A COMPARATIVE ACCOUNT OF THE SMALL PELAGIC FISHERIES IN THE APFIC REGION

by

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Abstract

The production of the small pelagics in the APFIC region was 1.2 mt/sq. km during 1995. Among the four areas in the region, the small pelagics have registered (i) the maximum annual fluctuations in the western Indian Ocean; (ii) the highest increase during the past two decades along the west coast of Thailand in the eastern Indian Ocean; and (iii) the consistent decline in the landings during the past one decade along the Japanese coast in the northwest Pacific Ocean. The short mackerels emerged as the largest fishery in the APFIC region, forming 19.5% of the landings of the small pelagics in 1995. The group consisting of the sardines and the anchovies has shown clear signs of decline during the past one decade in almost the entire region. Most of the small pelagics have unique biological characteristics such as fast growth, short longevity, late maturity, high natural mortality, shoaling behaviour, high fecundity and severe recruitment fluctuations. As many species of the small pelagics undertake migration, collaborative research programmes and close coordination are required among the APFIC countries for the stock assessment of all the major species. The management measures under implementation in these countries have been reviewed, with suggestions for regional cooperation for the management of the stocks of the small pelagics.

INTRODUCTION

The Asia-Pacific Fishery Commission covers four oceanic areas, which have been classified by the FAO as the western Indian Ocean (FAO Statistical Area 51), eastern Indian Ocean (Area 57), northwest Pacific Ocean (Area 61) and western central Pacific Ocean (Area 71). The APFIC region is one of the major producers of marine fish as it contributed 37.5 million mt (44%) to the total world marine fish catch of 84.7 million mt in 1995. The region is quite unique as the world number one fish producer (China), fish exporter (Thailand) and fish importer (Japan) are located in this area. The number of people involved in the fisheries sector in this area is probably the highest in the world, with China and India contributing the maximum. The coastal fisheries sector in this region could develop rapidly through the last 30 years because of the favourable institutional, environmental, socioeconomic, biological and technological factors. This region has also experienced one of the most dramatic rises and falls of a fishery, that of the Japanese sardine, twice in this century.

All the countries in this region have traditionally harvested the small pelagics in their coastal waters and a large population of fishermen are dependent on these resources. However, the history and the current status of the fisheries for the small pelagics vary greatly from country to country. For instance, the purseseines were introduced in the Gulf of Thailand in the 1920s (Chinese purseseines), in the Philippine waters in the 1940s, in the Java Sea and in the Arabian Sea (southwest coast of India) in the early 1970s; and, there are regions such as the Bay of Bengal (east coast of India), where the purseseines have not been introduced so far. Due to the differences in the pace of development of fisheries, many resources of the coastal waters in this region are under different phases of exploitation. Despite the large volume of information collected in recent years on the fisheries and the important biological features of the exploited stocks, explicit assessment has scarcely been made for many of the stocks, resulting in uncertainties in the formulation of appropriate policies. However, there are several indications suggesting that many stocks of small pelagics are being heavily exploited in recent years. It is being increasingly recognized that there is a need for proper management of fisheries for sustaining the catches rather than increasing them. Under these circumstances, many countries have established several regulatory measures for the conservation of the resources as well as for the alleviation of sectoral conflicts among the fishermen. While a few countries have partially succeeded, many others have failed in their attempts and the fisheries remain largely as open access properties especially in the western Indian Ocean, eastern Indian Ocean and western central Pacific Ocean. Considering the migratory nature of the small pelagics, it is evident that proper assessment and rational utilization of shared stocks are possible only with international cooperation.

The areas in the APFIC region vary greatly in their physical and environmental conditions. The region encompasses typical tropical areas (for e.g., the Persian Gulf, Arabian Sea, Yellow Sea, Gulf of Thailand) and the near-polar regions (for e.g., southeast of Africa, Okhotsk Sea, western Bering Sea). It also encompasses distinct oceanic areas of continuous upwelling and extremely high productive continental shelf (southwest coast of India, Gulf of Thailand, South China Sea), areas of narrow continental shelf with highly productive fishery resources (western Bering Sea, southeast Kamchatka Peninsula), areas of low productivity (coastal East Africa from Somalia to Mozambique), thousands of islands that have their own characteristic oceanic or near-oceanic features (Philippines, Indonesia, Seychelles, Mauritius, Comoros). All these factors determine the distribution, abundance and characteristics of the fish stocks. The environmental factors in these vastly diverse ecosystems govern the stock fluctuations, especially those of the small pelagics such as the Japanese sardine and Indian oil sardine. These factors and their influence on the fisheries have not been understood adequately. A critical evaluation of the long-term trends and fluctuations in the environmental conditions and their influence on the small pelagics is very vital to the sustained growth of these fisheries.

In addition to the climatic differences, there are also significant differences among the countries in terms of the GDP, importance of fisheries to their economies and other diversities such as ethnic, cultural, political, religious and social background. Despite these diversities, there are a number of basic similarities in the fisheries for the small pelagics. The complex nature of the fisheries, generally declining fish stocks, uncertainties in production, difficulties in enforcing management options and dependence of a huge human population on the small pelagics for employment and for food are some of the common problems in the APFIC region. This paper presents a compilation of the available information on these aspects in some of the APFIC member countries. For evaluating the current status of the small pelagic fisheries, the papers on this subject relating to the APFIC region (Martosubroto, 1997), India (Devaraj *et. al.*, 1997), Sri Lanka (Dayaratne, 1997), Australia (O'Brien, 1997), Gulf of Thailand (Chullasorn, 1997), Malaysia (Chee, 1997), Indonesia (Widodo, 1997), Philippines (Calvelo, 1997), South China Sea (Yanagawa, 1997), China (Tang *et. al.*, 1997) and Japan (Wada, 1997), which were presented in the workshop, have been primarily referred to, in addition to those by the FAO (1995; 1996).

PRODUCTION TRENDS IN THE SMALL PELAGICS IN THE APFIC AREA

During 1950-1995, the global marine fish production increased from 18.6 millionmtto 84.7 million mt, an increase of about 4.5 times. During this period, the marine fish production in the APFIC region increased from 6.35 million mt to 37.45 million mt (Table 1), an increase of nearly 6 times. Consequently, the contribution of marine fish production in the APFIC region to the global production increased from 34% in 1950 to 45% in 1995. The landings of the small pelagics in the APFIC region increased by 5 times, from 2.19 million mt to 10.95 million mt. The landings of the small pelagics increased almost consistently during 1950-1988, but gradually decreased from 11.60 million mt in 1988 to 10.95 million mt in 1995, a decline of 6% in the 7 year period.

The data on the landings in the four areas of the APFIC region show a fairly large variability among the areas as would be expected due to large differences in the potential yield as a result of features such as upwelling and river run inputs. The landings of the small pelagics ranged from 0.5 mt/sq.km. in the eastern Indian Ocean to 2.2 mt/sq.km in the northwest Pacific Ocean (Table 2). Inspite of the differences in the yield, the landings of the small pelagics in all the areas considerably increased during 1950-1995. There were, of course, periods of stagnations and fluctuations, and short-term and long-term decreases of individual fisheries which were rather unique to specific areas. The increase in the landings of the small pelagics was low, i.e., 3.6 times and 4.2 times in the northwest Pacific and the western Indian Oceans, respectively (Table 1). The increase was comparatively higher in the eastern Indian (9.2 times) and the western central Pacific Oceans (20.4 times). Consequently, the contribution of the northwest Pacific and the western Indian Oceans to the small pelagics production of the four APFIC areas decreased from 77.6% (1950) to 56.6% (1995) and from 11.0% (1950) to 9.1% (1995), respectively (Table 3). The contribution of the eastern Indian and western central Pacific Oceans increased from 5.5% (1950) to 10.1% (1995) and from 5.9% (1950) to 24.2% (1995), respectively. Clearly, the chronicles of marine fisheries as well as the fisheries of the small pelagics in these areas have undergone considerable changes during the four decades.

Western Indian Ocean

The western Indian Ocean encompasses areas of nearly continuous upwelling (off the Oman coast) as well as areas with seasonal, monsoon induced upwelling (off the coast of Iran and Pakistan and the Arabian Sea), which extends to the west coast of India. The Gulf of Aden and the Somali coast are also monsoon-driven upwelling areas that experience seasons of high productivity. The Persian Gulf, a shallow enclosed area, is characterised by warm saline waters which possess certain unique fisheries characteristics. The Red Sea, which is enclosed and has a narrow continental shelf, also has fisheries situations special to that area. The western Indian Ocean has a few small oceanic islands, the Seychelles, Mauritius and the Comoros, with their own characteristic oceanic or near-oceanic fisheries. Further to the south, South Africa has fisheries of temperate and subantarctic nature (FAO, 1996).

The total marine fish production in the western Indian Ocean increased by 6.6 times, from 0.55 million mt in 1950 to 3.65 million mt in 1995; and the production of the small pelagics by 4.2 times, from 0.24 million mt to 1.00 million mt. In other words, the contribution of the small pelagics to the total production decreased from 43.6% to 27.4%. The fisheries for the small pelagics in the western Indian Ocean exhibit the following characteristics, which constitute the major factors underlying the decline in their contribution to the total landings: (i) Unlike the demersal and large pelagic fisheries which registered an almost consistent increase in the landings during 1950-1995, the landings of the small pelagics fluctuated widely. For instance, the landings decreased from 0.56 million mt in 1960 to 0.37 million mt in 1963 and recovered to 0.54 million mt in 1964 itself; the landings increased from 0.56 million mt in 1969 to 0.82 million mt in 1971 and decreased to 0.56 million mt in 1973. Among the four areas of the APFIC, the small pelagics have registered the maximum annual fluctuations in the western Indian Ocean. Catches of the Indian oil sardine, jacks, herrings and short mackerels have fluctuated widely over the last four decades. (ii) The catches of the oil sardine along the southwest coast of the India and the pelagic percomorphs in the Persian Gulf and the Gulf of Oman, where these species form the basis of the most important commercial fisheries, have declined in the 1990s. (iii) In contrast, the catches of the large pelagics have increased steadily since the 1950s, with large increases in the skipjack and yellowfin tuna landings since the early 1980s. (iv) The catches of the demersal species also have increased steadily since 1950, with particularly large increases of the croakers and drums since the early 1980s. (v) Following heavy demand for the penaeid shrimps, the bottom trawl fishery targetted them and the catches of the shrimps increased sharply since the mid 1980s.

Of the 33 countries bordering the western Indian Ocean, India (53%), Pakistan (17%) and Sri Lanka (7%) contributed 77% of the small pelagics landings of the area.

1. *India*

The west coast of India and the Lakshadweep Islands in the Arabian Sea have been classified under the western Indian Ocean and the east coast and the Andaman & Nicobar Islands in the Bay of Bengal under the eastern Indian Ocean. The annual average landings of the small pelagics along the west coast of India increased from 0.20 million mt during 1950-54 to 0.76 million mt during 1991-95 (Table 4). The increase was possible due to the mechanization of the fishing vessels and the introduction of trawlers and synthetic filaments in the 1960s; introduction of purseseiners in the early 1970s; and the motorization of the traditional fishing craft in the 1980s. The Indian mackerel (17.7%), oil sardine and other sardines (13.3%), Bombayduck (12.6%), scads (10.7%), ribbonfishes (10.1%) and anchovies (6.8%) dominated the landings. The three dominant species, viz., the Indian mackerel *Rastrelliger kanagurta* (southwest coast), the Indian oil sardine *Sardinella longiceps*(southwest coast) and the Bombayduck *Harpodon nehereus* (northwest coast) are abundant along the specific areas in the west coast and their landings are the most fluctuating. Several environmental parameters such as the onset and intensity of the southwest monsoon, sunspot activity, variations in the pattern of coastal currents, salinity, dissolved oxygen, sinking of the offshore waters and sea level characterise the nature and intensity of upwelling, which leads to high plankton productivity, and in turn, determines the abundance of the pelagic stocks. The oil sardine fishery is causing concern in recent years as its annual average production, which increased from 0.03 million mt during 1950-54 to 0.23 million mt during 1965-69, consistently declined since then and was 0.12 million mt during 1990-95 along the southwest coast of India (Devaraj *et. al.*, 1997).

The unicorn cod, *Bregmaceros meclellandi* which formed a minor fishery (6880 mt/year) along the northwest coast during 1950-54, ceased to be a fishery any longer. In view of the consistency in the decline of the fishery during the past four decades, the unicorn cod may have to be listed as a vulnerable species and strategies devised to restore the population.

