2. Production: environments, species, quantities and values

INTRODUCTION

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

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

PRODUCTION

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

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

In North America, channel catfish is the top aquaculture species in the United States of America, while Atlantic and Pacific salmon dominate in Canada. In the Latin America and Caribbean region, over the last decade salmonids have overtaken

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

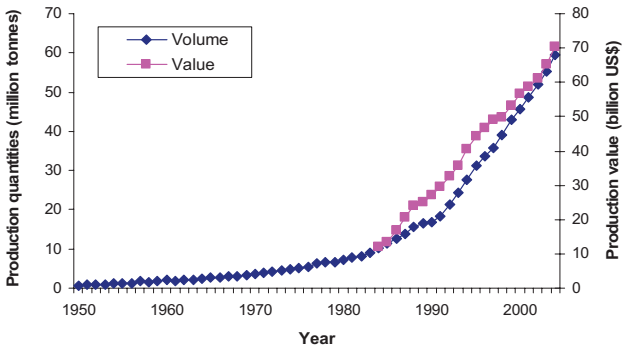


FIGURE 2
World aquaculture production with China and rest of Asia and the Pacific region disaggregated from the rest of the world between 1950 and 2004

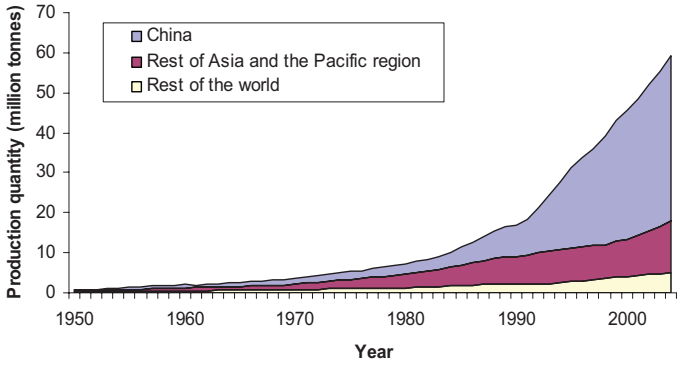
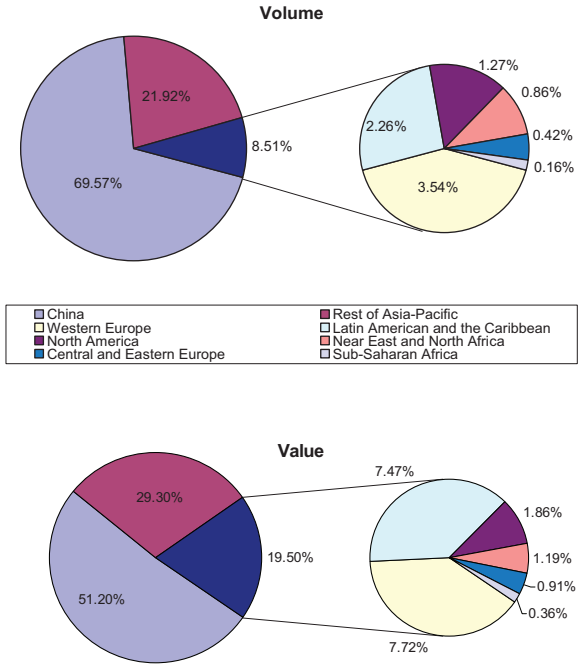


FIGURE 3
World aquaculture production by region with China disaggregated form the rest of Asia in 2004.



shrimp as the top aquaculture species group due to disease outbreaks in major shrimp producing areas and the rapid growth in salmon production in Chile (Figure 4).

