake fishers and workers in related activities such as processing plants and feed mills. It is believed that half-a-million are indirectly employed. Of the directly employed, 75 percent are male workers and only 25 percent are female.

In a regional context, aquaculture in Latin America offers employment opportunities to rural populations. However, workers are being gradually affected by decreasing wages, particularly those that fall in the lower wage-bracket categories. Throughout the region, shrimp culture in general continues to offer the vast majority of employment opportunities, both direct and indirect, due to the intense degree of recurring investment. Regarding gender equity, only 5 percent of the jobs are occupied by women. This is also mainly in technical and administrative areas. Regional statistics on the participation of women in aquaculture employment are scarce, but their presence in the workforce is acknowledged to be low. Women are employed mainly in processing plants, where they represent more than 90 percent of the labour force. With regards to subsistence aquaculture, women and children perform various activities such as feeding, sampling and processing.

The contribution of aquaculture to employment in the Eastern European region varies greatly among countries. Although aquaculture does not have a significant role in the overall economy in several countries, fish farms and processing plants provide much-needed employment in rural regions, where work opportunities are otherwise limited or do not exist. The number of people involved in aquaculture production in Eastern Europe is relatively low. Most of the employees have primary or secondary school education but some have only a few years of primary school education. The percentage of employees with higher education is low. The relatively well-trained people are usually the farm managers. A key issue in the development of aquaculture in Eastern Europe is human resources development.

For some countries in Eastern Europe, e.g. Estonia, fisheries are still of significant social, cultural and economic importance. Angling is also an important activity supporting approximately 1 500 companies that provide angling-related services in Poland, where there are 1 million active anglers. Currently, there are 1 200 people working in aquaculture farms in Serbia and Montenegro, of which 85 percent work in Serbia. Aquaculture and fisheries also offer many job opportunities for fishermen in Romania. The primary industry and the upstream and downstream industries offer jobs in several countries, especially where marine fisheries and aquaculture have importance in the economy. Thus processing plants, input suppliers, engineering

companies and transport and trading companies provide employment for local people. Capture-fisheries production, however, has drastically decreased since 1988 and has led to unemployment and poaching. Some of the redundant fishers in Eastern Europe found new jobs in aquaculture.

In Eastern Europe women are poorly represented in the fish farming sector. Only 5-10 percent of all workers in fish farms are women in Bosnia and Herzegovina, Czech Republic and Serbia and Montenegro. The involvement of women in aquaculture is higher in Ukraine, where the share of total employment by women is about 20 percent. Estonia and Russia are somewhat different from other countries as far as the employment of women is concerned. In Estonia, the gender proportions in aquaculture are practically in equilibrium. In Russia, the ratio of women is up to 70 percent of the total staff in some fish breeding farms.

Across the Near East and North Africa, at least 86 400 individuals work in aquaculture, the greatest number of which, approximately 60 000, work in Egypt, the region's largest producer. In some countries, with low production, there may be less than one hundred individuals employed in the aquaculture sector. Within the region, aquaculture offers a diversity of employment opportunities, whether full time, part time or seasonal. Employees may work directly in the aquaculture facilities; in support activities such as feed mills, processing units and distribution; and in ancillary activities such as pond building and construction.

Across the Near East and North Africa region, women form a very small part of the workforce. In the thirteen countries for which gender distribution is known, women in aquaculture are represented in only seven countries. Within two of these seven countries, Egypt and the Syrian Arab Republic, women are commonly employed in aquaculture. Across the region, children form a negligible part of the workforce. Interestingly, shrimp aquaculture in Saudi Arabia and Iran (Islamic Republic of) has also created employment opportunities for thousands of workers from various Asian countries, notably India, Philippines and Thailand.

The two primary aquaculture sectors in North America have evolved in parallel fashion with regard to the consolidation of a number of small farms over time into fewer and more efficient larger operations. This has occurred with channel catfish and salmon, and follows the model observed across the terrestrial agricultural sector. Even in the organic movement, which once held small-farm status as part of its appeal, larger corporations are producing organic crops more efficiently and successfully competing in the marketplace. This evolution towards fewer and more efficient larger operations is driven largely by the need for economies of scale to lower production costs and remain competitive as production increases and aquaculture products make the transition from products to commodities.

PHOTO CURTSEY ZHOU XIAOWEI

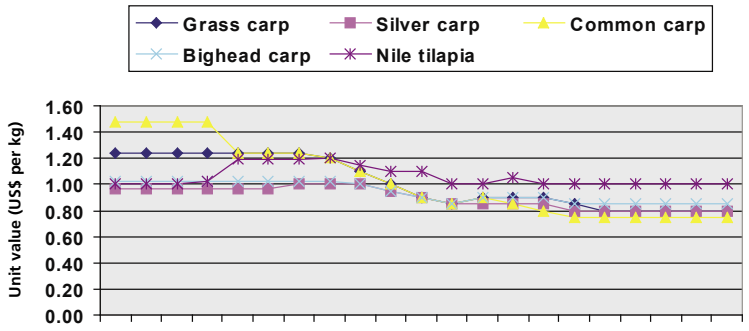
Figure 6 - *Oyster farming in China Xiamen, Fujian province, China. This popular culture practice in Fujian province not only produces a valuable commodity, but also helps to clean the water in the bay. Integrated marine farming which includes fish, molluscs and seaweed has proven to be highly environmentally friendly.*

Women are capable of gainful employment in every sector of the aquaculture industry but are under-represented. There is a gender imbalance in the Canadian aquaculture work force with about 72 percent male and 28 percent female (Mathews, 2004). The situation in the United States of America is likely to be similar, but comparable data are not available.

Food security and better nutrition

The role of aquaculture in food security has been adequately discussed in Chapter 4. However, affordability of fish is central to its accessibility to the poor sector of the society. In general, due to the expansion of both scale and efficiency of aquaculture there has been a downward trend in the unit value of many locally consumed food fish species including cyprinids and tilapia, as has been the case in China (Figure 7). It should be noted, however, that the decline in value as reflected in FAOSTAT 2005 is in terms of United States dollars. In countries where there is depreciation in the currency, the wholesale price may actually show an increasing trend in terms of local currency as is the case in India for various carp species. (Table 1).

FIGURE 7
Trend in the unit value of important food fish species in China



Source: Fishstat 2006

TABLE 1
Wholesale price changes of various carp species (Indian rupees per kilogram) during 1988-1999. (FAO, 2001)

Species/year	1988-89	1993-94	1998-99	% increase between 1988-89 and 1993-94	% increase between 1993-94 and 1998-99
Rohu	15.48	35.93	40.68	132.05	13.22
Catla	15.17	33.54	38.86	121.01	15.87
Mrigal	14.42	33.79	37.43	134.3	10.78
Other minor carps	12.36	31.61	35.49	60.9	12.29

Such downward trend in prices, while beneficial to the consumers in the short term also has its downside. The reduced unit value may not necessarily be attributable to lower production costs but may be due to increased supply. This would mean lower profit margins and would make small-scale operations less viable. When this happens, there will be a greater impetus to shift to high-value species that can return a substantially higher profit margin. This appears to be the case in China where there has been a surge in the production of high-value freshwater species such as mandarin fish, mitten-handed river crabs (*Eriocher sinenses*), river prawns (*Macrobrachium* spp.) and even the Pacific white shrimp (*Penaeus vannamei*). In the Philippines most of the cage and pen grown milkfish are produced by large-scale operators who make up for the low margin by going into large volume production.

PHOTO CURTSEY SIMON FUNGE-SMITH

Figure 8 - *Aerial view of a large milkfish farm in the Kiribati. Philippines is the largest producer of milkfish in the world and the culture of this species requires very little input resources. Some Micronesian states are engaged in milkfish framing not only for food but also as bait fish for tuna fishing industry.*

In South Asia, freshwater aquaculture is likely to continue, primarily for food rather than for cash (purely income generation) although much of the freshwater carp farming in India is market oriented.

The Pacific island nations have increasingly realized the role aquaculture can play to supply fish protein, particularly for inland rural villages where access to fresh fish is limited and lack of electricity does not allow the long-term storage of food. Some parts of the Pacific, particularly the large Melanesian countries are facing a food crisis situation from increasing population pressure, which is leading to poor nutrition and health. Generating another primary food source would help alleviate the reliance on imported processed, i.e. tinned, foods. Aquaculture is also seen as a viable alternative source of essential cash needs (for school fees, social obligations and other expenditure items) and as a back-stop to declining fisheries revenues and is also being integrated into tourism marketing campaigns.

There are examples where aquaculture has helped particularly vulnerable groups. For example, throughout sub-Saharan Africa small-scale fish ponds offer a valuable addition to the integrated farming systems without substantially adding to the labour burden, hence contributing to food security and improved nutrition at the family level. It has also been reported that fish farming may serve as a low labour solution for HIV/AIDS affected households (Bene and Heck, 2005).

