

Asian fisheries today: The production and use of low value/trash fish from marine fisheries in the Asia-Pacific region



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Simon Funge-Smith, Erik Lindebo and Derek Staples

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For copies write to:

The Senior Fishery Officer
FAO Regional Office for Asia and the Pacific
Maliwan Mansion, 39 Phra Athit Road
Bangkok 10200
THAILAND
Tel: (+66) 2 697 4000
Fax: (+66) 2 697 4445
E-mail: FAO-RAP@fao.org

Cover photos: Mixed fish landings (Theo Ebbers, 2004) and fish sauce vats in Phu Quoc, Viet Nam (Simon Funge-Smith, 2004)

Foreword

This report provides an overview of the Asia-Pacific situation with regard to low value/trash fish production, with special emphasis on the important impact of aquaculture development and human consumption demand. Fishing for low value/trash fish has in recent decades evolved as an important economic activity and the sustainability of these fishing activities will need to be assured for the overall well-being of small fishing communities in the region. One concern in this respect is that the increasing demand from aquaculture, and the benefits that accrue in terms of export earnings, may be at the expense of local fish markets and the fishery ecosystem.

The report includes recent information on the status and trends of low value/trash fish production and uses in the Asian region. It also highlights many emerging issues to identify actions to reverse the unfavourable trends and promote sustainable development of both fisheries and aquaculture and to provide input for a more thorough policy analysis. These issues include the increasing demand for trash/low value fish as feed for aquaculture (through both direct feeding and through conversion into fish meal/oil), the sustainability of harvesting in an attempt to meet this demand, the impact on the ecosystems, the incentives for lower post-harvest handling, growth overfishing of small juveniles of commercially important species, discarding at sea, and social concerns of using trash/low value fish to feed livestock rather than as a source of animal protein for poor people.

I trust that this report will raise awareness of the evolution of the fisheries in the Asia-Pacific region from “fisheries for the people” to “fisheries for aquaculture” and alert decision-makers at all level of government and non-government of the seriousness of the issues associated with this change. It is our hope that through the Asia-Pacific Fisheries Commission, a suite of actions will be agreed and implemented.



He Changchui

Assistant Director-General and
Regional Representative for Asia and the Pacific

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Acknowledgements

The report draws on a range of Food and Agriculture Organization of the United Nations (FAO) documents and data sources to provide insight into the current issues surrounding low value/trash fish production in the region, and are referenced throughout the report.

A number of comprehensive country studies were initiated by the Asia-Pacific Fisheries Commission (APFIC) and have provided the majority of the information discussed, and include:

Chuenpagdee, R. & Juntarashote, K. (2004) "Regional overview of status and trend of "trash fish" from marine fisheries and their utilisation, with special reference to aquaculture". April 2004.

Han, J. & Xu, H. (2004) "Overview of status and trend of "trash fish" from marine fisheries and their utilisation, with special reference to aquaculture: China".

Jayaraman, R. (2004) "Overview of status and trend of "trash fish" from marine fisheries and their utilisation, with special reference to aquaculture: India".

Kaewnern, M. & Wangvoralak, S. (2004) "Overview of status and trend of "trash fish" from marine fisheries and their utilisation, with special reference to aquaculture: Thailand".

Ramiscal, R.V. & Chiuco, M.B. (2004) "Overview of status and trend of "trash fish" from marine fisheries and their utilisation, with special reference to aquaculture: Philippines".

Uddin, A.M.K., Iftekhhar, M.S., Abedin, M.J. & Islam, M.S. (2004) "Overview of status and trend of "trash fish" from marine fisheries and their utilisation, with special reference to aquaculture: Bangladesh".

Widodo, J. (2004) "Overview of status and trend of "trash fish" from marine fisheries and their utilisation, with special reference to aquaculture: Indonesia".

A recent review carried out under the auspices of the Australian Centre for International Agriculture Research (ACIAR) was also used:

Edwards, P., Tuan, L.A. & Allan, G.L. (2004) "A survey of marine low trash fish and fish meal as aquaculture feed ingredients in Viet Nam". ACIAR Working Paper No. 57, 2004.

Unless stated otherwise, the information cited for specific countries herein are sourced from the above mentioned references. This report will review the overall conclusions of these regional studies with regard to the sustainability of current fishing/aquaculture practices in the Asia-Pacific region. Areas of concern for the region's policy-makers will be particularly highlighted.

All monetary values stated herein are quoted in United States dollars (\$).

Executive summary

The Asia-Pacific region dominates many aspects of world fishery production. In 2002, total production was in the magnitude of 133 million tonnes, where Asia-Pacific countries were responsible for 50 percent of capture fishery production and 89 percent of aquaculture production. The reliance of the region on fishing as a means of creating employment and providing export earnings and food security is apparent.

Throughout the region, captured and cultured marine fisheries continue to play an important role in the food security, poverty alleviation and economies of many countries. Marine fisheries resources have been largely overexploited and, as a result, development of coastal aquaculture has been encouraged to provide the protein, income, employment and export earnings for some countries. Such a policy trend implies, however, that sufficient food for aquaculture production will be available. Inevitably, a dangerous spiral has evolved where the demand for low value/trash fish has supported increased fishing pressure on already degraded resources. This raises some important questions regarding the social, economic and ecological costs and benefits of the system, its sustainability and future trends.

The marine capture fishery sector is dominated by small-scale, labour intensive vessel operations that use multiple gears to catch an extremely diverse species composition. Local markets and processing techniques are specialised and are generally geared towards the needs of the local community. Fisher folk are often considered to be among the poorest of the poor and the small fishing communities are highly dependent on fishing for their survival. This pressure seemingly fuels overexploitation and ecosystem degradation. The lack of appropriate management measures as well as conflicting short-term goals of production growth by national administrations provide further challenges to the development of sustainable fisheries in the region.

The increasing importance of low value/trash fish is very influential in this regard. Low value/trash fish can be defined in many ways and important regional differences feature in this report. For the purpose of our review we define low value/trash fish as:

Fish that have a low commercial value by virtue of their low quality, small size or low consumer preference. They are either used for human consumption (often processed or preserved) or used for livestock/fish, either directly or through reduction to fish meal/oil.

There is in general a lack of accurate information on how much low value/trash fish use is present in Asia-Pacific, but a conservative estimate is that 25 percent of the total marine capture is destined for livestock and aquaculture feed, based on the best available evidence. The uses of low value/trash fish are diverse and include:

- local consumption (e.g. fresh, dried);
- direct feed (e.g. livestock, high value species aquaculture);
- fish meal/oil production (e.g. for poultry, aquaculture); and
- value-added products (e.g. fish sauce, surimi, protein concentrates).

Several issues concerning the production and use of low value/trash fish need to be resolved in order to ensure that fisheries in Asia-Pacific contribute to the region's sustainable development. These include:

- increasing use of low value/trash fish for aquaculture and other animal feeds;
- competition between use of low value/trash fish for fish meal versus use of low value/trash fish for human food;

- sustainability of the current system;
- amount of fish that becomes trash due to poor handling and post-harvest strategies;
- growth overfishing – harvesting of juveniles of commercial species; and
- discarding of unwanted fish.

It is the continued expansion of aquaculture and its dependency on capture fisheries for low value/trash fish that is the main driver of the discussions in this report. The expansion is in response to stagnating marine catches worldwide, and the continued need for fish supply, employment creation and export earnings. The use of low value/trash fish as direct feed or fish meal for aquaculture is economically viable, and the increasing low value/trash fish prices reflect the fact that their supply is unable to meet the demand for fish feed. There is a general concern that the rapid expansion of aquaculture may ultimately be constrained by the dependence on low value/trash fish and fish meal, popularly referred to as the “fish meal trap”. Further, if one accepts that supplies of low value/trash fish are limited and that prices are increasing, Asia-Pacific countries may need to increase imports of fish meal from the global market for the aquaculture industry, or replace them with other feed materials. The replacement of fish meal in aquaculture diets is hence a major international research priority.

There is also an increasing conflict between the use of low value/trash fish for feed and human consumption. It has been argued that it would be more efficient and ethical to divert more of the limited supply to human food, using value-added products. Proponents of this suggest that using low value/trash fish as food for domestic consumers is more appropriate than supplying fish meal plants for an export, income oriented aquaculture industry, producing high-value commodities. On the other hand, food security can also be increased by improving the income generation abilities of poor people, and it can be argued that the large volume of people employed in both fishing and aquaculture has a beneficial effect.

The money made from low value/trash fishing is now also a main reason why many vessels continue to be economically viable and remain in fisheries. However, the increased exploitation levels of fish lower down the food chain could be important in the longer term. In fact, there is currently a lack of scientific evidence to inform fisheries managers of how sustainable the ecosystem is, and more research is needed in this regard. From a socio-economic perspective the gains from current fishing practices are clear, but perhaps more information should also be gathered on who the main beneficiaries are, and how a change in the fishery/aquaculture relationship would impact the community and its dependents.

The role of poor handling and post-harvest in small-scale fisheries continues to play a role in the supply of low value/trash fish. Even if it were possible for fishers to adopt better practices to land a better catch, the benefits of doing so are probably outweighed by the costs of capital investments. Indeed, if prices of low value/trash fish remain high then the incentives to land better quality fish for human consumption will not be strong. The same can be argued for growth overfishing that will likely need an overall reduction of fishing effort by the fleet (at a social cost) to allow juveniles to grow to a larger size before being harvested. One positive outcome of the current low value/trash fishing practice, however, is that, given the high level of utilisation of catches, the problem of discarding unwanted catch is rather negligible.

One obvious but important conclusion is the strong inter dependency between capture fisheries and aquaculture, which will require more coordinated management in the future. There is still an urgent need to understand the overall system better and, although we now have an initial understanding and quantitative data to start addressing the management issues, we now need to urge the research community to take up the challenge.

1. Introduction

1.1. Definitions of low value/trash fish

“Low value/trash fish” is a loosely used term that describes fish species with various characteristics but they are generally small in size, have low consumer preference and have little or no direct commercial value. The term is not really appropriate in many cases as these fish form the basis of human nutrition in many coastal areas in Asia-Pacific. Fish can be trash for one community but preferred in another, making a precise definition difficult. For this report we first define some characteristics of low value/trash fish and compare usage across a sample of countries.

Once caught, fish are either (i) retained or (ii) discarded (Figure 1). Of those retained, they are either used for (i) human food (in a range of product forms and markets), (ii) livestock/fish food (either fed directly to livestock/fish or used indirectly through processing into fish meal/oil that is used to make pellets or (iii) other uses (such as fertilisers).

The use of the terms “low value” and “trash fish” varies across the Asia-Pacific region (see Table 1) and can also change both seasonally and with location. However, in the six countries studied in Asia, low value/trash fish was recognised as being always of low economic value, generally small in size (though it can include larger fish if of low quality or waste from other uses) and having a low

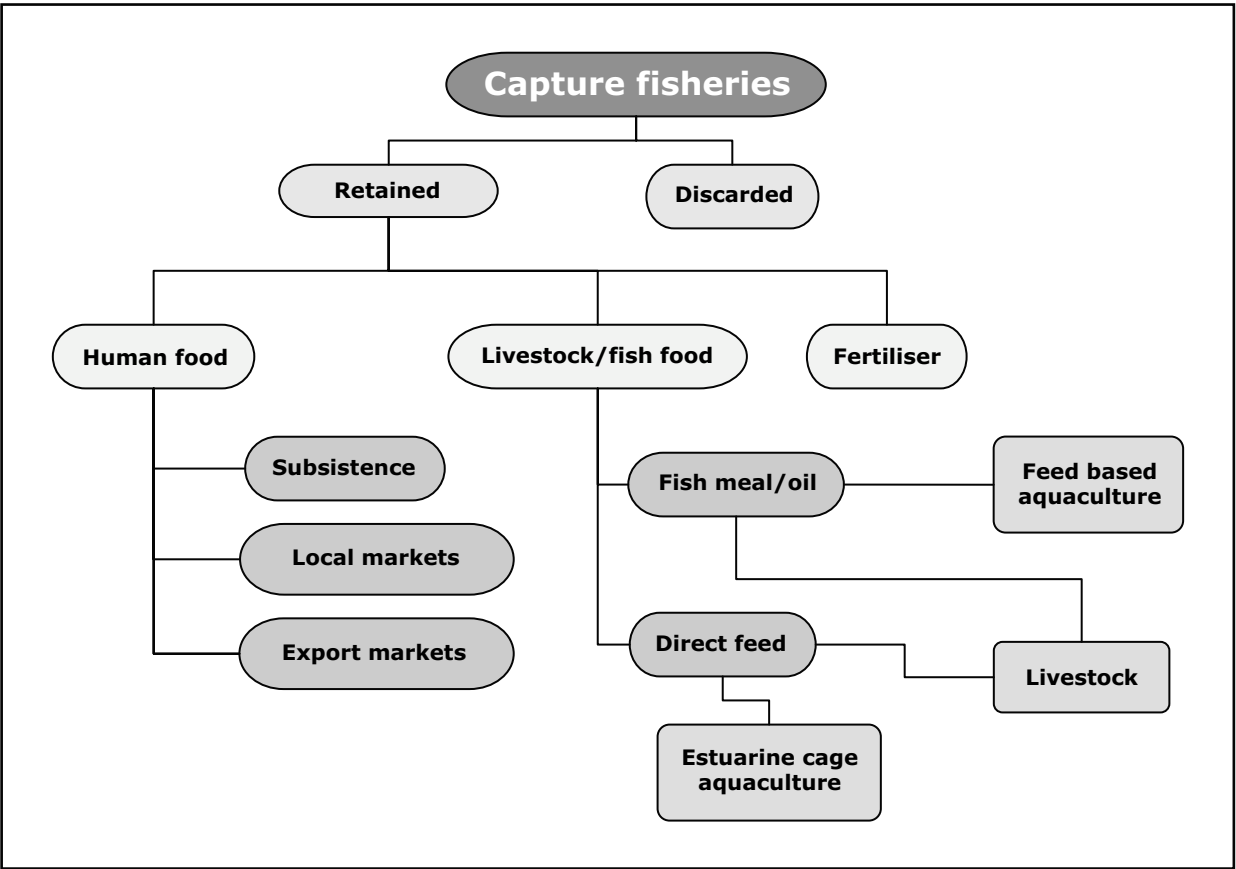


Figure 1: Major categories of fish in Asia-Pacific

consumer preference. They are usually taken as a bycatch¹ (in the sense that it was caught by non-selective fishing gear). A portion is often thrown away or discarded at sea, although this practice is quite minimal in many Asian fisheries.

