Emerging Trends and Experiences in Asia-Pacific Aquaculture: 2003

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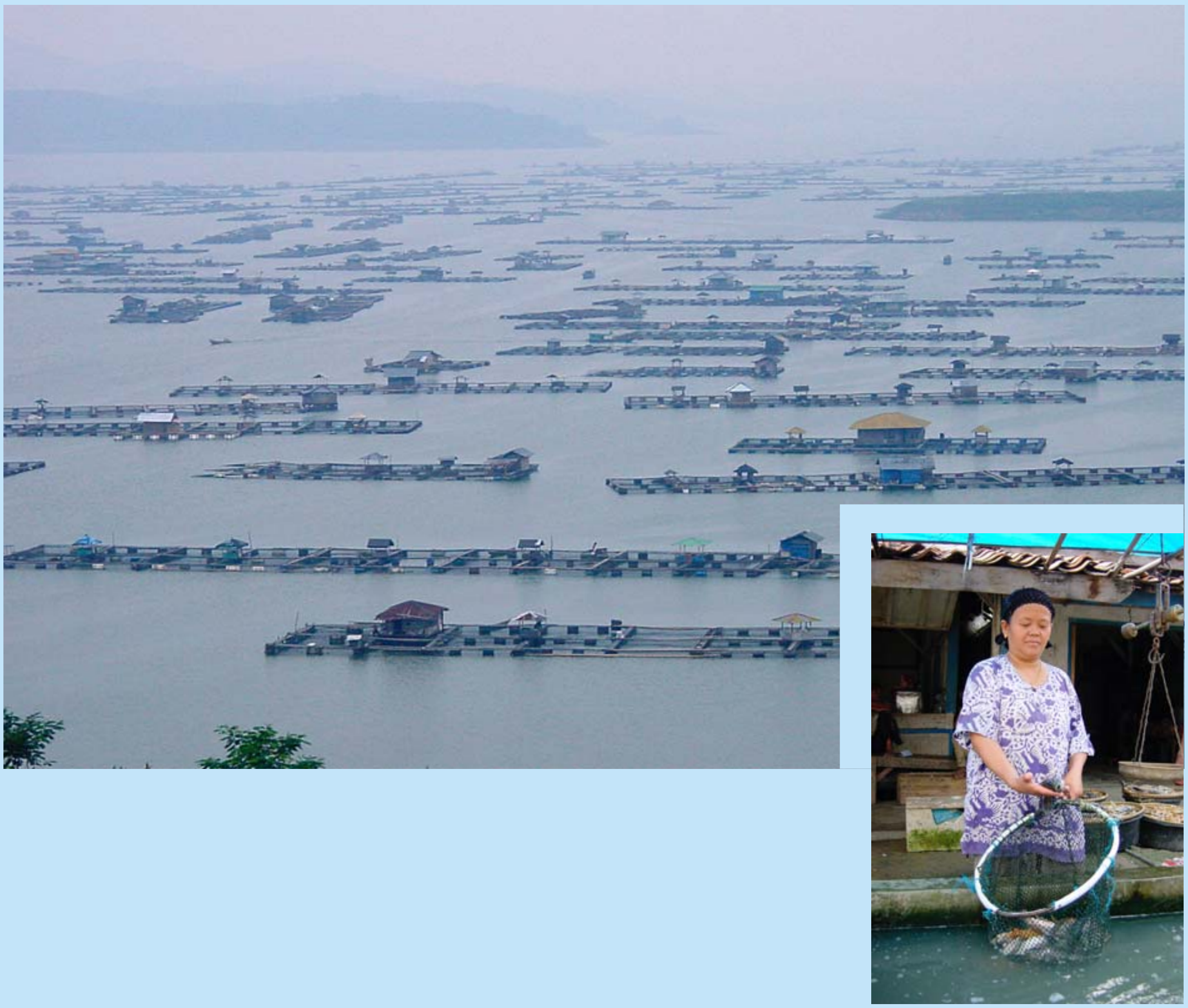

April 2004

Prepared by the

Network of Aquaculture Centres in Asia-Pacific

and Food and Agriculture Organisation of the United Nations

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Preparation of this document:
This document provides an overview of topical issues in Asian aquaculture for 2003, including a review of its status, progress in research and development, major issues and experiences, together with suggestions on actions for addressing opportunities and constraints. The document has been prepared by NACA and FAO to facilitate discussions at the 15th NACA Governing Council meeting, hosted by the Government of Sri Lanka on 21st-25th April 2004. The final version will be widely circulated as the editors hope it will prove a useful document for all involved in aquaculture, and related fishery development in the Asia-Pacific region.

Pending feedback on this 2003 document, further reviews may be considered by NACA and FAO as a way of bringing together regularly in one publication relevant and key issues facing development of aquaculture in the Asia-Pacific region.

Reference: NACA/FAO, 2004. Emerging trends and experiences in Asia-Pacific Aquaculture 2003. Prepared by the Network of Aquaculture Centres in Asia-Pacific and Food and Agriculture Organisation of the United Nations for the 15th NACA Governing Council Meeting, 21-25th April 2004, Colombo, Sri Lanka.

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Introduction

Aquaculture is the fastest growing food production sector, globally. The Asia-Pacific region is the biggest contributor to aquaculture production, producing over 90% of the total volume, and substantial social and economic value.

This first issue of this Review of Emerging Trends and Experiences in Asia-Pacific intends to provide an overview of aquaculture in the Asia-Pacific region. It complements other assessments on the state of aquaculture, notably that of FAO's "State of World Aquaculture," to provide governments and those assisting governments a comprehensive overview of the current status of the sector and the issues that affect its further development. The Review highlights the trends and emerging issues faced by the sector in the Asia-Pacific. The document has been prepared for the 15th Governing Council Meeting of NACA to support and encourage discussion and debate around the issues.

The review highlights a number of issues that have come to the fore during 2003, including international trading issues, progress on poverty reduction through aquaculture and aquatic resources management, food safety and several other important topics. Invariably though some important issues could not be covered. We hope further documents prepared for 2004 or beyond will explore other key issues; NACA and FAO welcome suggestions on topics for coverage in future reviews.

While the review has been initially prepared for the Governing Council meeting, NACA and FAO hope that it will be of wider interest to those involved in Asian aquaculture development and generate further debate and discussion to focus more sharply on and deeper into critical and key issues that would result in more effective and finely tuned action plans. Such action plans could be taken up collectively among Governments and their partners to address common regional issues, collaboratively by various stakeholders to solve problems of common interest, or jointly in special initiatives among like-minded partners to meet particular challenges.

A further intent of the document is to share experiences from the many centers, institutes, and experts working around the Asia-Pacific region on aquaculture development. The region holds a rich – arguably the world's richest – experience in aquaculture. As a network organization, NACA is always seeking ways to widely share these experiences and encourage collective efforts to support development and address challenges. Networking activities in poverty reduction, aquatic animal health management, marine fish farming and shrimp aquaculture are all featured, and we hope the review will provide another useful means of sharing such experiences, encouraging regional collaboration. Future reviews will seek to highlight further the work being done by the Asian aquaculture centers and institutes in the region.

The review focuses not only on aquaculture, but also relevant material on inland fisheries. Sustainable aquaculture development has to recognize the many links and relations to wild capture fisheries; the review reveals more clearly and brings out the importance of some of these links, and particularly the role of inland fisheries in Asia. This is in line with NACA's new mandate to promote regional cooperation on aquatic resources management and small-scale fisheries in Asia.

The document includes some recommendations from significant regional and international meetings in 2003. Perhaps the most relevant international meeting was the FAO Committee on Fisheries Aquaculture Sub-committee (ASC) held in August 2003. The ASC as a forum, notably arising from the recommendation of the 2000 "AquaMillenium Conference," is gradually shaping the global aquaculture agenda of FAO. Many issues raised during the ASC meeting are relevant to aquaculture development in the Asia-Pacific region; the recommendations are reproduced here in full to bring awareness and encourage discussion and joint action among Asia-Pacific governments to address the key issues.

NACA would like to thank FAO for their collaboration in this review, and the contributors for their time and expertise brought together in preparing this document. The review is a joint NACA-FAO initiative, with a contribution from the Secretariat of the Pacific Community, which is an associate member of NACA.

NACA and FAO hope you find this document useful. As this is the first issue, we welcome suggestions and comments to give it more value to readers, or to make us decide on whether to continue issuing the review in future years.

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Asian regional trends in aquaculture and related fishery activities

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Scope of this review

This review covers the countries of the Asia Pacific Region that report aquaculture statistics to FAO and which are within the regional area of competence of the FAO Regional Office for Asia and the Pacific. These include;

Oceania: Australia, Cook, Islands, Fiji, French Polynesia, Guam, Kiribati, Federated States of Micronesia, New Caledonia, New Zealand, Palau, Papua New Guinea, Samoa and Solomon Islands

South Asia: Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka

Southeast Asia: Brunei Darussalam, Cambodia, Indonesia, Lao People's Dem. Rep., Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam

China: China, Hong Kong SAR and Taiwan Province of China

Other Asia: Iran, Japan, Democratic People's Republic of Korea and Republic of Korea

Aquaculture status by region

Status and trends of aquaculture in the Asia Pacific region

The Asia Pacific region is the world's largest contributor to world aquaculture, producing 44 million metric tonnes[1] or 91 percent of global aquaculture production. In terms of production by value, the regions share is slightly less, at 82 percent of total value of global aquaculture production. Even when aquatic plant production is excluded (the vast majority of which originates in the Asia Pacific area), the region still remains as a dominant aquaculture production area, representing 89 percent of global aquaculture production by volume and 81 percent by value.

Top 10 aquaculture producing countries by volume (excluding aquatic plants) in 2001 were China, India, Indonesia, Japan, Thailand, Bangladesh, Chile, Viet Nam, Norway and USA. Seven of these were Asian countries dominating top 6 ranks. By value, China, Japan, India, Indonesia, Thailand, Philippines, Bangladesh and Viet Nam are amongst the top 10 producing countries (Table 1)

The growth of aquaculture production in the region has been very strong for last ten years, owing largely to the production from China with the annual growth rate of 13.8 percent[2]. Both inland culture and mariculture show steady growth but the growth rate was more rapid with the inland culture sector (Table 1 and Figure 1).

[1] It should be noted that regionally aggregated figures in this report are based on of national data, the quality which is known to be very uneven among countries. Some national figures are estimates or repetitions of the data previously reported to FAO.

[2] For the period of 1991-2001 without aquatic plants production

China[3] alone was reported to have produced 35 million metric tonnes or 71 percent of the world aquaculture production. To understand the enormous scale of aquaculture production in China, it can be compared with the total fisheries production of Peru (including both capture and aquaculture), the world second largest fisheries producer after China, which was 8 million metric tonnes in 2001. Peruvian fisheries production was still less than one quarter of China's aquaculture production alone! Since it is such a predominant producer, the scale of reported production can mask other regional trends and therefore in many parts of this review, Chinese aquaculture will be treated separately or presented as a region in its own right.

Figure 1 Trends in global aquaculture
(volume in '000 tonnes; value in US$ million, excludes plants)

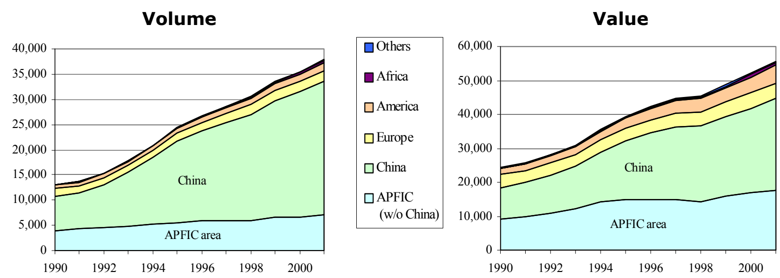
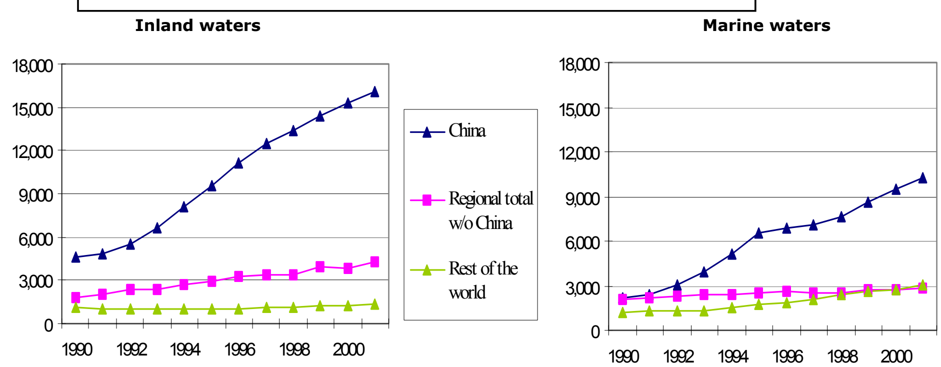


Figure 2 Trends in aquaculture production of Asia-Pacific region by environment



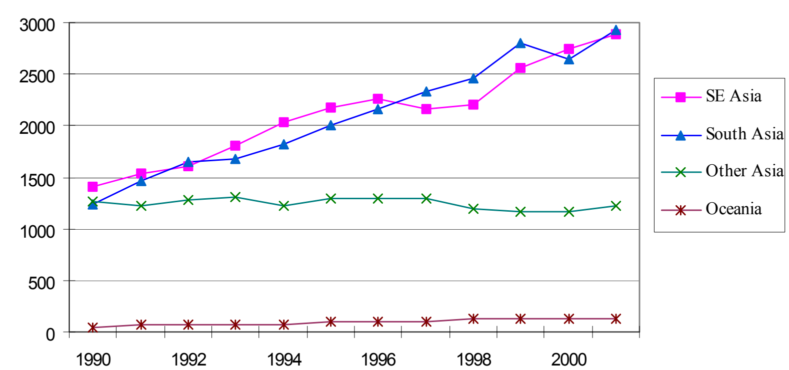
[3] The massive scale of China PR aquaculture production challenges statistical collection and there are uncertainties regarding the quantities reported.

Table 1	Top aquaculture producing countries in 2001				
	By quantity			**By Value**	
	Country	**Quantity**		**Country**	**Value**
1	China	26,050,101	1	China	26,245,691
2	India	2,202,630	2	Japan	3,383,416
3	Indonesia	864,276	3	India	2,537,569
4	Japan	801,948	4	Indonesia	2,397,368
5	Thailand	724,228	5	Thailand	2,376,712
6	Bangladesh	687,000	6	Philippines	1,725,413
7	Chile	566,096	7	Chile	1,718,185
8	Viet Nam	518,500	8	Bangladesh	1,219,700
9	Norway	512,101	9	Viet Nam	1,135,575
10	USA	460,998	10	Norway	1,022,967
	Others	4463478		Others	11,923,886
	Total	**37,851,356**		**Total**	**55,686,483**

Unit: mt (volume) 1000 USD (value)

Production in the rest of the Asia Pacific region (i.e. excluding China) has exhibited steady growth regardless of the culture environment. In particular, inland culture doubled its production from 1,827 thousand metric tonnes in 1990 to 4,240 thousand metric tonnes in 2001. Such advances far exceed the growth of aquaculture in the rest of the world (Figure 2).

Figure 3: Trends in aquaculture by sub-region



A comparison of top 20 cultured species [4]in the region between 1990 and 2001(excluding aquatic plants and molluscs) shows that there has been little change in the top 8 species in inland waters, which are dominated by Chinese and Indian carps.

[4] There is significant volume of production reported by large group of species, e.g. 2,123 thousand metric tonnes of fin fish production in 2001 were not identified at family, order or species level. Consequently, species items totals could have underestimated the real production of the individual species.

It is worth noting that number of carnivorous species has increased from three to seven species in the past 10 years. In marine waters, although there are changes in orders of species, there have been few changes in the combination of top 20 cultured species. (Table 2)

Status and trends by sub-regions. Looking at the Asia-Pacific sub-regions (Figure 3) excluding China indicates that growth in aquaculture production is not evenly distributed, and has been mainly achieved by two major driving forces, namely South Asia and Southeast Asia. These sub-regions show very similar growth trends, doubling their production levels since 1990 and reaching almost 3 million metric tonnes each by 2001.

Other Asian countries have had relatively stable production for last 10 years, ranging from 1,100 to 1,300 thousand metric tonnes. Production from the Oceania sub-region has showed relatively slow but steady growth until 1999 and thereafter it has levelled off at the level of some 130 thousand metric tonnes (Figure 4).

Table 2 Top 20 cultured species in Asia Pacific region by quantity

Inland waters (metric tonnes)					
	1990			2001	
1	Silver carp	1,416,568	1	Grass carp	3,561,344
2	Grass carp	1,041,953	2	Silver carp	3,465,103
3	Bighead carp	671,757	3	Common Carp	2,593,929
4	Common carp	658,406	4	Bighead carp	1,653,870
5	Tilapias	306,485	5	Crucian carp	1,526,570
6	Rohu	244,678	6	Tilapias	1,012,680
7	Catla	235,253	7	Rohu	833,816
8	Crucian carp	215,573	8	Catla	668,730
9	Japanese eel	163,505	9	Mrigal carp	589,841
10	White amur bream	161,615	10	White amur bream	541,115
11	Mrigal carp	160,107	11	Chinese river crab	286,156
12	Mud carp	80,289	12	Mud carp	220,118
13	Clarias catfishes	61,357	13	Japanese eel	217,939
14	Barbs	46,983	14	Black carp	190,707
15	Climbing perch	39,405	15	Macrobrachium	179,275
16	Black carp	37,852	16	Clarias catfishes	131,817
17	Milkfish	34,534	17	Soft-shell turtle	117,543
18	Cyprinids nei	25,596	18	Mandarin fish	116,423
19	Gouramis	25,129	19	Barbs	79,682
20	Trout, Salmon	24,867	20	Snakehead	72,908
	Misc. freshwater fish	776,847		Misc. freshwater fish	2,122,695

Top six cultured species in 2001 were all freshwater carps (Rohu, Catla, Mrigal, Grass carp, Common carp and Silver carp) and their aggregated production was 2,504 thousand metric tonnes accounting for 85 percent of total aquaculture production of the sub-region.

South Asia. A notable feature of aquaculture sector in South Asia is that the majority of production comes from inland waters and hence the growth of the sector has been mostly due increasing freshwater culture. Reported production of freshwater finfishes alone constituted 93 percent of total aquaculture production in 2001. South Asia's production increased rapidly from 1,179 thousand metric tonnes in 1990 to 2,730 thousand metric tonnes in 2001. There has been a notable increase in the production of Chinese carps (Grass carp, Silver carp and Bighead carp) production since 1996 (Figure 5).

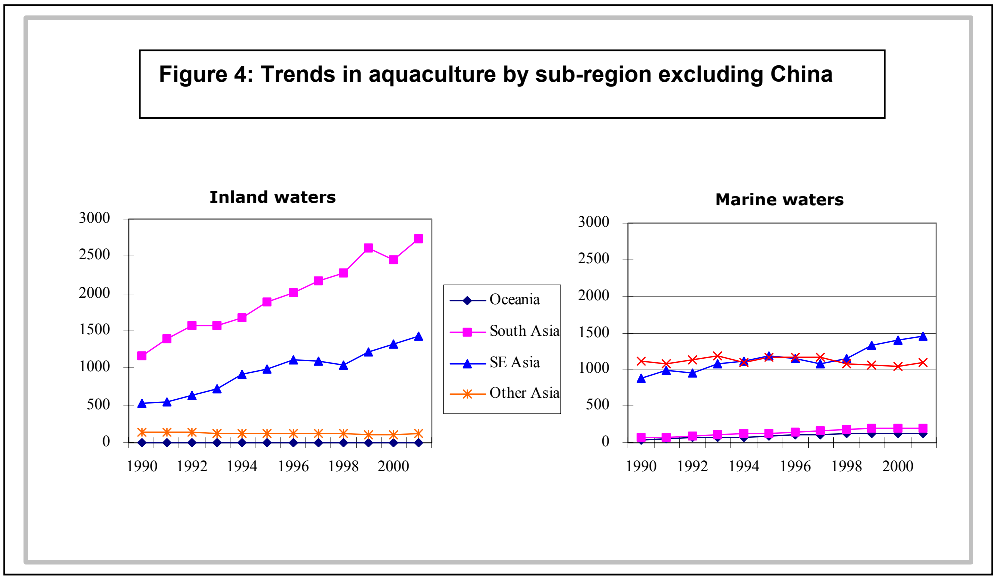


Figure 4: Trends in aquaculture by sub-region excluding China

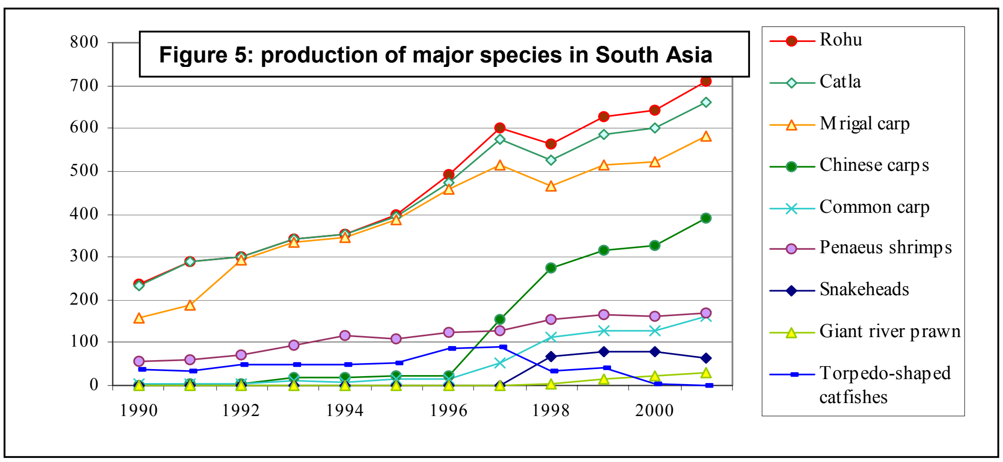


Figure 5: production of major species in South Asia

Mariculture in South Asia has not been an area of remarkable progress except for the production of crustaceans. Marine crustacean production, which was mostly comprised of Penaeid shrimp, has increased almost fourfold from 1990 and reached 199 thousand metric tonnes in 2001. In general, the level of diversification of cultured species is relatively low in this area and there has been very limited or no reported marine finfish production.

Table 2 Top 20 cultured species in Asia Pacific region by quantity (continued)					
Marine waters (metric tonnes)					
	1990			2001	
1	Milkfish	399,589	1	Giant tiger prawn	609,514
2	Giant tiger prawn	289,695	2	Milkfish	453,955
3	Fleshy prawn	185,074	3	Fleshy prawn	306,263
4	Amberjacks	161,568	4	Amberjacks	153,713
5	Seam breams	53,468	5	Other marine crabs	153,006
6	Tilapias	39,211	6	Seam breams	77,755
7	Banana prawn	32,823	7	Other penaeus shrimps	70,747
8	Other penaeus shrimps	32,190	8	Tilapias	57,573
9	Metapenaeus shrimps	29,267	9	Banana prawn	44,890
10	Trout, Salmon	28,408	10	Trout, Salmon	31,726
11	Barramundi	7,935	11	Barramundi	23,931
12	Mullets	7,922	12	Bastard halibut	23,064
13	Jack & horse mackerels	7,231	13	Metapenaeus shrimps	20,337
14	Bastard halibut	7,076	14	Groupers	12,970
15	Groupers	5,678	15	Mullets	12,871
16	Indo-Pacific swamp crab	3,786	16	Scorpionfishes	9,330
17	Puffers	2,895	17	Indo-Pacific swamp crab	9,214
18	Snappers	482	18	Southern bluefin tuna	9,051
19	Other marine crabs	24	19	Jack & horse mackerels	6,704
20			20	Puffers	5,769
	Misc. marine fish	61,942		Misc. marine fish	575,534
	Miscellaneous crustaceans	14,431		Miscellaneous crustaceans	64,275

Southeast Asia. Aquaculture production in Southeast Asia is very well diversified with 38 percent of freshwater fish, 26 percent of aquatic plants, 16 percent of crustaceans, 12 percent of marine/diadromous fishes and 7 percent of molluscs (by volume). In terms of production by value, highly priced crustaceans constituted an increased share of 49 percent of total production, followed by freshwater fish at 34 percent (Figure 6).

Top 10 cultured species in Southeast Asia (by volume, excluding aquatic plants) were Giant tiger prawn, Milkfish, Tilapias, Common carp, *Clarias* catfishes, Rohu, Green mussel, Blood cockle, Barbs and Gouramis.

The growth trend is particularly strong for freshwater finfish culture, which has increased from 537 thousand metric tonnes in 1990 to 1,429 thousand metric tonnes in 2001 with an average annual increment of 81 thousand metric tonnes. In the mariculture sub-sector, aquatic plants showed a surprising production growth. Crustaceans are a major cultured species throughout the sub-region and giant tiger prawn (*P. monodon*) has maintained the position of top produced species for the last decade, although very recently the massive increases in production of *P. vannamei* is challenging this position. *P. monodon* production decreased sharply in 1997 to the production level of 1992-1993, but thereafter has recovered to the level of 500 thousand metric tonnes in 2000 (Figure 7).

Figure 6: Proportion of production by species groups in Southeast Asia

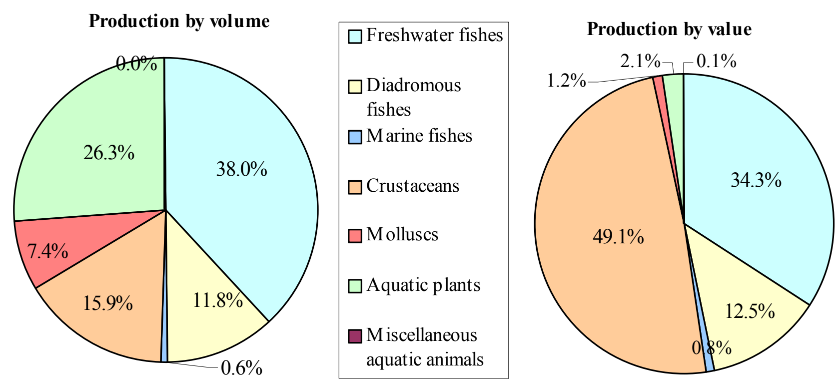
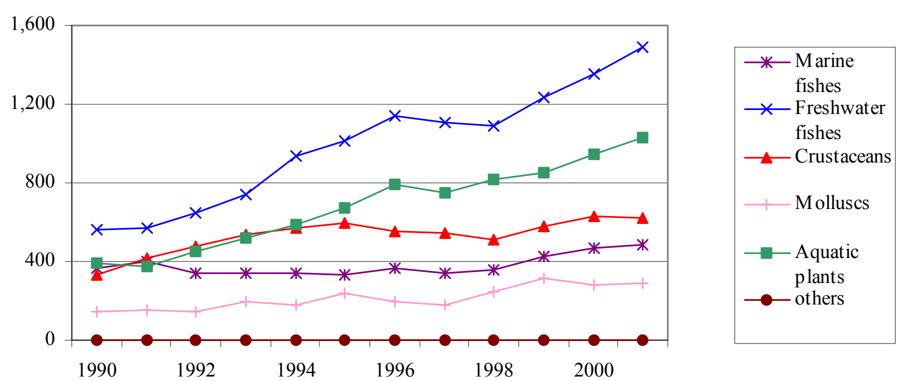
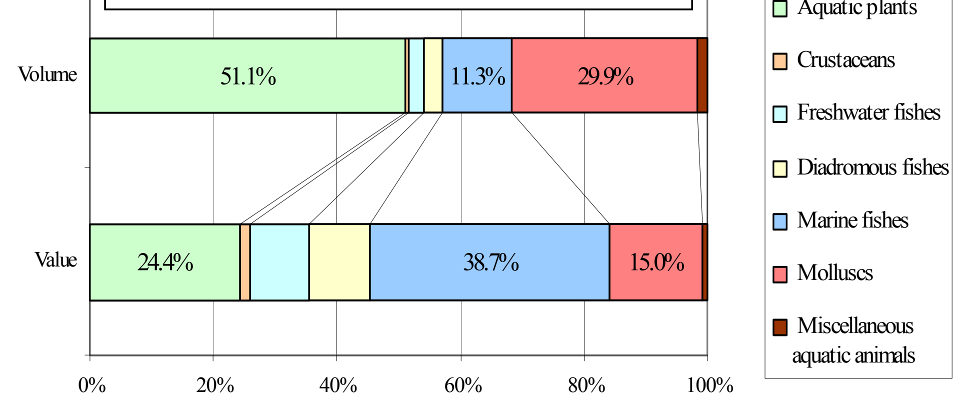


Figure 7: Trends by major species groups in SEAsia



Other Asia. In other Asia, particularly in East Asian countries, aquatic plants continue to be predominant, accounting for 51 percent of total production quantity. This is followed by molluscs (30 percent) and marine finfish (11 percent). However, the high economic value of marine finfish makes this species group the largest contributor in terms of value, constituting 39 percent of total production value. The percentage of high input carnivorous fish in total fish production was very high in this region (78 percent in 2001) while those of South Asia, Southeast Asia and China were all below 10 percent (Figure 8).

Figure 8: Production of other Asia: proportion of major species groups

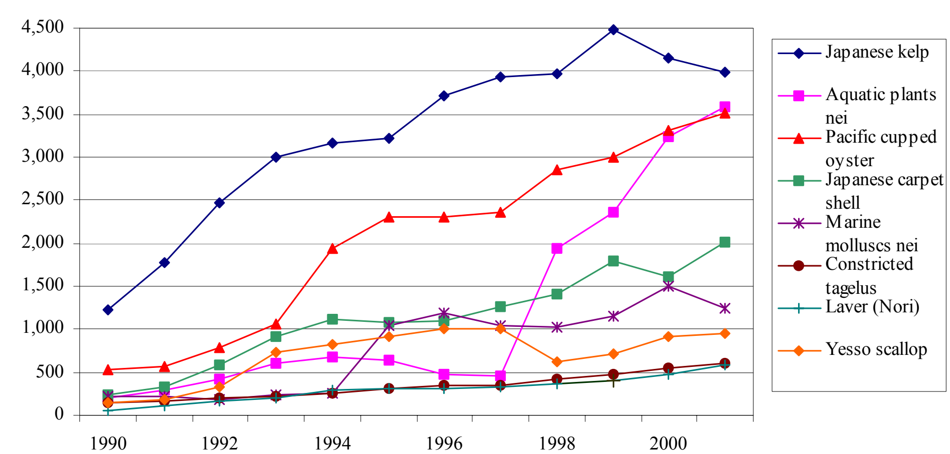


China. China has continuously exhibited strong growth both in inland waters and marine waters. Although most cultured species showed generally increasing trends, there are a number of species that may attract particular attention. These include:

Japanese kelp: this species has been the top cultured species in China and its production growth is outstanding; increasing from 1,222 thousand metric tonnes in 1990 to 3,989 thousand metric tonnes in 2001.

Miscellaneous aquatic plants: This massive volume of aquatic plants is not reported at the species level and production has jumped from 196 thousand metric tonnes in 1990 to 3,587 thousand metric tonnes. By 2001 the highest annual increment was 1,485

Figure 9: Trends in top eight cultured species

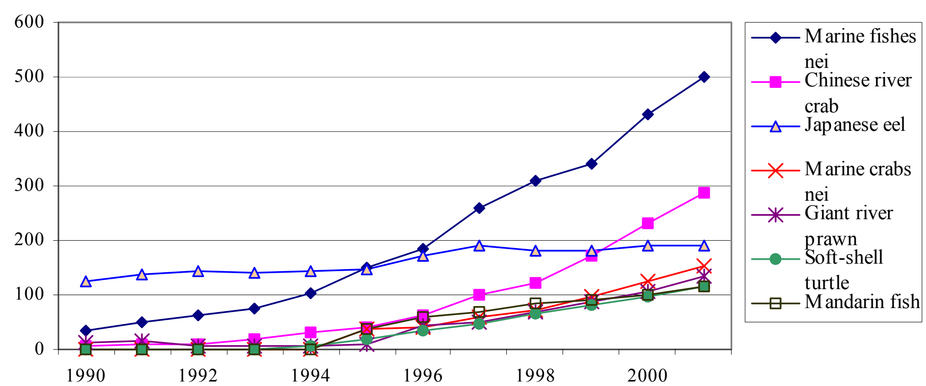


thousand metric tonnes (between 1997 and 1998). This group and Japanese Kelp are interesting because they are not particularly easy to intensify, therefore increases in growth suggests the development of large additional areas of seaboard for their culture. A description of the areas under culture for seaweeds in China would be very useful.

Pacific cupped oyster: This is another cultured species that has made outstanding growth; increasing from 532 thousand metric tonnes in 1990 to 3,508 thousand metric tonnes in 2001. As above, mollusc production is difficult to intensify and increased production suggests developments of new production areas (Figure 9).

Carnivorous species: Production of high value carnivorous species such as mandarin fish, Chinese river crab and marine finfish had been relatively low up to early 90's. However, this group started to make rapid growth since 1995. Many of the carnivorous species show very similar patterns of growth in production (Figure 10).

Figure 10: Trends in major carnivorous species production in China



Oceania. Aquaculture production from small island states in the Pacific is relatively limited; with aggregated production of all island states in 2001 of about 4,000 metric tonnes. (~0.03 percent of aquaculture production in the Asia-Pacific region).

The major cultured species in terms of volume are seaweed, clams, Penaeid shrimp, tilapia and milkfish. Live reef fish, aquarium fish and pearl, which are relatively low volume but high value commodities also bring in significant income to some Pacific Islands. Two commodities and three countries dominate the value of commercial aquaculture production in region. They are cultured black pearl from French Polynesia and the Cook Islands and marine prawn from New Caledonia. In 2002 the total export value was $US 153 million.

The Pacific is an important source of trade in the marine aquarium industry. Although the target species are mostly caught from the wild there is an increasing desire for culture-based sources. Giant clam culture for the ornamental trade is widespread throughout the region and the total export is probably in the range of 30,000 – 50,000 pieces/annum. The Pacific is a major supplier of live rock (wild harvest) with approximately 50,000 pieces of live rock currently presently being cultured in the Fiji Islands.

Kappaphycus seaweed culture is well established in the Kiribati atolls and is being rejuvenated in the Solomon Islands and Fiji Islands with forecasted production somewhere in the order of 1,500 metric tonnes for 2004.