IMPACT OF AQUACULTURE ON RURAL COMMUNITIES

Aquaculture development has been credited with stimulating the development of the rural communities in which they are located by direct employment of residents, and the generation of greater economic activity with the establishment of support services Aquaculture development brings with it an infusion of cash to areas which may not merit consideration for other types of industry. Wages for local labour become part of the local economy as they are used to pay for local goods and services. Commercial-scale investment also spurs the government to provide or improve the infrastructure of an isolated area in the form of roads, bridges and often electricity.

The impact is even more pronounced if the farm is locally owned, however small, since income from sales of the harvest become part of the local cash flow. Such is the case in Latin America where, the production centres dedicated to rural or small-scale aquaculture are mostly family owned, carrying out small-scale operations to produce fish for household consumption.

In Eastern European aquaculture, pond fish farming has never been really small-scale in most of the countries. However, there is now a shift towards small-scale operations. Numerous relatively small pond fish farms have been established after the division and privatization of fairly large state-owned pond fish farms in the past ten years. The percentage of state-owned farms is quite low now compared with the total number of farms. Nevertheless, other types of ownership were also established and the form of ownership varies widely, i.e. specialized fish-breeding facilities in Ukraine and Bulgaria are open joint-stock companies, mixed ownership, cooperatives and limited ownerships in some countries; concessions in Hungary, Croatia, Slovakia and Poland; and a relatively large holding (including several pond fish farms) in the Czech Republic that controls a third of marketable fish production in the country (FAO/NACEE, 2006) .

In Southeast Asia, the trend is expansion into open marine waters using sea cages. There are an estimated 1.12 million cage units in China, Malaysia, Thailand, Philippines, Indonesia and Viet Nam producing 550 000 tonnes of finfish, 85 percent of which are marine species. This has contributed to direct employment and ancillary enterprise employment and the development of coastal zones. A sobering lesson could be learned from the experience of DPR Korea, however. While it could have been exacerbated by cheaper imports of mariculture products, the explosive growth in mariculture

– encouraged by government incentives – led to overproduction, lowered the prices of products and caused bankruptcies among coastal farming communities (Bai, 2006).

In some countries, culture-based fisheries have been promoted for rural communities with mixed results. While there are successes, major issues have arisen with social conflicts, leasing and access rights and sustainability and questions over how to manage culture-based fisheries on a sustainable basis (with equitable distribution of benefits).

Bangladesh has a unique seasonal culture-based fisheries. Entire areas cannot be planted to crops during the flood season. Fish are stocked and the floodplains are surrounded by barrier nets so that fish can be caught by local fishermen. However, at the end of the rainy season the area reverts to the exclusive use of their respective owners, so the benefits are not necessarily shared optimally. In China, as well as in Thailand, it is common to have small impoundments managed like a fishpond but with everyone in the community having the fishing (or harvest) rights and is sometimes referred to as community-based aquaculture.

In a number of countries in the Near East and North Africa aquaculture is recognized as providing important opportunities to poor families; for employment and income, and as a source of nutritionally healthy and affordable protein. In Algeria, the national five-year plan for the development of fishery and aquaculture has as a priority: the improvement of living conditions in disadvantaged rural areas, via income and job opportunities from aquaculture. In the Syrian Arab Republic, aquaculture gives higher incomes than other agricultural activities, and thus is economically advantageous in rural areas.

Small-scale operations are actively encouraged in Lebanon, Libyan Arab Jamahiriya, Morocco and the Syrian Arab Republic, for their socio-economic benefits. In Egypt, employment in aquaculture compensates for some of the jobs lost from traditional lagoon fishing.

SOCIAL IMPACTS ARISING FROM ENVIRONMENTAL CHANGE

Environmental impacts of aquaculture development have received a high degree of attention typically where there is a strong element of conflict between resource users. Less well known are the cases of where aquaculture makes a positive contribution to the environment or where it can be used as a means towards reducing the negative impacts.

There are aquaculture systems that contribute to environmental rehabilitation. The most well-known are integrated farming systems. Less well-known is the fact that coastal aquaculture can also contribute to environmental improvement and thus to socio-economic improvement. Examples include: seaweed and mollusc culture, which remove nutrients and organic materials from coastal waters; mixed mangrove systems, which help restore mangrove habitats as in Indonesia and Viet Nam; coral reef fish mariculture, as an effective alternative to destructive fishing in coral reef areas; stock enhancement to rehabilitate fish populations; and aquaculture itself being an effective technique for monitoring environmental status (Kongkeo, 2001). Further examples are also available elsewhere in Asia and other parts of the world (see Chapter 5).

Negative social impacts

A discussion of the negative social impacts of aquaculture necessarily entails the consideration of environmental effects. Conflicts have been known to arise because of the pollution of water resources, blocking of access to the shore by aquaculture installations, salination of crop lands, encroachment, and decline in fish catch due to various aquaculture impacts including fish kills that also affect the wild fisheries and may lead to a reduction in biodiversity.

Food security, ironically, can also be negatively affected by some traditional and modern intensive aquaculture practices such as the use of small fish and trash fish for

fish feed. As one practice depends on small fish for fish feed and the other on high protein diets containing a significant amount of fishmeal, the result is a net loss of fish or protein. The impact is greater on the poor and needy as the market price of the potentially food grade fish is raised due to increasing market demands for them as fish feed (Edwards, 2003. cited in NACA/FAO 2004b). The other negative impact of certain aquaculture practices on food security is the depletion of wild stock because of poor practices in collecting wild seed for culture.

More serious social conflicts have been reported particularly by non-government organizations. These conflicts include violence between crop farmers and shrimp growers, between coastal fishers and shrimp growers, between artisanal fishers and cage and pen culturists, and even between those that want to raise fish in communal village tanks and those that only want the tank for water, and between small farmers and the bigger farmers. Major social conflicts can also arise because of competition for water at the small-scale level in sub-Saharan Africa, particularly between tobacco farmers and fish farmers.

Social impacts of brackishwater shrimp farming on rural fishing and farming communities, although at the time poorly documented, were cited by activists in their petition to the Supreme Court of India to shut down the sector in 1997. In this regard, a study on social impacts of shrimp farming in India (Patil and Krishnan, 1998) is illustrative of the need for good assessments of impacts to serve policy better.

The study by Patil and Krishnan (1998) enabled the government to identify the most pressing problems facing a group of villages and provide a guideline for arriving at a delicate balance between promoting the development of an industry that generates relatively good income and penalizing it for its associated negative impacts. It was able to expose the nature of each social impact and its magnitude to enable the development of effective legislation and other means to regulate shrimp farming impacts. Probably the most common and readily visible environmental impact that leads to negative perception of aquaculture is pollution of waterbodies and in shrimp farming, the salinization of freshwater bodies and crop lands. The principal causes include the poor siting of farms due to improper site selection or, fundamentally, lack of regulations and guidelines on zoning, poor feeds and feeding practices, and lack or weak enforcement of regulations on effluent standards and effluent discharges.

In a study supported by Australian Centre for International Agriculture Researvh (ACIAR) (NACA/DEAKIN/ACIAR, 2003), of three cascade reservoirs in Indonesia, it was found that uncontrolled development of fish cages led to intensified cutting of timber and bamboo in nearby forests which led to more rapid silting and flooding. The increased density of cages, increased stocking and poor feeding practices also led to frequent fish kills affecting even wild fish stock. This in turn resulted in poaching on the cages by poor fishers who had no fish to catch. The study points to the need for a better community-based reservoir management and sound technical advice on fish cage operation.

PHOTO CURTSEY SENA DE SILVA

Figure 9 - *Using trash fish in a marine cage farm in Viet Nam. Use of trashfish to feed marine carnivorous fish such as grouper and seabass is a common practice in Asia. However, this practice has been critisised due to use not only trashfish but also the cheap food grade fish to feed marine fish.*

In other cases conflicts have arisen between farmers and fishers due to escaped fish. An example is the case of salmon farming in Chile where artisanal

fishermen have claimed lower catches, perhaps due to predatory effects of escaped salmon on the wild population. Although fishers like to gain the right to catch escaped salmon, it has been denied by the government due to the lack of an established salmon fishery policy in the country (Soto and Moreno, 2001).