The main difference in use of the term is whether it includes those fish eaten by humans or whether it is restricted only to fish used in animal feeds. In the Philippines and Viet Nam the term refers to fish that is both eaten by humans and used in livestock/fish food (manufactured into fish meal/oil or fed directly to animals). The term trash fish is more restricted in Thailand and China where it only includes the livestock/fish food component. In Bangladesh and India, less is converted into livestock/fish food and it is mainly directly used for human consumption. In China (and to a lesser degree in Viet Nam), it includes a large amount of fish that are targeted for processing into fish meal/oil, for example Japanese anchovy and chub mackerel.

Table 1: Some characteristics of low value/trash fish in six countries in Asia-Pacific

Country	Low value	Small size	Low consumer preference	Human consumption	Livestock/fish food	Bycatch	Target	Discard
Bangladesh	X	X	X	X		X		+++
China								
"Trash fish"	X	X	X		X	X	X	+
"Low value fish"	X	X	X	X		X	X	+
India	X	X	X	X		X		++
Philippines	X	X	X	X	X	X		+
Thailand	X	X	X		X	X		+
"Trash fish"	X	X	X		X	X	X	+
"Low value fish"	X	X	X	X		X	X	+
Viet Nam	X	X	X	X	X	X		+

+++ = major discarding (confined largely to shrimp trawling)

++ = moderate discarding

+ = minor discarding

In view of the different uses of the terms in different countries, in this report we refer to all low value fish as low value/trash fish. It was decided to make the definition broad and emphasise that the two different categories of use had to be included in any description of low value/trash fish. The working definition of low value/trash fish is:

Fish that have a low commercial value by virtue of their low quality, small size or low consumer preference. They are either used for human consumption (often processed or preserved) or used to feed livestock/fish, either directly or through reduction to fish meal/oil.

It also noted that inland low value/trash fish share the same issues as marine low value/trash fish but are outside of the scope of this review while recognising their importance as human food, particularly for the rural poor.

It is stressed that it is more important to focus on the issues and types of use for these fish, rather than insisting on a regionally accepted generic term. However, it is important within the region, to

¹ The term "bycatch" is a generic term referring to catch that is incidental to the target species, noting that in many fisheries using non-selective gears, such as fish trawls, the term is sometimes used interchangeably for the unwanted portion of the catch that is discarded or sometimes to refer to the less desirable fish that are landed, i.e. low value/trash fish.

use the same term for the different categories of fish that are included under the umbrella term – low value/trash fish. There is an urgent need for a more consistent use of the term. Rather than trying to come up with an agreed definition, all countries should record low value/trash fish under their categories for use, i.e.

- (i) discards
- (ii) human food (fresh/dried/preserved/value-added products etc.)
- (iii) direct feed for livestock and fish (separate categories)
- (iv) fish meal/oil
- (v) other (e.g. fertiliser)

A fuller description of the use of the term low value/trash fish in these different countries is given below. Further insight into the species composition, production trends and use is given in Sections 2.1 and 2.2.

Bangladesh

Low value/trash fish in Bangladesh is low-value fish caught as bycatch from small mesh drift nets – a gill net (that targets hilsha fish); large mesh drift (that targets Indian salmon) and shrimp trawl with its twin rig trawl (that targets shrimp). Some of the bycatch is commercially valuable fish (by-products) while others are less valued and do not have a specified use. However, in the Bangladesh context, any fish has a value and, with the exception of the shrimp trawl fishery, almost all the fish species are landed and are consumed locally.

China

China has a rather detailed ecological and economic description of “trash fish”, which explicitly states that it is fish “not suitable for direct human consumption”. “Low value fish” refers to those eaten by humans. The nature of China’s fisheries is such that the bulk of the low value/trash fish is contributed by small pelagic species, some of which have potential economic value if not caught as juveniles. More recently, fish that were once considered “trash” and were discarded at sea (such as Japanese anchovy and Chub mackerel) have become target species in trawl and purse net fisheries as a result of fisheries resources overexploitation and the increasing demand from aquaculture, which provides a ready market for these species. This has become a common trend in several of the countries covered by this review.

Low value/trash fish generally comprise fish with small body sizes (with relatively low flesh ratios) and low economic values. They often decay more easily than the other more valuable fish and are very vulnerable to mechanical damage. Under normal weather conditions, they deteriorate and lose further processing value before they are landed.

India

The term low value/trash fish is often used in different ways throughout India and some confusion exists on what it actually means. It is often used interchangeably with the term bycatch. A case in point is bycatch from shrimp trawls, where the ratio of target species to the bycatch may be as low as 1 to 20. This incidental catch includes several species of fin and shellfish, which have varying values in the market. Those fish, by virtue of their small size or low consumer preference, have either little or no value and are therefore called low value/trash fish. In some fisheries a proportion of this low value/trash fish is discarded overboard (often to make space). Even within the landed catch there are some species whose size, appearance, and consumer preference constrain them from being

readily accepted as human food. In general, prices can be used as criteria for considering fish as low value/trash fish (e.g. fish fetching less than \$0.10 per kg).

Fish may be considered as low value/trash fish in one season but not so in another season and may be considered as low value/trash fish in one region but may find consumer acceptance elsewhere, and hence possibly not considered as trash.

Philippines

The term trash fish or “dyako” in local dialect has been used since the trawl era in the 1950s to refer to the lowest category of trawl-caught species. It is the least valued fish group mainly composed of juveniles of commercially important food species, as well as lesser known food species (both young and adult). In the present context, commercially-important food fish landed by pelagic fisheries that are spoiled and/or damaged (due to rough handling and poor post-harvest practices) that could still be used for industrial purposes are also considered as low value/trash fish.

Thailand

Trash fish are defined as those used for livestock/fish feeds, the majority being used for fish meal/oil. “Low value food fish” includes the very extensive use of fish for processing for human food in artisanal fisheries throughout Thailand. “True” trash fish is used for those species that are small in size even when they mature. However, juveniles of high value marine fishes make up a significant proportion of the total trash fish. Thai people refer to trash fish as “Pla ped”, which literally means “fish for ducks”, most likely because the fish have been traditionally used to feed ducks and other livestock. With the emergence of coastal cage-fish aquaculture, this fish is now increasingly diverted to aquaculture.

Viet Nam

In general, trash fish in Viet Nam is only bycatch. However, it is the most important fish product in terms of both weight and value. Trash fish is caught mainly from trawling for higher value fish, crustaceans and molluscs. There are many trash fish species, the composition of which depends on the fishing area and the type of gear. There are three categories and terms for trash fish in Vietnamese: trash fish, trawling fish and “pig fish”, the latter being the lowest quality and therefore having a more restricted meaning than the other two terms.

The identification of trash fish is not always clear. Previously it was fish of low or no economic value but such fish are now being converted into value-added products. Leatherjacket is a very bony fish, which was rarely eaten before the development of processing technology. It was either only salted and converted into fish sauce, or even used as a fertiliser in southern Viet Nam. Recently, a process was introduced involving drying it for export and now it has economic value and is not considered a “trash fish”. Pony fish also used to have a low value but now it is used to feed grouper, cobia and other species, and its value is increasing.

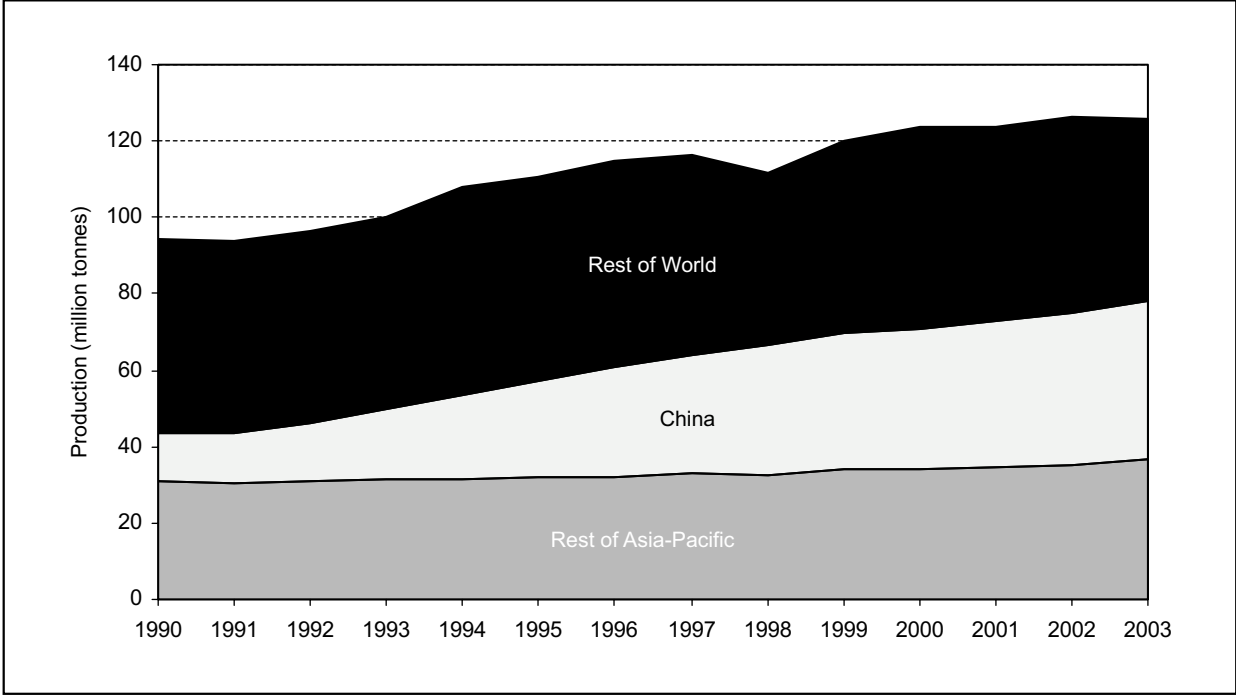
1.2. Asia-Pacific fisheries

The fisheries sector in the Asia-Pacific region can generally be divided into:

1. large-scale industrial/commercial subsector; and
2. small-scale artisanal subsector²

² Examples of how these two subsectors are defined in several different countries are given in Appendix 1.

In 2003, total world fishery production was reported to be 136 million tonnes, representing an increase of some 30 percent since 1990 (Figure 2). Marine capture fisheries production was 85.9 million tonnes in 2003 (FAO, 2005). In 2003, capture fishery production from Asia-Pacific accounted for half of world production, and the production from aquaculture reached almost 90 percent of the global aquaculture production of fish and shellfish.



Source: FAO (2005) and FAO database.

Figure 2: World fishery production (million tonnes)

Table 2: Marine capture fishery production 2003 (million tonnes) – Top 10 producers in Asia-Pacific

Country/Province	Production	World ranking
China	14.294	1
Japan	4.536	4
Indonesia	4.350	5
India	2.912	8
Thailand	2.620	9
Philippines	2.037	11
Republic of Korea	1.641	13
Viet Nam	1.535	14
Malaysia	1.283	16
Taiwan Province of China	1.132	17
Subtotal	36.34	–
World total	85.88	–
Share of Subtotal/World	42.3%	–

Source: FAO (2005) and FAO database.

In 2003, of the 20 top producers of marine capture fisheries, 10 were from the Asia-Pacific region (Table 2).

Three factors differentiate fisheries in the region from larger-scale temperate fisheries:

1. The dominance of small-scale fisheries, with most operations lasting from a day to a few days, irrespective of the economic value of the catch;
2. The tropical characteristics of the ecosystem, with individual species having

a relatively small stock size compared to those in temperate waters. As a consequence, fishers use a large number of gears and depend on a larger number of species for their livelihoods; and

3. The inherent flexibility of markets, since these are based on a long tradition of consuming a wide range of catch species, each in relatively small volumes and using extremely diverse local processing techniques.

According to official statistics, production in a number of Asia-Pacific fisheries peaked in the last two decades and is now stable or declining, depending on the area being fished. Highly intensive fishing, especially in trawl fisheries, targeting shrimp and other demersal species has also led to a change in catch composition. The share in landings of fast growing and short-lived species and the catch of small-sized juveniles of commercially important fish species is steadily increasing (so-called “fishing down the food chain”). There is also evidence (e.g. Gulf of Thailand) that the abundance of species at higher levels in the food chain has seriously declined with a resulting higher risk to biodiversity and increased vulnerability of fisheries. There is little doubt that the quality of stocks has deteriorated faster than the volume and value of fish caught. However, it appears that many fisheries remain financially viable due to strong market demand and low opportunity cost of attracting labour into the fishing profession.

Small-scale artisanal fisheries are typically labour-intensive fishing activities, often carried out as one of several income-generating activities. Small-scale, coastal fishing operations have been estimated to account for as much as 75 percent of the total fish catch from the region, although there are no really firm data on this. Regional variations to this figure obviously exist, for example, it is noted in FAO (2001) that some 88 percent of the demersal catch of 0.86 million tonnes in the Gulf of Thailand is taken by medium or large-sized industrial trawlers (i.e. vessels larger than 14 m in length). Catches from small-scale fisheries are regarded to be under-reported in many cases and the overall impact of small-scale fishing activities is not always appreciated. Conversely, industrial vessels represent only a small proportion of overall catches, although their impact on fisheries is more easily monitored and regulated through various administrative and technical means (e.g. vessel registration, gear restrictions, zoning, etc.).

In terms of involvement of people (employment and coastal livelihoods) of the countries covered by this review, the fisheries sector is dominated by small-scale fisheries. Hence, managing the industrial and small-scale fisheries that mostly target coastal fisheries resources needs to take into account both the social, economic and cultural considerations as well as the biophysical and ecological factors. The management of fishing capacity is generally addressed in relation to three key issues now affecting Asia-Pacific fisheries: declining resources, coastal degradation, and the threat of increased poverty in fishing communities.

Subsistence fishing³ still exists in some countries, although this is often confined to freshwater capture fisheries. The bulk of marine fisheries catch is sold, either in local or export markets (i.e. a “cash crop”). Thus, in addition to providing full-time and part-time employment to millions of people directly or indirectly involved in fishing, fisheries contribute to foreign currency generation.