The resources of the small pelagics are exploited by an array of craft and gears. Till the close of the 1970s, shoreseines, boatseines, castnet, *rampani* (large shoreseines) and gillnets were employed in the fisheries for the small pelagics. With the advent of purseseining in the 1970s, the traditional fishing systems began to lose their importance. The situation got further changed in the 1980s with the popularization of the ringseines (mini purseseines), coupled with the steady growth of the motorized fleet (traditional craft with outboard and /or inboard motor). The purseseines and ringseines have almost replaced the *rampanies* (large shoreseines) and boatseines. Presently, the trawls, purseseines and gillnets with specific mesh sizes are operated from mechanized vessels, and ringseines, boatseines and gillnets either from motorized or nonmotorized craft. The mechanized, motorized and nonmotorized vessels contributed 53%, 27% and 20% to the landings of the small pelagics during 1991-95. Unlike most other countries where the purseseiners contributed 75% to the catches of the small pelagics, the 520 purseseiners, which are restricted to the southwest coast, landed <10% of the small pelagics in the west coast of India. The trawlers, which outnumber the purseseiners by about 40 times, contributed 20% of the small pelagics. The trawls, which have been modified with a high opening, effectively exploit the pelagic stocks such as the Indian mackerel, jacks, scads and ribbonfishes which undertake diurnal vertical migration. Pelagic or midwater trawls are not operated, as experimental trawling did not yield encouraging results. The ringseines, which are very popular in the motorized sector, landed 0.18 million mt annually during 1991-95, which is a significant growth since the introduction of the gear in the mid 1980s. The ringseines contributed nearly 40% of the oil sardine landings. The jacks, scads and anchovies also have emerged as major fisheries of the ringseines. The ringseines are very efficient as the mesh size is very small (8 to 10mm) and the length of some of the nets is 1 km. Following complaints of mass destruction of juveniles of small pelagics by the ringseines, the operation is banned legally in a few places, but it is not implemented effectively.

1. Sri Lanka

The annual catches of the small pelagics increased from 35 000 mt during 1967-68 to 90 000 mt in 1983 mainly due to the motorization of the traditional craft and the introduction of synthetic nylon nets for gillnetting. However, the production dropped in 1984-85 and is presently stagnating at around 70 000 mt for the past one decade mainly due to the civil disturbances in the northern and eastern parts of the island nation. The continental shelf is wider and the fish productivity is higher in the north and east coasts than in the other coasts and more than 45% of the small pelagics were landed in the north and east coasts prior to the civil disturbances.

Sardines constituted about 50% of the landings of the small pelagics, followed by the herrings and the scads. Among the sardines, *S. longiceps, S. sirm, S. jussieu* and *S. fimbriata* were relatively dominant. Until 1980, the main fishing gears engaged in the exploitation of the small pelagics were the beachseines and the gillnets. In the early 1980s, purseseines were introduced and there were 69 purseseiners in 1990. This development led to conflicts between the fishers engaged in beachseining & gillnetting and those engaged in purseseining as all of them exploit the same resource. Following the conflicts, fishing regulations were formulated, which restricted the area of operation of the purseseiners beyond 10-15 km from the coast. In addition to this problem, it has been reported that the catch rate of the purseseiners declined from 185.7 kg/fishing operation (1985) to 52.0 kg/operation (1993) (Dayaratne, 1997)

Eastern Indian Ocean

The eastern Indian Ocean includes the Bay of Bengal in the north, the Andaman Sea and the northern part of the Malacca Straits in the east, and the waters around the west and south of Australia. The main shelf areas include those of the Bays of Bengal and Martaban, and the narrower shelf areas on the western and southern sides of Indonesia and Australia. Most of the fisheries for the small pelagics are concentrated in these shelf areas. The resources range from typical tropical species in the northern part of the area, to temperate species in the waters of the southern latitudes, west and south of Australia (FAO, 1996).

Catches in this area have increased consistently and remarkably during the last four decades (1950-1995). The total capture fisheries landings increased by 12.3 times, from 0.30 million mt (1950) to 3.70 million mt (1995) (Table 1); the landings of the small pelagics increased by 9.2 times, from 0.12 million mt in 1950 and peaked at 1.10 million mt in 1995. The landings of the small pelagics increased significantly in all the countries in this area. The moderate increase from 1950 to the 1970s was followed by a more rapid increase in the last two decades. In India, the production sharply increased from the year 1972, in Indonesia and Malaysia from 1975 and in Thailand, from 1982. Bangladesh is not a major marine fishing nation due to its historic focus on the large freshwater fishery resources. The statistics on fish catches in Bangladesh started only in 1984 and it was recorded that the landings of the small pelagics increased from 55 000 mt in 1984 to 125 000 mt in 1995. Toli shad, an estuarine species, dominate the marine catches. It is only in Australia, the landings, though increasing, were very low (25 000 mt) and formed only about 2% of the small pelagic landings of the eastern Indian Ocean area.

1. *Australia*

The only major fishery for the small pelagics is the pilchard fishery (*Sardinops sagax*) in western Australia. Commercial fishing for the pilchard began in the 1970s and the current catches are about 16 000 mt. The pilchard are exploited using purseseines with 20 mm mesh. It is estimated that the spawning stock biomass is 40 000 mt (O'Brien, 1997). Though there is scope for increasing the landings, the pilchard are not taken seriously as they are considered as low-value and sold as fish bait.

2. *India*

During 1950-1995, the annual landings of the small pelagics in the east coast of India increased by 4 times, from 72 000 mt to 280 000 mt (Table 4). Compared to the west coast, the annual fluctuations were less and the landings consistently increased in the east coast. However, consequent upon very high increases in the landings in other countries in the area such as Thailand and Indonesia, the contribution of India to the small pelagic landings of the eastern Indian Ocean decreased from 60% in 1950 to 26% in 1995.

Unlike the west coast, there is no single species that dominates the fishery. Sardines, Indian mackerel, anchovies and hilsa shad constitute about 50% of the landings. Interestingly, the catches of the Indian oil sardine, which constitute a dominant, highly fluctuating and a consistently declining fishery in the west coast, are continuously on the rise in the east coast since 1985. The annual average landings of the oil sardine were 38 536 mt in the southeast coast during 1991-95, but historically the oil sardine formed only a minor fishery here prior to 1985. The reasons for the increase are not clearly understood, but it seems to be due to (i) the migration of the stock from the west coast following intensive fishing pressure of ringseine operations, and/or (ii)increase in the productivity of the coastal waters of the southeast coast following heavy land discharges of organically rich wastewaters and likely shifts in the upwelling from the immediately continuous southwest coast (Devaraj *et. al.,* 1997).

Pelagic trawls, purseseines and ringseines are not operated along the east coast of India, as experimental and exploratory fishing indicated that the concentrations of small pelagics are not high enough for commercial exploitation by purseseiners or midwater trawlers. The small pelagics are landed by the trawls and by the conventional small meshed gillnets, bagnets and boatseines operated either from motorized or nonmotorized craft.

3. *Indonesia*

The Indonesian waters are partly in the eastern Indian Ocean and partly in the western central Pacific Ocean. The former includes the southern part of Java, western Sumatra and the adjoining islands. The latter includes a chain of Pacific islands and a chain of islands between Malaysia and Australia. Being the largest archipelagic state in the world, there is a high diversity of fish species. The status of marine fisheries development in Indonesia varies according to the geographical area and the concentration of human population. Hence, the fisheries management measures vary according to the development phase of the fishery.

Of the 1.35 million mt of small pelagics landed in Indonesia in 1995, only 16.7% was from the eastern Indian Ocean area and the rest from the western central Pacific area. However, the landings increased at an equally high rate during 1950-1995 in both the areas. The landings from the eastern Indian Ocean area increased from a mere 5 000 mt in 1950 to 225 000 mt in 1995 (Table 3). The increase was steep since 1976. The contribution of Indonesia to the small pelagic landings of the eastern Indian Ocean increased subsequently from 4.0% to 20.5%. The landings of the short mackerels, *Rastrelliger brachysoma* and *R. kanagurta* increased from about 7 000 mt in 1975 to 58 000 mt in 1995; the sardines from 6 000 mt to 25 000 mt; the anchovies from 3 600 mt to 47 000 mt; and the scads from 2 300 mt in 1975 to 32 500 mt in 1990, but decreased to 20 000 mt in 1995. Barring the landings of the scads which decreased between 1990 and 1995, all the other fisheries registered an increasing trend during the past four decades. Introduction of purseseines in the 1970s and the use of lights as fish lures during purseseining have substantially increased the landings of almost all the species of the small pelagics along the Indonesian coast.

4. *Malaysia*

The west coast of the peninsular Malaysia in the northern Malacca Strait is a part of the eastern Indian Ocean and the east coast is a part of the western central Pacific Ocean. The annual landings of the small pelagics in the west coast of Malaysia fluctuated very widely during 1950-1994. However, the trend in the landings could be categorised into 3 phases: (i) a stagnant phase during 1950-1965 when the annual landings ranged between 35 000 mt and 45 000 mt; (ii) a developing phase during 1966-1985 when the landings increased from 50 000 mt to 175 000 mt; and (iii) a highly fluctuating phase during 1986-1994 when the landings fluctuated widely, but were generally on the decline. The purseseiners, which were indtroduced during the late 1960s paved the way for increasing the catches of the small pelagics. During the 1970s and the 1980s, the emphasis on the use of traditional fishing gears such as driftnets shifted to a low key as more and more purseseines were employed. The number of purseseiners and the landings of the small pelagics reached the maximum of 377 and 175 000 mt, respectively along the west coast in 1985. Subsequently, the landings reduced to 105 000 mt in 1992 and the number of purseseiners also gradually reduced to 172 as the returns from the catches dwindled. However, the efficiency of purseseining was improved considerably during 1992-1994 through the introduction of colour echosounders, sonar, geographical positioning systems and FADs like spotlights. The use of spotlights as FADs facilitated the exploitation of a wide range of species, thereby making the fish purseseines less selective. Following these developments, the landings again increased and reached 180 000 mt in 1994.

In addition to the purseseiners, the trawlers have played a key role in developing the fisheries for the small pelagics. By employing high opening bottom trawls, the trawlers exploited large quantities of short mackerels. The contribution of the trawlers to the landings of the short mackerels in the west coast increased from <1% in 1970 to 13%, 30% and 29% in 1980, 1990 and 1994, respectively. On the contrary, the contribution of the purseseiners dropped from 99% in 1970 to 81%, 37% and 23% in 1980, 1990 and 1994, respectively.

The short mackerel are the mainstay of the fishery, contributing 56% to the landings of the small pelagics in 1994. *R. brachysoma* constituted 84% of the catches and *R. kanagurta* 16%. The other small pelagics that contribute to the fishery of the west coast are the bigeye scad, round scads, sardines, hardtail scad, round herrings and small tunas.

5. Thailand

The west coast of Thailand is located in the Andaman Sea and in the northern Malacca Strait in the eastern Indian Ocean and the east coast of Thailand is located in the Gulf of Thailand (western central Pacific Ocean). The landings in the west and east coasts were 260 000 mt and 500 000 mt, respectively in 1994 (Table 4). Though the west coast landed only 34% of the total landings of the small pelagics in the country, the increase in the landings along the west coast was phenomenal. During 1972-1995, the landings increased from a mere 2 000 mt to 260 000 mt, an increase of 130 times, which is the highest increase for any area among the APFIC countries during these two decades. During this period, purseseining developed extensively and some of the Thai fleets fished in other countries through various joint agreements. The joint venture fishery agreement between Thailand, Malaysia and Indonesia covers the whole of the northern Malacca Strait.

The landings of a few groups of small pelagics sharply increased during the past decades whereas those of a few others registered increases, but fluctuated widely. The landings of the anchovies increased from a mere 1 000 mt in 1990 to

68 000 mt in 1995, an increase of 68 times in 5 years and the landings of the short mackerels increased from 3 000 mt in 1981 to 78 000 mt in 1995. The increased number of light purseseine fleet from the Gulf of Thailand operating in this area contributed to the high landing of anchovies. The landings of the sardines increased from 2 400 mt in 1981 to 42 000 mt in 1986, but fluctuated widely since then. The landings of the scads also fluctuated severely from 2 000 mt in 1986 to 24 000 mt in 1991, to 9 000 mt in 1992 and then to 37 000 mt in 1995.

Northwest Pacific Ocean

This area encompasses a number of distinct ocean subareas, many containing particular extensive areas of highly productive continental shelves such as the northern portion of the South China Sea, the East China Sea, the Yellow Sea, the Sea of Japan and the Sea of Okhotsk. Other subareas have less extensive continental shelves, but are nevertheless also sites of productive fishery resources (e.g., the western portion of the Bering Sea, the eastern edges of the Ryukyu Islands, Japan and the Kuril Islands, and the southeastern part of the Kamchatka Peninsula), being characterised by zones of enrichment and concentration of biological processes related to interactions and confluences of swift western ocean bondary currents (FAO, 1996).

The trends in the landings of the small pelagics in the northwest Pacific Ocean have passed through 3 distinct phases: (i) moderate increase from 1.70 million mt (1950) to 4.75 million mt (1975); (ii) sharp increase from 4.70 million mt (1976) to 9.20 million mt (1986); and (iii) consistent and sharp decline from 9.20 million mt (1986) to 6.20 million mt (1995). Among the APFIC areas, the northwest Pacific Ocean is the only area where the landings have decreased consistently during the past one decade. The sharp increase and the subsequent fall in the landings were primarily due to the Japanese sardine (or Japanese pilchard), *Sardinops melanostictus*. The landings of this species increased from about 20 000 mt n 1972 to a historical peak of 5.4 million mt in 1988, and to an equally drastic decline in the next 7 years to reach 0.8 million mt in 1995. The contribution of the sardine to the landings of the small pelagics in the northwest Pacific Ocean decreased from 60% in 1985 to 13% in 1995.