Addressing the social impacts

Addressing the social impacts of aquaculture essentially means addressing sustainability issues, especially as social acceptance is one of the three elements of sustainability. The various strategies to address such impacts are described as below:

Internalizing costs

It has been argued that if blame must be assigned for the adverse impacts of aquaculture, it should be placed not on aquaculture itself but on the way it is undertaken (Anderson and De Silva, 1998). This implies, rightly, that better and more responsible management practices would avoid or mitigate the impacts. Such practices are enforced by legislation or adopted on a voluntary basis; they should have to be based on acceptable science-based standards, and subject to monitoring. Compliance with regulations and adoption of better management practices would necessarily entail cost to aquaculture. Having the aquaculturist shoulder the cost of preventing the farm effluent from polluting the environment is essentially not passing on that cost to society. Furthermore, authorities have averred that adopting such measures as better management practices actually pays for itself (Clay, 2004)

Adoption of better management practices

Adoption of better management practices for shrimp farming under shrimp health management projects in India and Viet Nam resulted in the following:

- India: reduction in disease prevalence by 65 percent, two-fold increase in production, 34 percent increase in size and improvement in quality of shrimps due to non-use of banned chemicals.
- Viet Nam: 1.5 times higher seed production by better managed hatcheries with 30 to 40 percent higher selling price for the fry, higher production and higher probability of making a profit, improved yields that were up to four times higher than non-BMP ponds.

Better yields and profitability apart, and contrary to a number of reservations that better management practices are a technical solution and ignore political and social issues in shrimp farming (Bene, 2005), the projects are providing indications that BMP adoption is not a problem for small-scale farmers that are organized. Being organized has enabled them to attain economy of scale to be able to adhere to best practices. Technical assistance from government is increasing their awareness and organizational capacity and, if not yet marketing skills. There is also the growing awareness that in being organized and responsible, they are in a stronger position to transact with suppliers and buyers. They are not yet participating in a certification and labelling scheme, but that is the next step envisioned for the project, and which the farmers themselves have asked to be initiated. The above projects

PHOTO CURTSEY ARUN PADIYAR

Figure 10 - *A meeting of small-scale cluster shrimp farmers in Andhra Pradesh, India. Recent introduction of better management practices in small-scale shrimp culture in India, in particular Andhra Pradesh, has been successful in reducing disease incidents and increasing culture period and volume ofg production.*

inc

have arguably served to enhance trust and cooperation among the players in the market chain which includes hatchery owners, the farmers and processors and exporters. The basis for this proposition is that the supplier of inputs, the farmer, and the buyer of products stand to gain more from each other by behaving responsibly towards one another than by taking advantage of each other.

While Clay (2004) says that BMPs can pay for themselves, he advocates support for small farmers to make the transition into better management practices, rather than leaving this to the market alone. He thinks the government subsidies in the short term would provide incentives for their adoption, adding that regulatory and permitting systems can also encourage the identification and adoption of these practices.

Integrating aquaculture in rural development plans

There are negative consequences from aquaculture that are not the result of bad practices but are associated with power structures in the community and the capacities of institutions. Among these are the exclusion of the poor from taking part or in being physically removed from aquaculture; resource appropriation by elites and the politically powerful sectors; and conflicts and violence. The negative consequences associated with a weak institutional context include poor linkages; coordination and coherence between sectors; unclear or overlapping mandates; unclear public/private sector responsibilities; uncertainties in tenure, property and user rights; weak regulatory regimes and enforcement capacity, rent seeking; ineffective communication; and underinvolvement of primary stakeholders in policy and programme formulation concerning the sector. Without some form of intervention short-term financial perspectives tend to dominate environmental and social issues (Haylor and Bland, 2006).

In this regard, Haylor and Bland (2001) argue for such interventions to be strategically planned. A generic recommendation is to integrate aquaculture in rural development planning which should come with sound governance, strengthening of institutions including farmer associations, provisions for multistakeholder participation, be people-oriented and with a multisectoral agenda.

Creating opportunities for participation of the poor

Concerns have been expressed that aquaculture interventions have not always directly addressed the needs of the poorest people. Aquaculture, the argument goes, requires resources such as land, ponds, water, credit and other inputs, by definition those involved in aquaculture are not the very poor. In this regard, an FAO/NACA consultation in 2002 collated experiences that clearly demonstrate that if aquaculture is properly planned there are considerable opportunities for poor people's entry (Friend and Funge-Smith, 2002). First, the consultation agreed that aquaculture offers significant advantages over other activities such as livestock and crop farming for the entry of poor people because it entails low-cost technologies using available on-farm inputs, is a low-investment and low-risk activity, requires low labour inputs that fit with household divisions of labour, is easily integrated into other livelihood and farm activities, and low levels of production provide important sources of household nutrition and buffers against shocks.

From experiences and lessons derived from various development projects implemented by governments and civil society organizations in several developing countries (Bangladesh, Cambodia, India, Laos, Nepal, Philippines, Thailand and Viet Nam), the consultation recommended measures for appropriate targeting of poor people, targeting the landless, creating opportunities for the poorer people, targeting the women, strategies for collective action, caution in providing subsidies and gratuities and adopting livelihood approaches.

Few aquaculture development initiatives reach the poorest. When aimed at poverty reduction, development assistance should be targeted carefully by clearly defining the

intended beneficiaries and devising appropriate strategies to help them benefit. The assistance needs to recognize specific and prevalent features of poverty among the intended beneficiaries, including the means of overcoming key barriers for entry into aquaculture and adoption of technologies, and to mitigate risks to which the poor are particularly vulnerable. The ADB (2004b) studies of small-scale freshwater aquaculture in Bangladesh yielded strategies for targeting the small and poor households, as follows:

Access to land and water. Access to land and water is the key requisite for fish farming. Conventional aquaculture development initiatives that emphasize the promotion of technology and provision of targeted extension services are unlikely to reach the functionally landless and the extremely poor. Without access to land and water resource or water area, the poorest are unlikely to engage in fish farming directly. In Latin America and the Caribbean, a region without long tradition of aquaculture, ownership of the land has been one of the obstacles for the development of small-scale family-type aquaculture. The situation varies in different regions of the world.

Access to other livelihood assets. Access to financial and human capital assets is necessary for households to benefit from aquaculture. The ability to pay for pond development and fish farming, including seed and feed, requires financial capital, access to credit, or both. Human capital, in terms of basic education and capacity to learn, is required for people to gain from training and extension services.

Leasing a pond. When the landless gain access to waterbodies or ponds through lease or other access arrangements for fish farming, secure access rights are critical. Eviction is common when access is not secure, and interrupted operation can result in loss of investment that the poor cannot recover from. Demonstrated profitability of fish farming may also increase the lease price of ponds beyond the reach of the landless because of an increasing demand for fishponds. Further, the profitability of fish farming may entice landowners to operate fishponds on their own or through caretaker arrangements.

Pond sharing. With a large number of dependents per family (typically, a family has 5–8 members), land inheritance leads to a multiple ownership of fish ponds, presenting an array of issues related to co-ownership and collective action among shareholders. Cost sharing, benefit distribution and assignment of responsibilities and accountabilities for pond management become difficult leading to underutilization and even abandonment.

Living marginally with risks. Most direct beneficiaries of fish seed and growout technologies in Bangladesh are not the poorest people. Small-scale landholders with fish ponds may have limited assets and may not be categorized as marginally poor or the poorest, but most small-scale landholders are only precariously above the poverty line.

Labour and cash inputs. Some socio-economic constraints remain even for those able to secure access to land or water bodies: several hours of daily labour may be required for food gathering, preparation, and feeding; while returns from fish farming are often highly seasonal. Feed requirements cannot always be met by pond fertilization and collection of feed from the immediate vicinity. Supplementary feed may require cash outlays. Lack of cash and difficulties in accessing credit are major barriers for the poor to undertaking aquaculture on their own. Although labour may be shared and minimized through collective action among farmers, organizational arrangements are not easy to meet.

Theft. Fish pond owners and cage operators often face the threat of poaching. The risk of theft increases when fish ponds or cages are far from farmers' households. Surveillance requires labour inputs for which the returns are not immediate. These constraints have limited the feasibility of fish farming to some extent, especially among households headed by females, who, on their own, are unable to protect their assets against an unfavourable social environment.

Stakeholders' involvement in governance

Ultimately, preventing conflict is the most effective way of addressing social impacts. This brings into focus the concept and practice of stakeholder involvement in policy making, planning and management (Sen, 2001). Stakeholder involvement has arisen out of a new general development model that seeks a different role for the state, which is based on pluralistic structures, political legitimacy and consensus. In aquaculture it is expected to lead to more realistic and effective policies and plans as well as improve their implementation. The reasons for this are that greater information and broader experiences make it easier to develop and implement realistic policies and plans, new initiatives can be embedded into existing legitimate local institutions, there is less opposition and greater political support, local capacities are developed and political interference is minimized.

Enabling the small and poor farmers and aquatic users to have a voice in policy and planning mitigates the inadvertent effect of policies and programmes of marginalizing the poor and weak. This has been a keystone of the Support to Regional Aquatic Resources Management (STREAM)[2] Initiative (established in 2001 as a NACA primary programme element by a multi-agency collaboration that includes FAO, United Kingdom Department for International Development (DFID), NACA and Voluntary Services Overseas (VSO, an international NGO). A growing body of lessons is providing useful guidelines to governments and development organizations for building capacity to support aquaculture and living aquatic resources for rural livelihoods of poor people in the region.

