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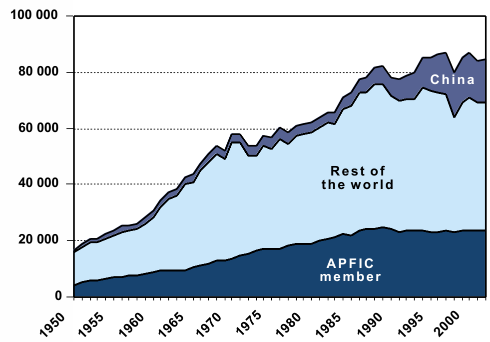
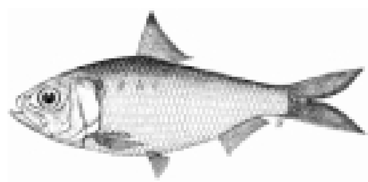
Status and potential of fisheries and aquaculture in Asia and the Pacific





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Status and potential of fisheries and aquaculture in Asia and the Pacific

By

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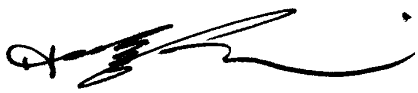
Preface

One of the important activities of the Asia-Pacific Fishery Commission (APFIC) is to provide its members with an overview of the status and potential of fisheries and aquaculture in the Asia-Pacific region. The region currently produces almost 50 percent of the world's fish from capture fisheries and 90 percent from aquaculture. Fish and fisheries are important in supplying animal protein and nutrition to a large part of the Asian-Pacific populations, and are increasingly becoming an important source of income and trade for the region.

There are many differences, most obviously geographical, between the sub-regions and seas of the region, but there are also many common trends that will have a large impact on the future supply of fish. One alarming trend is the rapid decline in the status of coastal fishery resources and ecosystems throughout the region.

Aquaculture production is increasing, with a large part of this increase being driven by massive growth in China. However, much of this aquaculture growth is dependent on the use of "trash fish" for feeding the cultured species (either directly or by processed fish meal/oil), and is not sustainable in the long term unless major changes take place in the management of capture fisheries and in aquaculture practices.

This report provides an excellent summary of the major trends and future potential for fisheries and aquaculture in the Asia-Pacific region and provides an insight into the many challenges that will need to be addressed if fisheries and aquaculture are to continue to contribute significantly to food security and poverty reduction in the region.



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Preparation of this document

This document was prepared for the twenty-eighth session of the Asia-Pacific Fishery Commission (APFIC), which was held in Chang Mai, Thailand from 3 to 5 August 2004. With this session, APFIC has assumed a new role as a "regional consultative forum", embarking on a new chapter in its endeavour to respond effectively to the changing requirements in the fisheries and aquaculture sector in the region. In support of the work of the Forum, APFIC is committed to improving the quality of information on the status and trends of fisheries and aquaculture in the region and to regularly reviewing and analysing the information. This document is aimed at informing APFIC member States of the current status and potential of fisheries and aquaculture in the Asia-Pacific region as well as the emerging issues facing the sector.

Abstract

Sugiyama, S., Staples, D. & Funge-Smith, S.J. 2004. Status and potential of fisheries and aquaculture in Asia and the Pacific. FAO Regional Office for Asia and the Pacific. RAP Publication 2004/25. 53 pp.

The fisheries and aquaculture sector is of fundamental importance to the Asia-Pacific region providing opportunities for revenue generation and employment, and contributing to food security. This document reviews the current status of inland and marine fisheries resources and their contribution to national economies and food security. Regional fishery data and information stored in FAO databases are analysed to provide a comprehensive picture of production trends of fisheries and aquaculture in the Asia-Pacific region, which is further illustrated by a detailed view of sub-regions and aquaculture production by species groups. It also touches upon issues that require closer attention in order for the fisheries resources to be managed in a responsive and sustainable manner.

Geographical scope of this review

States and areas

This review covers the States and entities of the Asia-Pacific region that report fisheries and aquaculture statistics to FAO, and which are within the area of competence of the Asia-Pacific Fishery Commission. They are sub-divided into the following sub-regions;

Oceania: American Samoa, Australia, Christmas Island, Cocos (Keeling) Islands, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Federated States of Micronesia (FSM), Nauru, New Caledonia, New Zealand, Niue, Norfolk Island, Northern Mariana Is., Palau, Papua New Guinea (PNG), Pitcairn Islands, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, and Wallis and Futuna Is.

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

Southeast Asia: Brunei Darussalam, Cambodia, Indonesia, Lao PDR (People's Dem. Rep.), Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste and Viet Nam

China: China PR (People's Republic of), Hong Kong SAR (Semi-autonomous Region) and Taiwan POC (Province of China)

Other Asia: Iran, Japan, Kazakhstan, Korea DPR (Democratic People's Republic of), Mongolia, Korea RO (Republic of), Tajikistan and Uzbekistan

Production areas

In cases where the fishing occurs on the high sea or in EEZs under access agreements, although the production is assigned to the flag vessel, the catches made outside the regional area mentioned above are excluded from this review. The regional area covers the FAO Major Fishing Areas (MFA) as follows:

Inland waters:	Asia – Inland waters Oceania – Inland waters	(MFA 04) (MFA 06)
Marine waters:	Western/Eastern Indian Ocean Northwest, Western/Eastern Central and Southwest Pacific Ocean	(MFA 51 and 57) (MFA 61, 71, 77 and 81)

Species

Data on aquatic mammals, aquatic plants, corals, pearls, sponges and crocodiles from capture fisheries are excluded.

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1. Contributions of fisheries and aquaculture in the Asia-Pacific region

The capture fisheries and aquaculture sectors are of fundamental importance to the Asia-Pacific region in terms of food security, revenue generation and employment. In many countries, catching or farming aquatic resources forms a vital part of rural people's livelihoods. In cultural terms, aquatic resources mean more than a source of income or food supply; traditional fishery products such as fish sauce and fish-based condiments are important ingredients of people's daily diet which are not easily substituted. People utilize all sizes and types of fish and there is very little discard or wastage of this valuable resource. It is only now becoming apparent that fish play an important role in both the food security and nutritional security of many rural and coastal populations.

1.1 Contribution to national economies

Fisheries and aquaculture production is a clear contributor to national economies across the Asia-Pacific region. Crude estimation of capture production value[1] indicates that the contribution of capture fisheries to GDP accounts for more than one percent in many States in the region **(Table 1)**. Capture fisheries are particularly important in Small Island Developing States (SIDS), where the fisheries sector plays a critical role in the national economies. The economic contribution of fisheries production is less in South and Southeast Asian States, yet there are still ten of these States to which fisheries contribute more than one percent of GDP. It is also worth noting that these figures for fisheries value are probably underestimated and do not adequately value the artisanal part of the sector. Overall it is clear that more policy attention should be paid to this important production sector. For example, according to the official reports from Cambodia, fisheries production is more valuable than rice production in the country.

Aquaculture also makes an important contribution to GDP. In Asian States, which are the production centre of aquaculture, aquaculture production accounts for over one percent of GDP in seven States. Statistics related to export income from aquaculture products are not generally available and this affects the estimation of the contribution to foreign currency earnings through exports of aquaculture products.

It is clear that the State listings above also closely match those States which export considerable amounts of aquaculture products (particularly shrimp). China PR is an exception in this case, since the majority of aquaculture products it produces are consumed domestically, although there is an increasing trend towards export focussed products.

Table 1
Contribution of capture fisheries and aquaculture to GDP

Production value as percent of GDP[2]			
Capture fisheries		Aquaculture	
Kiribati	33.549	Lao PDR	5.775
Marshall Is.	28.378	Viet Nam*	3.497
Maldives	17.294	Bangladesh	2.688
Cambodia	10.030	Philippines	2.633
Solomon Is.*	7.787	China PR	2.618
FSM	6.603	Thailand	2.071
Samoa	4.239	Indonesia	1.662
Viet Nam*	3.702	Cambodia	0.893
PNG	3.306	Kiribati	0.752
Vanuatu	3.294	India*	0.540
Tonga	2.865	Sri Lanka	0.468
Indonesia	2.350	Malaysia	0.366
Philippines	2.184	Nepal	0.345
Fiji Islands	2.046	Taiwan POC	0.324
Thailand	2.044	New Zealand	0.189
Bangladesh	1.884	Myanmar	0.167
Lao PDR	1.432	Korea RO	0.145
Sri Lanka	1.428	Japan	0.108
China PR	1.132	Iran	0.105
Malaysia	1.128		

Employment, income and trade

The information on employment in fisheries and aquaculture in the Asia-Pacific region is very scanty and only a few States report the number of fishers and fish farmers. Despite this, there are clear indications that fisheries and aquaculture play a substantial role in providing vital income

[1] The data to quantify the value of capture production is not readily available for many States. As indicative figures, unit value of 0.8 US$ per kg was applied for this estimation of capture production value.

[2] GDP values in 2001 calculated from the ESCAP official statistics except Taiwan POC. The data of States marked with an asterisk is from 2000.

generation opportunities to the people. In Indonesia, capture fisheries sector offered a fulltime or part time job to 3.3 million people[3], which accounted for 3.6 percent of the population of 15 years of age and over (2000)[4]. Gender segregated data on employment are available in India, where 7.9 million of male and 2.7 million of female workers were directly engaged in fishing and fish farming. In the Philippines the fisheries sector provides direct and indirect employment to over one million people, or about 12 percent of the agriculture, fishery and forestry sector workforce[5].

FAO (1998)[6] estimated that Asia accounted for 85 percent of the total global number of persons engaged in fisheries production (total 25 million). These figures typically represent full time fisheries and those for whom fishing is a highly significant activity. It is well known that such estimates typically do not include those who fish seasonally or as a supplemental part of a more diverse livelihood. The estimated figure can therefore be considered a lower threshold.

In addition to those people involved directly in the primary production sector, it should be noted that there are also a number of people who are engaged in the supporting industries of fisheries and aquaculture such as boat building, ice making, feed manufacturing, processing, marketing and distribution of fisheries and aquaculture products. As demand outstrips supply, the price of fish is increasing world wide and fish is becoming a "cash crop". In many cases, the more marketable fish are being sold to provide income that is used to purchase other more affordable food items.

Fisheries products are highly traded commodities in the Asia-Pacific region bringing valuable foreign exchange earnings to exporting States. Over the past 20 years, many developing countries have become net exporters of fish, rather than net importers, a trend very evident in the Southeast Asia region. Thailand is a major exporting State in the region, exporting 1.2 million tonnes of fisheries products with the foreign exchange earning of US$ 3.7 billion in 2002. Fish is a particularly important internationally traded commodity for SIDS where land-based resources are very limited. In Marshall Islands, the contribution of fisheries products was as high as 79 percent of total exported commodities of the State by value in 1997. In many developed States, such as Japan, the trend has been reversed with these countries becoming net importers, rather than net exporters. The quantity of imported fisheries products in China PR exceeded that of exported products in 2002; however, China PR achieved a remarkable trade surplus of US$ 2.4 billion from fisheries products, indicative of the strong value adding that occurred in the process.

1.2 Contribution to food security

Importance of fish in human nutrition

Fish is a food of excellent nutritional value and it makes a very significant contribution to the diet of many fish-consuming communities in both the developed and developing world.

Fish provides high quality protein and a wide variety of vitamins and minerals, including vitamins A and D, phosphorus, magnesium, selenium, and iodine, especially in marine fish. Fish is also a valuable source of essential fatty acids and its protein is easily digestible.

Even in small quantities, fish can have a significant positive impact on improving the quality of dietary protein intake by complementing the essential amino acids that are often present in low quantities in the rice-and-vegetable diets typical of many developing States. In particular, fish is a rich source of lysine which is an essential amino acid that is often deficient in rice diets with little animal protein.

Recent research shows that fish is much more than just an alternative source of animal protein. Fish oils in fatty fish are the richest source of a type of fat that is vital for brain development in unborn babies and infants. Closely spaced pregnancies, as often seen in developing States, can lead to the depletion of the mother's supply of essential fatty acids, leaving younger siblings deprived of this vital nutrient at a crucial stage in their growth. This makes all fish and especially fatty fish, such as tuna, mackerel and sardine, particularly good components of the diet of pregnant and lactating women. It is therefore apparent that fish makes a valuable contribution to the nutritional quality of the diets of the populations of many developing countries in the Asia-Pacific region.

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[3] FAO Fisheries Information, Data and Statistics unit.

[4] Statistics Indonesia of the Republic of Indonesia http://www.bps.go.id/index.shtml

[5] Bureau of Fisheries and Aquatic resources of the Philippines http://www.bfar.da.gov.ph/programs/gma_fisprogrm/fish_sector.htm

[6] FAO Technical Guidelines for Responsible Fisheries No. 7 *Responsible Fish Utilization*, FAO Rome 1998, 33 p.

Trends in fish consumption

Taken globally about one billion people rely on fish as their main source of animal protein, especially in coastal areas where the dependence on fish is typically high. About 20 percent of the world's population derives at least 20 percent of its animal protein from fish, and some small island States depend on fish almost exclusively. For instance, fish contribute more than, or close to, 50 percent of total animal proteins in some small island developing States and in Bangladesh, Cambodia, Indonesia, Japan and Sri Lanka.

Asia and the Pacific represents the most important region for fisheries and aquaculture production. It has a number of States with the highest per capita consumption. Importantly, the source of fish in the diet of rural people in this region is gradually changing. Rural populations that were once almost entirely dependent upon inland capture fisheries for their food have seen the decline of fisheries resources through environmental changes and changing water management regimes. Aquaculture fish has become an increasingly viable alternative to inland capture fish as cheap wild fish become less available. This trend is also accompanied by rising prices for fish.

Fish consumption in selected States

Globally 100 million tonnes of fish were available for consumption in 2001 and two-thirds of this total was consumed in Asia. Of this, 36.2 million tonnes were consumed outside China PR (14.0 kg per capita) and 42.6 million tonnes in China PR alone (25.6 kg per capita). Per capita consumption in Oceania was 23.0 kg. Maldives recorded the highest rate of per capita supply of fish (185.9 kg per year) in this region, followed by Kiribati (75.2 kg per year). There are considerable intra-regional variations depending on access to inland and marine capture fisheries and suitability of environments for aquaculture.

Existing estimates of food consumption are derived from food balance calculations based on reported catches. These provide statistics of total and per caput fish supply in live weight and contribution of fish to animal protein supply by State. However, as with production data, their reliability has often been questioned. In this review, fish consumption of selected States where survey data are available was examined.

Bangladesh

The availability of non-cereal protein food in Bangladesh has reportedly increased significantly and has had a sustained growth rate of over eight percent per annum in the fishery and livestock sectors in recent years. National nutrition surveys of Bangladesh during 1995-1996 indicated the average fish intake was 11.7-13.5 kg/capita/yr for rural and urban populations, with a national average of 12 kg/capita/yr.

Cambodia

Studies carried out in the late 1990s recorded a fish consumption of 38-58 kg/capita/yr in Southeast Cambodia. Another estimate puts the per capita consumption of fish in Cambodia as high as 67 kg/capita/yr.

India

Diet surveys in India in 1996 showed that the intake of fish and meat was very low (6.9 and 4.0 kg/capita/yr) in the diets of the urban and rural poor.

Lao PDR

Consumption of fish varies greatly ranging from 15 to over 57 kg/capita/yr. An overall average for most of the provinces lies between 15-25 kg/capita/yr.

Viet Nam

According to nutritional surveillance data in Viet Nam, the consumption of animal foods is noted to be increasing. In 1995, fish and sea food consumption in three sub-regions, namely Red River, Northern Central and Mekong Delta, were 15.6, 17.9 and 29.2 kg/capita/yr respectively.

2. Production trends in fisheries and aquaculture

The Asia-Pacific region is the world's largest producer of fish, from both aquaculture and capture fishery sectors. In 2002, this amounted to 46.9 million tonnes from aquaculture and 44.7 million tonnes from capture fisheries. However, it is common knowledge in the region that production from many small-scale operators, especially in inland areas, is not recorded. As expected, there is considerable variation in general trends among the five main sub-regions of Asia and the Pacific. Most of the growth in both aquaculture and capture fisheries has come from China, South Asia and Southeast Asia. Areas such as Japan, Korea DPR and Korea RO have shown a steady reduction in the supply of capture fish and consistent production in aquaculture. Oceania's production is minor compared with the other sub-regions, but continues to increase, although many of the fisheries in the Pacific small island developing States that operate at a subsistence level are not recorded.

2.1 Capture fisheries production in the Asia-Pacific region

Production from the Asia-Pacific region's capture fisheries totalled 44.7 million tonnes in 2002. The region has been the world's largest producer of fish for decades, with 48.0 percent of global production in 2002. In inland waters, the regional share has increased to 64.7 percent. Of the top 10 producers of capture fish in the world, five States came from the Asia-Pacific area, namely China PR (1st), Indonesia (4th), Japan (5th), India (7th) and Thailand (9th). Total capture fisheries production has steadily increased since 1950, mainly from the marine capture fisheries sector (**Figure 1**).

China PR remains by far the largest producer in the region with a reported production of 16.3 million tonnes in 2002, representing 36 percent of regional production. Chinese production is more than three times greater than that of Indonesia, which is the second largest producer in the region. Because of its enormous scale of production and remarkably high growth rate, China[7] is treated as a distinct sub-region in this review.

Total capture fishery production from marine waters for all the sub-regions, except China, peaked in 1989 at 24.7 million tonnes and gradually declined to 24.0 million tonnes in 2002. The sub-region grouped as "other Asia" was once the top contributor in the area, but has experienced a serious and continuous decline in production since 1988. In contrast, Southeast Asia has constantly increased production and maintained the largest share of the APFIC region since 1993.

[7] In this document, "China" refers to the sub-region that includes China PR, Hong Kong SAR and Taiwan POC.

In inland waters, capture fisheries production[8] has generally increased and its reported growth in the late 1990s was remarkable. However, this period also coincided with a change in the way several States estimated their inland fisheries production and it is likely that earlier production was underestimated. Even today, inland production figures may not reflect the true situation – for example, Coates[9] estimated that production from Southeast Asia was possibly under-reported by a factor of between 2.5 and 3.6.

Total inland production of the region in 2002 was reported as 3.4 million tonnes. South Asia and Southeast Asia contributed the greatest production compared with other sub-regions (**Figure 2**).

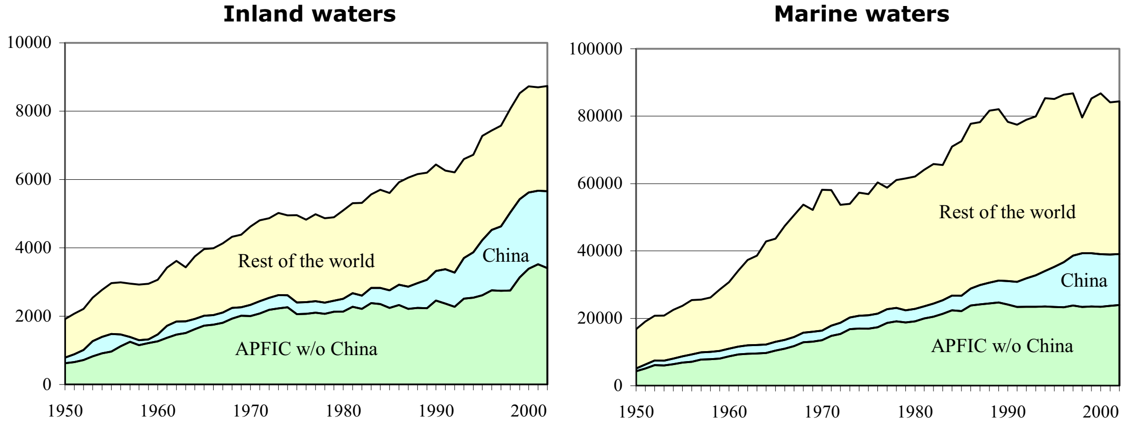
> Top 10 producers of capture fish in 2002 were China, Peru, USA, Indonesia, Japan, Chile, India, Russian Federation, Thailand, and Norway, of these five are in the Asia-Pacific region.

Total capture fishery production, however, masks considerable differences in the trends of the main species groups (**Figure 3**). Demersal marine fish were at the highest level of production of 5.2 million tonnes as early as 1974 and then declined to the lowest level at 3.7 million tonnes in 1983. Production then gradually recovered to 4.4 million tonnes in 2002.

[8] It is common understanding that fisheries information systems in the region have been particularly weak in inland areas. The relatively low level of inland capture production could be simply a reflection of poor quality of information. Constant increase of freshwater/diadromous production for some States could implicate the excessive reliance on estimation rather than actual measurement of production.

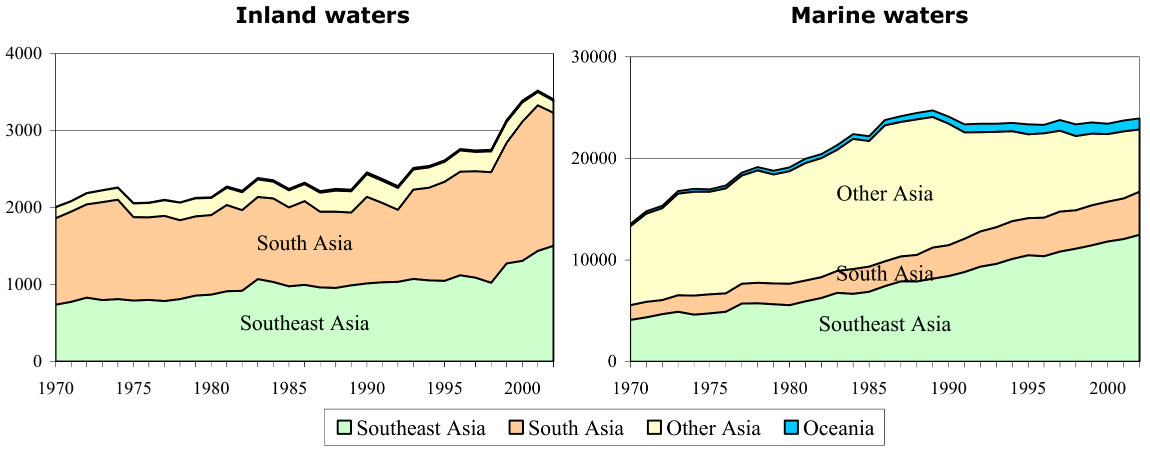
[9] Coates, D. (2003). An overview of inland capture fishery statistics of Southeast Asia. In: *New approaches for the improvement of inland capture fishery statistics in the Mekong Basin*. FAO & MRC, RAP Publication 2003/01. 45 pp.