Among the countries bordering the northwest Pacific Ocean, China and Japan land the maximum quantities of small pelagics. In 1995, these two countries landed nearly 90% of the small pelagics of the entire area.

1. <u>China</u>

The Chinese waters, which include the Bohai Sea, the Yellow Sea, the East China Sea and the South China Sea, encompass a total area of 4.87 million sq.km. As the coastline of China is very long and extends 37° latitudes from south to north, there is great difference in the temperature between the southern and the northern regions. Accordingly, warm temperate and cold water species occur in specific regions. The warm and warm temperate water species spawn in water temperature between 18°C and 30°C whereas the optimum temperature for the spawning of the cold water species is 3°C to 5°C.

The production of the small pelagics gradually increased from 0.13 million mt in 1950 to 1.02 million mt in 1988, and thereafter, quickly to 2.50 million mt in 1995 (Table 4). The major species forming the fisheries are the scad (*Decapterus maruadsi*), Japanese anchovy (*Engraulis japonicus*), Japanese mackerel (*Pneumatophorus japonicus*) and Spanish mackerel (*Scomberomorus niphonius*); the catches of these species were 515 000 mt, 489 000 mt, 372 000 mt and 227 000 mt respectively in 1995. These four species together contributed about 64% to the landings of the small pelagics. The fast development of the fisheries for the small pelagics during 1985-1995 was made possible through a clear understanding of the migratory behaviour of the individual species and by employing suitable gears in the appropriate areas of abundance. The scad and the Japanese mackerel are exploited by employing purseseiners with light attractants in the eastern and southern parts of the Yellow Sea during autumn and winter where they migrate for spawning; and in the feeding grounds in the East China Sea during spring and summer. In addition to this aimed fishing, the other gears employed include the driftnet in the western part of the Yellow Sea and the purseseine with a bag in the Fujian Province.

The Japanese anchovy, which did not form a fishery prior to the 1980s, are being exploited since the late 1980s. The annual landings of the species which were 40 000 mt in 1989, steeply increased to 489 000 mt in 1995. By conducting trial trawling during 1986-89, pelagic trawling was found to be very efficient for the anchovy fishery. Following this, pelagic pair trawlers were introduced and in 1995, there were 100 pairs of 370 hp trawlers for the anchovy fishery, which harvested 3 to 4 mt/haul when the anchovies migrated to the wintering grounds during November-February. When the anchovies migrate to the spawning grounds near the coast in the Yellow Sea and the Bohai Sea during May-June, they are exploited by using small trawlers and during the peak spawning period, by employing different kinds of fixednets along the coast.

The Japanese sardine were not found in the China waters before the 1970s. In the mid 1970s, the Kyushu stock of this warm temperate species moved to the southern and central parts of the Yellow Sea and to the South China Sea and formed a fishery since then. The landings of this species exhibit an increasing trend, from 21 000 mt in 1989 to 58 000 mt in 1995. They are caught by purseseine and setnet.

The growth of the Chinese fisheries resulted, at least to some extent, from the relaxation of domestic price controls and the consequent incentive to deploy excess fishing capacity, resulting in significant increase in fishing effort. The total power of the Chinese vessels operating in the East China Sea increased by a factor of 7.6 between the 1960s and the the early 1990s, while the catches increased by a factor of 2.6. Thus, the cpue decreased by a factor of 3.0 (FAO, 1995). This was accompanied by a dramatic shift in the catches from high-valued, large fish to low-valued, small fish, and from demersal and pelagic predators to small pelagics. The contribution of the small pelagics, which was only 16% of the total marine catch of China during 1972-1983, increased to 37% during 1990-1995. The quantity of mature fishes in the catches dropped significantly, with the bulk of the present catches consisting of immature fish (FAO, 1995).

2. Japan

The production trend of the small pelagics in Japan during 1976-1995 depicts one of the most eventful marine fisheries variations in the world. The production, which was increasing steadily from 1.2 million mt in 1950 to 2.9 million mt in 1976, suddenly shot up to 6.3 million mt in 1988, only to decline subsequently to 2.1 million mt n 1995. The marine fish catch of Japan, which was the highest in the world throughout the 1980s, decreased since 1988 and in 1991, China exceeded Japan in catch volume for the first time and since 1992, the apparent gap has continued to widen. These variations were due to a single species, the Japanese sardine (or pilchard). From an annual production of 0.3 million mt in 1910, the sardine fishery off Japan grew rapidly in the 1930s to become the largest single species fishery (2.5 million mt in 1940) that existed in the world at that time. In the early 1940s, the population abruptly collapsed. It remained at extremely depressed levels for nearly three decades (0.01 to 0.3 million mt per year) and then suddenly exploded in the mid 1970s and attained the peak of 4.5 million mt in 1988. Again, similar to the earlier collapse, the fishery rapidly declined for the second time and reached 0.6 million mt in 1995. It is reported that the catches have further declined in 1996 and currently the stock has touched a very low level. Japanese scientists are convinced that the fluctuations in the sardine abundance are not the result of fishing, but governed by ecosystem changes which may be related to climate variations (FAO, 1996). It is believed that the abundance is affected by the changes in the Kuroshio current lasting for periods of one decade to many decades.

The Japanese anchovy catches, which stongly increased off China, decreased off Japan from 0.3 million mt in 1990 to 0.2 million mt in 1994. The Pacific herring *Clupea pallasi*, which formed a major fishery in the 1910s (annual average landings: 1.1 million mt), also declined to 0.2 million mt in 1940 and reached a seriously low level from the 1970s onwards upto the present along the Japanese coast. The landings of the chub mackerel *Scomber japonicus* were highly fluctuating, ranging from 0.2 million mt (1991) to 0.9 millionmt (1986) during 1985-1994. Of the major species of small pelagics of Japan, the fisheries for the jack mackerel *Trachurus japonicus* and the Pacific saury *Cololabis saira* are stable.

The large and medium type purseseiners contribute <70% to the landings of the sardine, jack mackerel, chub mackerel and scads. An unit of large/medium type purseseiner consists of a netting boat (100 mt GRT) accompanied by one or two search boats and two or three carrier boats. Following the decline in the sardine catch, the number of units decreased from 208 in 1989 to 132 in 1994 and the number of fishing trips from 14 177 to 7 739, respectively. In spite of the decrease in the effort, the cpue decreased from 279 kg per trip (1989) to 175 kg per trip (1994). As the anchovy concentration is in the inshore waters, small scale fisheries involving small purseseines and boatseines are engaged in the anchovy fishery. On the other hand, almost 99% of the Pacific saury was caught by liftnets with fish attracting lights.

Considerable portions of the sardine (70%), jack mackerel (43%), chub mackerel (54%) and anchovy (60%) are used as food for aquaculture or processed to fish meal and fish oil. Following the decline in the catches, the import of fish oil and fish meal has substantially increased in Japan during 1990-1995.

Western Central Pacific Ocean

This area extends from the seas of the Southeast Asian countries down to the north and east Australia and further eastwards to the smaller island countries of the south Pacific. The area is dominated by a vast continental shelf which is bordered in the north by the Southeast Asian countries and in the southeast by Indonesia and Australia. The majority of this shelf area lies within the EEZs of the Southeast Asian countries, which, therefore, make a major contribution to the total production of the area. In 1994, the catches by Indonesia, Malaysia, Philippines and Thailand accounted for 97% of the total landings of the western central Pacific Ocean (FAO, 1996).

The catches of the small pelagics in this area have risen almost consistently since 1950, barring a decline only in some years. The catches increased from 0.13 million mt in 1950 to 2.65 million mt in 1995, an increase of over 20 times. However, individual countries in the area had periods of stagnation, e.g., the catches of Indonesia stagnated for 10 years between 1951 and 1960; the catches of Philippines for 12 years between 1975 and 1986; and the catches of Thailand for 18 years from 1978 to 1995. Among the four countries contributing to the bulk of the catches of the small pelagics, the overall increase during 1950-1995 was very rapid in Indonesia and the Philippines, compared to that of Malaysia and Thailand.

1. *Indonesia*

The western central Pacific Ocean area of the Indonesian waters includes the south Malacca Strait, the Java Sea, the Banda Sea, the Makassar Strait and the Sulawesi Sea. The Java Sea has emerged as the major fisheries centre of Indonesia. The catches of the small pelagics, which increased from 25 000 mt in 1950 to 1.1 million mt in 1995, were steep between 1972 and 1995 (Table 4). During this period, the catches of scads, trevallies, mackerels and sardines increased considerably.

The purseseine was introduced in the Java Sea in the early 1970s, and since then, it has emerged as the major gear exploiting the small pelagics. The purseseine fleet increased steadily both in number and efficiency and its operations extended from the traditional fishing grounds in the Java Sea to the Makassar Strait in the east and the South China Sea in the northwest. The operation of the purseseines increased from 4 495 gear units in 1983 to 6 929 units in 1992 and the CPUE also increased from 55.8 mt/unit in 1983 to 70.5 mt/unit in 1992. In 1992, the purseseiners landed nearly 50% of the total catches of the small pelagics. In addition to the purseseines, other seines such as the payang type seine, Danishseine and beachseine are also used, but restricted to the coastal waters. Whereas the CPUE of the payangseine increased from 9.8m mt/unit gear in 1983 to 12.6 mt/unit in 1992, the CPUE of the Danishseine and beachseine were stable at around 6 mt/unit in 1983 and 9 mt/unit in 1992 during the 10-year period. These traditional gears are used either from small sized motorized or nonmotorized craft. There were large number of these craft operating all along the coast, but they were getting reduced in number. They are either being withdrawn from operation or are modified as mini purseseiners. In general, there is no drastic change in the CPUE of the major fishing gears as far as the fisheries for the small pelagics in Indonesia are concerned.

2. Malaysia

The east coast of the peninsular Malaysia, Sarawak and Sabah is in the western central Pacific Ocean. With the encouragement given for the development of offshore fishing in the Malaysian EEZ in recent years, the fishing activities have increased steadily in the South China Sea area off the east coast of Malaysia, Sarawak and Sabah. However, compared to the substantial increase in the catches of the small pelagics by Indonesia and Thailand, the increase in the catches by Malaysia was moderate. Unlike the west coast fisheries which concentrated in the northern Malacca Strait and had distinct stagnant, developing and fluctuating phases during 1950-1995, the landings in the east coast increased consistently from 40 000 mt in 1950 to 200 000 mt in 1995 (Table 4). As the east and west coast fisheries were based on two different fishing areas, the catch composition along these two coastal areas was also different. Whereas the short mackerels dominated by *R. rachysoma* contributed 56% to the landings of the small pelagics in the west coast during 1994, the catches were dominated by *R. kanagurta* in the east coast. The scads (selar scads and round scads) contributed 43% to the catches. The purseseines landed 70% of the landings and the trawls <10%. The number of purseseiners increased from 178 (1978) to 431 (1990) and decreased to 295 (1994) in the east coast. During 1978-1985, the cpue ranged from 62.2 mt/craft/year to 96.8 mt/craft/year whereas during 1986-1994, the CPUE declined and ranged from 23.2 mt/craft/year to 47.8 mt/craft/year. Driftnets of varying lengths and mesh sizes are also engaged in exploiting the small pelagics mostly in the inshore waters.

3. The Philippines

The Philippines comprises 7 100 islands and a narrow continental shelf. It is bound by the Pacific Ocean on the east, Celebes Sea and Bornean waters on the south and the China Sea on the east and north. The Sulu Sea, where upwelling occurs, is a productive area. The other major fishing grounds are Visayan Sea, Moro Gulf, Tayabas Bay, Bohol Sea, Lamon Bay and Batangas coast.

The production of the small pelagics increased rapidly from 0.02 million mt in 1957 to 0.62 million mt in 1975 and was stagnating around 0.6 million mt till 1985. The production increased once again and reached 0.94 million mt in 1991 and was stagnating around 0.9 million mt till 1995. The scads (mostly round scad and bigeye scad) formed 30%, the sardines formed 30%, short mackerels 9% and anchovies 8% of the landings of the small pelagics. Though the production of each of these major four fisheries increased several times during 1950-1995, they were characterised by specific production trends. The landings of the scads fluctuated between 0.16 million mt (1963) and 0.22 million mt (1976) for 27 years (1962-1988) before reaching a peak of 0.3 million mt in 1992. The landings of the sardines fluctuated severely for 14 years (1973-1986) between 60 000 mt and 150 000 mt, but increased rapidly in the subsequent years to reach the peak of 265 000 mt in 1995. The landings of the short mackerels did not increase much after 1974 and were fluctuating between 70 000 mt and 80 000 mt. The landings of the anchovies, which were also fluctuating, reached the peak of 130 000 mt in 1988, but sharply decreased to 73 000 mt in 1995.