The lessons have included effective ways to organize and strengthen organizations or groups of poor people so that they become partners to government, development agencies and civil society in identifying potentials and developing solutions to improve aquaculture and aquatic resources management. Approaches included rural organization, establishment of one-stop-aqua shops for farmers, application of livelihoods approaches in rural development planning and implementation, improving the capacity of institutions to work towards poverty alleviation, developing local-level institutional models to better serve the objectives of rural farmers and fishers and encouraging the development of policies that respond to the needs and support the objectives of farmers and fishers who are poor, using approaches to giving poor people a voice in policy development, and sharing of better practices appropriate to poor people in rural areas.

Well-defined rights

Finally, while the above refers to a stakeholder role of the state, it also highlights a fundamental role of governance, which is to ensure that basic rights of individuals and the welfare of the public take precedence over that of interest groups. Defining basic rules to impartially arbitrate among potentially conflicting interests may prevent many of the conflicts from arising in the first place. (Bailly & Willmann, 2006). Legislation on integrated coastal area management, defining access rights and limitations to various types of activities, and recognizing basic individual rights such as access to shore or water with specific properties would help private and public promoters of aquaculture development plan their activities with more security and a more informed basis for decisions. Well-defined individual or collective rights act as incentive where those who have rights, either on the side of the aquaculture promoter or on the part of another interested party, can use them for persuasion or can claim them in front of jurisdiction capable of enforcement.

[2] www.enaca.org/stream

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8. Trends and issues

INTRODUCTION

From the studies and the reviews presented in this document, it is clear that aquaculture is developing, expanding and intensifying in almost all regions of the world, except in sub-Saharan Africa. As the global population expands, demand for aquatic food products is expected to increase. Globally, production from capture fisheries has levelled off and most of the main fishing areas have reached their maximum potential. Sustaining fish supplies from capture fisheries will, therefore, not be able to meet the growing global demand for aquatic food.

The current contribution of aquaculture to the world aquatic production in 2004 is about 45.5 million tonnes (excluding aquatic plants). According to FAO projections (FAO, 2002), it is estimated that in order to maintain the current level of per capita consumption, global aquaculture production will need to reach 80 million tonnes by 2050. Aquaculture has the potential to make a significant contribution to this increasing demand for aquatic food in most regions of the world; in order to achieve this, however, the sector (and aqua-farmers) will face significant challenges.

The reviews of regional aquaculture development status and trends confirm that aquaculture is making a significant contribution to global production and that a number of key development trends are taking place. It is apparent that the aquaculture sector continues to intensify and diversify, is continuing to use new species and is modifying its systems and practices. This is being achieved with the growing awareness that the resources upon which it and society in general depend must be used responsibly.

Markets, trade and consumption preferences, strongly influence the growth of the sector, with clear demands for the production of safe and quality products. As a consequence, increasing emphasis is placed on enhanced enforcement of regulations and better governance of the sector. It is increasingly realized that this cannot be achieved without the participation of the producers in the decision-making and regulation process, which has led to efforts to empower farmers and their associations and move towards increasing self-regulation. These factors are all contributing towards improving management of the sector, typically through promoting "better management" practices of producers.

This chapter describes current general global trends in the aquaculture sector, with additional specific focus on trends applicable to individual regions. These trends, both global and regional, have emerged during the regional review process. This chapter also looks at the past trends that have led the aquaculture sector to its current status.

One clear distinction that has emerged during the review process is the disparity between the sub-Saharan Africa region and almost the rest of the world. It is clear that in sub-Saharan Africa aquaculture development has stalled, despite numerous interventions and support programmes by regional and international development agencies and lending institutions. This can be attributed to a number of causes relating to fish consumption preferences, general level of economic development in rural areas, the policy and governance environment and limiting social factors.

In 2003, the second session of the Committee on Fisheries Sub-Committee on Aquaculture convened in Trondheim, Norway, requested FAO to provide a prospective analysis of future challenges in global aquaculture as the basis for deciding the longer term direction of the Sub-Committee's work (FAO, 2003). In response to the Sub-Committee's request, FAO conducted an Expert Workshop in Guangzhou, China, in

March 2006, among other objectives, to bring expert opinion on the future prospects of aquaculture. One of the outputs of this expert workshop is an information document prepared for the third session of the COFI Sub-Committee on Aquaculture, to be held in September 2006 in India[1], entitled: *Prospective analysis of the future aquaculture development: the role of COFI Sub-Committee on Aquaculture* (FAO, 2006a). This document, which will be published later in the year, further extends the scope of the present chapter on status and trends in aquaculture development and provides a vision of how the aquaculture sector will develop and be managed as a responsible global producer of aquatic food in the coming two decades.

GENERAL TRENDS IN GLOBAL AQUACULTURE

This section outlines and combines the general aquaculture development trends documented in the regional reviews with those discussed and verified at the Global Aquaculture Trends Review Expert Workshop held in Guangzhou, China, in March 2006. It must be stated clearly that these trends are particularly relevant and reflect the behaviour of the sector in countries where aquaculture is well established. As Asia contributes to over 90 percent of global production, it is difficult to discuss global aquaculture without having a bias towards Asia; these general trends may not necessarily reflect the overall scenario in some other regions, e.g. sub-Saharan Africa.

Continuing intensification of aquaculture production

Various factors are driving the aquaculture sector to intensify. The main driving force appears to be the unavailability of sites. As the availability of sites for aquaculture is becoming increasingly limited and the ability to exploit non-agricultural land is restricted, along with economic drivers, the aquaculture production systems are being increasingly intensified.

Intensification may sustain profitability of farming operations, but this comes at a cost. There are management issues (water and health in particular) associated with intensification and the environmental carrying capacity and regulatory concerns that relate to increased numbers or intensity of farms.

Not all farmers are able to intensify and, as production costs rise, part of the sector may reduce intensity to lower costs or reduce vulnerability to health or environmental problems.

Under appropriate circumstances, there are opportunities for organic aquaculture to play a role and this may become an economically viable form of management.

The sector continuously looks for novel ways to use land and water environments for production. The exploration of new systems not only requires identification of suitable areas, but also needs to use tools such as surveys, studies of carrying capacity; water quality monitoring and Geographical Information Systems (GIS), remote sensing and mapping.

As intensification proceeds, the need for institutional support, services and skilled persons are also in the increase; the need for more knowledge-based aquaculture is clearly increasing and education and training in aquaculture has regained or is regaining its importance worldwide.

Continuing diversification of species use

Aquaculture continues to explore new species options, particularly high-value species, in regions and countries where aquaculture is well established. While facilities for mariculture of high-value species have increased, reduction in facilities for the production of low-value high-volume species such as cyprinids is evident in

[1] http://www.fao.org/fi/NEMS/events/detail_event.asp?event_id=32029

those countries (particularly China). In the future, however, reduction in freshwater aquaculture areas may be offset partly by expansion in marine areas particularly for the culture of relatively higher-value species.

Regions and countries where aquaculture is still in its early stages; particularly Africa and some South Asian countries, freshwater species production is still continuing. In some South Asian countries better opportunities for giant freshwater prawn, *Macrobrachium rosenbergii,* are visible.

The development of indigenous species production for enhancement or restocking is continuing and might be promoted in the future as a means for improving livelihoods for people that rely on fisheries. It is also evident that the use of indigenous species has reduced the disease risks involved in, and has provided more stability to, aquaculture production. Seed production of indigenous species are continuing in support of stock enhancement programmes of inland waters, which are increasingly looking towards the use of indigenous species as concern and awareness over biodiversity issues increase.

Countries are continuing to introduce species or strains for aquaculture, while efforts are made to develop specific strains for aquaculture, particularly the high-value species. Although countries are endeavouring to comply with international norms and standards for the movement and introduction of live aquatic organisms, commercially driven movements and introductions that are not responsible are also evident in many regions of the world.

In the shrimp farming sector, effort has redoubled to attain the capability to locally commercialize the production of specific pathogen free (SPF) and specific pathogen resistant (SPR) broodstocks of a number of species (*Penaeus vannamei, P. chinensis* and *P. monodon).*

Import risk analysis is increasingly becoming a standard tool for ensuring responsible movement and introduction of species and strains for aquaculture. There is a need for significant capacity building and training to mainstream its use and ensure its application. However, as a consequence to increasing concerns over impacts of introductions, there will be stricter regulations on the import of new species.