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

GROWTH IN PRODUCTION

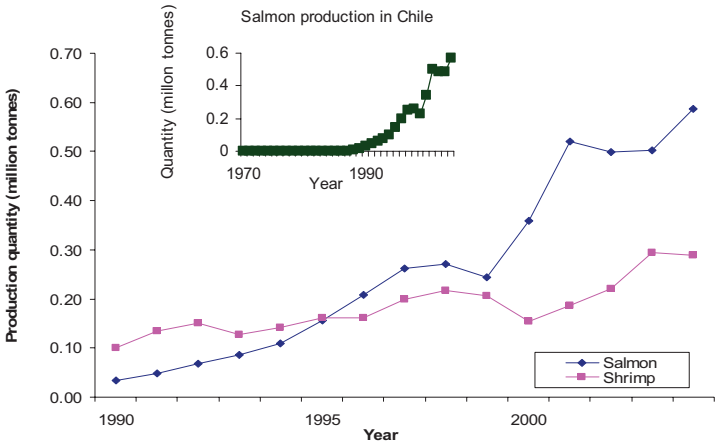
The phenomenal growth in world aquaculture over the last fifty years has been most notable in Asia and the Pacific region and, in particular, in China. The aquaculture development in China has resulted in significant differences in the present magnitude and the rate of growth of aquaculture among continents.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

World aquaculture has grown at an average annual rate of 8.8 percent from 1950 to 2004. Overall, Latin America and the Caribbean region had the highest average annual growth of 21.3 percent followed by and the Near East and North Africa and sub-Saharan Africa, with 10.8 percent and 10.7 percent respectively. The average growth rate for the

Asia and the Pacific region was 9.8 percent, while production in China, considered separately, has grown at a rate of 12.4 percent per year (Table 1).

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

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



BOX 1
Top ten producers of tilapia and mullet in 2004

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

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

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

FIGURE 5
Aquaculture production in Brazil between 1980 and 2004

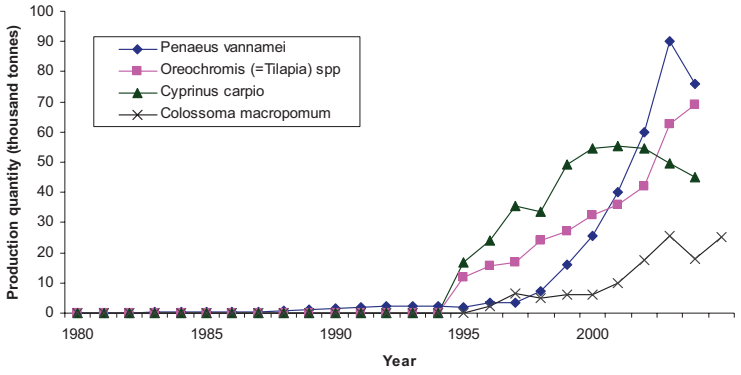
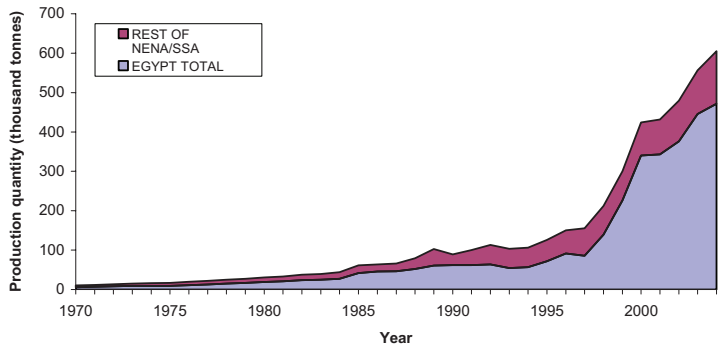


FIGURE 6
Total production of Nile tilapia, grey mullet and carps in Near East and North African and sub-Saharan Africa region with Egypt disaggregated from the rest, between 1970 and 2004