Figure 1
Trends in global capture production



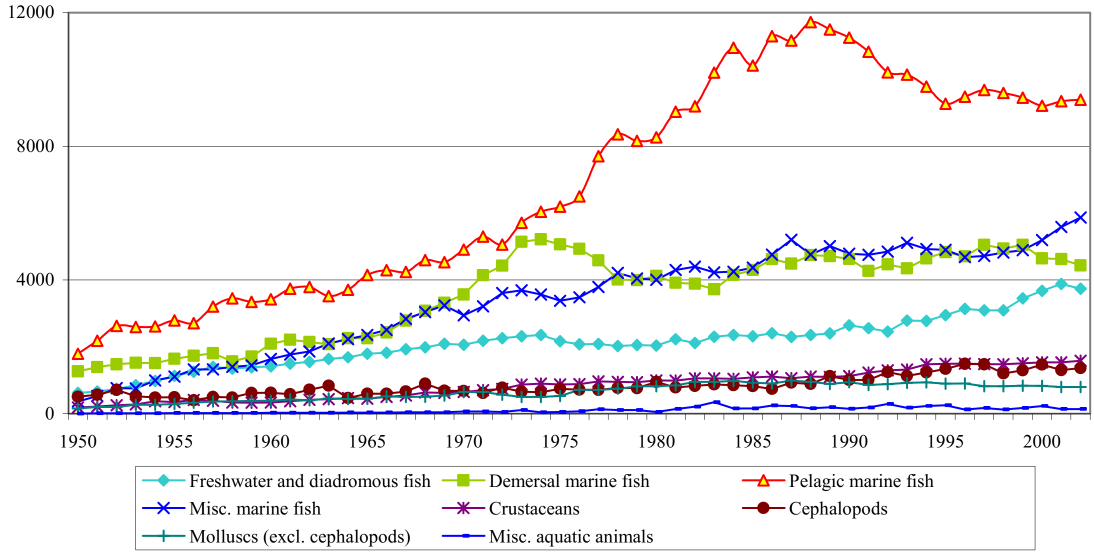
* Excluding aquatic plants Unit: 1000 tonnes

Figure 2
Trends in capture production by sub-region outside China



* Excluding aquatic plants Unit: 1000 tonnes

Figure 3
Trends in capture production by species group outside China



* Excluding aquatic plants Unit: 1000 tonnes

Pelagic marine fish followed the same upward and then downward trends, peaking at 11.7 million tonnes in 1988 and subsequently decreasing to the production levels of the early 1980s by 2002 (9.4 million tonnes). Other species groups such as freshwater/diadromous fish, crustaceans and cephalopods have grown steadily while mollusc production has levelled off at around 900 thousand tonnes.

A comparison of the top 20 species in the region (**Table 2**) shows that although there are changes in the rankings over time, the region's catch is dominated by small pelagic marine species (e.g. Japanese jack mackerel, Japanese anchovy, chub mackerel, Pacific saury, Indian oil sardine, Indian mackerels and scads).

It is significant that the reduction in catch of single dominant species such as Alaska pollock[10] in the early 1970s and chub mackerel[11] in the late 1970s brought up the relative ranking of large pelagic marine species (i.e. skipjack tuna and yellowfin tuna) in 2000. When the Chinese figures are included, the large catches of largehead hairtail (1.3 million tonnes), akiami paste shrimp (*Acetes spp.*) (578 thousand tonnes) and Japanese Spanish mackerel (519 thousand tonnes) from this sub-region increases their importance in the overall rankings

It should also be noted that there is considerable capture production not identified to the species level but recorded as marine/freshwater fishes nei (not elsewhere included), marine/freshwater molluscs nei and marine/freshwater crustaceans nei. The quantity reported under these categories has been increasing significantly in recent years, which indicates a worrying trend in available statistical quality. In 2002, 16.8 million tonnes of capture production was not identified to species, order, or family level.

2.2 Aquaculture production in the Asia-Pacific region

The Asia-Pacific region is by far the world's largest contributor to world aquaculture, producing 46.9 million tonnes[12] or 91 percent of global aquaculture production. In terms of production by value, the region's 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 the dominant aquaculture production area, representing 89 percent of global aquaculture production by quantity and 80 percent by value.

The growth of aquaculture production in the region has been very strong for the last ten years, resulting mainly from increased production from China (annual growth rate of 13.8 percent[13]). Both inland culture and mariculture showed steady growth but the growth rate of the inland culture sector was more rapid (**Figure 4**).

> Top 10 aquaculture producer States by quantity (excluding aquatic plants) in 2002 were China PR, India, Indonesia, Japan, Bangladesh, Thailand, Norway, Chile, Viet Nam, and USA. Seven of these are Asian States, dominating the top 6 ranks.
>
> By value, China PR, Japan, India, Chile, Thailand, Indonesia, Norway, Viet Nam and Bangladesh are amongst the top 10 producer States. **(see Table 3)**

China PR[14] alone reported to have produced 36.6 million tonnes or 79 percent of the world aquaculture production in 2002 (including aquatic plants). To understand the enormous scale of aquaculture production in China, it can be compared with the total fisheries production of Peru, the world second largest fisheries producer after China PR, which was 8.8 million tonnes in 2002 (including both capture and aquaculture). This was still less than one quarter of China's aquaculture production alone. Since China PR is such a predominant producer, the scale of reported production can mask other regional trends; therefore, China[15] will be treated separately and presented as a sub-region in its own right.

Even excluding China, the Asia-Pacific region still remains an important production area for aquaculture, exhibiting steady growth regardless of the culture environment. In particular, inland culture doubled its production from 1854 thousand tonnes in 1990 to 4 478 thousand tonnes in 2002. Such

[10] Its highest production was 2.7 million tonnes in 1973.

[11] Its highest production was 1.7 million tonnes in 1978.

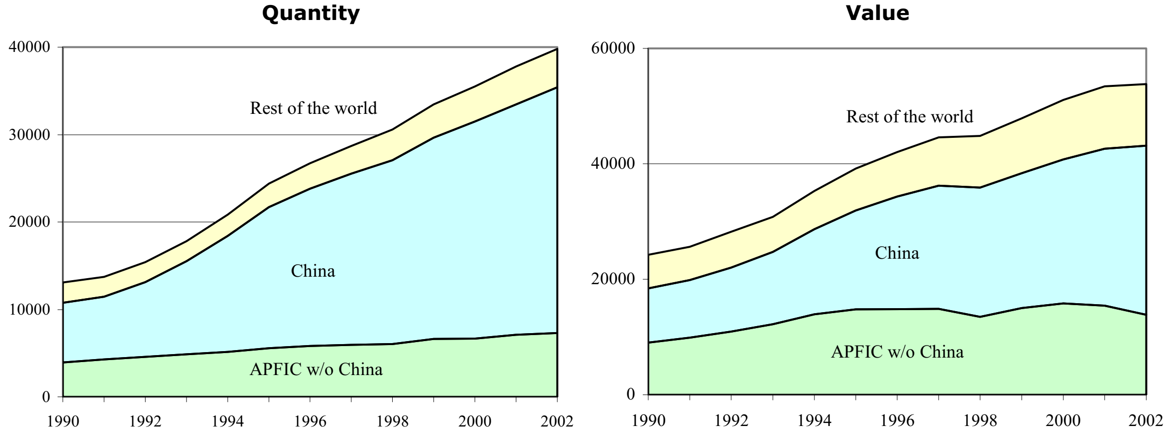
[12] It should be noted that regionally aggregated figures in this report are based on national data, the quality of which is known to be very uneven among States. Some national figures are estimates or repetitions of the data previously reported to FAO.

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

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

[15] See footnote 7.

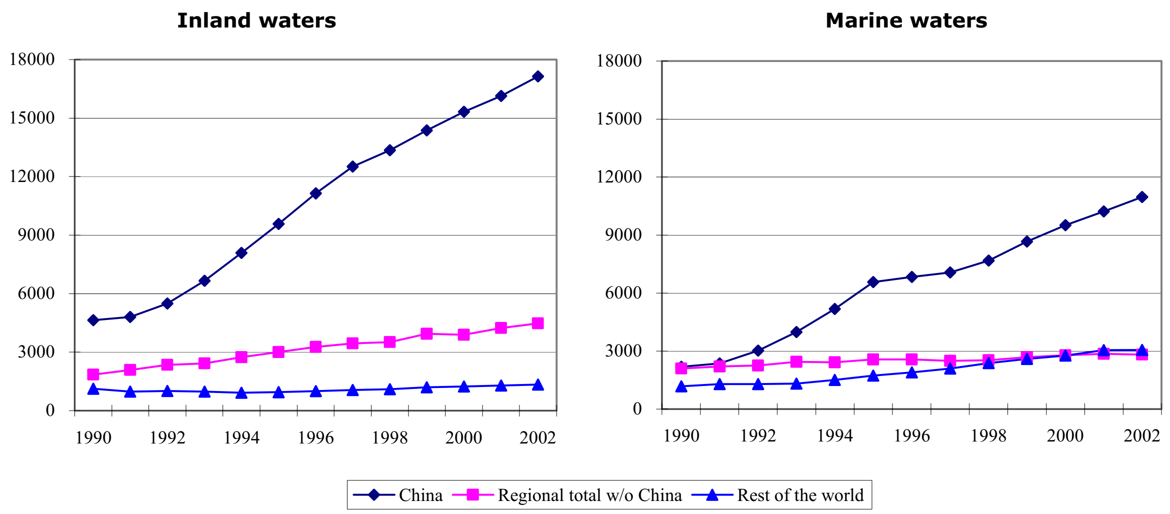
Figure 4
Trends in global aquaculture production



* Excluding aquatic plants

Unit: 1000 tonnes (quantity), million US$ (value)

Figure 5
Trends in aquaculture production of the Asia-Pacific region by environment



* Excluding aquatic plants

Unit: 1000 tonnes

Table 2
Top twenty capture production species in the Asia-Pacific region

	1960	1980	2000	(production)	2000 with China	(production)
1	Jap. jack mackerel	Chub mackerel	Skipjack tuna	1 333.1	Japanese anchovy	1 853.9
2	Jap. flying squid	Alaska pollock	Japanese anchovy	582.8	Largehead hairtail	1 420.5
3	Japanese anchovy	Skipjack tuna	Yellowfin tuna	572.9	Skipjack tuna	1 417.3
4	Chub mackerel	Natantian decapods	Jap. flying squid	570.4	Scads nei	1 163.5
5	Pacific saury	Jap. flying squid	Scads nei	523.7	Chub mackerel	872.9
6	Alaska pollock	Japanese anchovy	Chub mackerel	522.2	Akiami paste shrimp	594.8
7	Indian oil sardine	Indian oil sardine	Natantian decapods	500.6	Yellowfin tuna	585.6
8	Natantian decapods	Croakers, drums nei	Sardinellas nei	462.5	Japanese flying squid	576.3
9	Scads nei	Yellowfin tuna	Croakers, drums nei	461.5	Jap. Spanish mackerel	553.7
10	Indian mackerel	Sardinellas nei	Indian mackerels	458.1	Jellyfishes	504.4
11	Sharks, rays, skates	Stolephorus anchovies	Alaska pollock	446.2	Alaska pollock	460.0
12	Yellowfin tuna	Indian mackerels	Indian oil sardine	358.6	Natantian decapods	449.6
13	Skipjack tuna	Sharks, rays, skates	Yesso scallop	304.4	Croakers, drums nei	437.5
14	Clupeoids nei	Pacific saury	Pacific saury	288.7	Sardinellas nei	429.0
15	Croakers, drums nei	Scads nei	Tuna-like fishes nei	287.3	Indian mackerels nei	387.0
16	Indian mackerels nei	Clupeoids nei	Cephalopods nei	282.1	Cuttlefish, bobtail squids	386.3
17	Bigeye tuna	Tuna-like fishes nei	Clupeoids nei	278.3	Indian oil sardine	369.2
18	Stolephorus anchovies	Ponyfishes nei	Stolep. anchovies	276.1	Gazami crab	365.8
19	Sea catfishes nei	Bigeye tuna	Sharks, rays, skates	272.3	Silver pomfrets nei	309.4
20	Chumsalmon	Carangids nei	Jap. jack mackerel	271.5	Tuna-like fishes nei	309.0

Unit: 1 000 tonnes

Table 3
Top ten aquaculture producer States in 2002

By quantity			By value		
	Country	(1 000 tonnes)		Country	(million US$)
1	China	27 767	1	China	28 428
2	India	2 192	2	Japan	3 394
3	Indonesia	914	3	India	2 539
4	Japan	828	4	Chile	1 634
5	Bangladesh	787	5	Thailand	1 436
6	Thailand	645	6	Indonesia	1 418
7	Norway	554	7	Norway	1 155
8	Chile	546	8	Viet Nam	1 136
9	Viet Nam	519	9	Bangladesh	1 126
10	USA	497	10	Brazil	909
	Other	4 550		Other	10 621
	TOTAL	**39 799**		**TOTAL**	**53 798**

Excluding aquatic plants

Table 4
Top twenty cultured species in Asia-Pacific region by quantity

Inland waters					
1990			2002		
1	Silver carp	1 416.6	1	Silver carp	4 009.6
2	Grass carp	1 042.0	2	Grass carp	3 494.5
3	Bighead carp	671.8	3	Common carp	2 955.3
4	Common carp	658.4	4	Bighead carp	1 715.5
5	Tilapias	282.8	5	Crucian carp	1 700.6
6	Rohu	244.7	6	Tilapias	1 126.4
7	Catla	235.3	7	Rohu	578.4
8	Crucian carp	215.6	8	White amur bream	564.1
9	Japanese eel	163.5	9	Catla	469.1
10	White amur bream	161.6	10	Mrigal carp	424.0
11	Mrigal carp	160.1	11	Chinese river crab	340.0
12	Clarias catfishes	61.1	12	Black carp	225.3
13	Barb	47.0	13	Japanese eel	222.4
14	Climbing perch	39.4	14	Giant river prawn	191.4
15	Black carp	37.9	15	Clarias catfishes	182.1
16	Milkfish	34.5	16	Mandarin fish	130.0
17	Cyprinids nei	25.6	17	Soft-shell turtle	119.7
18	Gourami	24.9	18	Barbs	79.0
19	Trouts	24.7	19	Milkfish	55.3
20	Giant river prawn	18.5	20	Gouramis	46.7
	Misc. freshwater fishes	776.8		Misc. freshwater fishes	2 815.6

Marine/brackish waters					
1990			2002		
1	Milkfish	399.6	1	Giant tiger prawn	508.6
2	Giant tiger prawn	289.7	2	Milkfish	472.5
3	Fleshy prawn	185.1	3	Fleshy prawn	385.5
4	Japanese amberjack	161.6	4	Marine crabs nei	178.3
5	Silver seabream	52.0	5	Japanese amberjack	162.7
6	Tilapias	39.2	6	Silver seabream	73.4
7	Banana prawn	32.8	7	Other penaeus shrimps	65.7
8	Metapenaeus shrimps	28.6	8	Tilapias	50.9
9	Coho salmon	23.6	9	Banana prawn	42.9
10	Other penaeus shrimps	21.0	10	Bastard halibut	33.2
11	Kuruma prawn	9.3	11	Metapenaeus shrimps	22.4
12	Barramundi	7.9	12	Groupers	21.0
13	Mullets	7.9	13	Barramundi	19.7
14	Bastard halibut	7.1	14	Scorpionfishes	15.3
15	Indian white prawn	6.7	15	Indo-Pacific swamp crab	14.5
16	Japanese jack mackerel	5.9	16	Atlantic salmon	14.4
17	Indo-Pacific swamp crab	3.8	17	Mullets	17.4
18	Tilapias	3.8	18	Indian white prawn	9.5
19	Puffers	2.9	19	Coho salmon	8.0
20	Groupers	2.8	20	Chinook salmon	7.0
	Misc. fishes	38.6		Miscellaneous fishes	578.1
	Misc. crustaceans	4.5		Misc. crustaceans	230.7

* Colour cells indicate carnivorous species ** Excluding aquatic plants and molluscs Unit: 1 000 tonnes

advances far exceed the growth of aquaculture in the rest of the world (**Figure 5**).

A comparison of the top twenty cultured species[16] in the region between 1990 and 2002 (excluding aquatic plants and molluscs) shows that there has been little change in the higher ranked species in inland waters, which are dominated by Chinese and Indian carps. It is worth noting that the number of carnivorous species has increased during the past ten years. In marine waters, although there are changes in the order of species, major cultured species are generally dominated by high-valued carnivorous species such as penaeid shrimp, jacks, sea breams and salmons. Production of crabs has made significant advances in recent years (i.e. Chinese river crab in inland waters and marine crabs in marine waters) (**Table 4**).

2.3 Status and trends by sub-regions

South Asia – capture fisheries

The South Asian sub-region showed very strong and continuous growth during 1980-2002, nearly doubling its capture production from 3.1 million tonnes in 1980 to 6.0 million tonnes in 2002 (**Figure 6**). Although overall growth largely resulted from production in marine waters, South Asia has the largest share of inland capture production (29 percent of total capture fisheries production) among sub-regions in the Asia-Pacific area. Inland production was relatively stable during late 1970s and 1980s, but grew rapidly from the early 1990s. It reached the highest level of production at 1.9 million tonnes in 2001 but showed a sharp decrease in 2002 for the first time in the past 10 years.

It is notable that there are no dominant species among the top production species in this area. In comparison with top production species of other sub-regions, the combination of South Asian species is unique in the sense that freshwater species (Cyprinids nei: 5th), diadromous species (Hilsa shad: 3rd) and demersal species (Croakers/ drums: 2nd and Bombay-duck: 9th) are ranked high in the list (**Table 5**).

Freshwater fish and diadromous fish has been the number one production group for the last four decades (except in 1992) and achieved very rapid growth in the 1990s. Among marine species, pelagic fishes and demersal fishes showed almost parallel increasing trends with similar levels of production in 2002 (1 254 thousand tonnes and 1 190 thousand tonnes respectively). Crustacean production has been relatively stable and production levels of molluscs including cephalopods in this area have been very low (**Figure 7**).

Table 5
South Asia capture fisheries production, top ten species

Species	**Tonnes** (1 000)
Indian oil sardine	365.8
Croakers, drums nei	296.3
Hilsa shad	220.8
Natantian decapods nei	198.7
Cyprinids nei	183.8
Skipjack tuna	181.5
Giant tiger shrimp	157.1
Clupeoids nei	140.9
Bombay-duck	135.9
Hairtails, scabbardfishes	134.2
Marine fishes nei	1 081.7
Freshwater fishes nei	1 199.7

South Asia – aquaculture

South Asia's production increased rapidly from 1 179 thousand tonnes in 1990 to 2 807 thousand tonnes in 2002. A notable feature of the 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 to increasing freshwater culture (**Figure 8**).

> Top five cultured species in 2002 were all freshwater carps (Silver carp, Rohu, Catla, Common carp and Mrigal) and their aggregated production was 2 390 thousand tonnes accounting for 79 percent of total aquaculture production of the sub-region.

Reported production of freshwater finfishes alone constituted 93 percent of total aquaculture production in 2002. Although Indian carps (Rohu, Catla and Mrigal carp) have been the mainstays of the region's cultured species, there have been notable increases in the production of introduced Chinese carps in recent years. Silver carp production has increased almost five-fold in two years (1998-2000) becoming the top cultured species in 2002 for the first time. Similarly common carp production recorded very rapid increases since 2000. During the same period the production

[16] There is significant volume of aquaculture production reported by large group of species, e.g. 3 394 thousand tonnes of fin fish production in 2002 were not identified at family, order or species level. Consequently, the species items totals could have underestimated the real production of the individual species.

Figure 6
Trends in capture production of South Asia by environment

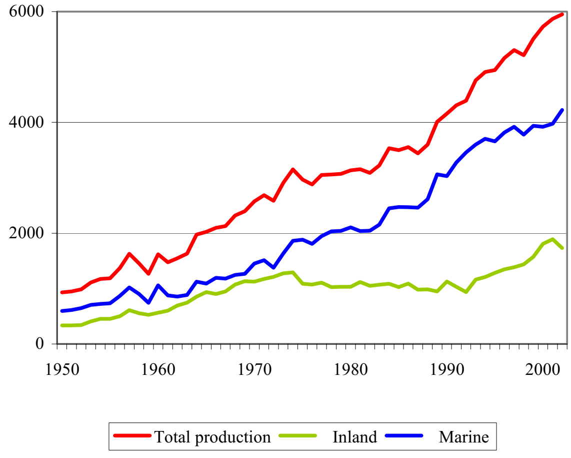
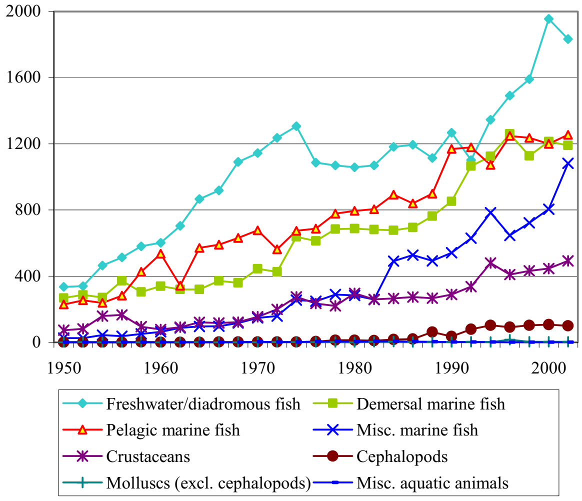


Figure 7
Capture production of South Asia by major species groups



* Excluding aquatic plants

Unit: 1000 tonnes

Figure 8
Trends in aquaculture production of South Asia by major species groups

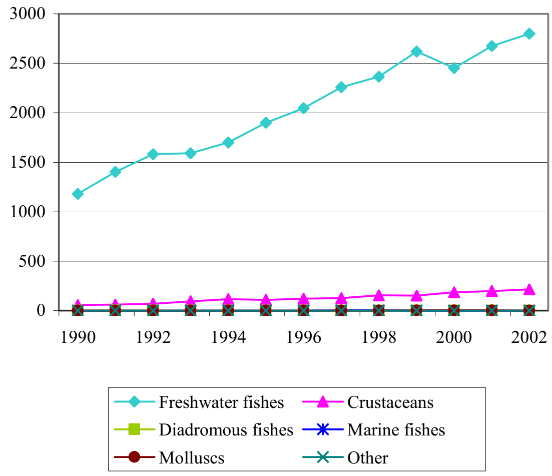
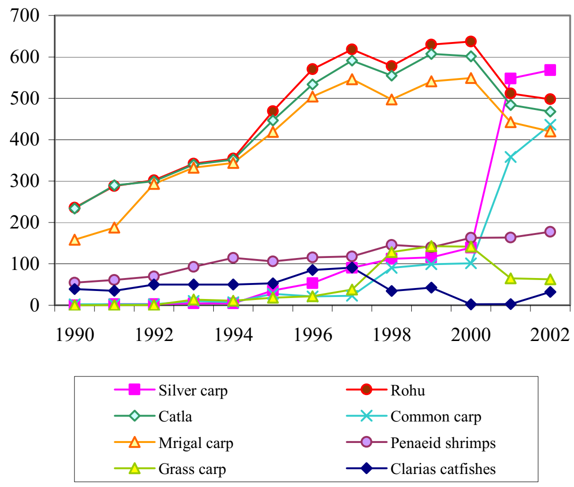


Figure 9
Aquaculture production of major species in South Asia



Unit: 1000 tonnes

of indigenous carps showed sharp declines (**Figure 9**).

Mariculture in South Asia has not been an area of remarkable growth except for the production of crustaceans. Marine crustacean production, mostly comprised of Penaeid shrimp, has increased steadily and reached 177 thousand tonnes in 2002. 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.

Southeast Asia – capture fisheries

Similar to the situation in South Asia, production growth in Southeast Asia has been very strong for the past four decades with marine capture production increasing linearly through this period. The production level of 14 million tonnes in 2002 (total capture production) was second only to the China sub-region.

Inland production increased gradually and reached 1.5 million tonnes in 2002. Considering the rich freshwater resources in the area, it is commonly thought that the proportion of inland capture production, which constitutes only approximately 11 percent of total production[17], might be particularly underestimated in this sub-region (**Figure 10**).