Continuing diversification of production systems and practices

As some traditional agricultural systems become increasingly uneconomic there has been a trend to promote or enable diversification. This may take the form of conversion from agriculture to aquaculture (e.g. rice land for aquaculture) or the integration of aquaculture into existing farming systems. People enter into such diversification to increase their earning capacity, without giving up their primary occupation as farmers. Further, secondary use of waterbodies for aquaculture is also increasing in Asia and Latin America, as a diversification in the use of water-bodies. This is becoming more viable in many countries as fish seed is now more widely available at affordable prices.

A critical feature of ensuring longer-term investment in sustainable aquaculture practices and avoidance of short-term environmentally damaging practices is the existence of farmer-friendly tenure systems. Increased terms of lease are often required and specific zoning of areas (e.g. mariculture parks) can provide an enabling environment for investment in aquaculture. Subsequent spin-off effects of employment and service sector opportunities may also accompany this. There is some evidence of such trends in some countries (China and countries of Southeast Asia); however, this trend will continue to expand into more countries and regions in years to come.

New systems require the development and dissemination of seed production technology (particularly the development of marine hatchery systems) and broodstock management for key species.

Appropriate infrastructure and services such as land-based handling and processing facilities (landing and holding facilities, transport and cold chains) and efficient

connections to markets are essential for success and countries are making improvements on these facilities and services.

Polyculture or integrated culture (particularly in marine systems) offers a means for diversifying products from a system, improving efficiency of resource use and reducing the negative environmental impacts. Although this has been a traditional practice in Asian freshwaters, as well as in coastal waters, particularly in China, there is need for more research and technology transfer on marine mixed plant/animal systems where such systems are less well developed.

Increasing influence of markets, trade and consumers

There is a trend of increasing fish consumption in many countries (although apparent consumption data [FAO, 2006b] shows a decrease in per capita consumption in many countries in sub-Saharan Africa) and this domestic and regional demand competes with export markets, particularly in Asia. Producers and processors are slowly moving towards greater value adding and development of processed products for export markets as an avenue for increasing foreign exchange earnings and improving profitability. In such circumstances, the choice of species for farmers is becoming geared to the demand for products in the international markets. Moreover, there is a trend towards targeting urban markets with standardized, value-added "easy-to-cook" or "supermarket-type" products.

New markets are continuing to develop and domestic demands are increasing in many countries, especially in Asia (e.g. China).

With more stringent demands of export markets, small-scale operators are facing increasing difficulties producing products for export. There is evidence that some small operators are leaving the sector as they become uncompetitive and unprofitable. A strategy to offset this is the formation of producer associations, which has demonstrated positive results in countries such an India and Viet Nam.

For some export commodities, exporting countries are looking at quota systems or mutual agreements on limiting production volumes in order to avoid destabilizing market prices.

There is a need to build capacity within the regions to enable countries and farmer groups to become capable of initiating or accessing market information and research, in particular, for the species targeting non-domestic markets. Processing and product diversification are developing in response to better market information.

There is a greater concern on the wholesomeness of aquaculture products and on making aquaculture operations environmentally benign.

The international and national demand for safe and higher quality aquatic products is increasing and there is a clear need to improve product quality and safety. There are improvements in cold chains and control systems for ensuring product quality and safety and more emphasis will undoubtedly be put in place for these aspects in coming years.

There is a clear trend towards development and implementation of safety and quality standards. In the last decade, greater emphasis was placed on better aquatic animal health management and food safety following public concerns and reports of contaminants in fish products in all regions of the world. Initiatives have been taken by the European Union to ensure that the benefits are translated in a harmonized manner across the Western European region and beyond. The use of antibiotics has declined significantly in the last decade in Europe and Latin America following the widespread use of vaccines in the salmon and bass and bream industries. Similarly, the stringent export regulations such as minimal residue levels for banned antibiotics and veterinary drugs have reduced the reliance on antibiotics in shrimp aquaculture in Asia and Latin America.

There is a growing trend towards the ecolabelling of aquatic products. FAO's guidelines for ecolabelling of capture fishery products are now in place, although

the same for aquaculture products are yet to be developed. Ecolabelling is often considered as no more than a marketing tool. However, with the increasing concern on environmental issues among the consumers worldwide, products that are grown in a responsible manner without harm to the environment are gaining a competitive edge particularly in the developed countries.

Enhancing regulation and improving governance of the sector

Aquaculture is maturing as a responsible sector and emphasis on better enforcement of existing legislation is becoming apparent. As enforcement of law is a continuing constraint in many countries, strong emphasis is being placed on increasing self-regulation by farmer associations and the sector in general. There is a general trend towards improving governance in aquaculture development and management.

As aquaculture often co-exists with agriculture in inland areas and with coastal and wetland natural resources elsewhere, there is a trend towards more integrated land use planning and registration of farms for aquaculture. This requires the establishment of farmer friendly tenure systems and appropriate environmental planning (e.g. land-use surveys and development of specific zoning, e.g. aquaculture zones), which is slowly gaining recognition.

It is clear that in some countries there is need to develop specific aquaculture legislation to better regulate the sector. The increasing requirement for traceability and certification is now leading towards adoption of mandatory registration of aquaculture facilities as part of national legislation.

Many countries are developing and implementing regulations on the use of antimicrobials, veterinary drugs and chemicals in aquaculture. Monitoring and surveillance programmes are also being established in some countries as a measure to reduce production losses from emerging diseases.

As an essential part of self-regulation of the sector, there will be further development of codes of practice and better management practices (BMPs) in collaboration with farmers. This also requires appropriate mechanisms for dissemination and communication of codes of practice through farmer organizations.

Aquaculture does not exist in isolation and increased regulation of the sector also requires that its external effects to be moderated. Against a trend of increasing intensification and increasing numbers of farms in some areas, there is a requirement for environmental impact assessment and routine environmental monitoring. Increasingly, there will be requirements for aquaculture to "pay the real cost"; for the environmental services that it utilizes. Mechanisms such as "polluter pays" and "resource rents" (user pays) will be put in place. This requires improved capacity for monitoring and concurrent development of laboratory infrastructure and capacity building within the competent agency or organization.

Effective regulation is only possible with an effective information system. This requires improved quality of aquaculture information and statistics. The types of information collected should be targeted at specific needs for management of the sector and there will be a concurrent need for information management systems that enable use of the information for local management and not be over centralized.

Drive towards better management of the aquaculture sector

In many countries, instead of high yield per unit area, aquaculture is now aiming more on economic sustainability and overall competitiveness. One of the key areas considered is the improved management of health. As pathogens and diseases are causing significant losses in global aquaculture, the sector is now giving strong emphasis to reducing the mortalities and losses due to diseases. This trend does not only focus on production and practice, but also the issue of acquiring quality inputs such as clean seed and quality feed, and sound advice to reduce risks of production failures.

The combined effect of all these trends is to drive the sector towards improved or better management. This is seen at the individual farm level as well as specific subsectoral levels. It has not occurred simultaneously throughout the aquaculture sector worldwide although, in the future, it will materialize as different pressures are applied (regulatory, market, environmental or social etc.).

SPECIFIC TRENDS IN GLOBAL AQUACULTURE

Besides the six general trends mentioned above, global aquaculture has shown some specific trends in addressing environmental and resource-use issues, responding to markets and trade, resolving social problems, improving economic performance, supporting poverty alleviation and food security, and strengthening national institutional, legal and policy frameworks.

Environment and resource use

Competition for land and water. Competition for land and water is leading to a higher degree of integration of agriculture and aquaculture, at least in Asia and Latin America. In Central and Eastern Europe, historically fish ponds were built on areas with poor soil conditions therefore competition with agriculture is not a major issue, especially not in the former Soviet Union countries, where land areas are being withdrawn from cultivation. There are opportunities for the integration of aquaculture with other human activities, which are based on adding value to utilization of water resources used for irrigation and recreation.

High energy costs. Similarly, increasing energy costs are leading not only, as expected, to finding low-cost energy sources but also to developing strategies and practices to reduce energy requirements (e.g. reduction in stocking density, aerator placements and changes in water exchange practices). In certain culture practices, energy cost for pumping could be minimized with the combined use of bio-remediation and low discharge or even zero discharge techniques, however, more research is required. The technology to use farm wastes from integrated farming to generate bio-energy is receiving renewed attention.

Continued reliance on fishmeal. Will the search for alternatives eventually result in greatly minimized requirement? Although the use of fish protein has been reduced through the use of proteins from terrestrial animals or vegetables there are limits to the level that non-fish proteins can be used. On the other hand, reduction of fish oil in aquatic animal diets is much more of a challenge. Even with reduced per unit usage, total requirement of fishmeal and fish oil is still growing with increased production levels and its availability and price will probably be one of the major constrains to the growth of the aquaculture sector.

Biosecurity. Countries continue to introduce species or strains for aquaculture. This will also be accompanied by the development of specific strains. Commercially driven, private-sector initiatives of unregulated introductions and transfers are evident in many parts of the world. However, at least in some countries, the mechanisms for introduction are becoming more stringent and Import risk assessment (IRA) is becoming increasingly a standard tool for ensuring responsible movement and introduction of species and strains for aquaculture. Significant capacity building and training is required to mainstream the use of IRA and ensure its effective application.