The small pelagics are exploited by a number of craft and gears. Offshore vessels of 3 GRT and above operate beyond 15 km from the shore while the coastal vessels, which are either motorized or nonmotorized and are less than 3 GRT, operate in the waters within 15 km. Purseseines, bagnets, trawls, ringnets and Danishseines are operated from the offshore vessels. During 1991-1995, the purseseines contributed 64.5%, ringnets 15.3%, bagnets 9.9% and trawls 6.1% to the landings of the small pelagics. The purseseiners, trawlers and bagnetters, which were introduced in the Philippine waters as early as the 1940s, increased in number, and there were 516 purseseiners in 1982, 932 trawlers in 1983 and 1009 bagnetters in 1965. The operation of these vessels was restricted in the subsequent years asd the cpue started declining. However, the efficiency of the purseseiners was increased by using FADs and by employing carrier vessels. The carrier vessels assist the purseseiners, ringnetters and the trawlers by maximizing the fishing time of the fishing vessels. The operation of the ringnet, which was introduced in the 1970s, also increased, and there were >500 ringnetters in 1995. Nevertheless, the landings of the small pelagics from the offshore vessels doubled during 1984-1995, forming 70% of the total landings of the small pelagics in 1995. In 1984, the offshore fisheries contributed only 50% to the landings. The landings of the small pelagics from coastal fisheries remained stagnant during 1985-95.

4. *Thailand*

The east and south coasts of Thailand border the Gulf of Thailand which is located in the western central Pacific Ocean. The Gulf of Thailand is considered to be one of the most productive areas of the world. The nature of the marine fishery resources is typical of the Indo-Pacific fauna. The landings of the small pelagics in the entire Gulf of Thailand were 639 000 mt in 1995, of which nearly 80% (500 000 mt) was landed by Thailand. The Thai production of small pelagics consistently increased from 40 000 mt in 1950 to 500 000 mt in 1995. The major fishery groups contributing to the landings of the small pelagics in 1995 were: mackerels (27.0%), sardines (24.0%), anchovies(16.1%), coastal tunas (15.6%) and scads (15.1%). The landings of all these groups, especially that of the mackerels fluctuated severely during 1950-1995. Of the five species of mackerels recorded, *R.neglectus* and *R.brachysoma* are abundant in the coastal waters and *R.kanagurta, R.faughni* and *Rastrelliger sp.* in the offshore waters. The landings of the mackerels increased from 20 000 mt in 1963 to 150 000 mt in 1968, decreased to 58 000 mt in 1971, and after further fluctuations, reached 150 000 mt in 1984, again declined to 80 000 mt in 1991 and was up again to 135 000 mt in 1995.

The fisheries for the small pelagics in the Gulf of Thailand have developed around purseseine. The Chinese purseseine, which was introduced in the 1920s to catch the mackerels, gained popularity and was later modified as the Thai purseseine. Since the early 1960s, the fisheries developed rapidly, resulting from the modification of the fishing gears, entry of fishing fleets into new fishing grounds and the development of support facilities and other infrastructures. The landings of the small pelagics increased from 30 000 mtin 1960 to 200 000 mt in 1971. In 1973, the fishing grounds for the round scads *Decapterus dayi, D.killiche* and *D. macrosoma* were discovered in the central part of the Gulf, resulting in substantial increases in the catches of the scads from 660 mt in 1972 to 129 800 mt in 1977. Intensive fishing for the round scads for five years by engaging purseseines with coconut fronds as luring device heavily exploited the resources, resulting in the depletion of the stocks. The catches of the scads declined to 28 000 mt in 1979 and fluctuated between 10 000 mt and 30 000 mt till 1995. However, the development of fish luring lights since 1978, large purseseines to catch coastal tunas and hardtail scad in deeper waters since 1982 and anchovy fisheries by using small meshed purseseines with luring devices since 1983 resulted in an overall increase in the production of the small pelagics. From 1971 to 1994, the number of luring purseseiners increased from 33 to 930, Thai purseseiners from 328 to 657, anchovy purseseiners from 42 to 285, pair trawlers from 522 to 1978 (in 1990) and otter trawlers from 2 203 to 8 830 (in 1990). These efficient craft and gears have either reduced or replaced the traditional encircling and drift gillnets, pushnets and beam trawl. The number of pair trawlers and otter trawlers has also been reducing since 1990. As a result of the rapid development and expansion of the pelagic fisheries, it is clear that all the stocks in the Gulf of Thailand are being fully exploited and a few stocks are subjected to overexploitation.

Production trends in major fisheries

The small pelagics mentioned here are the ones which are listed under group 24 (shads etc), group 34 (jacks, scads, mullets etc), group 35 (herrings, sardines, anchovies etc) and group 37 (coastal tunas, mackerels, snoeks etc) in the ISSCAAP (International Standard Statistical Classification of Aquatic Animals and Plants). During 1995, the groups 24,34,35 and 37 constituted 2.2%, 34.2%, 33.8% and 29.8% of the landings of the small pelagics, respectively in the entire APFIC area (Table 5). The contribution of these fisheries in each region has undergone considerable changes during 1950-1995. Whereas the contributions of groups 24 and 34 increased in each oceanic region, the contribution of group 35 decreased in the eastern Indian Ocean and in the northwest Pacific Ocean and that of the group 37 decreased considerably in all the regions except in the northwest Pacific Ocean. By analysing the production levels, the composition and the peak landings during 1950-1995, the following trends in the APFIC area are discernible: (i) The landings of the jacks, scads and sauries have attained the peak only in 1995, and hence, are on the rise in all the regions. (ii) The group 35, which recorded the highest landings in the western Indian Ocean in 1990 and in the northwest Pacific Ocean in 1988, has shown clear signs of decline after attaining the peak. The strongly shoaling species in this group, viz., the sardines off the southwest coast of India and off Japan, and the anchovies off India, Malaysia, Philippines and Japan are the species causing concern. (iii) Though the contribution of group 37 has decreased considerably in three regions, the fact that the landings in 1995 remain very close to the respective highest regional landings, suggests that the landings of this group are relatively stable compared to group 35.

The fisheries for the small pelagics are contributed by hundreds of species. Nevertheless, four fisheries, the scads, sardines, anchovies and short mackerels are abundantly distributed throughout the APFIC area, together forming 60% of the landings of the small pelagics.

Scads

The fisheries for the scads *Decapterus spp.* are probably the most successful ones among the small pelagics during 1950-1995. The catches of the scads increased phenomenally off China, Indonesia, Philippines and moderately off Japan and Malaysia (Table 6). The scad fishery is relatively small in the western Indian Ocean, where the jacks form formidable fisheries. The landings of the scads in the APFIC area were about 1.3 million mt in 1995, which was about 12% of the landings of the small pelagics. The discovery of the fishing grounds in the central part of the Gulf of Thailand, the deployment of luring and aggregating devices during purseseining and the operation of high opening trawls and pair trawlers contributed to the increases in the catches of the scads. Though the catches are generally on the increase in the entire area, they are stagnant in the Gulf of Thailand and are on the decline off the southern part of the Java Sea in the 1990s.

Sardines

The landings of the sardines, which recorded drastic declines in the 1990s, were 1.95 million mt (18% of the small pelagics) in 1995. The landings of the Indian oil sardine *Sardinella longiceps* off the southwest coast of India and of the Japanese sardine (or pilchard) *Sardinops melanostictus* off the Japanese coast, which have registered serious fluctuations over the past decades, are on a declining trend in the 1990s (Table 7). Among the small pelagics, these two stocks cause serious concern in the APFIC area. Contrary to the landings of the Indian oil sardine and the Japanese sardine, the landings of the other species of sardines increased considerably. The landings of *Sardinella gibbosa, S. fimbriata* and *Dussumieria spp.* increased in the Gulf of Thailand and off Indonesia, the Philippines and the east coast of India.

Anchovies

The total landings of the anchovies in the APFIC area were 1.24 million mt in 1995, which was 11.3% of the landings of the small pelagics. The Japanese anchovy *Engraulis japonicus* form a sizeable fishery in the Yellow Sea, East China Sea and Japan Sea, landing 489 000 mt and 200 000 mt in China and Japan, respectively in 1995 (Table 8). The Gulf of Thailand and the Java Sea are also highly productive regions for the anchovies, especially for *Stolephorus heterolobus*. The development of pelagic trawling in China and small meshed purseseines with fish luring lamps in Thailand and Indonesia are the major reasons for the increase in the landings of the anchovies. However, the landings off Japan, east coast of India and west coast of Malaysia are on the decline during the past one decade.

Short mackerels

The short mackerels have emerged as the largest group in the APFIC area. The landings were 2.13 million mt, forming 19.5% of the landings of the small pelagics in 1995. The major species are *Pneumatophorus japonicus* in the northwest Pacific Ocean and *Rastrelliger kanagurta* and *R. brachysoma* in the other three regions. The landings in China, Indonesia and Thailand are consistently on the rise for the past few years (Table 9). The landings of the mackerels are highly fluctuating in all the regions, making it extremely difficult to arrive at definite conclusions on the status of the fishery.

BIOLOGICAL CHARACTERISTICS OF SMALL PELAGICS

Our understanding of the biological characteristics of the fisheries resources form the general basis for planning appropriate assistance to the fishing industries and the fishermen in obtaining sustainable catches. During the past one decade, considerable progress has been made in the APFIC countries in defining the biological criteria used in determining the quantum of catch that could be realised from a given stock without reducing its abundance beyond certain level. The progress in determining the biological mechanisms, especially the growth, spawning, recruitment and mortality has been quite substantial.

Growth, fecundity and spawning

Though the environmental conditions of the APFIC area range from tropical to sub-Antarctic and sub-Arctic climates, majority of the countries experience tropical and subtropical climates. Hence, the problems in estimating the growth of the tropical fishes are encountered in most of the stocks in the APFIC area. In the absence of suitable methods for the determination of the age and growth of tropical fishes, several numerical methods developed in recent years, have allowed the conversion of length frequency data into age composition. Overlapping of the successive modal classes and the difficulty in collecting representative, nonselective, unbiased population samples are the frequent sources of problems in the application of this method. This problem is acute in the case of the small pelagics which have strong shoaling behaviour. The shoal is made up of fishes of the same size, and so, it is difficult to get a representative sample of the size composition of the population, especially from the most popular gear, the purseseine. By reviewing the growth pattern of tropical fishes, Devaraj and Vivekanandan (MS) have concluded that the range of growth coefficient values (K) in the von Bertalanffy growth equation is very wide among the small pelagics compared to other taxonomic groups. This problem is likely to affect the length-based models for estimating growth, mortality and other population parameters. Nevertheless, the freedom with which the length frequency method has been used for the determination of growth gives the impression that there is no alternative to the length frequency method. In the 1980s and the 1990s, this method has been repeated on the same or other species in different APFIC countries year after year, thus generating considerable information on the growth parameters of the exploited stocks. The major advancement during this period has been the effective employment of computer programmes such as the ELEFAN, LFSA and FiSAT.

Table 10 provides the annual growth coefficient values (K) of a few dominant species of small pelagics in the APFIC area. The small pelagics, as a group, have the following unique growth and reproductive characteristics: (i) The K values are uniformly high and the life span is short for most of the species. In other words, the small pelagics grow fast towards their small size limits, which is a major difference compared to other taxonomic groups. (ii) Due to this, the small pelagics are subjected to more recruitment fluctuations (Csirke, 1988). (iii) Many species of the small pelagics attain 60% of their L∝at the end of the first year itself and reach L max in 2 to 3 years. A few species of sardines attain even 80% of their L∝ at the end of the first year. In comparison, most of the large pelagics and demersals attain only about 30% of their L∝ at the end of the I year and reach L max in about 8 years (Devaraj and Vivekanandan, MS). (iv) Most species of small pelagics attain first maturity at a very late stage of their life. For instance, the sardines and short mackerels attain first maturity at <70% of their L∝. On the other hand, the large pelagics and demersals attain first maturity at a very early stage of their life (<40% of L∝). As the reproductive process demands considerable energy, the growth rate of fishes decreases after they attain maturity. The small pelagics, which have fast growth rate and short longevity, delay the process of maturation and prolong the body growth process for a comparatively longer duration in their life than the other groups. (v) Conceptually, small sized and fast growing fishes have high natural mortalities, and warmer the ambient water, still higher the natural mortality (Pauly, 1980). These factors indicate very high natural mortality for most of the stocks of small pelagics. It has been recognized that there is a relationship between mortality and growth of several fish species. The ratio of M/K for the sardines ranged from 1.90 to 2.33 and for all the other speceis between 1.30 and 2.00 (Table 10). Clearly, the sardines have a very high natural mortality in relation to their growth. As the body size of sardines, anchovies, short mackerels, shads and many species of scads are small, the predation mortality on these fishes should be very high. Unfortunately, there is no proper estimate on the predation mortality of the small pelagics. (vi) Most small pelagics are filter feeders or particulate plankton feeders. Hence they congregate in the upwelling areas where the physical environment produces a large biomass of phytoplankton and zooplankton. Due to their low trophic level, the shoaling small pelagics feed on the large plankton biomass thereby allowing them to reach high biomass levels. (vii) The small pelagics have very high fecundity, but estimations of the fecundity of individual fishes greatly vary within the species according to their sizes. For instance, the fecundity of individuals of different sizes of the scad *D. maruadsi* ranges from 25 200 to 218 800 in the East China Sea (Tang and Tong, 1997) and from 38 000 to 515 000 in the Gulf of Thailand (Chullasorn, 1997); the fecundity of *S. crumenopthalmus* between 42 000 and 484 000 (Widodo, 1997), that of *R.brachysoma* between 11 300 and 119 300 in the Manila Bay (Calvelo, 1997) and the relative fecundity of *S.gibbosa* between 12 800 and 41 300 in the Bay of Bengal (Devaraj *et al.*, 1997). It is not clear how far this individual variation in fecundity regulates recruitment. The theories on density dependent fecundity and/or fecundity dependent recruitment have not been adequately established for the stocks of the small pelagics. As the indivitual-to-individual and year-to-year variations in fecundity could cause high recruitment variabilities, an objective way has to be evolved for translating the population level consequences of variations in fecundity on the recruitment and the fisheries.