Table 6
Southeast Asia capture fisheries production, top ten species

Species	**Tonnes** (1 000)
Scads nei	550.7
Indian mackerels nei	460.0
Sardinellas nei	437.4
Skipjack tuna	348.4
Natantian decapods nei	323.3
Stolephorus anchovies	295.6
Tuna-like fishes nei	254.3
Yellowfin tuna	242.7
Carangids nei	239.3
Threadfin breams nei	214.4
Marine fishes nei	4 079.7
Freshwater fishes nei	1 032.0

In terms of production by main species groups, catches of the pelagic marine fish group and marine fish nei group have grown strongly and are a major driving force of the overall production growth (**Figure 11**). Other species groups (freshwater/diadromous fish, demersal fish, crustaceans and cephalopods) exhibited similar increasing trends, maintaining nearly the same share of production. The proportion of unidentified marine fish (marine fish nei) is notably high (29 percent of total production) in this sub-region because many States do not segregate marine fish production.

[17] see footnote 8.

Table 6 shows the top ten production species in Southeast Asia. Eight of the top ten production species are marine pelagic fishes and the top three ranks are dominated by the small pelagic fish group (scads, Indian mackerels, and sardinellas). The large pelagic fish group (skipjack tuna, tuna-like fishes, yellowfin tuna and carangids) also has relatively high production.

Southeast Asia – aquaculture

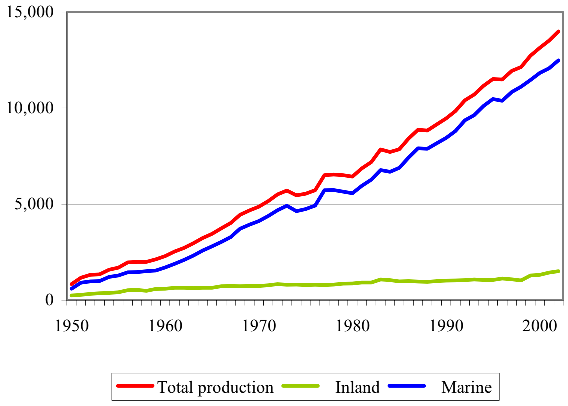
Aquaculture production in Southeast Asia is very diversified, comprising 39 percent of freshwater fish, 29 percent of aquatic plants, 13 percent of crustaceans, 13 percent of marine/diadromous fishes and 7 percent of molluscs (by quantity). In terms of production by value, highly priced crustaceans constituted an increased share of 49 percent of the total production, followed by freshwater fish at 35 percent (**Figure 12**).

The growth trend is particularly strong for freshwater finfish culture, which has increased from 564 thousand tonnes in 1990 to 1 556 thousand tonnes in 2002 with an average annual increment of 83 thousand tonnes. In the mariculture sub-sector, aquatic plants showed surprising production growth. Crustaceans have been a major cultured species throughout the sub-region, although this has declined since 2000 **(Figure 13**).

> Top ten cultured species in Southeast Asia (by quantity, excluding aquatic plants) were milkfish, giant tiger shrimp, tilapias, common carp, clarias catfishes, blood cockle, green mussel, rohu, barbs and gouramis.

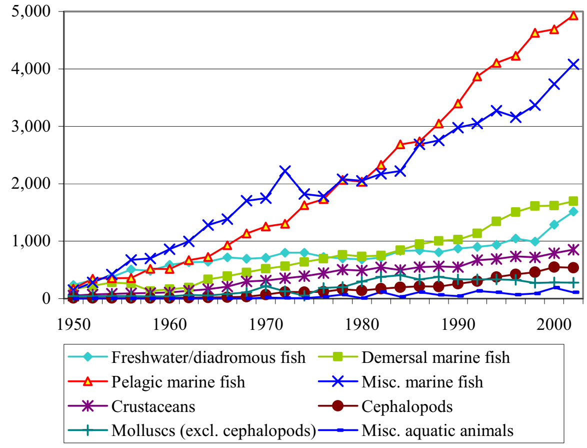
Zanzibar weed (*Eucheuma cottonii*) is the most widely cultured aquatic plant in the region with a production of 778 thousand tonnes in 2002. Apart from aquatic plants, Giant tiger shrimp (*Penaeus monodon*) maintained the position of top produced species until 2001, although very recently the massive increase in production of *P. vannamei* is challenging this position. *P. monodon* production decreased sharply in 2002, back to the production level of 1992.

Figure 10
Trends in capture production of Southeast Asia by environment



* Excluding aquatic plants

Figure 11
Capture production of Southeast Asia by major species groups



Unit: 1000 tonnes

Figure 12
Aquaculture production of Southeast Asia: proportion of major species groups

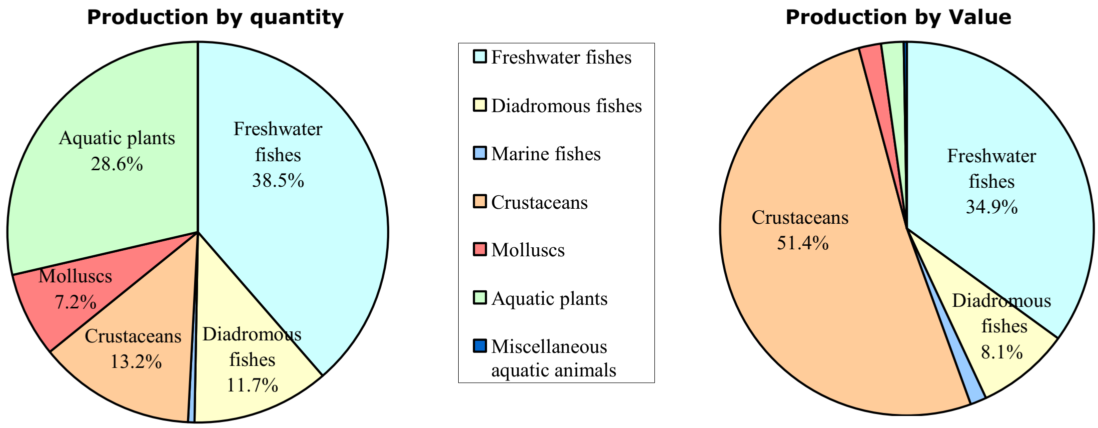
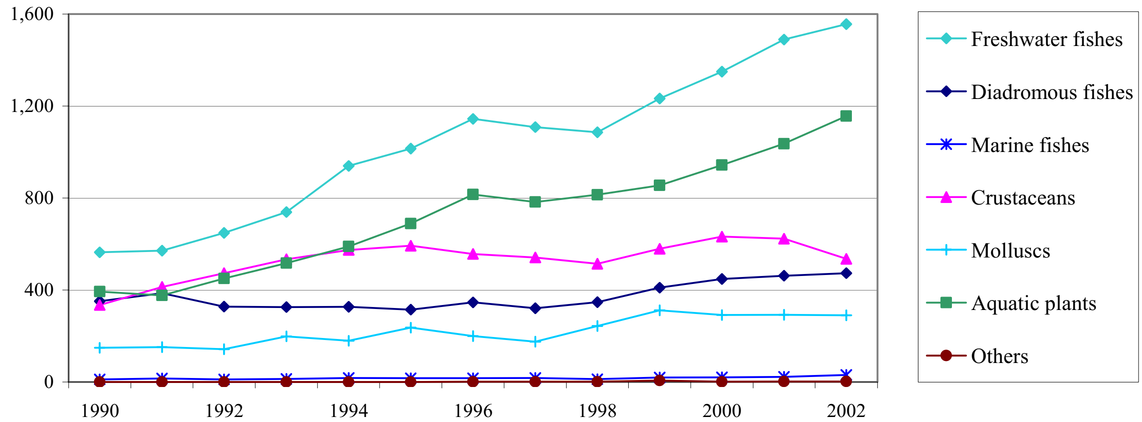


Figure 13
Trends in aquaculture production of Southeast Asia by major species groups



Unit: 1000 tonnes

China – capture fisheries

Chinese capture fisheries production can be divided into three periods that show distinct trends (**Figure 14**). The first period, 1950 to 1985, is characterized by relatively low rates of growth, during which all species groups exhibited a very similar pattern, albeit with some annual fluctuations. In the second period, 1986 to 1998, China reported very rapid and substantial growth in production in almost all segments of capture fisheries. Between 1992 and 1997, annual increments of total production constantly exceeded one million tonnes (the highest annual increment was 1.7 million tonnes in 1994/1995). The third period started with the introduction of the zero growth policy in 1998; total production started to decline for the first time in twenty years. The degree of decline was higher in marine production than in inland production.

Although most species groups showed similar rapid growth trends during the second period, trends in the third period varied widely. Production of the marine fish nei group declined sharply, whilst the crustacean group continued to grow. During this period, molluscs maintained the same production level (**Figure 15**).

Table 7
China capture fisheries production, top ten species

Species	**Tonnes** (1 000)
Largehead hairtail	1 296.2
Japanese anchovy	1 174.5
Scads nei	608.3
Akiami paste shrimp	578.6
Japanese Spanish mackerel	518.8
Chub mackerel	450.3
Silver pomfrets nei	386.3
Gazami crab	347.1
Golden threadfin bream	309.4
Cuttlefish, bobtail squids nei	299.7

Table 7 shows the top ten production species in China in 2002. Largehead hairtail and Japanese anchovy catches were extremely high with both species exceeding one million tonnes. A distant second group includes a variety of species group such as small pelagic fish (scads and chub mackerel), large pelagic fish (Japanese Spanish mackerel), bentho-pelagic fish (silver pomfrets), demersal fish (golden threadfin bream), crustaceans (akiami paste shrimp and gazami crab) and cephalopods.

Table 8
Unidentified capture production in China

Species group	**Tonnes** (1 000)
Marine fishes nei	3 595.5
Marine molluscs nei	1 376.7
Marine crustaceans nei	1 215.0
Freshwater fishes nei	924.2
Freshwater crustaceans nei	772.7
Freshwater molluscs nei	551.0
Total of "nei" groups	**8 435.1**
Total capture production	**17 767.2**

There are several notable differences in the Chinese production figures compared with other sub-regions. These include:

- Remarkably high proportion of crustaceans in Chinese production (18.8 percent in 2002) compared to those of other sub-regions. Proportions of crustaceans in Southeast Asia, South Asia and other Asia were 6.1 percent, 8.3 percent and 3.9 percent respectively.
- The large quantity of production reported within unidentified large groupings which far exceeded that of the other sub-regions. Total quantity reported under these groups was 8.4 million tonnes in 2002 representing 47.5 percent of the Chinese total capture production. Production of marine fish nei group in 2002 alone was almost equal to the total capture production of India (**Table 8**).
- The much smaller amounts of small pelagic fish in the catch.

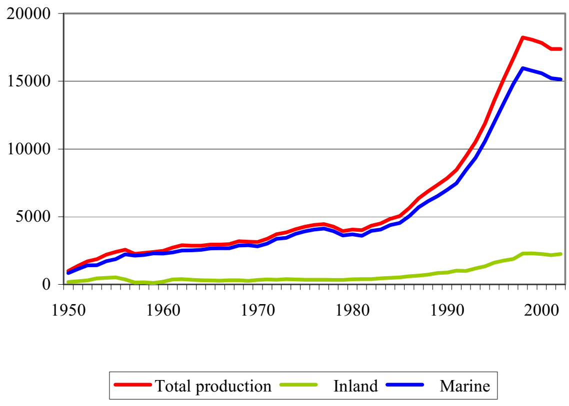
China – aquaculture

China has continued to show strong growth in all culture environments. Growth in inland culture came mainly from increased production of finfish culture, which according to official information is being achieved through the intensification of existing systems rather than any significant increase in production area. Growth in production from marine waters has been driven by two major groups, namely molluscs and aquatic plants (**Figure 16**).

In China generally, the production of most cultured species showed an increasing trend. However, there are a number of species worth highlighting, as follows:

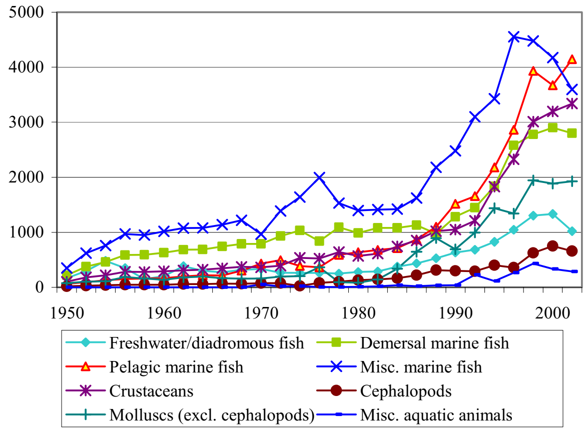
Japanese kelp (Laminaria japonica): this species has been the top cultured species in China and its production growth is remarkable; increasing from

Figure 14
Trends in capture production of China by environment



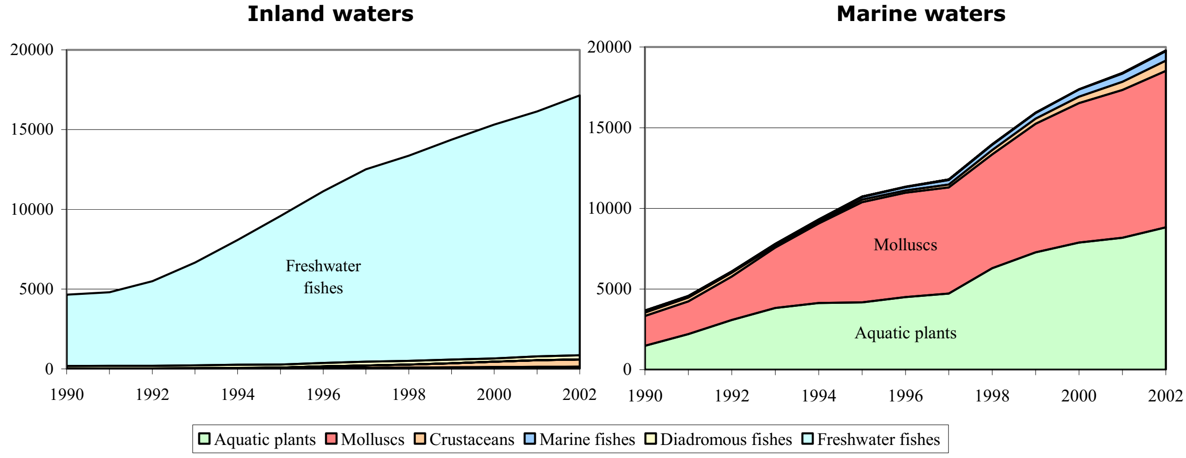
* Excluding aquatic plants

Figure 15
Capture production of China by major species groups



Unit: 1000 tonnes

Figure 16
Trends in aquaculture production of China by environment



Unit: 1000 tonnes

Figure 17
Trends in top eight cultured species in China (aquatic plants and molluscs)

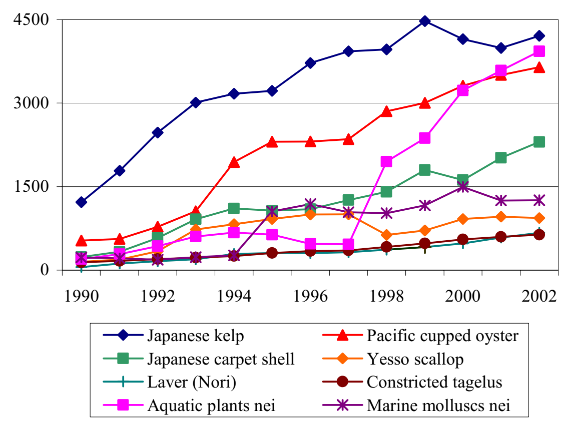
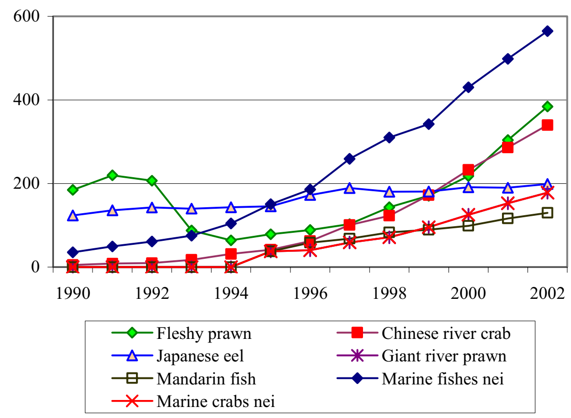


Figure 18
Trends in major cultured carnivorous species production in China



Unit: 1000 tonnes

1 222 thousand tonnes in 1990 to 4 208 thousand tonnes in 2002.

Miscellaneous aquatic plants: this massive volume of aquatic plants is not reported at the species level. However, production jumped from 196 thousand tonnes in 1990 to 3 931 thousand tonnes in 2002. The highest annual increment was 1 485 thousand tonnes between 1997 and 1998. As this group and Japanese kelp are not particularly easy to culture intensively, these increases suggest the expansion of additional areas of seaboard for their culture. A description of the areas under seaweed culture and production intensity in China would be very useful.

Pacific cupped oyster: this is another cultured species that has made outstanding growth; increasing from 532 thousand tonnes in 1990 up to 3 646 thousand tonnes in 2002. Mollusc production is also difficult to intensify and increased production suggests developments of new production areas as in the case of aquatic plants (**Figure 17**).

Carnivorous species: Production of high value carnivorous species such as mandarin fish, Chinese river crab and marine finfish had been relatively low up to the early 1990s. However, rapid growth has started to occur since 1995. Many of the carnivorous species show very similar patterns of growth in production (**Figure 18**).

Other Asia – capture fisheries

Since reported inland production in this region is low, the trend in total capture fisheries production is almost identical to the trend in marine production. Total production increased towards its peak production of 13.6 million tonnes in 1988, and thereafter decreased steadily (**Figure 19**). In its best years, the sub-region's share of global capture production was estimated as high as 40 percent.

Production by main species groups (**Figure 20**) provides a more detailed picture of the situation of the fisheries sector. During the late 1960s to early 1970s, demersal fish became the most important production group with a very rapid growth rate, achieving a three-fold increase in fifteen years. However, after the peak production of five million tonnes in 1974, it started to decline, gradually at first, but with a sharp decline after 1976. The current level of demersal fish production is as low as in the early 1950s. This reduction was compensated for by increased production of marine pelagic fish, the strong growth of which contributed to an overall increase of capture production until 1988, but then a similar decline to that of demersal fish production occurred. Current production levels have dropped to those of the early 1960s.

In terms of major production species, pelagic species predominate in this area. It is also notable that there is high production of cephalopods (Japanese flying squid) and molluscs (Yesso scallop) (**Table 9**).

Table 9
Other Asia capture fisheries production, top ten species

Species	**Tonnes** (1 000)
Japanese anchovy	679.5
Japanese flying squid	500.2
Skipjack tuna	479.2
Chub mackerel	420.8
Yesso scallop	306.7
Alaska Pollock	298.0
Pacific saury	232.5
Japanese jack mackerel	222.1
Chum salmon	211.7
Yellowfin tuna	164.5
Marine fishes nei	649.3
Marine crustaceans nei	67.4

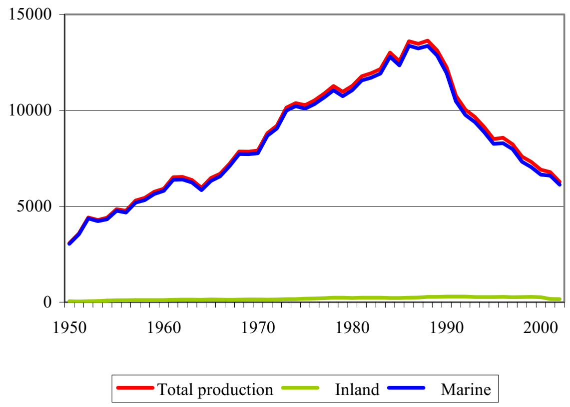
Other Asia – aquaculture

In other Asia, particularly in East Asian States, aquatic plants continue to be predominant, accounting for 54 percent of total production. This is followed by molluscs (28 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 42 percent of total production value (**Figure 21**).

Production trends by major species groups show that aquaculture production in this region has been very stable; most of the major species groups have been maintained at the current level of production for the last ten years. The only exception to this is aquatic plant production, which peaked in 1993 then decreased by almost half in 2000 (**Figure 22**).

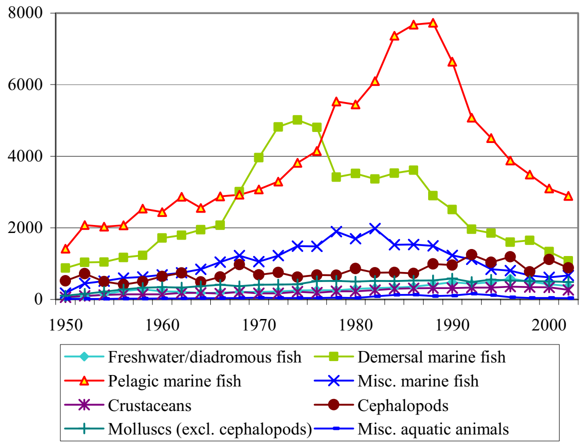
It is notable that the percentage of carnivorous fish in the total for fish production is very high in this sub-region (82 percent in 2002) compared with South Asia, Southeast Asia and China, which all have levels below 10 percent.

Figure 19
Trends in capture production of other Asia by environment



* Excluding aquatic plants

Figure 20
Capture production of other Asia by major species groups



Unit: 1000 tonnes

Figure 21
Aquaculture production in other Asia: proportion of major species groups

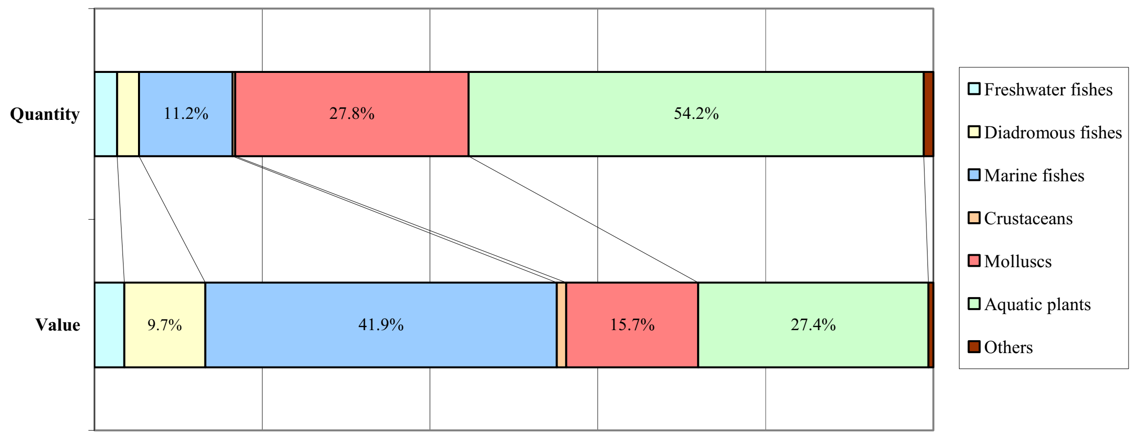
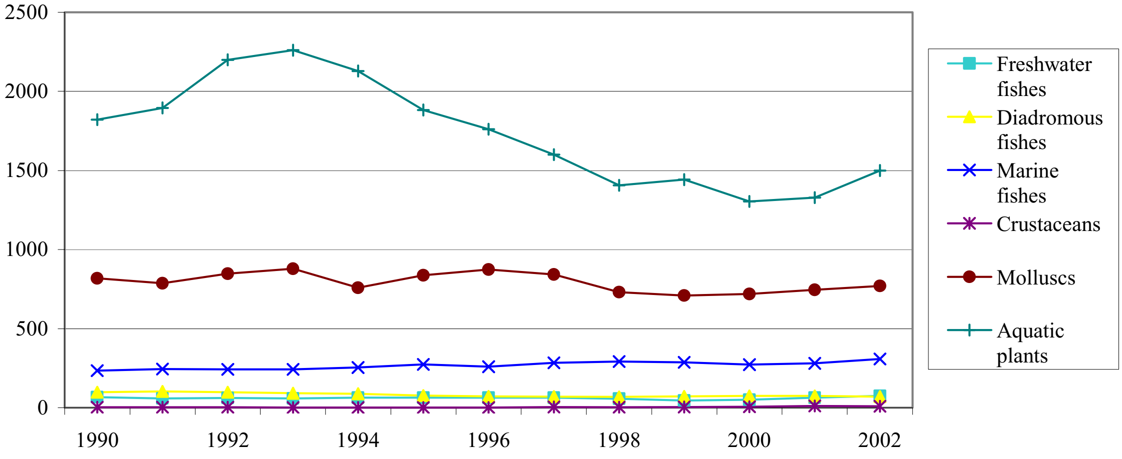


Figure 22
Trends in aquaculture production of other Asia by major species groups



Unit: 1000 tonnes

Oceania – capture fisheries

Similar to the other Asia sub-region, Oceania's capture production consists mainly of fish taken from marine waters. Although there have been annual fluctuations, it has continued to increase (**Figure 23**). Capture fisheries are often conducted on subsistence scale in many small island States and hence production may not be well represented in the official statistics. An effect of this is that general trends in production are basically determined by a few larger States such as Australia and New Zealand with well established commercial fisheries sectors, with the exception of offshore pelagic fisheries. Commercial offshore production has increased in many small island States and contributed to the increase in total production. Rapid growth of demersal fish production has mainly come from the States in temperate waters (i.e. New Zealand and Australia) (**Figure 24**).