Interest in inland freshwater aquaculture is growing, particularly amongst the larger Melanesian countries such as the Fiji Islands and Papau New Guinea. At present the most commonly farmed species are tilapia, common carp and *Macrobrachium* prawns.

The larger states in the region (New Zealand and Australia) have showed a steady growth in aquaculture production, which is largely attributable to increased production of finfish species. Major cultured species in these states were marine molluscs, salmonids and tunas.

Aquaculture's contributions

Table 3 – Contribution of Aquaculture to GDP[5]

Country	Aquaculture value as % of GDP
Lao PDR	5.775
Viet Nam	3.497
Bangladesh	2.688
Philippines	2.633
China	2.618
Thailand	2.071
Indonesia	1.662
Cambodia	0.893
Kiribati	0.752
India [6]	0.540
Sri Lanka	0.468
Malaysia	0.366
Nepal	0.345
Taiwan POC	0.324
New Zealand	0.189
Myanmar	0.167
Korea, Rep.	0.145
Japan	0.108
Iran	0.105

Contribution to national economies

Aquaculture is a clear contributor to GDP in many Asian countries accounting for over 1 percent of GDP in 7 of them (Table 3). Statistics related to export income from aquaculture products are not available and this constrains estimation of the contribution to foreign currency earnings through exports of aquaculture products.

From the table of importance to GDP, it is clear that the country listings also closely match those countries which also export considerable amounts of aquaculture products (particularly shrimp).

China is an exception in this case, since the massive quantity of aquaculture products it produces are largely consumed domestically, although there is an increasing trend towards export focussed products.

[5] GDP values calculated form ESCAP official statistics except Taiwan POC.
[6] Data for the year 2000

Contribution to food security - trends in fish consumption

The Asia-Pacific Region represents the most important region for aquaculture production, but also has countries with the highest per capita consumption. 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.

> Top 8 countries for aquaculture contribution to GDP were Lao PDR, Viet Nam, Bangladesh, Philippines, China PR, Thailand, Indonesia, and Cambodia.

The likely global trends for fish supply, demand and consumption have been forecasted by the International Food Policy Research Institute (IFPRI) in collaboration with the WorldFish Centre (Delgado et al, 2003). The conclusions of these projections are that consumption trends show an increase in the demand for fishery products for food. This is partly due to changing food habits and also due to 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 countries are expected to remain net exporters overall, but the percentage of their production exported is expected to decrease due to rising domestic demand. There does appear to be a trend of decreasing fish consumption in developed countries due to increased urbanization; however this does not seem likely to offset the increased demand for fish in developing countries.

The cost of fishery products is also expected to increase since in most of the projected scenarios, supply cannot keep up with demand. Projected rise in prices between 1997 and 2020 are about 15 percent. Since the yield from capture fisheries is not expected to increase greatly, there is great emphasis placed on the aquaculture sector ability to provide increasing quantities of fish to satisfy the increasing demand in all regions. Several conditions must be satisfied in order that aquaculture be able to achieve this expectation. The current reliance on fish meal as a protein source for feeds for aquaculture is a potential constraint (this is discussed in the next section).
The massive expansion of aquaculture that is required to satisfy the increasing demand for fish requires increasing production area as well as greatly increased intensity of production. Obtaining the land and water may be possible if the value of fishery products increases so that aquaculture can challenge other production systems for the use of the feeds, land and water required to effect this production. Alternatively, increased efficiency in the use of water and intensified production will reduce land requirements. The current intensity of production in many countries of Asia is such that there is considerable scope for increased production per unit area. However, the increased feed usage and probable increased water requirement will be a constraint.

Aquaculture currently competes with the livestock sector for fish meal 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 fish meals and increase the efficiency of their utilization. Whilst more efficient use of fish meal 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.

One scenario considered in the IFPRI/WorldFish report is that 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). The efficient culture of herbivorous/omnivorous fish is already a reality, however, it is apparent that current trends seem to indicate that the tendency that aquaculture is drifting towards higher value species that present greater profit margins. This trend is even being seen in species that are traditionally considered to be relatively low input species such as tilapia. The production of tilapia in several countries is moving away from the greenwater fertilized systems towards pellet fed intensified systems. This may be a reflection on the available areas for aquaculture and increasing restriction on water availability and to some extent environmental requirements. The production of higher value aquaculture species allows investment in more intensive production systems and their associated effluent treatments. The higher value products may also be easier to market and often have greater export potential.

It is inevitable that as fish prices rise, there will be a tendency for poorer parts of national populations to shift towards cheaper form of meat such as chicken and pork. The question is whether fish in the Asia and Pacific will remain a common (and even central) part of the diet of most people or increasingly become a luxury food item.

Fish consumption in selected Asian countries

Bangladesh. The availability of non-cereal protein food in Bangladesh has reportedly increased significantly consequent upon a sustained growth rate of over 8 percent per annum in the fishery and livestock sectors in recent years. National Nutrition Surveys of Bangladesh (1995-1996) on average food intake by different food groups reveal the average fish intake as 11.7 – 13.5 kg/capita/yr for rural and urban populations, with a national average of 12 kg/capita/yr

India. Diet surveys in India (NNMB, 1996) show that the intake of fish and flesh foods is very low in the diets of the urban and rural poor (6.9 & 4.0 kg/capita/yr).

Vietnam. According to nutritional surveillance data (1995) in Viet Nam, the food consumption of animal foods is noted to be increasing. Fish and sea food consumption in three areas (Red River, Northern Central and Mekong delta) were 15.6, 17.9 and 29.2 kg/capita/yr.

Table 4 – Net fish meal usage in the APFIC region (2001)

Country	Metric tonnes
China	1,622,136
Japan	688,396
Thailand	496,316
Taiwan POC	303,691
Philippines	156,126
Indonesia	104,479
Australia	104,012
Iran	68,096
Korea, Rep	59,578
Pakistan	33,742
Viet Nam	28,262
India	18,897
New Zealand	17,412
Sri Lanka	12,444
Bangladesh	6,358
Cambodia	2,200
Malaysia	1,316
Korea DPR	898
Papua New Guinea	792
Brunei Darussalam	328
New Caledonia	310
China, Macao SAR	301
Myanmar	257
Lao PDR	244

Some recent estimations for populations living in the Lower Mekong Basin[7] (Cambodia, Lao PDR, Thailand and Vietnam) also show the very significant role of fisheries products in the diet, with consumption ranging between 43 – 71 kg per capita per year.

The source of fish in the diet of rural people in the Asia region is gradually changing. Rural populations that were once almost entirely dependent upon inland capture fisheries for their fish have seen these resources decline through environmental changes and changing water management regimes. Aquaculture has become increasingly viable alternative to inland capture fisheries as prices rise and cheap wild fish becomes less available.

Aquaculture and resource utilization

Fish meal and other fish-based ingredients for aquaculture feed

The table below presents the 'apparent utilization' of fish based feed ingredients in Asia Pacific countries[8] (Table 4). The trends in the usage of fishmeal for aquaculture and other sectors are stable in many countries of the region (Figure 11).

The trend in global production of fishmeal appears to be relatively stable and currently available information suggests that there is little likelihood of increasing total global production. This means that the expanding aquaculture and livestock sectors will be competing for a resource that is not increasing. This situation has been referred to as the 'fish meal trap' (FAO, 2000) and it is considered that given the apparently limited supply of fish meal and fish oil, the expansion of some types of

[7] Mekong River Commission, Fisheries Programme, unpublished data.

[8] There are some important considerations when interpreting this information which are as follows:

1) 'Apparent utilization' is the sum of the quantities produced and imported, less the exported and re-exported quantities
2) Many countries do not submit complete information (e.g. Philippines does not report national production).
3) These feed ingredients have various uses and are not solely used as aquaculture feeds.
4) These ingredients do not include so called 'trash fish' which are small, low market value species landed as part of fisheries catches and which are utilized directly as feeds and not transformed into meals.

aquaculture will be constrained (or stopped). This assumes that there will be little improvement in the efficiency of use of fish meal and fish oil. It is also argued however, that given stable (neither increasing nor decreasing) supplies of raw fish for fish meal production, the growing demand for fishmeal will drive the price of fish meal and fish oil upwards. This will eventually reach a level where fish and shrimp farmers may not be able to afford to buy fish feeds that contain adequate amounts of fish meal and fish oil to effectively produce their animals.

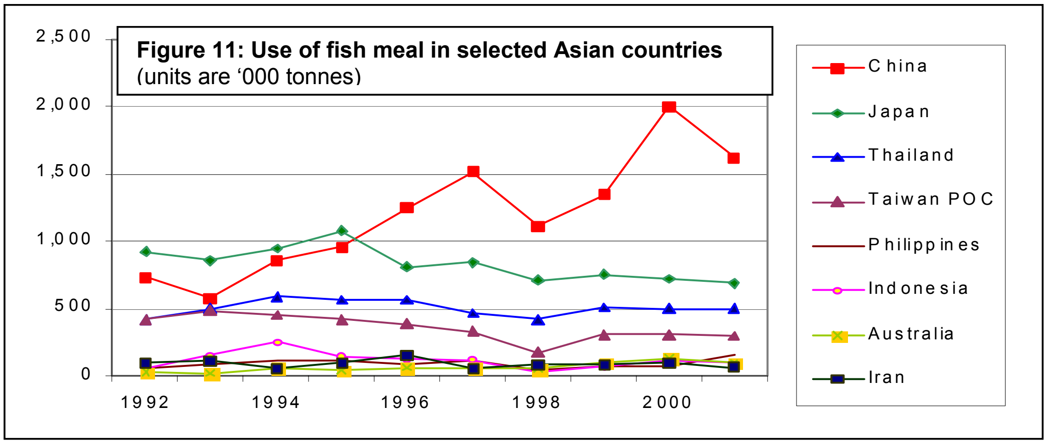


Figure 11: Use of fish meal in selected Asian countries
(units are '000 tonnes)

It was recently estimated that the global aquaculture industry uses about 35% of total fish meal supply (see chapter by Tacon, this volume). This is a significant increase over estimate use in 1988. By 2010, the same author estimates aquaculture share of fish meal usage will be 48% (Barlow, 2002; Barlow and Pike, 2002).

Globally, prices of fish meal and fish oil are all expected to increase – by about 18 percent by 2020 (and at a faster rate than fish prices which are expected to increase only 15 percent overall). Efficiency of use of fishmeal is expected to rise as a reaction to increasing prices and competition between the livestock sector and aquaculture sector for the resource. It should be pointed out that to date, the greatest advances in the area of reducing the reliance on fish meals appear to have been in the livestock sector.

Projections show that the rising cost of wild fish will also see aquaculture prices rising. The higher price for fish products may enable aquaculture to command a higher share of the fishmeal market. There is no doubt that the high value sector of aquaculture is growing and this sector is the most reliant on feeds containing fish meal and fish oil. Even within the aquaculture sector there are likely to be shift in feeding and feed composition since the freshwater aquaculture sector has a greater opportunity to use non-marine sourced feed ingredients (particularly slaughterhouse wastes, brewery wastes and agricultural milling by-products). The purchasing power of maricultured fish and crustaceans will enable this part of the sector to afford higher fish meal prices as demand increases.

Combining the total aquaculture production of carnivorous fish species and crustaceans cultured in all types of environment[9], the approximate requirement for

[9] Freshwater, brackish water and marine waters

fishmeal for the Asia Pacific region including China PR in 2000 was over 1.2 million metric tonnes.

The fish meal requirement of freshwater fish aquaculture is a far more difficult estimation to make, since feeds vary from complete feeds containing fish meal to supplemental feeds with no fish meal whatsoever. It is clear from the Chinese statistics that China is already quite dependent upon imported fish meal and this situation will become an increasingly important feature of the Chinese aquaculture industry.

The inescapable conclusion is that even though fish prices will rise, the price of fishmeal will rise even more quickly and therefore there is considerable pressure on aquaculture to reduce its reliance on feeds containing fish meal and also increase the efficiency of its current usage of this resource.

Small low market value fish produced from capture fisheries ('trash fish')[10]

The huge number of artisanal fisheries in the region generates a large quantity of fish that is of relatively low market value and acceptability. Much of this artisanal catch is consumed or utilized locally as part of household food security, artisanal processing or as aquaculture and livestock feeds. Indeed, utilization may be extremely efficient with none of this is being wasted and being converted through drying, fermenting and salting into a very wide range of human food products.

On contrary, the landing of such small fish by larger commercial trawlers presents a greater problem. These fish are typically landed at a single point (port) and typically in a poor state of preservation or severely damaged from the capture method. Utilization of this fish is either through conversion into fish meal or direct use for livestock or aquaculture in the general vicinity of the landing site. This fish is probably not typically used for human consumption, although fermentation into fish sauces or extracts maybe possible.

The quantity of fish landed in this way is increasing in many countries as a result of increasing fishing pressure.

There is limited information on trash fish production and utilization; however some indication can be derived from mariculture statistics. The cage culture of fish is typically reliant on the use of feeds rather than natural fertility of waters. Cage culture can therefore be separated into two types of operation – those using formulated fish feeds/pellets (which are typically based around fish meal) and those operations that are using 'trash fish' directly, the trash fish being obtained from trawler landings or the production from artisanal fisheries.

[10] Much of this information is derived from an ongoing regional review of trash fish production and utilization by FAO Regional Office for Asia and the Pacific. For further information please contact Simon.FungeSmith@fao.org

Use of 'trash fish' for aquaculture[11]

China. Mainland China is reporting declining trash fish catch since the late 1990's and this is already impacting the price and availability of fishmeal. An estimated 4 million metric tonnes (2000) of trash fish are used directly for aquaculture representing 72.3 percent of the trash fish landed in China. Trash fish are making up an increasingly large component of China's marine fishery catch with a recent estimate of nearly 70% of total catch being trash fish type species.

A rough estimate of China's total fish meal requirement for aquaculture, based on reported production figures, ranges between 3.0 - 3.6 million metric tonnes. This figure is strongly influenced by assumed fish meal used for the culture of freshwater omnivorous species. Further analysis of this particular pert of the Chinese aquaculture sector is needed.

Domestic trash fish landings could provide one million metric tonnes of this and it is assumed that the rest is sourced from imports. China's reported net (production + import – export) fish meal usage in 2000 was nearly 2 million metric tonnes (FAO Fishtat) of which 806 thousand metric tonnes was national production.

Philippines. The estimated use of trash fish for aquaculture in the Philippines is 144,638 metric tonnes, of which an estimated 80 percent is used for marine cage culture.

Vietnam. A recent study in Viet Nam concluded that there is rapidly increasing use of trash fish for aquaculture and that future planned increases in aquaculture production will be constrained by finite sources of feed fish.

Bangladesh. Trash fish landings in Bangladesh are either utilized directly or converted into fish meal. It is estimated that 5,000-7,000 metric tonnes of trash fish are used for aquaculture in this way.

Live fish trade – food fish and ornamental aquarium fish

Fisheries dedicated to the live food fish trade, the ornamental trade, and local subsistence economies generate billions of dollars each year. The live reef fish trade has two main components-live food fish and ornamental aquarium fish. Accurate figures are not available on the total value of these trades, but extrapolation from partial estimates indicates that the total value of the aquarium trade exceeds USD 1 billion per year.

There are concerns regarding the manner in which aquarium and live reef food fish are exploited from their environments. The methods for collection and transportation can be wasteful, although for some areas this is one of the few commercially exploitable resources. The total annual net benefit of sustainable coral reef fisheries across Southeast Asia is estimated to be USD 2.4 billion per year.

[11] Unless otherwise referenced the information in this section is drawn from the regional review (see foot note 10).

The marine and freshwater aquarium trade

Southeast Asia is the hub of this trade, supplying up to 85 percent of the aquarium trade[12]. In 1985, the world export value of the marine aquarium trade was estimated at USD 25 million to 40 million per year. Since 1985, trade in marine ornamentals has been increasing at an average rate of 14 percent annually. In 1996, the world export value was about USD 200 million. The annual export of marine aquarium fish from Southeast Asia alone is, according to 1997 data, between 10 million and 30 million fish with a retail value of up to USD 750 million, the actual value at point of sale is considerably higher.

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 (live animals for aquariums only). Asia provided more than 50 percent of the global total ornamental fish supply (FAO, 2000).

Estimates place the value of the marine ornamental trade at USD 200-330 million per year[13] and the overall value of the marine fish trade, accounts for about 10 percent of the international ornamental fish trade (marine and freshwater included) (UNEP, 2003).

A total of 1,471 species of marine fish are traded worldwide but the ten 'most traded' species account for about 36 per cent of all fish traded for the years 1997 to 2002.

Ornamental marine species (corals, other invertebrates and fish) are collected and transported mainly from Southeast Asia, but also increasingly from several island nations in the Indian and Pacific Oceans, to consumers in the main destination markets: the United States, the European Union (EU) and, to a lesser extent, Japan.

The marine aquarium trade is not confined to marine finfish, but also includes corals, and other invertebrate species. Coral species in seven genera (*Euphyllia, Goniopora, Acropora, Plerogyra, Catalaphyllia*) are the most popular, accounting for approximately 56 per cent of the live coral trade between 1988 and 2002. Sixty-one species of soft coral are also traded, amounting to close to 390 thousand pieces per year.

An important distinction that can be made between the freshwater and marine aquarium trades is the level of reliance on capture of animals rather than culture. It is roughly estimated that the freshwater aquarium trade relies on cultured animals for 98 percent and only two percent of the products are captured[14]. The marine aquarium trade relies on capture for 98 percent of its production versus 2 percent culture (MAC, 2004). There is therefore significant potential for increasing the contribution of aquaculture to the marine aquarium trade and the freshwater aquarium trade is also a significant aquaculture contributor in terms of value. By calculation – if the freshwater aquarium trade is 90% of total aquarium trade and 98% of that is cultured,

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

[13] 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 intra-regional trade which also adds value

[14] http://www.nmsfocean.org/chow/Best.pdf

then a crude estimate of the wholesale aquaculture value is approximately USD 794 million.

There are increasing trends to certify the aquarium trade if undertaken responsibly. There are opportunities for remote islands to benefit from this resource which is often one of the few livelihood options available to them.

Live finfish (Groupers, wrasse etc.)

The markets for live groupers and other reef finfish are concentrated in Hong Kong SAR, Singapore and increasingly China (Table 5).

In 2000, Hong Kong SAR alone imported an estimated 24,362 metric tonnes of live food fish. Typical wholesale prices for these species range from USD 11 to 63 per kilogram Overall average wholesale price for reef fish was USD 20/kg (Lau et al, 1999).

The very high retail values of these fish enable them to be brought long distances in well boats or to be transhipped and held in cages. These fish are sourced throughout Southeast Asia and also from Pacific islands. Estimates of the value of this trade vary. One estimate for Hong Kong SAR alone put the value at approximately USD 400 to 500 million. The total quantity for the principal importing countries

Table 5 - Live fish imports to China, Hong Kong SAR, Macao SAR and Singapore in 2000

Country	Live fish Imports (metric tonnes)
China PR	888
China, Hong Kong SAR	24,362
China, Macao SAR	4,601
Singapore	3,337

More recently the culture of groupers has been expanding as hatchery technology and transfer of this knowledge has enabled the establishment of grouper aquaculture. In particular Indonesian aquaculture of grouper has increased dramatically in recent years.

Production trends by species group

Carnivorous species or species requiring higher production inputs

Eels. Japanese eel production has declined to a stable level at around 24,000 metric tonnes and those of Taiwan POC have declined greatly by 2000 and the production in 2001 was extremely low. In contrast, production in China PR has risen steadily peaking in 1997 and has remained just below this level ever since.

Australia, Indonesia, Malaysia, Korea RO also produce some quantities of eel through aquaculture.

Barramundi and Japanese Seabass. Barramundi (*Lates calcifer*) is gaining ground with increasing production in Indonesia from both brackishwater culture and mariculture. Thailand's production has increased but now appears relatively stable, probably due to limited site availability and market saturation. Australian production is also rising. There has been a significant reduction in production from Hong Kong

SAR which may be due to a shift towards higher value species and limited site availability. Korea RO is also producing Japanese Seabass (873 metric tonnes in 2001). There does not seem to be a very large international trade in these species either live or processed and future expansion may be reliant on development of regional or international markets.

Salmonids - Brackishwater/Mariculture. Culture of salmonids (Chinook, Coho, Atlantic Salomon and Rainbow trout) in brackish water and mariculture is reported from Australia, New Zealand and Japan. Japanese Coho salmon culture declined sharply in 1995 and hit the lowest in 1998 dropping to 32 percent of its 1992 production. New Zealand's Chinook salmon production is relatively stable.

Australian brackish water culture of rainbow trout has declined over the past 10 years from 890 metric tonnes (1990) to zero reported in 1997. In contrast over the past 10 years the Australian Atlantic salmon industry has developed considerably.

Salmonid - Freshwater culture. Freshwater production of trout species in the region has been fairly stable over the last decade with the exception of the development of the industry in Iran, which has made good progress. The Ayu sweetfish production in Japan has declined about 25% in the last decade.

Other carnivorous fish. Over 20 species of other carnivorous finfish are reported and are principally cultured in marine or brackish waters; typically in cages.

Japanese culture of Amberjack (*Seriola*) is the leader (153,075 metric tonnes) and is stable. Production of several other Japanese species is also quite stable (such as pufferfish, several mackerel species and bastard halibut) and it is assumed that is due to site limitations effectively preventing further expansion. In these countries (particularly Japan and RO Korea) it is inevitable that they will increasingly turn to imports from neighbouring countries such as China.

Cobia (*Rachycentron*) is increasing rapidly in Taiwan Province of China in 6 years from almost nothing to over 3,300 metric tonnes in 2001. Culture of this species is also taking off rapidly in other countries such as Viet Nam, possibly as a result of increasing availability of fingerlings from Taiwan POC and local sources. The very rapid growth rate of this species and relative hardiness in ponds makes it an attractive species for aquaculture, although market acceptance is variable.

Southern Bluefin tuna in Australia has emerged as a significant industry for the country over the past 10 years reaching 9,051 metric tonnes in 2001. Although the volume is relatively low compared with the Japanese Amberjack production, the very high value of this product makes it a significant economic activity where it is practiced.

Seabream. Seabream production is confined to Japan, Taiwan POC, Korea RO and Hong Kong SAR. The Japanese production of seabream (71,996 metric tonnes) is signficant and nearly half that (47 percent) of amberjack.

Other marine finfish not elsewhere identified (nei). This group of fish is of interest because of the large reported production from China PR. Since the individual species are not reported, trends cannot be determined. It is probably fair to assume that most of these fish are carnivorous and are being fed in trash fish from the Chinese capture fisheries (Table 6).

Table 6 – Aquaculture production reported under "marine finfish nei"	
Country	**Metric tonnes**
China	494,725
Japan	7,991
Taiwan POC	2,892
Malaysia	2,015
Hong Kong SAR	919
Indonesia	733
Australia	330
Korea RO	216
Philippines	160
Singapore	123
Brunei Darussalam	30
French Polynesia	4

Finfish requiring lower inputs

Freshwater omnivorous and herbivorous fish have been important food fish for developing countries in the Asia Pacific Region (Table 7). Traditional production methods have become diversified and intensified, starting with fertilized polyculture systems and moving towards systems using supplemental feeds and even complete feeds. As demand for fish increases and prices rise, the further pressure on intensification and use of feeding can be expected in many countries.

Backyard ponds are an increasingly common sight in many countries; however this production is frequently missed in national statistical surveys due to the small unit size. In many cases ponds may be below the size required for registration and is not viewed as a significant economic activity. The large numbers of these ponds and the aggregated production and value to the households engaging in the activity is probably very significant.

The lack of reliable information from this part of the sector currently limits the evaluation of the grass-roots impact of rural aquaculture in the Asia-Pacific region.

Table 7 - Top 10 freshwater species (2001)	
Species	**Metric tonnes**
Grass carp	3,561,344
Silver carp	3,465,103
Common Carp	2,593,929
Bighead carp	1,653,870
Crucian carp	1,526,570
Tilapias	1,012,680
Rohu	833,816
Catla	668,730
Mrigal carp	589,841
White amur bream	541,115

It has been suggested that the wide range of species that are currently produced from aquaculture will reduce as greater rationalization and aggregation of production operations focused onto a small number of species. This lesson has been taken from the livestock sector and is considered to be an essential part of the "industrialization "of aquaculture. This trend does not appear to be the case so far in the Asia-Pacific region with farmers increasingly seeking out new species that give them a marketing or profit advantage.

Tilapia. This 'industrialization' trend is seen in some countries with species such as Tilapia. There is a trend towards standardization of size, feeds and production systems, some quality control, avoidance of off-flavours, and marketing into supermarket chains.

Table 8 – Tilapia top six producing countries	
Country	**Metric tonnes**
China	672,307
Philippines	106,746
Indonesia	105,106
Thailand	98,377
Taiwan POC	82,781
Malaysia	16,253
Lao PDR	6,230
Sri Lanka	3,250

However, even with Tilapia, there is still the flexibility of systems, strains and colours of fish. There is probably more diversity in Tilapia culture systems today than 10 years previously with a range of characteristics including:

- Colouration (red, white and black strains)
- Monosex and mixed sex
- Pellet fed, supplemental feed and fertilized greenwater
- Freshwater and brackishwater
- Cold tolerance

Reported exports of tilapia are low. The continuing domestic demand and the high quality required for export targeted fish means that domestic marketing is still attractive in many countries (Table 8).

Table 10 – Milkfish top eight producers (2001)		
Country	**Culture Environment**	**Metric tonnes**
Philippines	Brackish water	211,594
Indonesia	Brackish water	209,525
Taiwan POC	Brackish water	21,892
Philippines	Marine	9,941
Singapore	Marine	985
Kiribati	Brackish water	18
Cook Islands	Brackish water	<0.5
FSM	Brackish water	<0.5

Carps and Barbs (cyprinids). Carps and barbs continue to be most popular species group among Asia Pacific countries dominating 9 ranks of top 10 freshwater species production. Their production is particularly important in terms of vital supply of protein in major populous countries in the region such as China, India and Bangladesh (Table 9).

Table 9 – Carps and barbs top 10 producing countries (2001)	
Country	**Metric tonnes**
China	12,892,221
India	1,964,287
Bangladesh	530,000
Indonesia	236,495
Myanmar	115,793
Thailand	60,199
Lao PDR	43,770
Iran IR	42,750
Philippines	19,568
Nepal	16,570

Silver carp had the highest production but in 2001gave its top production species position to grass carp for the first time.

Common carp, the third largest production species, is literally the most commonly cultured species in the region; 18 countries and areas have reported culturing this species.

Although production of most of species in this group generally exhibit increasing trends, the rate of growth for some species has started to show signs of slowing down since 1997 (e.g. silver carp and bighead carp).

There are reports that the profitability of production of these species in India and China is declining and farmers are starting to explore the production of alternative higher value species. Since the markets of these species are largely domestic, there is limited opportunity for export, although India for example does export to neighboring Nepal and Bangladesh. Myanmar has also recently exported rohu.

Milkfish. Milkfish culture is a strong tradition in the Philippines which reflects country's preference for the species (Table 10). There are also traditions of milkfish culture in some of the Pacific Islands (Kiribati, Nauru, Cook Islands and Palau). Milkfish have typically been produced in brackish water ponds but there is an increasing trend in the reported mariculture production, indicating the more intensive cage systems. These cage systems are fed with either pellets or trash fish and are part of the general trend of intensification of mariculture in the Philippines.

Indonesia and Philippines are traditionally the largest producers. Taiwan is reducing its production possibly because it increasingly focuses on higher value species. Singapore is also steadily developing its mariculture of milkfish

Mullet. Pond based brackishwater culture is typical but Korea RO is reporting increasing mariculture production in 2000 and 2001. Indonesia is the largest producer but its growth in this sector has leveled off in recent years. Thailand has greatly reduced production in recent years and Taiwan POC has also seen a gradual reduction in production.

Crustaceans

Whilst a number of crustacean species are cultured, the predominant commercial species are brackishwater shrimps, freshwater prawns and freshwater/brackish water crabs.

Penaeid shrimp culture. Marine shrimp continued to dominate crustacean aquaculture, with two major species accounting for over 53 percent of total crustacean production in 2001 (the giant tiger prawn, *Penaeus monodon;* and the fleshy prawn, *P. chinensis*). Whilst the giant tiger prawn ranked 5th by weight in terms of regional aquaculture production in 2001, it ranked first by value at USD 4.692 billion (Table 11).

Table 11 – Penaeid shrimp top ten producers (2001)

Country	Metric tonnes
China	304,182
Thailand	280,000
Indonesia	148,558
India	102,930
Viet Nam	67,500
Bangladesh	60,000
Philippines	42,390
Malaysia	27,014
Taiwan POC	8,878
Iran	7,607

Shrimp production levels in the region reached 1.2 million mt by 2001 (accounting for more than 40% of total shrimp landings). The aquaculture production of *P. monodon* has ranged between 480 to 610 thousand mt since 1993, whilst its contribution to shrimp production has declined from 70% to 48% in 2001, as *P. chinensis* and other Penaeus shrimp productions have increased. The production trends in the region have been increasing over the past 10 years for the major producers. China PR suffered major setback in the mid-1990's with the impact of viral diseases on shrimp culture. Since that time, production has slowly recovered.

Other major producers, Thailand and Viet Nam, have also encountered fluctuations in production which are primarily associated with the impact of disease. Productions in the Philippines, India, Sri Lanka and Indonesia have also been affected by the impacts of viral disease (typically WSSV). Generally the high international market demand has maintained interest in the culture of shrimp for export.

More recently, the introduction of *P. vannamei* for culture in the Asia Region has led to increasing production of this species[15]. China has a large and flourishing industry for *P. vannamei* with production of more than 270 thousand metric tonnes in 2002 and an estimated 300 thousand metric tonnes (71 percent of total shrimp production) in 2003, which is higher than the current production of the whole of Latin America. Other Asian countries with developing industries for this species include Thailand (estimated production of 120 thousand metric tonnes in 2003), Viet Nam and Indonesia (30 thousand metric tonnes each), Taiwan POC, the Philippines, Malaysia and India (thousands of tonnes each) [16].

Total production of *P. vannamei* in Asia was approximately 316 thousand metric tonnes in 2002, and it has been estimated that this will increase to nearly 500 thousand metric tonnes in 2003, which would be worth some 4 billion USD on the export market. However, not all the product is exported and a large local demand exists in some Asian countries.

The main reason behind the importation of *P. vannamei* to Asia has been the (perceived) poor performance, slow growth rate and disease susceptibility of the major indigenous cultured shrimp species, *P. chinensis* in China and *P. monodon* virtually everywhere else. Shrimp production in Asia has been characterized by serious viral pathogens causing significant losses to the culture industries of most Asian countries over the past decade. It was not until the late 1990s, spurred by the production of the imported *P. vannamei*, that Asian (and therefore world) production levels have begun to increase again.

There are problems associated with this dramatic increase in the production of *P. vannamei* in terms of the marketing of the product. With so many countries now producing essentially the same product (a relatively small white shrimp), global prices have dropped dramatically during 2002 - 2003. This has also had follow on effects regarding the actual value of the product sold and disagreements regarding possible “dumping” of shrimp onto markets.

[15] The information related to *P. vannamei* is presented in a full review document of the introduction and culture of *P. vannamei* in the Asia Pacific region. FAO and Consortium Program on Shrimp Farming and the Environment (in press).
[16] The reported production of *P. vannamei* to FAO in 2001 was 5,809 mt; only Taiwan POC officially reported the production.

Freshwater prawns. China and India has recently increased the production of freshwater prawns (their productions were zero and 311 mt in 1994 and 128 thousand and 24 thousand in 2001 respectively). Other producers have had relatively stable productions (Table 12). Since it is not as easy to intensify production of freshwater prawns due to territoriality and divergent growth effects, the growth of this sector is reasonably slow. In some countries the sector has shrunk as attention and resources have been diverted towards the brackishwater shrimp production.

Table 12 – Freshwater prawn top eight producers (2001)

Country	Metric tonnes
China	128,338
Viet Nam[17]	28,000
India	24,230
Thailand	12,067
Bangladesh	7,000
Taiwan POC	6,859
Malaysia	752
Iran IR	23

Although the principle species cultured in freshwater (*M. rosenbergii*) does not suffer the same problems with viral disease that impacts the brackishwater shrimp industry so severely, export markets for freshwater prawns are much smaller and less developed. It seems that consumers are not as used to these species as brackishwater shrimp. On contrary, freshwater prawns enjoy quite good domestic markets especially in South and Southeast Asian countries.

Crabs. Chinese river crab and Indo-Pacific swamp crab are major cultured crabs. Chinese production of this freshwater crab showed very strong growth since 1994 and was ranked 11th by volume and 6th by value in 2001 among freshwater species. Indo-Pacific swamp crab showed relatively stable production trends for the past decade.

Mollusc

Mollusc culture is split into low value species produced in extensive type systems (*e.g.* seeded blood cockle mudflats, mussel and oyster stake culture) through to high value species produced in intensive systems (fed systems, and possibly recirculation). Whilst it is possible to separate species such as Abalone or Giant clam as high value species, there are difficulties with some species such as mussels that may be cultured in low input systems in one country (*e.g* Thailand) but relatively high input in another (*e.g.* New Zealand). Many countries report their mollusc production in a large grouping such as marine molluscs nei (Table 13).

Table 13 – Lower value molluscs top ten production (2001)

Country	Species	Metric tonnes
Thailand	Green mussel	89,000
Malaysia	Blood cockle	70,754
New Zealand	New Zealand mussel	64,000
Thailand	Blood cockle	35,000
Taiwan POC	Northern quahog	25,741
Korea, Rep	Japanese carpet shell	16,433
Korea, Rep	Korean mussel	13,653
Philippines	Green mussel	13,513
Taiwan POC	Asian clam	10,030
Korea, Rep	Inflated ark	7,359

The IFPRI/WorldFish study projected increasing mollusc production, although this may have been based on current production trends rather than the resource potential. The issue of site availability is likely to constrain development of mollusc culture in several countries as can be seen for the examples of Japan and Korea.

[17] This figure was reported as Freshwater crustaceans nei. Which was most likely freshwater prawn production, and hence it is included here.