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

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

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

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

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

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

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

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

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

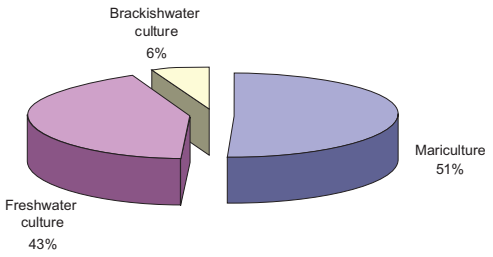
BOX 2

Top 10 aquaculture producers in the world in 2004

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

PRODUCTION BY ENVIRONMENTS

FIGURE 7
Aquaculture production by environment in 2004



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

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

DIVERSITY OF MAJOR SPECIES GROUPS AND SPECIES USED IN AQUACULTURE

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

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

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

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

FIGURE 8
World aquaculture production by major taxonomic grouping in 2004

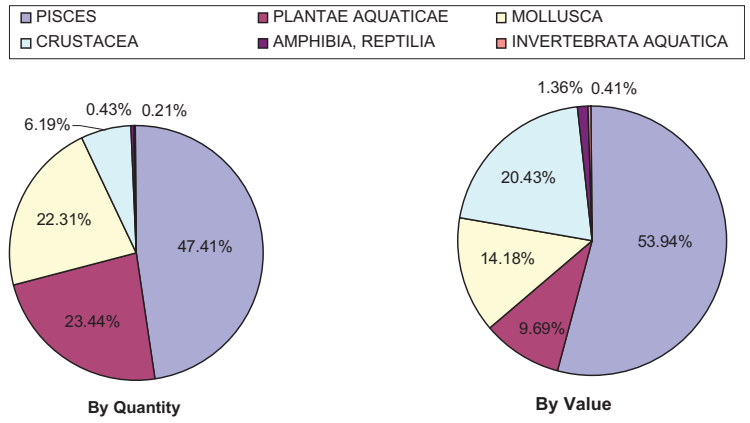
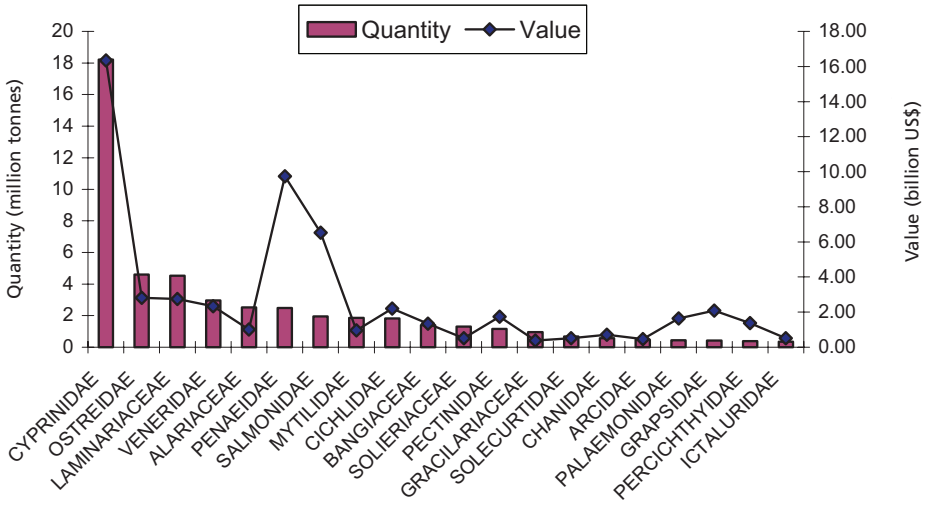


TABLE 2
Number of species in aquaculture with reported production in 2004 in FAO FISHSTAT PLus database by continent and major grouping