The top ten species produced from capture fisheries in Oceania (**Table 10**) are distinct from those of the rest of the region as the majority of them are from the temperate waters of New Zealand and Australia.

Table 10
Oceania capture fisheries production, top ten species

Species	**Tonnes** (1 000)
Blue grenadier	201.7
Skipjack tuna	166.4
Wellington flying squid	50.0
Yellowfin tuna	47.8
Southern blue whiting	42.1
Albacore	33.1
Jack and horse mackerels	32.3
Snoek	23.3
Orange roughy	22.6
Pink cusk-eel	21.9
Marine fishes nei	62.6

Oceania – aquaculture

Aquaculture in the Oceania sub-region occurs in two distinctly different environs; larger developed States in temperate waters and small developing island States in tropical waters. Aquaculture production from the small island States is relatively limited. The aggregated production of all island States was 29 462 tonnes in 2002 (less than one percent of aquaculture production in the Asia-Pacific region).

The major cultured species in terms of quantity are seaweed, clams, penaeid shrimp, tilapia and milkfish. Two commodities and three States dominate the value of commercial aquaculture production in region. They are cultured black pearl from French Polynesia and the Cook Islands and shrimp from New Caledonia. In 2002 the total export value was US$ 153 million.

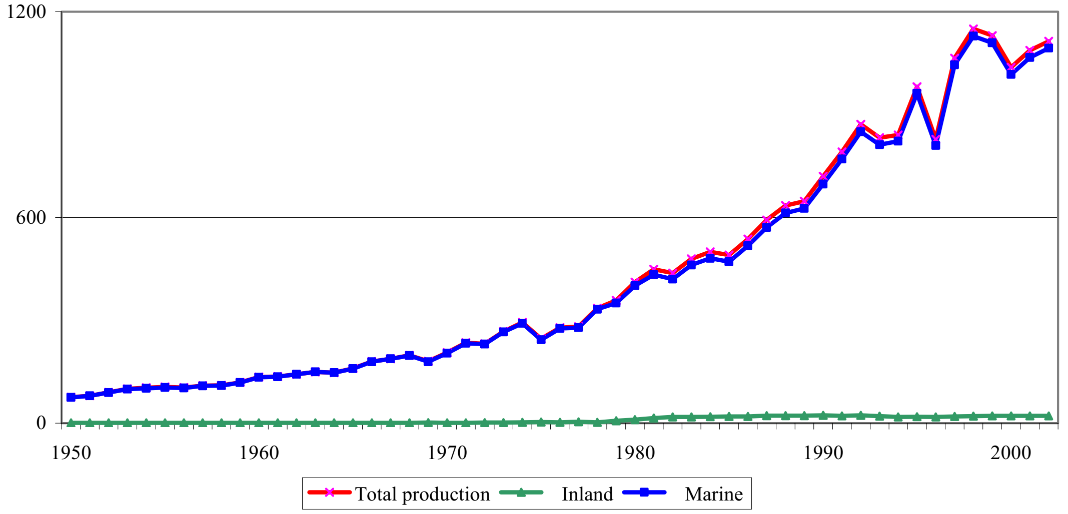
Live reef fish, aquarium fish and pearls, which are relatively low in quantity but high in value commodities, bring significant income to some Pacific Islands. The Pacific is an important source of trade in the marine aquarium industry. Although the target species are mostly caught from the wild, there 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 also a major supplier of 'live rock' (rock encrusted with coralline algae) with approximately 50 000 pieces of live rock currently being cultured in the Fiji Islands.

Eucheuma cottonii (Zanzibar weed) culture is well established in the Kiribati atolls and is being rejuvenated in the Solomon Islands and Fiji with forecasted production in the order of 1 500 tonnes for 2004.

Interest in inland freshwater aquaculture is growing, particularly amongst the larger Melanesian States such as Fiji and Papua 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 shown a steady growth in aquaculture production, which is largely attributable to increased production of finfish species. Major cultured species of these States were marine molluscs, salmonids and tunas.

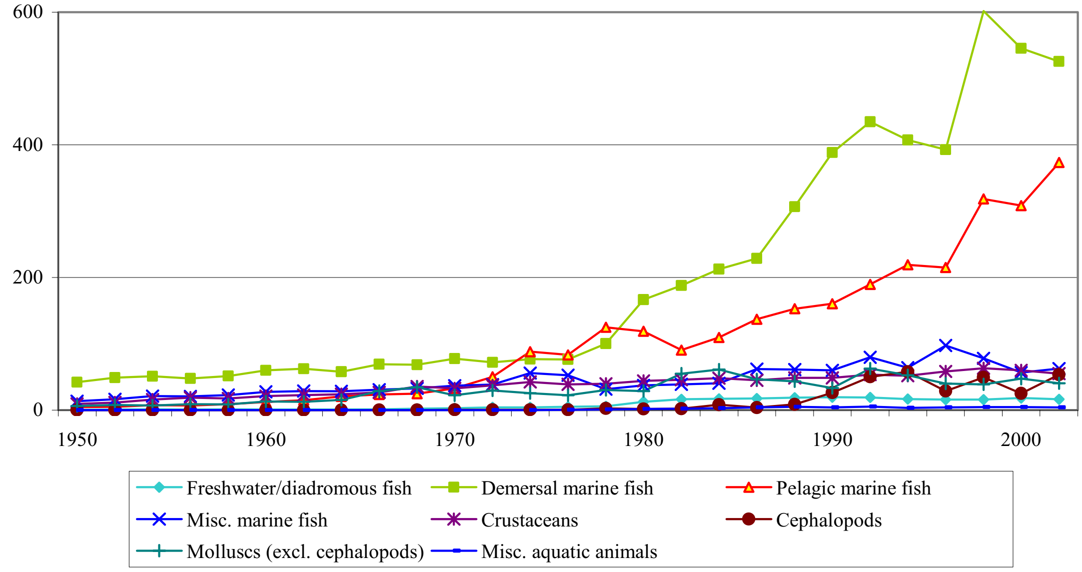
Figure 23
Trends in capture production of Oceania by environment



* Excluding aquatic plants

Unit: 1000 tonnes

Figure 24
Capture production of Oceania by major species groups



* Excluding aquatic plants

Unit: 1000 tonnes

3. Status of resources

The management of fishery resources in the Asia-Pacific region needs to be improved as overfishing is increasing and the abundance of the more valuable species has declined. In this review, we first look at a number of the major seas of the region to determine the degree to which ecosystems have been impacted by fishing, and the situation in terms of serial depletion of key major groups in the ecosystem. Evidence is derived from two sources – trawl surveys carried out throughout the region and catches by major groups of the region's Large Marine Ecosystems (LMEs).

In inland waters, most fisheries are small-scale activities where the catch per capita is relatively small and used mainly for subsistence purposes. The lack of accurate reporting of these small-scale fisheries makes it difficult to describe their status but it is generally felt that they are under considerable pressure from loss and degradation of habitat and overfishing.

Marine waters

3.1 Measuring the status of fishery resources

Traditionally, the status of capture fisheries has been described by (i) providing a summary of the time series trends in production for a fishery or region and (ii) presenting an assessment based on the number of fisheries or stocks categorized as being under-exploited, fully exploited or over-exploited (e.g. SOFIA[18]). However, in many seas of the APFIC region, such descriptions are not sufficient and may in fact be misleading. Reporting total production often masks what is actually happening in the fishery, and both of the above indicators also rely on the existence of accurate and timely fishery statistics from all the sub-sectors of the fishery, including small-scale fisheries. Calculating the percentages in terms of exploitation also relies on having reliable stock assessments, at least for the more abundant fish stocks in a fishery. In the APFIC region characterized by multi-species/multi-gear fisheries, it is very rare to find a fishery satisfying the above two conditions.

Pauly and his co-workers at the University of British Columbia (UBC), Canada have been advocating a more ecosystem-based approach to the assessment of fisheries – the so-called "fishing down the food chain[19]" approach. The basic concept of this is presented in **Figure 25**.

This approach is based on a hypothetical fishery in which industrial-scale fishing (mainly bottom trawling, purse seining and long-lining) expanded in the 1950s and 1960s. The catches in the earlier stages of this development were dominated by large longer-lived predators. As these became fished down, fishers expanded their efforts moving further away from their home base and starting to take smaller, less predatory fish. During this period, total production from the fishery can be expected to be maintained, masking the serial depletion that is occurring. Most alarming is that throughout this period, the total amount of fish in the ocean is continually declining and the catch rates of the major groups are also declining as they, in turn, become overexploited.

3.2 Evidence from trawl surveys

Biomass analyses

The WorldFish Centre (WFC) has recently prepared a number of papers on the status of fisheries from eight APFIC States (Bangladesh, India, Indonesia, Malaysia, the Philippines, Sri Lanka, Thailand and Viet Nam). These analyses are based on trawl survey data, spanning the period 1920 to the present (Trawlbase)[20] and the coverage of surveys is shown in **Figure 26**.

Overall, analyses of the trawl surveys showed substantive degradation and overfishing of coastal stocks. For trawl surveys where there were more than 25 years between surveys, the amount of fish (measured as tonnes/km^2) had declined to between 6 and 33 percent of the original value. In all cases, the amount of fish had declined, some as much as 40 percent in 5 years. The most dramatic declines were in the Gulf of Thailand and the East coast of Malaysia. Two examples, one for the Gulf

[18] FAO (2000) The state of world fisheries and aquaculture. Food and Agriculture Organization of the United Nations, Rome, 142 pp.

[19] Pauly, D., Christensen, V., Dalsgaard, J., Froese, R. and Torres, F. Jr. (1998) Fishing down marine food chains. Science 279, 860-863.

[20] Silvestre, G.T., Garces, L.R., Stobutzki, I., Ahmed, M., Sontos, R.A.V., Luna, C.Z., Lachica-Alino, L., Christensen, V., Pauly, D. and Munro (eds.) (2003) Assessment, management and future directions for coastal fisheries in Asian States. WorldFish Centre Conference Proceedings 67, 1 120 pp.

Figure 25
“Fishing down the food chain”
A hypothetical model of the impact of fishing on a marine ecosystem

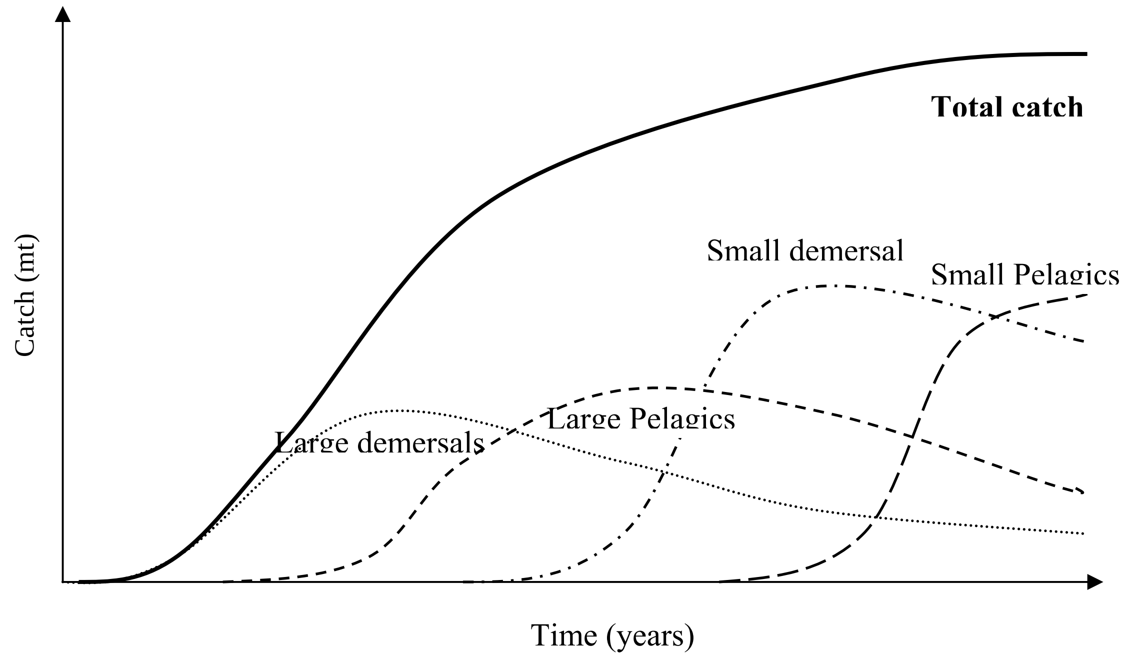
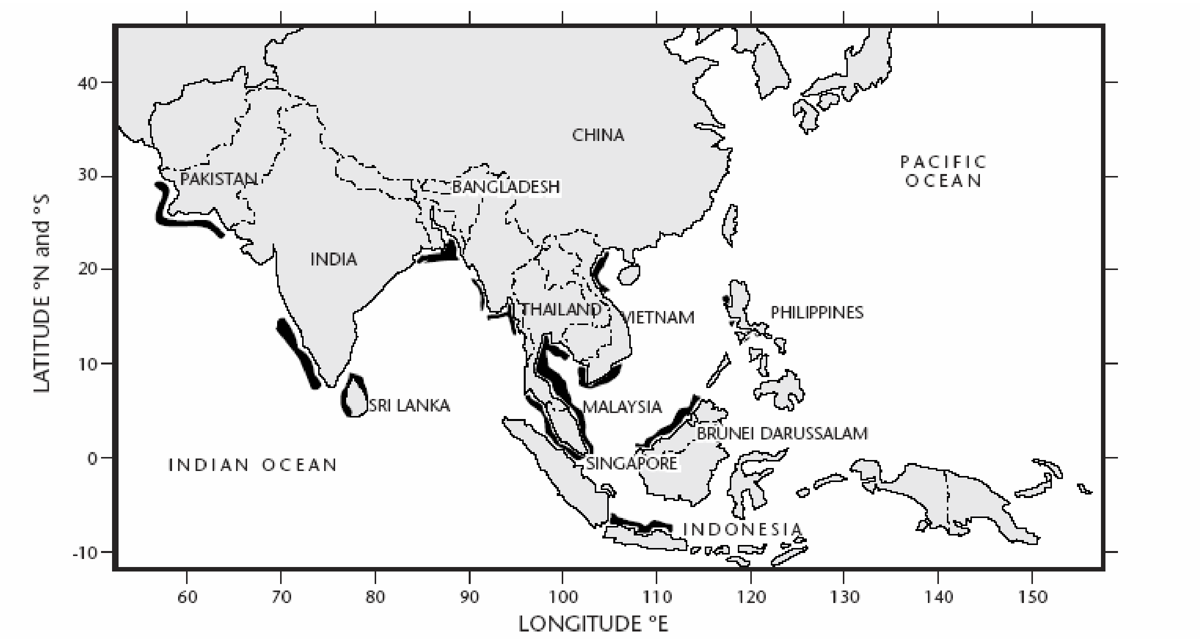


Figure 26
Trawl surveys in the Asian region
From Silvestre, G.T., Garces, L.R., Stobutzki, I., Ahmed, M., Santos, R.A.V., Luna, C.Z. and Zhou, W. (2003). South and Southeast Asian coastal fisheries: Their status and directions for improved management. Conference Synopsis and recommendations, p. 1-40 in Silvestre, G.T., Garces, L.R., Stobutzki, I., Ahmed, M., Santos, R.A.V., Luna, C.Z., Lachica-Alino, L., Christensen, V., Pauly, D. and Munro (eds.) Assessment, Management and Future Directions for Coastal Fisheries in Asian Countries. WorldFish Centre Conference Proceedings 67, 1 120 pp.



of Thailand and one for Manila Bay are given in **Figure 27**.

The massive decline in the amount of fisheries resources available for today's fishers has also been associated with changes in the composition of the catch. Surveys in the Gulf of Thailand and in the Lingayen Gulf in the Philippines have shown that the abundance of larger, more valuable species (e.g. groupers, snappers, sharks and rays) higher up in the food chain have declined, while smaller species lower in the food chain (e.g. triggerfish, cardinal fish and squids/octopus) have increased to relative abundance. In the Gulf of Thailand trawl survey catch in the 1960s, the top 10 species (or species groups) were made up of rays, bream, goatfish with some squid, lizard fish and snapper (**Figure 28**). By contrast in the mid-1990s, less desirable pony fish, squid, barracuda, and lizard fish had become much more prevalent.

The Trawlbase survey study enabled an estimation of the exploitation rate for 427 stocks in the region. With the exception of the coast of Brunei Darussalam, where fishing pressure is less intense, the majority of stocks were being fished at levels above the recommended optimum range.

Ecosystem modelling

A new approach to fishery assessment is emerging, and in the case of the eight States with extensive trawl survey data, facilitated by having good estimates on the amount of fish present in the sea. This approach is based on ecosystem modelling (e.g. Ecopath and Ecosim) that allows an analysis of the structure and function of whole ecosystems and how they have changed over time. Christensen and his co-workers at the UBC are pioneering the approach and have recently concluded an analysis of the impact of fishing in the South China Sea[21]. This analysis clearly showed that for this large sea, "fishing down the food chain" has occurred, indicating gradual replacement of large, long-lived predators by small, short-lived fish lower down the food chain, often referred to now as "trash fish". The only exception to these trends was off the coast of Brunei Darussalaen where fishing pressure is much lighter than in other States, since it effectively has marine protected areas (MPAs) around its oil rigs.

Socio-economic assessments

As part of the analyses of historical trawl data, the WFC also carried out some in-depth socio-economic assessments of the eight participating States. This profiling allowed an assessment of the importance of coastal fisheries in terms of earnings, employment, trade and nutrition and their contribution to the economy. The profitability of fishing operations in Malaysia, Thailand and Viet Nam was studied, and broken down to several sub-sectors.

In general, it was shown that fishing is still a profitable enterprise in all three States, particularly for the owners of industrial fishing vessels. Owners of industrial craft and gear earn large profits (up to 30 percent per year) while artisanal, small-scale fishers often have an extremely marginal livelihood. Unfortunately, industrial fishing employs few crew and provides little opportunity for unemployed or under-employed small-scale fishers. Even within small-scale fisheries, benefits are not evenly distributed. The loss in revenue and profits associated with overfishing were demonstrated using the Gulf of Thailand as an example (**Table 11**). Based on 1995-1996 data, large rent dissipation and excess capacity (in both labour and capital) can be clearly seen. Similar analyses have been done for the Philippines and other areas in the past.

These analyses of trawl survey data are continuing and the available results all point to substantive degradation and biological overfishing in most of the survey areas spread across South Asia and Southeast Asia. The amount of fish now available for the region's fishers is only a small percentage of that originally available before the rapid escalation of industrial fishing.

3.3 Evidence from Large Marine Ecosystems

Trends across Large Marine Ecosystems

In this analysis, the trends in catch composition for the major Large Marine Ecosystems of the APFIC region were examined. LMEs are relatively large regions (200 000 km^2 or more) characterized by distinct bathymetry, hydrography, productivity, and trophically dependent populations. Their seaward limit usually extends beyond the continental shelf. Being defined by natural parameters, they most often straddle political boundaries. They have been identified for the purpose of comprehensive

[21] Christensen, V.T., Garces, L.R., Silvestre, G.T. and Pauly, D. (2003). Fisheries impact on the South China Sea large marine ecosystem: A preliminary analysis using spatially explicit methodology, p. 51-62 in Silvestre, G.T., Garces, L.R., Stobutzki, I., Ahmed, M., Sontos, R.A.V., Luna, C.Z., Lachica-Alino, L., Christensen, V., Pauly, D. and Munro (eds.) Assessment, management and future directions for coastal fisheries in Asian States. WorldFish Centre Conference Proceedings 67, 1 120 pp.

Figure 27
Declines in the abundance of fish in (i) Manila Bay and (ii) Gulf of Thailand as measured by trawl surveys. From same source as Figure 26

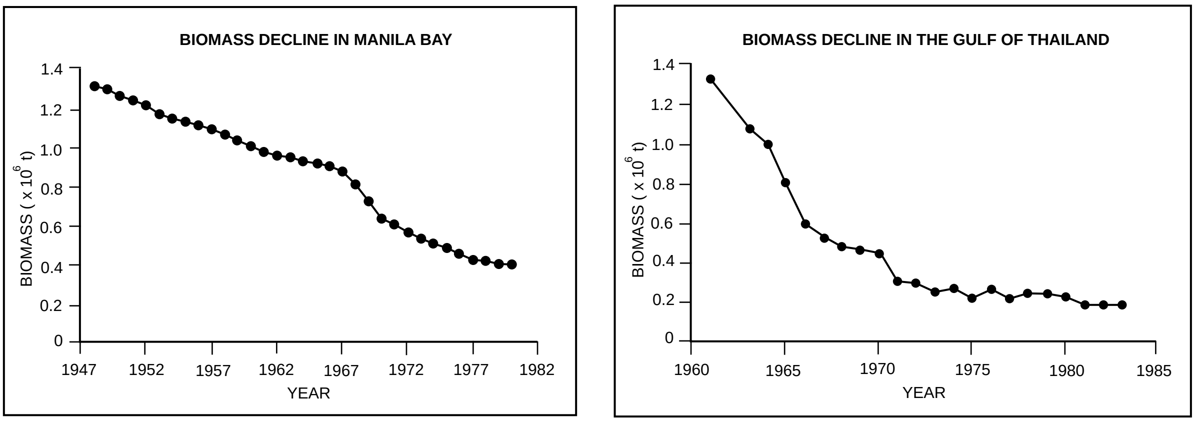


Figure 28
Changes in the composition of the top ten species taken from trawl survey catches in the Gulf of Thailand between 1966 and 1995. Data from same source as Figure 26

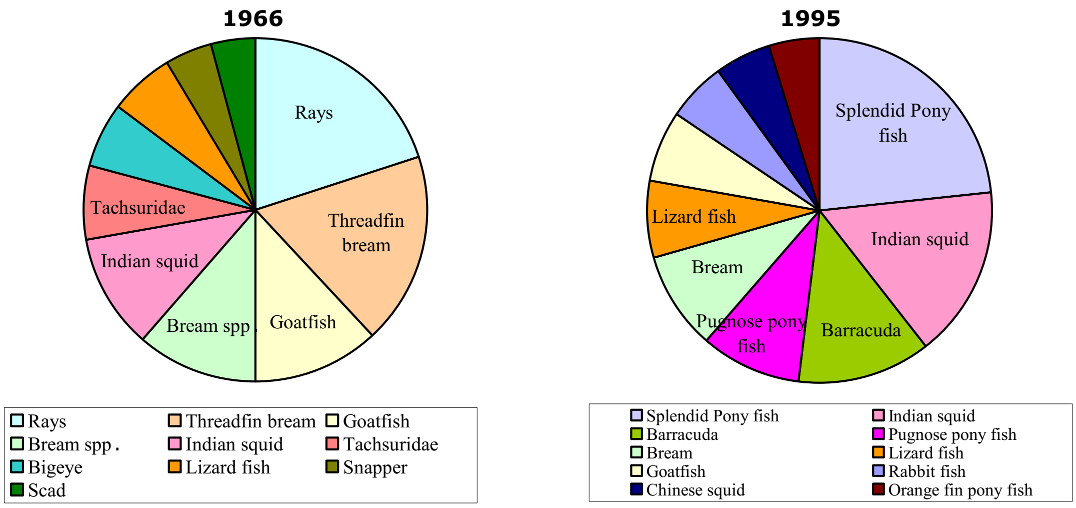


Table 11
Comparison of catch, revenues, costs and profits at different levels of fishing effort (MSY = maximum sustainable yield; MEY = maximum economic yield). From same source as Figure 26

State of fishery	Effort (std. hr x 10^6)	Catch (Tonnes x 10^3)	Revenue (Baht x 10^6)	Costs (Baht x 10^6)	Profit (Baht x 10^6)
MSY	28.57	985	6 578	1 992	4 586
MEY	21.75	952	6 359	1 517	4 842
Open access	62.70	654	4 372	4 372	0
Actual (1995)	56.88	728	4 862	3 966	896

monitoring and could also be used as a basis for ecosystem-based management of shared natural resources in the future. To date, 63 LMEs have been described world wide with 20 of these being in the APFIC region (**Figure 29**).