Bangladesh and India

Small-scale artisanal and coastal fishing are important livelihoods in Bangladesh and India. Bangladesh reports about 1.2 million people engaging in full-time fisheries and another 10.2 million part-time fishers. The artisanal fishing sector contributes more than 90 percent of total fisheries landing in Bangladesh. There is almost the same number of non-mechanised and mechanised boats in Bangladesh, both adding up to a total of about 44 000 units. The main fishing gear is gill net, which contributes more than half of the catch, about 37 percent of which are hilsha (*Tenualosa ilisha*), a pelagic fish that school in coastal waters and migrate up river to spawn.

³ “Subsistence fishing” as the term is used here, refers to fishing activities where the catch is largely used for home consumption and is not substantially traded.

In India, there are about 1.45 million fishers, and another 10 million people in fishing related business, including processing and marketing. Fishing is conducted from traditional fishing crafts, motorised boats (most converted from traditional boats) and small mechanised boats. The mechanised fishing fleet contributes about 68 percent of the total marine landing. Common gears used are hook and lines, gill nets and boat seines. About 70 percent of landing comes from the west coast (Arabian Sea), and the rest is from the Bay of Bengal.

About 25 percent of total marine fisheries landing in India consist of demersal species, mainly caught by trawling. The rise in motorised and mechanised fishing gears and the increasing number of offshore fishing vessels is being driven by estimates of potential growth in demersal fishing in these waters. In contrast, the trawl fishery is relatively small in Bangladesh. A total of 80 trawlers were in the fleet in 2002, 44 are shrimp and 36 fish trawlers. Despite this, trawlers contribute about 30 percent of total fisheries landings and the number of large vessels being purchased by fishing companies is increasing.

China

About 1.2 million people are directly engaged in fishing in China and another 280 000 people in processing and marketing. There are about 280 000 small fishing vessels in the marine fisheries. Gears used include trawls, fixed nets, small-scale drift nets, purse seines and other gears. Trawl fishing (both otter trawls and pair trawls) contribute about 45 percent of total landing, with the rest caught by small-scale fishing gears and off-shore pelagic gears. Trawls are used to catch demersal species such as croakers, with the dominant species being the largehead hairtail. There is a large fishery that targets Japanese anchovy and juvenile chub mackerel to supply a large part of the fish used for livestock/fish feed.

Philippines

The Philippines splits the marine fisheries sector into “municipal” (small-scale, using vessels of three tonnes or less) and “commercial” (using vessels weighing more than 3 tonnes) types. Despite this separation the municipal fishing sector clearly consists of commercial fisheries (i.e. catching fish that are destined to be sold). Municipal fishing takes place in inland or coastal waters, using either fixed gears or small vessels, and employs more people (about 676 000 persons) than commercial fisheries, although it contributes only 25 percent of total marine landing. Many gears are used by this sector including gill nets, hook and line, beach seine, fish corral, ringnet, baby trawl, spear and longline. Purse seine, targeting pelagic fish such as round scad, Indian sardines, frigate tuna, skipjack, etc., contributes about half of the entire commercial landing.

Thailand

There are about 57 800 marine fishing households in Thailand, most of which engage in small-scale fisheries. Vessels less than 14 m in length are considered small-scale. In such households, most family members, including women, are involved in fishing, using mainly shrimp trammel nets and crab gill nets or fish traps.

Rapid development of the industrial trawl fishery took place in Thailand in the mid to late 1960s, followed by Malaysia (early 1970s) and then Indonesia. In Thailand, this development meant a tripling of the number of otter board trawls, pair trawls and beam trawls within a period of ten years. By 1989, the number of Thai trawlers peaked at about 13 100 boats. Adding to this was a small number of push nets that targeted demersal fishes. The catch per unit effort declined from over 300 kg/hour in 1963 to about 50 kg/hour in the 1980s, and 20–30 kg/hour in the 1990s. This was accompanied by a decline in mean trophic level of catches in the Gulf of Thailand (Pauly and Chuenpagdee, 2003).

1.3. Fishing in the context of poverty

Fishers and their families in the Asia-Pacific region are often considered to be among the poorest of the poor. These families often have small land parcels unsuited to agriculture or are landless occupying marginal coastal lands. Often the only significant possession is the fishing vessel that supports their livelihood. This is closely linked to their high exposure and vulnerability to accidents, natural disasters and other shocks.

This raises the issue of whether fisher folk are poor because they are fishers or whether they are fishers because they are poor. These two paradigms are shown in Figure 3. The first paradigm in Figure 3 is called conventional wisdom and relates to the open access nature of fisheries that allows more and more people to enter the fishery which, because of the “tragedy of the commons” leads to biological and economical over exploitation of the resource, the dissipation of rent and finally impoverishment of the fishing community. This is the classical Malthusian concept of poverty: over exploitation of the resource results in low catch, which equates with low income and poverty. From this perspective, therefore, the problems lie solely within the fishery sector itself and the solution is better fisheries management.

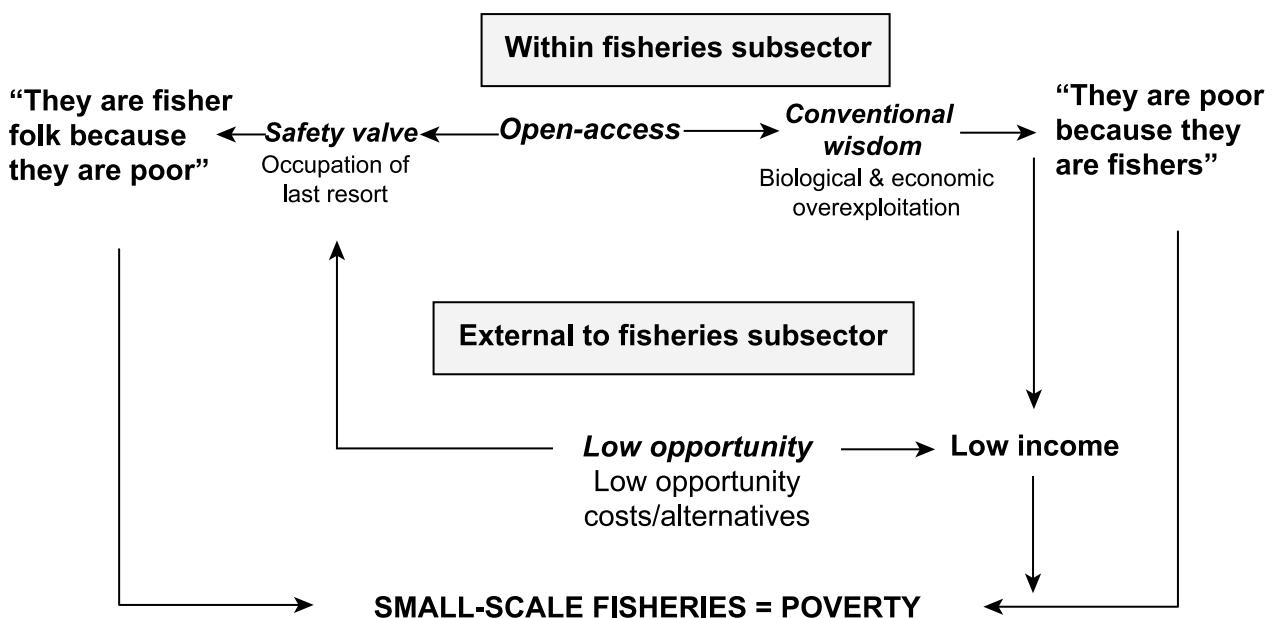


Figure 3: Relationship between small-scale fisheries and poverty as conceptualised in the literature (redrawn after Béné (2002))

The second is the low opportunity paradigm. Poverty is explained by using the concept of low opportunity incomes due to the lack of alternative incomes outside of the fisheries sector that drives (or keeps) fishers' incomes at a low level. Thus the causes of poverty lie outside the fisheries sector and the solution is to improve the economic situation outside the subsector. In this scenario, it is important to note that a small-scale fisheries subsector is extremely mobile, with people moving into and out of fishing, both seasonally and over longer time scales, depending on the relative attractiveness of other activities compared with fishing at any given time.

Linking these two paradigms creates the perception that fisheries, because of its “open-access” nature, as well as lack of alternative opportunities, often offer employment of last resort. Some see this safety valve aspect of small-scale fisheries as a desirable aspect and not necessarily an undesirable attribute as espoused by the conventional wisdom. All these arguments, however, all end up with the same conclusion that “small-scale fisheries = poverty”.

There are considerable difficulties in, firstly, defining who is a fisher and, secondly, what is a fishing community. There is added complexity in measuring poverty in small-scale fishing communities, but despite these difficulties FAO (2002c) has estimated the number of income-poor, small-scale fishers worldwide. Estimates suggest that 5.8 million (or 20 percent) of the world's 29 million fishers may be small-scale fishers, earning less than \$1 per day, the majority of which live in the Asian region. These estimates exclude aquaculture activities. Related activities, such as boat building, marketing and processing, may involve a further 17.3 million income-poor people. These figures suggest an overall estimate of 23 million income-poor people, plus their household dependents, relying on small-scale fisheries, predominantly in Asia (Table 3). It is also probably fair to say that these figures are underestimates.

Table 3: Poverty in Asian small-scale fisheries (1 000 people)

	Asia	World	Share of Asia
% of population on < \$1 per day	25.6%	–	–
Income-poor fishers	4 821	5 759	–
Related income-poor jobs	14 464	17 278	–
Total income-poor	19 286	23 037	84%

Source: FAO (2002c).

Many countries have committed themselves to gradually introducing rights-based fisheries management systems for regulating access to coastal and marine resources. This process is planned to go hand-in-hand with the decentralisation of fisheries management authority and functions to subnational administrative levels, increased participation of the stakeholders and the introduction of co-management. It is assumed that the closer the small-scale coastal fisheries management authorities are to resource users, the better they can accommodate specific socio-economic, political and ecological local characteristics into their particular management systems.

Despite this move towards rights-based fishery, there is still a need to resolve the multiple objective framework of management policies on national and regional levels. Policy goals can often be contradictory and *inter alia* include:

- reduction of user conflicts;
- increase in fish production;
- safeguarding employment and incomes;
- resource sustainability;
- expansion of aquaculture and offshore operations; and
- export promotion.

Although many countries have their own policy, legal and institutional or regulatory frameworks to manage their respective fisheries, these systems are generally based on short-term objectives and goals such as increasing production levels, rather than the long-term comprehensive and sustainable management of fisheries (Vichitlekarn, 2004). In the long run, policy-makers and managers will have to realise that trade-offs will be required to meet the priorities for the country, and priority objectives will have to be agreed.

2. Low value/trash fish in the Asia-Pacific region

2.1. Sources and production trends

While noting the widely divergent definitions of low value/trash fish across the region and the lack of sound statistics, recent estimates of low value/trash fish production obtained through our reviews are tabulated below (Table 4).

Table 4: Estimations of low value/trash fish production in Asia-Pacific (tonnes)

Country	Low value/trash fish	% of total catch	Dominant gear	Year of estimation	Source
Bangladesh	71 000	17%	Gill nets (48%) Non-mechanised set bags (42%)	2001–2002	Uddin <i>et al</i> , 2004
China	5 316 000	38%	Trawl	2001	Han and Xu, 2004
India	271 000	10–20%	Trawl	2003	Jayaraman, 2004
Philippines	78 000	4%	Trawl (41%) Danish seine (22%) Purse seine (12%)	2003	Ramiscal and Chiuco, 2004
Thailand	765 000	31%	Trawl (95%)	1999	Kaewnern and Wangvoralak, 2004
Viet Nam	933 183	36%	Trawl	2001	Edwards <i>et al</i> , 2004

These countries account for over half of the marine capture fish production in the Asia-Pacific region. A weighted average of low value/trash fish across the six countries is 35 percent of the total marine catch. Noting that varying amounts are used for livestock/fish feed in the different countries (100 percent in China and Thailand, by definition, and little in India and Bangladesh), a conservative estimate for the amount of fish used for livestock/fish food in Asia would be in the order of 25 percent of the capture fisheries production. In a separate study, Malaysia estimates its catch of trash fish (i.e. fish not used for human consumption) in 2003 as 32 percent of the total marine capture landings (DOF, 2003).

Using the statistics provided by FAO for capture and aquaculture production in the region, a very approximate “back of the envelope” calculation to trace the flow of fish products through (i) direct human use and (ii) indirect human use through aquaculture can be developed (Figure 4). For 2003, the recorded Asian capture fishery landings was about 39.3 million tonnes (for all carnivorous and omnivorous fish and excluding molluscs and seaweeds) and the latest estimate for discarding is 1.8 percent (i.e. 720 000 tonnes), giving a total capture figure of 40.0 million tonnes. Applying the 25 percent factor to the landed catch gives a figure of 9.8 million tonnes being used for livestock/fish, and 29.5 million tonnes being used for total human consumption. The total aquaculture from Asia for all fish excluding molluscs and seaweeds is also estimated as 28.0 million tonnes. From these figures (summarised in Figure 4) it is clear that the diversion of marine fish via aquaculture is providing a very significant proportion (approximately 50 percent) of the total fish provided to humans (both within Asia and exported to other more developed countries). An increasing proportion of this is high-valued carnivorous species which is increasingly dependent on imported fish meal/oil.