Table 14 – Higher value molluscs top ten production (2001)		
Country	**Species**	**Metric tonnes**
Korea, Rep.	Pacific cupped oyster	3,490,972
Philippines	Slipper cupped oyster	231,495
Taiwan POC	Pacific cupped oyster	174,117
New Zealand	Pacific cupped oyster	19,042
Taiwan POC	Abalones nei	16,837
Hong Kong SAR	Pacific cupped oyster	15,000
Taiwan POC	Abalones nei	7,722
Korea, Rep.	Yesso scallop	4,912
New Caledonia	Pacific cupped oyster	3,500
Korea, Rep.	Abalones nei	1,100

In these two countries, the productions of molluscs and seaweeds have been relatively stable for many years. This indicates that suitable sites are now all taken. Unlike fish culture, the intensification of mollusc culture is quite difficult and probably not economically viable. The trend in mollusc culture is more likely to be a shift from lower value species to higher value species in those areas where sites are suitable (Table 14). A further dimension is the development of intensive on shore culture operations such as those for abalone and a number of gastropod species.

Aquatic plants

Aquatic plant production can be divided into two distinct groups (Table 15). The first group consists of seaweeds of temperate waters solely and traditionally used for food purposes and the second group consists of tropical species mainly processed as a source of commercially valuable biopolymers (carrageenan, agar) that are used for various food and non-food purposes.

Table 15 – Aquatic plants top ten cultured species (2001)	
Species	**Metric tonnes**
Japanese kelp	4,419,356
Laver (Nori)	1,132,037
Zanzibar weed	664,068
Wakame	264,467
Red seaweeds	212,473
Spiny eucheuma	65,382
Elkhorn sea moss	30,502
Caulerpa seaweeds	25,843
Gracilaria seaweeds	17,000
Warty gracilaria	15,611

Seaweeds for food purposes. This group include Japanese kelp, Laver (Nori), Green laver and Wakame. The production of these species is confined to East Asian countries and has a relatively stable production. The only exception of this is Japanese kelp culture. This has increased rapidly in recent years, probably due to continued expansion of cultured areas in China. Production of Japanese kelp peaked in 1998 and since then has showed a decreasing trend. This might indicate that the rapid expansion of production area reached a limit and further sites are not available.

Seaweeds for biopolymers. This group consists of *Eucheuma*, *Gracilaria*, red sea weeds and others. The Philippines has the highest production of these aquatic plants and Zanzibar weed production in Philippine far exceeds the production of other seaweeds (664 thousand mt in 2001). New areas are being investigated for expansion of seaweed production since global demand for carrageenan and other alginates are expected to continue to rise (Table 16).

Table 16 – Aquatic plants top ten producing countries (2001)	
Species	**Metric tonnes**
China	8,159,450
Philippines	785,795
Japan	511,755
Korea, DPR	391,000
Korea, RO	373,538
Indonesia	212,473
Malaysia	18,863
Viet Nam	16,000
Taiwan POC	15,628
Kiribati	1,190

Reptiles and amphibians

Reported species are soft shell turtle, crocodiles and frogs. China PR has greatly increased its reported production of soft-shell turtle in the past 5 years. Crocodile production is growing quickly in the region with Cambodia exporting juvenile crocodiles to both Vietnam and China PR. Thailand also has crocodile farms. This production is rarely reported in fishery or aquaculture statistics.

There is limited data on frog production, although frogs are being increasingly cultured in many countries. The small size of a typical frog farm (using small cement tanks or even pens) means that quantification of this type of operation is problematic.

Niche aquaculture species

There are a number of niche aquaculture species that this review does not cover with statistical information. These species are either cultured at pilot/experimental level or a simply not reported by many countries. Some of the species are not food type commodities (*e.g.* sponge and pearls, ornamental shells, ornamental fish) and are therefore not routinely monitored by the authority reporting fisheries information.

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Review of aquaculture in the Pacific islands

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Introduction

This review provides a brief overview of the status of aquaculture in the Pacific islands, and development issues.

Aquaculture and inland fisheries

Commercial aquaculture

Commercial aquaculture is relatively new to the Pacific region whilst its research and development stages stretches back several decades. The present value of aquaculture production is difficult to quantify due to a lack of information. The complete picture can sometimes be distorted because the aggregated production assigned to the Pacific Islands often does not account for the contribution made by metropolitan territories such as French Polynesia. But, on average, over recent years the amount is estimated to be somewhere in the range of USD130-180 million dollars per annum. Two commodities account for about 90 per cent of the total value, these are cultured black pearls and marine prawns.

Cultured pearls. Cultured black pearls are the product of the black-lip pearl oyster (*Pinctada margaritifera*). The world supply of cultured black pearls is almost entirely produced from French Polynesia and the Cook Islands in eastern Polynesia where the oysters are naturally plentiful.

In these two countries the pearl industry is the second most important economic sector after tourism. French Polynesia reached a peak in production in 1999, valued at USD164 million dollars and 10.8 tonnes (Institut des Statistiques de Polynésie française). Currently there are thirty five atolls in French Polynesia and where pearl farming occurs or is under development. In the Cook Islands, cultured black pearls are mostly produced from one atoll and in 2000 a peak export of USD9 million dollars was achieved (Cook Is. Government Statistics). Thereafter an overproduction of poor quality pearls and disease mortality in both countries reduced the total value of exports to USD131 million in 2002.

Elsewhere in the region, pearl farms have been established in the Fiji Islands, Marshall Islands, Federated States of Micronesia, Solomon Islands, Kiribati, Papua New Guinea and Tonga.

Shrimp farming. New Caledonia is the largest producer of shrimps in the region. In 2003 the country produced USD22 million dollars (1,800 tonnes) of the western blue prawn (*Litopenaeus stylirostris*). With new farms under development the amount of production is expected to double by 2007 to 4,000 tonnes.

The Fiji Islands is also actively developing farming of marine prawn (*Penaeus monodon, L. Stylirostris*) and freshwater shrimp (*Macrobrachium rosenbergii*). The demand from the domestic market, estimated at 600 tonnes per annum, is being met mostly by imported products.

***Kappahycus* seaweed.** For the past decade Kiribati has been the main source of seaweed in the Pacific. In 1999 there was 1,200 tonnes exported with a value of

USD360,000 dollars. In the past five years, a single atoll has been almost the sole producer of seaweed and in 2002 the national exports declined by more then half as farmers on this particular atoll turned to tourism income from visiting cruise liners.

In the late 1980s Fiji rejuvenated seaweed farming and for five years after that exported around 500 tonnes per annum. Thereafter production declined drastically amid reports of domestic marketing and distribution problems (Source: Unpublished Government reports).

In 2002 seaweed farming was revived in the Solomon Islands after an earlier project ceased in 1991. By the end of 2003 several hundred farmers were reported to be active, mostly in the Western Province region (Source: Presentation to the SPC regional seaweed meeting, 2003). The recent success of seaweed in the Solomon Islands has drawn the attention of its Melanesian neighbours Vanuatu and Papua New Guinea.

The total production forecast in 2004 for the region is expected to exceed 1,500 tonnes.

Other species/commodities. The Pacific is an important source in the global marine ornamental industry. Most of the trade involves wild caught fish, coral and invertebrates. About seventy five percent of the export is from Fiji where the industry is worth some US$19 million.

Giant clam cultivation for the marine ornamental market is one of the most common forms of aquaculture in the region. Commercial hatchery production occurs in Fiji, Palau, Marshall Islands, Tonga, Vanuatu, Cook Islands, Kiribati, Samoa and American Samoa. In 2002, Tonga alone sold around 18,000 clams to the aquarium market (Source: Ministry of Fisheries, Tonga). In view of market demand and current hatchery production amongst the region, there are probably between 30-50,000 giant clam pieces exported per annum.

Coral cultivation for the ornamental market occurs at several countries in the region, particularly Fiji, Vanuatu and Marshall Islands. The largest commercial farm, in Fiji, produces 25,000 pieces from 40 different species. In 2003, the annual trade in live rock was estimated at 700,000 metric tons, almost entirely wild harvested with just 50,000 pieces currently under cultivation (Lindsay et al, 2004).

Several species of seawater, brackish and freshwater fishes are farmed for commercial purposes. A successful barramundi (*Lates calcarifer*) farm has been established in Papua New Guinea in Madang. In French Polynesia the few commercial barramundi farms have turned their interest towards the local fish species *moi* (*Polydactylus sexfilis*). Live tilapia is popular at the municipal markets in Fiji where more then 100 tonnes per annum is sold per annum. In Guam the quantity of tilapia has been decreasing since a peak of 150 tonnes in 1993. In Kiribati a semi-commercial government farm produces milkfish (*Chanos chanos*) for the tuna baitfish with plans to market adult smoked fish to overseas markets.

Mozuku seaweed (*Cladosiphon* sp) has a large market established in Japan which has traditionally been supplied from Okinawa island. The seaweed occurs naturally in

Tonga and New Caledonia. In Tonga about 250-350 tonnes of mozuku is harvested per year of which between 50-100 tonnes is cultivated. The dried product exported to Japan fetches up to USD150 dollars per kilogram.

A few species of crustaceans are being developed for aquaculture. The freshwater crayfish known as red claw (*Cherax quadricarinatus*) is farmed in New Caledonia with 6 tonnes produced in 2001 and production expected to rise to meet the domestic demand of 50 tonnes. Some small scale farming of mud crab (*Scylla* spp) occurs around the region. There is some potential in farming the wild caught seed for spiny rock lobsters (*Panulirus* spp).

Artisanal and subsistence aquaculture

In comparison to the neighbouring south east Asian countries, subsistence or artisanal aquaculture in the Pacific is not that well developed. But interest in freshwater fish and shrimp farming is growing amongst rural communities especially those inland with poor access to coastal fisheries.

In Fiji the tilapia is becoming a popular species. Based on the government records of hatchery reared fry it is estimated that about 400 tonnes of tilapia is harvested per annum, often for commercial gains. The Mozambique tilapia (*Oreochromis mossambicus)* was widely introduced but is not considered a good candidate for farming. The variety currently being promoted by the Government is the GIFT strain.

In Papua New Guinea the number of inland and highland fish farming ponds has been increasing. A recent assessment by ACIAR in 2003 (unpublished report) estimated 10,000 fish farmers to be active. The Golden and Cantonese varieties of the common carp (*Cyprinus carpio*) are mainly being farmed but interest is now focussed on tilapia. Rainbow trout (*Oncorhynchus mykiss*) are being farmed in the highland in altitudes upwards of 1,300 meters.

One species of growing interest in the region is the Pacific shrimp (*Macrobrachium lar*). This species is indigenous throughout the Pacific region and is a close relative to the commonly farmed giant fresh water shrimp (*Macrobrachium rosenbergii*) found in Asia. *M. lar* can easily be collected as fry from the wild, attains a large size and is reputed to survive under high stocking densities, attributes that make it a likely candidate for aquaculture. There are reports from several countries of shrimp being successfully harvested from integrated taro swamps or cage culture.

Inland fisheries

Aquaculture and culture based fisheries such as restocking is not well developed amongst the inland fisheries of the region and there remains much scope for further work.

In Papua New Guinea both of the major river systems, the Sepik River on the east coast and the Fly River on the west, support inland fisheries with potential for aquaculture development. The barramundi fishery in the Fly River and Lake Murray is a major commercial fishery that went through a boom-bust experience. Record landings in 1999 were about 170 tonnes valued at approximately USD200 thousand dollars (Unpublished report, National Fisheries Authority, 2003). Mozambique tilapia, originally introduced to the highlands, spread into the lowland and coastal Sepik River areas and became an important artisanal fishery.

In Fiji there are a diverse species of molluscs, crustaceans and fishes considered to be valuable freshwater fisheries. About 300,000 tonnes of the shellfish *Batissa violacea* is harvested per annum. Other fisheries include Mozambique tilapia, eels (*Anguilla* spp), Tawe (*Puntius* spp), Pacific shrimp (*Macrobrachium lar*) and Palaemon shrimp. According to Ministry of Fisheries records collected at municipal markets about 170-200 tonnes of *Macrobrachium* shrimp and 25 tonnes of Palameon shrimp are sold per annum.

Aquaculture policy and legislation in the Pacific Islands

A recent review of twenty one Pacific Island countries conducted for the SPC by Evans et al, (2003) provided a useful benchmark of the status of aquaculture policy and legislation in the region. The review found that there was a general absence of aquaculture policies both at regional and national levels. Similarly the majority of countries do not have specific legislation dealing with aquaculture, often relying on provisions in other statutes, particularly fisheries legislation.

Although the circumstances for each country are distinct the Evans review found some common issues that should be prescribed in policy and legislation. These minimum conditions include (1) provision of effective means for allocation of space (2) provision of statutory rights for sale of aquaculture fish and collection of broodstock and spat (3) renewable licensing for environmental effects (4) devolution of monitoring and enforcement of controls and (5) seafood safety controls.

Efforts are being made to promote regional standards in the absence of national policy or legislation. For example at the 3rd SPC Heads of Fisheries meeting (Noumea, August 2003) some motherhood principles were adopted regarding translocation and introduction of aquatic organisms[1].

Institutional support

Aquaculture research and development is mostly under the realm of government operated facilities. There are at least fifteen Pacific Island countries with relatively significant aquaculture facilities in-place.

In addition there are a number of regional and international agencies in the Pacific that have an interest or direct involvement in aquaculture. The Secretariat of the Pacific Community (SPC) based in New Caledonia is an intergovernmental agency with 22 Pacific Island member countries and serves as a Pacific regional focal point for the sector. The SPC maintains networking, information clearing and technical assistance services in a similar fashion to that provided by NACA to its member governments. The SPC aquaculture portal http://www.spc.int/aquaculture provides updated information and links to the Pacific region.

[1] SPC-HoF Guidelines for the Introduction and Translocation of Aquatic Organisms for Aquaculture and Culture-Based Fisheries. http://www.spc.int/coastfish/Reports/HOF3/E-WP8.pdf

Opportunities for cooperation with the Asia Region

Bio-security

A cursory desktop review recently carried out at SPC discovered that more then half of the recent introductions of new species into the region were for the purposes of aquaculture. On this basis alone it can be appreciated that aquaculture sector has an important responsibility to minimise the risks of virulent diseases, noxious pests or undesirable genetic traits. Many national and regional institutions in the Pacific are seeking to develop their capacity the field of biosecurity and there is potential overlap with existing and emerging capacity in the Asia region.

Marketing

It is thought that one of the main constraints to establishing sustainable aquaculture in the region is poor marketing research and systems. The Pacific and Asia might benefit from accreditation schemes that promote aquaculture systems. In instances where global demand exceeds supply the sharing of market intelligence may help establish stable production. In any regards knowledge of emerging trends in production amongst regions may help avoid countries from duplicating effort and flooding the market place.

Policy and legislation

Many countries in the Pacific region have not taken a strategic approach to aquaculture development. It is notable that those few countries which have (for example the French Territories), now have commercially successful industries in place.

There are potential lessons to be learnt, model legislation, codes of practice and etc which could be shared amongst the Pacific-Asia regions.

Socio-economic

The notion of the Pacific as idyllic islands with swaying palm trees and reefs teeming with fish protein is a misnomer. Food security and poor nutrition remains a pressing issue in the region. There are also limited gender opportunities to participate in cash generating activities.

Aquaculture innovation may contribute to the solution in these areas. These challenges are not unique to the Pacific and are shared by the Asia region, which provides the possibility for collaboration.

Technical cooperation

The exchange of technical expertise between the Asia and Pacific region may be of mutual benefit. For example the Pacific region by virtue of its relative pristine nature may serve as a source of specific pathogen free (SPF) broodstock for the Asia region. Or the domestication of the indigenous freshwater shrimp *Macrobrachium lar* utilising existing knowledge of the Asian *M. rosenbergii* shrimp may provide rural people in the Pacific and Asia with a hardy aquaculture species which can be integrated into existing agricultural practices.

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International trade and aquaculture in Asia

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Introduction

The nations in Asia-Pacific are increasingly focusing their efforts to gain clearer understanding and take strong and unified actions to address issues being faced by their aquaculture sectors in producing commodities for highly competitive markets, and increasing challenges in international trade of aquaculture products. The most visible aquaculture trade issue in 2003 was the US antidumping case against several major developing country shrimp producers, but though highly significant, this trade problem only serves to highlight the growing significance of international trade and aquaculture products, as aquaculture continues its transition to a major food producing sector and supplier of internationally traded seafood products.

> Trade figures show the importance of aquatic products trade to developing economies. In 2001 the value of global fish exports was US$ 56 billion, 50% of this from developing countries, 25% by Asia. More significantly the net export revenues from fisheries for developing countries was US$18 billion. The developed countries imported more than 80 percent of world imports in value. The EU, USA, and Japan together imported 77 %.

Major aquaculture producing countries in Asia increasingly have to address a wide spectrum of trade issues. It has become essential to assume responsibility not only for the quality of the product but for the actions taken, or not taken, in producing it (AquaMillennium 2000 Report). Environmental and social responsibility are joining food safety and quality assurance as requisites to market access. During 2003, regional efforts have been intensified to address non-technical barriers to trade. And because of the imperative to address poverty, governments are taking on the practical but knotty question of how trade in general and compliance with regulations and standards, in particular, can benefit rather than work to marginalize small and poor producers. (In the trade of live reef fish, concern extends to conserving biodiversity and the resource base, protecting the health and welfare of fishers, and maintaining the harmony of fishing communities).

Most farms in Asia 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.

Overview of market access and trade issues and their implications

Food safety and quality

Demand for safer seafood is increasing and as a result the international trading environment is changing, with food safety issues in particular receiving considerable attention. This has given rise to a number of challenges for Asia that need urgent attention (see the chapter on “Food Safety and Quality in Aquaculture”, this volume).

Trade barriers

Food safety and quality are no longer the only requirements to accessing markets. But even SPS measures have been used as an excuse to raise non-tariff barriers to trade. Linkages to environmental responsibility, animal welfare, labor 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, 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 that they might eventually be pushed out of the business. Governments of developing Asian nations can ill afford, for economic as well as political reasons, to allow small farmers to be taken over or pushed aside. The challenge therefore is to enable the small farmers of Asia 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 require much commitment from and cooperation among stakeholders.

The impediments to trade providing the perceived benefits to poor countries have mostly come in the form of non-tariff trade barriers. The future of fish exports from the developing countries is seriously threatened by regulations, which are being progressively imposed by the major fish importing countries. For example, the directive on "zero tolerance" effectively makes producers of poor exporting countries pay for the cost of reducing the risk of eating seafood products to the health of consumers of rich importing countries. Experts point out this is a valid and acceptable requirement, but for one crucial scientific point: the minimum level of any of the substances in question – chloramphenicol or nitrofurans -- causing ill-health, such as cancer, has not been established. In other words, producers are paying to reduce a risk that is not established and, therefore, for an uncertainty that is completely unknown. Nonetheless, countries have launched measures – some rather expensive for a developing country -- to prevent banned chemicals from getting into seafood products. That said, some of the better measures include adopting codes of practices and/or better management practices that reduce or eliminate the use of chemicals and drugs in culture systems

> Sanitary standards have been be used to raise barriers by the lowering of, say, residue tolerances to extreme levels. For instance, the directive on "zero tolerance" to aquatic products containing residual chloramphenicol and nitrofurans effectively makes producers of poor exporting countries pay for the cost of reducing the risk of eating seafood products to the health of consumers of rich importing countries.

A very recent issue is bio-terrorism. At the AquaMarkets conference[1], the Bio-Terrorism Act in the USA was mentioned as a possible non-tariff trade barrier. At the

[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.

least, it has added more steps and therefore costs to export procedures; some claimed it will mean more and longer delays in delivery or outright rejection of shipments. 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 people. Efforts are in fact being done to comply with the requirements of the law; a case in point -- Thailand and the USA 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 US. Still and all, the bottom line to exporters is additional procedures and costs.

Other recent 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 US. While industry observers in Asia and the US 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, Asian exporters must face up to the reality that anti-dumping measures will remain a threat, whatever their motivations.

These realities that face 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 of 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 programs that address these issues will find it more difficult to compete with those that have responsible programs.

Trade liberalization and poverty

The recent spate of free trade agreements (FTAs) being negotiated or already signed by various countries or by economic blocs such as ASEAN with other countries prompts this cautionary note relating to free trade and its impact on poverty. On 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, macroeconomic stabilization, exchange rate adjustment and adequate safety nets." Recent studies on the impact of trade liberalization on reduction of poverty show that it can alleviate poverty but evidence is still not strong since findings vary among countries (UNESCAP, 2001). There is a growing clamor for more studies on the impacts of FTAs on, especially, the agriculture sector that would also provide governments with better guidelines for negotiations.

Regional initiatives and responses to trade and related issues

The issues outlined above have prompted an increasing need to bring a trade dimension to work on aquaculture development in the region. The responses that have been initiated, and the broad and specific options that have been recommended by NACA initiatives on trade in aquatic products are noted below.

Strengthening capacities to comply with SPS standards

Asian countries are moving towards strengthening implementation of sanitary and phytosanitary standards in aquaculture production, for food safety and aquatic animal health reasons. Trace-ability of product is going to become essential for products to enter major importing markets. Application of HACCP is now moving back down the production chain from the processing plants to the producers, and eventually will include all inputs to aquaculture, such as feed and seed.

With the concern that international standards are being applied as trade barriers -- without consideration of the circumstances and reality of Asian aquaculture production, and the potential costs to small-scale producers to adopt international sanitary and phytosanitary standards at farm level -- participation of developing countries in development of international standards, such as the CODEX and OIE (World Organization on Animal Health) standards, needs to be given higher priority, by both developed and developing countries, to ensure their relevance to and fair application in Asian aquaculture.

> On hazard management, a WHO/FAO/NACA Study Group in 1997, recognized the wide knowledge gap as a hindrance to the process of risk assessment and the application of risk-management strategies on food safety assurance for aquaculture products, and the difficulty in applying HACCP to small-scale farming systems. (A follow-up activity to the study was a training on implementing HACCP procedures in fishfarms). The importance of Asia as a region of production, and within Asia, of freshwater finfish, which are mostly sold in the domestic market (even as tilapia is now exported in higher volumes, milkfish in various product forms is vigorously promoted in foreign markets, and Vietnamese *Pangasius* catfish or “basa” has been exported in significant volumes) has a significant bearing on human health problems associated with products from aquaculture. These make farm-level HACCP – particular for small farms – worthy of a strong research and development attention.

Developing countries need to engage more actively and effectively in the standard setting processes of international bodies such as Codex and OIE. The fishery sector in Asia, for example, thanks to a joint FAO, NACA and OIE initiative, has started to participate in OIE’s aquatic animal health standard setting, which has traditionally been the domain of livestock veterinarians. AquaMarkets 2003 emphasized the importance of developing “common positions” through cooperation and put forward these positions more effectively to international standard setting bodies. Awareness raising of the importance of SPS in trade of aquatic products, and capacity building among governments and private sector is also important. Many fishery agencies in the region are not fully aware of the issues, and their implications, but small-scale producers will be hit hard by the trade standards when applied. Producers increasingly bear the costs of applying new standards for food safety and animal health and small-scale producers are probably least well equipped to do this. Measures need to be put in place if small-scale producers in particular are not to be squeezed out of the seafood trading system.

Certification of aquaculture products

Concern has been raised that certification and labeling may become another non-tariff barrier and the implications of such a possibility for small-scale producers. Certification related to better management of aquaculture, if implemented in a fair and practical way, sensitive to the needs of small producers, may provide opportunities to support responsible and sustainable development of aquaculture, addressing the negative environmental and social concerns over some forms of aquaculture. This will require the active participation of developing countries in the process of development of certification principles and schemes that take account of the special circumstances of aquaculture development in Asia. At the same time, the possibility of increased confusion in seafood markets, and additional cost burdens among producers and producing countries exists from multiple certification schemes; several organic and other certification schemes are being developed or promoted. As some form of certification and eco-labeling of aquaculture products is inevitable, the time is right to actively engage the producers and producing countries of Asia in the process of developing "principles, criteria and standards" and in understanding and harmonizing approaches to certification.

Proposed certification in the live fish trade will go even further in addressing a mix of health, environmental, ecological, social, economic, community welfare, and cultural issues (ADB, 2003). For cultured reef fish species, work on standards for better aquaculture practices is going on that form the basis of codes of practices and might eventually be incorporated in certification schemes.

Finding ways to benefit fully from market chains

With increasing attention to food safety, labeling and trace-ability, market chains are becoming more vertically integrated, according to the "farm to plate" philosophy. Thailand has declared 2004 as "Food Safety Year" to increase awareness and improve systems for safe aquaculture production, and link "safe" food producers to processors and market access. Capacity building and technical assistance will be essential to ensure small-scale producers can participate and benefit from such trends. The implications of trace-ability for the small-scale services and input suppliers surrounding some aquaculture systems with very fragmented input supply and trading systems remains to be seen. At the same time, vertically integrated market chains may provide producers with more stable markets, and indeed opportunities for funding from "higher" in the chain to support costs of transition to better practices.

> Shrimp farming generates globally US$6-7 billion at the farm gate. At the consumer plate, the product is worth well over US$40 billion. The strict food safety requirements and SPS measures being required are increasingly being put on the producer at the bottom of the chain – adding an additional cost to small-scale producers at a time when commodity prices for shrimp products are at best stable, and likely going down. Ways need to be explored to bring some of the values to assist producers develop, and adapt to the modern market chains and consumer demand.

Building the right institutions

Traditional fisheries and aquaculture institutions are not yet well equipped to address issues surrounding trade and aquaculture products. With major shifts in trading patterns and market chains, the appropriate institutional support will be necessary for small-scale aquaculture producers, and the network of support services and associated small-scale industries, if they are not to be excluded from or driven out of the international fishery trading system. The issues need to be understood, and trading positions and capacity building and national policies and institutions put in place to provide the necessary support to small-scale producers. There are considerable benefits to rural communities and poor people from responsible development of aquaculture and international trade in aquaculture products. Institutional change may be necessary also, such as more emphasis on empowering farmers and farming groups to organize at the base of the chain. The opportunities for "self – help groups", formal or informal organizations of small-scale farmers, as a way of bringing small-scale producers together, and a foundation for better market access are promising and need to be explored.

As many Asian nations face common issues affecting the aquaculture sector, there is a considerable opportunity and need to improve national, regional and international cooperation to share information on markets and trade in aquaculture products, and to ensure that relevant information on fisheries and aquaculture are provided to those engaged in trade negotiations, and to enhance cooperation between private and public sector. AquaMarkets 2003 emphasized that nations in the Asia-Pacific region should develop common stances on regional and international issues of interest to the aquaculture sector, such as in harmonizing standards and technical regulations, and develop common regional positions and understanding on issues of interest to the region, for example on Codex Alimentarius, OIE standard setting, and other relevant work on international aquaculture standards. There are a number of other trading issues and agreements being discussed in the "Doha Development Round", even after the problems of Cancun, including Multilateral Environment Agreements, subsidies, services and others, that will have an influence on international trade of aquaculture products. Better understanding of the issues, and participation of developing countries in the discussions will be essential.

Finally, AquaMarkets 2003 emphasized transparency and cooperation in information sharing and the need to strengthen information 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 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% 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.

Pro-poor policies and interventions in trade

NACA/STREAM in collaboration with a UK based organization recently launched a study that addresses the issue of trade in aquatic products and poverty. Supported by the DFID "EC-Poverty Reduction Effectiveness Fund" or EC-PREP, the project, "International Seafood Trade: Supporting Sustainable Livelihoods Among Poor Aquatic Resource Users in Asia," seeks to identify options that improve the effectiveness of poverty reduction in international seafood trade. To do so, the project is investigating trade policies and mechanisms that support environmentally and socially responsible seafood production in order to (i) provide clearer understanding of seafood trade and poverty in producing countries, (ii) identify mechanisms for pro-poor development interventions in seafood trade, (iii) support the gathering of experience from the wide diversity of stakeholders involved, (iv) ensure widespread dissemination of findings and development options to the key institutional and individual stakeholders, and (v) explore innovative market based mechanisms and pursue these through EU-Asia business partnerships. Commodities of interest under the project are shrimp and marine fish, especially reef species, including ornamentals. The expected outcomes of the project are a review of trade and poverty in fishery sector, emphasizing aquaculture production; a better understanding of poor people's livelihoods and seafood trade through "case studies"; options for pro-poor seafood trade; and information materials to aid policy and program planning.

The growing awareness that environmentally sensitive aquaculture makes good business sense and helps the poor and small farmers has spurred efforts to further promote adoption of environmentally and socially responsible farming practices through appropriate standards or codes of conduct. In this regard, and following up 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 conclusions elaborate on a number of issues highlighted by AquaMarkets 2003 and support the underlying themes of: (i) promoting trade to improve the lot of poor farmers (ii) helping small producers comply with market requirements, including exploring ways of cooperation among them, and among participants in the market chain, as a pathway to enhance competitiveness and encourage responsible aquaculture and marketing practices, and (iii) providing the environment and empowering farmers to organize to strengthen their capacities to negotiate for favorable terms and to achieve economy of scale. The report of the Forum that includes a set of 15 conclusions is found in www.enaca.org/aquamarkets.

Conclusions

The specific responses to the various market access and trade issues outlined in this review would be facilitated by a number of options recommended by AquaMarkets 2003[2] and Global Aquaculture Forum. These are 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.

These are:

- Cooperation among farmers and promotion or enhancing the role of farmers associations.
- Cooperation among stakeholders, particularly those along the marketing chain, to strengthen their linkages and improve overall competitiveness.

[2] The 10-point recommendation of AquaMarkets 2003 is found in www.enaca.org/aquamarkets. These were also recommended for incorporation into the report of the APEC Fisheries Working Group Workshop, "Current Situation and Market Perspectives for Aquaculture Products," held in November 2003 in Lima, Peru, by the workshop participants.

- Investment in capacity building for quality assurance, and assistance in the development of codes of practices and guidelines for better management and manufacturing practices.
- Cooperation among governments with the view of reaching a common and cohesive stand on issues that impact in their aquaculture sector and facilitating trade among or between each other, including the simplification of trade procedures.
- Provision of well-informed advice to governments for more effective participation in various forums including trade negotiations.
- Improving the domestic marketing system to increase its impact on the social objectives of poverty reduction and food security assurance.
- Consistent policies that assure adequate incentives in the form of real prices for products, without intervening directly in prices.

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Poverty reduction and aquatic resources

Graham Haylor

Introduction

The Millennium Development Goals call for a reduction in the proportion of people living on less than $1 a day to half the 1990 level by 2015. This means reducing from 28.3 percent of all people in low and middle income economies to 14.2 percent. The Goals also call for halving the proportion of people who suffer from hunger between 1990 and 2015.

If projected growth remains on track, global poverty rates will fall to 13 percent – less than half the 1990 level – and 360 million more people will avert extreme poverty. So while poverty would not be eradicated, that would bring us much closer to the day when we can say that all the world's people have at least the bare minimum to eat and clothe themselves.

At the World Food Summit organized by the United Nations Food and Agriculture Organization (FAO) in Rome in 1996, food security was defined as "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." It was at the same summit that countries originally committed to reduce the number of malnourished people in the world by half by the year 2015.

Progress in eradicating hunger, however, has been slow and the situation has been worsening in some regions, notably South Asia. Malnutrition plays a role in more than half of all child deaths. Malnutrition in children is caused by consuming too little food energy to meet the body's needs. Adding to the problem are diets that lack essential nutrients, illnesses that deplete those nutrients, and undernourished mothers who give birth to underweight children. Raising incomes and reducing poverty is part of the answer. But even poor countries need not suffer high rates of child malnutrition. They can make big improvements.

According to the Director General of FAO, fisheries and aquaculture contribute significantly to food security in the Asia-Pacific region. Fish make up more than 50% of animal protein in most countries of the region. Fish provides a high protein food with additional benefits such as calcium, vitamin A, omega-3 fatty acids and iodine, deficiencies in which are detrimental to the physical and mental development of all people, especially children. Speaking in Bangkok in 2001[1] the FAO Assistant Director-General and Regional Representative for Asia and the Pacific said that greater recognition must be given to the nutritional role of fish for the poor, especially those living on and near water bodies. Fish and other aquatic resources, even when eaten in small quantities, often have a defining role in nutritional security and it is this security that is most threatened as the natural supplies disappear. Fish production should be adequately considered in order to obtain a fuller picture of food availability and nutritional adequacy.

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[1] Workshop on Improvement of Fishery Statistics in Asia and Pacific Countries Bangkok, Thailand, 6-10 August 2001 Opening statement By Dr. R. B. Singh

Poverty reduction objectives often fall to the public sector, and to their credit Asian fisheries line agencies (which deal with aquaculture and aquatic resources) have long accepted poverty reduction as part of their role. Whether prominent or somewhat buried, within the mission of each line agency with responsibility for aquaculture in Asia will be a phase relating the objectives of aquaculture development and poverty alleviation. Unfortunately, it is a good deal rarer to find aquaculture objectives within the policy documents of national and international development agencies; although there is increasing evidence that aquatic resources management – both capture fisheries and aquaculture - can play an effective role reducing poverty.

One the one hand, not unreasonably, the *fisheries specialists*, alone or associated within agriculture, livestock or environmental agencies have tended to take a resource focus to their work. "The resources exist and therefore we should encourage aquaculture". "Research has delivered technologies which are commercially successful and therefore we should extend these to poor people". These remain worthy objectives and reflect noble sentiments but they perhaps presuppose too much about the access to resources of people who are poor and the capacity of vulnerable people in remote areas with little voice and limited service provision.

Development specialists, on the other hand, tend to seek richer understanding of their 'poor clients'. They have developed ways to learn about strengths, fears and vulnerabilities and are beginning to think in terms of entitlements and rights. These are big and important issues in the lives of people who are poor. The ideas that comprehensive baskets of livelihood choices should result from such approaches to poverty alleviation perhaps assumes too much about the universal (multi-disciplinary) knowledge that development specialists working together with people who are poor can have.

It is clear that fisheries and development specialist have much to offer and much to learn from each other. It is therefore highly appropriate that the major contemporary trends in Asian aquaculture that relate to poverty reduction are the gradual coming together of these groups, the emergence of a shift in thinking, the appearance of new ways of working and the beginnings of impacts from poverty reduction efforts involving aquatic resources.