Much of the information referred to here has been taken from the NOAA website, which acknowledges sources of information and has an extensive reference list[22], as well as an analysis of the FAO catch database as modified by the University of British Columbia[23].

The Asia-Pacific region is characterized by considerable diversity in LMEs in terms of their fisheries and driving forces (**Table 12**). The most productive (total recorded catch since 1950) are the East China Sea, the Kuroshio Current and the South China Sea. Following closely behind, are the Yellow Sea, the Sea of Japan, the NW Pacific high seas area, and the Bay of Bengal.

The Indonesian Sea, the Gulf of Thailand and the Sulu-Celebes Seas are clustered in another group, followed by the much smaller catches in New Zealand and Australia.

An interesting feature of many of the LMEs is the dominance of a small number of small pelagic and benthopelagic species in the landings (in terms of weight). The major species are the South American pilchard (*Sardinops sagax)*, chub mackerel (*Scomber japonicus)* and the largehead hairtail *(Triciurus lepturus)* in the Kuroshio Current, Sea of Japan, Yellow Sea, East China Sea, and the South China Sea. In the Bay of Bengal, Arabian Gulf, Sulu-Celebes Seas, Indonesian Sea, and NW Australia, anchovies (*Stolephorus spp.* and Engraulidae*)* form a large part of the catch with other small pelagic species such as the sardine (*Sardinella spp.)* common in some areas. Pacific saury (*Colobis saira)* has formed a large part of the catch in the high seas of the NW Pacific.

Exceptions to this pattern are the heavily trawled areas of the Gulf of Thailand and Northern Australia where more demersals, threadfin breams and shrimps, respectively, are taken, although even in these areas catches of anchovies are almost as high as the demersal catches.

[22] Large Ecosystems of the World: http://www.edc.uri.edu/lme/

[23] UBC large Marine ecosystems: http://www.seaaroundus.org/lme/lme.aspx

Trends in selected Large Marine Ecosystems

There are obviously numerous ways that the LMEs can be classified but for the purpose of this review they are grouped as follows:

i. Offshore deepwater systems dominated by pelagic fishes (e.g. Kuroshio Current and NW Pacific);
ii. Heavily fished coastal systems that display sequential depletion of species groups characteristic of "fishing down the food chain" (e.g. Yellow Sea, Gulf of Thailand and NW Australia);
iii. Coastal systems that are still showing increasing reported catches (e.g. Bay of Bengal and South China Sea); and
iv. Fisheries managed under tight access right control (e.g. South East Australia and New Zealand Shelf).

These examples have been analysed in some detail below.

i) Offshore deepwater pelagic systems

Kuroshio Current

The Kuroshio Current LME is dominated by the warm Kuroshio Current that flows in a northeasterly direction along Japan's east coast. This LME has a huge latitudinal expanse, providing it with a rich variety of marine habitats. The region has a generally mild, temperate climate. The underwater topography of the LME includes the Japan Trench, the Shatsky Rise, the Ryukyu Trench and the Okinawa Trough.

The Kuroshio Current LME is considered a moderately high (150-300 $gC/m^2/yr$) productivity ecosystem with coastal areas that are highly productive. Japan and China are the major fishing nations in the region. The fish catch includes Japanese sardine, Pacific saury, anchovy, jack mackerel, horse mackerel, frigate mackerel, yellowtail, filefish, herring, sea robin, and parrot bass (**Figure 30**). The sardine population, which is characteristic of small pelagic fish populations, has shown marked fluctuations, attaining an all time maximum in the 1930s, then showing a decrease from 1964 to 1971. It has since increased. With the fluctuations there have been accompanying geographic shifts of spawning and nursery grounds. As is the case in the Sea of Japan, the system has always been dominated by small to mid-sized pelagics, with a more recent trend to large pelagics.

Figure 29
Large Marine Ecosystems of the APFIC Region
1. Sea of Japan; 2. Kuroshiro Current; 3. Yellow Sea; 4. East China Sea; 5. South China Sea; 6. Bay of Bengal; 7. Gulf of Thailand; 8. Arabian Sea; 9. Sulu-Celebes Seas; 10. Indonesian Sea; 11. Western-Central Pacific; 12. Pacific Hawaiian; 13. N Australia; 14. NW Australia; 15. W Australia; 16. NE Australia; 17. E Australia; 18. SW Australia; 19. SE Australia; and 20. New Zealand

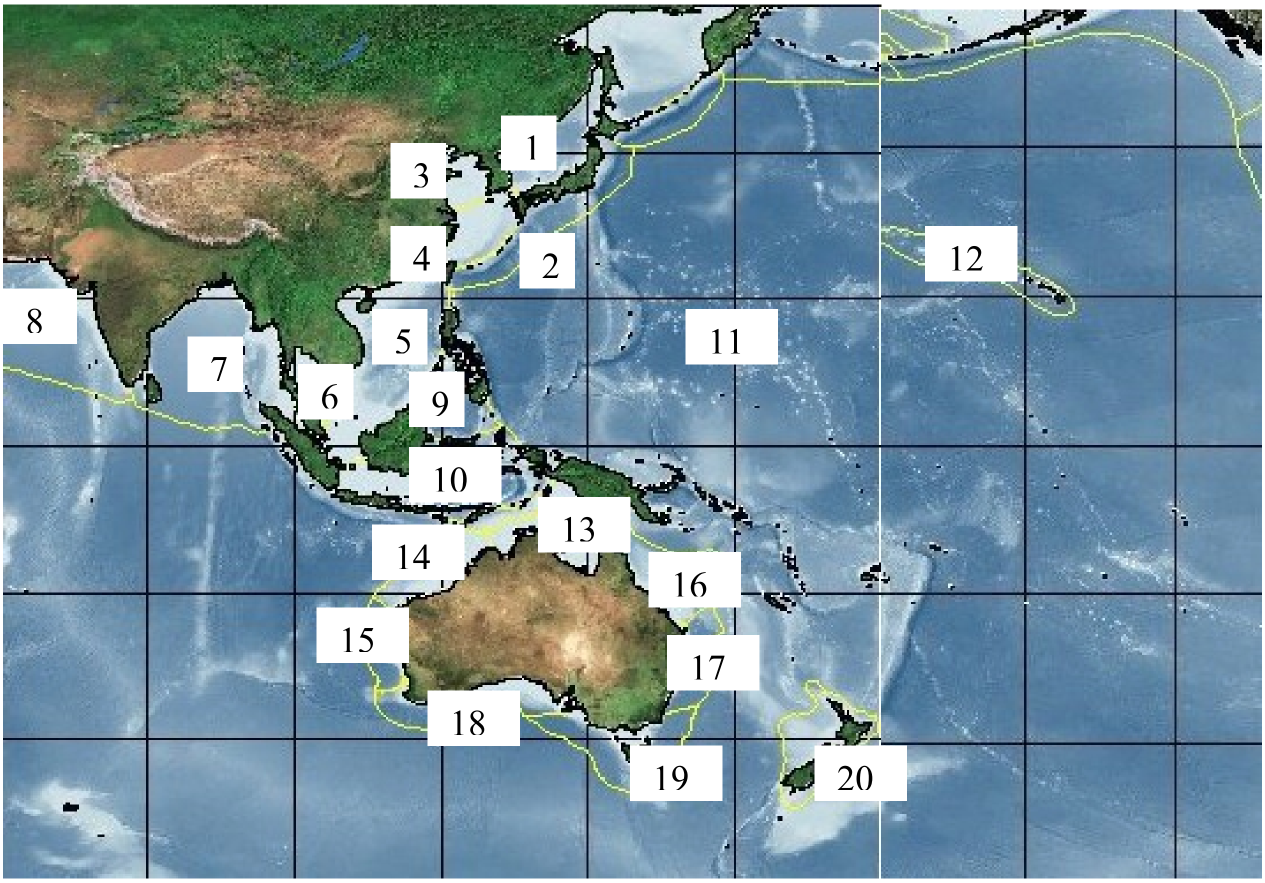


Table 12
The large marine ecosystems of the Asia-Pacific region (excluding W Australia, E Australia, NE Australia and SW Australia)

LME	Fishery	Trends	Driving Force (s)
Sea of Japan	Mixed 1. Small pelagics 2. Large bentho-pelagics	Demersals peaked in 1970s Small pelagics peaked in mid-1980s Large bentho-pelagics peaked in early 1970s Recent increase in squid, large pelagics, lobsters and crabs	Climate Fishing Habitat Pollution
Kuroshio Current	1. Small pelagics 2. Pelagics	Small pelagics and pelagics peaked in mid-1980s	Climate
Yellow Sea	Mixed 1. Large bentho-pelagics 2. Small pelagics 3. Shrimp 4. Pelagics	Small pelagics peaked in late 1970s and early 1990s Large bentho-pelagics leveled off in early 1970s Recent increase in pelagics and small demersals	Climate Fishing Habitat Pollution
East China Sea	Mixed 1. Small pelagics 2. Small demersals 3. Large bentho-pelagics	Small pelagics peaked in late 1980s Small demersals peaked in late 1960s and again in late 1990s Shrimp increasing	Fishing Pollution Habitat Climate
South China Sea	Mixed 1. Small pelagics 2. Pelagics 3. Large bentho-pelagics 4. Demersals	Increasing trends in all groups up until late 1990s Pelagics still increasing	Fishing Pollution Habitat
Bay of Bengal	Mixed 1. Pelagics 2. Small pelagics 3. Small demersals 4. Shrimp	All groups increasing	Fishing Pollution Habitat
Gulf of Thailand	Mixed 1. Demersals 2. Pelagics 3. Small pelagics 4. Shrimp	Demersals peaked in early 1970s followed by a sudden decline during 1980s and 1990s Pelagics peaked in early 1970s Small pelagics fluctuating annually Pelagics peaked in early 1970s	
Arabian Sea	Mixed 1. Pelagics 2. Small demersals 3. Shrimp 4. Medium bentho-pelagics	Pelagics stable since mid-1980s but increasing recently Small demersals and shrimp increasing until recently Bentho-pelagics stable	Fishing Pollution Habitat

Table 12 *(continued)*

LME	Fishery	Trends	Driving Force (s)
Sulu-Celebes Sea	Mixed 1. Small pelagics 2. Pelagics 3. Demersals 4. Large pelagics	Small pelagics increasing with annual fluctuations Pelagics peaked in late 1980s Large demersals peaked in late 1950s Demersals peaked in 1970s and late 1990s Large pelagics stable since early 1990s	Fishing Pollution Habitat
Indonesian Sea	Mixed 1. Pelagic 2. Small pelagics 3. Large pelagics 4. Demersals	Pelagics peaked in late 1980s but stable since early 1990s Small pelagics still increasing Large pelagics showed rapid growth during 1990s but declined over recent years Demersals peaked late 1990s	Fishing Pollution Habitat
Western-Central Pacific	Mixed 1. Small pelagics 2. Cephalopods 3. Large pelagics	Small pelagic catches cyclical Cephalopods slowly increasing Large pelagics stable with annual fluctuations Flatfish peaked in late 1950s Demersals peaked in late 1980s	Climate Fishing
Insular Pacific Hawaiien	Mixed 1. Small pelagics 2. Demersals 3. Molluscs 4. Large pelagics	Small pelagics cyclical peaking in late 1950s and late 1980s Demersals peaked in mid-1980s Molluscs peaked in late 1960s, early 1970s Large pelagics declining since late 1980s	Climate Fishing Habitat
N Australia	Mixed 1. Shrimp 2. Large pelagics 3. Small demersals	Shrimp catches cyclical Large pelagics peaked in late 1980s Demersals peaked in early 1970s and early 1990s	Climate Fishing
NW Australia	Mixed 1. Small demersals 2. Pelagics 3. Small pelagics 4. Shrimp	Small demersals peaked in early 1970s and early 1990s Pelagics peaked in mid-1990s Small pelagics increasing Shrimp catches stable	Fishing Habitat
SE Australia	Mixed 1. Small pelagics 2. Molluscs 3. Lobsters, crabs	Small pelagics peaked in early 1990s Molluscs peaked in early 1970s and mid-1980s Lobster, crab catches steady	Climate Fishing Pollution Habitat
New Zealand shelf	Mixed 1. Large demersals 2. Large bentho-pelagics 3. Small bentho-pelagics	Large demersals cyclical but stable since 1990 Large bentho-pelagics cyclical but relatively stable Small bentho-pelagics peaked in late 1980s	Climate Fishing Pollution Habitat

Western and Central Pacific

The Western Pacific Warm Pool is one of the 56 biogeochemical province defined by Longhurst[24]. The Pool is a zone of low productivity which can extend over a range of 80° of longitude (nearly 8 000 km) and has the warmest surface waters in the world. The Warm Pool can undergo spectacular east-west displacements of up to 400 km as part of the El Niño/La Nina cycle.

The current status of fisheries in the South Pacific was recently reviewed by APFIC[25]. The fisheries catch was divided into oceanic resources that include tunas, billfish that live in the open-water pelagic habitat and coastal fisheries. The offshore resources form the basis of the regions industrialized fisheries and have been fished by an international fleet from 26 different nations over the past 25 years – 15 Pacific Island States and 11 distant-water fishing nations with the bulk of the catch being taken by Japan, USA, Korea RO, and China PR. About 1.6 million tonnes of tuna, as well as an unknown amount of by-catch have been taken from the Western and Central Pacific each year during the 1990s. The main species are skipjack (the majority of which is taken by purse seiners), yellowfin and bigeye tuna (an increasing catch associated with drifting fish attracting devices), and albacore (caught by long-line and trolling with a significant part taken by Pacific Island States) (**Figure 31**).

The coastal resources include a wide range of fin-fish and invertebrates and form the basis for the region's small-scale fisheries. Although dwarfed in both volume and value by the oceanic tuna fisheries, the regions coastal fisheries provide most of the non-imported fish supplies to the region and have a crucial role in food security. The present catch figures are roughly estimated based on agriculture censuses, household surveys or nutrition studies. The best estimate available is about 144 000 tonnes, with about 70 percent of this coming from subsistence fisheries, which despite their importance do not attract much government attention, although anecdotal reports of their depletion in many islands are common. Major species include finfish, beche-de-mer (sea cucumbers), octopus, lobsters, giant clams, crabs and seaweed. Several high-value products are exported from the region. In a recent World Bank study, coastal fisheries management was examined at 31 locations in the Pacific Islands. The study concluded that there was an urgent need to reduce overall fishing effort. Although many of the communities had adopted restrictions to fishing by outsiders, few were effectively regulating their own harvest.

ii) Ecosystems with "fishing down the food chain" effects

Yellow Sea

The Yellow Sea LME is a semi-enclosed body of water bounded by the Chinese mainland to the west, the Korean Peninsula to the east, and a line running from the north bank of the mouth of the Yangtze River (Chang Jiang) to the south side of Cheju Island. It covers an area of about 400 000 km^2 and measures about 1 000 km by 700 km. It is shallow with a mean depth of 44 meters, and it slopes gently from the Chinese continent. The Yellow Sea LME is classified as highly productive (>300 gC/m^2/yr) ecosystem. It has marked seasonal variations and supports substantial populations of fish, invertebrates, marine mammals, and seabirds. It has both cold temperate species (eel-pout, cod, flatfish, Pacific herring) and warm water species (skates, gurnard, jewfish, small yellow croaker, spotted sardine, fleshy shrimp, southern rough shrimp) (**Figure 32**).

With its 276 fish species, the Yellow Sea LME is an important global resource for coastal and offshore fisheries. However, it is one of the most intensively exploited areas in the world, and has exhibited a pronounced change in ecosystem structure and "fishing down the food chain" effect. Due to overexploitation and natural fluctuations in recruitment, some of the larger-sized and commercially important species were replaced by smaller, less valuable, forage fish. When bottom trawlers were introduced in the early twentieth century, many stocks were intensively exploited by Chinese, Korean, and Japanese fishers and all the major stocks were heavily fished in the 1960s, which had a significant effect on the ecosystem. Pacific herring and chub mackerel became dominant in the 1970s. Smaller-bodied and economically less profitable anchovy and scaled sardine increased in the 1980s and took a prominent position in the ecosystem. Cold-water species such as the Pacific cod (*Gadus macrocephalus*) are almost extinct. It appears fishing has greatly affected both the structure and functioning of the Yellow Sea ecosystem.

[24] Longhurst, A. (1995) Seasonal cycles of pelagic production and consumption. Progress in Oceanography 36(2): 77-167.

[25] Gillett, R., D. (2002) Pacific Island fisheries: regional and country information. APFIC, FAO Regional Office for Asia in the Pacific, Bangkok, Thailand Publication 2002/13, 168 pp.

Figure 30
Reported landings from the Kuroshio Current LME

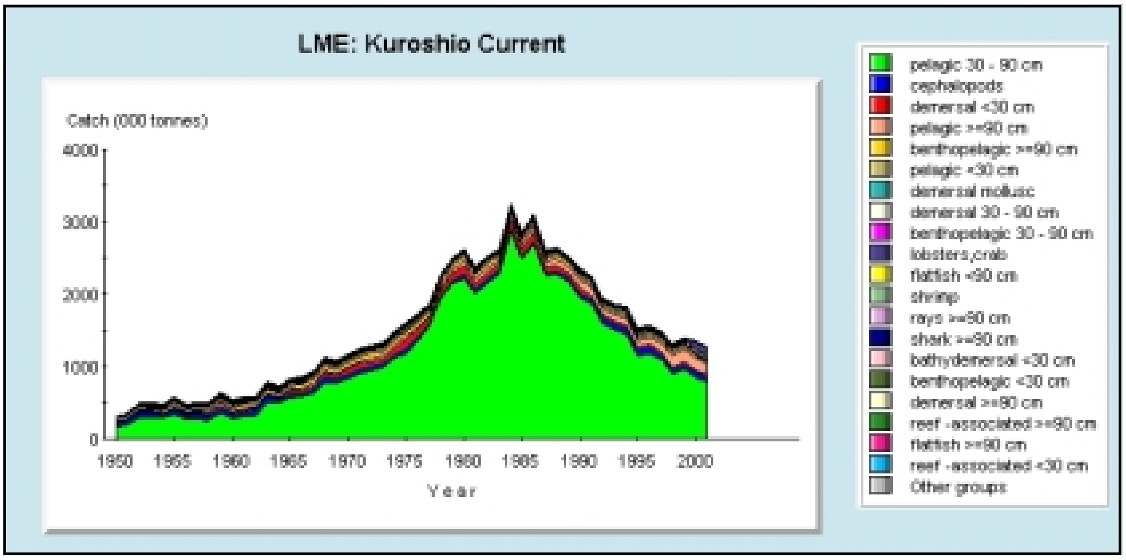


Figure 31
Reported landings from Western and Central Pacific

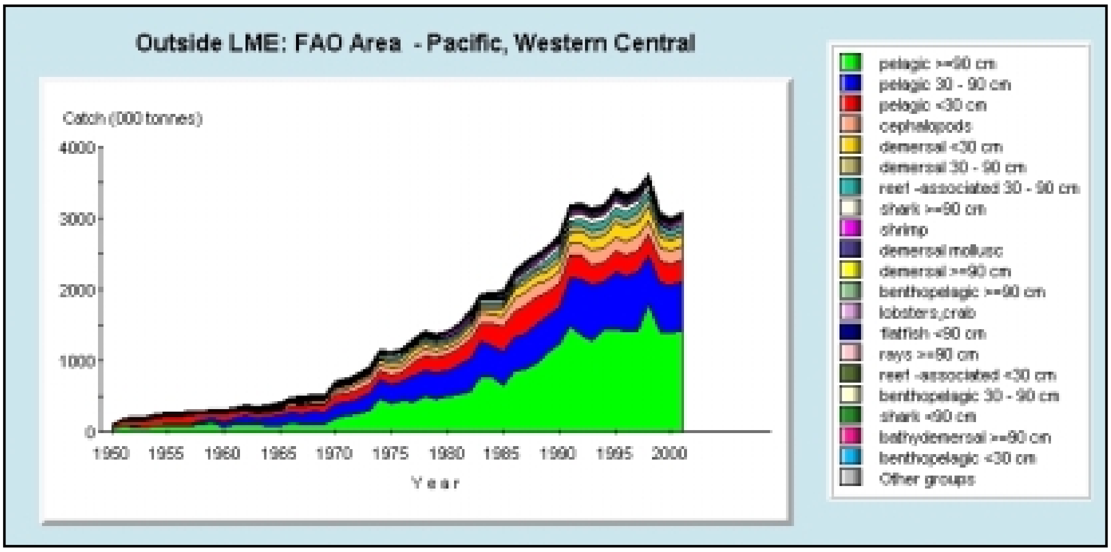
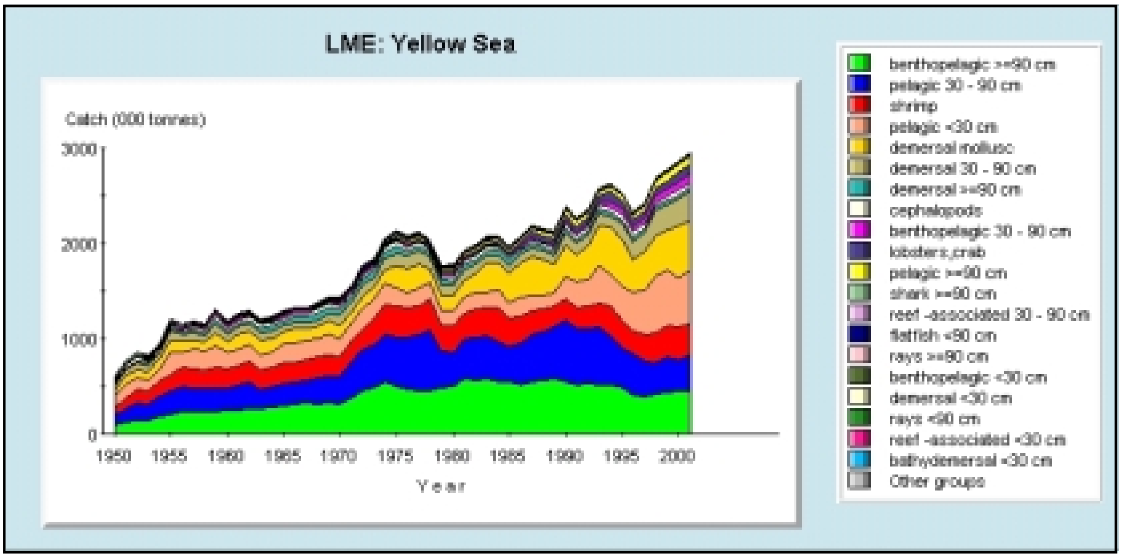


Figure 32
Reported landings from the Yellow Sea LME



Gulf of Thailand

The Gulf of Thailand LME is a semi-enclosed sea immediately to the northwest of the South China Sea LME from which it is separated by two sills. Monsoon seasons and the intrusion of sea water from the South China Sea are the two natural phenomena that seem to drive the LME and are the major causes of oceanographic change in the absence of any massive regime shift. The Gulf of Thailand is relatively shallow, with depths varying between 45 and 80 meters. The LME is considered as being a highly productive (>300 $gC/m^2/yr$) ecosystem. Its high primary production levels are partly the result of increased nutrient loading from rivers and shrimp farms. Primary production is concentrated in coastal areas between Malaysia and Cambodia, and near Viet Nam.