At the local level, prices of low value/trash fish vary depending on species, seasons and abundance of other fish and fishery products. Prices also fluctuate with the demand for fish meal in the livestock

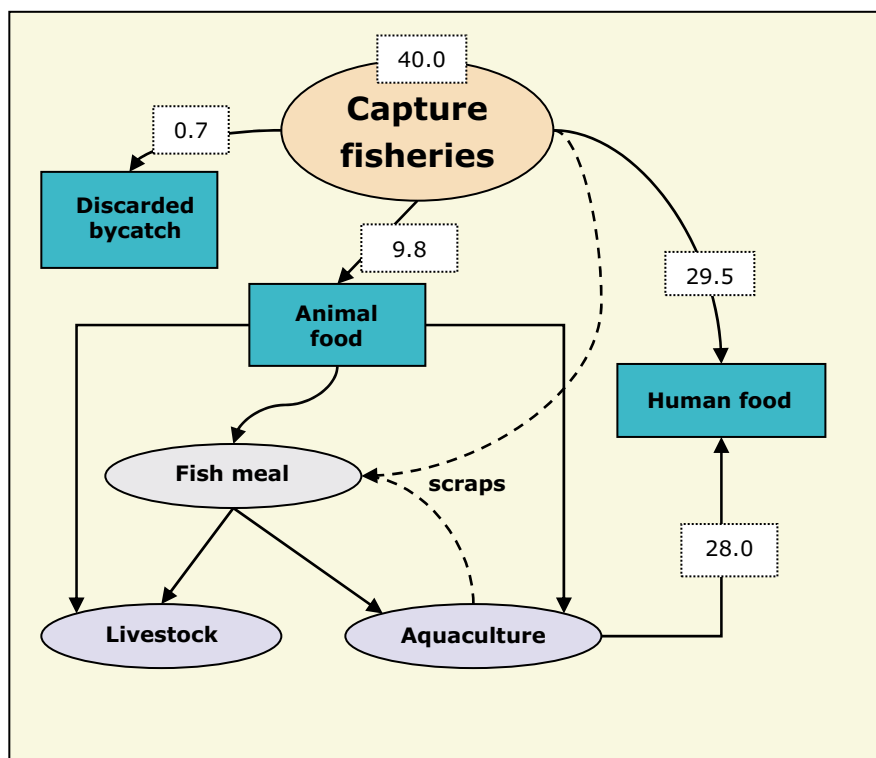


Figure 4: Production flows by major categories of fish in Asia-Pacific (amounts expressed in million tonnes)

and aquaculture industry and the availability of raw materials for fish meal production. At the low end, fresh low value/trash fish has been known to fetch as little as \$0.04 per kg (e.g. Thailand), while its price can be as high as \$1.50 per kg (e.g. India). Prices for low value/trash fish at landing places in Bangladesh range from \$0.08 to \$0.15 per kg. Fish meal producing industries, however, buy low value/trash fish at higher prices (\$0.25 to \$0.35 per kg), depending on the protein concentrations of the low value/trash fish. Because fish traders bring low value/trash fish to the factory to sell, the price includes transportation costs as well as remunerations for fish traders.

Bangladesh

A total of 15 identified fish species and some unidentified species constituted low value/trash fish in 2001/2002. Main low value/trash fish species are sharks (28 percent), rays (15 percent), and crabs (12 percent). The rest are shrimps, kukurjib, cuttlefish and olua. The unidentified species include shrimp species, crustaceans, invertebrates and juveniles of different migratory species. It should be noted that although sharks are shown as trash, they are also targeted by gill nets for their fins, and only their flesh is used as low value/trash fish (although in some artisanal fishing communities it is dried for human consumption). Similarly, ray skin is expensive, but the flesh is trash.

The majority of low value/trash fish (48 percent of total low value/trash fish landing) comes from gill net fisheries, followed by set bag net fisheries with non-mechanised boats (42 percent). About 16 percent of total landings from trawling is low value/trash fish.

China

Hundreds of species of marine fish in Chinese waters can be considered as low value/trash fish. Most of them are pelagic fish and many are small, bony, oily fish that cannot be directly used for

human consumption, such as Japanese anchovy, Japanese pilchard, Pacific herring and sandlance. Some fish species are caught when they are still juveniles, for instance, chub mackerel, filefish, jack and horse mackerel, and Japanese Spanish mackerel. These fish do not attract high market values, and most are, therefore, destined to feed mills. It appears that a lot of these fish are caught in large pair trawls.

Demersal species are also an important part of the low value/trash fish in coastal China. In a recent study on low/value trash fish in two ports in China, it was estimated that low value/trash fish amounted to over 60 percent of the catch from otter trawlers, rising to as much as 90 percent of the total catch in May (Grainger *et al*, 2005).

Before the 1980s, the price of low value/trash fish in China was less than \$0.12 per kg. With the consideration of some pelagic fish species as low value/trash fish, prices have gone up slightly, but are still lower than \$0.20 per kg. The price of Japanese anchovy, for example, has been increasing from \$0.07 per kg in the early 1990s to the current price of about \$0.15 per kg. Because of the use of low value/trash fish in fish meal production, low value/trash fish prices are influenced by the imported fish meal prices. It is predicted that the price of low value/trash fish will continue to rise in the next few years due mainly to the overexploitation of low value/trash fish and other marine resources. Demand for low value/trash fish as major raw materials for fish meal and fish oil production, as well as for direct feeding, will also increase with the expansion of aquaculture. Finally, consumer demand for low value/trash fish will increase as people (particularly those in the low or middle income classes) gradually accept the less expensive fish products that are made from low value/trash fish. In all likelihood, the declining catch and increasing market demand will drive up the prices.

One of the biggest global markets for fish meal is China, where it is used in protein concentrates for livestock and in aquaculture feeds. With 35 to 44 percent protein content, feed producers or farmers mix it with cereals and other nutrients to produce finished feed. The amount of pork and poultry feed is of the order of 18 million tonnes. The use of fish meal in these feeds runs from 4 to 10 percent, although some of these products are occasionally free of fish meal. Using an average of four percent, this translates into an input of 720 000 tonnes of fish meal for livestock feeds. The domestic fishmeal production increased fourfold from 100 000 tonnes in 1992 to 400 000 tonnes in 2002, with peak production of 755 000 tonnes in 1999, due largely to the rapid development of aquaculture. Current demand far exceeds this supply and China is increasingly reliant on imports.

India

Marine fish species like silverbellies, flatfish, ribbon fish, sciaenids, carangids and catfish constitute low value/trash fish in India. Generally big sized catfish, wallago attau and *Mystus seenghala* are consumed readily, but small size fish are considered low value/trash fish. However, such low value/trash fish find ready consumer acceptance in West Bengal and, for example, small size catfish like *Heteropneustus fossilis* are ranked under "choice fish".

In India, prices of low value/trash fish species have not been stable for many reasons. During glut seasons, many species earn a low price and thus fall into the low value/trash fish category. The price of low value/trash fish is likely to go up owing to the ever-widening gap between the demand and supply. Prices also vary according to species. Prices for silverbellies and stomatopods are as low as \$0.06 to \$0.15 per kg. Others, such as rays, eels, clupeids, sciaenids, ribbon fishes, flat fishes and crabs, fetch higher prices (\$0.20 to \$1.50 per kg), depending on their quality and sizes.

Philippines

Marine low value/trash fish are grouped into two categories: the commercially known fish that are too small for the fresh fish market and the non-commercially known species both in adult and juvenile forms. The commercial low value/trash fish group from demersal fisheries consists of fish in the following groups: slipmouths, lizardfishes, goatfishes, mullets, mojarras, flatfishes and glassfishes. Non-commercial fish groups consist of cardinal fish, puffer fish, trigger fish, trumpet fish, flying gurnards, goby fish and filefish.

Landings of low value/trash fish in the Philippines result mainly from the use of demersal gears. About 41 percent of total low value/trash fish landings are caught by trawls, 22 percent by modified Danish seine, 12 percent by beach seine, and 4 percent by push net. Modified Danish seine operate similarly to trawls and thus result in relatively high percentages of low value/trash fish. Beach seine and push nets are operated in shallow waters and, due to their poor selectivity, they catch many juvenile fish and other species.

The retail price of fresh low value/trash fish of small-sized commercially important species in the Philippines is about \$0.70–0.90 per kg. Low value/trash fish sold directly to fish farms get lower prices (\$0.05–0.27 per kg). Prices for sun-dried low value/trash fish vary from as low as \$0.05–0.09 per kg to as high as \$1.42–1.78 per kg, depending on species, size and market location. The higher priced fish, for example, are sold at Metro Manila, whereas the lower priced fish are found near the landing sites.

Thailand

During 1995–1999, low value/trash fish production of trawl fisheries was composed of at least 35 species, 9 of them were small species and the other 26 species were juveniles of high value fish (9 pelagic species and 17 demersal species). Other aquatic species such as cuttlefish, shrimp, krill and crab were also taken. There were 14 species of low value/trash fish from push net fisheries, i.e. 3 species of small fish and 11 species of juveniles of high value fish (5 pelagic species and 6 demersal species).

In terms of landing by gears in Thailand, about 95 percent of total low value/trash fish landing comes from trawl fisheries, and about 45 percent of trawl landings is low value/trash fish. Otter board trawls contribute about 75 percent of total low value/trash fish, followed by pair trawls (19 percent). The other demersal fishing gear that catches some low value/trash fish is the push net (about 1.4 percent). In addition to trawls and push nets, purse seines contribute about 3 percent to the total landing of low value/trash fish.

Ex-vessel prices of low value/trash fish in Thailand vary slightly from \$0.04–0.07 per kg depending on the season. High prices for low value/trash fish are generally obtained during January to May, and during August and September. This is probably due to low value/trash fish production during the dry season and during periods of strong monsoonal winds. It is likely that the price of low value/trash fish will continue to grow given the high demand from the fish meal industry and expanding cage-fish culture operations.

In the Gulf of Thailand, the proportion of low value/trash fish in the fishery statistics has steadily increased and has reached about 60 percent of the total catch (FAO, 2001). A significant part of this low value/trash fish is made up of juveniles of commercially important species that could produce a more valuable catch if the juveniles were given time to grow to adulthood. The total catch of the demersal fisheries in the Gulf of Thailand in 1997 was about 1.4 million tonnes, which was composed of 800 000 tonnes of food fish (for human consumption) and 600 000 tonnes of low value/trash fish (used for fish meal and oil).

Foreign trading of low value/trash fish in Thailand can be related to the production of fish meal. In the past, more than 50 percent of domestic fish meal was exported to other Asian “countries/provinces”, especially Singapore, Malaysia, Indonesia and Taiwan Province of China. However, due to the increase in the domestic livestock industry, changing policy towards livestock production in Singapore and availability of exporters such as Chile and Peru on the world market, the export amount of fish meal decreased sharply from 73 000 tonnes in 1987 to only about 1 670 tonnes in 1994. Recent government data indicates that the volume of fish meal exported from Thailand has since been increasing. In 1997, the total amount of exported fish meal increased from 1 240 tonnes (\$0.57 million) to 19 000 tonnes (\$10.8 million) in 2002. Besides export, some fish meal is also imported to support the animal feed industry in Thailand, especially chickens where a significant proportion is exported. Data indicates that total amounts of imported fish meal were high over several years. In 1997, 1999, 2000 and 2001, the total amount of imported fish meal, and value, for each year was higher than 64 000 tonnes (\$31.1 million).

Viet Nam

There are conflicting data on the volume of low value/trash fish landed. The inshore fishery in Viet Nam is heavily overfished but the total fish catch, as well as the proportion of biomass of trash in the total catch, continue to rise (Edwards *et al*, 2004). There has been a dramatic rise in the use of low value/trash fish in aquaculture with a probable doubling of its price, indicating a finite supply.

The Vietnamese Ministry of Fisheries estimated production of 200 000 tonnes of low value/trash fish from a total catch of 1.4 million tonnes in 2002, or 14 percent of the total. This represents “real” low value/trash fish, not including another 200 000 tonnes of more valuable small species such as leatherjacket and pony fish, formerly considered as low value/trash fish. Another 20 percent of the catch would be small individuals of fish such as grouper which would be a valuable species if large, leading to a sum of about 50 percent for low value/trash fish in the broadest sense of the term in the total catch.

There are over 100 species of marine low value/trash fish that are used as an aquaculture feed or aquaculture feed ingredient in Viet Nam. Fish comprise the greatest share, but low value/trash fish also includes small molluscs, crustaceans and echinoids. The composition of low value/trash fish also varies depending on the type of gear used to fish, but most is from trawling, hence one of the common names in Vietnamese for low value/trash fish, “trawling fish”. Composition also varies by area or region. The major low value/trash fish species by area are anchovy in the central and southwest, lizard fish in the north, central and southeast and pony fish in the central and southwest. The relative abundance of low value/trash fish is also highly seasonal. Low value/trash fish comprises mainly demersal species, but pelagics may be used when fish landings exceed local marketing or fish processing capacity. Spoiled higher value species may also be used as low value/trash fish.

In Viet Nam there is intense competition for fish for direct human consumption, fish sauce manufacture and direct feeding to fish. The current price of low value/trash fish is rather high for fish meal production because of such competition, estimated to be around \$0.06–0.19 per kg. Prices for anchovy to feed grouper and lobster can be as high as \$0.19–0.38 per kg. If the price of low value/trash fish continues to increase, even existing fish meal plants may not be financially viable.

Low value/trash fish used to comprise only 30–40 percent of the catch from trawling, but has risen to 50–60 percent, and even up to 80 percent in the southwest region according to provincial records. Furthermore, fishing boats need to fish at increasing distances and for longer periods of time. An interesting finding, however, is that overfishing has seemingly reduced the grazing pressure on low value/trash fish by larger predatory fish, leading to a growth in the low value/trash fish biomass.

2.2. Uses

Low value/trash fish (using our broader definition) are important food sources for poor people in various community groups living along the coastal areas. Small-scale fisher folk generally keep low value/trash fish for home consumption, after selling other fish with high market demand. Some of the low value/trash fish are consumed fresh, some are dried. Drying is a general practice used to preserve fish to avoid spoilage and for easy distribution. Bangladesh reports, however, some health concerns about drying due to the use of chemicals and pesticides to cure the products. Consumption of dried fish has also been a long tradition in the Philippines and Thailand. The proportion of low value/trash fish for human consumption can be quite high, e.g. in Bangladesh about 60 000 tonnes of the total 71 000 tonnes of low value/trash fish landed are consumed either directly or as dried forms. In China, low value/trash fish have traditionally been used as a main ingredient to supplement the daily diet with protein (FAO, 2002c). A significant factor that determines how low value/trash fish are used is the location of the landings and the available infrastructure to deal with these landings.

Many countries report that some low value/trash fish are used as direct feeds for livestock and aquaculture. In China, both fresh and frozen low value/trash fish are used directly to feed cultured animals, such as shrimp, crab or fish species in small farms, especially when formulated feed are not available or prices are too high. The Philippines and Thailand use low value/trash fish as direct feeds for grouper and mud crab culture to enhance growth. In the Philippines, some portions are also given to tilapia, prawn and milkfish in grow-out ponds as supplement feeds by pond owners.

In Asia, utilisation of low value/trash fish for fish meal production varies between countries. The extent of fish meal production and use is sometimes difficult to estimate, and often the most reliable estimation method is to back calculate from aquaculture production statistics (Edwards *et al*, 2004). Large-scale manufacturing of fish meal using low value/trash fish as raw materials is prominent in Thailand and the Philippines. A small-scale and household production is found in Bangladesh, where the poultry sector dominates utilisation of fish meal. Currently, there are 35 established poultry feed producing plants, producing about half of the poultry feed used in the country. The other half comes from smaller scale, household level producers located around the country. The production has declined in India owing to the increased emphasis on export of high quality fish and fishery products. China, on the other hand, is developing this new industry to respond to the growing demand from aquaculture and poultry sectors. The importance of fish meal in animal feed production is given further attention in Section 3.2.