Genetic improvement and domestication. Improving aquaculture production demands genetic resource management of farmed aquatic species, including indigenous species and new species for development. Considerable improvements have been made to domesticate and improve key species through a variety of genetic improvement strategies including selective breeding, hybridization, chromosome-set manipulation and advanced genetic engineering technologies. Major species-groups that have been genetically improved include, *inter alia*, tilapia, carps, salmon, trout, oysters and catfish.

Important traits for genetic improvement include growth rate, conversion efficiency, environmental tolerances, disease resistance and body shape. Recent progress has been made in the domestication and genetic improvement of marine fishes and crustaceans.

Environmental management. Aquaculture has continued to attract largely unsubstantiated negative publicity as an environmental polluter. The output of nitrates and phosphates from aquaculture is considered insignificant in terms of contributing to nutrient loading in most regions of the world but may have local impacts on eutrophication and algal blooms. Great strides have been made in the last decade in mitigating nutrient and organic inputs from aquaculture. Notable advances and innovation in automated feeding technology has significantly reduced feed input whilst maintaining productivity and improving economic efficiency. These developments were strengthened by the increased use of fallowing by farmers. Such improvements have been particularly noticeable for some commodities such as salmon.

Most Latin American and Caribbean countries do not seem to have adequate national aquaculture plans and policies to guide the overall development and management of the sector; thus development has been mainly determined by the private sector and the requirements of international markets. Equally, there are numerous shortcomings in the control and surveillance to enforce environmental regulations, a case in point being the initial destruction of mangroves caused by the shrimp farming industry in several countries in Asia and Latin America that fortunately now has been largely rectified by improved awareness and better aquaculture siting and planning practices.

Markets and trade

With the emergence of application of stringent product export standards, particularly aiming at improving food safety, it is evident that the capability of the different countries to analyse for "contaminants" or "residues" at the level of precision required by the importing countries is lacking. These include antibiotics, pesticides and heavy metals. Further, the capability of each country to apply HACCP concepts in the production systems, as a precursor for addressing much needed traceability, is also questionable. While not having adequate capacity to address the issue, the countries are still facing difficulty in adopting harmonized standard for aquaculture products, whether for export or for domestic consumption. Although there are attempts to harmonize standards, at least by regional or economic/political grouping basis, it is difficult to predict how long it will take to develop globally harmonized standards, if at all possible.

The trade in aquaculture products and species for non-food uses is also increasing. This includes aquatic species of significant economic importance, particularly the ornamental species, now being cultured in many countries in the world, and being considered by many new entrants to the aquaculture industry.

Social impacts, employment and poverty reduction

From the socio-economic point of view, aquaculture has had an important impact on the economy of rural and less-privileged communities throughout the different regions, having created opportunities for employment and contributed to the available food. However, quantification of this impact is extremely difficult due to lack of adequate reliable data.

Institutions to support responsible development of aquaculture

It is increasingly clear that effective institutions are an essential requirement for the responsible development of aquaculture. Public and private-sector institutions at local, national, regional and international levels continue to develop.

Most governments are promoting responsible aquaculture using different approaches and strategies. The development and promotion of codes of practice, better management

practices, certification systems and standards are taking place, although at a slower pace, and are strengthening and empowering farmers.

Effective policies, legal frameworks and institutions are being created as they are necessary prerequisites for the development of aquaculture; however, in some countries, the enabling policies are still absent, obscure or complicated, thus hindering aquaculture. Some key challenges the aquaculture sector in any one country may have to confront are a lack of coordination between the multiple agencies that share regulatory responsibility, legislation that may not be in harmony with present and future status of the industry and with other related legislation, and unclear or conflicting priorities within the policy-making and regulatory spheres.

Farmers' organizations, civil society, and consumers' associations as well as institutional buyers such as the supermarket chains and other key stakeholder groups are beginning to exert stronger influence on policies and regulations, but are also actively promoting the development of standards and codes that aim at ensuring an environmentally and socially responsible aquaculture sector.

MAJOR REGIONAL AQUACULTURE DEVELOPMENT TRENDS

This section describes some major regional aquaculture development trends besides the general trends outlined earlier in this chapter. These specific regional trends have been derived from the regional aquaculture development status and trends analyses conducted by FAO during 2005 (See Chapter 1, Introduction).

Asia and the Pacific

Most countries in the region have policies strongly supportive of aquaculture development. In Australia, for example, the industry set itself a vision at a National Aquaculture Workshop held in Canberra in August 1999, which stated that by 2010 a vibrant and rapidly growing Australian aquaculture industry will achieve US$2.5 billion in annual sales by being the world's most efficient aquaculture producer.

There is a general trend in East Asia including China to expand to new species for culture particularly for premium species. The phenomenal growth of the river crab, mandarin fish, cobia and turbot in China are indications of such a trend. In the Republic of Korea, there has been a great increase in production of high-value fish species, such as olive flounder and black rockfish during the last few years and a new interest in culturing penaeid shrimps. The vision of the Republic of Korea is a restructured aquaculture industry with an optimal production system and enhanced competitiveness.

Reduction in its facilities for producing high-volume species such as cyprinids can be expected in China, perhaps not deliberately as in the Republic of Korea. However, reduction in freshwater aquaculture areas may partly be offset by expansion in marine areas particularly for the culture of relatively higher-value species.

There is a greater concern on the wholesomeness of aquaculture products and on making aquaculture operations environmentally benign. Furthermore, instead of high yield per unit area aquaculture in the East Asian subregion is now aiming more at efficiency, cost efficiency and competitiveness.

In shrimp farming there will be redoubled effort to have the capability to locally commercialize the production of SPF and SPR broodstock of *Penaeus vannamei, P. chinensis,* and *P. monodon*.

Of the countries making up South Asia, Nepal and Bhutan are completely landlocked and have the least developed aquaculture. The subregional trend therefore does not apply to Nepal and Bhutan where the main concern is to increase aquaculture activities and intensify existing operation. Elsewhere, freshwater aquaculture is likely to continue, grow and diversify. The culture of the giant freshwater prawn may increase as interest picks up.

In brackishwater aquaculture, the ambivalence towards shrimp farming continues in the sense that its contribution to the economy is recognized even as its negative effects on the environment, actual or perceived, are decried. Such situations will continue to lead to the adoption of environmentally friendly technologies such as zero discharge or low water exchange systems. Thus the use of bio-remediation in shrimp culture may increase and become a standard practice.

The infatuation with shrimps in South and Southeast Asia is likely to continue. This time the object is wholesomeness (safety and quality) and efficiency rather than just high-volume production. The region will have to come to terms with *P. vannamei* as at the moment only India and the Philippines have held out against its legalization although the Philippines is initiating steps to lift the ban on its culture. With the continued inability of the United States of America-based suppliers of broodstock to supply the massive number of SPF brood animals required, many of the hatcheries in the region are forced to use locally grown second or third generation stock. This will persist until a local capability to commercially produce SPF stock is established. Meanwhile, SPF broodstock producers, particularly from the United States, are now beginning to set up operations in a number of countries in the region.

The current focus of interest in Asia is the domestication of native penaeid shrimp species particularly *P. monodon*. Work is ongoing in many countries in Asia. Simultaneously, the major *P. vannamei* producing countries such as China, Thailand and Indonesia are developing local capability to produce their own SPF breeding stock. On a smaller scale there is also ongoing work on genetic improvement of the giant freshwater prawn, *Macrobrachium rosenbergii,* through collaborative work between Indonesia, Philippines and Thailand.

The growing scarcity of high health *P. monodon* broodstock that was one of the precursors for embracing *P. vannamei* has driven the various countries in the subregion finally to follow the lead of Thailand in giving high priority to broodstock development of the native species. Developing a captive breeding stock of *P. monodon* had not been a high priority in Indonesia, Malaysia and Philippines since wild-caught broodstock that are healthy enough had been readily available. Once high-health captive *P. monodon* breeding stock becomes commercialized and consistent in quality, many farms in Southeast Asia will likely revert to the native species. But the species is not likely to become the predominant species of choice again. Instead, the species mix will likely be shaped by the market and relative competitiveness.

There is a trend towards expansion into open marine waters using sea cages as is in the Philippines, but the growth of such development is unlikely to be high. In the Philippines, marine cages are attractive because of the high local demand for milkfish. Elsewhere interest for sea cages is more for the higher-value species such as grouper. This is especially so in China, Viet Nam, Malaysia, Thailand and Indonesia.

The rapid growth of the carageenan refining industry in China with its high demand for *Eucheuma* will fuel further expansion in seaweed farming in Southeast Asia. Chinese processors are driving farmgate prices for dried *Eucheuma* to record levels in the Philippines.