Building on the resource-focused approach to Asian aquaculture by putting people at the centre of development thinking

As introduced above, the scope for aquaculture in poverty alleviation has previously been diminished by a resource-focused approach, which sometimes over simplifies how (poor) people and (aquatic) resources interact and thus affects the way in which support is provided. An emerging approach in Asian aquaculture looks in more detail at livelihoods[2] issues and seeks opportunities to support resource management, access, and helps to understand the properties of resources including their utility for aquaculture, as well as

[2] For more information about livelihood approaches see www.livelihoods.org

the *functioning*[3] they permit and the benefit they generate. This shift in thinking brings to light new issues and helps to build a more complete understanding of the role that aquaculture, and aquaculture service providers, can play in poverty reduction.

The box below attempts to encapsulate the shift in thinking from "resources" to "people" and the issues this approach throws up.

Resource-focused approach	**People-centered approach**	**New issues**
Resources exist	Resources exist	

	Some people secure command over resources	• Who has:
		  • Right of access?
		  • Security of tenure?
		  • Security from theft?
		• What are the social conventions of ownership[4]?

	Some resources have desirable properties	• Is there an appropriate natural environment (regarding: water quality, quantity, productivity, freedom from disease, not vulnerable to shocks such as floods, drought)? • Is there appropriate human and social capital (i.e. knowledge and networks of support)? • Is there connecting infrastructure (access to fish seed, access to inputs, and access to markets)? • Are there effective support services (financial, technical and institutional support)?
	What can a person succeed in doing with resources at his or her command?	(In the context of motivations, interests and circumstances of people) • Can resources yield aquaculture produce? • Can aquaculture produce provide improved nutrition?
Poor people grow fish	The state of well-being generated from succeeding	• Can poor people improve well-being through aquaculture? • Can assets be built up through aquaculture (better used water resources, more effective infrastructure, savings, knowledge, useful links and relationships) • Can aquaculture reduce vulnerability?

[3] *Functioning* is an achievement of a person. It is different from having access to resources (which precedes it) and having utility in the form of well-being, which follows from that functioning. (For more explanation about functioning and utility see Sen, 1981)

[4] I.e. Why is ownership (e.g. of a fish pond) accepted? – Because she got it through exchange through paying some money which she owned. Why is ownership of that money accepted? – Because she got it through selling goods. Why is ownership of those good accepted? – Because she made them with her own labor, and so on.

Highlighting the role of aquatic resources in the lives of people who are poor and developing new ways of working

Until recently, the special role played by fish and other aquatic resources as an essential component of poor people's diet and the role which fisheries and small-scale aquaculture plays in poor people's livelihoods has been almost ignored. So much so that planning, policy and support to this sub-sector has been very limited.

The problem has been that there is little available documentation of the lessons that have been learned, few opportunities for dialogue and mutual learning, and sometimes poorly coordinated efforts to inform policy makers of the benefits of these approaches. The awareness of successful practice among policy-makers, government agencies, regional institutions, non-government workers and natural resource users has been low.

> In the current context of many fully exploited and exhausted fisheries and campaigns against some commercial shrimp practices, the United Nations Food and Agriculture Organization (FAO) Code of Conduct for Responsible Fisheries (CCRF) is an important call for action towards responsible aquatic resources management and extremely relevant to environmental as well as social sustainability. Another key vehicle to counter the under representation of the role of aquaculture and aquatic resources management in the lives of poor people has been the NACA-FAO *Aquamillenium* Conference resolutions. NACA, co-ordinating the wishes of 15 Asia Pacific governments continue to highlight how small-scale aquaculture and fisheries form the mainstay of the livelihoods of millions of poor people across Asia Pacific', through its programs and the regional STREAM Initiative

However, in recent years a number of prominent Asian and international organization have been responsible for highlighting the role of aquatic resources in poor peoples lives[5] and developing new ways of working.

Too often it has been assumed that a lack of technical knowledge is the key constraint to poor people's management of natural resources. However evidence is increasingly showing that poor people already have an enormous store of 'indigenous technical knowledge', but this knowledge is often undervalued or ignored. Similarly, effective policies and ways of working already exist yet are little shared around the region.

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[5] Amongst these are the Asian Institute of Technology, Aquaculture and Aquatic Resources Management (AARM) Outreach Program (notably the value of non-rice rice field harvest), the Network of Aquaculture Centers in Asia Pacific (NACA) and the Food and Agriculture Organization (FAO) of the United Nations (UN) (and the Aquamillenium Conference, 2000), the International Union of Conservation of Nature (IUCN), the Mekong River Commission (MRC) (in their ten year plan for *Freshwater Aquaculture in the Lower Mekong Basin*), the International Institute for Rural Reconstruction (IIRR) (in their write-shop on Utilizing Different Aquatic Resources for Livelihoods in Asia) and the Support to Regional Aquatic Resources Management (STREAM) Initiative (in their regional capacity building and policy development work).

The Mekong River Commission in its aquaculture planning process (Phillips, 2002) lends weight to the emerging trend towards poverty reduction objectives within Asian aquaculture around the lower Mekong. The report recommends that:

- The main thrust of future aquaculture development should be directed towards small-scale aquaculture.
- Building effective support services for small-scale aquaculture are emphasized.
- Planning processes and policy reflect the needs of rural households and support improved access to extension services.
- Research agendas of national institutions, and indeed the MRC's own agenda of support, should evolve, and based on the needs and livelihoods of rural households.

MRC highlights that there are some experiences already (e.g. they cite the MRC READ project areas, in southern Lao PDR, the NACA regional STREAM Initiative), and that the greatest potential for small-scale aquaculture to contribute to development probably lies in the food insecure and remoter areas of the basin, such as highlands and areas away from major fisheries of the Mekong and the Great Lake in Cambodia. They conclude that there is a need to further share and extend these approaches to other areas and that strategic analysis of aquaculture potential should be undertaken to support key areas.

Just such analysis and actions have been underway since 2001 through the 'Support to Regional Aquatic Resources Management' or 'STREAM' Initiative which has been established by a coalition of development partners including the Network of Aquaculture Centers for Asia Pacific (NACA), the UN Food and Agriculture Organization (FAO), the international NGO Volunteer Services Overseas (VSO) and the UK government Department for International Development (DFID), to address the need for learning and communications. The STREAM Initiative encourages national governments and NGOs to engage with the new thinking and take on new ways of working to address poverty issues through aquaculture and fisheries. It aims to support poor people's livelihoods through improved communications, and by influencing institutions and policy development to better support the needs of poor people who are involved with fishing and small-scale fish farming. An FAO Expert Consultation in support of the STREAM Initiative (Friend & Funge-Smith, 2002) summarizes many of the recent lessons learnt:

- Understanding the context - of poor people's livelihoods, as well as institutional and policy making processes is essential
- Targeting - in an inclusive manner - is essential to ensure that benefits reach poor people, and that strategies are appropriate to poor people's circumstances
- Effective participation of poor people and project partners is essential, both as a means to an end and as an end in itself
- Aquaculture and aquatic resource management strategies may not in themselves be sufficient to address all the needs of poor people, but can be important components of wider, cross-sectoral interventions. This requires more effective co-ordination, with innovative partnerships
- Supporting poor people to organize effectively to exert influence on development planning and policy making processes, to secure rights of access to and control over aquatic resources, and to share and learn from each other's experience
- Supporting institutions to be more responsive to the needs of poor people is essential in order to ensure that the deep-rooted causes of poverty are addressed, and that strategies adopted are sustainable

The regional organizations represented in the consultation shared their ideas on what works and what does not work when aquatic resources is used as an entry point for poverty reduction.

What works?	Why does it work?
• Demand-led, farmer first, people centered approaches	• This develops strategies that are appropriate to local context and poor people's needs
• Extension of appropriate technologies (for example, hapa spawning hapa nursing)	• Low cost, low risk - very appropriate for poorer groups such as women
• Low food chain species, in low cost systems and marketed at small size	• Consumed within the household (whereas high value species are more likely to be sold)
• Breaking up the production cycle, deliberately identify opportunities for poor landless people to become involved in parts of this.	• Creates opportunities for groups that would otherwise not be able to derive direct benefits from aquaculture
• Transparency and involvement in decision making	• Generates sense of ownership • All have something to offer, and benefits to gain
• Target all the household members	• Women and girl children may otherwise be denied access to benefits
• Technologies have to be developed according to the local context	• Integration of aquaculture and aquatic resource interventions for the poor where they are integrated with agriculture is better. i.e. must be part of the larger livelihood system • Adoption is often quicker than if aquaculture is used as an individual intervention
• Farmer field schools	• Farmers given opportunity to discover and learn processes rather than be told facts • This enables them to make decisions from a position of knowledge
• Networking /partnerships exposure trips	• May be costly and difficult to establish, however there can be considerable benefits
• Farmer to farmer visits	• Relate well to each other • Use farmers to train other farmers
• Projects endorsed by respected persons (royal projects), but follows other preceding principles	• Motivates people and ensures full effort from local people • Ensures that projects meet the needs of intended beneficiaries
• Monitoring and evaluation should involve participatory process that can identify qualitative aspects - including local people's indicators of success	• Allows poor people to critically assess strategies and outcomes
• Good staff facilitators	• Maximizes communication, experience sharing group strengthening
• Targeted, limited subsidies	• Some form of subsidy may be appropriate, particularly for the poorer farmers, but there must • be some form of contribution from the target beneficiary
• Supporting local fry traders as extension workers	• Fry traders and seed producers have the greatest incentives to transmit information and skills to their clients.

What does not work?	Why does it not work?
• Inappropriate subsidies and training allowances	• Subsidies can suppress farmer innovation, creating artificial environment for production that may not be viable once subsidies are no longer available • If farmers are providing their own inputs they make more careful decisions
• Large centralized hatcheries	• Do not reach remote areas too expensive and often fail after withdrawal of support • Opportunities for poor people to become involved in hatchery production and trade are denied
• Technology led interventions	• Mostly technologies already developed were not targeted at the poor and adoption is low
• Overseas training for extension staff	• Poor design & inappropriate curricula • Not cost effective • Trained staff may leave the sector (although capacity developed may be useful in other aspects of work)
• Top down management planning, extension etc.	• Out of touch with local circumstances and local needs • Leads to jealousy and problems with patron client relationships • Maybe we want to do this? Social capital and networking is damaged
• Targeting only the poorest	• NGO in a series of villages and targeted only the poorest - when they left the poor who had been targeted had lost access to the patrons that they had previously relied upon
• Projects themselves should not provide credit	• Causes problems and is inefficient. The project should seek to work through existing finance structures. Project should facilitate access • Might be possible provided there are distinct separations between the roles - i.e. a specific person for the credit - but there may still be some confusion
• Short term projects	• Insufficient time for learning • Slow reaction time means results often only occur after project closure

The beginnings of impacts from poverty reduction efforts involving aquatic resources

DFID research and development support, channeled through STREAM is already giving people a role in policy making and beginning to shape new policies and the beginnings of impacts from poverty reduction efforts involving aquatic resources. For example in India where the process for bringing through the voices of poor people, or ‘making it easier for people to speak for themselves’ has involved many stakeholder meetings at village, state, regional and national level. There has been engagement with state and national level policy actors through an iterative consensus-building mechanism. A range of communication materials have been used to bridge discourse gaps including the use of live drama, video films, and short statements by representative fishers and farmers, implementers and state and national level policy actors (STREAM, 2003), these various media products successfully supporting communication with apical policy makers in Delhi (DFID, 2004).

FAO and VSO support includes the provision of technical assistance and livelihoods capacity building support to NACA members. It is hoped that this will contribute to enhancing the livelihoods of the rural people through improved management of aquatic resources and sustained support that can make a positive difference.

The future

The future direction for poverty reduction through aquatic resources management holds many new challenges. How to build associations and groups to work together? How to bring service provision to vulnerable groups? How to influence institutions to hear? How to co-manage fisheries with local communities? How to encourage sustainable management of inland and coastal resources and how to combat destructive practices? How to ensure trade in fisheries products brings benefits to poor people? How to breakdown the so-called digital divide and bring the positive elements of globalization to work for poverty reduction?

Yet new thinking, such as people-focused approaches and understanding of entitlements, are giving rise to new ways of working, of engagement and empowerment and new ways of communicating are already breaking down discourse gaps. The use of innovative communications processes is breaking hierarchies and building bridges. Internet tools and electronic communication combined with new skills in facilitation and management are now bringing cost-effective solutions to problems that only 3 years ago seemed implausible. Advances in monitoring and evaluation continue to open up new vistas and new insights to understand and to combat poverty.

There has perhaps never been a more exciting time to be building institutions and policies with people, through a livelihoods lens, and sharing these more widely than has ever been possible.

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Food safety and quality in aquaculture

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Background

International trade in aquaculture and wild fisheries products – or seafood[1] - is a multi-billion dollar sector, with global volumes expanding from around $7 billion in 1976, to $57 billion in 2003. Developing countries dominate seafood exports, contributing over 50% to the internationally traded seafood, with developed countries accounting for 80% or more of the imports. Asian developing countries top seafood production statistics, contributing to international trade, as well as domestic consumption. Aquaculture now contributes significantly to global seafood trade as well as domestic consumption, and the sector is expected to continue to become increasingly significant due to stagnating supplies from wild capture fisheries.

At the same time the volume of trade and consumption is increasing, consumer demand for safer seafood is also increasing and as a result the international trading environment is changing, with food safety issues in particular receiving considerable attention. Apart from concerns around food safety driven by requirements to remain competitive in export markets, there is also increasing awareness of the need to give proper attention to assuring food safety for domestic consumers in Asian developing countries.

Whilst aquaculture offers considerable opportunities for better control of quality and safety of products for human consumption that wild fisheries, the growing awareness of food safety in aquaculture products have lead to a number of challenges for Asia requiring urgent attention.

"Shared responsibility"

"The Study Group recognized that the production of safe foods from aquaculture was the shared responsibility of governments, industry and consumers, each having an important role to play in the protection of human health. Action at all levels is required for the development of regulations and the provision of resources for enforcement of, education and training in, and research on, responsible practices of aquaculture. The Study Group recommended the adoption of an integrated approach to the control of hazards associated with products from aquaculture. This will require close collaboration between the health, agriculture and aquaculture, food safety and education sectors. (from WHO/NACA/FAO,1999).

Some food safety challenges

Traditionally, food safety in aquaculture and capture fisheries has been concerned with post-harvest handling and processing. Now, with importing country consumers and regulators becoming more concerned about residues and quality, attention is shifting to the way seafood is produced hence there is more concern about food quality and safety at the farmer level, including inputs used, where they came from, and the way farms and animals are managed. Such challenges require new approaches to farming, with aquaculturists working together with food safety experts to develop systems for farming aquatic animals that assure food safety – this is the concept of "shared responsibility" highlighted by a 1997 WHO/NACA/FAO study group (see box). This is particularly important for species

[1] Seafood refers to traded aquatic animal products.

destined for international trade, such as shrimp, but is also important for domestically traded products. Internationally accepted, science based quality control mechanisms, such as risk assessment and HACCP and Good Hygienic Practice (GHP), will become essential requirements for trading in aquaculture products.

Food safety concerns are also leading to new demands for trace-ability of aquaculture products. This will not be easy with the large number of small-scale farmers engaged in production, and the fragmented supply chains operating in many countries. Substantial institutional re-organization, legal and policy development, awareness raising, capacity building, and investment, will be essential among the diverse stakeholders in public and business sectors to make this work. A workshop organized by FAO during 2003 has, for example, emphasized the importance of upgrading policy and legal frameworks, capacity building and institutional re-organisation within ASEAN countries to enable them compete in international markets (FAO, 2004). Cooperation through the market chain – from input suppliers, farmers, traders, processors and exporters – will be essential to address stringent international standards and trace-ability requirements. Farmers, or countries, that are unable to put in place the relevant structures will fail to access many major importing markets, potentially creating significant social and economic impacts.

With most countries in Asia giving increased attention to food safety, there is a growing proliferation of product certification systems, "good aquaculture practice" guidelines, Codes of Conduct, and other mechanisms/schemes intended to provide a basis for safe and sustainable seafood production. Without some harmonization among regional countries, this proliferation of certification schemes has potential to confuse consumers and importing countries, lead to increased costs, and potentially constrain trade. Harmonisation of standards for food safety will be further driven by practical considerations with the increasing number of "free trade agreements" and need to harmonize approaches among trading partners.

Asian domestic and intra-regional trade in aquaculture products, services and inputs such as feed and chemicals, is growing, in line with increasing free-trade agreements between countries. This opens new opportunities for trade and development, perhaps helping to avoid some of the complex procedures of other importing regions, but also poses challenges. This further emphasizes the need for harmonization of food safety assurance procedures among trading partners in Asia. Such cooperation may also avoid problems of residues being transferred from one country to another.

International food safety standards are being set with minimum inputs from the region, in particularly from the producing sector, for various reasons. Asia needs to enhance and organize better its inputs to international food safety standard setting bodies such as Codex Alementarious, given the importance of such standards for future trade in aquaculture products from the region.

Applying new food safety standards and trace-ability poses special organizational difficulties for the large community of small-scale farmers in the region, and as a consequence, some of the poorest farmers might be at risk due to difficulties in participating in such schemes. There is a need therefore to better understand the implications of new food safety standards and international trading standards for small-scale farmers, and develop suitable market-oriented solutions to the problems faced by the small-scale sector, allowing the sector to benefit from the development opportunities offered through trade, while reducing exposure to the associated risks.

Asian aquaculture systems have many traditional and diverse advantages in safe, healthy and sustainable seafood production, such as some ecologically sound integrated farming systems. Collaborative research and development should be used to encourage both the traditions and innovations in aquaculture farming that can give the region comparative advantage in this new trading environment.

Possible actions

There are a number of actions that can be considered by nations in the Asia-Pacific region, to address the challenge of food safety issues in aquaculture development and trade. Some suggestions are given below. Such actions will be most effective if carried out in a collaborative way among countries, including trading partners and by sharing of experiences from advanced to less advanced nations.

Awareness and capacity building

There is generally a need to raise awareness of food safety in the aquaculture sector, to build capacity for assessment and development of management strategies and systems for assuring quality and safety. Regional cooperation to prepare training (perhaps organized as widely available modules) and awareness materials on key food safety issues in aquaculture which can be widely shared among producers, processors, institutions and agencies in Asia would be useful. Training of trainers type training courses might be organized at national and regional levels, using the training material developed, to support capacity building.

The need for regional technical guidelines?

To provide technical guidance and promote harmonized approaches to food safety in aquaculture production, as well as assisting in identifying policy and legal requirements, a set of technical guidelines on food safety in aquaculture production in Asia might be useful. The approach might be modeled on the Asia Regional Technical Guidelines on Health Management and Trans-boundary Movement of Live Aquatic Animals (FAO/NACA, 2001), adopted by 21 Asian governments in 2000, but focusing on food safety concerns in aquaculture production. The box suggests some issues that might be considered in such guidelines. Preparation of these guidelines should be conducted a participatory way, involving not just aquaculturists, but also food safety expertise, and the business sector, including industries such as feed and chemical businesses. It will

Elements for consideration in regional technical guidelines on food safety in aquaculture production?

Use of GHP, HACCP, and risk assessment
Safe aquaculture production
Farming systems, management and food safety
Farm inputs (feed, seed, chemicals etc.)
Development of trace-ability systems
Monitoring, testing and validation issues
Institutional, legal and policy requirements (farm registration, licensing etc.)
Implementation approach (particularly considering different levels of development)
Mechanisms for national, regional and international cooperation and networking

be essential to finds ways to effectively engage aquaculturists and involve the business sector in such a process.

Aquaculture certification systems

There is increasing interest in certification systems as one strategy for assuring the quality of aquaculture products. The recent Outlook for Fish to 2020 has pointed out that "Food safety certification will become important to the survival of all fishers in the next two decades, and eco-labeling will become important to most" (Delgado et al, 2003). The are questions about the delivery of such certifications cost-effectively and their credibility to large numbers of small-scale fish producers, but the stakes are increasingly clear. The possibility of developing a harmonized set of standards for voluntary certification of aquaculture farms and certification of products based on farm performance, as recommended by regional participants during Aquamarkets 2003, should be explored (Aquamarkets 2003), including issues related to their implementation and relevance to the small-scale sector. The approach should include food safety, but may also perhaps consider other elements of sustainability in seafood production that will become more important in future.

Generating knowledge on food safety in aquaculture

To support the development of farming and management systems, better practices and guidelines for safe seafood production, there are many opportunities for practical, problem solving oriented research. The WHO/FAO/NACA Study Group (WHO/FAO/NACA, 1999) concluded that there were considerable needs for information associated with food production by the aquaculture sector. Such gaps in knowledge hinder the process of risk assessment and the application of appropriate risk management strategies with respect to food safety assurance for products from aquaculture. Some of the key issues are highlighted in the adjacent box.

Knowledge gaps and research needs in aquaculture and food safety (from the WHO/NACA/FAO study group):

Biological hazards:

- Trematodes and other parasites, including epidemiology studies and management measures
- Bacterial contamination and microbiological risk assessment of products from aquaculture

Chemical hazards

- Agro-chemical hazards and development of better management practices
- Better practices for safe and effective use of chemotherapeutants in aquaculture.
- Feed contaminants and transfer to edible fish tissues and implications of this for human

There is also a need particularly for better understanding of the special problems faced by small-scale producers, particularly in less-developed countries, such as the social and economic costs of compliance to food safety standards, the role of small-scale farmer groups and farming clusters in organization of market access, among others. Understanding the implications of certification and ecolabeling is also required, and to use such understanding to develop credible and practical systems that address small-holder concerns. An example of a new collaborative research project that will investigate the problem of fish borne trematodes in Vietnam, through partnership between aquaculture and food safety experts, with wider regional relevance, is also noted below.

Promoting more effective international cooperation

To assist the region, and promote further understanding and cooperation among trading partners, there is a need for further initiatives to bring countries together in Asia, and with major importing regions to discuss issues, share experiences, and develop solutions to problems. Particular opportunities may exist for dialogue, as well as technical and financial assistance, between Asian developing countries and the EU, Japan and the Americas, as well as enhanced south-south cooperation on food safety and aquaculture production.

> **Fishborne zoonotic (transmission between humans and animals) parasites (FZPs)** have been found to have high prevalences in Vietnam, presenting a significant risk not only to the nation's public health, but also to the food safety of rural and export-orientated aquaculture. "FIBOZPOPA" is a research capacity building project supported by DANIDA bringing together key Vietnamese and Danish institutions from the human health and aquaculture sectors. They will address three major obstacles to sustainable control of FZPs namely: (1) limited institutional capacity for investigating FZPs and for conducting risk assessment on these parasites; (2) lack of baseline information on the prevalence and distributions of FZPs in aquaculture; and (3) limited collaboration among stakeholder institutions. FIBOZOPA will create national awareness of the occurrence, risks and preventive measures for FZP infections in humans and fish, as well as specialized knowledge on how to manage such the problems, from central Government to local levels.

To ensure Asia's concerns and the reality of Asian aquaculture production systems are also reflected in international trade setting bodies, the region needs to get better organized to provide coherent and science-based inputs to the standard setting process, particularly FAO/WHO Codex. There is a need therefore support better cooperation with Codex to address the problems and concerns of Asian producing countries in food safety and aquaculture production, emphasizing the philosophy of the SPS agreement for "special considerations of the requirements of developing countries….". There is a need support communication of special issues from developing countries in Asia to the global policy arena.

Sharing of experiences – the need for effective communication and information exchange

To support capacity building and awareness raising, enhanced communication is required, including local language materials. This may be achieved in various ways, including further development of relevant web sites to contain relevant information to support in-country training activities, enhance networking and sharing of experiences on the various aspects of food safety and aquaculture production. Sharing of experiences through case studies that demonstrate novel approaches or offer learning opportunities should also be supported.

Also cooperating and information sharing with other sectors are important. Human health institutions and aquaculture institutions may together achieve a more effective and deeper insight into problems and solutions regarding food safety. A collaborative implementation strategy is required, bringing together the experiences and synergies of different nations and agencies to address food safety in aquaculture production. At country level, there needs to be enhanced cooperation, among relevant government agencies, the aquaculture industry and the business sector. At regional and international levels, cooperation between FAO, NACA, APEC, and other interested and specialized agencies for technical and financial assistance is also essential to move the process forward.

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Emerging aquatic animal health issues in Asian aquaculture - the regional response

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Introduction

Although aquaculture is one of the fastest growing food production sectors in the world, aquatic animal diseases remain one of the major bottlenecks for the development of the sector. As aquaculture has intensified and expanded, both nationally and regionally, more and more new diseases have emerged, and more will emerge and spread in the future. Trans-boundary movement of live aquatic animals in the region is one of the principal reasons for increased occurrence and spread of several serious diseases (Subasinghe *et al*, 2001). The spread of aquatic animal pathogens has directly led to serious disease outbreaks in Asia, impacting on aquaculture productivity, livelihoods, trade and national economies. Such problems have also indirectly impacted on trade of aquatic animal products, within Asia, and between Asia and major trading partners, such as through indiscriminate use of chemicals in disease control.

This chapter provides a brief insight into emerging health issues and diseases in the region, regional responses and highlights the need for effective surveillance and emergency preparedness programs, and also the importance of implementation of structured health management programs based on the agreed regional frameworks of the "Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals"(FAO/NACA, 2000). The chapter also elaborates on the discussions and recommendations from the Asia Regional Advisory Group (NACA 2004), a regional body of experts established to advise on aquatic animal health issue in the Asia-Pacific region.

Emerging diseases in Asia

Within 2003, several significant diseases problems have emerged that are summarized below.

Koi herpes virus: Mass mortalities of koi and common carp first occurred in the Asia-Pacific region in Indonesia in June 2002 and continued to cause serious losses in 2003 (NACA/FAO, 2003). Although the precise aetiology of Indonesian outbreaks is still uncertain, the evidence (NACA, 2003) suggests possible involvement of koi herpes virus (KHV). In October 2003, confirmed KHV outbreaks caused mass mortalities in cultured carp for the first time in two lakes in Ibaraki Prefecture of Japan and since then spread to large parts of the country affecting cultured and wild populations of carp (FAO/NACA, 2003). Estimated losses run to the tune of US$ 15 million in Indonesia and US$1.4 million in Japan. Koi herpes virus is known to cause significant economic losses among all ages of both common carp and Koi carp. The virus was first detected in 1997 in Israel and since then has spread globally. According to Gilad et al (2003) a single strain of koi herpes virus had spread worldwide by the unregulated trade in ornamental fish. KHV has now reported from many countries in the world, and could become a considerable problem to ornamental koi carp as well as common carps, both cultured and wild. The spread of this virus into common carp populations represents a significant concern to food security – going well beyond its traditional threat to the ornamental fish industry.

Responding to an urgent request from the Government of Indonesia, NACA, with the timely support of Australia and FAO, constituted an emergency task force in 2002 to investigate the problem and advise the government on control measures. This task force provided significant insight to the problem and recommended a series of control measures. The task force studies set the stage for a follow up project assistance from FAO through its Technical Cooperation Programme (TCP) in 2003. This project provides assistance to improving national aquatic animal health capacity including establishing a virology laboratory; evaluation of legislation on aquatic animal health; finalization of Indonesia's National Strategy on Aquatic Animal Health; training of field extension workers and farmers on aquaculture health management; technical training of project staff on virology and health management; epidemiological investigations on KHV; establishment of surveillance and reporting systems for KHV and future pilot testing of such systems; and aquatic animal information system - Indonesia chapter as part of FAO's Aquatic Animal Pathogen and Quarantine Information System (AAPQIS).

KHV outbreaks in the region have significant trade implications for the high value ornamental koi carp industry, and the important food fish common carp. Active trade in ornamental fish poses a potential risk for spread of KHV. In recognition of this risk, "mass mortalities of koi carp" was listed under the "unknown diseases of serious nature" category in the FAO/NACA/OIE regional QAAD reporting list effective from 2003. Since the listing of koi mass mortality in QAAD, Singapore and Thailand introduced active surveillance and quarantine programs in 2003 aimed at preventing introduction and spread of KHV. In response to recent confirmed KHV outbreaks in Japan, 'infection with koi herpes viruses has now been added to the list of diseases prevalent in the region in the QAAD, to become effective for reporting from 2004.

Spring viraemia of carp (SVC): This virus was presumed to be exotic to the region till recently. However, in 2003, SVC virus was isolated from common carp and koi carp in China PR (NACA/FAO, 2003)**.** The SVC virus detected in China PR did not cause mortality, but is a serious concern. In view of the occurrence of SVC virus in China PR, it has been included under diseases prevalent in the region in the revised QAAD to be effective from 2004.

Viral nervous necrosis (VNN) and grouper iridoviral disease: The marine finfish farming industry is not free from disease problems. Some of the serious diseases in the region include VNN and iridoviral diseases. Recognising the importance of iridoviral disease, in terms of its potential to spread and cause economic loss, "grouper iridoviral disease" was included for listing in the QAAD under other important diseases effective from January 2003. Since the listing came into effect, Hong Kong China and Singapore have reported the occurrence of iridoviral diseases. The occurrence of VNN and grouper iridoviral diseases is generally accepted as being widespread, but not being officially reported. In view of the increasing importance of marine finfish farming in Asia, and extensive movement of fry, fingerlings and adult fish, countries with active marine finfish farming should strengthen surveillance and reporting of viral diseases in marine finfish in the region. The research work on development of marine fish farming clearly also needs to give additional focus on putting in effective disease control measures.

Taura syndrome virus (TSV) and White spot syndrome virus *(*WSSV): The shrimp culture industry is still under the grip of serious viral pathogens. Taura syndrome virus (TSV) is a new addition to the list. Irresponsible introduction of *P. vannamei* based on perceived/projected advantages is largely believed to be responsible for TSV incursion to the Asia-Pacific (Smith and Briggs, 2003). In 2003, TSV has been reported in *P. vannamei* from China PR, Indonesia and Thailand. Reports of TSV in native P. *monodon* from Indonesia and China PR are also a cause for concern. Co-habitation of *P. monodon* and *P. vannamei* in hatcheries and farms has been suggested as responsible for movement of pathogens between species and such pathogen transfers between species may have serious consequence. It is still early to estimate the economic impact of TSV in the region, but is certainly an additional problem to the already disease hit industry. White spot syndrome virus *(*WSSV) continued to cause serious disease outbreaks in *P. monodon* in 2003 in many countries of the region (FAO/NACA, 2003). Now there are reports of WSSV causing mortalities in cultured *P. vannamei* in China PR and Indonesia. TSV may be under-reported due to existing government restrictions on *P. vannamei* introductions and limited screening. The spread of TSV may be greater than indicated by QAAD reports and there is a need for improved reporting of TSV in the region.

Molluscan diseases: Little attention has so far been given to molluscan diseases in the region, although serious losses are known to be occurring. This may indicate the limited diagnostic and technical capacity in the region for molluscan pathogens. Recent abalone die offs reported in Taiwan Province of China and China PR are causes of concern, more so because these problems have prompted movement of abalone seed and farming to countries in Southeast Asia. There is yet no confirmatory aetiology, but viruses and/or *Vibrio alginolyticus* have been implicated. Japan, Australia, Republic of Korea, Taiwan Province of China and China PR have large abalone industries. Recognising the potential to spread, 'Abalone viral mortality' has been included as an unknown disease of a serious nature in the QAAD list to be effective for reporting from 2004. In view of the importance of mollusc aquaculture to Asia, as well as movement of their spat and adults, efforts are required to better understand problems, improve reporting of their pathogens, and put in effective disease control measures.

Other emerging disease problems: There are several other emerging diseases which, are worth mentioning. The slow growth syndrome in *P. monodon*, mourilyan virus (MoV) in shrimps, peripheral neuropathy and retinopathy in *P. monodon*, and white tail/body disease in *Macrobrachium rosenbergii*, are concerns to the region. Epidemiological studies, effective disease outbreak investigations and clear case definitions are required to better understand these problems and their impacts.

Need for regional collaboration

Aquatic species are widely moved within and between countries in the Asia-Pacific region and between the region and elsewhere. Trans-boundary aquatic animal diseases are a major risk and an important constraint to the growth of aquaculture with potential to impact on international trade and the people whose livelihoods depend on aquatic resources. Well known examples of introduction of pathogens to new aquatic systems and hosts leading to serious consequences in the Asia-Pacific region include epizootic ulcerative syndrome (EUS) in fresh and brackishwater fishes, white spot syndrome virus (WSSV) and taura syndrome virus (TSV) in cultured shrimp and viral nervous necrosis (VNN) in grouper. Continued occurrence of koi mass mortality in Indonesia and the recent outbreak of koi herpes virus (KHV) in Japan are grim reminders of dangers associated with trans-boundary spread of pathogens.

Careful examination of the history and spread of these diseases in the region indicate how irresponsible or ill-considered movements of live animals can impact aquaculture and wild fisheries resources. In many cases, these impacts are a direct result of absence of national and regional disease management strategies or non-compliance by stakeholders to such strategies. Regional approaches through pro-active cooperation are essential to assist Asian countries to reduce risks of aquatic animal diseases impacting on the livelihoods of aquaculture farmers, national economies, trade, environment and human health. NACA implements its programs throughout the region in partnership with governments, industry, NGO's, donors and development agencies. With FAO and the World Organisation for Animal Health (OIE) guiding principles for responsible movement and aquatic animal health management have been established in the Asia Regional Technical Guidelines on Health management and the Responsible Movement of Live Aquatic Animals (see box above), and now adopted as a regional strategy by 21 governments in the Asian region. These guidelines provide a basic framework of management actions required to understand and manage risks of transboundary aquatic animal diseases. NACA's regional program is oriented towards promoting cooperation in Asia, and in collaboration with major international partners of FAO and OIE, to assist countries in Asia implement better health management in the aquaculture sector. The major outputs from NACA's regional aquatic animal health program, agreed by NACA members during the recent Technical Advisory Committee meeting of the organization, are:

Major elements of the Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals (FAO/NACA, 2000)

Pathogens of importance
Disease diagnosis
Health certification and quarantine
Disease zoning
Disease reporting and surveillance
Contingency planning
Import risk analysis
National legislation and policy frameworks
Capacity building and Implementation

1) Practical National Aquatic Animal Health Strategies developed, adopted and implemented in member countries
2) Widespread adoption of better aquatic animal health management practices
3) Improved surveillance, reporting and response to disease emergencies
4) Harmonized diagnostic procedures and approaches to risk assessment
5) Improved regional and international cooperation in aquatic animal health

Regional Responses

Since defining a framework for disease control in the region, NACA, FAO and OIE with various partners have worked towards support in implementation. Supporting documents have been prepared that provide further guidance to Asian countries, including the Asia Regional Technical Guidelines referred to above, the Manual of Procedures (FAO/NACA 2001) and an Asia Diagnostic Guide (Bondad-Reantaso *et al.* 2001). All documents take into full consideration the provisions of the World Trade Organization's Agreement on the Application of Sanitary and Phytosanitary Measures (WTO-SPS Agreement) (WTO 1994), as well as Article 9 - Aquaculture Development - of the Code of Conduct for Responsible Fisheries (CCRF) (FAO 1995).