The commercial species found on the shallow Gulf of Thailand consist of crabs, lobsters, rays, sharks and small pelagics (mainly Indian mackerels (*Rastrelliger spp.)*, anchovies, and stolephorus spp.), originally caught by artisanal fishers and supplying local markets (**Figure 33**). Most important among these are the anchovies used for making fish sauce. In the 1960s, demersal trawl gear was introduced from Germany (as trialed in the Philippines), which led to the development of a Thai demersal trawl fishery, operating in the shallow grounds bordering Thailand's coasts. The ecological impact of the increase in trawling effort has been well documented and was used to describe the original "fishing down the food chain" phenomenon. The catch composition changed both within species (toward smaller individuals), and between species (toward a mix consisting predominantly of small, short-lived species). The species groups most adversely affected by trawl fisheries were crabs, lobsters, rays, sharks and other large fishes. Studies of the impact of the various fishing gears operating in the Gulf of Thailand demonstrate that these fisheries have fundamentally altered, and continue to alter, the functioning of that ecosystem. However, even in this extreme case, modelling has shown that the impact still appears to be reversible although a drastic reduction of fishing effort, especially by bottom trawlers and push-netters would be needed to replenish these stocks and halt further ecological degradation of this LME.

Northwest Australian shelf

The Northwest Australia LME extends from Northwest Cape in the State of Western Australia to the vicinity of the Timor Sea. The LME has a wide continental shelf and it includes topographical features such as the Exmouth Plateau, the Rowley Shelf and the Sahul Shelf. The tropical waters are warm, and the coast includes reefs and extensive mangrove forests. Tropical cyclones are common seasonal events in this LME. It is considered to be a low productivity (<150 $gC/m^2/yr$) ecosystem. The warm tropical waters are the home of corals, fish, starfish, sponges, turtles and shells.

In the Northwest Australia LME, fish stocks are quite small and the level of endemicity is low, with most species distributed widely in the Indo-West Pacific region. Reef fisheries occur in the Rowley Shoals, a chain of coral atolls at the edge of the LME's wide continental shelf. Demersal species that are fished here include snapper, beam, emperors and lizard fish (**Figure 34**). These have historically been fished by foreign fleets that caused widespread habitat destruction with an associated decline in the demersal fish catch and a switch to smaller, less valuable fish. A large part of the area is now closed to pair trawlers and access to foreign fleets has been withdrawn, and there is some evidence that the habitat is recovering. A small domestic trap fishery for demersal fish exists in areas subjected to little trawling. It is thought that there will be an expansion of trap fishing in the two closed areas after the species composition changes induced by trawling are reversed.

iii) Systems with reported increasing catches

Bay of Bengal

The Bay of Bengal LME is located in the tropical monsoon belt and is bounded by Bangladesh, India, Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka and Thailand. The Bay's southern part merges into the Indian Ocean. The LME is strongly affected by monsoons, storm surges, and cyclones. Major rivers (Ganga-Brahmaputra-Meghna, Mahanadi, Godavari, Krishna and Salween) introduce large quantities of silt into the Bay of Bengal during the monsoon season from July to September. The Bay of Bengal LME is considered to be moderately productive (150-300 $gC/m^2/yr$).

Commercial species include anchovies, croakers, shrimp and tuna (yellowfin, big eye and skipjack). Shrimp is a major export earner. FAO data show a steady rise in total landings in all major groups since the 1950s (**Figure 35**). Heavy fishing is a comparatively recent phenomenon, so that stocks have not been subjected to fishing pressure over a lengthy period of time but there is now increased competition and conflicts between small-scale and large-scale fishers. There is an

Figure 33
Reported landings from the Gulf of Thailand LME

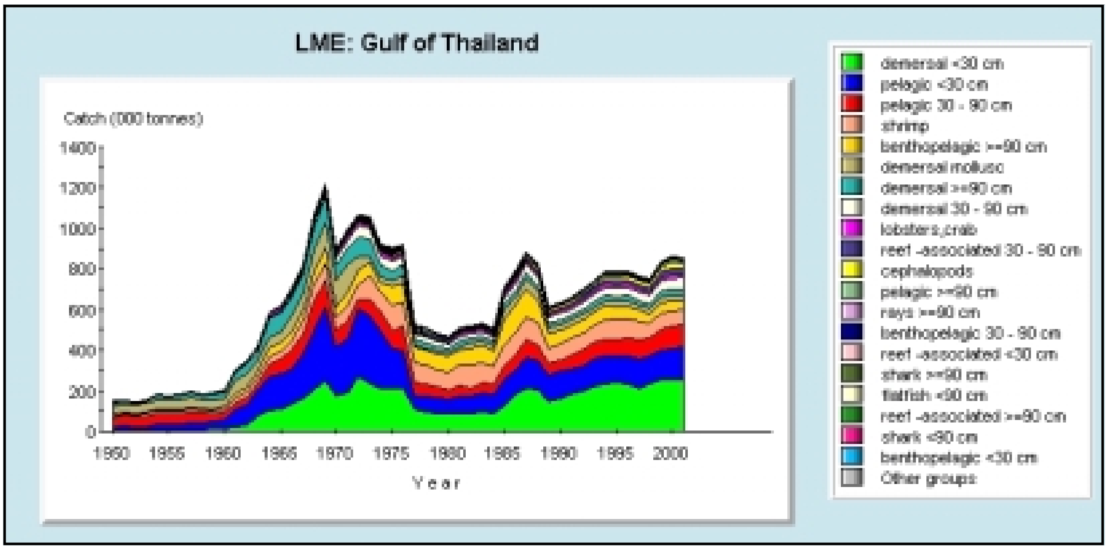


Figure 34
Reported landings from the Northwest Australian Shelf LME

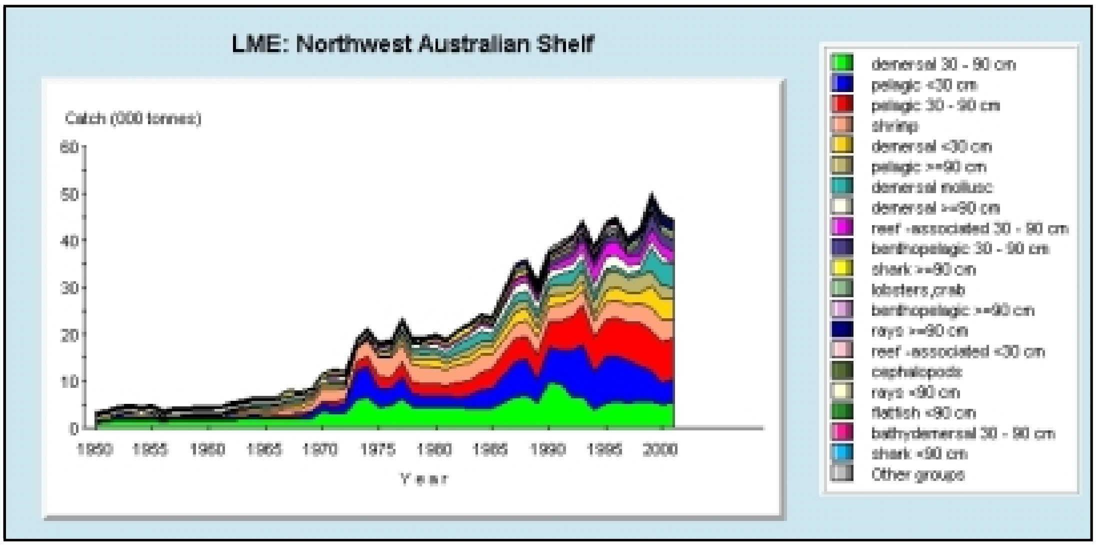
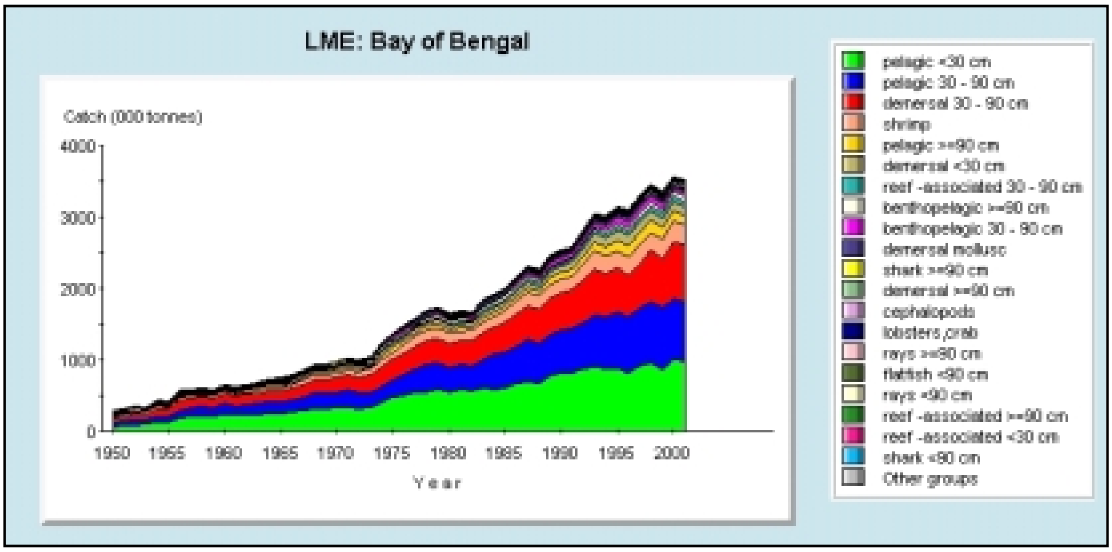


Figure 35
Reported landings from the Bay of Bengal LME



alarming increase in cyanide fishing in this LME's coral reefs for the lucrative live food fish markets in Hong Kong and Singapore. Mangroves and estuaries – critical fish spawning and nursery areas – are also under stress or threatened by pollution, sedimentation, dams for flood control (as in Bangladesh), and intensive coastal aquaculture. States bordering the Bay of Bengal rate over-exploitation of marine resources as the number one problem in the area.

South China Sea

The South China Sea LME is bounded by the coasts of Viet Nam, China PR, Taiwan POC, the Philippines, Malaysia, Thailand, Indonesia and Cambodia. It is separated from the Gulf of Thailand to the West, by a shallow sill. The South China Sea contains many biological subsystems and a variety of habitats. These include mangrove forests, seagrass beds, coral reefs and soft-bottom communities. The 50-meter depth contour largely follows the coast, with the widest shelves occurring along the eastern edge of the LME. Much of the South China Sea is below 200 meters with oceanic waters, ranging in depth from 200 to 4 000 meters, covering nearly half of the Sea.

It is considered a moderately high productivity (150-300 gC/m^2/yr) ecosystem. High productivity levels are found in gulfs, along the coast, and in reef and seagrass areas, common in the Philippines portion of the LME. The coastal and estuarine areas off Viet Nam, China PR and Cambodia are very productive and, in the past, a substantial fraction of the catch was taken by artisanal, non-mechanized boats. The Viet Nam/China PR area was lightly exploited from the mid-1970s to the mid-1980s, but by now much of this potential has probably been realized.

The total fish harvest was approximately 5.0 million tonnes a year in 2001, with an increasing trend until very recently (**Figure 36**). Although catches were apparently increasing for all trophic level groups, ecosystem modelling has shown that this area has also been subjected to "fishing down the food chain". Five of the States fishing this LME are among the top eight shrimp producers of the world. Fishermen sometimes use small-meshed nets and practice destructive fishing methods, such as cyanide and dynamite fishing.

In deep oceanic waters (200 to 4 000 m), fisheries are limited mainly to large pelagic fishes – tuna with some billfish, swordfish, shark, porpoise, mackerel, flying fish and anglerfish. The deeper coralline areas and those situated in the central portion of the LME are only lightly exploited, leaving room for a possible increase in catch from this area, although the resources are probably rather limited.

iv) Fisheries under tight management control

Southeast Australian Shelf

The Southeast Australia LME extends from Cape Howe, at the southern end of the state of New South Wales, to the estuary of the Murray-Darling river system in the state of South Australia. It borders the Southern Ocean and the western boundary currents flowing into the West Wind Drift, which circulates around the continent of Antarctica. It contains the island of Tasmania and Bass Strait, which separates that island from the state of Victoria on the mainland. The LME has a diversity of habitats such as seagrass beds, mud flats, intertidal and sub-tidal rocky reefs, mangrove forests and pelagic systems. It has been classified as a highly productive (>300 gC/m^2/yr) ecosystem, despite the low nutrient input into the area.

Some of the species harvested are scallops (in Bass Strait), rock lobster (Tasmania), and abalone (Tasmania and Victoria) and finfish in the Southeast trawl fishery. The long-standing trawl fishery has seen serial depletion of several of its important fish stocks, including eastern gemfish and more recently the deepwater orange roughy that is found associated with sea mounts (**Figure 37**). The fishery has been managed under individual transferable catch quotas (ITQ) since the early 1990s, but to date, these do not appear to have been very effective in reducing overfishing in this multi-species fishery.

New Zealand shelf

The New Zealand Shelf LME surrounds the islands of New Zealand and stretches across 30 degrees of latitude from the sub-tropics in the north down to the sub-Antarctic region. The shelf surrounding New Zealand varies in width from 150 km in the northeast and southwest, to 3 000 km on the northwest and southeast plateaus. The northern half of the LME is influenced by the warm South Equatorial Current, while the southern half is influenced by the cooler West Wind Drift. The marine environment is diverse and includes estuaries, mudflats, mangroves, seagrass and kelp beds, reefs, seamount communities and deep sea trenches. The New Zealand Shelf LME is considered to be a moderately high (150-300 gC/m^2/yr) productivity ecosystem.

Figure 36
Reported landings from the South China Sea LME

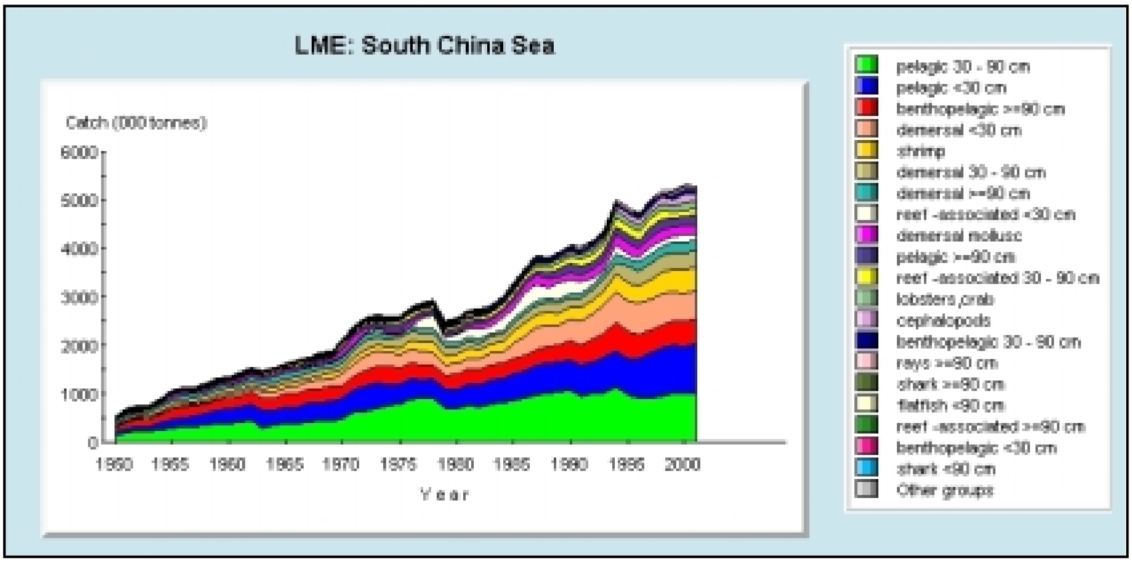


Figure 37
Reported landings from the Southeast Australian Shelf LME

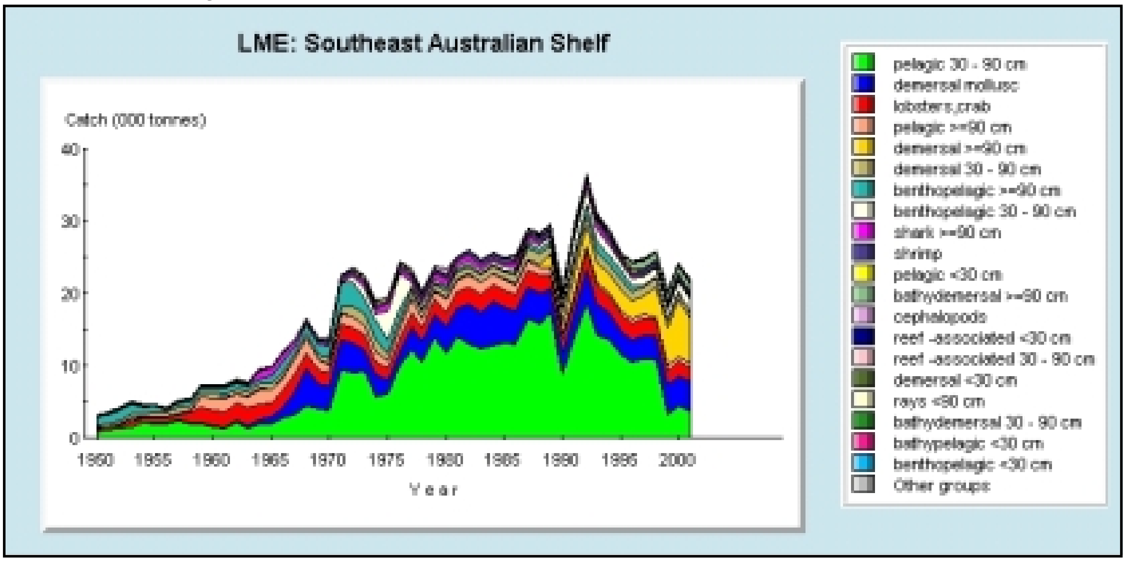
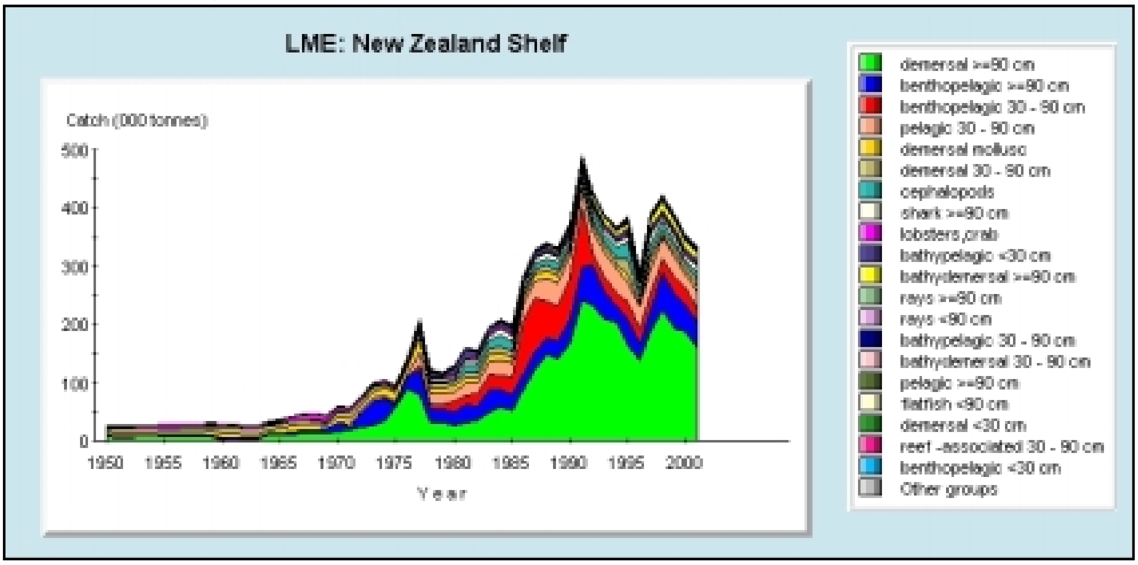


Figure 38
Reported landings from the New Zealand Shelf LME



Maori cultural ties with fisheries are strong and their fishing rights are recognized in law. Fishing is a popular leisure activity for as many as one in five New Zealanders. Among the important commercial fisheries of the area are those for migratory predators such as tuna, billfish, and sharks. There is also a bottom fishery for the orange roughy, an important blue grenadier fishery and a coastal fishery for a variety of crustaceans and mollusks (**Figure 38**). The fishing industry is mostly export-oriented. All fisheries are managed under an ITQ system, that the NZ government claims has resulted in sustainable fisheries. Prior to the introduction of the system, overfishing of coastal resources had occurred. There are conflicting reports on the extent to which these have recovered, although there is evidence that certain groups, such as lobsters are responding to the new management regimes. As in Australia, the long-lived deepwater species such as orange roughy have continued to decline, offset by the discovery of new stocks and expansion in fishing. Other important stocks, such as the blue grenadier appear to be fished sustainably at present.

Inland waters

3.4 Water resources

Asia is blessed with the most freshwater in the world, estimated at 13 510 km^3. However, because of the high population density, the per capita availability of freshwater is the lowest and competing usages of freshwater has a major impact on fisheries. The main water resources for fisheries are the rivers and flood plains, natural lakes and man-made impoundments. Asia has the largest number (49) of rivers than any other continent and also has the highest cumulative river channel length. The seasonal floodplains of States such as Myanmar and Bangladesh all have major fisheries. In contrast, Asia has relatively few natural lakes. Most of these are confined to volcanic areas, notably in the Indonesian and Philippine archipelagos, and in northern India. The major exception is the Great Lake or Tonle Sap in Cambodia which occupies 200-300 km^2 in the dry season, expanding to 10 000-12 000 km^2 in the wet.