Migration

Almost all marine fishes undertake one form of migration or the other, the understanding of which, is important for planning a successful fishery. The migration could be either vertical, which is often diurnal, or horizontal which may be either along the coastline or between inshore waters and the highseas and may extend for a longterm. Though the small pelagics are not known to undertake long distance interoceanic migrations similar to the highsea tunas, the groups such as the short mackerels, Spanish mackerels, scads and trevallies have been recorded to migrate fairly long distances between fishing and spawning grounds. The shads migrate between estuaries and inshore waters. The implication of the migratory behaviour is that a large sea area must be covered in order to obtain random samples for the assessment of population parameters. One example of the source of bias is the estimation of population parameters based on samples drawn from the spawning grounds, where shoals consisting of larger individuals are dominant. For a few temperate species such as the North Sea herring, the migratory patterns have been fairly well studied and ways to avoid bias in sampling and misinterpretation of results have been devised. On the contrary, the knowledge on the migration of most of the tropical pelagic stocks is very limited.

Another important reason for the necessity to study migration is to find solution to the problems of stock sharing between countries. The complex problems involved in shared stocks are the problems of stock identification and migration routes. Based on migration, Caddy (1982) has classified marine fisheries resources into the following five categories: (i) stocks that remain almost entirely within a single national jurisdiction; (ii) nonmigratory stocks lying across the boundary between adjacent zones and continuously available in each zone; (iii) migratory stocks moving across boundary areas, but available in each zone only on a seasonal basis; (iv) highsea stocks that are occasionally or partially available inside national areas; and (v) highsea stocks which occur outside the EEZs. Most of the small pelagics are under category (iii) and stock identification and knowledge on the migratory route are the prerequisites for the management of these stocks. Several ways have been suggested to monitor migration (Sparre and Venema, 1992): (i) One easy way is to follow the commercial landings and tap the knowledge of the fishermen. (ii) Acoustic equipments could be used to map the distribution and estimate the abundance of small pelagics. (iii) Tagging is probably the best way to study migration. Sophisticated acoustic and radio tags have been developed, which allow continuous observation of the movements of a single fish.

The FAO/SEAFDEC workshop on shared stocks has identified at least 40 stocks as currently being shared by two or more countries in Southeast Asia (FAO, 1985). The following are the major species shared by Thailand, Malaysia, Indonesia and Philippines in the western central Pacific Ocean: the round scads *D. macrosoma* and *D. maruadsi;* the trevallies *Caranx spp., Carangoides spp., Alectis spp.* and *Selaroides spp.*; the sardines *Sardinella spp.,* the short mackerels *R .kanagurta, R. brachysoma* and *R.faughni*; the Spanish mackerels *Scomberomorus spp.,* and the coastal tunas *Auxis spp., Euthynnus affinis* and *Thunnus tonggol* (FAO, 1985). The other probable shared stocks in the APFIC region are : (i) between India and Pakistan in the western Indian Ocean: the trevallies *Caranx* spp. and *Carangoides* spp., the grenadier anchovy *Coilia dussumieri, Thryssa* spp., the short mackerel *R. kanagurta*, the Spanish mackerels *S. commerson* and *S. guttatus* and the coastal tunas; (ii) between India and Sri Lanka in the eastern and western Indian Oceans: the sardines *Sardinella* spp. (including the Indian oil sardine *S.longiceps*), the short mackerel *R. kanagurta*, the small tuna *Auxis thazard* and the flyingfishes *Hirundichthys* spp.; (iii) between India and Bangladesh: the Bombay duck *Harpodon nehereus,* the hilsa shad *Hilsa ilisha* and others; (iv) between China and Japan in the northwest Pacific Ocean: the scad *D. maruadsi*, the Japanese sardine *S. melanostictus*, the scaled sardine *Harengula zunasi*, the Japanese anchovy *E. japonicus,* the Japanese mackerel *P. japonicus* and the Spanish mackerel *S. niphonius*.

In order to identify the shared stocks and to assess their status, information on the environmental factors which influence their distribution, abundance and migration is vital. Despite acknowledging the importance of tagging studies, no collaborative regional research approach has been initiated in the APFIC region. Research to answer questions on geographic limits, spawning areas and seasons, nursery grounds etc of the migratory species is weak or lacking. Collaborative research on these subjects should form an important agenda for the regional research organizations.

STOCK ASSESSMENT OF SMALL PELAGICS IN THE APFIC REGION

The shoaling small pelagic stocks usually do not fit well into the conventional population dynamics models because of their highly variable characteristics, thus making their assessment and management difficult and uncertain (Csirke, 1988). The immediate response of the stocks to the variations in the environment and their migratory nature make the assessment very complex. The best known examples are the Japanese sardine, Indian oil sardine, the scads, the short mackerels and the coastal tunas. The effects of environmental variations on the stocks are often confused with the changes in the stock that may occur due to fishing. Several estimates of the stocks of the small pelagics made on the basis of the conventional models have been upset by the large changes in the stock abundance due to various perturbations in the environment. For instance, the potential yield of the small pelagics in the northwest Pacific was estimated to be 5.8 to 6.5 million mt in 1985 with a scope to increase the catch by only 0.1 to 0.2 million mt at the maximum (Chikuni, 1985). It was thought that the total catch of the five major species had reached the maximum or even the excess level. Contrary to these estimates, the catch of the small pelagics reached, temporarily 9.2 million mt during 1986-1988. A change in the oceanographic conditions along the Pacific coast of Japan appears to be the most likely explanation. This phenomenon of the small pelagics tends to invalidate the estimates of the potential yield from any given area. Beverton (1963) concluded that, from the point of view of the overall fisheries prospects, fishing for the small pelagics is a high risk activity as compared to fishing for the more reliable and robust demersal stocks for which the conventional stock assessment models work much better.

The basic methods potentially available for monitoring the abundance of the small pelagics are the same as those used for estimating the abundance of other groups of fish. However, there are specific reasons for the uncertainties in the assessment of the stocks of the small pelagics (Devaraj and Vivekanandan, MS): (i) The highly variable nature of the stocks is one of the major reasons. (ii) As the small pelagics are fast growing and live a short span of life, decrease or increase in recruitment will be quickly followed by a severe decrease or increase in the stock size and vice versa. The quick changes in the stock size necessitate decision making on the management measures at very short notice and the existing stock assessment methods may not suit this requirement. (iii) The CPUE may not be a reliable indicator of the abundance. The catch/haul or catch/h will be high if one shoal is sighted even if the stock had declined to a very low level. The catch/haul may estimate the average size of shoal, rather than the population abundance. Catchability may be more reliable if the effort includes search time. (iv) It is difficult to quantify the fishing efficiency of gears employed in exploiting the small pelagics. In the trawl fisheries for the demersal stocks, development and improvement of the gear involve building larger vessels with higher engine power, increasing the mouth opening of the net, reducing the codend mesh size etc. These factors could be quantified and the effort could be estimated on a standard term. Improvements in the pelagic gears involve changes in techniques in fish finding such as acoustic instruments and in fish aggregation such as light lures, which are difficult to measure and standardize. (v) A fish shoal is normally made up of fish of about the same size, and hence, it is difficult to get a representative sample of the length composition of the population which would affect length-based assessment of the stocks.

There are a few methods that tend to work better for the small pelagics. Acoustic surveys are suitable for pelagic fishes and may provide reliable indices of abundance when used in a longterm monitoring programme, but may be misleading when employed as a one time estimate of absolute biomass (Csirke, 1988). The relation between the biomass and the acoustic properties is still uncertain, and species identification generally requires direct biological sampling, usually with nets. Different vessels and equipments could give different acoustic measurements and cross calibration is necessary for comparing the survey results. Egg and larval surveys also seem to work reasonably well in estimating the abundance of those species which release easily identifiable pelagic eggs.

Notwithstanding the limitations in estimating the stocks of the small pelagics, several assessments have been made in the APFIC region in recent years (Table 11). Most of the estimates have been made in localised areas without properly considering the geographical distribution of the stocks. It is possible that a portion of the stock is overexploited in one area or country, but is underexploited in another. The high concentration of the Indian oil sardine extends along the southwest coast of India in the Arabian Sea (between 8°N and 16°N latitudes), along the northwestern coast of Sri Lanka, and, since the mid 1980s, along the southeast coast of India in the Bay of Bengal between 8°N and 16°N. It is not clear whether the fishery is supported by a single stock or several stocks. Whereas the stock in the southwest coast of India is being overexploited by purseseines and ringseines, the newly emerging stock off the southeast coast appears to be underexploited in the absence of purseseines and ringseines as only the conventional gillnets operated from motorized and nonmotorized craft exploit this stock. The Japanese sardine are, again, an example of how a stock gets distributed over a wide geographical area depending on the prevailing environmental conditions. The following stocks of the sardine *S.melanostictus* have been identified: (i) the Pacific stock, (ii) the Ashizuri stock, (iii) the Kyushu stock and (iv) the Japan Sea stock (Chikuni, 1985). During the temporary periods of high catches (1930s and 1980s), it was only the Kyushu stock which dominated over the others by extending its distribution and spawning grounds in the south-north direction from the southern tip of Kyushu (25°N) up to the Pacific coasts of Japan (55°N). The stock identity was lost during these periods as there was a mixing with other stocks. The stock was shared and intensively exploited by the Japanese, Korean and the USSR vessels in the 1930s and the 1980s, but in the 1990s, the Chinese vessels too joined the fray as the stock extended to the East China Sea and the Yellow Sea. With the drastic decline in the abundance during 1940-1980 and in the 1990s, however, the original stock appears to have separated itself into the four stocks mentioned above. Similarly, understanding of the geographical distribution and abundance of stocks is available only to a limited extent for the other resources in the APFIC areas, such as the short mackerels in the western central Pacific Ocean. SEAFDEC, with limited success, initiated the improvement in the collection of statistics of multispecies fisheries in the countries in the western central Pacific Ocean for stock assessment purposes. Without identification of stocks and the knowledge of their geographical areas of distribution of the species concerned, stock assessment of the species could not be wholesome. The current pace of development on the estimation of the stock parameters in the individual countries is in the right direction.

The actions which are required now for meaningful stock assessments are as follows: (i) Identification of geographical distribution and abundance of major stocks. (ii) Collective compilation of basic data essential for stock assessment in the whole geographic areas of distribution of each stock. Such collection and compilation of data require uniformity in the estimations, especially the catch, effort and size composition. (iii) Collective analysis of the data to provide reliable estimates on the potential yield of the stock and to suggest the optimum level of fishing. (iv) Identification of the overexploited stocks and mechanisms to limit fishing on the heavily exploited stocks, which would often require an international machinery. These measures require close coordination of the countries, which are involved in harvesting the same stock.

MANAGEMENT OF SMALL PELAGICS

In the IPFC meetings conducted prior to the 1970s, the discussions used to be generally centring around questions of development of marine fisheries and improvement of catches. In the succeeding years, particularly after the late 1980's the emphasis gradually shifted from improving the catches to sustaining the catches and from fisheries exploitation to fisheries management. During the earlier phases of fisheries development, the resources remained rather underutilized, whereas in the subsequent phases, most of the resources were either fully exploited or, as feared, overexploited. Although the possibility of expanding the fisheries to the offshore has been repeatedly considered by the coastal countries, particularly by India, Indonesia, Malaysia and Thailand, no convincing evidence of the existence of such resources has ever been provided (FAO, 1996). Hence, the concerned countries have developed mechanisms of managing their fisheries for sustaining the resources and the catches. Regular monitoring surveys are being conducted in many of these countries with the objective of assessing the status of the stocks in response to fishing and environmental changes. The results of these evaluations, however, do not play a major role in the management decisions and in implementing the decisions. Therefore, the priority of fisheries in the APFIC region revolves around the issues of strengthening and implementing the management measures for sustaining the resources and their fisheries.