There is no report on direct use of low value/trash fish for fertilisers both in agriculture and aquaculture. However, decomposed uneaten low value/trash fish used as direct feeds may accelerate natural food bloom in the pond. Use of low value/trash fish for fish oil is reported in India and Bangladesh. It is likely that some cheap fish oil, e.g. from sardines, is produced to use as raw material in shrimp feed production.

In Bangladesh, fish oil is produced at the household level, using crude methods of boiling the guts/parts of mainly shark and hilsha. In Thailand and the Philippines, assorted low value/trash fish species (defined here as low-value species) are used as raw materials for fish sauce production, together with other pelagic fishes, like roundscad, sardines and anchovy. An estimate from the Philippines suggests that about 25 tonnes of low value/trash fish is used in a small fish sauce processing plant for 6–7 months of the fermentation process.

Table 5 outlines some of the most common uses of low value/trash fish in the Asia-Pacific region. There has been considerable innovation in recent years in an attempt to utilise previously unwanted bycatch, especially from shrimp trawl fisheries and from finfish trawlers. Many of these activities have been the result of bycatch utilisation programmes supported by governments, research, or development agencies, while some have been driven primarily by the market.

Table 5: Examples of low value/trash fish use in the Asia-Pacific region

Country	Human consumption	Direct animal feed	Fish meal	Fish oil	Other
Bangladesh	Direct consumption, often dried	No record	Poultry feed	Sporadic production for fish feed	–
China	Innovation in new products (e.g. fish meat filling), dietary protein supplement	Poultry, livestock, shrimp, crab and fish	Relatively new, but production has increased dramatically due to aquaculture demand	No record	Some use as fertiliser to enrich primary production in ponds
India	Increasing consumption levels, fresh or dried	Some used for fish and poultry	Poultry feed, production declining due to increase in direct consumption	Shrimp feed production	–
Philippines	Consumed directly, fresh or dried (as much as 50 percent of low value/trash fish)	Aqua farms (e.g. crab, grouper)	Demand as poultry and animal feed	No record	Fish sauce
Thailand	Some low value/trash fish are processed (e.g. dried) for human consumption	Chicken, duck and pig feed. Aquaculture (e.g. crab, grouper)	Dominant use of low value/trash fish (as much as 90 percent), especially poultry feed. Recent decrease due to use of surimi processing waste	No record	Fish sauce
Viet Nam	Direct human food (e.g. sun dried)	Livestock (pigs) and coastal aquaculture feed	Fish powder, artisanal and industrial processing, mainly for pigs and poultry feed. Increasing demand due to aquaculture	Mostly imported	Fish sauce

Uptake of value-added products from bycatch has been successful in the region, particularly with the introduction of surimi technologies. In this regard, further product development will likely play an important role in bridging the gap between fish supply and demand in many developing countries. FAO (2003) draws on a forthcoming FAO technical paper *Utilisation and marketing of fisheries bycatch products: Indonesia, Malaysia, Philippines and Thailand* that examines the bycatch landings in the region, in terms of species composition, volume, and the handling and processing of bycatch based products. Marketing channels, production costs, profit margins and consumption of a range of products (e.g. fish meal, fish crackers, fish balls, fish sauce, dried fish and surimi) are also considered. This information will help shed light on the economic implications of utilising bycatch and low value/trash fish at various levels in the production chain in different Asia-Pacific countries.

The levels of poverty in many countries, in addition to rising population levels and increasing pressure on target species, suggest that markets for bycatch are increasing, thereby helping to make discard reduction in the form of bycatch utilisation increasingly economically feasible (FAO, 2003). Shrimp trawlers are also interested in developing bycatch markets due to falling profitability from shrimp trawl

operations, and seasonal fluctuations in shrimp catches that allow for retention of finfish at certain times without any impact on storage capabilities of shrimp. In Asia-Pacific (especially Thailand, Malaysia, Philippines and Myanmar), many species have been found to have suitable gelling properties for the production of surimi products. Other developed products, or in the process of being developed, include fish mince, fish noodles, fish flakes, fish pickle, fish satay and fish jelly.

China, however, leads other countries in advancement of the processing technology to fully utilise low value/trash fish by transforming them into various food products that are gaining public acceptance. Fish meat filling products are the most important food products that use low value/trash fish as raw and processed materials. Fish meat filling is a kind of low fat and digestible complete protein, used as a key ingredient in products such as fish steak, fish balls and fish cakes. Processed products from low value/trash fish are considered good animal protein. As they are well processed with no fish smell, they play an important role in supplemental nutrition for children (e.g. protein hydrolysates and fish protein concentrates).

In some countries there is resistance to sophisticated market development. In Bangladesh, consumers are traditionally more accustomed to freshwater species and there are many religious restrictions on consuming different fish species. In India, fresh and salted/dried fish are the only popular products seen in the domestic market, partly because some value-added surimi products are being produced for the export market, thereby restricting supply on the local markets. In Indonesia, processors have been reluctant to invest in value-added technology because salted fish is the main market demand, and investment costs are thought to be high (FAO, 2003).

FAO (2003) further highlights some problems of product development, namely:

- variable quantities and species mix of bycatch, which means that value-added products may vary in texture and taste;
- significant price that may be needed to encourage vessels to land bycatch in a suitable condition, and the fact that this price then makes bycatch expensive; and
- difficulties associated with promoting new products and responding to what the consumer wants.

Box 1: The Vietnamese case

In Viet Nam, the Ministry of Fisheries estimates the percentage use of the marine finfish catch to be as follows:

- Export – 20 percent
- Fresh human consumption in Viet Nam – 20 percent
- Feeding to animals (livestock, aquaculture) and fish meal – 25 percent
- Fish sauce – 25 percent

In this respect, there are several different uses for low value/trash fish:

- Fish sauce
- Direct human food
- Livestock feed
- Aquaculture feed

Processing low value/trash fish for surimi is a recently developed process, but aquaculturists can pay more for low value/trash fish than processors of surimi. Pigs in coastal areas are traditionally fed low value/trash fish with rice bran, water spinach and banana stems. The most recent use of low value/trash fish in Viet Nam is for coastal aquaculture, the development of which depends on low value/trash fish. The demand for low value/trash fish for cage culture is a contributory factor to the recent doubling in the price of low value/trash fish. The price of low value/trash fish for fish meal production is rather high because of competition for it for fish sauce manufacture and more recently from direct use in fish culture. Previously, low value/trash fish was also used as a crop fertiliser.

There are two types of fish meal in Viet Nam: “fish powder” produced in a traditional artisanal way by sun-drying and grinding; and fish meal product using an industrial process in which raw materials are cooked before being dried. Fish powder is mainly used to feed livestock (pigs and poultry). Total production of fish powder was estimated to be about 185 000 tonnes and industrially produced fish meal of about 80 000 tonnes with a capacity of 100 000–130 000 tonnes.

Feed mills in Viet Nam only use domestically produced fish meal for livestock and some freshwater fish for grow-out feed as it is generally of poor quality. Fish meal is produced from low value/trash fish, low value fish (e.g. sharks), spoiled fish and processing wastes. Over 500 000 tonnes of fish are processed producing 300 000 tonnes of processing by-products. Fish meal for higher quality feed for fish fingerlings and crustaceans is imported and represents about 90 percent of the total fish meal used. Fish oil for aqua feed manufacture is also imported. Future demand for fish meal is expected to increase dramatically as aquaculture production increases and some species, such as catfish, are increasingly fed pelleted diets containing fish meal. While high market value species such as grouper, lobster and shrimp may be able to compete for fish meal on the local market, catfish and tilapia will need to be fed increasing amounts of plant-based proteins.

There are competing uses for low value/trash fish for livestock feed, fish sauce and direct human food, as well as for aquaculture feed and fish meal. Another common name for low value/trash fish is “pig fish” as it is used in traditional small-scale pig rearing at the household level. However, large-scale pig farming uses formulated feed and competes for fish meal. The species defined as low value/trash fish are also changing as some species previously considered to be low value/trash fish are now being used as human food fish because of advances in processing technology. An example is leatherjacket, a bony fish that was rarely eaten in the past but can now be de-boned and sun-dried for export.

3. Issues associated with low value/trash fish

3.1. Overall drivers

The issues related to low value/trash fish landings from multi-species/multi-gear fisheries in the Asia-Pacific region are underpinned by the rapid development of the aquaculture industry and the increasing demand for fish by consumers. The fisheries that have evolved under these two pressures represent new challenges for sustainable fisheries management in the region. Several issues concerning low value/trash fish need to be resolved in order to ensure that fisheries of the Asia-Pacific region contribute more to the region's sustainable development. These include:

- increasing use of low value/trash fish for aquaculture and other animal feeds;
- competition between use of low value/trash fish for fish meal versus use of low value/trash fish for human food;
- sustainability of the current system;
- amount of fish that becomes trash due to poor handling and post-harvest strategies;
- growth overfishing – harvesting of juveniles of commercial species; and
- discarding of unwanted fish.

3.2. Increasing use of low value/trash fish for aquaculture and other animal feeds

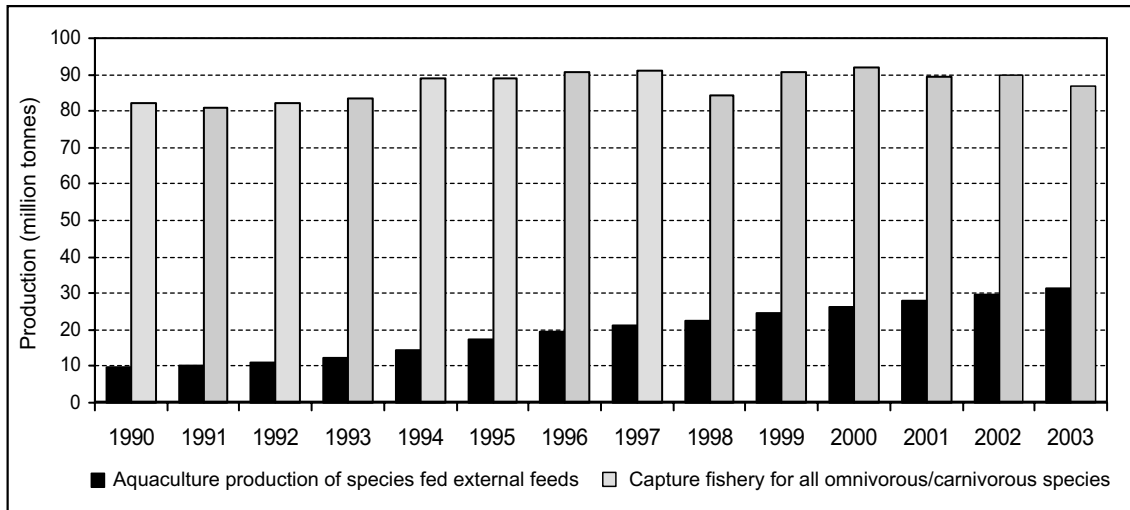
Recognising the potential effects of declines in the marine capture fisheries, many governments in the region have turned to aquaculture as a means to increase fish supply, provide employment and generate foreign income. On the one hand, aquaculture development can be seen as a viable option to utilise low value/trash fish and yet, on the other hand, it is contributing to increasing fishing pressure on the already overexploited fish stocks in the region.

It is currently acknowledged, by both scientists and managers, that coastal resources are being “fished down the food chain” and the percentage of low-grade low value/trash fish has risen considerably in recent years. Over the last decade, the price of low value/trash fish has also 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 (and well as a source of affordable food). Given that aquaculture is predicted to grow while capture fisheries remain stable, it will become increasingly more difficult to meet the demand for low value/trash fish.

World aquaculture production of fish, crustaceans and molluscs reached 42.3 million tonnes in 2003, excluding 12.0 million tonnes of seaweed. Aquaculture by China – the largest producer – amounted to 29.8 million tonnes. Other major producing countries in 2002 were: India (2.2 million tonnes), Indonesia (9 993 000 tonnes), Bangladesh (857 000 tonnes) and Thailand (771 000 tonnes), cf. Figures 5 and 6 (FAO, 2005).

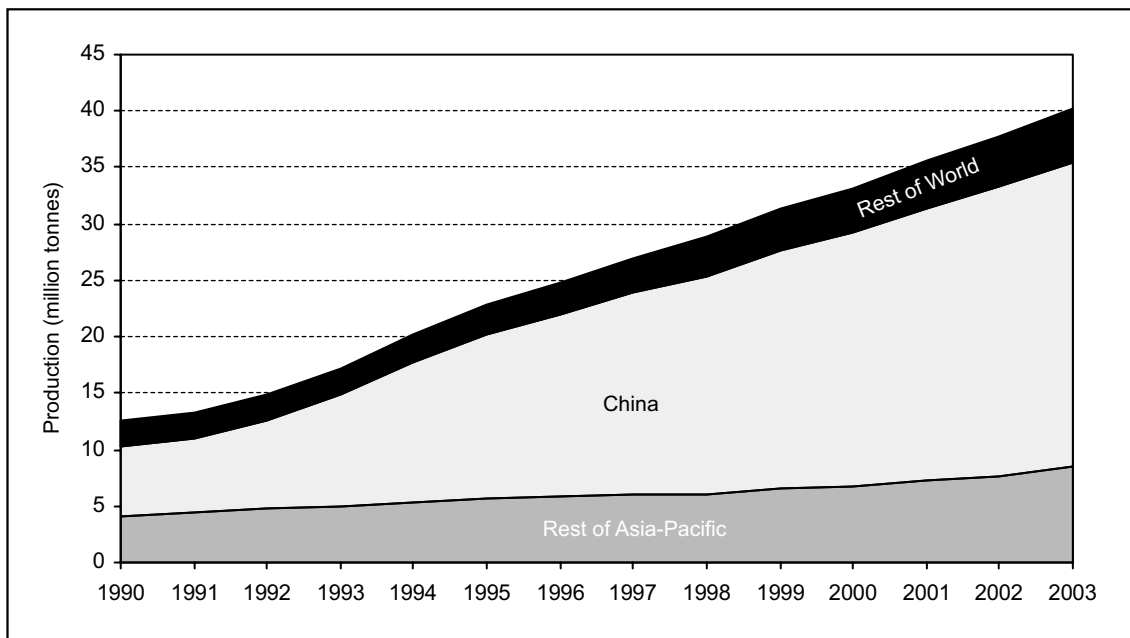
In 2003, a total of 10 producers from the Asia-Pacific region are in the top 20 marine producers while 13 are in the top 20 for inland areas (Table 6).