Recognizing the increasing serious socio-economic, environmental and possibly international trade consequences arising from disease incursions related to the introduction and spread of trans-boundary pathogens/diseases through irresponsible movement of live aquatic animals, an APEC and FAO supported project to build capacity in "Import risk analysis" (IRA) was successfully implemented by NACA during 2002 and 2003. The first training workshop was completed from 1-6 April 2002 in Bangkok, Thailand, and a second training workshop was held from 12-17 August 2002 in Mazatlan, Mexico. The two training workshops brought together regulatory authorities and administrators responsible for trade of live aquatic animals and aquatic animal health specialists to share experience, raise awareness, build capacity and contribute to the development of a practical manual for risk analysis to support responsible aquatic animal movements. Important outputs include technical proceedings of the workshops and a practical manual on IRA for aquatic animals that will be available in 2004. The documents will provide further support to Asian governments development of health management measures based on understanding and analysis of risk, a key element of the WTO SPS agreement and the Asia Regional Technical Guidelines.

In an effort to determine what surveillance options can best support scientifically valid zonation frameworks for aquatic animal diseases, an Expert Consultation was organized by FAO, the Federal Department of Fisheries and Oceans Canada (DFO Canada) and the Office International des Epizooties (OIE) in October 2002. The objective of the Consultation was to provide recommendations for surveillance and zonation that will be useful for designing national programmes aimed at reducing the risks of diseases resulting from transfers of live aquatic animals. The resulting document (Subasinghe *et al*, 2004) provides technical information and recommendations to the Competent Authorities of countries in Asia wishing to implement surveillance and zonation to demonstrate that they have a 'reliable system of disease control and surveillance' in place. These valuable guidelines complement an excellent practical manual on surveillance prepared by ACIAR (ACIAR's Tacklebox – Survey Toolbox for Aquatic Animal Diseases by Angus Cameron). This new manual for disease surveillance is targeted specifically at aquatic animals and includes additional introduction to basic epidemiology for aquatic animal health, as well as basic guidelines for general management interventions to address common aquatic animal problems. The next step now is to encourage and support the development and implementation of effective surveillance systems, through capacity building, awareness raising and other technical support.

Within ASEAN, there have been welcome efforts at promoting closer collaboration among ASEAN members in disease control. The Department of Fisheries, Malaysia in collaboration with NACA organised a regional Seminar " Harmonization of Quarantine Procedures for Live Fish among ASEAN Member Countries" in February 2003, in Penang, Malaysia. The seminar succeeded in developing "Draft Guidelines for harmonization of quarantine procedures of live fish among ASEAN member countries". The ASEAN Sectoral Working Group on Fisheries is now working towards further development of the document and comprehensive procedures for implementation of the guidelines at the operational level. Further collaboration within ASEAN will be supported during July 2004, when the Department of Fisheries Malaysia, in collaboration with NACA and FAO, with support from the United States Department of State will organized a workshop on "Building capacity to combat invasive alien species and associated trans-boundary pathogens in ASEAN countries". The workshop is expected to assist ASEAN countries build their national capacities to combat the impacts of aquatic invasive alien species (IAS) and associated trans-boundary pathogens in aquaculture.

The importance of cooperation among countries of the same watershed was highlighted in the Asia Regional Technical Guidelines. Within the Mekong/Lancang basin, an international workshop, *International Mechanisms for the Control and Responsible Use of Alien Species in Aquatic Ecosystems,* was convened during August 2003, in Xishuangbanna, People's Republic of China to promote cooperation in the Mekong/Lancang in responsible movement of aquatic animals, including both disease and exotic species issues. The workshop was a cooperation between the Asian Institute of Technology (AIT), Food and Agriculture Organization of the United Nations (FAO), Mekong River Commission (MRC), Network of Aquaculture Centres in Asia-Pacific (NACA), University of California Sea Grant College Program (UCSG), World Conservation Union (IUCN), Ministry of Agriculture of the Peoples Republic of China and the FAO/Netherlands Partnership Programme (FNPP). The outcome as agreed among the senior policy makers and scientists present provides a strong basis for further cooperation among the six Mekong/Lancang basin in control and responsible movement of aquatic animals.

The Regional Advisory Group in its second meeting has reviewed many of the key aquatic animal health issues in Asia during its recent meeting in November 2003, covering regional disease reporting systems, emerging aquatic animal disease problems, implementation of the Asia Regional Technical Guidelines, and ways to further strengthen regional and international cooperation in Asian aquatic animal health management. The QAAD list was revised to conform with changes to the OIE *Aquatic Animal Health Code* and to reflect the aquatic animal disease situation in the region, including emerging diseases noted above. The AG urged Asian governments to implement practical disease control measures in line with TG and emphasized the need for effective programs on surveillance and emergency preparedness. Countries with susceptible species were also urged to take steps to strengthen surveillance for emerging pathogens.

In response to KHV outbreak in Asia, an international conference on KHV was organized in Japan in March 2004, by the Fisheries agency of Japan in collaboration with OIE and SEAFDEC. This has provided useful guidance to the region in dealing with this problem. FAO, NACA and the World Fish Centre will in collaboration with the Government of Indonesia hold a workshop on "Emergency preparedness and response to aquatic animal diseases in Asia" in Indonesia in September 2004. These activities will provide a platform for countries to share information and experience and facilitate development and implementation of practical and comprehensive emergency, contingency, plans as part of their national aquatic animal health strategies.

Identification and establishment of Regional Aquatic Animal Health Resource Base was one of the key recommendations of the first regional advisory group (AG) meeting in 2002. The resource base in aquatic animal health was proposed to be identified at three levels; regional resource experts (RRE), regional resource centres (RRC) and regional reference laboratories (RRL). A cohesive networking among

RRE, RRC and RRL in aquatic animal health is a requirement in the region to provide diagnostic support and to build capacity for implementation of the Asia Regional Technical Guidelines. Work has started on this resource base during 2003, and it is hoped that in the coming years an effective network of resource centers will provide valuable support within the Asia region to national agencies with assistance in the diagnosis of key regional diseases, assistance in responding to disease emergencies and act as contact points for advice and capacity building in close cooperation with FAO, NACA and OIE.

Future

Aquaculture has suffered significant losses due to trans-boundary diseases, and increasing risks are foreseen in future as aquaculture expands in the region. Enabling government policies coupled with strong resolve and commitment among stakeholders, will not only help in disease control but also facilitate responsible movement of aquatic animals and contribute to development of sustainable aquaculture in the region, and responsible trade with major trading partners.

There is considerable information in the region on better risk management practices for fish/shrimp culture. As a part of NACA's regional initiative to control aquatic animal diseases, ongoing collaborative projects in India and Vietnam are exploring and validating effective extension approaches to promote widespread adoption of better management practices (BMPs). The outcome from the India work, shows that it is possible to reduce risks of crop losses from shrimp disease and improve productivity and profitability of small-scale shrimp farms through disease control programs by providing access to science-based disease control principles, by providing technical support that enables farmers to adapt BMPs principles to their own circumstances and by promoting local self-help groups (aquaclubs) to facilitate cooperation and communicate BMPs to a wider group of farmers, and to collectively address health management problems. Extending the concept of risk management through adoption of BMPs to a wider area poses considerable challenges. New methods should focus on collective approaches and facilitate farmer to farmer interaction through self-help groups and voluntary associations. There is a need to identify institutional (government/private) framework to implement BMPs on a wider area.

The future growth in aquaculture and trade in aquatic animals will have to give increasing attention to disease control and health management, as well as food safety concerns of importers and consumers. Consumers and markets are becoming more demanding and the need for implementing socially and environmentally responsible aquaculture practices, improve food safety, trace-ability and labelling are becoming more and more important. Demonstrating compliance to international standards in aquaculture production and trade will be a key to success of aquaculture and future trade in aquaculture products.

Various global instruments, codes of practice and guidelines (either voluntary or obligatory) exist that provide certain levels of protection, all aimed at minimizing the risks due to pathogens/diseases associated with aquatic animal movement. Within Asia, The Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals and their associated implementation plan, the Beijing Consensus and Implementation Strategy (BCIS), (FAO/NACA,

2000) provide the basic framework and guidance for national and regional efforts in reducing the risks of disease due to trans-boundary movement of live aquatic animals. There is strong endorsement by many regional, inter-governmental and global organizations and a shared commitment from national governments to support its implementation. It is the responsibility of the governments to act now, and make provisions within their development plans to implement the technical guidelines.

Most countries face significant challenges in the practical implementation of health management strategies, specifically in areas of diagnosis, surveillance, risk analysis, emergency preparedness and quarantine and certification programs. This is mainly due to inadequate national capacity. There is therefore a need to continue the strong regional cooperation in aquatic animal health in the Asia-Pacific region. Country specific needs have been identified and several national strategies have been developed. What is required now is the strong political will that would bring the implementation process forward. This is the only way to protect the regional aquaculture from serious health problems, which we have witnessed and suffered for almost a quarter of a century.

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Recent developments in marine fish farming and seafarming

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Introduction

Aquaculture of marine fish continues to grow, as part of the overall growth trend in seafarming development in Asia. High-value finfish species are of increasing aquaculture interest, particularly in Southeast Asia. Species such as groupers (Serranidae, Epinephelinae) bring high prices (up to US$70 /kg wholesale) in the live markets of Hong Kong and southern China (McGilvray and Chan 2001). Marine finfish aquaculture is also an important contributor to the economies of coastal communities in SEAsia, potentially providing an alternative to wild caught fish caught using destructive fishing (ADB, 2003).

Much of the marine finfish aquaculture in Southeast Asia, however, relies on the capture and grow-out of wild-caught juvenile fish: around 70–85% of cultured groupers are from wild-caught fry. In some areas, the use of hatchery-reared fry is becoming more common. For example, in Indonesia, an estimated 15–25% of cultured groupers are now hatchery-reared, while in Taiwan this proportion may be as high as 70%. However, wild-caught groupers make up the bulk of the seedstock supply in many parts of Southeast Asia, including Vietnam, Thailand and the Philippines. The trade in wild fry is associated with a number of resource management issues, including: overfishing, use of unsustainable harvesting techniques (including cyanide), high levels of mortality; inadequate supply to support the demand of a developing aquaculture industry (Sadovy 2000). To meet the demand for seedstock for aquaculture, and to reduce pressure on wild fisheries, there is a recognised need to develop commercial marine finfish hatcheries throughout the Asia-Pacific region to supply hatchery-reared seedstock (Sadovy, 2003).

Asia-Pacific Cooperation in Marine Finfish Aquaculture

One of the constraints to the development of sustainable grouper aquaculture in the Asia-Pacific region has been the uncoordinated nature of the substantial regional research effort that has taken place over the last two decades. Researchers and practitioners felt they were working in isolation and were unaware of the many similar lines of research being undertaken by other laboratories.

In response to the identified need to improve communication and coordination of research effort, the Asia-Pacific Grouper Network was established in 1998 at a grouper aquaculture workshop held in Bangkok, Thailand. The network is coordinated by the Network of Aquaculture Centres in Asia-Pacific (NACA) and has received support from the Australian Centre for International Agricultural Research (ACIAR) and the Asia-Pacific Economic Cooperation (APEC), through its Fisheries Working Group.

Recognizing the importance of marine fish farming in the Asia-Pacific region, senior government representatives at the NACA 13th Governing Council Meeting in 2002 absorbed the grouper network into NACA's core programme, to ensure its long-term sustainability. The coverage of the network was also expanded to include other species such as sea bass, snapper, cobia, tuna and marine ornamentals and the name was changed to the Asia-Pacific Marine Finfish Aquaculture Network (APMFAN).

The overall objective of the network is to promote cooperation to support responsible development of marine finfish aquaculture within the Asia-Pacific region. Network activities are particularly directed at development of marine finfish aquaculture that:

- Provides an alternative source of income and employment for coastal people, especially those currently engaging in destructive fishing practices;
- Provides a quality alternative source of fish to wild-caught species, including fish fingerlings, that may be captured using destructive fishing techniques;
- Contributes to protection of endangered reefs and reef fish from the pressures of illegal fishing practices through responsible aquaculture development;
- Promotes environmentally sustainable marine fish culture practices by addressing environmental constraints to marine fish culture associated with present practices, such as feed and fingerling supply; and
- Promotes diversification of marine fish culture species appropriate to local economies and markets.

With such diverse and complex problems there is a need to share knowledge and experience to assist in finding solutions. The network provides the platform for cooperation in the Asia-Pacific region where aquaculture specialists can work with government agencies, non-government organisations, the private sector, communities and markets to ensure that aquaculture is integrated into broader objectives of conservation and poverty alleviation in coastal areas.

Marine fish network program structure:

1 Production technology
  1.1 Broodstock
  1.2 Larviculture
  1.3 Nursery
  1.4 Grow-out
  1.5 Post-harvest
2 Environment
3 Marketing and Trade
4 Food safety and certification
5 Socio-economics and coastal livelihoods
6 Fish health
7 Training and extension

A major focus of APMFAN has been to provide a structure to help coordinate the overall research effort within the region. This approach has been used to minimise overlap and prevent duplication of research effort on marine finfish aquaculture. To achieve this participants in the network developed a program structure, within which individual projects contribute to the overall achievement of program goals. The structure of the APMFAN program is shown in the attached box. The following gives some information of status and progress.

Production technology

Production technology for marine finfish, particularly high-value species in demand in the lucrative live fish markets, remains a major constraint to the development of sustainable marine finfish aquaculture in the Asia-Pacific region. Recent improvements in hatchery production technology for fingerling production, and development of compounded feeds, have contributed to enhancing sustainability of marine finfish aquaculture.

Hatchery production of fingerlings: Substantial improvements in marine finfish hatchery production technology have resulted in increased production of fingerlings to supply high-value markets. The Australian Centre for International Agricultural Research (ACIAR) project FIS/97/73 *Improved hatchery and grow-out technology for* *grouper aquaculture in the Asia-Pacific region* has been instrumental in supporting research to improve hatchery production for groupers and other high-value marine finfish. Overall, the 4 years of the ACIAR project have seen survival of green grouper *Epinephelus coioides* increase from around <5% to around 30%, and survival of humpback grouper *Cromileptes altivelis* improve from <10% to up to 40%. Future research in this area will focus on improving the reliability of fingerling production in marine finfish hatcheries.

Key outcomes from the ACIAR project were:

- Optimising environmental variables of temperature, salinity, aeration, and light levels provided valuable information contributing to greater larval survival.
- Larval nutrition research indicated the essential fatty acid requirements of one species of grouper (*Epinephelus coioides*). Further work will be aimed at developing larval diets to provide suitable levels of various fatty acids the larvae require.
- Research described the development of the digestive tract in larval groupers. This is fundamental to knowing the capacity of the larvae to digest both live and artificial feeds.
- Highly sensitive fluorescent techniques were developed to assess the levels of digestive enzymes in the gut of fish larvae. Grouper larvae were shown to have very low levels of digestive enzymes (e.g. protease) compared with some other species of fish larvae that have been examined, such as barramundi. This may help explain why grouper larvae are more difficult to rear than barramundi.
- Assessment of techniques to maintain or decrease the size of super-small (SS) strain rotifers (*Brachionus rotundiformis*) for use in grouper hatcheries.
- Improved intensive and semi-intensive larval rearing techniques resulted in survival rates increasing from around 3% at the beginning of the project to 30% for greasy grouper / estuary cod (*E.coioides*), and from 5% at the beginning of the project up to 50% for humpback grouper / barramundi cod (*Cromileptes altivelis*).
- The viral disease viral nervous necrosis (VNN) continues to cause major mortalities in hatchery-reared grouper and remains a major limiting factor in successful seed production.
- Technology developed under the project has been adopted by farmers, including ‘backyard hatcheries’ in Bali. A socio-economic analysis of these small-scale hatcheries demonstrated that they are highly profitable, with payback periods generally <1 year and IRR’s of 12–356%.

The ACIAR project has made an important contribution to increased production of grouper fingerlings in the Asia-Pacific region. For example, production of high-value grouper species in Indonesia is increasing rapidly. In 2002 Indonesian hatcheries produced 2.7 million fingerlings of tiger grouper (*Epinephelus fuscoguttatus*) and 0.7 million fingerlings of humpback grouper (*C.altivelis*). Based on an estimated 50% mortality rate of fish during grow-out, this is equivalent to between 15–30% of Indonesian grouper production for 2001.

Grow-out feeds: Most marine finfish culture in Southeast Asia relies heavily on the use of small low-value or bycatch fish species, commonly termed ‘trash fish’. The term trash fish is inaccurate in that these fish species would not necessarily otherwise be wasted, and alternative uses include protein sources for other agricultural commodities (such as pigs and poultry) or even human food (Tacon and Barg 1998, and review below by Tacon). The availability of trash fish is often seasonal; for example fishers may not be able to fish for these low-value species during rough weather. It is also becoming scarce in some parts of the region, and long-term use of such feed is probably unsustainable. The low value of trash fish often means that they are poorly handled, and rancidity and vitamin degradation may lead to nutritional deficiencies in the fish to which they are fed. Feeding losses from trash fish are much higher than those from pellet feeds, e.g. 20–38% for trash fish versus 10% for pellet feeds used in salmonid culture (Wu 1995, Phillips 1998). Because of these losses, feeding trash fish increases local pollution in the vicinity of the cages. The use of trash fish may also assist the spread of fish diseases, as well as constitute a loss of marine fish resources.

The region therefore needs towards better feeding practices. There is an increasing trend towards the use of pelleted compounded diets for marine finfish culture. Although pellet diets still utilise comparatively high inputs of aquatic resources (typically 2–3 kg of fisheries product inputs for each 1 kg of cultured product) these are better than the typical input ratios for trash fish (usually 5–10:1). In addition, compounded diets provide an opportunity to replace fish protein sources with terrestrial protein such as meat and blood meals derived from abattoir by-products; in the case of grouper diets, up to 80% of fish meal can be replaced. Commercial diets are now available for more commonly cultured species, such as milkfish (*Chanos chanos*) and barramundi / sea bass (*Lates calcarifer*). However, because of the relatively low level of aquaculture production of groupers (compared with milkfish or barramundi / sea bass) there has been little interest from commercial feed companies in developing diets for which there is a relatively small market. The increasing demand for aquaculture groupers, and the continuing demand for high quality product, as well as the problems of trash fish availability and quality, are driving the need to develop compounded diets for these species.

The ACIAR grouper aquaculture project has determined many of the major nutritional requirements of groupers in regard to developing pellet diets:

- Protein of Australian meat and bone meal and wheat gluten and local and imported fishmeal was found to be well digested (Apparent Digestibility (AD) >76%). The protein digestibility of Australian blood meal was variable but generally low as also was the digestibility of rice bran. Intermediate in protein digestibility were local ingredients such as shrimp head meal, palm oil cake meal and soybean meal.
- Research with humpback grouper / barramundi cod (*C. altivelis*) showed that diets had to be high (> 55%) in protein and moderate (12–15%) in lipid to optimise growth rate and nutrient retention in the fish. Increasing the amount of lipid in the diet only increased fat deposition without any improvement in growth or food conversion efficiency. These findings need to be confirmed with other grouper species.
- Other research showed that many terrestrial protein meals have potential as partial replacements for fishmeal in grouper grow-out diets. Good quality meat and bone meal can replace more than two thirds of the fishmeal without any adverse effect on grouper performance. Plant protein meals such as soybean and lupin have been shown capable of successfully replacing from one third to half of the fishmeal.

- Researchers in Indonesia have categorised (cost, seasonal availability, composition, digestibility) a range of potential ingredients for use in locally-made grouper diets.
- Commercial feed producers in Indonesia and the Philippines are now trialing grouper diets based on the outcomes of the project's research.

There are several constraints to the widespread use of compounded diets for grouper aquaculture:

- Farmer acceptance of pellet diets is often low because of the perception that these diets are much more expensive than trash fish. Farmers often do not appreciate that the food conversion ratios of pellet diets (usually 1.2–1.8:1) is dramatically better than that of trash fish (usually 5–10:1) and so the relative cost of pellet diets is often comparable, or lower than, the cost of trash fish required to produce the same biomass of fish.
- Lack of farmer experience in feeding pellets may result in considerable wastage.
- Fish fed on trash fish may not readily convert to a dry pellet diet, resulting in poor acceptance and perceived lack of appetite.
- Many rural areas have no storage facilities, and this can result in degradation of the pellets, particularly vitamin content, resulting in poor growth and disease in fed fish.
- Variable product quality may also impact substantially on farmer acceptance of pellet diets.

The issue of farmer acceptance of pellet diets is being addressed under the new ACIAR project (FIS/2002/077) *Improved hatchery and grow-out technology for marine finfish in the Asia-Pacific region* which will commence in mid-2004. Further, ongoing reviews on trash fish use, being conducted by ACIAR and FAO should provide further guidance on this critically important issue. In addition, there is a need to explore further options for farming of marine fish species that feed lower in the food chain, requiring less marine resources during culture.

Environment

The environmental effects of fish cage culture are poorly understood in the tropics, though there is a very substantial literature from temperate areas, primarily concerning the effects of salmonid farming in North America and Europe. The extent of nutrient impacts originating from fish farming is determined by coastal hydrography and geomorphology, with the effects more apparent in semi-enclosed waterways. With the rapid expansion of sea cage farming in the Asia-Pacific region there is a need to develop tools and farming protocols to underpin sustainable industry development.

The environmental issues relating to marine sea cage farming identified at the Workshop on Sustainable Marine Finfish Aquaculture in the Asia-Pacific Region (HaLong City, Vietnam, 2002) were: (i) lack of equitable planning tools; (ii) lack of means of estimating carrying capacity; (iii) lack of cost-effective tools for impact assessment; and, (iv) risk of disease. 'Clustering' of cage culture operations in specific locations raises the risk of environmental damage, yet there are at present no protocols for monitoring or for management of these effects.

These issues are to be addressed in ACIAR project FIS/2003/027 *Minimising environmental effects of finfish grow-out cages in Indonesia and Australia*. This project will sample sea cage operations in Australia (Northern Territory) and Indonesia (Bali and Southern Sulawesi).

The project intends to develop current best practice guidelines for siting and environmental management of tropical marine fish cage culture, compatible for both northern Australian and Indonesian environments, including the provision of planning and mapping outputs. It was also adapt/develop an appropriate model to determine carrying capacity of generic environments for fish cage culture, including external factors. Carrying capacity will be determined by quantifying impact in terms of production intensity.

Key environmental issues in marine fish farming, to be addressed through better management.

- Use of wild fry and fingerlings
- Chemical and drug use in aquaculture
- Grow out farms siting and habitat interactions
- Waste control and effluent management
- Harmful algal bloom management
- Aquaculture feed supply and management
- Fish health management (including risks of trans-boundary spread of pathogens)
- Food quality and safety issues
- Socio-economic, gender and poverty issues

Environmental issues associated with marine fish farming are also receiving increasing international attention, notably highlighted at the recent Convention on Biological Diversity meeting in Kuala Lumpur during 2003. The Secretariat of the Convention on Biological Diversity (2004) has proposed various solutions for avoiding the adverse effects of mariculture on biological diversity, that will need to be considered in future development of marine fish farming in the region.

Marketing

Much of the impetus to developing marine finfish aquaculture comes from the high prices paid by the live fish markets, particularly the Hong Kong market. Much of the current demand (~75%) for live fish is currently met by wild fisheries but there is opportunity for aquaculture supply to expand in the near future. There are a number of important economic, social and environmental issues, including supply and demand issues, involving future development of the trade that would benefit from research. On the supply side, the sustainability of the industry is in doubt due to over-exploitation and the use of destructive fishing practices in some supplying countries (e.g. cyanide fishing and the targeting of spawning aggregations). Increased supply from aquaculture is likely to significantly impact the live reef food fish markets.

On the demand side, the future market potential for wild-caught and cultured live reef product is largely unknown. Demand analysis to include the impact of income and population growth in Hong Kong, China and southern PRC, and consumer preferences for different fish attributes (such as colour, rarity and taste) would be beneficial to developing country (most of whom are small-scale/subsistence fishers) and Australian fishers.

Market aspects of the live reef food fish trade will be addressed in an ACIAR-funded study (ADP/2002/022) *Economic and Market Analysis of the Live Reef Fish Food Trade in the Asia-Pacific*. This project will:

- Quantify short and long-term demand of live reef fish in Hong Kong, China and southern PRC sourced from Asia-Pacific developing countries.
- Quantify short and long-term supply of live reef fish from wild-caught and aquaculture production sourced from Asia-Pacific developing countries.
- Measure the key cost and risk components of the marketing chain.
- Quantify future changes in supply and demand for live reef fish arising from new technology, management practices and economic growth, and to identify the beneficiaries of these developments.
- Identify the highly-valued product attributes (e.g. colour, taste, texture) of wild-caught and aquaculture live reef product.
- Identify possible policy options to improve market performance.
- Build capacity in economic assessment through the Asia-Pacific to provide and coordinate economic research and disseminate information on the trade utilising the existing live reef fish research and development networks (APMFAN, SPC, WorldFish).

To underpin developments in marine fish farming, as well as seafarming in general, the importance of market research as a basis for development of seafarming, including trade and economic analysis, understanding of customer preference and requirements, value-added potential cannot be overemphasised.

Food supply, certification

A major activity supporting this aspect of the program has been the APEC-funded study on *Developing Industry Standards for the Live Reef Food Fish Trade*, a collaboration of the Marine Aquarium Council (MAC) and The Nature Conservancy (TNC). The goal of the project is to build a consensus on what 'best practices' are needed to ensure a sustainable industry for all participants along the market chain. The project focuses on wild-caught and cultured fish, and covers standards and practices relating to: fish stock assessment, capture and culture methods, transportation and holding and human health and safety issues.

NACA and APMFAN has been instrumental in supporting developing the Aquaculture Standards section of these standards. Aquaculture as an alternative to wild caught live fish, is becoming an increasingly important supplier of fish to the LRFFT, and is seen as a significant way of reducing pressure on many highly valued and endangered species. At the same time, concerns exist that many source countries see the market in LRFF as unlimited and continue to develop their aquaculture industries. The considerable work of organisations such as APEC and ACIAR on development of grouper culture technology provides a basis for discussion of aquaculture industry standards. The requirements for the handling, holding, distribution and consumption of live reef fish are important in terms of maximising utilisation of marine resources (i.e. minimise mortality) and enhancing the quality of LRFF exports.

There is some concern that small-scale farmers may find it difficult to adopt highly technical standards. Therefore, as in shrimp farming, attention must be given towards understanding the constraints and costs of adopting standards among smaller-scale fishing and farming communities.

Coastal livelihoods

Marine finfish aquaculture provides important socio-economic benefits to coastal communities throughout the Asia-Pacific region. An APMFAN study of the development of 'backyard' hatcheries in northern Bali (Siar *et al.* 2002) showed that they contribute substantially to the economic development of this area. One reason for the large-scale adoption of backyard hatcheries is the substantial increase in income that Indonesian farmers can obtain from fish culture compared with more traditional agricultural pursuits such as coconut plantations.

A recent study implemented by STREAM and funded by APEC on *Improving Coastal Livelihoods Through Sustainable Aquaculture Practices*, identified the potential benefits of developing sustainable aquaculture to provide alternative livelihoods for coastal communities involved in unsustainable fishing practices, particularly destructive fishing. However, limited accessibility to technology and capital may result in limited access to these benefits by poor people in these communities. The challenge remains to undertake marine finfish aquaculture within a sustainability framework that incorporates a range of measures to reduce environmental impacts while simultaneously providing socio-economic benefits. One such strategic planning framework has been proposed by Haylor *et al*. (2003); this comprises four core stages: analysis, knowledge building, constituency-building and action, drawing on case study experiences with coastal communities and attempts to discourage destructive fishing practices and to encourage sustainable livelihoods through aquaculture. Market incentives, perhaps associated with the adoption of live reef fish standards and possible eco-labeling schemes, will also have an influence on the future development of marine finfish aquaculture targeting the live fish markets.

The APEC study also emphasizes the importance of providing different options for coastal communities. With an objective of providing an alternative source of income and employment for coastal people, especially those currently engaging in destructive fishing practices, cooperation in coastal seafarming will need to broaden beyond marine fish.

Fish health

The largely unregulated trade in aquatic organisms for aquaculture in the Asia-Pacific is widely recognised as being responsible for the spread of aquatic animal pathogens within the region. Aquaculture of live reef food fish contributes to this trade through the movement of juvenile fish (both wild-caught and hatchery-reared) throughout the region, and, to a lesser extent, the movement of grown-out fish to local or international markets. Of specific concern with relation to groupers are the diseases viral nervous necrosis (VNN – also known as viral encephalopathy and retinopathy, VER), grouper iridoviral diseases and parasitic blood flukes.

Grouper iridoviral diseases are not currently considered by the OIE for international listing, but they are of concern in the region. They have now been listed by the Asia Regional Advisory Group under "Any other diseases of importance" for regular regional reporting (NACA, 2003), to assist in the collection of occurrence data. Since the listing of grouper iridoviral disease from January 2003, Hong Kong China and

Singapore have reported the occurrence of iridoviral diseases, but this virus is known to be much more widespread. In view of the increasing importance of marine fin fish culture in the region, countries with marine fin fish culture activities need to further strengthen surveillance and reporting of marine fin fish diseases. A specialist workshop of marine finfish health experts (Bondad-Reantaso et al, 2000) proposed the strategies indicated in the box below to minimise risk of pathogen transfer during movement of live grouper.

Health management strategies to reduce risks of grouper disease and spread of pathogens with trans-boundary movement of live groupers:

- Improve hatchery health management practices (eg through screening, reducing risks of entry of pathogens)
- National and regional disease monitoring and surveillance for important diseases.
- Responsible trans-boundary movement through adoption of the 'Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals'.
- Develop capacity and regional specialist centers for marine fish disease diagnosis and management
- Development of better on-farm health management practices
- Development of vaccines and effective vaccination practices

Training and extension

Communications: The communication strategies adopted by the network reflect the rise of internet-based communication methods, particularly e-mail and the World Wide Web. The use of electronic communication strategies allows rapid and widespread dissemination of information at relatively low cost. The network produces two e-newsletters: (1) A fortnightly e-news service with brief items on recent developments in marine finfish aquaculture, and (2) A quarterly newsletter that covers research and development issues in more depth, including invited contributions from network participants.

The APMFAN web site (www.enaca.org/grouper/) contains a wealth of information on marine finfish aquaculture, including archived articles from technical experts throughout the Asia-Pacific region, workshop proceedings and presentations, and contact details for those wishing to obtain more information about the subject.

Workshops: Workshops have proven to be an ideal mechanism for facilitating formal and informal exchange of ideas and experiences between grouper aquaculture researchers, aquaculture managers and industry. The high level of regional interest in marine finfish aquaculture has supported workshops at various centres throughout the region, including Thailand, Australia, Indonesia, the Philippines and Vietnam. This ability to utilise network resources to hold workshops in different locations has allowed many local representatives to participate, who would otherwise find it difficult to attend.

A major feature of the workshops has been the continued development of the network's research, development and extension program, and the development of individual projects to support it. For example, the network workshop held in Hat Yai, Thailand, in April 1999 identified a number of needs for enhancing the sustainability of grouper aquaculture in the region with particular emphasis on grouper viral diseases. Based on these recommendations, network participants developed several projects that were subsequently funded by APEC, including:

- Publication of a husbandry and health manual for grouper, coordinated by the Southeast Fisheries Development Centre’s Aquaculture Department, and
- Development of a regional research program on grouper virus transmission and vaccine development, assisted by the fish health section of the Asian Fisheries Society and the Aquatic Animal Health Research Institute, Thailand.

Publications: The network has developed a number of publications. An excellent example of the strength of the networking approach to developing extension information is the Husbandry and Health Manual for Grouper. Access to network participants provided the coordinating agency, SEAFDEC AQD, with a wealth of information and experience from grouper aquaculture researchers and practitioners throughout the Asia-Pacific region. Following publication of the original English version, network participants provided translation into local languages: Filipino, Indonesian, Mandarin, Thai and Vietnamese. The result was a high-quality publication of direct application to farmers in the major grouper farming countries of Southeast Asia.

Staff exchanges: To encourage cooperation and coordination of network activities, the network has supported staff exchanges between participating institutions, funded by both ACIAR and APEC. These exchanges have supported the development of human resources, provided a basis for capacity building, and ensured the transfer of new technology on various aspects of grouper culture to participating economies.

Training: In addition to more traditional extension techniques, such as written publications and workshops, APMFAN has a strong focus on ‘hands-on’ training to facilitate technology uptake by farmers. An example of this is the Regional Grouper Hatchery Production Course, which the network has run annually at the Gondol Research Institute for Mariculture, Bali, Indonesia, over the last 3 years. The Gondol course provides hands-on training for a limited number (~15) of participants at a centre renowned for its excellence in developing production technology for marine finfish, particularly groupers.

The success of the course is evident from the results that have been achieved by course participants. In Thailand, Indonesia, Vietnam, Malaysia and Australia course graduates have been able to apply the techniques learnt from the training and have successfully produced grouper fingerlings, including *Epinephelus coioides*, *E.fuscoguttatus* and *Cromileptes altivelis*. Further courses are planned based on the success of the first two.

Other network partners have also incorporated recent research results into their training courses. For example, the Aquaculture Department of the Southeast Asian Fisheries Development Centre has incorporated recent technological improvements in grouper hatchery production into their regular Marine Finfish Hatchery course, and Department of Primary Industries, Queensland, has run a series of workshops for farmers interested in grouper aquaculture in Australia. The Gondol Research Institute for Mariculture has run several courses in the Indonesian for local farmers and fisheries officers.

Through this training course, APMFAN has spread the impact of the research outcomes of the ACIAR project, as well as other projects, beyond the agencies that are formally involved in the project, and has provided direct technology transfer to farmers.