In principle, the management of the fisheries for the small pelagics involves the same problems as the management of the other fisheries. However, certain features such as migration and dispersal of the stocks and response to the changes in the environment and the consequent instabilities pose uncertainities and problems to the managers. There are not many practical ways of manipulating the physical events influencing the seas and the fish stocks to serve the objective of fisheries management. However, identification and understanding of those physical events and their role in influencing the fish stocks are necessary to plan the anthropogenic activities concerned with fisheries. Even if the major causes of dramatic changes in the stocks are recognised due to the environmental perturbations rather than due to fishing, a management strategy is required when the stock is declining. Such a strategy is essential to conserve the spawning stock and to maintain reproduction at a safe level. This approach should help to slow down the rate of collapse on the one hand and to hasten the recovery on the other. There are examples, the herring fishery of British Columbia, where severe restrictions were imposed soon after an environment-caused decline became apparent, and the stock subsequently recovered quickly. It appears that if appropriate action is taken (which may be temporary, but should be strictly implemented), the stocks may not be allowed to collapse completely.

The effects of the natural causes on the rise and fall of the fish stocks are apparent only for a few stocks, viz., the Japanese sardine, the Indian oil sardine and the Pacific herring. It appears that the other major stocks such as the anchovies, scads and short mackerels are tolerant to changes in the environmental conditions and their stock fluctuations may be due to either density dependent species replacement, as suggested by many researchers (Antony Raja, 1969; Chikuni, 1985; Devaraj *et. al.*, 1997) or fishing.

Management practices in vogue in the APFIC region

From the production trends of the small pelagics during 1950-1995, it is evident that most of the fisheries in the western Indian Ocean, eastern Indian Ocean and western central Pacific Ocean have passed through the following three distinct phases: (i) a stagnant initial phase when the catches were low; (ii) a steep increase following the introduction and expansion of efficient craft and gears such as the purseseiners and the pelagic trawlers, the operations of which were aided by fishing luring and aggregating devices; and (iii) a stagnant, or in some fisheries, a declining third phase, which is conspicuous in recent years. It appears that the increase in the number and efficiency of fishing craft and gears has sustained the catches only for a few years and the fish stocks could withstand no further increase in fishing pressure. Realising this, the APFIC member countries follow such management measures as closed seasons, closed areas, licensing the vessels, limiting the number of vessels, mesh size regulation etc. (Table 12).

(i) *Western Indian Ocean countries*

In the western Indian Ocean, the large number of small fishing vessels operating a variety of gears makes monitoring of the status of the stocks and the implementation of fisheries management difficult. Given the huge fisher population and the lack of alternative employment, the fishing intensity remains high in the west coast of India, Pakistan and Sri Lanka. In the west coast of India, *ad hoc* management measures are being implemented by restricting the operation of purseseiners and ringseiners during the southwest monsoon period (June-August). Due to decreasing catch rates, the number of purseseiners and ringseiners has stabilized during the 1990s. The most important management measures for the small pelagics in Sri Lanka are the regulation of beachseine and purseseine, by limiting the number and size of craft, mesh size of the gear and the area of operation.

(ii) *Eastern Indian Ocean countries*

Scientific management of fisheries resources is not yet well established in many regions of the eastern Indian Ocean, although development has reached a point where it is necessary. Fisheries management involving the control of effort is better established in Malaysia than in the rest of the region, except in Australia, where resource management is effectively implemented. For the pilchard fishery in western Australia, the fleet has been rationalised over time since the introduction of individual transferable quotas based on total allowable catch, which has been fixed at 25% of the estimated total biomass (O'Brien, 1997).

(iii) *Western Central Pacific Ocean countries*

In the western central Pacific Ocean countries, various conventional management measures are in vogue to restrict fishing effort, although fishing intensity keeps increasing. The stocks of short mackerels and round scads are heavily exploited in the Malacca Strait, the Java Sea, the central part of the Gulf of Thailand and the coastal waters of the Philippines; the sardines are heavily exploited in the Bali Strait. Evidently, management actions have not been entirely successful in decreasing the fishing capacity and there is an indication of overcapacity of fishing vessels. Overexploitation of resources is continuing in the various sections of the coasts of Thailand, the Philippines and Indonesia. The increase in the catches in the region in the 1970s and the 1980s was due to, in addition to the increase in the number and efficiency of fishing craft and gears, the extension of fishing to new grounds, as the catches from the traditional areas were sharply decreasing. Some of the catches made by Thailand were reported to have originated from outside its waters in the late 1970s (FAO, 1992); Indonesia increased its catches in the 1980s through the development of fisheries in the eastern part of the country; and Malaysia through the development of industrial fishing in its east coast. These countries fish in the waters of their neighbouring countries also through various bilateral agreements. Indonesia provides fishing access to foreign fleets 16 km off its archipelago in the South China Sea and on the Pacific side. Malaysia, despite the impediments in the buyback scheme of fishing vessels introduced in 1985, is once again initiating reintroduction of the scheme to reduce fishing pressure in the coastal waters. Compared to the Southeast Asian countries, the fishing intensity in the southern part of the western central Pacific (Australia and New Zealand) is low.

(iv) *Northwest Pacific Ocean countries*

Among the APFIC areas, management schemes are well developed in the northwest Pacific. Japan, especially, is following a set of effective management measures covering the entire fisheries along its coast. The three major laws of fisheries are concerned with: (i) control of fishing effort, (ii) conservation of resources and prevention of conflicts between fishermen; and (iii) coordination and self reliance in cooperative association with harmonious fishing and resources management (Chikuni, 1985). Fishing licenses are given to individuals who belong to the fisheries cooperatives. Fishing effort in each of the fisheries is regulated by a combination of the total number of vessels to be licensed, size category and the allowable engine power for each vessel size. The activities are coordinated by well organized bodies, in which the fishermen, scientists and representatives of public interest serve as members. Ironically, the Japanese fisheries, which have been the best managed fisheries in the APFIC region, have historically witnessed the maximum number of drastic production collapses. In 1997, Japan has begun a new management system based on total allowable catch (TAC) in addition to the existing systems (Wada, 1997). The Japanese sardine, short mackerels, jack mackerel and Pacific saury are the target species for management by the TAC system. There will be provision to allocate the TAC to individual fishermen also (Individual Quota System). China is also following stringent management measures such as closed fishing areas, closed fishing seasons and restriction of effort. Boat building and licensing are regulated. The fishermen have to pay a tax of about 30% of the total profit per capita towards fish resource protection and enhancement (Tang *et al.*, 1997).

(v) *International organizations associated with fisheries management in the APFIC region*

Besides the research, development and management network in the individual countries, there are several international organizations in the APFIC region which assist and coordinate national and international programmes in fisheries development, promote regional research activities and examine management problems. The Indian Ocean Fishery Commission (IOFC) and the Indian Ocean Tuna Commission (IOTC) for the western and eastern Indian Ocean; the Bay of Bengal Programme (BOBP) for the eastern Indian Ocean; the South Pacific Fisheries Forum Agency (FFA), the Southeast Asian Fisheries Development Centre (SEAFDEC), the International Center for Living Aquatic Resources Management (ICLARM), the Asia-Pacific Fishery Commission (APFIC), and the Indonesian-Malaysian-Thailand Growth Triangle (IMTGT) Project are the major international organizations involved in the regional promotion of the western central Pacific Ocean fisheries. In the northwest Pacific, there is no functional multilateral organization, although such an organization would be helpful in the assessment and management of shared stocks. Five bilateral fisheries agreements between individual countries exist currently in the northwest Pacific region. All these promotional bodies are only advisory and do not have any regulatory power.

Problems in managing the fisheries for the small pelagics

Most of the developing countries in the western Indian Ocean, eastern Indian Ocean and western central Pacific Ocean experience severe constraints in effectively implementing the regulatory measures. The major constraints which are common for the developing countries in these areas are as follows: (i) The natural variabilities and inadequate scientific information on stock abundance are being increasingly recognized as the causes for the uncertainities in fisheries management. (ii) As the small pelagics consist essentially of low value fish groups with large biomass, their fisheries are carried out by a large number of small scale fishermen who are totally dependent on these fisheries for their day-to-day life. In India alone, there are 180 000 nonmotorized and 32 000 motorized craft and about 0.7 million active fishers (70 % of the total 1million active marine fishers) engaged in the fisheries for the small pelagics. Considering their socioeconomic status, the government has not imposed any restriction on their fishing activities and has limited the management measures to the mechanised craft and to some extent, to the motorized craft. (iii) The intrinsic inefficiencies in fisheries management in the tropical developing countries also need to be examined and considered seriously. For instance, the restriction of fishing effort could take various forms such as the restriction on the number of vessels, number of days at sea, fishing hours, engine power, length of net, fish holding capacity of the vessels etc. Restriction of any of these parameters either partly or fully makes fishing inefficient. To overcome the restrictions, the fishers select and expand the parameters which are not subjected to restrictions. If the number of vessels is restricted, the number of fishing days is increased; if the number of fishing days is restricted, the fishing efficiency is increased by investing in larger and powerful vessels; if the fish-hold capacity is restricted, fast moving vessels and carrier boats are used. If there are simultaneous restriction on the number of vessels and days, fishing duration per day and engine capacity are increased, and sophisticated fish finding equipments, fish aggregating devices and efficient gears are inducted. The small pelagics are of low commercial value and expensive vessels and equipments are required to realise high rates of profitability. Therefore, only those who invest heavily could survive and the artisanal fishers find the going tough. (iv) The dwindling catches and the fishing restrictions often result in conflicts between the fishermen. (v) In almost every fishery, evaluation of the effects of the management measures is virtually impossible due to the lack of appropriate data, relevant to the situation, before the regulation was introduced. (vi) For the fisheries management system to be effective, monitoring, control and surveillance are necessary to enforce the regulations. Many of the developing countries do not have a proper surveillance system as it is an expensive practice. Due to these constraints, fisheries management in the developing countries in the APFIC region, by and large, has not been functioning well.

Human activities (other than fishing) in the coastal areas

In addition to the climatic and hydrographic factors which *inter alia*, cause fluctuations in the abundance of the small pelagics, there are several anthropogenic activities in the APFIC region, threatening the health of the stocks and the wellbeing of the fishing communities. In addition to overfishing in the coastal areas, the anthropogenic activities include oil and gas extraction, reef and tin mining, cutting of mangroves, and sewage discharges which result in habitat degradation and pollution of the aquatic environment. These activities which are on the increase, cause serious pressures on the environment, with direct and indirect impact on the fish stocks. The main problems in the developing countries in the APFIC region include high population pressure in the coastal areas and poor facilities for waste treatment, as indicated by high levels of coliform bacteria and BOD (Table 13). Most of the domestic sewage is generally discharged raw directly into the coastal waters that may adversely affect the coastal ecosystem. Significant growth in agricultural operations has also increased the amounts of herbicides and pesticides in rivers which may reduce the survival of juvenile fishes, shrimps and molluscs in coastal areas. Other human induced activities include increased terrestrial runoff of silt due to land reclamation and deforestation leading to siltation and changes in water temperature, salinity and transparency, with consequent damages to the coral reefs and aquatic vegetations. These factors are of importance since a high percentage of marine fish production comes from stocks which pass their early and most vulnerable stages in coastal waters (FAO, 1992). In the inshore waters of China and Japan, anthropogenic induced problems such as land reclamation, heavy metal pollution and oil spills affect the fisheries. The frequency of red tides appears to be increasing. In the southern coast of Australia, viral epidemics are causing large scale mortality of pilchards. Another matter of concern is the destruction of marine habitats. Coral reefs and mangroves are degraded in many countries bordering the Bay of Bengal with pristine areas now being found only in small pockets along the Gulf of Mannar in the southeast coast of India, the west coast of Sumatra and along the northern Andaman Sea coast of Thailand. Realising the values of mangroves and coral reefs and their importance in sustaining the coral ecosystems, a few countries have gazetted these areas as marine parks and closed them for all forms of fishing activities. Unplanned tourism development in the coastal areas also has resulted in the destruction of habitats.

The wider impact of these human disturbances on the stocks of the small pelagics, either on shortterm or longterm basis, could not be immediately quantified. For instance, it would be difficult to demonstrate that destruction of 100 sq.km. of mangroves in a particular locality would lead to loss of x tonnes of fish. Another basic difficulty in examining the effects of these factors on the fish stocks is that of distinguishing between human and natural causes. At the international level, there is need for research on the effects of human activities on the fish stocks. There is also need for analysing the economic relationship between land and sea uses and the resources and communities affected or benefitted by these uses. It is estimated that 80% of marine pollution comes from land-based sources, whereas their harmful effects are felt by the coastal fisheries. Perhaps the governments could think of pricing systems for natural resource uses. In Japan where communities have exclusive rights to fishing areas, those who wish to use areas for other purposes (for disposal of wastes etc), must pay the affected communities for these uses (FAO, 1993). An integrated and holistic approach to coastal zone management has to be taken urgently in addressing these problems following the guidelines which already exist in many countries. Promoting awareness on the impact of inappropriate uses of resources on fisheries has to be given much greater importance. The participation and cooperation of all users of the coastal zone, including the public and the private sectors and the NGOs are important.