FAO estimates that an annual global production increase of 3.3 percent until 2030 is feasible in the aquaculture sector (FAO, 2002c). IFPRI (2003) gives an estimate of some 2.8 percent until 2020. The production of high-value species will increase the most given the rising demand for these fish products. The biggest rise in production is expected to be in China. However, the expansion of



Source: FAO (2005) and FAO database.

Figure 5: Aquaculture and capture fisheries production (million tonnes)



Source: FAO (2005) and FAO database.

Figure 6: World aquaculture production (million tonnes)

aquaculture is dictated by a number of factors. The availability of suitable ecosystems and clean water, the role of pollution linked with intensive aquaculture and options for increasing fish density will all have an important impact on possible expansion. One of the main constraints on increasing aquaculture production is the development of cost-effective feeds and feed strategies (Edwards *et al*, 2004).

In April 2000, the Bangkok Declaration on Aquaculture Development Beyond 2000 recognised that:

“A great proportion of aquaculture production comes from developing countries, where aquaculture will continue to contribute to peoples’ livelihoods, food security, poverty alleviation, income generation, employment and trade.”

Table 6: Aquaculture production 2003 (1 000 tonnes)* – Top 20 producers

Marine/brackish water areas			Inland areas		
Country/Province	Production	World ranking	Country/Province	Production	World ranking
China	11 149	1	China	17 743	1
Japan	809	2	India	2 102	2
Indonesia	519	5	Bangladesh	766	3
Thailand	453	6	Viet Nam	548	4
Viet Nam	390	8	Indonesia	477	5
Republic of Korea	374	9	Thailand	320	7
Philippines	305	10	Myanmar	238	8
Taiwan Province of China	144	16	Taiwan Province of China	208	9
Malaysia	117	18	Philippines	155	11
India	113	19	Iran	84	13
			Lao PDR	65	14
			Japan	50	17
			Malaysia	50	18
Subtotal	14 373	–	Subtotal	22 807	–
World total	18 063	–	World total	24 241	–
Share of World	79.6%	–	Share of Subtotal/World	94.1%	–

Source: FAO (2004b) and FAO database.

Note: * Excludes aquatic plant production.

Developing countries will continue to export high value products (e.g. brackish-water shrimp, marine finfish and pellet-fed tilapia) and import or domestically produce fish of lower value for consumption (e.g. carp and mussels). Coastal aquaculture, particularly farming of brackish-water shrimp and carp culture in freshwater ponds, has developed rapidly. In many areas, these culture practices have been transformed from extensive systems to semi-intensive and intensive culture systems, where large amounts of feeds are required.

There is concern that the rapid expansion of aquaculture may be constrained in the future by dependence on low value/trash fish and fish meal which are used as aquaculture feed ingredients (Tidwell and Allan, 2001 and New and Wijkström, 2002). There has been a prominent debate of the relevance of the so-called “fish meal trap”. It is well known that the preferred protein source in most aquaculture feeds is fish meal. This implies that the natural limits of the supply of fish meal and oil will in the future restrict the development potential of global aquaculture, since the culture of many species rely on fish meal and oil for growth. Some regard this to be only partly relevant in the shorter term, as aquaculture is only one competitor for global fish meal supplies. The demand for livestock is still greater than aquaculture, although this is gradually shifting. A second consideration is that the fish meal component of feeds could be replaced by vegetable protein (e.g. soya) or mono-cellular proteins. An impact in the longer term of such replacement will tend to be lower growth rates of cultured fish (fish-based feed contain higher quality proteins resulting in greater growth if compared to vegetable-based feed). Prices of fish meal and oil will also tend to rise as competition between the aquaculture and livestock sectors increases (it is perhaps worth noting that chicken, cattle and pigs do not naturally feed on fish and therefore the inclusion of fish meal in feeds for these animals is a nutritional/economic convenience rather than absolute necessity – the same cannot be said for carnivorous fish!).

However, if one accepts that supplies of low value/trash fish are declining and prices are increasing, the Asia-Pacific countries may need to increase imports of fish meal from the global fish meal market for the aquaculture industry, or replace them with other feed materials, including plants and other protein supplement. The replacement of fish meal in aquaculture diets is hence a major international research priority.

Countries like Thailand, China and the Philippines rely more heavily on low value/trash fish as raw materials for aquaculture feed, compared with India and Bangladesh. As there are constraints to semi-intensive and intensive forms of aquaculture in Bangladesh, demand for low value/trash fish as fish meal is likely to remain low. Fish meal and oil is today traded on a global market, where prices are being determined by global supply and demand. Peru and Chile are the world's leading producers of fish meal and oil and the Pacific fisheries of these countries are essential for sustaining the global supply. This supply is heavily affected by the El Niño phenomenon. Hence, in 1998 and 2002 for example, supply was low and global prices were high. The high prices of fish meal compared to other inputs (e.g. around \$0.80 per kg while snail meat costs only about \$0.08 per kg) is also another factor limiting growth. The proportional use of fish meal and oil for global aquaculture has also risen dramatically in recent years. Wada *et al*/(2004) show that in 1988, some 10 percent of fish meal and 16 percent of fish oil were used for aquaculture purposes. By 2000, this had risen to 35 percent and 54 percent, respectively. The expected expansion of aquaculture will place further pressure on global demand and prices.

China

Prior to the 1970s, the main species cultured in Chinese marine fishing areas were seaweeds and molluscs, while herbivores and filter-feeding fish species (e.g. Chinese carp) dominated freshwater aquaculture. There were no feed manufacturers for aquatic animals. With the introduction of high-value species (e.g. shrimp) in the late 1970s, the home-based feed processing model quickly failed to meet the increasingly high demand for high-quality feed, and this stimulated the development of the fish feed industry. The development of the feed industry further induced the private sector to engage in the farming of more high-value species in the late 1980s and early 1990s, resulting in the expansion of aquaculture output. Here, feed related issues have been alleviated through the sponsoring of research in feeds and nutrition, the establishment of a regulatory framework for the development of the feed industry, and the provision of economic incentives to investors (e.g. preferential tariffs on raw materials for feed manufacture). This policy has been in line with the overall government policy of pushing for the Chinese population's full participation in the economic life of the country, including the aquaculture sector, where the primary goal has been fish self-reliance (FAO, 2002c).

The rapid expansion of the aquaculture and poultry industries has resulted in the development of fish meal manufacturing plants in many parts of China. At the beginning, much of low value/trash fish used for fish meal production were unidentified fish species, but now Japanese pilchard and Pacific herring are mostly used, along with other low value/trash fish species such as Japanese anchovy, Japanese sandlance, sardine, catfish and black scraper. As raw materials are limited and demand is high, most feed manufacturers accept any species that are available. In China, there are currently about 12 000 feed mills producing various kinds of animal feeds, including fish feed. Of these, about 1 900 have a production capacity exceeding five tonnes per hour. The state still plays an important role in the production of feed for aquatic animals and owns slightly more than 47 percent of the mills, although this is down from 99 percent in 1990 (FAO, 2002c). In the last ten years, domestic fish meal production has increased fourfold from 100 000 tonnes in 1992 to 400 000 tonnes in 2002, with production peaking in 1999 at 755 000 tonnes. This production, however, is not sufficient to cover the high demand and thus China has become the biggest importer of fish meal in the world.

It is estimated that about 13 to 18 million tonnes of formulated feed are needed, but domestic production is still at around 5–6 million tonnes. The imported amount is reported to be as high as one million tonnes. The Chinese government has been very concerned about resource overexploitation and thus has restricted marine fishing. This has resulted in the decline of low value/trash fish landings, which consequently affects fish meal and fish oil production. The government policy seems to conflict with this resource conservation, however, as there is also promotion of the transformation from omnivorous freshwater fish culture to high value carnivorous species. Requirements for low value/trash fish and fish meal for aquaculture will certainly increase, while competition will increase in other countries that are also expanding their aquaculture industries.

India

Increasing emphasis on export promotion in India has led to the development of aquaculture, although there is very strong domestic demand for freshwater fish. Aquaculture shrimp production has steadily increased and reached 114 000 tonnes in 2001. As the trend continues, use of low value/trash fish for fish meal production is likely to expand. Estimates of fish meal used to produce shrimp in 2001 were 41 000 tonnes and 200 000 tonnes per year for Indian major carp. Using these estimates and considering that the trend is likely to continue, about 270 000 tonnes of low value/trash fish may be needed to produce fish meal for aquaculture in India.

Philippines

Following the trend in the past ten years of aquaculture development in the Philippines, an annual growth of 6 percent is expected. This level is expected to be sustained, as the government has focused on promoting this sector to supplement marine capture fisheries landings. It is estimated that about 226 000 tonnes of low value/trash fish is needed for fish meal production and direct feed in aquaculture. Considering that domestic production of low value/trash fish is only about 78 000 tonnes, a significant proportion of fish meal used for aquaculture must be imported. It is also likely that a substantial part of feeds used in aquaculture are natural (or supplemental) rather than complete formulated aquafeeds.

Thailand

Fresh low value/trash fish are used to directly feed sea bass and grouper in cage culture on the Gulf and Andaman coastlines of Thailand. Production is 9 262 tonnes, which implies a low value/trash fish requirement of approximately 65 000 tonnes (FCR⁴ of 7:1 fresh to fresh). This amount is relatively small when compared to demand of fish meal from coastal aquaculture, especially brackish-water shrimp farms. An estimate of fish meal needs for aquaculture production is about 248 000 tonnes per year. As in other countries, use of feed substitutes, such as soybean, have been increasing and will influence the demand for low value/trash fish.

Demand for low value/trash fish depends largely on demand for livestock and aquaculture feeds. Approximately 51–68 percent of fish meal production is used in the domestic feed industry every year. The rest of the production is exported. Domestic fish meal demand and price have been increasing due to the expansion of the marine shrimp culture industry. In 1987, domestic uses of fish meal were 273 000 tonnes and increased to 734 000 tonnes in 1994. The average growth rate during that period was approximately 15.4 percent.

⁴ Food conversion ratio.

The Animal Feed Producers Association reported in 2003 that 606 000 tonnes of low value/trash fish were used as raw material for animal feeds, 41 percent of which was used for aquatic animal feed, while 22 percent and 20 percent were used for chicken and pigs, respectively.

Viet Nam

There has been a dramatic rise in the use of low value/trash fish in aquaculture with the development of marine cage culture of grouper and lobster, and the expansion of *Pangasius* species culture in cages, ponds and, more recently, pens.

There are no official data on the use of low value/trash fish in the aquaculture industry in Viet Nam although an estimate can be made from the farmed production of species that are fed low value/trash fish. Most recent estimates of low value/trash fish used for inland and coastal aquaculture ranged from 64 800 tonnes to 180 000 tonnes and 71 820 to 143 640 tonnes, respectively. The total amount of low value/trash fish used for aquaculture in Viet Nam was estimated to be between 176 420 and 323 440 tonnes. There is concern that in the future the rapid expansion of aquaculture may be constrained by increasing dependence on low-value marine low value/trash fish and fish meal. From a reported aquaculture production of 0.65 million tonnes in 1999, the Vietnamese government is planning for production to double to 1.15 million tonnes by 2006, and triple to two million tonnes by 2010 (cf. Appendix 2 for further insight).

The price of low value/trash fish has risen over the last 3–5 years. The main reason for this is the increasing demand for low value/trash fish for feeding fish and livestock. Future expansion of aquaculture using local supplies of low value/trash fish is likely to be constrained with grouper farmers already reporting that they could not afford to buy it when the price rises. It appears that farmers raising higher value lobster can still afford to purchase relatively expensive low value/trash fish. At least 90 percent of fish meal is imported. Some 150 000–200 000 tonnes of fish meal will be required over the next decade for aquaculture, two to three times the present level of use. However, the price of imported fish meal continues to rise. Furthermore, there is an increasing trend to use pelleted feed because of poor water quality in culture using “home-made” or “farm-made” feeds based on raw fish and/or crustacean by-products. Almost all shrimp culture is based on pelleted feed and the proportion used by *Pangasius* catfish farmers has reached 10–20 percent. Attempts are also being made to feed marine finfish and lobster with pelleted feed.

3.3. Competition between use of low value/trash fish for fish meal versus use of low value/trash fish for human food

There is also an increasing conflict between the use of low value/trash fish for animals/fish and for human consumption. Supplies of low value/trash fish are finite, and as indicated by a recent increase in price, demand is outstripping supply. It has been argued that it would be more efficient and ethical to divert more of the limited supply to human food, using value-added products, etc. Proponents of this suggest that using low value/trash fish as food for poor domestic consumers is more appropriate than supplying fish meal plants for an export income oriented aquaculture industry, producing high value commodities. On the other hand, food security can also be increased by improving the income generation abilities of poor people, and it can be argued that the large number of people employed in both fishing and aquaculture has this beneficial effect, via income generation, rather than direct food supply.

Without external interventions (such as incentives and subsidies) it will be the economics of the different uses of low value/trash fish in different localities that will divert the fish one way or the other. For example, in Viet Nam, as the national demand for fish sauce is predicted to double over the next 10 years, there appears to be direct competition for mixed low value/trash fish between *Pangasius*

feeds and those needed to make low-cost fish sauce. By contrast, culture operations for high value marine finfish and lobsters can afford to pay more for anchovy than fish sauce manufacturers in central Viet Nam. Traditional small-scale pig rearing uses low value/trash fish but large-scale pig farming uses agro-industrial formulated feed containing fish meal.

3.4. Sustainability of the current system

As a result of the expansion of aquaculture (and local livestock production), low value/trash fish has a ready market and can be sold easily in many localities. This can then be converted into higher-grade fish/crustacean (and livestock), some of which are sold at good prices. Hence, there seems to be little incentive to discourage the harvesting of low value/trash fish given their important contribution to aquaculture, overall employment and consequent export earnings. Also, the low value/trash fish catch is based on a large number of short-lived highly productive species for which, apart from targeted low value/trash fisheries in China, there is little evidence of current overexploitation leading to a reduction in overall fish production. The demand for low value/trash fish has led to increased levels of low value/trash fishing by small-scale vessels in particular, and is now an important reason why many vessels can continue to be economically viable and remain in fisheries.