Future Actions

Future development of sustainable marine finfish seafarming in the region will benefit from the networking approach outlined above.
Specific activities include:

- Further expansion and formalisation of participation in the marine fish networking
- Development of additional research projects to address priority areas, including:
    - Fish health, particularly viral diseases.
    - Enhancing environmental sustainability, for example, through developing more environmentally-friendly feeds and management techniques.
- Ensuring that benefits of research and development outputs are spread widely in the region through enhanced communication.
- Providing direct outcomes to researchers and farmers by providing specialised training.
- Undertaking further market research to determine longer-term research and development strategies.

Further, there would be considerable benefits for development in the region if the approach adopted for marine fish was further widened to include other seafarming commodities and options. Together with the marine fish networking, such a seafarming network would help provide a range of options for food production, and livelihood improvement for people in the coastal areas around the region.

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Regional efforts to improve management of shrimp farming: what more needs to be done?

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Introduction

World aquaculture production continues to grow rapidly. World aquaculture production continues to grow rapidly. In 2001, global aquaculture production reached 48.4 million metric tonnes, with a value of US$61.47 billion. Although crustaceans represented only 4.1% of total production by weight, they comprised 18.8% of total global aquaculture by (farm gate) value in 2001. The annual percent rate of growth (APR) of the shrimp farming sector has been significantly higher than other food production sectors, although in terms of growth, shrimp production has decreased to more modest levels over the last decade (averaging 5%) relative to the double-digit growth rates which were observed during the 1970's (23%) and 1980's (25%).

In Asia, two major species accounting for over 53 percent of total crustacean production in 2001 (the giant tiger prawn, *Penaeus monodon;* and the fleshy prawn, *P. chinensis*). Whilst the giant tiger prawn ranked 5th by weight in terms of regional aquaculture production in 2001, it ranked first by farm-gate value at US$ 4.7 billion. Shrimp production levels in the region reached 1.2 million mt by 2001 (accounting for more than 40% of total shrimp landings). The aquaculture production of *P. monodon* has ranged between 480 to 610 thousand tonnes since 1993, whilst its contribution to shrimp production has declined from 70% to 48% in 2001, as *P. chinensis* and other *Penaeus* shrimp species have increased.

The rapid expansion in shrimp farming, fuelled by high profitability and strong demand mainly from affluent consumers in importing countries, has provided a number of developing countries in Asia and Latin America with substantial foreign currency earnings from shrimp exports. Shrimp as a commodity makes substantial contributions to trade flows in fishery products from developing to developed nations.

In Asia, shrimp farming has emerged as a main source of employment and income for hundreds of thousands of people. Employment and income is generated in production, associated service and supply industries, such as feed mills, ice plants, drug and chemical suppliers, as well as in shrimp trading, processing and distribution, including retailing and exporting. Although global prices for shrimp have been declining in recent years, returns from shrimp farming have until very recently continued to be quite high compared to other aquaculture and agricultural crop options, and the livelihoods of many small-scale farmers and communities in coastal Asia are connected to the shrimp industry in various ways. Most shrimp farming in Asia is still undertaken by small-scale farmers owning less than 5 ha of land in rural coastal areas. Because earnings from the production, export and trade of shrimp products are so significant, expansion of shrimp farming continues in both Asia and Latin America, and there is an emerging interest in Africa, where there has been relatively limited shrimp farm development to date. However, during 2003 shrimp farming in Asia faced a number of crisis, including most prominently a price crash and an antidumping threat from a major importing country, and in many ways such problems have highlighted the fact that Asia has probably reached a turning point in shrimp farming. What are the problems, and where to next?

Rapid growth of shrimp farming has raised controversy in both shrimp producing and shrimp importing countries. Public opinion in importing countries, and some exporting countries is being influenced by high profile concerns over environmental and social impacts of shrimp aquaculture, food safety issues, and, more generally, the long-term sustainability of shrimp farming practices. Major issues raised include the ecological consequences of mangrove conversion to shrimp ponds; salinization of groundwater and agricultural land; pollution of coastal waters from pond effluents; use of fish meal and oils in shrimp feeds; biodiversity issues arising from the collection of wild shrimp seed and more recently from the introduction and spread of the exotic species of *Penaeus vannamei* to Asia; residues in shrimp products leading to major importing problems; and diversion of local food resources for export and social conflicts and benefits. Several countries are still trying to sustain their shrimp farming in the face of disease problems, and sustainability is still questioned because of "self-pollution" when too many shrimp farms are crowded together in a single production area, and the emergence of economically debilitating shrimp disease outbreaks, related to trans-boundary spread of pathogens. Such problems are acute in some areas of Asia, where there has been rapid expansion of shrimp farming, with insufficient attention given to appropriate site selection, farm design, and to responsible farm management systems.

On a larger scale, planning and co-ordination of the sector's development, institutional capacity, and overall planning and management of coastal areas, has largely failed to keep up with the rapid and all too often unplanned pace of shrimp aquaculture development. Compounding this problem, several of the leading shrimp-producing countries have weak governance institutions and coastlines that support exceedingly high human populations (most notably Bangladesh, India, Indonesia, and Vietnam), raising severe difficulties for management of an essentially new and resource-demanding coastal farming activity. It is safe to say that the controversies around shrimp farming have now reached the stage where concerted efforts are required to address the problems. Whilst the global demand for shrimp is still increasing, only those countries, and businesses, that take serious and concerted efforts to address the problems are likely to survive the current crisis.

Consortium Program on Shrimp Farming and the Environment

Due to the strong interest globally in shrimp farming and issues that have arisen from its development, a Consortium Program involving the World Bank, the Network of Aquaculture Centres in Asia-Pacific (NACA), the World Wildlife Fund (WWF), and the Food and Agriculture Organization of the United Nations (FAO) was initiated to analyze and share experiences on the environmental and social impacts as well as better management practices of shrimp aquaculture. The development of work program for the Consortium benefited from the recommendations of the FAO Bangkok Technical Consultation on Policies for Sustainable Shrimp Culture (FAO, 1998), a World Bank review on Shrimp Farming and the Environment (World Bank, 1998), and an April 1999 meeting on shrimp management practices hosted by NACA and WWF in Bangkok, Thailand. The objectives of the Consortium program were to: (a) generate a better understanding of key issues involved in sustainable shrimp aquaculture; (b) encourage debate and discussion around these key issues to lead to consensus among stakeholders; (c) identify better management strategies for sustainable shrimp aquaculture; (d) evaluate the cost for adoption of such strategies and other potential barriers to their adoption; (e) create a framework to review and evaluate successes and failures in sustainable shrimp aquaculture which can inform policy debate on management strategies for sustainable shrimp aquaculture; and (f) identify future development activities and assistance required for the implementation of better management strategies that would support the development of a more sustainable shrimp culture industry.

The Consortium program was initiated in August 1999 and involved complementary case studies on various aspects of shrimp aquaculture. The case studies provided wide geographical coverage of major shrimp producing countries in Asia, Latin America, and Africa, as well as studies and reviews of a global nature. The cases documented and analyzed global experiences in management of shrimp aquaculture, identified key environmental and social issues, and identified examples of "better management practices" (BMPs) that can be applied to enhance the positive social and economic impacts of shrimp farming and reduce negative social and environmental impacts. The major issues to be addressed through better management are highlighted below. The process of identify these management principles was also informed by stakeholders during a FAO/Government Australia Expert Consultation on "Good Management Practices and Institutional and Legal Arrangements for Sustainable Shrimp Culture" held in Australia during December 2000, a meeting on shrimp certification hosted at the Pew Charitable Trusts in Philadelphia during August 2001, consideration of the FAO Code of Conduct for Responsible Fisheries (particularly Article 9 concerning aquaculture development) as well as Consortium Program studies. A draft report is available (World Bank et al, 2002).

Key principles, or "Better Management Practices (BMPs)" for shrimp aquaculture

- Locate shrimp farms in areas that make efficient use of land and water suitable for shrimp production and in ways that conserve biodiversity, ecologically sensitive habitats and ecosystem functions.
- Design and construct shrimp farms to reduce or limit off-site ecological damage.
- Use water exchange practices that minimize impacts on water resources.
- Use shrimp post-larvae and broodstock efficiently in order to reduce demand on wild stocks.
- Use feed types and feed management practices that make efficient use of feed resources, and ideally contribute to net production of aquatic animal products.
- Control off-site impacts associated with discharge of effluent and solid wastes.
- Minimize risks of disease affecting farmed and wild stocks.
- Ensure food safety and quality of shrimp products and reduce risks to ecosystems and human health from chemical use.
- Develop and operate farms in a socially responsible way that benefits local communities and the country.
- Develop shrimp aquaculture in ways that contribute effectively to rural development, and particularly poverty alleviation in coastal areas.

There are indications already that the consortium approach and case study findings are having positive impacts.

Some elements of the BMPs have been incorporated into several "codes of conduct" or "codes of practice" being developed around the Asia region. The case study of the north-central coastal areas in Vietnam explored the role of shrimp aquaculture in coastal community development. The information generated in Vietnam contributed to raising awareness in the country about connections between shrimp aquaculture and poverty alleviation. The findings and approach adopted have contributed to the development a new government policy orientation within the Ministry of Fisheries towards poverty focused aquaculture development. Shrimp aquaculture in Bangladesh has been marked by significant local social conflict and confrontation between NGOs, government and private sectors. The case provided a basis for dialogue between NGOs and the government and led to wider appreciation of social issues in shrimp culture development. The case study also provided a means for addressing social problems through encouraging local farmer participation in shrimp aquaculture.

The Consortium's thematic review on mangroves provided a basis for development of a global Code of Conduct for the Management and Sustainable Use of Mangrove Ecosystems, a guidance document to support better management of mangroves, being prepared by the International Society of Mangrove Ecosystems (ISME), the Centre for Tropical Ecosystems Research (CenTER Aarhus), and the World Bank. Another consortium case looked at the production and market implications of third-party certification systems for shrimp aquaculture. The goal of this work was not to create a certification system but rather to identify what the major issues and implications are for such work. Government delegates recognized the work of the Consortium during the recent meeting of the FAO Aquaculture Sub-Committee, and considered the BMP principles as an important basis for possible future international agreement on management principles for shrimp aquaculture.

What more needs to be done?

In Asia, the case studies provide understanding on the major issues to be addressed in shrimp producing countries, and management strategies that can improve environmental and social performance. The challenge now is implementation of better management practices.

In March 2002 the Consortium organized a Stakeholder Consultation hosted by the World Bank in Washington DC, USA. This Consultation was important because of the participation of a broad range of sector stakeholders, from different regions where shrimp farming is important, providing perspectives from industry, governments, civil society/NGOs and regional and international organizations. The meeting created a rare opportunity for stakeholders to interact and share experiences across different levels in the market chain and across regions. Meeting participants came to broad agreement on future actions to support implementation of better management practices in shrimp aquaculture in Asia, and elsewhere around the globe. The major outcomes as they related to the future of shrimp farming in Asia are summarized below.

International agreement on management principles: The Consortium program provides a basis for development of an internationally acceptable set of principles for responsible management of shrimp aquaculture. Such principles, if agreed upon through a transparent and consultative process, would provide a basic instrument for guiding future management in the sector—by governments and business—and eventually form the basis of an internationally accepted shrimp aquaculture certification system. Government participants at the recent FAO Sub-Committee on Aquaculture recommended an international set of principles be developed to guide more responsible shrimp farm development, and there is increasing consensus on the need for such principles, not only in shrimp farming, but also more broadly in the aquaculture sector.

Shrimp certification: The awareness of consumers in importing nations about how seafood products are produced is growing, and certification of shrimp aquaculture products is receiving increasing attention. In Europe and the US, mandatory labeling of the origin of seafood products is being introduced, and there are several initiatives moving towards certification of products from aquaculture, intended to respond to consumer and buyer demand for sustainablyproduced, quality seafood. Shrimp farming in particular is now the focus of several codes of conduct and certification schemes and it is likely that certification of farmed shrimp, in one form or another will become essential for future international trade and marketing. The potential for labeling to become a further non-tariff barrier is a concern expressed by developing countries in Asia, and the implications for smaller-scale shrimp producers may be particularly significant. Certification related to better management of shrimp aquaculture, if implemented in a fair and practical way, sensitive to the needs of small producers in developing countries, however, may provide opportunities to support responsible and sustainable development of aquaculture and to address some of the negative environmental and social concerns about shrimp aquaculture. This will require the active engagement and participation of Asia in the process of development of certification principles and schemes that really take account of the special circumstances of aquaculture development in the region. The issues at stake here are very significant, in terms of the number of people involved with aquaculture (small-scale producers, input suppliers, traders, and others), and financial sums involved.

> In India, NACA has cooperated with the Marine Products Development Authority (MPEDA), the Australian Centre for International Agricultural Centre (ACIAR) and ICAR to establish "better management practices" among groups of small-scale farmers in West Godavari district of Andhra Pradesh. The results are promising: they show the benefits of encouraging farmers to establish farmer groups to work together adopt and adapt better management practices to local conditions; they show that economic performance of shrimp farming can be improved by the adoption of better management practices; and, they offer the opportunity for better organization of farmers into groups to meet increasingly stringent market demands for quality shrimp.

At the same time, the development of multiple certification schemes has potential to lead to increased confusion in seafood markets, as well as additional costs burdens for industry associated with having to conform to multiple standards. As some form of certification and eco-labeling of aquaculture products is therefore inevitable, there is a need to actively engages the producers and producing countries of Asia in the process of an internationally harmonized set of "principles, criteria and standards" for certification. To encourage discussion on certification principles, and systems, the Consortium has established a certification web site♦, where many existing schemes can be found, together with

♦ www.enaca.org/certification

relevant information on certification, and the opportunity for public comment and discussion.

Supporting implementation of better management practices: The Consortium partners are working to widely disseminate findings from the program, and working closely with interested countries for effective communication of findings. In both India and Vietnam, work is ongoing with government and the business sector to support implementation of better management practices, with a particular emphasis on small-scale farming communities. This work has shown the importance of effective communications of better management practices, and provides improved understanding of the institutional, policy and production constraints to implementing better practices. At the same time, economic analyses show that implementation of several BMPs actually lead to reduced costs and increased farm profitability.

Development of shrimp farming in Asia and other developing countries has highlighted the weak institutional and policy environment that supports coastal resource use and management in coastal areas. Although market-driven approaches such as certification may improve management in the sector, there continues to be a need for stronger coastal management institutions. The responsibility for effective management and sound development of aquaculture and shrimp farming lies not only with the business sector, but also with the government, and considerable support is still required for the effective development of these institutions.

Research opportunities: There are opportunities for research to address key gaps in the Consortium program. During the Stakeholder Consultation in Washington, issues identified for research included: the need to better understand impacts of the World Trade Organization (WTO) and services agreement (including extension services) on shrimp aquaculture development and certification; the need for further research on coastal wetland restoration on abandoned shrimp farm land; social dimensions of BMP's and engaging small-scale producers in shrimp certification, including poverty impacts (positive and negative) of BMP implementation; economics of BMP implementation and cost reduction studies (including studies on reducing energy costs); and legislation studies, including examples of where is it working, and minimal legal requirements to support implementation of core BMP principles.

Communication and cooperation: The Consortium program emphasized the importance of effective communication in the aquaculture sector. A web site was established to disseminate the findings from the Consortium program. As aquaculture continues to expand globally and becomes more diverse and complex, the need to promote cooperation, capture lessons learned, and share learning and experiences will increase as well. The Consortium program created a basis for movement towards implementation of better management practices for shrimp aquaculture. The findings came from a consultative process that involved cooperation and inputs from a wide range of groups, including government, non-government and business sectors. The program has started to identify future development activities and assistance required for the implementation of better management strategies that would support moves toward a more sustainable shrimp culture industry. The Consortium's partnership approach shows that such cooperation is not only fruitful in the short-term but also provides a platform upon which such cooperation can be further extended in the future to address other major international issues affecting aquaculture development.

The Consortium partners continue work on the program, and are committed to promoting communications on management principles, ensuring effective dissemination and uptake of the program findings. There is still much that needs to be done to support implementation of more sustainable farming practices in shrimp farming. The Consortium partners welcome suggestions and opportunities to widen partnerships that promote further active cooperation in seeking solutions for a more sustainable future development of the shrimp sector.

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Fisheries in inland waters in Asia, with special reference to stock enhancement

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Introduction

Inland fisheries, according to available statistics, currently accounts for about 10 percent to the world fish supplies. There is a general consensus that inland fish production, particularly from some of Asia's most productive systems, such as the Mekong river system, is grossly underestimated, and as such the contribution of inland fish to world fish supplies is significantly higher than 10 percent.

In Asia, inland fish production is important, but its contribution to the fish supplies is being somewhat masked by the increases in aquaculture production. Apart from the total production *per se*, inland fish is important to food security in many other ways too. Notably, inland fish production generally; caters to rural populations, provides an affordable animal protein source, often to rural masses, enables persons with minimal skills to be engaged in resource exploitation at a subsistence level, and little of the produce is converted into feed ingredients for farmed animals including fish, unlike in the case of the marine fish production, of which nearly 25 percent is converted into fishmeal, and almost all of the inland fish production, in one way or the other, is used for direct human consumption.

Inland fisheries also offer substantial employment opportunities, mostly in the rural sector, where generally such opportunities are limited, and more often than not also offer a means of subsidising agricultural incomes. Most inland fisheries require very meagre capital, and can often be practiced as a part-time activity, such as for example operating a few traps in a paddy field, irrigation channel, or receding floodplain, and permit persons with different skill levels to exploit the resources, often in a environmentally non-destructive manner. This chapter provides a brief overview of inland fisheries in Asia, with an emphasis on experiences in inland fisheries stocking, or enhancement[2].

Resources

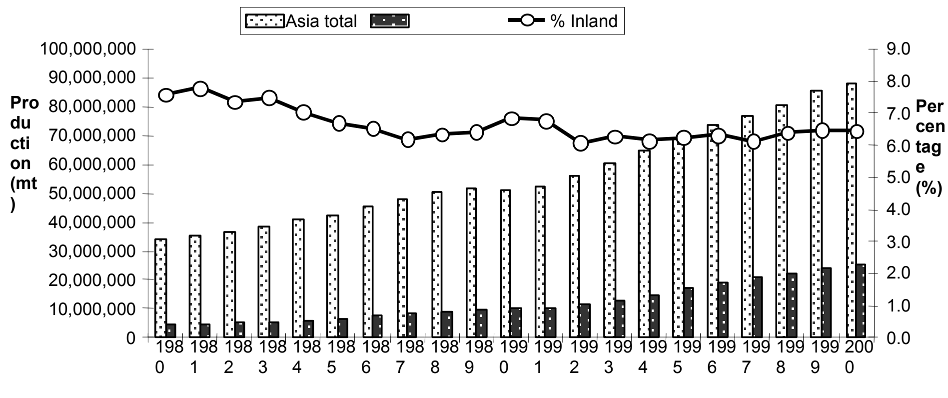
Outwardly, Asia appears to be the continent that is blessed with the most amount of freshwater, approximating 13,510 $km^3\ yr^{-1}$. But on the other hand, the average amount of freshwater available per caput is lowest in Asia, amounting to only 3.92 $m^3\ yr^{-1}$. The low per capita availability of water in Asia is implicit of the competition for this primary resource in the continent, and therefore one of the realities the expanding aquaculture industry will have to confront in the not too distant future. From a fishery view point the main water resources are the rivers and flood plains, and natural lakes and man-made impoundments of various sizes.

Inland fish production in most countries, as in the case of Asia as a whole has been steadily increasing (Figure 1). In Figure 1 inland capture fishery production is compared to that from aquaculture; two fishery sectors that are likely to compete for a common primary resource- water- for development, in the foreseeable future, if not now. In almost all the countries considered presently, except perhaps in Indonesia, the inland capture fishery has increased over the years, the most significant increase being in Cambodia. On the other hand, it is evident that in most countries aquaculture has

[2] The chapter is summarised from a FAO publication in press (DeSilva, S. 2004. Fisheries in inland waters in the Asian region with special reference to stock enhancement practices. RAP Publication 2004/xxx)

become increasingly important, but still in six out of the ten countries viz. Bangladesh, Cambodia, Laos PDR, Myanmar, Sri Lanka and Thailand, considered presently, inland fisheries contribute more than 40 percent to the total inland fish production.

Figure 1. Total and inland fish production in Asia, and the percent contribution of the latter to the total (based on data from the FAO)



These trends are also reflected in per caput captured and cultured fish production (Figure 2). The current inland fish production per caput, and hence availability, varies widely amongst countries, ranging from about 2.2 (Sri Lanka) to 21.5 kg caput^{-1} year^{-1} (Cambodia), with only Bangladesh, Cambodia, China and Laos PDR exceeding 10 kg caput^{-1} year^{-1}.

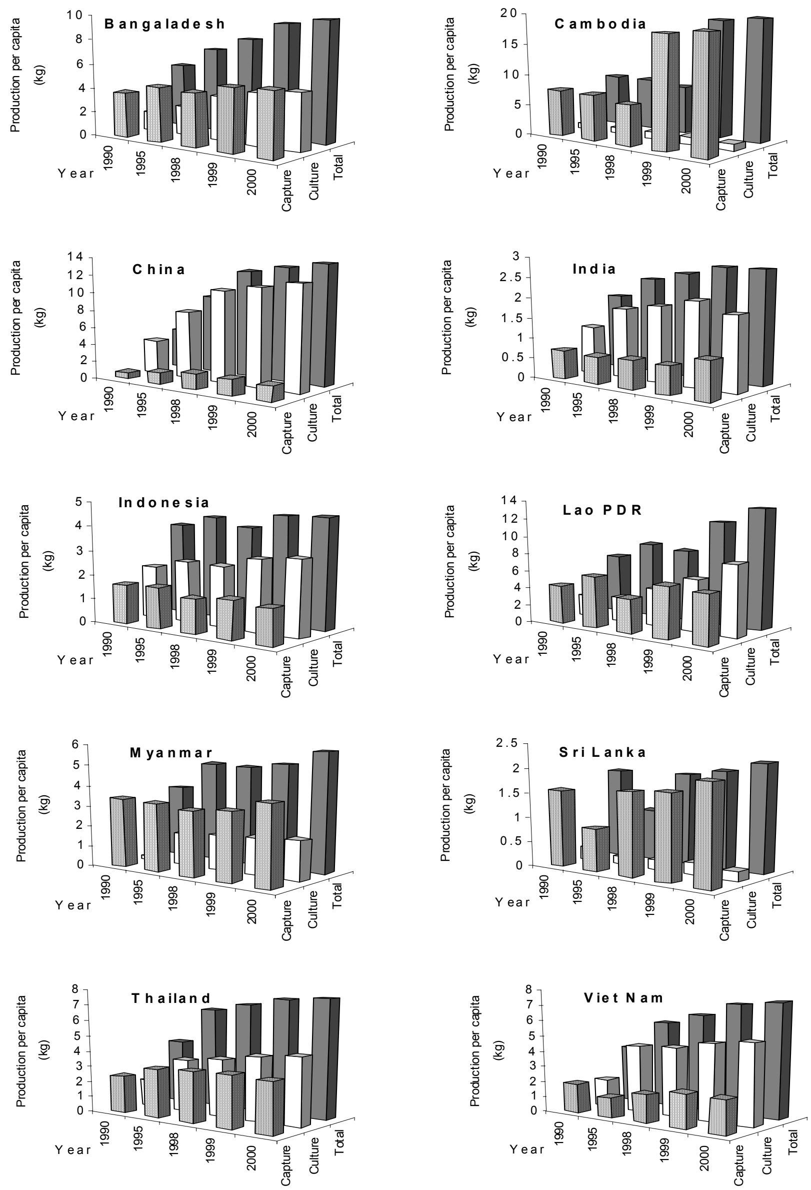
Stock enhancement

Objectives for stock enhancement differ markedly between developed and developing countries. Welcomme (1996) characterised the differing strategies with regard to management of inland waters for fish production, and these are equally applicable, with minor modification, for stock enhancement in inland waters. Stock enhancement in developing countries could adopt one of four broad strategies, or combinations thereof;

- Use as a seeding mechanism for replenishing depleted "breeding stocks", as in the case of Indonesian reservoirs particularly of species indigenous to the country, but not necessarily to a particular water body;
- Replacement of existing, self recruiting species/ stocks, with species/ stocks with more desirable traits such as higher growth rate, reduced tendency to stunt, etc. A good example in this regard would be the endeavours to replace *Oreochromis mossambicus* with *O. niloticus*, a practice that has become increasingly popular over the last three to four decades in most Asian lakes and reservoirs, and the more recent attempts to replace the original stocks of *O. niloticus* with the "GIFT" strain of *O. niloticus* (GIFT- Genetically Improved Farmed Tilapia);
- Regular stocking of species with a view to sustaining a fishery, and in most instances such stocked species are unlikely to form breeding populations in the water bodies, often requiring migration to a riverine habitat for breeding; the species used commonly for such purposes include the Chinese and Indian major carps; and

- Regular stocking of floodplains to compensate for reductions in recruitment resulting from developments related to flood control (eg. Bangladesh) and increase fish yields, and/ or develop new fisheries to enhance fish supplies (eg. Myanmar).

Figure 2. Production per capita of the inland capture, culture and total fishery in selected Asian countries in selected years.



The following gives a brief overview of the resources and enhancement practices in different types of water bodies found in the Asian region.

Large water bodies

River and floodplain fisheries

Asia contains some of the world's largest rivers, that contains social and economically important fisheries. Among the most productive fisheries are the floodplains, or seasonal wetlands. These are formed by overspill of flood waters from the rivers to which they are connected. Welcomme (2000) suggested that living aquatic resources in floodplain rivers have to be extremely robust as these need to respond readily to year-to year variations in flood strength; even being capable of surviving prolonged periods of drought. Floodplain topography is very diverse. Natural productivity of floodplains is very high, and often acts as the nursery grounds for many riverine species, and indeed some commercially important species spawn in the floodplains. The importance of floodplains for riverine fish has been aptly dealt with by Welcomme (1985) and others.

In Asia, floodplain stock enhancements, for all intents and purposes, can be considered to be restricted to Bangladesh and Myanmar. The floodplain fisheries in both countries are important not only from a fisheries production view point but also socio-economically, providing livelihoods to large numbers of people. With increasing developments related to flood control, and consequent habitat changes, natural recruitment of stocks have declined resulting in reduced fish yields. It is in this context that measures are being taken to counteract this reduction through stock enhancement. On the other hand, certain floodplains, or portions thereof, may be completely cut off from the parental river by damming, thereby creating a perennial water body. Such water bodies do not receive the annual influx of nutrients from flooding, the water regime comes under greater human control, and the fishery practices in these become more akin to the culture-based fisheries model than to a stock enhancement *per se*.

The importance of floodplains as a nursery ground and a breeding, and feeding ground for many riverine fish species have been well documented. It is in this context that human intervention, through physical changes to the floodplains and or biological intervention such as through stock enhancement, introductions/ translocations that could bring about an influence on biodiversity. Most stock enhancement activities, almost with out exception, involved exotic species; for example use of Chinese carps and *P. gonionotus* in Bangladesh and Indian major carps and tilapia in Myanmar. However, to assess biodiversity of floodplain fisheries, which unlike other waters do not always have a permanent/ resident fauna, and a fauna which changes from flood season to flood season, is difficult. To assess changes in biodiversity under such conditions is hard, but it is even harder to correlate changes to activities related to stock enhancement.

Large lakes and reservoirs

The great bulk of the lacustrine water resources in Asia are the man-made lakes or reservoirs, and natural lakes are few in number and acreage. Large here refers to lacustrine water bodies that have a surface area larger than 1000 ha. Admittedly, this is a relatively subjective division. On the other hand, and in general, in water bodies which are smaller the fishery practices are somewhat different to those in water bodies >1000ha, and indeed even smaller. The most obvious difference being that the fisheries in the latter tend to be open access as opposed to those in smaller water bodies which tend to be individually or corporately owned. These differences, by implication, makes the strategies adopted/ used to enhance fish yields from such waters widely different, and equally resulting in different impacts on the fish yields as well as on the community and other stakeholders.

What is evident from the stock enhancement practices adopted by different countries is that it has been rather ad hoc, and lacked serious follow-up. The instances, in which stock enhancements have been successful, except in the case of self-reproducing species, are very few and far apart. The bulk of the successes are almost entirely confined to medium sized water bodies, such as in the case of EaKao Reservoir, Vietnam. In almost all instances the numbers of fish stocked have been rather arbitrary and have not been based on any apparent scientific reasoning. Similarly, the species combinations used which have been more of a reflection of availability than on scientific data, except to point out that in certain instances stocking has attempted to fill vacant niches. In large water bodies the trophic relationships are never straight forward. Consequently, to base a stocking strategy on experiences in aquaculture ponds, in accordance with the polyculture principle in which a species is selected to fill a food niche, may not necessarily be the most suitable approach for large water bodies for a number of reasons. Foremost amongst these are;

- The relatively low natural productivity of larger water bodies,
- Greater influences of catchments and climatic factors on productivity,
- Ill- defined cycles of productivity,
- Complex trophic relationships,
- Relative inaccessibility, seasonal or otherwise, to certain food sources resulting from physico-chemical stratifications, and finally
- The nature of the fishery itself which may prevent and/ or minimise recruitment of the stocked species.

It was also apparent that there was no attempt to correlate the amount stocked to the potential productivity of the particular water body, which indeed should be the first step before determining the species composition of the seed stocked. In this regard, and currently in inland fishery management, a number of tools are available to predict the total yield from a water body, since the development and successful application of the Morpho Edaphic Index (MEI) for inland water bodies in North America (Ryder, 1965). MEI has been utilised for this purpose for tropical water bodies, though primarily for natural lakes (Henderson and Welcomme, 1974). Other fish yield prediction indices (eg. chlorophyll a- Oglesby, 1977; shore-line development- Moreau and De Silva, 1991), including one based on catchment land-use patterns, which appear to be significant factor influencing reservoir productivity and hence fish yield, using geographic information systems (De Silva *et al*., 2001) has also been developed. Such predictive models are increasingly used in managing individual fisheries, such as in Sri Lanka, through determining the number of operable crafts in a water body; a strategy that is expected to be increasingly adopted by other countries also.

Unplanned attempts to stock large lacustrine waters yield very little rewards, except perhaps for the carnivorous, often naturally recruited, indigenous species already inhabiting the water bodies; the stocked fish providing often an unexpected and an easy fodder to them. On the other hand, there is no reason to presuppose that well planned and well executed stock enhancement strategies will not yield positive results, even though such instances are very few and far apart. It is in this context that the following steps are suggested to develop suitable stock enhancement strategies for large, inland, lacustrine waters in the Asian region.

- Does the water body require a stock enhancement strategy? Stock enhancement is not cheap, and one of the foremost pre-requisites for developing a strategy is to evaluate whether the water body requires any form of stock enhancement or not. In this regard a number of questions need to be addressed;
    - o The current yield and the species composition of the fishery
    - o Whether the fishery is primarily dependent on indigenous and/ or exotic species
    - o Whether the main constituent species of the fishery are self-recruiting, and whether spawning occurs in the water body or not, and
    - o Consumer acceptance of the main constituent species.

- How much to stock? This is perhaps the most difficult question to answer. However, consideration of a number of factors could lead to meaningful results.
    - Determine the potential fishery yield of the water body using an appropriate yield- predictive model.
    - If there is significant gap between the actual and predicted yield the fish stocks need to be enhanced.
    - After the expected yield from the species to be stocked is estimated, the growth rate of each species in the fishery (and or from comparable habitats) can be used to determine the time taken for a suitably sized fingerling (more than 14 cm in length) to reach the most desired mean landing size (for eg. 700 g).

One of the most crucial aspects of stocking is to ensure that the stocked fish are of suitable size. In Chinese culture-based fishery practices, where the predatory pressure is minimal, years of experience and trial and error have shown that the most desirable size for stocking is above 13 cm in length (approximately 25g fish). In large reservoirs, on the other hand, there is bound to be considerable predatory pressure, and consequently it will be appropriate to stock fingerlings above 13 cm in length.

Constraints to stock enhancement in large water bodies

One of the main constraints to developing and sustaining stock enhancement strategies for large water bodies is the lack of economic viability. Lack of economic viability arises primarily as a result of most programs being ad hoc and not being determined on scientific criteria as pointed out previously. Even if the latter is fulfilled a major constraint to developing sustained stock enhancement programs, in most countries in Asia is likely to be the availability of suitably sized seed stock. In spite of the technical capability of all nations to artificially propagate almost all of the species that are required for stocking, good quality fingerling availability, in large numbers is a major constraint. The seed that is produced is mostly channeled into aquaculture and culture-based fisheries leaving a large gap in the requirements for stock enhancement programs in large water bodies. Indeed, for all intents and purposes this lack of availability of seed stock in all probability have been the primary cause for the rather ad hoc and ill planned stock enhancement programs; in essence the latter have been a secondary use for “left over” seed stock.

Fisheries in large water bodies in Asia, with a few rare exceptions (Ayunha reservoir, 3700 ha in Phu Yen Province in central Vietnam), are open access. Consequently, and invariably, any stock enhancement strategy has to be undertaken by the relevant state agencies for the public good, and not entirely for profit. In the present economic climate accruing cost for the public good is becoming a rarity. Perhaps, there will be a need to develop a co-management strategy to limit "open access' of such stocked waters, and in turn the stakeholders will have to develop a mechanism of renumerating for the seed stock, perhaps through a nominal levy imposed on the individual catches, fishing licenses, etc. Although the latter system is in operation in respect of some of the large reservoirs in Vietnam, there is no evidence to demonstrate that stocking is cost effective.

Large water bodies in most of Asia are under the purview of different administrative organisation, such as irrigation and agriculture authorities, and rarely or never under fisheries authorities. More often than not, fingerling stocking in large water bodies is rarely coordinated with water release schedules, nor are suitable structures installed near sluices to prevent loss of stocked seed. Lack of coordination between stocking and water release, especially in the immediate post-stocking period, before the seed find its most suitable niche can often result in loss of stocked seed. It is unfortunate, however, that this aspect has not been studied in detail, any where in the world, except that of Jhingran (1992), and essentially remains an unknown entity, that affects the returns from all stock enhancement programs. Jhingran (1992) reported nearly a 300 percent increase in fish production in three reservoirs in India as a result of coordination between the water release and stocking and provision of devices to prevent fingerling escape from the spillway.