Suggested management measures

Considering the geographical distribution and migration of the small pelagics, it is being increasingly recognized that effective management of the resources has to be done at two levels, national and regional. National management should be concerned with the actual implementation of the various policies which have been evolved for bringing about sustained development while regional management should seek to identify the common issues and facilitate their resolution for the benefit of the member countries of the region as a whole. For evolving and implementing stronger national management measures, management networks and work programmes are required in each country. They include: (i) establishment of a body for fisheries management with representatives from the fishermen, industry, scientists, NGOs, managers, financial institutions and politicians; (ii) data collection for catch and effort, important biological characteristics, marketing situation, price structure, social responses to fisheries events; (iii) classification of fisheries based on their geographic distribution and status of exploitation; (iv) periodic review of the status of fisheries, existing management policies and identification of the areas of weaknesses; (v) regulation of other human activities in the coastal areas; (vi) modification of the policies wherever necessary by focussing attention on management for sustaining the catches rather than increasing the catches in the coastal areas; (vii) evolving strong national policies by removing open access and common property rights; (viii) development of alternative activities for the extra manpower, if any, by interacting with the concerned parties; (ix) inculcating in the fishermen the necessity for responsible fishing and designing fisheries which would be regulated by the fishermen themselves; (x) development of mechanisms of accountability among the fishers on their catches, earnings and expenses on fishing; (xi) improvement of research, development and training facilities; (xii) development of a strong mechanism of implementing the policies and surveillance; (xiii) allocation of separate funds for fisheries management; (xiv) development of good legal frameworks; (xv) development of postharvest technologies and a good marketing system; and (xvi) evolving system for the prevention of disasters due to natural calamities and for restoration, rehabilitation and reestablishment of the affected men and materials.

For evolving regional level management measures, the following actions are necessary: (i) formation of a strong body to design regional policies; (ii) development of a mechanism to strengthen national management measures; (iii) identification of the regional changes in fisheries, especially the shared stocks and periodically advising the member countries; (iv) provision of strong scientific support for fisheries development by imparting training on the technological changes; (v) development of a system for communication, exchange of data and interaction on management experiences among the member countries; (vi) promotion of compatibility and consensus among the countries in sharing the stocks based on mutually agreed stock assessment studies; and (vii) generation of adequate funds for implementing the management programmes.

A critical scrutiny of the available information on the small pelagics in the APFIC region reveals that a few important aspects have not been considered hitherto in evolving and implementing management policies in the APFIC region:

(i) It is important that a uniform method of data collection is evolved for the estimation of fishing effort and fishing efficiency of all the major gears. As the nonselective gears such as the purseseine often catch several fish groups in a single haul, thereby influencing the stocks of all the concerned groups, it is more appropriate that the assessment of the status of exploitation is gear-based rather than single fishery-based, say, the sardine fisheries or the anchovy fisheries. Further, this kind of information is important in assessing how the regulatory measures applied on one particular fleet/gear in the fishery affect the remaining fleets, and to determine whether regulating one kind of fleet alone will be beneficial.

(ii) Information available on the relationship between the environmental factors and production is very limited, especially for the western Indian Ocean, eastern Indian Ocean and western central Pacific Ocean regions. Collaborative oceanographic cruises, experimental fishing and tagging should be conducted in these areas.

(iii) Collaborative research works on shared stocks such as the scads, mackerels and coastal tunas should be conducted among the countries in the APFIC region. These research efforts should focus on the assessment of the resources in the EEZ and international waters and for recommending proper sharing of these resources.

To prove the possibility of interactions between the shared stocks between and among the coastal countries, the SEAFDEC has recommended the need to do collaborative research to determine similarity/dissimilarity in stocks through tagging, electrophoretic and mitochondrial DNA studies, morphology or any other means.

(iv) Remote sensing is one technology which has not been put into proper use for fisheries purposes. For the marine environment, this technology offers immense opportunity to learn more about the dynamics of sea surface temperature (SST) and colour (chlorophyll) which are of critical importance especially in relating surface features including primary productivity with the small pelagics. Details of the effects of the monsoons on the oceanographic parameters could be monitored and mapped out, which would be helpful in determining and predicting the spatial and temporal distribution of the stocks. Remote sensing facilities already exist in countries such as India, Japan and China. At present, India is using this technology to locate potential fishing zones (PFZs), especially of the pelagics. The forecasts of the PFZs have been found to be valid in the case of the small pelagics, and the abundance of oil sardine has been observed to be related to optimum SST and dissolved oxygen concentration. Although only a beginning has been made, the results obtained in India and elsewhere do indicate the possible future applications of satellite derived chlorophyll and SST distribution for the purpose of directing and controlling fishing effort.

(v) The advancements in postharvest technologies and marketing are still inadequate in many APFIC countries and do not match with or correspond to the rapid advancements made in harvesting technologies. Most of the small pelagics are low value fishes, characterised by unpredictably sudden high or low landings, leading to sudden glut or scarcity in the market. Hence, the postharvest technologies and the market should be able to cope up with the abrupt changes in fish arrivals. As the small pelagics are a cheap source of protein for the large coastal populations, any rise in their prices will seriously affect the poor and depress their access to the limited supplies. The postharvest technologies for the small pelagics present 3 distinct scenarios in the APFIC region: (i) In India and Sri Lanka, the small pelagics are consumed mostly in fresh condition or sun-dried during periods of glut. There is large scope for these countries to develop suitable postharvest technologies for the production of value added fish and fish-based products. Development of value added products reduces wastage of fish and arrests further lowering of the value through drying and salting during periods of glut in these countries. (ii) The Southeast Asian countries have developed a number of value added products in the past two decades, with an increasing amount of them destined for export. In recent years, there are complaints of increase in prices of fish due to the importance given to export. (iii) In countries such as Australia and Japan, the sardines and anchovies are primarily used as fish meal in aquaculture farms and as baits in fishing operations. It is essential that these countries launch programmes on increasing the utilization of low value species for direct human consumption in view of the rapidly increasing demand for fish products in these countries, which are increasingly becoming fish importers.

The nature of the issues in managing the fisheries is common to many countries in the APFIC region. The implementation of the management schemes will be expensive, but the costs can be reduced by proper planning and by involving the fishing communities. Clearly, there is need for a strong political will to conserve the fishery resources and sustain the benefits to the countries in the region.

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Table 1. Landings (million mt) of small pelagics in the APFIC areas in 1950 and 1995; figures in parentheses represent total landings.

Area	Landings 1950	Landings 1995	Increase in landings	Highest landings	Year	Remarks on small pelagics landings
Western Indian Ocean	0.24 (0.55)	1.00 (3.65)	4.2 times (6.6 times)	1.06	1990	Severe annual fluctuations
Eastern Indian Ocean	0.12 (0.30)	1.10 (3.70)	9.2 times (12.3 times)	1.10	1995	Consistent increase
Northwest Pacific Ocean	1.70 (4.90)	6.20 (21.80)	3.6 times (4.5 times)	9.20	1986	Increase during 1950-87; consistent decline since then
Western Central Pacific Ocean	0.13 (0.60)	2.65 (8.30)	20.4 times (13.8 times)	2.65	1995	Consistent increase
All areas	2.19 (6.35)	10.95 (37.45)	5.0 times (5.9 times)	11.6	1988	Increase during 1950-88; gradual decline since then

Table 2. Production of total fish and small pelagics in the APFIC areas during 1995.

Oceanic region	Continental shelf area (000sq.km.)	Total catch (t/sq.km.)	Potential* (t/sq.km)	Small pelagics catch(t/sq.km)	% of small pelagics
Western Indian	790	4.6	16.4	1.3	28.3
Eastern Indian	2210	1.7	4.5	0.5	29.4
Northwest Pacific	2770	7.9	9.4	2.2	27.8
Western Central Pacific	3120	2.7	3.5	0.9	33.3
APFIC area	8890	4.2	6.7	1.2	28.5

* calculated from FAO (1996)

Table 3. Percentage contribution of each area to the production of small pelagics.

Oceanic area	1950	1995
Western Indian	11.0	9.1
Eastern Indian	5.5	10.1
Northwest Pacific	77.6	56.6
Western Central Pacific	5.9	24.2

Table 4. Comparison of small pelagic landings in 1950 and 1995 (from Martosubroto, 1997).

Region/country	Landings (mt) 1950	Landings (mt) 1995	Increase	Remarks
Western Indian				
India	200000	760000	4 times	Annual fluctuations in major fisheries
Sri Lanka	5000	70000	14 times	Highest (90000 t) in 1983; stagnant at around 70000mtsince then
Eastern Indian				
Australia	14000	25000	6 times	Pilchard is the only fishery
India	72000	280000	4 times	Increase since 1984
Indonesia	5000	225000	45 times	Steep increase since 1975
Malaysia	35000	175000	5 times	Steep increase during 1975-1984
Thailand	2000	260000	130 times	Moderate increase during 1972-1981; steep increase since then
Northwest Pacific				
China	125000	2500000	20 times	Steep increase since 1988
Japan	1200000	2100000	75%	Reached peak of 6.25 millionmtin 1988; sharply declined since then
Western Central Pacific				
Indonesia	25000	1100000	44 times	Consistent increase; pronouced since 1972
Malaysia	40000	200000	5 times	Consistent increase
Philippines	25000	900000	36 times	Steep increase between 1958-1975 and 1986-1991
Thailand	40000	500000	12 times	Consistent increase

Table 5. Landings (million mt) of major fishery groups; the figures in parentheses represent percentage contribution to the landings of small pelagics.

Group/ ISSCAAP No.	Western Indian Ocean		Peak landings		Eastern Indian Ocean		Peak landings		Northwest Pacific Ocean		Peak landings		Western Central Pacific Ocean		Peak landings		Total	
	1950	1995	millionmt	year	1950	1995	millionmt	year	1950	1995	millionmt	year	1950	1995	millionmt	year	1950	1995
Shads etc (No.24)	0.001 (0.1)	0.01 (1.0)	0.03	1984	Negl.	0.17 (15.5)	0.18	1992	Negl.	0.05 (0.8)	0.05	1995	Negl.	0.01 (0.4)	0.10	1995	0.01 (0.5)	0.24 (2.2)
Jacks, sauries, scads etc (No.34)	0.06 (25.0)	0.37 (37.0)	0.37	1995	0.03 (25.0)	0.30 (27.3)	0.30	1995	0.40 (23.5)	1.90 (30.6)	1.90	1995	0.03 (23.0)	1.17 (44.1)	1.17	1995	0.52 (23.6)	3.74 (34.2)
Herrings, sardines, anchovies etc (No.35)	0.07 (29.1)	0.37 (37.0)	0.58	1990	0.04 (33.3)	0.32 (29.0)	0.32	1995	0.90 (53.0)	1.95 (31.5)	6.20	1988	0.05 (38.5)	1.06 (40.0)	1.06	1995	1.06 (48.2)	3.70 (33.8)
Mackerels, snoeks etc (No.37)	0.11 (45.8)	0.25 (25.0)	0.27	1993	0.05 (41.7)	0.31 (28.2)	0.31	1995	0.40 (23.5)	2.30 (37.1)	2.80	1978	0.05 (38.5)	0.41 (15.5)	0.45	1994	0.61 (27.7)	3.27 (29.8)

Table 6. Comparison of landings of scads in 1950 and 1995 (from Martosubroto, 1997).

Oceanic region/ country	Landings (mt) 1950	1995	Increase	Remarks
Western Indian				
India	-	2000		Consistent increase
Pakistan	-	2000		Consistent increase
Eastern Indian				
Indonesia	-	20000	-	Increase during 1979-1991; on the decline since then
Malaysia	5000	9000	2 times	Gradual increase
Thailand	-	37000	-	Steep increase since 1981; but highly fluctuating
Northwest Pacific				
China	50000	515000	10 times	Consistent increase
Japan	10000	50000	5 times	Consistent increase
Western Central Pacific				
Indonesia	1000	210000	210 times	Consistent increase
Malaysia	1000	35000	35 times	Consistent increase
Philippines	-	270000	-	Very high increase, especially in 1958, 1975 & 1992
Thailand	1000	96283	96 times	Spurt in 1977 (130000 mt) from nil catch; stagnant around 80000 mt since then

Table 7. Comparison of landings of sardines in 1950 and 1995 (from Martosubroto, 1997).