Expansion into marine waters for the production of food fish is taking place as competition for land and water becomes more acute. Aquaculture as a source of food rather than income is more related to freshwater aquaculture with the exception of the Philippines where the most important food fish species, i.e. milkfish is produced primarily in brackishwater and efforts are underway to produce a fast-growing saltwater-tolerant strain of tilapia. While the red strain of tilapia is known to be salt tolerant, this is not well accepted in the local Philippine market.

Aquaculture in the Pacific is undergoing a state of rejuvenation with the emergence of significant commercial activity and commodities suitable for rural development. Many governments lack the strategic framework required for aquaculture development.

Policies, legislation and strategic planning have not been properly addressed. Many failures in the past of government or private sector ventures have been attributed to poor economic and financial planning, leading to non-profitable scales of investment or unrealistic market expectations.

The Pacific label as a pristine and clean green image could be a marketing drawcard. There are successful examples. The marine ornamental trade also has the potential to increase its benefits from proper use of labelling and certification, and with operators employing ecologically sustainable techniques. Examples of sustainable practices being pilot-tested include pre-settlement larval capture systems and tending of coral gardens. Cultured black pearl requires a significant investment in marketing. There is a trend in some countries towards integrating this effort with their national tourism marketing campaign.

There is an increasing realization of the role aquaculture can play to supply fish protein, particularly for inland rural villages where access to fresh fish is limited and lack of electricity does not allow the long-term storage of food. Some parts of the Pacific, particularly the large Melanesian countries are facing a food crisis situation from increasing population pressure, which is leading to poor nutrition and health. Generating another primary food source would help alleviate the reliance on imported processed, i.e. tinned foods. Aquaculture is increasingly seen as a viable alternative source of essential cash needs (for school fees, social obligations and other expenditure items) and as a back-stop to declining fisheries revenues.

Drawing on indigenous farming practices and indigenous resources will be important to developing aquaculture appropriate to local needs and scales, in particular to addressing subsistence and semi-commercial needs, and extensive and small-scale farming. For example the region is trialing integrated freshwater shrimp with swamp "dalo" farming.

Biosecurity will become a key issue. Because the Pacific does not have a tradition of aquaculture there are few domesticated species that the region can draw on, and the introduction of new genetic material and translocation of species will be an integral aspect of the development efforts in aquaculture. Bearing in mind the high regard for biodiversity in the region there is a strong need for responsible practices. Addressing biosecurity will involve cross-sectional approaches, for example fisheries, quarantine, and veterinary and environment agencies.

Central and Eastern Europe

There is a long history of freshwater aquaculture, which is still based on the use of traditional methods and equipment with the dominant technology being extensive and semi-intensive polyculture carp-based production in ponds, although there are regions where other species play a dominant role (e.g. sturgeon, salmonids and whitefish).

There was a drop in aquaculture production in this region after the political and economical changes in the early nineties, which was followed by a slow increase after the stabilization of the sector. However, the production level in 2003 was still below that of 1993 and was only about 50 percent of the peak production level of 1990.

The low exploitation of marine resources is clearly indicated by the low marine aquaculture production per 1 km length of coastline in Eastern Europe, while the utilization of the Annual renewable water resources (ARWR) for freshwater aquaculture production is about the same in both subregions.

It appears that the development of marine aquaculture in the future has a better potential in Eastern Europe, even if the differences in geographic and climatic conditions between Eastern and Western Europe (where marine aquaculture is well established) are taken into account.

Market has been the driving force of aquaculture development in Eastern Europe since the early nineties, however, market orientation of some farms is slow and

aquaculture development is highly dependent on the overall economic situation and political decisions in a given country.

The post-harvest sector is relatively undeveloped, although there have been some positive changes recently. The sector continues to be dependent on supply of good quality seed and feed; economic efficiency in the use of these resources must be considered for all systems, including intensive and potential "organic" farming.

Marine and brackishwater production is very limited and about 70 percent of the production is from Croatia, where tuna production shows significant growth.

Aquaculture will remain an important supplier of healthful food for local populations; however, export production (especially niche market segments) will offer new opportunities. Local production is unlikely to satisfy the increasing demand for fish and seafood in the foreseeable future.

While aquaculture continues to be a significant contributor to rural development (especially through various forms of pond fish farming), it will play an important role in the recovery of species diversity in natural waterbodies.

There is some scope for marine aquaculture development in some countries where good conditions are available. Appropriate research, technology development and investment will become major requirements.

Human resources management (including language training) is a vital component of aquaculture development in the region, better collaboration among farmers, and between science and practice at national and international levels will become vital to regional aquaculture development.

Latin America and the Caribbean

With the development of new technologies and better management of the production systems, efficient production has been attained in spite of the disease problems that have affected shrimp aquaculture in several countries. Salmon aquaculture has strived to a high level of production.

As an activity truly led by the private sector and supported with technical and scientific support by the public sector, aquaculture has achieved a relatively important role in the economic development of most countries of the region, in particular Brazil, Chile, Ecuador and Mexico.

Rural aquaculture in Latin America is still largely dependent on state or international technical and financial support schemes. As this sector is very valuable in the overall improvement of rural life and alleviating poverty, alternative strategies must be sought to enhance rural aquaculture.

The aquaculture sector supports and employs a significant number of people: professionals, mid-level technicians, field operators, producers, fishermen and service providers. However, the actual impacts of employment are yet to be quantified.

Chile appears to be continuing to increase its salmon production to become the world leader while Brazil is likely to produce a lion's share of shrimp and freshwater aquaculture in the region in the foreseeable future. Other countries will also increase their production, diversify species and expand the sector in the years to come.

The species that are most widely cultured in the region are: salmonids, marine shrimp and tilapia. However, during the last 10 years, there have been important increments in the production of other groups of species such as seaweeds, molluscs, caracids and catfish.

Near East and North Africa

Across the region, aquaculture is expected to grow; in some countries this growth is expected to be significant. Beyond this, there are no universal trends in changes in aquaculture, since the individual combination of geophysical, economic and social factors in each country affects the farming systems that are practised at present, and can be developed in future.

When the region is considered as a whole, three trends in aquaculture are apparent, although it should be emphasized that each does not apply across the region. The three main trends in food fish production are; (a) increased culture of marine species, (b) intensification of aquaculture, and (c) more integrated agriculture-aquaculture. The main trend in non-food aquatic species is towards production of ornamentals.

Within marine species, both diversification and intensification are anticipated, driven by such forces as successful research by government laboratories providing technical knowledge and stock, availability of private investment and potential export markets. Intensification is mainly driven by such forces as limited availability of land and water.

Marine aquaculture of finfish and crustaceans has been increasing in the region, and the increase is expected to continue. Furthermore, several countries (Bahrain and Oman which are emerging regional producer countries and Saudi Arabia, a more established regional aquaculture producer) have identified increased mariculture as a specific goal. Bahrain will focus on production of juveniles of marine fish for sale, release and semi-commercial mariculture activities, and Oman and Saudi Arabia will concentrate on producing marine shrimp. Other mariculture trends of note are the development of marine cage culture in Iran (Islamic Republic of), production of fingerling gilthead seabream in Kuwait (for export within the region), and tuna fattening in Oman. In Tunisia, the trend towards increased diversification of marine species including bivalves, octopus, shrimp and tuna is, in part, influenced by European markets.

Within the last ten years, many countries in the Near East and North Africa region have imported new non-endemic aquatic species, particularly finfish, which are either already established as an integral part of aquaculture production, or are being studied as potential aquaculture species. Six of these newly introduced species are already contributing significantly to aquaculture production at the national level in some countries (e.g. gilthead seabream, tilapia, European seabass, meager, penaeid shrimp and European crayfish).

The common factor driving the growth of aquaculture across the region has been, and probably will continue to be, the need to increase the domestic food supply, partly because the wild catch may be unstable or falling. Other forces include the need to increase export revenues, and support of socio-economic programmes via provision of employment and affordable nutrition in poor regions. From within the sector, technical and organization progress and improvements in infrastructure, are also important driving forces.

Successful and sustainable development of aquaculture can be limited by a wide variety of factors in North Africa and the Near East. Some of these are beyond the control of the sector, such as civil war and drought which have directly affected Lebanon and Iraq in the last decade. Other factors can be influenced, in a limited way, such as land and water availability, or more extensively, such as technical challenges, underdeveloped markets, poor disease monitoring and control, complex administrative procedures and scarce funding (from bank credits, subsidies or investment) and inadequate training and research.

Successfully addressing four key priority issues is essential for the continued growth of aquaculture in North Africa and the Near East: i) farming systems, technologies and species; ii) marketing and processing; iii) health and diseases; and iv) policies, legal frameworks, institutions and investment. While there is a consensus among countries in the region about the importance of these issues, the relative importance of each of the four issues will vary from country to country, dependent largely on the state of development of the aquaculture sector in individual countries (developing or developed).