Small and medium-sized inland water bodies

The acreage of small water bodies (<400ha) in the region is estimated to be 66,710,052 (FAO, 1999). The great majority of these water bodies are man-made, except perhaps with the exception of oxbow lakes (locally known as baors) in Bangladesh and are irrigational in function, often depending on relatively small catchments for water, These water bodies tend to supply water for down stream agricultural activities, such as rice paddy cultivation, etc. More often than not, these water bodies come under the purview of government authorities such as Agrarian Services (Sri Lanka) and or a division of the Agricultural Services (eg. Thailand, Laos PDR, etc.), and in general day to day management of the water resources is carried out by government approved organisations, comprising primarily of the down stream farming community (ies). Such organisations are known variously, in the different countries. Perhaps, one of the few exceptions in the above regard are the leased flood plain fisheries in Myanmar, where large areas of the flood plain are often converted into almost perennial water bodies, up to about 600 ha, and are under the purview of the Fisheries Authorities of the Government. In PR China, each water body is managed by a Reservoir Bureau, with sub-components for catchment, downstream and fishery management.

Small water bodies have very different characteristics to those considered earlier. In general, in small water bodies natural fish production is too low to support any fishery, and as such any form of fisheries development in these have to be done in conjunction with a regular stock enhancement program. Also as small water bodies tend to be managed by individuals and or organised groups of individuals, these groups tend to have direct and/ or indirect ownership to the stocked fish, and therefore fishery activities in such waters conform to the accepted definition of aquaculture. These practices are commonly referred to as culture-based fisheries (De Silva, 2003) and/ or aquaculture based fisheries (Lorenzen, 2003), and the former terminology will be used in this text.

The scope for fisheries development in small water bodies i.e. culture- based fisheries development in small water bodies is recognised by many (Welcomme and Bartley, 1998; De Silva, 2000, 2003; Lorenzen *et al*., 2001) to have the one of the highest potential to increase food fish production in Asia in the ensuing years. Such developments have added benefits to most communities and foremost of these are;

- Providing an affordable and a fresh animal protein source
- Contribute significantly to rural household income, and farmer income,
- Encouragement of multiple and non-consumptive use of a primary resource-water, with little foreseeable negative influence(s) on the traditional usage of the resource by the community,
- Synergies that result from a communal activity, with relatively undefinable and unquantifiable but often with positive influences on the immediate community,
- Relatively less resource intensive and needs little capital expenditure compared to most forms of aquaculture, and
- Opening up of new opportunities for some sectors of the community as a direct result of culture- based fishery development.

Fishery development in small inland water bodies, in most ways, is akin to pond culture and the commonalities are manifold;

- The environment is relatively manipulable,
- The water body can be prepared so that almost all the stock is what was seeded (through removal of ‘wild fish’ prior to stocking),
- Seed stock can be based on potential consumer acceptability and marketability,
- All stock is harvestable, and partial/ staggered harvesting can be carried out to suit market demands, and
- The natural productivity, if so desired, with in limits, could be enhanced through fertilisation.
- In general, the greatest difference between pond culture and culture-based fisheries is that latter is a secondary user of the water resource and rarely needs other energy inputs such as in the form of food (may be with the exception of grass when grass carp is stocked).

The current status is such that most developing countries in Asia, with suitable mediuem and small-scale water resources, have embraced culture-based fisheries as a potentially significant contributor to fish food supplies, particularly amongst the rural poor. The latter group are the immediate beneficiary of such activities by virtue of the fact that most of the water resources suitable for culture-based fisheries are invariably located in rural areas. In general, culture-based fisheries in Asia have received much attention in the recent years and have been aptly dealt with (see Thyaparan, 1982; Lorenzen, 1995; Middendorp *et al*., 1996; Lorenzen *et al*., 1998; Nguyen *et al*., 2001; De Silva, 2003; Lorenzen, 2003, amongst others). The common features of culture-based fisheries are that these tend to be a communal activity, and are mostly village based. The yield from culture-based fisheries far exceeds (Middendorp *et al*., 1996; Lorenzen *et al*., 1998; Nguyen *et al*., 2001) those from other larger, inland water bodies, and in certain instances even that from semi-intensive pond fish culture. Perhaps the greatest strides in culture-based fisheries have been made in PR China, when the yield increased from about 50 000 to 1 million t in the period 1980 to 1997, with a concurrent increase in per ha yield from about 80 to 763 kg ha^{-1} $year^{-1}$ (Song, 1999).

Based on the estimated acreage of 66,710,052 ha of small water bodies in the Asian region (FAO, 1999), De Silva (2003) predicted that the culture-based has the potential to produce 2.5 million t of fish, even only if 15% of the above acreage is used and the best practices as seen in China are adopted. Indeed, this is not an unrealistic estimation, particularly in view of the increasing emphasis by respective governments on culture-based fisheries development in the region, and the accompanying changes that are being introduced to improve institutional structures to make it a success. As culture-based fishery activities are mostly communal, success of the respective fisheries depend to a significant extent in having the appropriate village institutional structures in place and operational (Lorenzen *et al*., 1998).

Constraints

Culture-based fisheries is a relatively new development in many Asian nations, and consequently the technical aspects as well as management and socio-economic aspects, perhaps with the exception of PR China, are still in a process of evolution. In spite of this a number of constraints common to most nations are recognisable, and need to be addressed.

Species combinations. One of the main constraints in optimising yields from culture-based fisheries in most nations is the lack of knowledge on the most appropriate species combinations that should be used. Use of ad hoc species combinations and stocking densities could lead to reduction in yield as well as production of under-sized fish, resulting in low economic gains. The water bodies suitable for culture-based fishery activities differ widely in their morphometry, catchment features, hydrological regimes, and consequently in biological productivity. The final yield from a water body will not only depend on the species stocked (and the size at stocking) but also on the biological productivity of the water body, which determines the food availability to the stocked seed, and hence their growth and well being. The success seen in China PR in this regard is based on the stocking strategies that have been worked out to suit the productivity of each water body.

Seed supplies. With regard to culture-based fisheries in Asian nations, the problems with regard to seed supplies are not restricted to quantity and quality only. In view of the fact that culture-based fisheries is a secondary activity, by and large conducted in small non-perennial water bodies, the timing of the supply of seed stock is crucial, and availability has to coincide with the filling of these water bodies with the onset of rains. Indeed, De Silva (1988) pointed out that the failure of the culture-based fishery development program in Sri Lanka in the early 1980s was primarily due to the unavailability of suitably size at the correct time. The problem tends to be further exacerbated in most nations as the main species used in the programs (Chinese and Indian major carps) are often artificially propagated only once a year, although the technology is currently being developed to obtain multiple spawnings in a year.

Management structures/ institutions. The importance of management/ institutional structures in developing culture-based fisheries was highlighted previously. The relevant management/ institutional structures differ from nation to nation, and are dependent on the existing socio-political *milieu* of each nation. With out exception culture-based fisheries are conducted in water bodies that are a common property resource, with open access. However, for fishery developments appropriate management/ institutional structures, relevant and in conformity to the socio-political *milieu* are needed, and it is appropriate to highlight the different approaches adopted by some nations in this regard.

Harvesting and marketing. In the region, the main harvesting period in most culture-based fisheries is dictated primarily by the water regime in these non-perennial water bodies; harvesting being done as the water body dries up. In general, this would mean that in a given area there will be simultaneous harvesting in many such water bodies, often leading to an excess supply, with in a very short time frame, and lead to a reduction in farm-gate price. The situation is further exacerbated as the great bulk of culture-based fisheries in the region are conducted in rural areas of low population density, where marketing channels are not that developed, as yet. In most nations in Asia, perhaps with the exception in PR China, culture-based fishery activities are taken up by traditional agricultural farmers, as a subsidiary activity, and it is important that activities result in a net economic gain to maintain their interests and hence long term viability. Hence the need for addressing the above issue is crucial.

Major issues in inland fishery enhancements

Biodiversity issues

Except perhaps the oxbow lakes in Bangladesh, all culture-based fisheries elsewhere in the region is conducted in quasi-natural habitats; most commonly man-made water bodies, some ancient, some relatively recent. Needless to say these habitats are colonised by indigenous flora and fauna, to varying degrees, but generally the fish populations are not sufficiently large to support subsistence or artisanal fisheries on their own, and hence the secondary use of the waters for culture-based fisheries. it is evident that one other characteristic feature of these fisheries, with the exception of PR China, is that the practices depend on exotic species, either wholly or partially. For example the culture-based fisheries in nations such as Sri Lanka, Thailand and Vietnam are based almost wholly on exotic species (Indian and Chinese major carps, common carp etc.) and nations such as India and Bangladesh to a lesser extent.

As the activities, by and large, are conducted in quasi-natural waters any apparent negative affects on the biodiversity of the indigenous flora and fauna of such waters can not be strictly considered to be invasive. Indeed, the interactions and potential competition in small water bodies in the region have been barely studied. In one such study, in Sri Lanka, Wijeyaratne and Perera (2001) concluded that although some of the exotics and indigenous species shared common food resources because of the nature of these food resources and their great abundance did not result in a foreseeable competition per se between the two groups, a conclusion supported by a study of Piet (1996) also. On the other hand, the negative affects of culture-based fisheries could emanate from exotic escapees invading the natural habitats of indigenous species.

There is no evidence to date that this has occurred. When one considers the fact that all exotic species used in these fisheries have been introduced for other aquaculture and stock enhancement strategies, it will be difficult, if not impossible to discern a cause and effect relationship. What is important is to ensure that in the future that no new exotics are introduced for culture-based fisheries development *per se* and make do with species that are available currently, and also to explore the possibilities of using more and more indigenous species but not at the cost of maintaining and/ or improving the yields obtained from current practices.

Although surface freshwaters which accounts for only a very small proportion of all waters on earth it is estimated to contain 2.4 percent of all known living species, and per unit area it is richer in species than land (3.0 vs 2.7), and about ten times richer than oceans (3.0 vs 0..2) (McAllister, 1999). Freshwaters also account for a relatively richer ichthyo fauna, and an estimated 41 percent of the approximate 25,000 species of fish occur in freshwaters. On the negative side is that estimates suggest that 20 to 35 percent of freshwater fish are threatened or extinct, 43 percent of crocodilians and 59 percent of freshwater mammals are threatened (McAllister, 1999). An analysis of fishes under threat in the 1996 IUCN Red List indicated that species that depend on freshwater at any stage of the life cycle are 10 times more likely to be threatened than marine and brackishwater species (Froese and Torres, 1999). These authors, who confined themselves to only those species listed in FishBase observed that 547 of the 637, or nearly 85 percent of the species threatened had a link to freshwater. All of the above facts go to show the need to consider impacts of stock enhancement, a major and potential development if fisheries in inland waters in developing countries, on sustainability and biodiversity.

The common perception is that apart from the recent developments, such as dam building and general deterioration of the quality in natural waters that introduction of species, deliberate and/or accidental, has been influential to a significant extent on affecting biodiversity. However, in more erect treatment on the subject, with reference to tilapias in the Asia-Pacific region, which have made a major impact on fisheries and aquaculture in the region, De Silva *et al*. (2004) concluded that there is no objective evidence, as yet, to show that these introductions have overly affected biodiversity in the region. Indeed, these authors went on to demonstrate that most evidence that have been brought forth previously in this regard were misinterpreted and misconstrued.

Most stock enhancement practices in Asia, except perhaps in PR China and India tend to use exotic species, mostly Indian and Chinese carps which are known to grow faster to a bigger size. There had not been a concerted attempt to assess the influences of these species on the biodiversity in any of the nations, except the preliminary study on stock enhancement in beels in Bangladesh (Hossain *et al*., 1999). Even more disconcerting is that with in national boundaries, translocations of some of the above species are a common occurrence/ practice. More often than not such translocations are not considered as "introductions", and any affects on biodiversity brought about by such translocations within national boundaries get little or no attention.

All in all there is an urgent need to address biodiversity issues in Asian waters, particularly in relation to fish species usage in stock enhancement practices. It is not only direct affects of such practices that would be important but also the affects on genetic diversity of the used species brought about through generations of inbreeding. Unlike in aquaculture where the use of species with reduced diversity may not be that crucial to biodiversity, as only a few escapees may have the opportunity to influence the natural stocks, in the case of stock enhancement there is a greater probability of mixing of such stocks with the natural stocks, there by increasing risks on the biodiversity of natural systems.

Socio- economic issues

It is evident from the forgoing sections that all forms of stock enhancement in the Asian region have one purpose; that of increasing the fish food supplies, through which it will contribute to the nutrition of the populations, provide additional employment opportunities and in the long term contribute significantly to poverty alleviation. It is also important to note that in the great bulk of stock enhancement practices in Asia occur in rural areas, by design rather than choice, because the water bodies utilised for this purpose happen to be located in rural areas.

One of the major issues with regard to stock enhancement is that it is conducted in common property resource waters, with open access. This could be one reason that stock enhancement in large, lacustrine waters, in most Asian nations, such as lakes and reservoirs has not yielded the expected results/ returns. On the other hand, flood plain stock enhancements, which are prevalent in Bangladesh and Myanmar have adopted different approaches, and there by endeavoured to minimise social affects on the fishery practices *per se*, and endeavour to bring about equity within the community- the primary stakeholders. This however, is easily said than achieved in countries such as Bangladesh where old social traditions and hierarchies are still prevalent and are a part and parcel of the societal structure.

The success of most stock enhancement practices is highly dependent on community participation. Different practices bring together different communities; enhancement in beels in Bangladesh succeed when coherent groups of traditional fishers are formed, where as culture-based fisheries depend on mobilising farmer groups into adopting a somewhat alien practice for individual and community benefit that generates synergies and community well being. In all instances some intervention is needed, at least at the initial stages, finally culminating in sustainable practices managed and owned by the relevant community/ stakeholders. In this regard perhaps the successful stock enhancement practices that are prevalent in the region are good examples of a purposeful secondary use of a primary resource- water- for the community well being, which is expected to filter down to other such activities as the practices mature.

Of course there is also a down side to stock enhancement. In the main this pertains to stock enhancement of large, lacustrine waters, which are usually a common property resource. All evidence indicates, perhaps with the single exception of stocking giant freshwater prawn in Thai reservoirs, that the returns are not cost-effective. Indeed, the most devastating affect on inland fisheries, literally resulting in a complete collapse of the inland fishery in large lacustrine waters, occurred in Vietnam when the subsidised stock enhancement program was withdrawn by the Government as a consequence to economic liberalisation that commenced in mid-1980s. Asian nations need to reconsider strategies in respect of stock enhancement of such waters; it may be that the fingerling size at enhancement need to be increased significantly if a economically viable return is to be obtained; or it may be that nations are better advised to use the stocking material for other purposes, such as rationalising stock enhancement programs in smaller water bodies that are more suitable for culture-based fisheries development, and so on. Most importantly, stock enhancement practices should not be used for the sole purpose of political gain, as is often the case in some nations.

In contrast to large lacustrine waters, stock enhancement in flood plain and culture-based fisheries has shown to be cost effective and economically viable, and sustainable in the long term. It need to be however, pointed out that the number of socio-economic studies available on stock enhancement practices in Asia is few and far apart; there is an urgent need for such studies to ensure improvement and sustainability of these practices, and to effect a greater mobilisation of the communities. A sizeable array of studies in individual nations will also enable a better comparison of performances amongst nations and a realisation of technologies and extension work that ought to be put in place for achieving better results.

It has also been shown in the previous sections that the success of stock enhancement practices depend largely on the availability of suitable institutional structures, aptly demonstrated for Bangladesh (Toufique, 1999), Sri Lanka (Pushpalatha, 2001) and Thailand (Lorenzen *et al*., 1998). In Vietnam which is in a relatively infantile stage of development of culture-based fisheries the average tenure of a lease ranges from three to six years, but variable between provinces and with in a province. More often than not farmer lessees find the time period too short and the uncertainty has, on occasions, inhibited development. However, with the current commitment of the Government of Vietnam to develop inland fisheries it is expected that more uniform regulation in respect of leases will be brought forward. Such problems are not unique to Vietnam. For example, in Sri Lanka the non-perennial, small water bodies utilised for culture-based fisheries development are under the purview of the Department of Agrarian Services, which delegates its authority for water management purposes to Farmer Committees that essentially consist of down stream users. However, under the Agrarian Services Act fisheries development/ activities are prohibited in such waters, suggesting that there is an urgent need to change the statute to encourage down stream farmers to take up fishery activities. The most important change that is needed in all Asian nations is a change in public perception; that fishery activity in a water body does not negatively affect down stream activity and/ or use of the water body for daily household needs.

General Conclusions

Inland fisheries contribute only about ten percent to the global fish production. Asia is the leading producer of inland fish, accounting for over 80 percent of the total production. Until recently inland fisheries sector had taken back stage in fisheries development plans, particularly so with the emphasis being on aquaculture development, through out the world, and Asia was no exception. As aquaculture development in most Asian countries is beginning to face major problems in respect of resource availability, primary and secondary, as well as environmental concerns and related public perception, inland fishery development is seen as non-invasive, less resource intensive mode of increasing fish food supplies, particularly to the rural poor. Consequently, in the recent past inland fisheries in Asia are beginning to have an upsurge and the attention, from governments, development authorities and the general public, it richly deserves.

Inland fisheries in Asia are mostly a rural, artisanal activity, catering to rural masses, providing an affordable source of animal protein, employment opportunities and household income. Stock enhancement is an integral component of most in inland fisheries. With increasing developments artificial propagation techniques of fast growing and desirable fish species and the consequent increased availability of seed stock such activities are beginning to affect inland fishery production in most Asian nations. Indeed, new avenues of production, such as culture-based fisheries are being adopted increasingly and are seen as a way forward in most countries. Inland fishery activities also have the distinct advantage in that its developments are less resource intensive than for aquaculture, for example. Further more, these are environmentally non-invasive than aquaculture in general.

Stock enhancement in all inland waters has not been successful, particularly so in large lacustrine water bodies and in rivers, perhaps apart from a few exceptions. The economic viability of stock enhancement of such water bodies have not been demonstrated for any water body in any of the Asian nations; the fisheries of such water bodies being dependent on naturally recruited stocks, perhaps require only occasional replenishment of broodstock. The most successful stock enhancements in Asia are in flood plain beels and oxbow lakes in Bangladesh, and the utilisation of small water bodies, which on there are not capable of supporting a fishery, leading to culture-based fisheries where stock and recapture rates are very high. Culture-based fisheries development however, requires major institutional changes and these are being affected by respective governments, and in general can be considered to have the greatest potential for further development. The added advantage of culture-based fisheries is that it is considerably less resource intensive, and by and large a community activity which could generate synergies that are advantageous to the community. The main problem facing the developments is the possibility of over production and glutting of the market because harvesting in given region is mostly based on hydrological regimes of the water bodies; harvesting occurring when the water levels are receding. This however, is not insurmountable through the introduction of planned, staggered harvesting and inter-community cooperation.

Stock enhancement in inland waters will continue to be affected and influenced by fingerling availability. In general, although fry production of fish species that are sought after is thought to be adequate there is a bottle neck in fingerling availability. This again is mostly felt in the culture-based fishery programs in which fingerling availability has to coincide with filling of small water bodies, which tend to be, by and large, rain fed. In the case of flood plain enhancement the problem is less compounded because flooding and the spawning of preferred species often coincide.

One of the major concerns of stock enhancement in inland waters is the possible affects of it on biodiversity, for two reasons; firstly most nations depend wholly or partially on exotic species for stock enhancement, and secondly freshwater fishes are known to be amongst the most threatened amongst vertebrates. It is important that major studies are undertaken to evaluate the current situation so as to enable remedial steps be taken, if needed, without causing a major destruction in some of the stock enhancement practices that are gaining momentum.

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Feeds and feed management

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Introduction

There is no doubt that the third millennium will herald marked changes in our global food production systems. The over-riding reason for these changes is the stark realization (after years of environmental abuse) that our planet has it's *limits*, both in terms of it's available natural resources (i.e., land, water, energy, nutrients, natural biota), and through its ability and capacity to harness and recycle these resources and sustain *life* as we currently know it. All too often our planet has been viewed as a limitless resource for the sole exploitation and enjoyment of mankind, rather than as a fragile *living* ecosystem of inter-dependent plants and animals. Well the bells are ringing loud and clear, and the message is there for *all* to see: through the activities of our modern societies (and the development of our towns, cities, agriculture and industries), we are now negatively impacting *all* things, from the air that *we* breath, the water that *we* drink, the food that *we* eat, the land that *we* live on, to the very weather of our planet and the well-being of all living things (Tacon, 2003).

The upshot of the above is that aquaculture (the farming of aquatic plants and animals), like all other food production systems, will have to become increasingly more environmentally and ecologically *responsible* if it is be truly *sustainable* in the long run and be socially accepted as an economically viable means of producing food for an ever hungry population (FAO, 1995, 1997; Raven, 2002; Stickney and McVey, 2002; Tacon and Barg, 2001). With world population expected to reach 8 billion by 2030, pressure on the environment will continue to mount. The challenge of the coming years is to produce enough food to meet the needs of an additional 2 billion people while preserving and enhancing the natural resource base upon which the well-being of present and future generations depends.

The present paper is based on a more detailed review recently conducted by the author for DFID, divided in two parts, the first part briefly dealing with trends in aquaculture production (with particular reference to the fish and crustacean species that are fed on aquafeeds), and the second part dealing with trends and challenges to nutrient supply and aquafeed production. The main focus of the report is on nutrient supply and access for semi-intensive production in artisanal and small-scale commercial systems, and in particular how current/future changes and pressures in agricultural/aquaculture practice, ingredient/fertilizer use and cost, land/water use, population pressures and service costs (including labour, energy and transportation costs) are likely to impact on the future development of the aquaculture sector.

Aquaculture production

Diversity of cultivated species and farming systems

In contrast to terrestrial farming systems where the bulk of global production is based on a limited number of animal and plant species, 241 different farmed aquatic animal and plant species were reported in 2001 (FAO, 2003a), including 146 finfish species, 53 mollusk species, 30 crustacean species, 9 plant species, 2 amphibian/reptilean species, and one or more sea squirts. The large number of species cultivated reflects the wide number of potential candidate species available within the different countries and regions of the world, and wide diversity of production systems employed by farmers. However, this figure is almost certainly considerably higher, as over 9.66

million metric tonnes (mmt) or 20% of global aquaculture production was not reported to a specific species level in 2001 (FAO, 2003).

Dominance of low food chain species

As in all natural ecosystems, low food chain species currently dominate aquaculture production, with aquatic plants (10.56 mmt – 21.8% total global aquaculture production), filter feeding molluscs (11.27 mmt or 23.3%), filter feeding finfish (5.88 mmt or 12.1%), herbivorous/omnivorous finfish (15.15 mmt or 31.3%), and omnivorous/scavaging crustaceans (1.98 mmt or 7.0%) constituting over 93% of total aquaculture production (45.01 mmt) by weight in 2001. Only 3.40 mmt or 7% of total aquaculture production was in the form of carnivorous finfish species in 2001. Figure 1 illustrates these issues on a global scale.

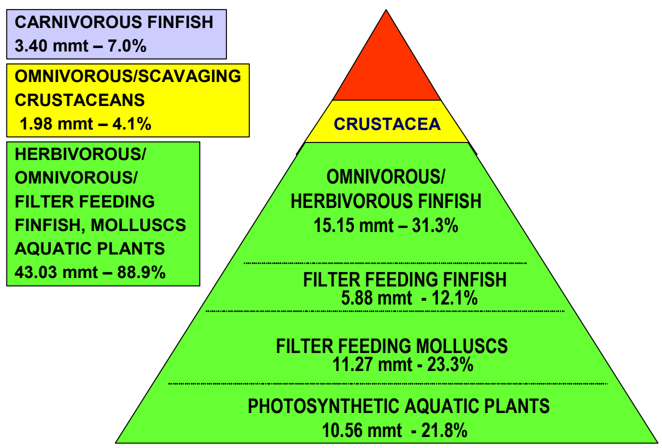


Figure 1. Aquaculture production pyramid by feeding habit and nutrient supply in 2001

Asian aquaculture production

Total aquaculture production within the Asian region in 2001 was reported as 44.0 mmt and valued at US $ 50.5 billion (FAO, 2003a); the region representing 90.9% and 82.2% of total global aquaculture production by weight and value in 2001. The sector has increased 15-fold by weight from 2.8 in 1970 to 44.0 mmt in 2001, with the sector growing at an Average Percent Rate (APR) of 9.4% per year since 1970. Of particular importance is that China is by far the largest aquaculture producer in the world, producing 70.7% of total global aquaculture production in 2001, with nine of the top ten aquaculture producing countries being located within the Asian region in 2001 (see earlier review in this report by Shunji Sugiyama and Simon Funge-Smith).

Economic importance of high-value cash crop species

Since the start of the eighties there has been a noticeable shift within most developing countries (including the target countries listed in this report) toward the production of higher-value (in marketing terms) finfish and crustacean species, and by so doing maximizing possible economic gains and more lucrative export opportunities and incentives/credits.

Thus, although the giant tiger prawn (*Penaeus monodon*) was only ranked 19th by species weight in terms of total global aquaculture production in 2001, it ranked first by value at $ 4.7 billion; total farmed shrimp production in 2001 being 1.27 mmt and valued at US $ 8.4 billion, with Asia contributing over 84% of total global farmed shrimp production (FAO, 2003a). For example, the ranking of farmed shrimp production within the target countries by value in 2001 was as follows: Thailand – 1st US $ 2.0 billion, Indonesia – 1st US 0.88 billion, Philippines – 1st US $ 0.70 billion, India – 2nd US $ 0.67 billion, Bangladesh – 2nd US $ 0.2 billion, Viet Nam – 2nd US $ 0.30 billion, China - 6th US $ 1.8 billion, and Republic of Korea – 7th US $ 25 million. The bulk of shrimp production within these countries is currently destined for export as a dollar-earning cash crop to developed country markets, including the U.S.A., the European Union, and Japan.

A similar situation is also emerging for finfish and other crustaceans. For example, within China there has been a significant shift from the mass production of low-value filter feeding cyprinid species (silver carp, bighead carp; usually gown as a polyculture of different cyprinid species within manure-fed farming systems) towards the production of higher-value aquaculture species (Hishamunda and Subasinghe, 2003), including other freshwater fish species (grass carp, common carp, crucian carp, nile tilapia, mandarin fish), freshwater/marine crustaceans (Chinese river crab, marine crabs, giant river prawn), brackishwater fish (Japanese eel, salmonids), and marine fish species; over 67 marine fish species reportedly being cultured, including the large yellow croaker, Japanese flounder, groupers, Japanese sea perch, and seabreams etc. (Hong and Zhang, 2001). In general those fish species with the highest market value are those having carnivorous feeding habits and/or of marine/brackishwater origin. However, it is also important to highlight here that at present 93.1% of total finfish production in Asia is realized within freshwater, with only 3.9% and 3.0% realized within marine and brackishwater environments (Figure 2).

Trends in nutrient resource use

Farming systems

In general terms, the farming systems currently employed by finfish and crustacean farmers can be broadly divided into three basic categories, namely extensive, semi-intensive or intensive farming systems. Although the precise definition of these systems vary from country to country, farmer to farmer, and author to author, the following generalizations can be made regarding the operating characteristics of these different farming systems:

Extensive Farming Systems (EFS)– usually realized within large earthen ponds, employing low water exchange, low fish/shrimp stocking densities, no artificial aeration, little or no fertilization and/or supplementary feeding, low labor inputs, producing low fish/shrimp yields, and having low production costs.

For example, in the case of shrimp, EFS typically involve the use of large earthen ponds (ranging in size from a few hectares to as much as 100 ha), employ low water exchange (tidal or pump, 0-5% water exchange/day), low shrimp stocking densities (usually below 5 shrimp m^{-2}), no artificial aeration, little or no fertilization and/or supplementary feeding, low labor inputs (less than 0.1 person/ha), have low shrimp yields (typically under 1,000 kg shrimp per hectare/year), and generally have low production costs (US $ 1-3/kg live shrimp). Examples of shrimp producing countries within the region employing EFS include Viet Nam 85% of all farms, India 75%, Indonesia 50%, and China, Philippines 30% (Rosenberry, 1999, 2001); India 85% of all farms, Indonesia 60%, Viet Nam 40%, China 30% (Dr. Chingchai Lohawatanakul/Dr. Chen Ming Dang, Charoen Pokphand Foods Public Company Ltd – personal communication).

Semi-Intensive Farming Systems (SIFS) – usually realized within small to moderate sized earthen ponds, employing moderate water exchange, intermediate fish/shrimp stocking densities, partial or continuous aeration (particularly during the final phase of production), fertilization and/or supplementary/complete diet feeding, moderate labor inputs, producing moderate fish/shrimp yields, and having moderate to low production costs.

For example, in the case of shrimp, SIFS typically involve the use of small to moderate sized earthen ponds (< 1 to 20 ha in size), employ moderate water exchange (pumping, 5-20% water exchange/day), intermediate shrimp stocking densities (5-25 shrimp m^{-2}), partial or continuous aeration (particularly during the final phase of production), fertilization and/or supplementary/complete diet feeding, moderate labor inputs (0.1-0.5 persons/ha), produce moderate shrimp yields (1,000-5,000 kg shrimp/hectare/ year), and have moderate to high production costs (US $ 2-6/kg live shrimp). Examples of shrimp producing within the Asian region employing SIFS include Thailand 70%, China 65%, Philippines 60%, Indonesia 25%, and India 20% (Rosenberry, 1999, 2001); Viet Nam 45% of all farms, China, Indonesia 30%, India, Thailand 10% (Dr. Chingchai Lohawatanakul/Dr. Chen Ming Dang, Charoen Pokphand Foods Public Company Ltd – personal communication).

Intensive Farming Systems (IFS) - usually realized within small sized earthen/lined ponds/raceways/tanks or cages/pen enclosures, employing high water exchange rates (although not always, as in the case of closed culture systems), high fish/shrimp stocking densities, partial and/or continuous aeration (particularly during the final phase of production), fertilization and/or complete diet feeding, high labor inputs, producing high fish/shrimp yields, and having generally high production costs.

For example, in the case of shrimp, IFS typically involve the use of small sized earthen/lined ponds/raceways/tanks (0.1-2 ha), employ high water exchange rates (pumping, 25-100% water exchange/day; although not always, as in the case of the recent emergence of closed zero-water exchange culture systems; Moss et al. 2001), employ high shrimp stocking densities (above 25 shrimp m^{-2}), partial or continuous aeration (particularly during the final phase of production), fertilization and/or complete diet feeding, have high labor inputs (1-3 persons/ha), producing high shrimp yields (above 5,000 kg shrimp/hectare/year), and generally have high production costs (US $ 4-8/kg live shrimp). Examples of shrimp producing within the Asian region employing IFS include Thailand, Indonesia 25%, China, India 5% (Rosenberry, 1999, 2001). Other more recent industry estimates report IFS within key Asian countries as Thailand 90% of all farms, China 40%, Viet Nam 15%, Indonesia 10%, India 5% (data according to Dr. Chingchai Lohawatanakul/Dr. Chen Ming Dang, Charoen Pokphand Foods Public Company Ltd – personal communication – personal communication).

On a general basis, most aquaculture production systems for carnivorous high-value finfish species are carried out using intensive pond/tank-based or cage-based farming systems, including most marine finfish species, salmonids, and eels. However, there is no general rule for omnivorous/herbivorous fish species, as these may be cultured within EFS, SIFS or IFS depending upon local conditions and the farming expertise and financial resources of the farmer. Although no precise statistical information exists concerning global fish production and farming systems, it is estimated that about 80% of total global finfish production is currently realized within semi-intensive or extensisve pond-based farming systems (Tacon and De Silva, 1997).

Finfish and crustacean feeding methods

As with all animal production systems, the growth and production of farmed finfish and crustaceans is entirely dependent upon the supply and intake of dietary nutrient inputs or feeds; the latter usually representing the largest single operating cost item of most semi-intensive and intensive finfish or crustacean farming operations, typically between 25 and 50% of total farm production costs (Kam et al. 2003a, 2003b; Leung and Sharma, 2001). In general, the feeding methods employed by farmers can be broadly divided into four basic categories (Tacon, 1988), as follows:

- ***No fertilizer or feed application*** **-** typical of traditional extensive farming systems where finfish/crustacean growth and production is totally dependent upon the consumption of food organisms naturally present within the pond ecosystem and influent water;

- ***Fertilizer application*** **-** as above, but with the application of chemical fertilizers and/or organic manures to stimulate and enhance the natural productivity of the pond ecosystem and so increase natural food production and availability for the cultured finfish/crustacean species;

- ***Fertilizer and/or supplementary feed application*** typical of semi-intensive farming systems where shrimp growth is depended upon the co-feeding of *endogenously* supplied natural food organisms (the production of which is usually enhanced through the application of fertilizers) and *exogenously* supplied supplementary feeds (the latter usually in form of simple farm-made moist/dry aquafeeds or industrially formulated commercial aquafeeds; and

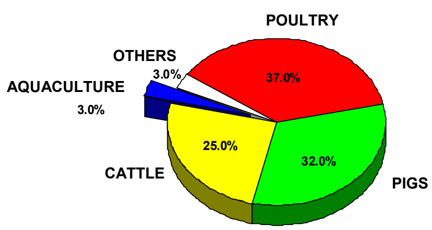
- ***Fertilizer and/or Complete Feed Application*** typical of intensive farming systems where finfish/crustacean growth is almost totally dependent upon the external provision of a nutritionally complete diet for the entire culture period; the latter usually supplied in the form of a formulated commercial aquafeed or to a lesser extent, in the form of a farm-made aquafeed or fresh food item such as low-value *trash fish*;

In general, the choice of the feeding method is largely dependent upon the intended farming system, finfish/crustacean species grown, intended finfish/crustacean stocking density to be employed (and consequent grazing pressure and natural availability per stocked animal), the resources available to the farmer in terms of nutrient/feed inputs and financial, and the market value of the cultured species. Thus feeding methods typically range from the use of low cost extensive/semi-intensive fertilization/supplementary diet feeding methods (the latter usually employing locally available feed resources in the form of farm-made aquafeeds) in the case of small-scale farming operations, to the use of intensive fertilization/feeding methods (the latter usually in the form of industrially compounded aquafeeds) in the case of large-scale commercial farming operations.