Reservoirs have been constructed over many centuries in some States in Asia, (e.g. Sri Lanka), but more recently, construction of reservoirs for irrigation, hydropower and flood protection has become common in many parts of the Asia-Pacific region. These come in many forms ranging from large impoundments resulting from damming major rivers to small rain-fed ponds. The reservoir resource in Asia is large and accounts for over 40 percent of the global large reservoir capacity. It has been estimated that developing States in Asia have 66.7 million ha of small to medium reservoirs with 85 thousand ha occurring in China.

3.5 Fishery resources

Most inland fisheries are small-scale activities where the catch per craft (or catch per capita) is relatively small and the catch more often than not disposed of on the same day. The main exceptions are the industrialized fisheries in the lower Mekong Basin and the “fishing lots” in the Tonle Sap of Cambodia and the fishing “inns” of Myanmar. The lack of accurate reporting of these small-scale fisheries makes it difficult to describe their status but it is generally felt that they are under considerable pressure from loss and degradation of habitat and overfishing. Freshwater fishes are reported to be the most threatened group of vertebrates harvested by man. The World Resources Institute estimated that half of the World’s species were lost during the last century and that dams, diversions and canals have fragmented many major rivers, severely impacting fisheries resources.

In general, the reported catches of inland fisheries in most States have continued to increase, although many of the inland water habitats have been altered and degraded. Rivers and floodplains, in particular, have been heavily impacted with the construction of dams, roads, channels and other irrigation systems. The training of water to reduce the impacts of flooding has probably had widespread effects on inland fisheries in the region, although the real impacts are poorly documented. Fishers regularly complain that catches are declining, but it is uncertain to what extent this is an effect of increasing fishery pressure or the loss of fishery resources through habitat degradation and changing water flow regimes.

In some areas, the way the systems function has been altered enormously by greatly reducing the seasonal “flood pulse” that previously resulted in large areas of land becoming flooded during the wet season. This in turn has impacted on the ability of many species of fish to migrate to their spawning grounds and has also altered the flow pattern with accompanied habitat changes (e.g. running water to lakes). Some mitigation attempts have been made in terms of fish ladders to allow fish to migrate around dams but their success compared with original conditions is typically unknown.

Changing agricultural cropping patterns, irrigation development and the increased use of chemicals and pesticides in intensified agricultural production have all had some impact on wild fishery resources. Changing rural livelihoods have also led people away from their traditional dependence on fishery resources as livestock has supplanted wild resources.

As in the marine environment, changes in species composition are also occurring. Catches of large, long lived species such as the giant catfish and large cyprinid species are becoming rare and there is evidence of “fishing down the food chain” in some inland areas. In the Mekong River, for example, the giant catfish (*Pangasianodon gigas*) has now become extremely rare and endangered. On the other hand, the status of some inland fishery resources has been enhanced through stocking programmes, introductions of exotic species, habitat engineering and habitat improvement.

Stock enhancement is an integral part of most inland fisheries in the Asia-Pacific region. With developments in artificial propagation techniques of fast-growing and desirable species and increased availability of seed stock, the use of this intervention is increasing, particularly where some sort of access restriction or user rights is in place. The economic viability of stock enhancement in large lakes and rivers has not been demonstrated in any Asian State and, in general, these fisheries depend naturally on recruited stocks. In floodplain depressions and in small water bodies, stock enhancement has proved to be very successful. These cultured-based fisheries are seen as a way forward in China PR and many States in the region.

Of particular importance to many States of the Asia-Pacific region are rice-field fisheries that either depend on natural introduction of wild fish or stocking fish, either simultaneously or alternately with the rice crop (probably more correctly defined as aquaculture). This aquatic production, in addition to the rice crop itself, is important for rural livelihoods in developing States. Its local consumption and marketing are particularly important for food security as it is the most readily available, reliable and cheapest source of animal protein for farming communities as well as the landless. This importance is generally underestimated and undervalued. It is reported that the availability of this aquatic resource is declining. Anecdotal evidence from China, Viet Nam, Lao PDR, Cambodia, Thailand and elsewhere, suggests that it is considerably more difficult to find such food now than a decade or so ago. This is a result of increasing demand through human population increases and activities such as the use of pesticides, destruction of fish breeding grounds and the use of illegal fishing methods such as poisons and electro-fishing.

4. Aquaculture production trends by species group

This part of the document will deal with the review of major groups of species that are currently cultured in the Asia-Pacific region. The manner of grouping species will be according to the trophic needs of the species and in some cases the degree of reliance on external inputs (such as feeds and infrastructure for culture).

4.1 Carnivorous species or species requiring higher production inputs

Eels

Japanese eel production has declined to a stable level of around 22 000 tonnes and that of Taiwan POC has declined greatly to the level of 1999. In contrast, production in China PR has risen steadily, until it peaked in 1997, remaining just below this level since. Australia, Indonesia, Malaysia, Korea RO also produce some quantities 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 (1 432 tonnes in 2002).

There has been a limited international trade of these species either live or processed and future expansion may be reliant on the development of regional or international markets.

Salmonids – Brackishwater/Mariculture

Culture of salmonids (chinook, coho, Atlantic salmon 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 point in 1998 dropping to 32 percent of its 1992 production. New Zealand's chinook salmon production is relatively stable.

Australian brackishwater culture of rainbow trout has declined over the past 10 years from 890 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. Ayu sweetfish (*Plecoglossus altivelis*) production in Japan has declined about 25 percent 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 (162 563 tonnes in 2002) and yields are stable. The production of several other Japanese species is also quite stable (such as pufferfish, several mackerel species and bastard halibut) and it is assumed that this is due to site limitations which effectively prevent further expansion. In Japan and Korea RO particularly, it is inevitable that there will be a turn towards imports from neighbouring States such as China PR.

Cobia (*Rachycentron*) culture increased rapidly in Taiwan POC in six years from almost nothing to over 2 400 tonnes in 2002. Culture of this species is also taking off rapidly in other States such as Viet Nam and Thailand, possibly as a result of the increasing availability of fingerlings from Taiwan POC. The very rapid growth rate of this species and relative hardiness in ponds makes it an attractive species for aquaculture, although market acceptance is not yet definite.

Southern Bluefin tuna culture in Australia has emerged as a significant industry for the country over the past ten years reaching 4 000 tonnes in 2002. Although the quantity 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 production is confined to Japan, Taiwan POC, Korea RO and Hong Kong SAR. The

Japanese production of seabream was 71 866 tonnes in 2002, nearly half that (44 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. Most of these fish are assumed to be carnivorous and are fed by trash fish from the Chinese capture fisheries.

Table 13
Aquaculture production reported under "marine finfish nei"

Country	Tonnes
China PR	560 404
Japan	8 182
Taiwan POC	3 372
Indonesia	2 937
Malaysia	2 669
Hong Kong SAR	597
Korea RO	379
Philippines	74
Singapore	47

4.2 Finfish requiring lower inputs

Freshwater omnivorous and herbivorous fish have been important food fish for developing States in the Asia-Pacific region. 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, further pressure on intensification and the use of feeding can be expected in many States.

Backyard ponds are an increasingly common sight in many States; 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 production from them is not viewed as a significant economic activity. However, 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 evaluation of the grass-roots impact of rural aquaculture in the Asia-Pacific region.

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 States 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.

However, even with tilapia, there is still considerable flexibility of systems, strains and colours of fish. There is probably more diversity in tilapia culture systems today than 10 years ago 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

Table 14
Tilapia top eight producer States (2002)

Country	Tonnes
China PR	706 585
Philippines	122 390
Indonesia	109 768
Thailand	100 576
Taiwan POC	85 059
Lao PDR	26 872
Malaysia	20 757
Sri Lanka	3 670

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 States.

Carps and Barbs (cyprinids)

Carps and barbs continue to be the most popular species group among Asia-Pacific States dominating eight ranks of the top 10 freshwater species by production. Their production is particularly important in terms of the vital supply of protein in major populous States in the region such as China PR, India and Bangladesh.

Silver carp has maintained the highest production for decades. Grass carp was once in a distant second place but has recently closed the gap between the two species.

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

Table 15
Carps and barbs top ten producer States (2002)

Country	Tonnes
China PR	13 243 954
India	1 875 715
Bangladesh	566 919
Indonesia	237 041
Myanmar	108 096
Thailand	61 521
Iran	54 801
Lao PDR	29 858
Philippines	18 151
Nepal	17 100

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

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 little opportunity for export, although India for example does export to neighbouring Nepal and Bangladesh.

Milkfish

Milkfish culture is a strong tradition in the Philippines which reflects the country's preference for the species. 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 brackishwater ponds but there is an increasing trend in reported mariculture production, indicating the use of more intensive cage systems. These 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 the Philippines are traditionally the largest producers. Taiwan is reducing its production, possibly because of increasing attention to higher value species. Singapore has steadily developed its mariculture of milkfish.

Table 16
Milkfish top seven producer States (2002)

Country	Culture Environment	Tonnes
Philippines	Brackish water	203 512
	Marine	17 312
	Freshwater	11 164
Indonesia	Brackish water	222 317
Taiwan POC	Brackish water	28 424
Singapore	Marine	956
Guam	Brackish water	80
Kiribati	Brackish water	14
Tonga	Brackish water	14

Mullet

Pond based brackishwater culture of mullet is typical but Korea RO is reporting increasing mariculture production since 2000. Indonesia has the largest production of this species and experienced a sharp decline in 1998. Taiwan POC has relatively stable production but has seen a gradual reduction in production Thailand has greatly reduced production in recent years.

4.3 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 48 percent of the total crustacean production in 2002 (the Giant Tiger shrimp, *Penaeus monodon;* and the fleshy shrimp, *P. chinensis*). Whilst the giant tiger shrimp ranked 9th by weight in terms of regional aquaculture production in 2001, it ranked 3rd by value at US$ 3.21 billion.

Cultured shrimp production in the region reached one million tonnes in 2002 (accounting for 34 percent of total shrimp landings). The production of *P. monodon* has ranged between 480 and 610 thousand tonnes since 1993, whilst its contribution to overall shrimp production has declined from 70 percent to 49 percent in 2002, as *P. chinensis* and other Penaeus shrimp production has increased.

Production trends in the region have increased over the past ten years for the major producers. China PR suffered a major setback in the mid-1990s due to the occurrence of viral diseases in shrimp culture, but since that time, production has slowly recovered.

Table 17
Penaeid shrimp top ten producer States (2002)

Country	Tonnes
China PR	384 141
Thailand	162 100
Indonesia	137 548
India	114 970
Viet Nam	67 500
Bangladesh	57 581
Philippines	37 032
Malaysia	25 582
Taiwan POC	9 966
Myanmar	6 550

Other major producers, Thailand and Viet Nam, have also encountered fluctuations in production which are primarily associated with the impact of the diseases. Production in the Philippines, India, Sri Lanka and Indonesia has also been affected by the impact of viral diseases (typically WSSV[26]). 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[27]. China PR has a large and flourishing industry for *P. vannamei* with production of more than 270 thousand tonnes in 2002 and an estimated 300 thousand tonnes (71 percent of total shrimp production) in 2003, which is higher than the current production of the whole of Latin America. Other Asian States with developing industries for this species include Thailand (estimated production of 120 thousand tonnes in 2003), Viet Nam and Indonesia (30 thousand tonnes each), Taiwan POC, the Philippines, Malaysia and India (thousands of tonnes each) [28].

[26] Shrimp White Spot Syndrome Virus

[27] 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. Please contact the third author for a copy of this.

[28] The reported production of *P. vannamei* to FAO in 2001 was 5 809 tonnes; only Taiwan POC officially reported the production.

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

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

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

Freshwater prawns

China and India have recently increased the production of freshwater prawns (their respective productions were zero and 311 tonnes in 1994 as compared to 113 743 tonnes and 30 500 in 2002). Other producers have had relatively stable productions.

Since it is not easy to intensify production of freshwater prawns due to their territorial habits and divergent growth effects, the development of this sector is reasonably slow. In some States the sector has shrunk, as attention and resources have been diverted to brackishwater shrimp production.

Although the principle species cultured in freshwater (*M. rosenbergii*) does not suffer the same problems with viral diseases that impact the brackishwater shrimp industry so severely, export markets for freshwater prawns are much smaller and less developed. This is because consumers in general are not as familiar with these species as with brackishwater shrimp. Freshwater prawns, however, enjoy good domestic markets especially in South and Southeast Asian States.

Table 18
Freshwater prawn top eight producer States (2002)

Country	Tonnes
China PR	113 743
Thailand	31 174
India	30 500
Viet Nam[29]	28 000
Bangladesh	7 998
Taiwan POC	7 026
Malaysia	535
Indonesia	400

Crabs

Chinese river crab (*Eriocheir sinensis*) and Indo-Pacific swamp crab (*Scylla serrata*) constituted the major cultured crabs in the region. Chinese production of this freshwater crab and marine crabs[30] has shown very strong growth since 1994 and they were ranked 11th and 4th respectively among the region's top culture production species in inland and marine waters in 2002. Indo-Pacific swamp crab showed relatively stable production trends for the past decade.

4.4 Molluscs

Mollusc culture is split into low value species produced in extensive cultured systems (e.g. seeded blood cockle mudflats, mussel and oyster stake culture) and 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 States report their mollusc production in a large grouping such as marine molluscs nei.

The IFPRI/WFC outlook on fish supply[31] projected increasing mollusc production, although this may have been based on current production trends

Table 19
Lower value molluscs top ten production (2002)

Country	Species	Tonnes
China PR	Japanese carpet shell	2 300 941
China PR	Constricted tagelus	635 486
China PR	Blood cockle	237 534
Thailand	Green mussel	89 200
Malaysia	Blood cockle	78 712
New Zealand	New Zealand mussel	78 000
Thailand	Blood cockle	40 000
Taiwan POC	Northern quahog	30 711
Korea RO	Japanese carpet shell	16 071
Korea RO	Korean mussel	13 353

Table 20
Higher value molluscs top ten production (2002)

Country	Species	Tonnes
China PR	Pacific cupped oyster	3 625 548
China PR	Yesso scallop	935 585
Japan	Yesso scallop	271 996
Japan	Pacific cupped oyster	221 376
Korea RO	Pacific cupped oyster	170 286
Taiwan POC	Pacific cupped oyster	19 800
Thailand	Cupped oyster nei	16 110
Philippines	Slipper cupped oyster	12 569
Australia	Pacific cupped oyster	4 924
Australia	Sydney cupped oyster	4 605

rather than the resource potential. The issue of site availability is likely to constrain future development of mollusc culture in several States as can be seen for the examples of Japan and Korea RO.

In these two States, the production of molluscs and seaweeds has been relatively stable for many years. This indicates that suitable sites may now all be 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. A further dimension is the development of intensive on shore culture operations such as those for abalone and a number of gastropod species.

4.5 Aquatic plants

Aquatic plant production can be divided into two distinct groups. 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

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

[30] Although the species name is not specified in Chinese official statistics, it is most likely Indo-Pacific swamp crab.

[31] Delgado, C.D., Wada, N., Rosegrant, M.W., Meijer, S. and Ahmed, M. (2003). Fish to 2020. Suplly and demand in changing global markets. WorldFish Centre Technical report 62. 226 pp.

biopolymers (carrageenan, agar) that are used for various food and non-food purposes.

Table 21
Aquatic plants top ten producer States (2002)

Countries	Tonnes
China PR	8 809 090
Philippines	894 856
Japan	558 248
Korea RO	497 557
Korea DPR	444 295
Indonesia	223 080
Malaysia	18 871
Taiwan POC	16 799
Viet Nam	16 000
Kiribati	12 600

Seaweeds for food purpose

This group includes Japanese kelp, laver (Nori), green laver and Wakame. The production of these species is confined to East Asian States and has a relatively stable production. The only exception to this is Japanese kelp culture, which has the largest share of production (41 percent in 2002). Its production was doubled from two million tonnes in three years to 1993 and another one million tonnes was added in the next six years. This rapid increase was probably due to continued expansion of cultured areas in China. Production of Japanese kelp peaked in 1999 and since then has stabilized, which 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 seaweeds and others. The Philippines has the highest production of these aquatic plants and *Eucheuma cottonii* (Zanzibar weed) production in the Philippine far exceeds the production of other seaweeds (778 thousand tonnes in 2002).

New areas are being investigated for the expansion of seaweed production since global demand for carrageenan and other alginates is expected to continue to rise.

Table 22
Aquatic plants top ten cultured species (2002)

Species	Tonnes
Japanese kelp	4 726 400
Laver (Nori)	1 330 325
Zanzibar weed	790 563
Wakame	287 563
Red seaweeds	223 080
Spiny eucheuma	83 051
Elkhorn sea moss	21 409
Gracilaria seaweeds	17 643
Warty gracilaria	16 775
Eucheuma seaweeds	12 920

Major cultured aquatic plants in East Asia are Laver (Nori), Japanese kelp and Wakame. They are all seaweeds for food purposes in contrast to those produced in Southeast Asia, which are mainly used as a source of commercially valuable biopolymers

4.6 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 five years. Crocodile production is growing quickly in the region with Cambodia exporting juvenile crocodiles to both Viet Nam and China PR. Thailand also has crocodile farms. This production is rarely reported in fishery or aquaculture statistics.

There are limited data on frog production, although frogs are being increasingly cultured in many States. 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.

4.7 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 the pilot/experimental level or simply not reported by many States. 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.

5. Selected issues facing fisheries and aquaculture in Asia and the Pacific

5.1 "Trash fish" catches

"Trash Fish" is a broadly used term that relates fish species that by virtue of their small size or low consumer preference have little or no commercial value. The use of the term "trash fish" varies among States and fisheries and can also change both seasonally and with location.

One category of "trash fish" includes species those that are not used for human consumption. They may be either landed, or discarded at sea. The landed portion of this type of trash fish is often composed of small fish that are targeted for processing into fish meal and oil or used for small-scale rural aquaculture and livestock raising. Japanese anchovy and chub mackerel are typical species that fall into this category. Those fish that have become damaged during fishing operations or in on-board storage can also be categorized in this group.

The other category of "trash fish" is low-value fish that are directly used for human consumption. The huge number of small-scale fisheries in the Asia-Pacific region generates a large quantity of this type of "trash fish", much of which is consumed or utilized locally as part of household food security, by way of artisanal processing. Utilization may be extremely efficient with nothing being wasted and a lot being converted through drying, fermenting and salting into a very wide range of human food products. In countries such as Bangladesh, almost all of fish caught is consumed.

The issues relating to these types of "trash fish" are different but interconnected. One major issue for the region is the increasing demand for "trash fish" for aquaculture and other animal feeds. Recognizing the potential effects of declines in marine capture fisheries, many governments have turned to aquaculture as a means to increase fish supply, provide employment and generate foreign income. Aquaculture development can be seen as a viable option to utilize "trash fish"; however, its demand for fish meal and "trash fish" can be seen as increasing fishing pressure on the already over-exploited fish stocks in the region. Over the last decade, the price of "trash fish" has risen considerably and it is predicted to increase over the next few years due to increased demand for fish meal and fish oil to meet market demands for aquaculture of carnivorous fish (as well as a source of affordable food). Declining stocks of many trash fish species such as Japanese anchovy, chub mackerel and filefish in China PR will aggravate the situation. Given that aquaculture is predicted to grow while capture fisheries remain stable, it will be difficult to meet the demand for trash fish.

Another issue relates to fish landed by larger industrial vessels. These fish are typically landed at a single point (port) and typically in a poor state of preservation or severely damaged by the capture method. Utilization of this fish is consequently very limited; either through conversion into fish meal or direct use for livestock or aquaculture in the general vicinity of the landing site. Would better post-harvest handling and processing yield a better return for this limited resource?

A linked issue is the capture of juvenile fish of potentially important commercial species (so-called "growth overfishing"). Trash fish currently constitute about 60 percent of the total trawl catch from the Gulf of Thailand and between 18 and 32 percent of trash fish are juveniles of commercially important fish species. Given a chance to grow to a larger size, these species would provide much more benefits, both in terms of production and more importantly in terms of value.

Before 1970, trash fish were caught mainly as a by-catch of trawling, set nets and drift nets. Although used as food in some poorer areas of the region, a lot of this fish was thrown back into the sea. With the decline in fish abundance in many seas of the region, and the shift from high trophic level to the more abundant lower trophic level species, trash fish increasingly became the target species.

The overall amount of trash fish actually landed in the Asia-Pacific region is not well known, but recent estimates from some States give an indication of the amount of trash fish currently being landed. In China PR, for example, the recorded trash fish production rose from 1.3 million tonnes in 1980 to over 5 million in 2002. In the South China Sea, the catch of trash fish exceeded 60 percent of the total marine production. Trash fish currently constitute about 60 percent of the total trawl catch from the Gulf of Thailand and between 18 and 32 percent of these trash fish are juveniles of commercially important fish species. In Viet Nam, some of the traditional gear is of very small mesh size leading to 30-80 percent of the catch coming from juvenile and trash fish. In Western Malaysia trawl landings consisted mainly of trash fish (51 percent), demersal fish (14.9 percent) and pelagic fish (13.3 percent).

Another indicator of trash fish production and utilization can also 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 using 'trash fish' directly, the trash fish being obtained from trawler landings or from small-scale fisheries.

Use of "trash fish" for aquaculture in selected States[32]

Bangladesh

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

China PR

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

A rough estimate of the total fish meal requirement for aquaculture for China PR, based on reported production figures, ranges between 3.0 and 3.6 million tonnes. This figure is strongly influenced by assumed fish meal used for the culture of freshwater omnivorous species such as grass carp, common carp, crucian carp and tilapia. Further analysis of this particular part of the Chinese aquaculture sector is needed.

Domestic trash fish landings could provide one million tonnes of this usage and it is assumed that the rest is sourced from imports. The reported net fish meal usage[33] for China PR in 2000 was nearly two million tonnes of which 806 thousand tonnes was national production[34]. One estimate of future needs is that China will require about 13-18 million tonnes per year in the future but can only produce five million tonnes, leaving a large gap to be filled from imports.

Philippines

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

Viet Nam

A recent study in Viet Nam concluded that there is rapidly increasing demand for trash fish for aquaculture. The total amount of trash fish used for aquaculture is estimated to be between 176 thousand and 323 thousand tonnes. In general, trash fish are a by-product of fishing for higher value fish with the exception of one fishery in southeast Viet Nam, where trash fish is the main target as this is more economic than fishing for larger species. Any future planned increases in aquaculture production will probably be constrained by the finite sources of feed fish.

5.2 Fish meal and other fish-based ingredients for aquaculture feed

The tables below present the 'apparent utilization' of fish-based feed ingredients in the Asia-Pacific region[35]. The trends in the usage of fish meal for aquaculture and other sectors are stable in many States of the region (**Figure 39**).

It was recently estimated that the global aquaculture industry uses about 35 percent of total fish meal supply (**Figure 40**). This is a significant increase over estimated use in 1988. By 2010, the

[32] Unless otherwise referenced the information in this section is drawn from the regional review (see footnote 12).

[33] Net fish meal usage = (production + import – export).

[34] FAO FISHSTAT (2002 edition).

[35] 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 States do not submit complete information (e.g. the 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.

same author estimates the aquaculture share of fish meal usage will be 48 percent.[36]

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"[37] and it is considered that given the apparently limited supply of fish meal and fish oil, the expansion of some types of aquaculture will be constrained (or stopped). It is argued 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.

Table 23
Net fish meal usage in the Asia-Pacific region (2001)

Country	Tonnes
China PR	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 RO	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

[36] http://www.iffo.org.uk S.M. Barlow "The world market overview of fish meal and fish oil" Paper presented to the 2nd Seafood By-Products Conference, Alaska, November 2002.