Limited availability of suitable sites for new aquaculture activities is a common problem in the region, and may be manifested as shortage of land, insufficient

freshwater, insufficient tidal fluctuation for land-based marine and brackishwater aquaculture, and few marine sites suitable for existing systems. Further challenges for some countries, particularly those with a developing aquaculture sector, is adequate supply of finfish fry/seeds and shellfish spat, and reliance on imported aquafeed. Research and technology transfer between countries in the Near East and North Africa are seen as key solutions to developing suitable new technologies that can be adopted for use in the remaining available sites, particularly those in the marine environment. Emphasis will need to be placed on finding systems that are suitable for the specific geographic locations and level of technology available.

In the Near East, interest in producing shrimps will continue to be high in the subregion. But the constant threat of diseases is also driving the leading producing countries such as Saudi Arabia, Oman and Iran (Islamic Republic of) to look into alternative species. In Iran some shrimp producers are looking into *P. vannamei* as an alternative to *P. indicus*. How this develops will depend both upon government policy and how well the species fares in the high salinity environment and harsh climate.

Already the subregion (Near East) is no longer totally dependent on wild-caught broodstock of *P. indicus* since breeding stock of the species can readily be grown in ponds. The practice now is to merely use unselected first generation breeders. There will be high interest in moving on towards a breeding programme similar to that now happening in Southeast Asia.

The subregion is also looking into the culture of various marine finfish species such as grouper, seabream and seabass as alternative species. Saudi Arabia, Iran (Islamic Republic of) and United Arab Emirates are already developing capability to propagate marine finfish and pursuing the recruitment of experienced people from Southeast Asia and training of their own nationals. European fish cage manufacturers and suppliers are making some inroads in the region.

North America

Aquaculture in North America over the past decade has grown at an average annual rate of 4.3 percent and in 2003 produced only 1.6 percent of global aquaculture output representing 2.7 percent of total value in 2003.

One noteworthy product of the North American aquaculture industry is the SPF and SPR broodstock of *P. vannamei* and to a much lesser extent *P. stylirostris.* Without the commercial availability of these selected strains the shrimp industry in China and Southeast Asia would have been hard put to recover from disease outbreaks and the lack of healthy natural broodstock with their consequent effects on the global supply and price of shrimps.

Aquaculture expansion is supported by the governments of both Canada and the United States but considerable public opposition has been generated over environmental concerns. These concerns centre on nutrient pollution, escapes, competition with wild fish, disease transmission and seafood safety. There is considerable misinformation being circulated regarding aquaculture, its environmental effects and the health risks of consuming cultured products.

Aquaculture production in North America contributes significantly to local economies in regions of the United States and Canada characterized by low levels of economic development and high rates of unemployment. Localized impacts can be highly significant. For example, catfish farming in Chicot County, Arkansas, generates a total economic impact of US$359 million, providing US$20 million in tax revenues and 2 534 jobs, accounting for 46 percent of total employment in the county (Kaliba and Engle, 2004).

One development in the United States that bears watching is the introduction of a bill in the United States Senate that would have created a law known as the "National Offshore Aquaculture Act of 2005". Although the bill as now proposed faces stiff

opposition due to environmental and other concerns, this is the first time an attempt has been made to provide a regulatory framework for the use of the EEZ waters in the United States for aquaculture. Its passage into law, if ever, may have significant effects on United States aquaculture production, import needs for seafood and global trade in aquaculture products. It should be noted that the United States national policy as stated in their National Aquaculture Act of 1980: is to "encourage the development of aquaculture" as a way of "reducing the United States trade deficit in fisheries products, for augmenting existing commercial and recreational fisheries, and for producing other renewable resources, thereby assisting the United States in meeting its future food needs".

Sub-Saharan Africa

Countries considered in the sub-Saharan Africa region (see Chapter 1) have considerable scope for aquaculture development but generally share similar key constraints hindering the unfolding of its potential. It should be noted, although a broad reference to sub-Saharan Africa is made in this chapter, countries such as South Africa, Nigeria, Kenya, Madagascar, and Ghana stand out in terms of progress made in national aquaculture development and the current overall status of aquaculture.

During the period 1998 to 2004 aquaculture production in sub-Saharan Africa increased from 46 882 tonnes to 80 434 tonnes.

Though non-commercial aquaculture (subsistence aquaculture produced mainly for household use) is still practised at low levels of intensity, the commercial sector appears to be at the threshold of a new dawn in the region.

Fish supply currently cannot meet regional demand. Throughout the region per capita consumption over the last two decades has decreased by an average of 2.1kg/person/year, and marine fish imports have increased by 177 percent during the same period. The supply deficit has clearly affected the price of fish, and it is clear that this has driven the development of commercial aquaculture.

The noticeable change to commercial farming and higher levels of intensification (such as greater use of farm-made feeds, inorganic fertilizers and better-managed and synchronized harvesting) are being observed. However, it is not fully understood whether the greater degree of commercial farming in comparison to 1999 is a consequence of non-commercial farmers switching to commercial farming or whether the "new wave" of commercial farmers are progressive new entrants into the sector, spurred on by the escalating fish price.

Except in South Africa, Madagascar, Mozambique and the United Republic of Tanzania, mariculture is underdeveloped and underexplored in the region as a whole. However, several countries have identified the potential for the farming of prawns, fish, seaweed or shellfish and some are on the threshold of initiating the development of mariculture sector.

Within the overall context of aquaculture in the region the commercial sector is making advances at all levels of scale and intensification. Apart from Nigeria and Madagascar, this sector now also appears to be making notable advances in Uganda, Ghana, Kenya, Côte d'Ivoire, Zambia and Malawi. It is predicted that the development and adoption of Strategic Aquaculture Development Plans in several countries will further trigger its development.

In most countries, non-commercial aquaculture is still considered to form part of a livelihoods diversification strategy to reduce risks and provide greater food security at the family level. The non-commercial sector, as in the past is constrained by various biotechnical, institutional, infrastructural and economic factors, the most important of which are the quality and type of extension provided and the lack of quality fish seed and feed. The level of management remains low and most farmers use the pond as a "bank" for food and cash as and when needed.

The cutback in donor support for aquaculture development, since the mid- to late 1990s, seems to have had notable effects on institutions. In particular, this is evident with respect to capacity (planning), management, research, training and the quality and intensity of extension. Several countries have reported that extension either has collapsed remained static or has seriously regressed. The most appropriate method for extension appears to be the participatory on-farm approach; however, this method is practised mainly by donor supported projects and its long-term sustainability has not been tested. Overall, it can be concluded that new and more effective means of extension are required.

It has been suggested that non-commercial aquaculture will not be likely to make significant contributions to national fish supply in any of the target countries. To increase national fish supply requires paradigm shifts in the support role of lead agencies and donors.

Western Europe

The continuing stagnation of capture fisheries and soaring demand for seafood products in Western Europe has spurred the expansion of the aquaculture sector in the Western European region since the 1970s. The rate of growth over the last decades, however, has not been consistent and shows characteristics of a new agro-food industry that is fast showing signs of slowing down in the last decade.

The major expansion in aquaculture between 1994 and 2003 was overwhelmingly dominated by marine finfish production particularly that of Atlantic salmon in northern Europe. Norway (71 percent), United Kingdom (19 percent) and Faeroe Islands (10 percent) were the major players driving the soaring increases in Atlantic salmon that accounted for almost all the increase in salmon production since 1994.

In southern regions of Western Europe seabass and seabream farming has similar significance for Greece, Turkey, Spain, Italy and France, which in 2003 accounted for 95 percent of production mainly from sea cages.

The increased production and supply of farmed species notably salmon, trout, bass and bream was accompanied by a steady fall in farmgate prices triggering restructuring of the industry farming the major species all over Western Europe.

These challenges have not negatively impacted on production. Falling prices were offset by substantial increases in volume of the key finfish species.

There has been a continued increase in interest for the farming of other species such as cod and halibut. The likely impact these new species may have, however, is difficult to ascertain at present and will probably be dictated by national regulatory authorities rather than technical constraints. The diversification initiatives are occurring against a backdrop of limited production sites and increasing environmental challenges.

Creative marketing is an emerging strategy for diversification. In the last decade quality labels have been promoted to attract sales. More recently organic labels have been created to command higher priced niche markets. Countries in the region have varying rules for organic production but as yet there are no European or internationally harmonized standards. While these strategies may raise prices on the margins of the industry its mass appeal is uncertain and its impact on increased production is unclear. There has been also interest in ecolabelling of aquaculture products in countries such as France and Italy but it is unclear if such labelled products progress from the current niche status to a more mainstream role in the retail sector.

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Annex I

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