Compound animal feed and animal production

According to Gill (2003a) the total production of industrially compounded animal feeds in 2002 was 604 mmt, with poultry feeds representing 37% of total production, followed by pig feed (32%), cattle feed (25%), small animal feeds (includes pet foods, rabbits, laboratory animals etc.) and aquafeeds (3%) (Figure 2). By country, the largest animal feed producer in the world in 2002 was the USA at 143.4 mmt, followed by China at 61.3 mmt. Total animal feed production within the other target countries in 2002 in order of feed production was the Republic of Korea 14.1 mmt, Thailand 8.5 mmt, India 8.0 mmt, Philippines 4.6 mmt and Indonesia 3.0 mmt; with no information being reported for Bangladesh (Gill, 2003a).

Figure 2. Estimated global industrial animal feed production in 2002 for major farmed species
(values expressed as % dry as-fed basis)



TOTAL ESTIMATED INDUSTRIAL ANIMAL FEED PRODUCTION IN 2002 – 604 MMT
(Source: Gill, 2003a)

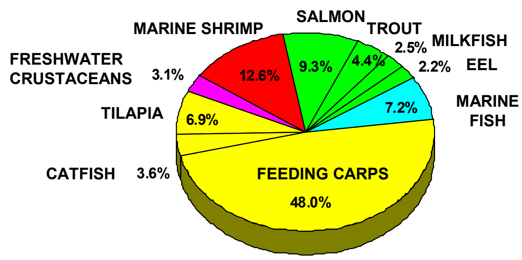
The above feed industries support the growth and development of the resident terrestrial animal livestock production sector, and as such represents as competitor with the domestic aquaculture and aquafeed sector for available feed resources and services (including water, land, labour and energy). Global production of the different major classes of terrestrial meat products has been compared with farmed aquatic products; farmed aquatic meat values calculated using mean FAO conversion values of 1.15 for finfish (gutted, head on), 2.8 for crustaceans (tails/meat, peeled), and 9.0 for molluscs (meat, without shells), fresh weight basis. From the data presented it can be seen that farmed aquatic meat production currently ranks fourth in terms of global farmed meat production (23.2 mmt in 2001) after pig meat (91.5 mmt), poultry meat (70.4 mmt) and beef and veal (56.3 mmt). In China it ranks second to pig meat production. However, it should also be said that the livestock sector is also a provider of animal manure for use as a pond fertilizer within several of the target countries.

Fed aquaculture species and aquafeed production

Although total global farmed finfish and crustacean production was estimated at 26.42 mmt in 2001 (FAO, 2003a), only about 20.5 mmt or 78% was in the form of finfish and crustacean species whose production is dependent upon the provision of external nutrient inputs in the form of compound aquafeeds or fresh/processed feed items such as *trash* fish or agricultural byproducts; the data including 2.26 mmt of unidentified freshwater fish species, but excluding filter feeding fish species such as silver carp, bighead carp and catla. It has been estimated that the total production of industrially compounded aquafeeds in 2001 was about 16.7 mmt. Major species groups currently dependent upon the use of compound aquafeeds in 2001 included the non-filter feeding carps (8.0 mmt of aquafeeds used in 2001), marine shrimp (2.1 mmt), salmon (1.56 mmt), marine finfish (excludes mullets; 1.21 mmt), tilapia (1.16 mmt), trout

(0.74 mmt), catfish (0.60 mmt), freshwater crustaceans (0.52 mmt), milkfish (0.42 mmt) and eels (0.37 mmt).

Figure 3. Estimated global compound aquafeed production in 2001 for major farmed species
(values expressed as % total aquafeed production, dry as-fed basis)



TOTAL ESTIMATED COMPOUND AQUAFEED PRODUCTION IN 2001 – 16.70 MMT

Conservative projections for global compound aquafeed production have estimated production increasing to 21 and 29 mmt by 2005 and 201, respectively. These projections compare favorably with the estimates made by International Fish Meal and Fish Oil Organization (IFFO; Pike and Barlow, 2003), who projected global compound aquafeed production increasing from 13.6 mmt in 2000, to 15.8 mmt in 2002, to 32.4 mmt by 2010, respectively. However, at present no statistical information exists concerning the global production of farm-made aquafeeds.

Dependency of fed aquaculture species upon capture fisheries for feed inputs

Although aquaculture's contribution toward total world fisheries landings has increased 7-fold over the past three decades, increasing from 4% to 29% of total fish and shellfish landings from 1970 to 2001, this increase would not have been possible without aquaculture's consumption of feed inputs derived from capture fisheries. As mentioned previously, the finfish and crustacean aquaculture sector is currently heavily dependent upon capture fisheries for sourcing key nutrients and feed ingredients for use within compound aquafeeds, including high quality animal proteins and feeding attractants (in the form of fish meal, and to a lesser extent fish solubles, shrimp meal, squid meal, fish/squid liver meals, fish/crustacean hydrolysates, and krill meal), essential dietary lipids (in the form of fish oil, and to a lesser extent fish and squid liver oils), and fresh/live food items such as *trash* fish, shellfish, marine invertebrates, and aquatic plants and algae (Delgado et al. 2003; Hardy and Tacon, 2002; Tacon and Barg, 1998;) For example, on the basis of the information presented in this report although only about 20.5 mmt or 42.4% of total global aquaculture production in 2001 were aquafeed-fed finfish and crustacean species (as compared with filter feeding fish), these fed-species consumed the equivalent of 17 to 21 mmt of marine fish on a wet weight basis.

Dependent aquaculture species and current use of fish meal and fish oil

The dependency upon fish meal and fish oil is particularly strong for those higher value aquaculture species feeding high on the aquatic food chain, including all carnivorous (ie. fish/invertebrate animal eating) finfish species and most omnivorous/scavenging crustacean species.

Finfish and crustacean species which are currently reliant upon fishmeal as the main source of dietary protein within compound aquafeeds include: Finfish: all farmed marine species, excluding mullets and rabbitfish; diadromous species, including salmonids (salmon, trout, char), eels, barramundi, sturgeon, and excluding milkfish; freshwater species - mandarin fish, pike, pike-perch, snakehead, certain freshwater *Clarias* catfishes); and Crustaceans: all marine shrimp, crabs, and freshwater prawns. A similar dependency also exists for fish oil (as the main source of dietary lipids and essential fatty acids within compound aquafeeds) for the above species, with crustaceans currently being less dependent than carnivorous finfish due to the lower levels of dietary lipids generally used within crustacean feeds. In addition to the above, fish meal and fish oil are also commonly used as a secondary source of dietary protein (usually included at low dietary inclusion levels) and lipid for many omnivorous cultured finfish species, including freshwater carps, tilapia, catfish and milkfish (Tacon, 2003).

In terms of fish meal and fish oil usage, it is estimated that the compound aquafeed sector consumed about 2.62 mmt of fish meal and 0.59 mmt of fish oil in 2001, or equivalent to 43.1% and 53.6% of the total global production of fish meal (6.08 mmt) and fish oil (1.10 mmt, respectively; FAO, 2003a). On a species group level salmonids consumed the largest proportion of fish meal and fish oil in 2001 (29.4% and 64.5% of total used in aquafeeds, respectively), followed by marine fish (22.6% and 20.3%), marine shrimp (19.3% and 7.0%), feeding carp (15.3% in the case of fish meal) and eels (6.9% and 2.5%). The total use of fish meal and fish oil within compound aquafeeds is almost certainly higher than the figure given above, as an additional 2.6 mmt of finfish and crustacean production (equivalent to 10% total finfish and crustacean production) was not included in these calculations (includes unknown freshwater fish species (2.26 mmt in 2001), marine crabs and other marine crustaceans (0.2 mmt), Mandarin fish (0.12 mmt), and other miscellaneous freshwater fish species (*Colossoma* sp., Snakeheads, Gourami etc.). According to IFFO (Pike and Barlow, 2003) fish meal and fish oil usage within compound aquafeeds in 2002 was estimated to be 2.22 mmt and 0.73 mmt, respectively.

The total estimated use of fishmeal and fish oil within aquafeeds (3.2 mmt in 2001, dry basis) was equivalent to the use of 12.8 to 16.1 mmt of pelagics (using a dry meal/oil to wet *fish* weight equivalents conversion factor of 4 to 5) for the production of 17.69 mmt of the major farmed-fed finfish and crustacean species in 2001. Cultured species groups currently consuming more *fish* through feeding than is being produced through farming in 2001 included marine eels (current pelagic input per unit of production 3.4-4.2), marine fish (2.9-3.7), salmonids (2.6-3.3), marine shrimp (1.7-2.1), freshwater crustaceans (1.0-1.3), whereas, net fish producers included milkfish (0.33-0.42), catfish (0.28-0.35), tilapia (0.24-0.29), and feeding carp (0.15-0.19).

Moreover, coupled with the use of trash fish as a direct food source for farmed fish and crustaceans within many Asian countries (D'Abramo et al. 2002; Edwards and Allen, 2003; Edwards and Tuan, 2003), it is estimated that the aquaculture sector consumed the equivalent of 17-20 mmt of *fish* as feed in 2001 (either in the form of fishmeal, fish oil or trash fish, expressed in live weight equivalents) for the total production of 17.69 mmt of aquafeed-based farmed fish and crustaceans in 2001. However, in contrast to the 8 to 11% annual growth rate of the aquaculture sector over the past decade, the proportion of the global fish catch destined for non-food uses (including for reduction into fish meal and fish oil, or for direct animal feeding) has remained relatively constant, in recent years fluctuating from a low of 25.3 mmt in 1998 (strong El Nino year) to a high of 34.8 mmt in 2000 (Figure 16); total capture fisheries in 2001 reported as 92.4 mmt, including 61.1 mmt destined for direct human consumption and 31.3 mmt or 33.9% destined for non-food uses (FAO, 2003a).

Future trends concerning fish meal and fish oil usage

It follows from the above discussion that for those aquaculture species and exporting/importing countries currently dependent upon the use of these relatively finite fishery commodities as feed inputs, that consumption of these commodities will have to increase if current dietary inclusion levels are to be maintained at equivalent levels. For example, according to IFFO (Barlow and Pike, 2003) the aquaculture sector's consumption of fish meal and fish oil is expected to increase from 34% (2,217 tmt) and 56% (732 tmt) of the total global production of fishmeal and fish oil in 2002, to 48% (2,854 tmt) and 79% (953 tmt) of total global fishmeal and fish oil production in 2010, respectively; this increase being equivalent to a 29-30% increase in global fishmeal and fish oil usage by the aquaculture sector from 2002 to 2010.

The above predictions by IFFO differ from those of present author and others (Hardy and Tacon, 2002; Tacon and Forster, 2000), who estimate that fishmeal and fish oil use by the aquaculture sector will actually decrease rather than increase in the long term. It is expected that total fishmeal and fish oil usage will decrease by 40% in the case of fishmeal (from 2,614 tmt in 2001 to 1,550 tmt in 2010) and 25% in the case of fish oil (from 594 tmt in 2001 to 447 tmt in 2010).

The main reasons why fishmeal and fish oil use by the aquaculture sector is expected to decrease in the long term is due to a combination of increasing economic/market pressures placed upon the fishmeal and fish oil manufacturing industry and animal feed compounder on the one hand, and the consequent search, development and use of lower cost and more sustainable alternative dietary protein and lipid sources by the commercial aquafeed manufacturing sector on the otherhand so as to maintain profitability and sustain the growth of the feed-dependent aquaculture sector. Examples of increasing economic/market pressures placed upon the fishmeal/aquafeed manufacturing sector, include:

- The increasing market demand for the production of less environmentally contaminated fish meals and oils (through the selection of less contaminated fish stocks and/or through increasing legislative controls limiting fishmeal/fish oil use within aquafeeds; Pike, 2002),
- The increasing global demand for the use of potentially food-grade pelagics (including mackerel, sardines, herring, pilchards, anchovies) for direct human consumption rather than for reduction into fish meal and fish oil (Edwards and Allen, 2003; Edwards and Tuan, 2003; Hoq, 2000; Wray, 2001),
- Increased global competition for available stocks of fish meal and fish oil by the rapidly emerging aquafeeds and compound animal feed manufacturing sector within developing countries (including China, Thailand, Indonesia, India, Chile, Brasil; D'Abramo et al. 2002; Edwards and Tuan, 2003; FAO, 2003a),

- A global trend toward increasing fish meal and fish oil prices with increasing market demand for these valuable commodities (Hinrichsen, 2003), and
- Increasing consumer awareness for the increased food/feed safety and traceability in the food production process (Best, 2002; Soponpong, 2002), and environmental, ecological and social sustainability of our food production process (Costa-Pierce, 2003; Naylor et al. 1998; Raven, 2002; Tacon, 1997).

Moreover, as a result of increased aquaculture production and decreasing fish/shrimp market prices (Harvey, 2003; Hinrichsen, 2003), aquafeed manufacturers and farmers alike have been forced to reduce feed costs (through the development of fishmeal and fish oil replacers) and/or by improving on-farm feed performance so as to maintain profitability. In the case of fish meal replacers, the most promising results have been obtained using protein-rich oilseed and grain by-product meals (including soybean, rapeseed, corn gluten, wheat gluten, and to a lesser extent pea and lupin meals) and using terrestrial animal byproduct meals (including poultry byproduct meal, meat meal, meat and bone meal, and to a lesser extent feather meal and blood meal; Bharadwaj et al. 2002; Cheng et al. 2002; Cremer et al. 2003; El-Saidy and Gaber, 2002; Kikuchi, 2002; Menasveta et al. 2003; Millamena, 2002; Tan et al 2003; Williams et al. 2003a, 2003b; Zhu and Yu, 2003). However, total replacement of fish oil for carnivorous fish species with commercially available plant and animal oils has been more problematic, although some plant oils (including soybean, rapeseed and linseed oils) have achieved some success as fish oil replacers (depending upon the species farmed; Bell et al. 2003; Regost et al. 2003a, 2003b).

On a final note, it is important to mention here the current widespread use of *trash* fish and other potentially food grade food items as feed inputs for the culture of high value carnivorous fish/crustacean species within many (if not all) of the target countries in this study (D'Abramo et al. 2002; Edwards and Tuan, 2003; Hambrey et al. 1999, 2001; Hong and Zhang, 2001; Hoq, 2000; Seng, 2001; Yap, 2003). Apart from the obvious questions regarding the long term ecological sustainability of farming carnivorous aquaculture species (as compared with herbivorous and omnivorous species/filter feeding species: as is the current practice in terrestrial livestock farming) and potential deleterious/negative environmental impacts of coastal fishing practices for sourcing and using *trash* fish as feed (due to over feeding and eutrophication), the use of these potentially food-grade items as feeds by the aquaculture sector has been shown to have a direct negative effect on the food security of the poor and needy by raising the market price of these finite and much sought after commodities due to increasing market demands (Edwards and Tuan, 2003; Hambrey et al. 1999, 2001).

Conclusions and recommendations

The above brief review highlights the following:

The lack of information:

- Lack of available statistical information within Asian countries concerning the number and size of current farming operations (breakdown by EFS, SIFS, IFS) and on-farm feeds and feeding methods currently employed (including industrial and farm-made aquafeed production): the last regional expert consultation of on-farm made aquafeeds having been conducted over 10 years ago by FAO/AADCP in December 1992 in Bangkok (New et al. 2003).

- The lack of available published information on the cost, availability and usage of available nutrient sources within member countries, including current government rules and regulations concerning aquafeed manufacture and on-farm usage, including ingredient/fertilizer procurement, importation and taxes/incentives;

Influence of government policy on aquaculture and aquafeed development

- The promotion of the culture of high-value aquatic species, linked with government incentives and tax breaks, encourages the production of cash crops destined for export markets rather than for domestic consumption; the latter usually being carnivorous fed finfish and crustacean species dependent upon the use of fishmeal/trash fish.
- The promotion of the culture of high-value aquatic species encourages the use of more expensive off-farm nutrient resources and inputs, including the use of imported feed ingredients (especially with government incentives and tax breaks) and industrially compounded aquafeeds, including imported fish meal, fish oil, oilseed meals, and local available supplies of trash fish;
- The promotion of the culture of high-value aquatic species over lower-value filter feeding/omnivorous species risks detracting from the importance of producing affordable farmed aquatic species for domestic consumption and improving the food security and health of the poor and needy, including driving up the market demand and price of trash fish out of the reach of the poor (Hambrey et al. 1999);
- The promotion of the culture of high-value carnivorous finfish and crustacean species by government is questionable and encourages the use of unsustainable feeding practices on animals whose dietary nutrient requirements are for the most part poorly understood (Seng, 2001);

Promotion of more sustainable low food chain species

- The need to promote the culture of aquatic species which can utilize locally available nutrient and aquatic resources, including marine and freshwater aquatic plants (water cress, taro, seaweeds etc), filter feeding mollusks and fishes, herbivorous/omnivorous finfish and crustacean species, and aquatic species tolerant of poor water quality (air breathing herbivorous/omnivorous fishes, crustaceans, and amphibians).
- The need to improve the integration of aquaculture with other agricultural farming activities such as irrigation, crop production, and animal husbandry and by so doing improve resource use efficiency and productivity, including water and nutrient use.
- The need to reduce the dependence of aquaculture upon capture fisheries for sourcing its dietary protein and lipid nutrient inputs through the selection of species feeding lower down on the aquatic food chain and/or through the development of improved microbially-based farming systems based upon the exploitation of natural food webs and nutrient cycles (Tacon et al. 2002).
- The need to assist government with the development of feed-related legislation and development policies, including Good Management Practices for aquatic feed manufacture and on-farm feed management, including quality control and farmer extension/service (FAO, 2001; Yap, 2003).
- The need to promote the nutritional merits of consuming fish and seafood, especially among children and women. If there is one single food source that could address in one single blow the large majority of the world's major nutrition

disorders (ie. malnutrition resulting from a deficiency of protein, polyunsaturated fatty acids, vitamin A, vitamin D, vitamin B12, calcium, phosphorus, magnesium, iodine, iron, zinc, copper and selenium) it is seafood or aquaculture produce.

Promotion of improved nutrient resource use

- The need to conduct national workshops concerning aquatics feeds and feeding within each of the target countries for information gathering and exchange, and to present the results generated from these workshops to a regional expert consultation for policy formulation and direction, including research and training constraints and needs;
- The need to compile nutrient resource directories for selected target countries within the region. Presented in the form of digital atlas and database, the directory would enable the user with information on the fertilizer and feed resources of the country, where they are geographically located, how much is available and when, who is currently using this resource and how, the composition and cost of this resource at source and with transportation, and an assessment of the existing animal feed manufacturing sector and its regulations (Tacon et al. 1987); and
- The need to demonstrate more sustainable cost-effective feeds and feeding systems based upon the use of local renewable nutrient resources for key herbivorous/omnivorous fish species within selected target countries, through the implementation of on-farm feeding trials on selected fish/shrimp farms, including the use of improved production methods using periphyton/microbial enhancement techniques.

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Annex:

Recommendations from 2003

Background

This section provides the recommendations arising from several key international and regional meetings held during 2003. They are reproduced here, as a reference for some issues noted during this review, and to highlight relevant recommendations for future regional actions.

Second Session of the Committee on Fisheries (COFI) Sub-Committee on Aquaculture

The Second Session of the Committee on Fisheries (COFI) Sub-Committee on Aquaculture was held in Trondheim, Norway, from 7 to 11 August 2003 hosted by the Government of Norway. The following recommendations are abstracted in full from the meeting report[1] formulated as "matters requiring the attention of the FAO Committee on Fisheries".

The Sub-Committee:

FAO Fisheries Department's Efforts Towards Implementing the Recommendations of the First Session of the COFI Sub-Committee on Aquaculture

i) **appreciated** the effort of FAO Fisheries Department in responding to the recommendations of the First Session of the Sub-Committee and drew attention to the issue of the funds available for the Department's activities in the sub-sector.

ii) **unanimously called** for increased Regular Programme budget funding support to aquaculture activities.

iii) **welcomed** the establishment of a trust fund to facilitate work on some of the priority areas identified by the First Session of the Sub-Committee. The Sub-Committee expressed appreciation to the Government of Japan for providing US$ 500,000 to be used over five years for the above-mentioned priority areas. It invited other donors to consider providing similar support to promote the work of the Sub-Committee.

iv) **acknowledged** the important contribution aquaculture makes to the livelihoods of rural people and that the promotion of commercial aquaculture could enhance the capital assets of smallholders and that experiences gained in this sector should be widely disseminated.

v) **recommended** that priority be given to the following activities: (a) assistance to the sustainable development of smallholder aquaculture, (b) promotion of commercial aquaculture - initially through organizing a conference on the promotion of commercial aquaculture in Africa, and (c) development of regional networking.

Recent Efforts by FAO Regional Fishery Bodies in Responsible Aquaculture and Culture-Based Fisheries

vi) **expressed** its appreciation to FAO for its valuable efforts to promote sustainable aquaculture and culture-based fisheries and was grateful for the activities undertaken following its First Session.

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[1] *FAO Fisheries Report/FAO Rapport sur les pêches/FAO Informe de Pesca.* No. 716. Rome/Roma, FAO. 2003. 91p.

vii) **underscored** the critical importance of regional bodies, noting that these organizations should have increasingly important roles in the future. It emphasized the necessity for FAO to continue to support regional bodies as these receive more emphasis in global aquaculture development.

viii) **reaffirmed** the worthy contribution that aquaculture makes to national economies and the varied socio-economic and environmental impacts, and urged Regional Bodies to assist with elaboration of essential standards and guidelines for specific aquaculture systems, including regular and organic aquaculture.

ix) **welcomed** the symbiosis between its own mandate and that of the COFI Sub-Committee on Fish Trade and stressed the advantages to be gained through complementary and collaborative action.

x) **stressed** the need to address the question of how trade regulations deal with cultured and wild-caught organisms and in this light, encouraged the Sub-Committee on Fish Trade to work with the World Customs Organization to take up these key trade issues.

Progress in Implementing the Provisions of the Code of Conduct for Responsible Fisheries (CCRF) Relevant to Aquaculture and Culture-Based Fisheries

xi) **reaffirmed** its support for the CCRF and emphasised its pivotal position in assuring sustainable aquaculture development, including culture-based fisheries.

xii) **recommended** FAO to develop a web-based reference of aquaculture codes of practice and legislation as a means to facilitate information exchange.

xiii) **reiterated** that monitoring of and reporting on the implementation of the Code was crucially important, through country reports involving national agencies, regional bodies and international institutions.

xiv) **suggested** that FAO Regional Bodies establish a database on the ecological background of main species so as to help members conduct science-based risk analyses on these species.

xv) **suggested** the following inter-sessional activities be considered within budget limitations:

- assistance with environmental risk assessments;
- assistance with integrated planning aquaculture development in coastal areas and watersheds;
- development of sustainability issues in aquaculture feed and best-management feed strategies.

Improving the Status and Trends Reporting on Aquaculture

xvi) **expressed** its appreciation for the work of FAO in this area and recognized FAO as the appropriate organization to compile global aquaculture data and information.

xvii) **endorsed** the upcoming Expert Consultation on Improving Global Status and Trends Reporting on Aquaculture, as well as the subsequent working group of national experts seeking to improve the FAO aquaculture questionnaires.

Strategies to Improve Safety and Quality of Aquaculture Products

xviii) **stressed** the importance of health and safety of aquaculture products and appreciated FAO's activities in this area.

xix) **urged** FAO to assist in the harmonization of standards for health and safety of aquaculture products through the Codex Alimentarius Commission process, as well as to promote equivalence among systems.

xx) **recommended** that its activities and those of the COFI Sub-Committee on Fish Trade should be well coordinated and effective collaboration encouraged, taking into consideration their respective areas of competence.

Towards Responsible Practices in Culture-Based Fisheries

xxi) **emphasized** the importance of :

- appropriate management schemes for stocking activities and other culture-based fisheries, based on ecological evaluation of water bodies and fishery resources, and appropriate community-based management;
- regional collaboration on stocking programmes and coordination of measures associated with stocking practices in transboundary waters;
- strong support for the application of the principles of the ICES Codes of Practice on Introductions and Transfers of Marine Organisms, and recognition of relevant provisions of the Code of Conduct for Responsible Fisheries and the Convention on Biological Diversity;
- recognition of both benefits and significant dangers of using alien species in culture-based fisheries.

xxii) **identified**, among others, seed profiling, lack of seed, cost effectiveness of stocking programmes, the importance of environmental risk assessment and socio-economic feasibility assessment of culture-based fisheries and stocking practices as key areas requiring further work to promote this very important sector of aquaculture.

xxiii) **suggested** that the following inter-sessional activities should be undertaken, possibly through the formation of inter-sessional technical working groups in conformity with FAO Basic Texts:

- formulation of technical guidelines and best practices for responsible stocking programmes;
- feasibility assessment of shrimp ranching;
- specific risk evaluations of transfers of selected species;
- support to regional cooperation on and coordination of stocking programmes covering and potentially affecting transboundary water;

- compilation of case studies illustrating successful stocking practices in the marine, coastal and inland environments.

Other Matters, Emerging Issues and Related Areas of Work

xxiv) **recognized** the importance of the issue of trans-boundary movements of exotic species and its potential inherently risks of pathogen, genetic or ecological impact and shared the concerns expressed in the document COFI:AQ/II/2003/8.

xxv) **expressed** its appreciation for the valuable guidance provided by FAO and other international organizations such as the International Office of Epizootics (OIE) and the Network of Aquaculture Centres in Asia-Pacific (NACA) in reducing such risks and in particular with respect to the prevention of the spread of aquatic animal diseases associated with introductions of live fish and movement of exotic species.

xxvi) **supported** the holding of inter-sessional technical activities, possibly through the formation of inter-sessional technical working groups in conformity with FAO Basic Texts, to address the following issues:

- Risk assessment and management associated with the movement and transfer of live aquatic animals;
- Introduction of exotic species, including ornamentals;
- Accidental introduction through ballast waters.

xxvii) **noted** the outcomes of the Expert Consultation on Good Management Practices and Good Legal and Institutional Arrangements for Sustainable Shrimp Culture that was held in Brisbane, Australia, in December 2000 and requested that FAO facilitates and develops follow-up activities recommended at the Consultation.

xxviii) **requested** that FAO should work to review and analyse the various certification systems in place with a view to ensure harmonized approaches and procedures for the development and implementation of shrimp aquaculture product certification systems. The Sub-Committee recognized the importance of further developing work and diagnostic tools for pathogens and disease identification.

xxix) **underscored** the need for continued collaboration with the COFI Sub-Committee on Fish Trade on shrimp culture and trade issues.

xxx) **agreed** that the Secretariat should provide a prospective analysis of future challenges in global aquaculture as a basis for a discussion of the longer term direction of the Sub-Committee's work.

xxxi) **noted** that the United States of America and the European Community offered to jointly lead, in collaboration with FAO, the inter-sessional work on environmental risk assessment, including species introductions and undertaking a thematic evaluation of social and economic impact of aquaculture.

xxxii) recommended that additional resources should be sought within the Regular Programme or through Extra-Budgetary resources to undertake aquaculture activities.

Acknowledgements

xxxiii) **expressed** its appreciation to the Government and people of the Kingdom of Norway for their hospitality and the excellent facilities that were provided at the Session.

Date and Place of the Third Session

xxxiv) **agreed** that its Third Session should be held in 2006.

xxxv) **welcomed** the offer by India to host the session and noted the confirmation by the United States of America to host a session of the Sub-Committee.

xxxvi) **also noted** the expressed wish of Guatemala to host a session of the Sub-Committee.

Recommendations of Aquamarkets 2003

AquaMarkets 2003[1] was co-organized by NACA, the Philippines Bureau of Fisheries of the Department of Agriculture and the Department of Trade and Industry, with cooperation from PhilSrimp, Inc. The planning and preparations involved ASEAN, FAO, Federation of Aquaculture Producers Association (FEAP), WTO, EC delegations in Bangkok and Manila, SEAFDEC Aquaculture Department, National Academy of Science and Technology of the Department of Science and Technology (DOST/NAST), Bangus Association of the Philippines, Inc. and the Philippine Aquaculture Congress and Exhibition (PACE). The meeting was held from 2nd-6th June 2003.

The participants at the Aquamarkets 2003 consultation endorsed the recommendations on markets and trade and on food quality and safety contained in the Bangkok Declaration on Aquaculture in the Third Millennium[2] and made the following recommendations to further support the region in accessing markets and meeting market requirements for products from aquaculture:

1. Encourage nations in the Asia-Pacific region to improve national, regional and international cooperation in order to better share information on markets and trade in aquaculture products, and to ensure that relevant information on fisheries and aquaculture are provided to those engaged in trade negotiations.

2. Improve information exchange and communication on marketing and trade in aquaculture products in the Asia-Pacific region, such as through the development of a regional web site, linked with national focal points for information exchange.

3. Give special consideration to small holders and economically vulnerable people in the development of policies in the area of marketing and trade. Enhance understanding of relevant issues (such as the structure and conduct of the domestic market, market infrastructure, investment needs and finance) to inform policy-making and support fair trade.

4. Enhance cooperation between private and public sector, on activities to improve access to markets and meeting market requirements.

5. Encourage nations in the Asia-Pacific region to develop common stance on issues of interest to the aquaculture sector. In particular, efforts are required to harmonize standards and technical regulations, regionally as well as internationally.

6. Encourage importing countries and regions, such as the EC, to harmonize the application of rules and standards and to make these transparent.

7. Encourage common regional positions and understanding on issues of interest to the region, for example on Codex Alimentarius, the World Organization for

[1] The full report of the meeting can be found at www.enaca.org/aquamarkets.
[2] The Aquamillenium report including recommendations can be found at http://www.enaca.org/Aquaculture3rd.htm

Animal Health (OIE) standard setting, and other relevant work on international aquaculture standards.

8. Examine the possibility of establishing a harmonized certification system for aquaculture products from the region.

9. Organize further national and regional consultations to promote better national and regional cooperation and information sharing.

10. Request regional and international organizations to provide support, technical assistance and capacity building to national and regional efforts with a view to implementing the above recommendations of the consultation, including capacity building on WTO agreements and negotiations issues.

East Asia Seas Congress

The following highlights the Recommendations on Fisheries and Aquaculture made by participants of the aquaculture and fisheries workshop at the "East Asian Seas Congress 2003[3]", for submission to Ministers at the Ministerial Forum of the Congress. The workshop, held on 12 December 2003, agreed on recommendations after discussing the papers presented and considering the points made by the panelists and participants. The recommendations are divided into three parts: (1) fisheries; (2) aquaculture; and (3) regional partnerships.

Fisheries

The workshop recognized the importance of capture fisheries to livelihoods and food security of coastal communities in East Asia and the expected increase in demand for fish products. It also recognized the importance of the existing agreements and codes of conduct for improved management of national and regional fisheries resources, notably UNCLOS, Agenda 21, the FAO CCRF and the recent Commitments at WSSD in Johannesburg to restore depleted fish stocks to maximum sustainable yields by 2015. The Conference participants urged governments to take immediate action to restore the capture fisheries of East Asia by:

1. Reducing fishing activities through: (a) eliminating illegal, unregulated and unreported fishing; (b) removing excess fishing capacity; (c) empowering fishing communities to work with local governments to plan ways to reduce fishing and training them to police their rules; (d) encouraging communities to establish/increase the number of "no-take" marine reserves and monitor their success; (e) evaluating the need for other ecosystem interventions (e.g., habitat restoration and restocking) to restore production; and (f) assisting fisher families to maintain a decent level of living through support of family planning programs;

2. Building socially just, rights-based fisheries systems by: (a) creating new legal frameworks to establish and protect user rights; (b) encouraging and supporting fishing communities to manage fisheries resources and habitats; (c) helping create the political will and just administration for small-scale fishing communities; (d) promoting trust, equity and gender balance; and (e) creating strong and sustained advocacy for fisheries ("Fish for All" Campaign); and

3. Promoting locally feasible, alternative livelihoods for fishing communities through: (a) proactive support for new opportunities in small-scale aquaculture, livestock and agriculture enterprises, artisanal trades, tourism, etc; and (b) promoting partnerships between the private sector, government and local communities to support investments in sustainable livelihoods.

Aquaculture

The workshop participants recognized that socially and environmentally responsible aquaculture can improve food production, reduce the price of fish, alleviate poverty and sustain livelihoods, it was also agreed that poorly planned and managed

[3] See www.pemsea.org for further details of the conference.

aquaculture results in operations that fail to recover the full social and environmental costs and should therefore be discouraged. In addition, the workshop also recognized the need for adoption of, and compliance with, regional and international agreements, the FAO CCRF (particularly Article 9 on Aquaculture). The participants urged governments to take urgent action to improve and revise national policy frameworks for aquaculture by:

1. Promoting participation of local communities and stakeholder rights through (a) recognizing tenurial rights over natural resources for aquaculture (resource use, land ownership, access to water); (b) providing access to information on co-management opportunities and rights; and (c) facilitating community consultation and negotiations with local government;

2. Protecting the environment and biodiversity through: (a) zoning aquaculture within the context of ICM to prevent marginalization; (b) preventing degradation of coastal habitats to provide options for aquaculture over large areas; (c) ensuring coastal water quality for aquaculture and other uses; and (d) rehabilitating degraded habitats to provide more options for aquaculture; and

3. Providing institutional and legal support to the emerging industry through (a) encouraging the use of market incentives that reward responsible practice; (b) applying appropriate resource use fees and penalties to socially unjust enterprises; (c) encouraging corporate social responsibility by large enterprises and other sectors within catchments that affect habitats for aquaculture; (d) organizing small-scale producers to facilitate full entry into aquaculture; (e) supporting research that enables entry of poor people and reduces the ecological footprint of aquaculture; and (f) promoting South-South marketing of low-value fish species.

Regional Partnerships

The workshop participants recognized the collective and rich experience of the countries of East Asia in various aspects of fisheries management and that partnerships can address the immediate needs of communities. They also recognized that the stocks of many species of valuable fish straddle national boundaries and that many marine species are cultured throughout East Asia.

It was recommended that governments work together to increase the supply of fish through the restoration of capture fisheries and the development of socially and environmentally responsible aquaculture. This can be done by promoting regional cooperative management of fisheries and aquaculture through:

1. Establishing or strengthening regional networks to share knowledge and lessons learned;
2. Identifying the extent of shared resources and issues to promote common management approaches;
3. Applying an ecosystem approach;
4. Supporting best management practices;
5. Meeting regularly to set and maintain international standards;
6. Asserting the needs of the region with World Trade Organization (WTO); and

7. Encouraging a coordinated approach for development agencies to promote a more responsible and more productive fisheries and aquaculture sector in the East Asian region.