[37] See FAO (2000) The State of World Fisheries and Aquaculture, 2000, page 115.

These predictions assume that there will be little improvement in the efficiency of use of fish meal and fish, and that effective substitutes will not be found in the near future. It could be easily expected that the efficiency of the use of fishmeal will rise as a reaction to increasing prices and competition between the livestock and aquaculture sectors for the resource. It should be pointed out that to date, the greatest advances in the area of reducing reliance on fish meal appear to have been in the livestock sector. Considerable research is also being done to find substitutes including other sources of fish meal, and vegetable substitutes, including genetically modified plants.

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 shifts 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 environments[38], the approximate requirement for fishmeal for the Asia-Pacific region including China PR in 2000 was over 1.2 million tonnes. The fish meal requirement of freshwater fish aquaculture is far more difficult to estimate, since feeds vary from complete feeds containing fish meal to supplemental feeds with no fish meal whatsoever.

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 to increase the efficiency of its current usage of this resource.

[38] Freshwater, brackish water and mare water.

Figure 39
Usage of fishmeal for aquaculture and other sectors

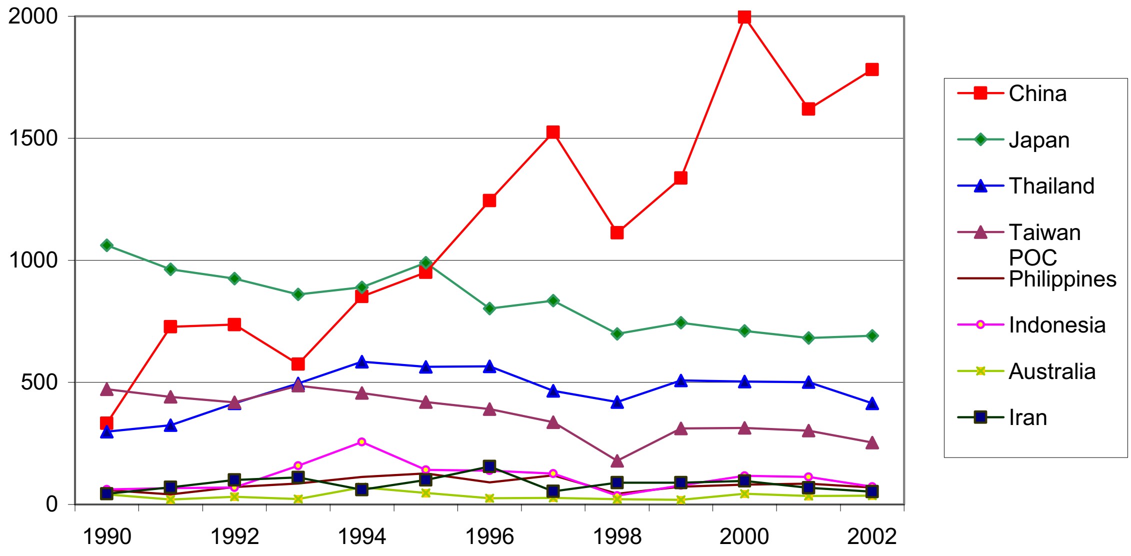
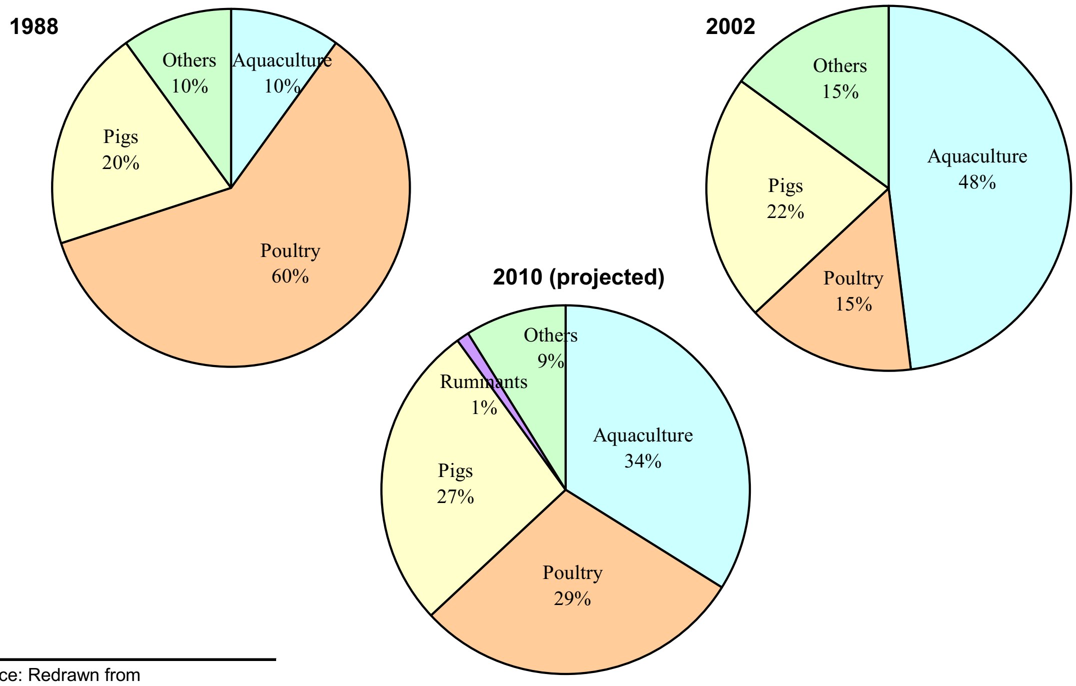


Figure 40
Share of total fishmeal use



Source: Redrawn from
1) S.M. Barlow & I.H. Pike " SUSTAINABILITY OF FISHMEAL AND FISH OIL SUPPLY" Paper presented at the Scottish Norwegian Marine fish farming conference, University of Stirling, Stirling Scotland, June 2002
2) S.M. Barlow "THE WORLD MARKET OVERVIEW OF FISH MEAL AND FISH OIL" Paper presented to the 2nd Seafood By-Products Conference, Alaska, November 2002, http://www.iffo.org.uk

5.3 Live fish trade – food fish and ornamental aquarium fish

Fisheries dedicated to the live food and ornamental fish trade 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 US$ 1 billion per year.

There are environmental concerns regarding the manner in which aquarium and live reef food fish are exploited. 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 US$ 2.4 billion per year.

The marine and freshwater aquarium trade

In 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[39].

Estimates place the value of the marine ornamental trade at US$ 200-330 million per year[40] and the overall value of the marine fish trade, accounts for about 10 percent of the international ornamental fish trade (marine and freshwater included)[41].

A total of 1 471 species of marine fish are traded world wide but the ten 'most traded' species account for about 36 percent of all fish traded for the years 1997 to 2002.

Southeast Asia is the hub of this trade, supplying up to 85 percent of the aquarium trade[42]. In 1985, the world export value of the marine aquarium trade was estimated at US$ 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 US$ 200 million. The annual export of marine aquarium fish from Southeast Asia alone was, according to 1997 data, between 10 million and 30 million fish with a retail value of up to US$ 750 million; the actual value at point of sale is considerably higher.

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.

Coral species in seven genera (*Euphyllia, Goniopora, Acropora, Plerogyra, Catalaphyllia*) are the most popular, accounting for approximately 56 percent of the live coral trade between 1988 and 2002. There were also 61 species of soft coral 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[43]. The marine aquarium trade relies on capture for 98 percent of its production versus 2 percent culture[44]. 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 makes up 90 percent of the total aquarium trade and 98 percent of that is cultured, then a crude estimate of the wholesale aquaculture value is approximately US$ 794 million.

There are increasing trends to certify the aquarium trade as "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 PR.

[39] FAO SOFIA 2000.

[40] 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.

[41] http://www.unep-wcmc.org/index.html?http://www.unep-wcmc.org/resources/publications/UNEP_WCMC_bio_series.htm~main

[42] 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/

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

[44] Marine Aquarium Council website.

In 2000, Hong Kong SAR alone imported an estimated 24 362 tonnes of live food fish. Typical wholesale prices for these species range from US$ 11 to 63 per kilogram. Overall average wholesale price for reef fish was US$ 20/kg[45].

Table 24
Live fish imports to China PR, Hong Kong SAR, Macao SAR and Singapore in 2000

Country	Tonnes
China PR	888
China, Hong Kong SAR	24 362
China, Macao SAR	4 601
Singapore	3 337

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 the Pacific Islands. Estimates of the value of this trade vary. One estimate for Hong Kong SAR alone put the value at approximately US$ 400 to 500 million.

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 notably in recent years.

[45] Lau, P. & R. Parry Jones. (1999). The Hong Kong trade in Live reef fish for food. TRAFFIC East Asia and World Wide Fund for Nature Hong Kong, Hong Kong.

6. The outlook for fisheries and aquaculture in Asia and the Pacific

6.1 Global and regional trends

The International Food Policy Research Institute in collaboration with the WorldFish Centre has recently published "Fish to 2020"[46]. Based on a global supply and demand model the study examined six different scenarios. Although each of the scenarios provided some differences, especially in timing of critical trends, the study predicts that production and consumption will continue to increase in developing States, but slow down in developed States resulting in an increase in the price of fish, especially fish meal and fish oil, wild fish, and high-value fish (assuming that consumers will not greatly shift their preferences to other commodities such as poultry as fish prices increase).

Consumption trends will drive an increase in the demand for fishery products for food, partly due to changing food habits but also due to the increasing purchasing power of several developing States. Most forecasts for the future predict a stable or decreasing supply from capture fisheries and an increasing proportion coming from aquaculture. As a result of these trends the price of fishery products is also expected to increase since in most of the projected scenarios, supply cannot keep up with demand. Projected rises in prices between 1997 and 2020 are about 15 percent, and significantly for aquaculture, increases in prices of fish meal and fish oil are predicted to be up to 18 percent.

Fish trade is increasing rapidly with roughly 40 percent of global fish output being traded across State borders. This proportion is considered to be high compared to that of meat (less than 10 percent). For such a perishable product, this high proportion of traded output is surprising, but it mirrors changes in diets world wide, and turnarounds in supply and demand. Globally, the main source of fish production has shifted from developed to developing States and the share of aquaculture has increased substantially. Seafood demand from developing States is expanding rapidly and major shifts in seafood and aquaculture production, trade, and consumption world wide are expected to continue over the next 10-20 years with an increasing south-south trade in seafood in relation to north-south trade.

[46] see footnote 31.

Developing States are expected to remain net exporters overall, but the percentage of their production exported is expected to decrease due to rising domestic demand. There appears to be a decreasing trend of fish consumption due to increased urbanization; however this does not seem likely to offset the increased demand for fish in developing States.

6.2 Coastal fisheries

Based on current trends, production from capture fisheries in the Asia-Pacific region will decline over the next 10-20 years unless excess fishing capacity and fishing effort is greatly reduced. Increased production in the North Sea after two world wars, for example, showed that heavily exploited fish stocks can recover when released from their heavy fishing pressure. Current examples include several fish stocks in waters of the USA where fishing has been drastically reduced. Ecosystem modelling has also shown that the situation can be reversed. However, it is unknown to what extent severely altered ecosystems such as the Yellow Sea and the Gulf of Thailand would recover.

It could be argued that "fishing down the food chain" is both a good and an unavoidable consequence of the growing demand for fish in that removing predators may lead to more of their prey being available for humans. This simplistic view, however, seldom holds up in practice as it often leads to increases in, or outbursts of, previously supressed species such as invertebrates. The ecosystem changes associated with heavy fishing are not clearly understood, but it is known that the effects can be increased variability and unpredictability.

There have been few studies on the benefits that would accrue if fishing effort could be reduced. One example for the Gulf of Thailand was given earlier (**Table 1**). Another estimate made for the Philippines showed that for the demersal and small-scale pelagic fisheries in shallow coastal waters in the mid-1980s, the level of effort was 150-300 percent needed to gain the maximum economic yield resulting in a wastage of US$ 450 million[47]. Although much of the trash fish currently

[47] Silvestre G. and Pauly, D. (1997) Status and management of tropical coastal fisheries in Asia. ICLARM Conference Proceedings 58, 208 pp.

being caught consists of species that would not grow to much larger sizes; about 30 percent is thought to consist of juveniles of commercially high value fish species. If fishing pressure would be reduced on these species, they could make a much more significant contribution to catches and to incomes.

Many States in the Asia-Pacific region have agreed to a number of high level principles relating to fisheries and sustainable development (e.g. the World Summit on Sustainable Development; the UNCED's Agenda 21, and the FAO Code of Conduct for Responsible Fisheries). Although these principles are often stated in legislation and policies, this alone will not bring about the improved management that is needed. Decisions need to be made on how to implement them, especially in the context of small-scale fisheries. A key factor to turn around the current trends would be for States to resolve the competing policy imperatives of:

i) optimal and sustainable use of fish resources and their supporting ecosystems;
ii) economic objectives, especially in relation to either small- or large-scale fisheries;
iii) social objectives, including maximizing employment and improving livelihoods;
iv) objectives related to equity, including access for only small-scale fisheries; and
v) any other objectives (for example trade liberalization, market access etc.) which may have impacts on this sub-sector

Very few fisheries (both globally and in the Asia-Pacific region) have adequately considered and resolved the trade offs among these objectives. For example, trade-off agreements need to be reached on:

- Equity versus efficiency;
- Maximising sustainable yields (and economic benefits) versus widespread employment and providing a safety net for the poor;
- Export-oriented production versus national food security;
- Imports versus national self sufficiency;
- Large-scale versus small-scale fisheries;
- Long- and short-term management goals;
- Market liberalization versus protection of small-scale fisheries; and
- Foreign fishing vessels versus local fleets

In fisheries, this lack of clarity with respect to objectives often leads to conflict amongst competing sub-sectors (e.g. small-scale fishing versus large-scale fishing) resulting in many management interventions implemented only to alleviate the symptoms, but not solving the problem itself.

The obvious dilemma in relation to reducing capacity and fishing effort in the Asia-Pacific region is that a large part of the production comes from small-scale operators, and they are often totally dependent on fishery resources for their livelihood. Despite efforts to "modernize" small-scale fisheries in the region, for a variety of reasons these have not been successful and the level of small-scale fishing activity has not decreased. Given the significant contribution that small-scale fisheries make to food security and poverty alleviation, the role of small-scale fisheries and how they fit into the multiple activities of rural economies should be carefully examined. Unlike large-scale industrial fisheries, they have low visibility and receive little attention from policy makers. They are often open access enterprises that contribute little to the national GDP and command little political attention and support through research, subsidies etc. As such, they tend to be dealt with through project work funded by donors.

The vision for small-scale fisheries should be one in which their contribution to sustainable development is fully realized and their contribution to national economies and food security is recognized, valued and enhanced. This will require a paradigm shift in policy, resulting in fishers, fish workers and other stakeholders having opportunities to participate in decision-making processes. In doing so, their capability and human capacity should be enhanced, which subsequently leads to a situation where social, economic and ecological systems are managed in an integrated and sustainable manner, thereby reducing conflict. The move towards decentralization and co-management in the region is an attempt to achieve this.

Many projects across the region have demonstrated that co-management cannot be achieved without using a more holistic livelihoods approach (i.e. dealing with all the issues outside of fisheries such as health, education, alternative livelihoods, etc.) and empowering communities through improved organization to enable them to have a greater say in issues that affect their future. Larger issues such as poverty, inadequate sanitation, inadequate water supplies etc. have to be addressed before more responsible fishing is possible. It is probably the right time to take stock of the lessons learnt through these projects and formulate "best practices" for the guidance of future activities. APFIC is currently putting together a database of project sites to help in this analysis.

Co-management will also require considerable capacity building at all levels so that all those involved can communicate common goals and understand each other's roles and responsibilities. This needs to be done through "on-the-job" training involving tackling every day issues and finding solutions that are practical and feasible.

Some progress is being made through a number of projects in the region that attempt to address conservation and management issues by first dealing with larger problems of poverty (hunger and underdevelopment), in terms of health, education and general human well-being. However, these should be considered in the context of national and regional aspirations, not just as isolated projects supported by donors and non-governmental organizations.

The reduction of industrial fisheries fleets should result in an increase in net benefits from the resources, via taxation on the remaining fishers for example, useful for easing the transition of those who have had to stop fishing. It could also be argued that if more fish are available for small-scale fisheries, there would be more marketing and distribution jobs and alternative employment. This would be in contrast to the present situation where taxes from outside the fisheries are used as subsidies to maintain fishing at levels that are unsustainable. The short-term cost to cut down on the number of large vessels, e.g. trawlers, probably justifies the investment and in the long run there would be significantly lower investment and operating costs in the fleet. More detailed analyses on the costs and benefits of improved fishery management are required.

6.3 Offshore fisheries

Global fisheries have been characterized by a steady expansion of fishing from inshore local regions to further offshore fishing grounds as the local stocks became depleted. Many believe that this trend can be continued in the Asia-Pacific region and many States in the region include further expansion into offshore fisheries as part of their future fishery plans. Although the potential is relatively unknown, it is dangerous to assume that the offshore regions will supply fish in quantities that we are familiar with in inshore regions. It is well known that biological productivity declines exponentially as one moves away from the coast. Of the 363 million km^2 of ocean, in less than seven percent are waters with a depth of less than 200 m, and this continental shelf area accounts for 90 percent of the global fish catch. The rest comes from deep-water demersal fish and highly migratory fish such as tuna that roam the vast desert-like expanse of the open ocean. It is unlikely that this percentage will change dramatically over the next 10-20 years.

There have been some resource surveys for deep-water demersal fish in the region, in particular, those done by India. The Fishery Survey of India (FSI) is responsible for survey and assessment of marine fishery resources of the Indian EEZ. With its headquarters at Mumbai, the Institute has seven operational bases at Porbandar, Mumbai, Mormugao and Cochin along the west coast; Madras and Visakhapatnam along the east coast and Port Blair in the Andaman & Nicobar Islands. A total of 12 ocean-going survey vessels have been deployed for fisheries resources survey and monitoring. At the time of writing, FAO did not have access to these results and would be interested in hearing more on this subject. Experience from other parts of the world, however, has shown that many of the scarce deepwater demersal stocks are long-lived (over 100 years) species of low productivity and many have already been overexploited in many temperate waters. FAO's Fishery Committee of the Eastern Central Atlantic (CECAF) has just decided that, although current catch levels of the Alfonsino (*Beryx decadactylus*) and similar deep-water fishes in the CECAF zone are low, CECAF States will begin submitting annual reports on high-seas fishing activities for non-tuna species. The Committee stated that "Any exploitation of these species should be carefully designed, taking into account the very low level of sustainable yield of these fish populations and the isolation of sea-mount benthic ecosystems."

Purse-seine fishery in the Western and Central Pacific (WCPO) has accounted for around 55-60 percent of total catch in the area since the early 1990s, with annual catches in the range of 790 000-1 200 000 tonnes. The majority of the WCPO purse-seine catch (>70 percent) is taken by the four main distant-water fishing fleets (Japan, Korea RO, Taiwan POC and USA), which currently number around 140 vessels.

The current catch history for tuna in the WCPO is shown in **Figure 41** and the status of tuna species in the WCPO and the Indian Ocean is given in **Table 25**.

There has been an increasing contribution from the growing number of Pacific Island domestic vessels in recent years (40 vessels in 2000), with the balance from Philippines fisheries and a variety of other fleets, including a small seasonally active Spanish fleet.

Assessments of the stocks in both the WCPO and the Indian Ocean highlight the variability in recruitment in the faster growing more productive tuna species (skipjack and yellowfin), driven to a large extent by climatic changes such as the El Niño. Skipjack tuna, in particular is considered as biologically underexploited at the moment (although there is some concern over economic overfishing resulting in low prices in the Pacific). In contrast, the longer-lived slower growing bigeye tuna is showing signs of overfishing in both oceans. Scientists warn that because of the multi-species nature of the purse seine and longline fishery the impacts of fishing on skipjack could have a negative impact on more vulnerable species. In this respect, they advise that the Tuna Commissions should consider how to implement management measures to address over-fishing and alleviate over-fished stock conditions in the future.

In summary, it would appear that any expansion into offshore waters will be limited for both pelagic and demersal fisheries, unless more selective fishing gears for tunas can be developed. Overall, therefore, even to maintain the status quo in capture fisheries in the region, especially in terms of providing food security and poverty alleviation for the region's poor, the many issues highlighted in this review will need to be addressed. It is unlikely that any State can do this unilaterally, and a concerted and collaborative effort will be required.

6.4 Aquaculture

Since the yield from capture fisheries is not expected to increase greatly, there is an emphasis being placed on the aquaculture sector's ability to provide increasing quantities of fish to satisfy increasing demand in all regions. Several conditions must be satisfied in order that aquaculture be able to achieve this expectation.

Figure 41
Tuna catches in the Western and Central Pacific region

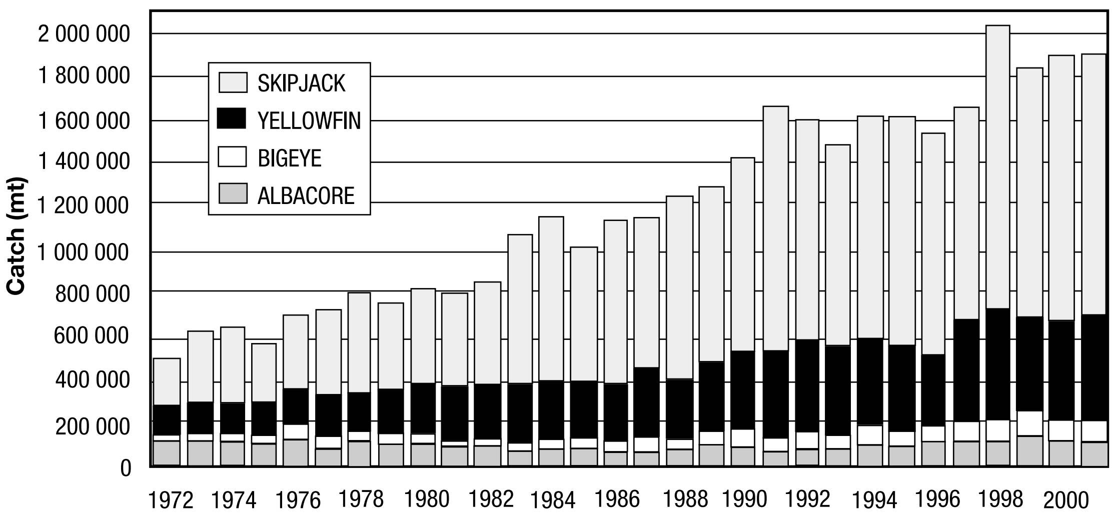


Table 25
Status of tuna species in the Western and Central Pacific and in the Indian Ocean

Species	Central & Western Pacific	Indian Ocean
Skipjack tuna	Underexploited	Underexploited
Yellowfin tuna	Under/fully exploited	Fully exploited
Bigeye tuna	Fully/overexploited	Fully/overexploited
Albacore tuna	Underexploited	Underexploited
Swordfish		Overexploited

The massive expansion of aquaculture required will need increased 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 States 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. The current reliance on fish meal as a protein source for aquaculture feeds is a potential constraint (this has already been discussed in the previous section).

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, reduced reliance may be more difficult to achieve. 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/WFC report is that a rapid expansion of both the 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 indicate 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 States is moving away from 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 forms of meat such as chicken and pork. The question is whether fish in the Asia-Pacific region will remain a common (and even central) part of the diet of most people or increasingly become a luxury food item.

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