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

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



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

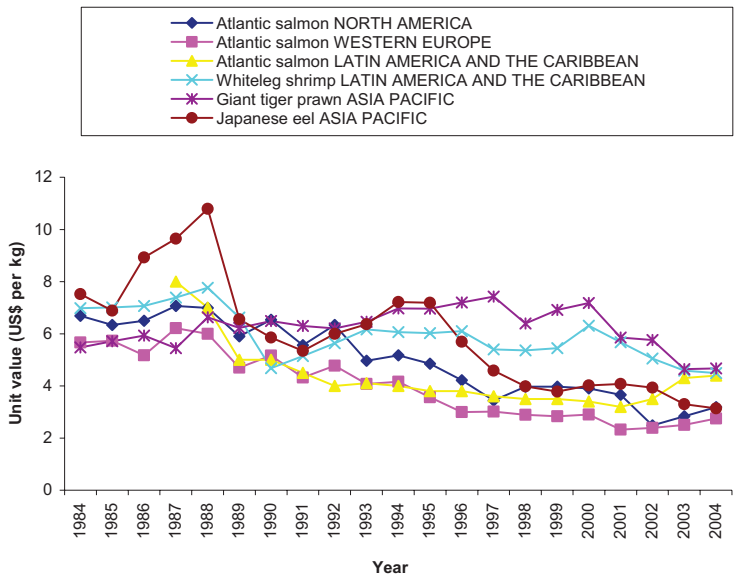
There are more species of fish cultured than other major taxonomic groups. The cyprinids, with 18.2 million tonnes valued at US$16.3 billion, emerge as the most important taxonomic family by quantity and by total value. By volume, Ostreidae (oysters) are a distant second at 4.6 million tonnes and are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

VALUE OF PRODUCTION

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

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

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



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

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

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

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

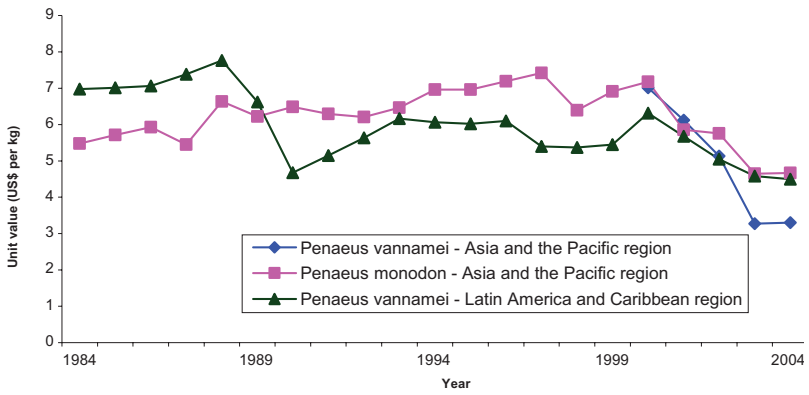
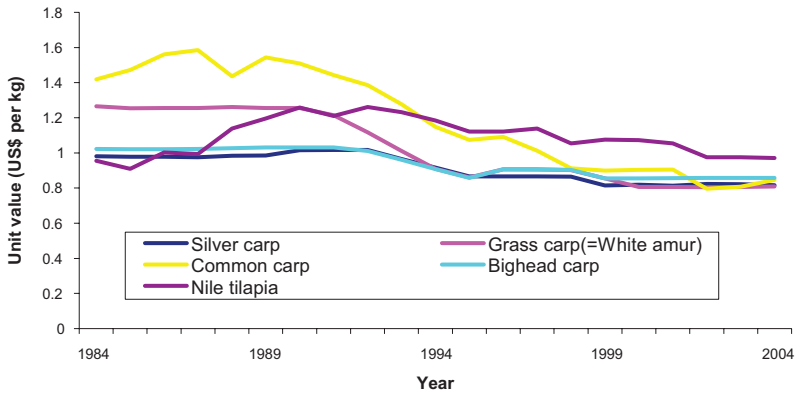


FIGURE 12
Trend in the unit values of selected lower-value species in Asia and the Pacific region between 1984 and 2004



USE OF INTRODUCED SPECIES

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

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

COURTESY OF MATT BRIGGS

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

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

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

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

COURTESY OF SENA DE SILVA

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

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

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

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

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

THE CULTURE OF ORNAMENTALS

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

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

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

COURTESY OF ZHOU XIAOWEI

Neon Tetras in an ornamental fish shop in Kunming, China – Ornamental fish industry is expanding globally, and is worth considering as an aquaculture activity.

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

CULTURE SYSTEMS

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

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

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

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

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