It has been argued that overfishing has reduced the grazing pressure on small fish by larger predatory fish, and small species have increased in abundance, for example pony fish. It is indeed a rather interesting notion that overfishing in the region has allowed the biomass levels of low value/trash fish to improve. The current situation also results in little apparent wastage from the ecosystem (i.e. no discarding). However, it should be acknowledged that there is little available evidence of what impacts the current (and probably increasing) exploitation are having on the overall ecosystem.

The concern, to both fisheries and aquaculture, is that there is no way of knowing how sustainable this system is. It is possible that the multispecies tropical nature of these fisheries can sustain such exploitation patterns, although if one traces the history of development of fishing in heavily fished countries such as China, one question is how long this can continue. There is emerging evidence that continued heavy exploitation pressure on even the annually recruiting species can lead to overfishing and a consequent decline in production, e.g. Japanese anchovy catches in China. The WorldFish Centre is currently doing analyses of low value/trash fish trends in several countries based on past scientific trawl surveys that may improve our knowledge on this critical issue. Reduced fishing capacity may, in fact, result in increased catches for a smaller number of vessels, although it will be difficult to reconcile who would be refused access to the resources.

From a socio-economic perspective, the benefit of catching low value/trash fish is obvious. The low value/trash fish are an important food source for many people, especially the poor, as well as an important source of income. The range of utilisation of these low value/trash fish for human consumption suggests very little waste associated with them. However, serious conflicts over use are common. Trawlers in the region tend to operate close to shore and use very small mesh sizes. They thus cause conflicts with small-scale sectors and destroy fisheries stock and ecosystem services. Government measures have attempted to eliminate and resolve these conflicts through banning trawling in the western half of Indonesia, heavy restrictions in some areas of the Philippines and Malaysia, prohibition from within three km from shore in Thailand, and within 40 m depth in Bangladesh. Such regulations are unfortunately difficult to enforce and success has been rather limited, unless supported by local communities and administrations. Increasingly, small-scale fishers are the main endorsers of responsible fishing practices, through community-based and co-management programmes, often with strong support from local government.

Overall knowledge of the dynamics of these low value/trash fisheries must be enhanced. Serious efforts to improve statistical records of low value/trash fish, and to identify and quantify where and

how these low value/trash fish are used, is urgently needed. The composition of landings must be identified and probably categorised in the national catch statistical system (certainly for major species), such that groups like “other fishes”, “miscellaneous”, “low value/trash fish”, disappear. Local communities can assist in recording the amount of catches of these fish at small landing sites. Knowledge about who uses the fish and who benefits from their use are also fundamental. This will inevitably require supplemental information gathering beyond catch records that utilises local knowledge to support conventional statistical approaches.

Another aspect of the sustainability issue is that the low value of low value/trash fish does not reflect their high ecological value. These small fish serve a niche in the marine ecosystem and are certainly food to other fish and marine animals. Removing them in large quantities from the environment creates a void in the food chain, and could eventually lead also to the reduction or loss of larger fish species, not just of its own species. Fishing with demersal gears that destroy habitats adds to the overall ecological impact.

An analysis of the capture-aquaculture relationship relating to economic efficiency and biological sustainability could provide further in-depth information on a desirable management approach. Sound economic studies are urgently required to better understand the current system as it has evolved in Asia, in terms of:

- who are the beneficiaries (in terms of numbers, status and location);
- what are the costs and benefits of moving to a right-based fisheries management approach; and
- what are the costs and benefits of diverting low value/trash fish away from animal/fish feeds into more value-added products?

3.5. Amount of fish that becomes trash due to poor handling and post-harvest

Because less money and effort is needed to be spent on handling and there is a market that can accommodate the catch, some larger fish are caught and included as low value/trash fish for fish meal and fish oil. Indeed, it is clear that with high demand and good economic gains of low value/trash fish from the fish meal production sector, many have decided that careful handling and chilling is not essential. According to some reports in Viet Nam, 20–30 percent and even 50–60 percent of high value fish on some offshore trawlers becomes waste because of poor storage.

Even if it were theoretically possible to improve the product, the limiting factor of small-scale and artisanal vessels is the lack of chilling equipment and on-shore infrastructure to access high value urban or export markets. Hence it may be difficult for these vessels to land a high quality product for the human consumption market without incremental increases in infrastructure and costs. With proper handling, landing and supply of high quality fish to local markets should still be possible, where fishing grounds are close to port. Of greater interest are perhaps the industrial vessels, which with the proper equipment and skills, should be better at ensuring a high quality catch. The underlying incentive for this to materialise, however, is that the economic gains of doing so outweigh the gains of landing fish on the low value/trash fish market. Here it is fundamental that the national authorities establish appropriate policies to help structure the sector, especially in relation to the national goals of food supply to the population versus income generation. Indeed, as long as the low value/trash fish market is vibrant then fishermen will have few incentives to improve the overall quality of their landed catch.

The quality of low value/trash fish destined for feed-mill factories is also a major concern. Even though it has a high protein content and quality when caught, the quality declines rapidly as only ice

or chilled water is used to preserve it on board ship, especially when boats may be at sea for 1–4 weeks. The resulting quality of the fish meal is often poor because low value/trash fish is degraded by the time it reaches the fish meal plant, hence limiting its use to lower product-value aquaculture operations.

3.6. Growth overfishing – harvesting juveniles of commercial species

Another related issue of low value/trash fisheries is the capture of juvenile fish of potentially important commercial species (so-called growth overfishing). As stated earlier, between 18 and 32 percent of low value/trash fish in the Gulf of Thailand are juveniles of commercially important fish species. Given a chance to grow to a larger size, these high-value species could be harvested much more effectively, both in terms of total catch of these species, but more importantly, in terms of value. However, to increase the catch of these species, a dramatic reduction in overall fishing effort would be required and the overall lower quantity of catch would then have knock on effects to markets and aquaculture. As with the current system of using low value/trash fish for aquaculture, this higher value catch would still be supplying the wealthier parts of the population. Social costs in terms of reduction in employment and livelihoods would be large and the actual economic benefits (and distribution of benefits) need to be studied in greater detail.

In Bangladesh, bag net fisheries are highly non-selective, and can cause high damage to migratory coastal and estuarine species. This type of gear basically restricts the migration of juvenile marine fauna to the sea to complete their routine lifecycle and thereby reduces the total catch of the coastal fisheries, as well as reducing the chances of the total regeneration capacity of the stock.

Juvenile/trash fish excluder devices (JTEDs) have been trialled in trawl needs in several Southeast Asian countries. However, given the many conflicting uses for low value/trash fish, it is difficult to envisage a management system that optimises the supply of low value/trash fish for both human and livestock/fish uses and at the same time excludes juvenile fish. Socio-economic studies are required to assess the costs and benefits of different management interventions such as juvenile fish excluder devices in nets, etc.

3.7. Discarding of unwanted fish

Discarding practices are seen by many as a waste of fish and fish protein, although it has to be realised that the impact on the species taken is the same whether they are landed or not. In fact, the discarding practice will benefit some species in the ecosystem, such as scavengers, if carried out in large volumes. Obviously the degree of discarding varies according to the market available to the fishers and can vary considerably by gear type and location. It is nevertheless clear that discarding at sea will decline if unwanted catches can be landed for economic gain.

International instruments, including UN Resolutions, the Kyoto Declaration and the Code of Conduct for Responsible Fisheries, have highlighted the need to reduce, or minimise discards. There are two principal approaches to addressing the discard problems; namely a) reducing bycatch and b) increasing utilisation of bycatch. These two harvest strategies may be complementary and in any given fishery, an appropriate balance between bycatch reduction and utilisation is required (FAO, 2004a). Again there is a need for analyses of the trade-offs between promoting bycatch reduction and utilisation. In particular, the balance between highly selective fishing which targets one trophic level (or species) only, and less selective fishing which is likely to impact upon several trophic levels (or species groups), requires further attention so that the best scientific advice can be made available. Examples of bycatch utilisation legislation in Asia-Pacific countries are given in Table 7.

Table 7: Examples of bycatch utilisation legislation in the Asia-Pacific region

Country	Legislation or Code	Key strategy
Bangladesh	Marine Fisheries Ordinance	Shrimp trawlers must have at least 30 percent of their total catch as fish
India	Maritime Zones of India Rules 1982 (amended April 1985), Regulation 5	Crews may not discard substantial surplus catch, catch exceeding authorised quantities shall be retained onboard, recorded, and surrendered as required by authorised officers
Indonesia	Decree No. 561 of the Ministry of Agriculture on the utilisation of the by-products of fisheries Presidential Decree No. 85 of 1982	All entities fishing prawns are bound to utilise as foodstuff for the population the fish resulting as a by-product from their fishing activities All fish bycatch to be handed over to the State owned company

Source: FAO (2003).

Early worldwide estimates of bycatch and discards were provided by FAO in 1994 and were assessed to be in the region of 27 million tonnes, or about 32 percent of total marine capture production (FAO, 2004a and FAO, 1996). Since then, several updates have been published noting a variety of factors that may have led to a decline in global discard levels during the late 1990s. FAO (2004a) analysed global discards on a fishery-by-fishery basis and supported the affirmation that global discards have significantly declined in recent years. Based on a discard rate of eight percent for the 1992–2001 period, the report estimates yearly average discards to be around 7.3 million tonnes. However, the report applies a different methodology to estimate global discards, and hence is not directly comparable to previous estimates. The reasons cited for this decline include:

- greater utilisation of bycatch species both for aquaculture and human consumption, as a result of improved processing technologies and expanding markets for lower-value catch;
- adoption of more selective fishing technologies and methods;
- a decline in the intensity of fishing for some species having high bycatch rates; and
- intervention of fisheries management (e.g. regulatory measures, improved enforcement, “no discard” legislation).

For the Asia-Pacific region, the greater utilisation of low value/trash fish has been of particular importance. Indeed, with some exceptions, discards in most fisheries in China and Southeast Asia are now considered to be negligible. There has been a change in perception of what constitutes a target species. Given the expansion of markets for low-value fish, almost all catches can now be regarded as “targeted” (i.e. no bycatch or discards). Exceptions will of course occur. In Brunei, contrary to other Southeast Asian countries, no low value/trash fish fishing is allowed (for aquaculture or local consumption), and hence a discarding estimate of some 70 percent is still being quoted.

FAO (2004a) estimates that trawl fisheries for shrimp and demersal finfish account for over 50 percent of total discards, while representing only 22 percent of total landings. Trawl fisheries and tropical shrimp fisheries⁵ account for over 55 percent and 27 percent of the total estimated discards, respectively. Small-scale fisheries account for at least 8.5 million tonnes (11 percent) of discards. In the analysis, most small-scale fisheries in the Asia-Pacific region were assigned very low or zero discard rates, given the supporting expert evidence summarised in Table 8.

⁵ China, India and Thailand, all with low or negligible discard rates, account for over half of the penaeid shrimp catch.

Table 8: Landings, discards and weighted discard rate in the Asia-Pacific region (tonne)

Country	Landings	Discards	Discard rate
Bangladesh	314 966	64 578	17.0%
Brunei	1 214	3 579	74.7%
Cambodia	49 343	0	0.0%
China	14 777 934	74 261	0.5%
India	2 849 066	57 917	2.0%
Indonesia	3 104 788	270 412	8.0%
Malaysia	1 027 276	10 377	1.0%
Myanmar	880 594	27 371	3.0%
Philippines	744 583	7 521	1.0%
Thailand	2 752 878	27 807	1.0%
Viet Nam	3 547 346	17 826	0.5%
Total	30 049 988	651 649	1.83%
FAO statistical area			
Eastern Indian Ocean (57)*	2 931 174	205 428	6.5%
Western Central Pacific (71)*	9 366 816	407 826	4.2%

Source: FAO (2004a).

Note: * excluding tunas.

Fisheries with high discard rates include the Bangladeshi industrial finfish and shrimp trawl that has an estimated discard rate of some 80 percent. The high discard rate for Brunei is due to extensive discarding in the multispecies finfish and shrimp trawl fisheries, based on 1998 figures, and likely reflects the greater purchasing power of the population and the lack of markets for lower valued species. Discarding in the Indonesian shrimp trawl fishery in the Arafura Sea is estimated to be over 80 percent, based on 1998 figures. Here discards have remained high, despite the introduction of bycatch exclusion devices, largely due to poor enforcement and the lack of local markets for bycatch. Increasing quantities of fish are being exported overland from Myanmar's trawl fisheries to feed the growing demand in southeastern China (FAO, 2004a).

A number of national bycatch reduction initiatives have also been implemented (Table 9). Despite the best intentions of these bycatch reduction measures, problems with enforcement and user conflicts have been observed.

Table 9: Examples of bycatch reduction in Asia-Pacific shrimp trawl fisheries

Country	Measures
Bangladesh	Shrimp trawlers limited to 30 days of fishing Mandatory 45 mm mesh size at codend Restrictions in place limiting trawling within the 40 m depth zone
Indonesia	Zoning of fishing activities (to reduce conflict and bycatch) Use of fishing/closed season Ban on trawling in Arafura Sea Trawling in East Indonesia limited to more than 10 m in depth Mesh size minimum of 25 mm
Philippines	Closed season for some areas No trawling within 7 km from the shore and within water of less than 7 fathoms Closure of bays, gulfs and inland waters to trawling Prohibition of motorised pushnet and commercial trawling in some municipalities in Ragay Gulf

Source: FAO (2003).

Reports from the countries studied show, in general, lower discarding figures than those estimated by FAO (2004a) although they all indicate that a certain amount of catches from trawls and push nets are directly discarded because of high grading (i.e. keeping more valuable species which earn a higher market price and discarding less valuable sizes of fish) to provide storage space for higher value fish.

Edwards *et al* (2004) concludes that one reason for insufficient supply of low value/trash fish for fish meal manufacture is because about one third of the fishery catch is thrown overboard. Fishers need improved technology so a higher percentage of the catch can be landed. In general terms, the retention of low value/trash fish at sea to eliminate discards, as well as gear modifications and improved fishing methods to eliminate bycatch and discards, could be useful.

Bangladesh

It is estimated that during the early 1990s over 10 000 tonnes of low value/trash fish were discarded and wasted at sea. The discards, however, rose along with the increased efforts (more vessels and more gears) over the last decade and have been estimated at around 20 000 tonnes during 2001/2002. Fisheries with relatively high discards are set bags with non-mechanised boats (6.6 percent of total catch), shrimp trawls (6.2 percent), and gill nets (5.2 percent).

China

When freezing capacity is limited, low value/trash fish that would fetch a low profit margin are discarded at sea, to make space for other high value fish. Low value/trash fish are also very perishable, and with a lack of processing equipment on board, some fishers discard low value/trash fish at sea.

Indonesia

Discards in Indonesia are considered insignificant as everything is used for home consumption or for commercial purposes, except for the Arafura Sea shrimp fishery.

India

There is hardly any waste in Indian fisheries, i.e. everything landed is used in one form or another. Even the poorest quality of fish is left on shore to dry to be used as feed for animals.

Philippines

Wastage of low value/trash fish occurs from discarding at sea by the capture fishery sector, especially commercial fishing boats where high grading of catch occurs. Low value/trash fish consumes added effort, space and costs (ice). In addition, higher discarding rates and sorting preference in this sector are associated with longer days spent at sea, distanced fishing grounds and landing areas. The seasonality of catch also plays a factor in the discarding process. During peak season and when harvest of commercially valuable species is high, low value/trash fish are even discarded at times by fishers since the market is flooded with better quality fish and market price is too low, or when the volume collected is negligible. Based on onboard observations, it is estimated that discarding can be as much as 25–30 percent of the trash catch for trawl and push net. During the lean season, however, landing of low value/trash fish is high and commands a better market price.

Information on discarding non-valued fish by type of fishery is available only for the push net and trawl fisheries. The discard rate for the push net fishery is around 12 percent of the total catch while

in the trawl fishery, 10 percent are discarded at sea. Observations on the composition of non-valuable fish discards include fish known to be fatal when consumed or those species that could pose a danger while sorting. Some fishes discarded are lionfish, pufferfish, anglerfish and eels. Lately, however, even pufferfish has found new markets in the Bicol region in dried form. In the municipal sector, it is customary that as long as markets for certain species exist, fishers will try to bring ashore all they can harvest. The “harvest all” mentality is usually observed due to accessibility of the fishing grounds and landing areas.

Thailand

There is some wastage of low value/trash fish as some are discarded at sea due to their low quality. Before 1975, there were not many fish meal plants and only 50 percent of low value/trash fish produced was utilised. At present, fishers do not discard much low value/trash fish, as they can sell them to fish meal plants.

Viet Nam

A fishing fleet has been reported to be specifically targeting low value/trash fish, as this is more financially beneficial than trawling for more valuable species with low value/trash fish as a bycatch (NIRAS, 2001). Discarding will be a concept that is irrelevant if the trend continues.

4. Conclusions

4.1. Current dilemma

Throughout the region, captured and cultured marine fisheries continue to play an important role in the food security, poverty alleviation and economies of many countries. Marine fisheries resources have been largely overexploited, and as a result development of coastal aquaculture has been encouraged to provide the needed protein, income, employment, and export earnings for some countries. Such a policy trend implies, however, that sufficient food for cultured marine fisheries will be available. Inevitably, a dangerous spiral has evolved where the demand for low value/trash fish has supported increased fishing pressure on already degraded resources. This raises some important questions regarding the social, economic and ecological costs and benefits of this system, its sustainability and future trends.

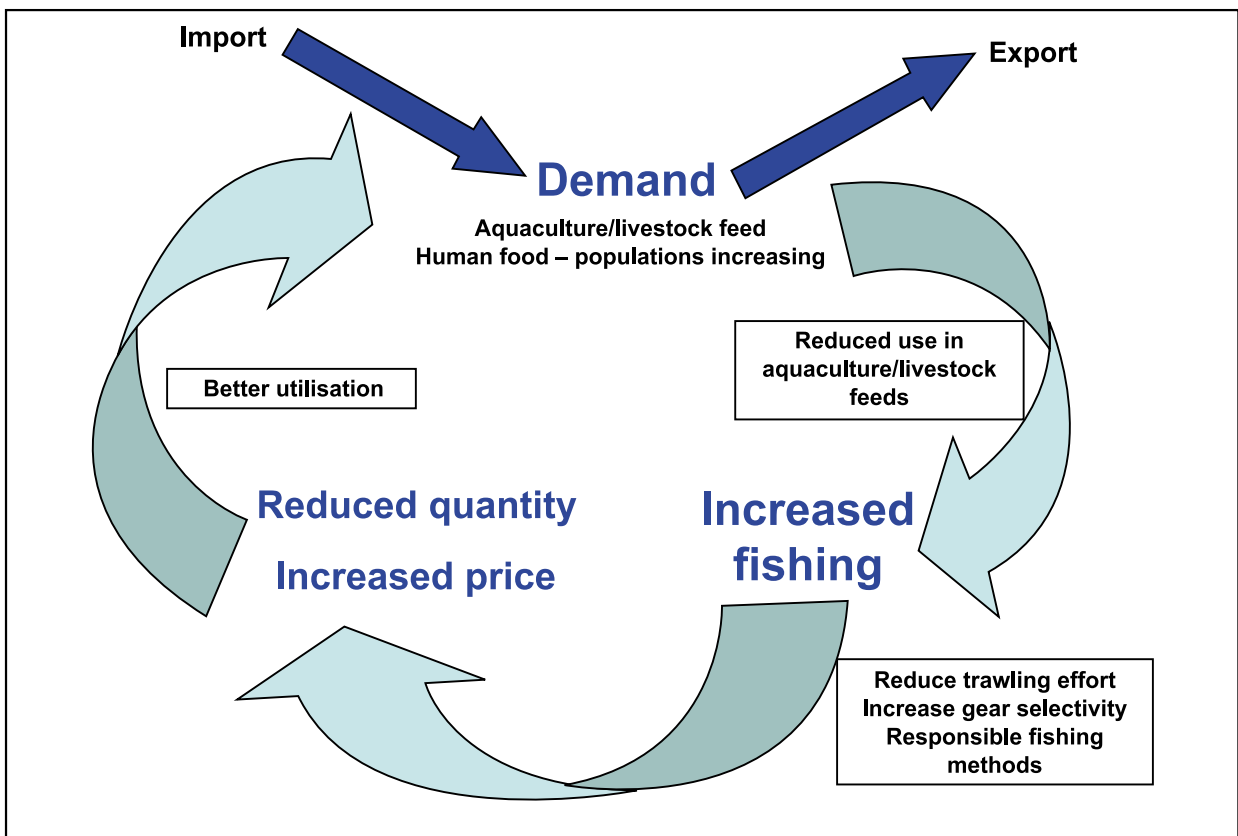


Figure 7: The low value/trash fish spiral. Increasing demand, increased fishing, degraded resources and increased price

One obvious but important conclusion is that given the strong interdependency between capture fisheries and aquaculture in the Asia-Pacific region, management of these two subsectors cannot be carried out in isolation of each other. This interdependency raises many important questions. For example:

- has the system evolved into a sustainable system whereby overfishing of more traditional fishery resources has allowed an increased supply of low value/trash fish to meet increased demands;

- what impact is harvesting the juveniles of potentially commercial species having on the total supply of high-quality fish for human consumption both in the region, and globally;
- where will the food for the increasing aquaculture sector in the region be sourced from in the future;
- what will be the implications of an increasing gap between supply and demand (and resulting increase in the price of fish) for food security and poverty alleviation in the region;
- will substitute feeds for livestock and fish (if developed) result in a collapse of the existing low value/trash fish markets and impact the livelihoods of Asia-Pacific fishing communities;
- will current fishery policies that advocate reduction in fishing capacity and rights-based fisheries management actually improve the overall situation; and
- last but not least – who are the beneficiaries and the losers of the current system and how would that change through management interventions?

As highlighted in the report, there is an urgent need to understand the system better. This report has given some insights on how fisheries are evolving in the Asia-Pacific region, but questions, such as those raised above, remain unanswered. We now have an initial understanding and enough quantitative data to start addressing them and urge the research community to take up the challenge.

4.2. Future prospects

Estimated future demand is expected to rise given the continued growth in the aquaculture sector. The competition between the use of low value/trash fish for livestock and aquaculture production and

**Table 10: Lower and upper projection levels for 2010
(million tonnes)**

	Pessimistic scenario	Optimistic scenario
Capture fisheries	80	105
Aquaculture production	27	39
Total production	107	144
Less fish for non-food uses	33	30
Available for human consumption	74	114

Source: <http://www.fao.org/fi/>

human consumption will also likely continue to increase. Predictions of FAO in relation to overall fisheries production are portrayed in Table 10, and clearly depict the significant roles of both aquaculture production and non-food uses in the years to come.

As shown in Figure 7, interventions to slow down or halt the viscous spiral that has developed can be made at several points in the cycle. These include (i) Reduced use of low value/trash fish in livestock/fish feeds, (ii) reduced fishing effort, particularly trawling, (iii) more responsible fishing gear and practices, including juvenile/trash excluder devices (JTEDs) and (iv) better utilisation of the fish for human consumption.

Fishery interventions

1. reduce trawling and push net effort (and clearly monitor the effect of capacity reduction);
2. introduce improved selectivity of fishing gears/fishing practices;
3. facilitate reduction in “race for fish” through rights-based fisheries and co-management;
4. protect juvenile nursery areas (refugia/closed areas, seasonal closures); and
5. provide alternative social support measures (including employment).

Improved utilisation

1. improve post harvest fish handling; and
2. develop new fish products through processing.

Improve feeds for aquaculture

1. change over from direct feeding to pellet feeding;
2. reduce fish meal content by substitution of suitable ingredients in pellets;
3. invest in feed research for inland/marine species; and
4. promote adoption and change over to pellet feeds.

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Table 11: Examples of small-scale and industrial/commercial fisheries classifications

Countries	Small-scale fisheries	Industrial/Commercial fisheries
Cambodia	Coastal fisheries: small-scale fisheries with/without engine (from 5–50 hp) operating in Zone 1.	Commercial fisheries: more than 50 hp operating in Zone 2.
Indonesia	Small-scale fisheries: a) Outboard engines less than 10 hp or 5 gt operating in Zone 1. Trawls, purse seines and gill nets are not allowed, except for purse seine with a head rope less than 120 m. b) Inboard engines less than 50 hp or 25 gt operating in Zone 2. Trawl and purse seine are not allowed, except purse seines with a head rope less than 300 m.	Industrial fisheries: a) Inboard engine less than 200 hp or 100 gt operating in Zone 3. Purse seining is allowed, except those with a head rope less than 600 m. b) All fishing vessels and fishing gear operating in Zone 4.
Malaysia	Traditional fisheries: small-scale fisheries using traditional fishing gears (i.e. other than trawls and purse seines) with vessels less than 10 gt operating in all zones concentrating in Zone 1.	Commercial fisheries: Medium and large-scale fisheries using commercial fishing gears such as trawls and purse seines. a) With vessels less than 40 gt operating in Zone 2. b) With vessels from 40–70 gt operating in Zone 3. c) With vessels above 70 gt operating in Zone 4.
Philippines	Municipal fisheries: small-scale fisheries with vessels of less than 3 gt operating in Zones 1 and 2.	Commercial fisheries: a) Small-scale commercial fisheries from 3.1–20 gt vessels operating in Zone 2; can also operate within 10.1–15 km (within Zone 1) if authority is granted by the concerned local government unit (LGU). b) Medium-scale commercial fisheries: from 20.1–150 gt operating in Zone 2; can also operate within 10.1–15 km (within Zone 1) if authority is granted by the commercial local government unit (LGU). c) Large-scale commercial fisheries: more than 150 gt operating in Zone 2.
Thailand	Small-scale fisheries: vessels of less than 5 gt operating in Zone 1.	Large-scale fisheries: vessels of more than 5 gt operating in Zone 2.
Viet Nam	Small-scale fisheries: vessels with no engine, or with engines, but less than 40 hp.	Large-scale fisheries: vessels with engines more than 40 hp.

General conclusions of the ACIAR report on *A survey of marine trash fish and fish meal as aquaculture feed ingredients in Vietnam*
Edwards, P., Tuan, L.A. and Allan, G.L. (2004)

- The total marine fish catch in Vietnam continues to rise, as well as the proportion of the biomass of trash fish in the total catch. This is due to overfishing. However, the quality of trash fish is usually poor because of inadequate preservation on board ship.
- There has been a dramatic recent rise in the use of trash fish in aquaculture with the development of marine cage culture of grouper and lobster, and the expansion of freshwater culture of river catfish in cages, ponds and pens.
- The availability of trash fish as a direct feed is likely to restrict the future expansion of aquaculture as supplies are finite, as indicated by a recent doubling of the price of trash fish.
- There are conflicting uses for trash fish for livestock feed, fish sauce and direct human food as well as for a direct aquaculture feed and fish meal manufacture in some areas. Traditional small-scale pig rearing uses trash fish but large-scale pig farming uses agro-industrial formulated feed containing fish meal. The national demand for fish sauce is predicted to double over the next decade. Some species previously considered as trash fish are now being used as human food fish because of developments in processing technology.
- Fish powder produced in a traditional artisanal way by sun drying and grinding is mainly used to feed livestock.
- Fish meal produced domestically, using an industrial process in which raw materials are cooked before being dried, is mostly of poor quality because trash fish is degraded by the time it reaches the fish meal plant. It is used by feed mills to produce feed for livestock and some grow-out feed for freshwater fish.
- Fish offal from processing may be used in fish meal manufacture when trash fish is in short supply, but it can only be used up to 5–20 percent of total ingredients as its protein content is too low and its ash/calcium content too high.
- At least 90 percent of fish meal is imported to meet the rapidly growing demand caused mainly by the development of aquaculture. Fish oil is not produced locally in industrial fish meal production and is also imported. Future demand for fish meal is expected to increase dramatically as an ingredient in industrial aqua feeds.
- As the prospects for increased production of quality fish meal (and fish oil) do not look promising, the future development of Vietnamese aquaculture will be strongly influenced by the availability and price of fish meal (and fish oil) on the international market.
- Although high value marine species such as grouper, lobster and shrimp may be able to compete for fish meal on the international market, this is unlikely to be the case for freshwater river catfish and tilapia. The latter will need to be fed increasing amounts of plant-based proteins, including possibly defatted rice bran.