Oceanic region/country	Landings (mt) 1950	1995	Increase	Remarks
Western Indian				
India	5000	92000	14 times	Highly fluctuating in a cycle of 5-6 years
Pakistan	1000	50000	50 times	Increase during 1978-82 and 1990-93
Eastern Indian				
India	1000	70000	70 times	Sudden increase in 1975; fluctuating since then
Indonesia	1000	25000	25 times	Increasing since 1977
Thailand	1000	30000	30 times	Sudden increase in 1982; fluctuating since then
Northwest Pacific				
China	Nil	58000		Fishery since 1970s; increasing trend
Japan	250000	600000	2.5 times	Spurt since 1973, reaches 4.5 million mt in 1988 and declines to 0.6 million mt in 1995

Table 8. Comparison of landings of anchovies in 1950 and in 1995 (from Martosubroto, 1997)

Oceanic region/country	Landings (mt) 1950	1995	Increase	Remarks
Western Indian				
India	15000	82000	5.5 times	Stagnant during 1950-72; sudden increase since then but highly fluctuating
Pakistan	1000	18000	18 times	Sudden increase since 1988
Eastern Indian				
India	10000	12000	Marginal	Reached 36000 mt in 1983; declining
Indonesia	1000	37000	37 times	since then
Malaysia	8000	11000	Marginal	Stagnant during 1950-75; increase since then, steep since 1985
Thailand	1000	68000	68 times	Declining since 1982 (from 35 000 mt) Stagnant (<1 000 mt) during 1950-90; phenomenal rise since then
Northwest Pacific				
China	1000	489000	489 times	Steep increase in 1990s
Japan	40000 0	200000	Nil	Declining trend
Western Central Pacific				
Indonesia	2500	100000	40 times	Consistent increase
Malaysia	2000	10000	5 times	Gradual increase
Philippines	2000	68000	34 times	Fluctuated but increased till 1987 (130000 mt); Steep decline since then
Thailand	500	100000	200 times	Moderate increase during (1970-81); steep during 1982-85 and 1988-90

Table 9. Comparison of landings of short mackerels in 1950 and in 1995 (from Martosubroto, 1997).

Oceanic region/country	Landings (mt) 1950	1995	Increase	Remarks
Western Indian				
India	60000	135000	2.2 times	Fluctuating
Eastern Indian				
India	10000	24000	2.4 times	Fluctuating
Indonesia	1000	50000	50 times	Consistent increase
Malaysia	10000	100000	10 times	Highly fluctuating
Thailand	1000	78000	78 times	Steep increase since 1981
Northwest Pacific				
China	132000	372000	3 times	Consistent increase
Japan	* 90000	660000	7 times	High landings during 1965-75; highly fluctuating
Western Central Pacific				
Indonesia	5000	140000	28 times	Consistent increase
Malaysia	5000	18000	3.6 times	Moderate increase
Philippines	1000	75000	75 times	Increase during 1964-74 and 1983-90
Thailand	40000	135000	3.4 times	Highly fluctuating

* landings for the year 1986.

Table 10. Biological characteristics of a few species of small pelagics in the APFIC region.

Species	Locality	Loo (mm)	K (annual)	M	M/K	Reference
SCADS						
Decapterus russelli	West coast of India	232	1.08	1.90	1.76	Reuben, *et al.*, 1992
- do -	Malaysia	240-270	0.81-1.01	1.63-1.82	1.8-2.0	Mansor, 1987
- do -	Java Sea	245-283	0.4-1.2	0.65-2.18	0.7-2.2	Widodo, 1988
- do -	Philippines	330	0.80	1.60	2.00	Ingles & Pauly, 1984
D. macrosoma	Java Sea	231-256	0.7-1.1	0.62-1.86	1.90	Widodo, 1988
- do -	Philippines	230-330	0.50-1.26	1.10-2.20	2.00	Ingles & Pauly, 1984
D. maruadsi	Manila Bay	269-330	0.45-0.80	1.03-1.50	2.00	Corpuz *et al.* 1985
JACKS & TREVALLIES						
Caranx carangus	East coast of India	444	0.65	0.95	1.46	Reuben, *et al.* 1992
C. leptolepis	- do -	213	1.43	2.19	1.53	- do -
Selar crumenophthalmus	Gulf of Thailand	284	2.40	3.30	1.37	Chullasorn, 1997
Selaroides leptolepis	East coast of India	202	0.82	1.35	1.65-1.77	Reuben, *et al.* 1992
- do -	Java Sea	220	1.20	2.21	1.84	Suwarso, 1993
Alepes kalla	West coast of India	171	0.83	1.40	1.69	Reuben, *et al.* 1992
A. djeddaba	- do -	326	0.61	0.99	1.62	- do -
Atule mate	- do -	340	0.85	1.22	1.44	- do -
Atropus atropus	- do -	440	1.00	1.26	1.26	- do -
SARDINES						
Sardinella longiceps	West coast of India	207	1.60	3.60	2.25	Annigeri, *et al.* 1992
- do -	Philippines	210	1.10	2.10	1.91	Ingles & Pauly, 1984
S. albella	East coast of India	152	1.41	3.10	2.20	Bennet *et. al.* 1992
S. gibbosa	- do -	171	1.44	3.20	2.22	- do -
S. fimbriata	West coast of India	220	0.98	2.16	2.20	- do -
- do -	Philippines	140-220	0.70-1.60	1.63-3.0	1.91-2.3	Ingles & Pauly, 1984
S. *sirm*	East coast of India	380	0.53	1.16	2.19	Bennet, *et al.* 1992
- do -	Philippines	273	0.86	1.66	1.93	Ingles & Pauly, 1984
Dussumieria acuta	- do -	210	1.05	1.97	1.90	Corpuz, *et al.* 1985

Table 10 Cont'd.

Species	Locality	Loo (mm)	K (annual)	M	M/K	Reference
ANCHOVIES						
Stolephorus devisi	West coast of India	113	2.04	2.61	1.28	Luther, *et al.* 1992
S. bataviensis	- do -	116	2.03	2.61	1.29	- do -
- do -	East coast of India	135	1.40	2.25	1.61	- do -
S. indicus	Manila Bay	157-163	1.05-1.42	2.23-2.67	1.9-2.1	Ingles & Pauly, 1984
S. punctifer	- do -	92-106	1.15-1.85	2.55-3.53	1.9-2.3	Ingles & Pauly, 1984
S. heterolobus	Gulf of Thailand	89	1.80	3.54	1.97	Chullasorn, 1997
- do -	Philippines	120	1.60	3.10	1.94	Ingles & Pauly, 1984
Coilia dussumieri	West coast of India	265	1.07	2.15	2.00	Fernandez & Devaraj, 1996
SHORT MACKERELS						
Rastrelliger brachysoma	Malaysia	240-338	0.52-1.04	1.22-1.92	2.00	Mansor, 1987
- do -	Samar Sea	245-340	1.1-1.6	2.89-3.10	1.5-1.8	Corpuz , *et al.* 1985
R. kanagurta	West coast of India	238	2.84	1.24	0.44	Devaraj, *et al.* 1994
- do -	Gulf of Thailand	229	2.76	3.75	1.36	Chullasorn, 1997
- do -	Malaysia	290-357	0.73-1.21	1.97-2.01	1.7-2.0	Mansor, 1987
- do -	Java Sea	239-262	0.65-2.78	1.00-2.58	1.60	Suwarso, 1993
- do -	Samar Sea	280	1.55	2.43	1.56	Corpuz, *et al.* 1985

Table 11. Stock assessment of a few major groups of small pelagics in APFIC countries.

Group/Species	Location	Period	Annual stock (mt)	MSY (mt)	Reference	Annual yield(mt)	Exploitation level
WESTERN INDIAN OCEAN							
Oil sardine	Southwest coast of India	1984-88		150000	Annigeri, *et al.* 1992	117000 (1996)	Over
Lesser sardine	Southwest coast of India	1976	90000		George, *et al.*, 1977	43458 (1991-95)	Fully
Anchovies	Westcoast of India	1984-88		57300	Luther, *et al.* 1992	52000 (1991-95)	Fully
Indian mackerel	Southwest coast of India	1934-73		70788	Devaraj, *et al.*, 1994	113860 (1991-95)	Over
Ribbonfish	West coast of India	1984-88		65600	Thiagarajan, *et al.*, 1992	60000 (1991-95)	Fully
Horsemackerel	West coast of India	1985-89		11500	Reuben, *et al.*, 1992	18230 (1991-95)	Over
Bombayduck	Northwest coast of India	1982-86	76893	54631	Kurian & Kurup, 1992	85766 (1996)	Over
All small pelagics	Sri Lanka			95000	Dayaratne, 1997	65000 (1993)	Optimum
EASTERN INDIAN OCEAN							
Lesser sardines	Southeast coast of India	1976	170000		George, *et al.*, 1977	50268 (1991-95)	Under
Anchovies	Southeast coast of India	1984-88		30500	Luther, *et al.*, 1992	20115 (1991-95)	Under
Indian mackerel	Southeast coast of India	1984-88		25300	Noble, *et al.*, 1992	40285 (1991-95)	Over
Ribbonfish	Southeast coast of India	1984-88		20400	Thiagarajan, *et al.*, 1992	20773 (1991-95)	Fully
Pilchard	Western Australia			40000	O'Brien, 1997	16000 (1995)	Under

Table 11 Cont'd.

Group/Species	Location	Period	Annual stock (mt)	MSY (mt)	Reference	Annual yield(mt)	Exploitation level
WESTERN CENTRAL PACIFIC OCEAN							
Sardines	Gulf of Thailand	1990-91		104000	FAO, 1995	-	Over
Anchovies	- do -	- do -		104000	- do -	-	Over
Indian mackerel	- do -	- do -		32866	- do -	-	Optimum
Indo-Pacific mackerel	- do -	- do -		75250	- do -	70451 (1982-91)	Fully
- do -	- do -	1984-93		104000	- do -	- do -	- do -
NORTHWEST PACIFIC OCEAN							
Japanese sardine	East China Sea, Southwest of Japan & Yellow Sea	1986-88	650000	370000	Ding, *et al.*, 1988	-	Under
Scaled sardine	Bohai Sea & Yellow Sea	1986-88		35000	Tang, *et al.*, 1997	35000 (1995)	Optimum
Japanese anchovy	East China Sea & Yellow Sea	1984-93	3000000 500000	1500000	Tang, *et al.*, 1997	489000 (1995)	Under
Japanese mackerel	East China Sea & Yellow Sea	1978-82		300000	Tang, *et al.*, 1997	372000	Over

Table 12. Management measures in practice for small pelagics in the APFIC region.

Country	Level of exploitation	Groups	Basis for conclusion	Reasons for the status	Management measures	Reference
India	Over	Sardines, mackerel in the southwest coast	Decline in CPUE of PS & RS	Intensive fishing, small mesh	(i)Closed season (ii)Closed areas for mech.vessels	Devaraj, *et al.* ,1997
	Under	Sardines in southeast coast	Recent emergence of oil sardine fishery	No PS; pelagics exploited only traditional craft	(i)Closed areas for mech.vessels	
Sri Lanka	Optimum	All small pelagics in southwest & southeast coast	FAO study in 1981; update required	Motorization; increase in PS	(i)Area of PS operation restricted	Dayaratne, 1997
	Under	All small pelagics in northwest & northeast coast	Regular fishing affected	Political	Nil	
Thailand	Over	Sardines, round scads, anchovies	By comparing MSY and present yield	Increase in number & efficiency of PS	(i)Closed season (ii)Closed areas for PS & TR (iii)Restriction on lures & mesh size	Chullasorn, 1997; FAO, 1997
	Fully	Mackerels, big eye scads & all other small pelagics	- do -	- do -		
Malaysia	Over	All small pelagics in east coast	Decline in cpue since 1985	Increase in number & efficiency of PS	(i)Closed areas (ii)Strict licensing	Chee, 1997
	Optimum	All small pelagics in west coast	CPUE stable	PS fishery developed recently	- do -	

PS: Purseseine; TR:Trawl; RS: Ringseine; TAC: Total Allowable Catch; ITQ: Individual Transferable Quota.

Table 12 Cont'd.

Country	Level of exploitation	Groups	Basis for conclusion	Reasons for the status	Management measures	Reference
Indonesia	Fully Optimum	All small pelagics in Java Sea & Bali Strait All small pelagics in other coasts	Decline in landings CPUE stable	Increase in number & efficiency of PS Surveillance; Social control on fishing	(i)Trawl ban (ii)Licensing (iii)Closed areas, seasons (iv)TAC	Widodo, 1997
Philippines	Heavily	All small pelagics	Decline in cpue	Increase in number & efficiency of PS, RN, TR	(i)Closed areas (ii)Closed seasons	Calvelo, 1997
China	Over Optimum Under	Japanese mackerel, Pacific herring Scaled sardine & many others Japanese anchovy, Japanese sardines	Small sized individuals on the increase Stock-catch estimations - do -	Increase in effort Stocks able to withstand increase in effort Emergence of new fisheries	(i)Closed areas (ii)Closed seasons (iii)Strict licensing (iv)Regulations in boat building (v)30% of profit per capita for management	Tang, *et al*., 1997
Japan	Over Fully Optimum	Japanese sardine Chub mackerel Japanese anchovy, Pacific saury Jack mackerel	Stock estimation - do - - do - - do - - do -	Environmental fluctuations Appropriate management measures - do -	(i)Closed areas (ii)Closed seasons (iii)Licensing (iv)Effort control (v)Community based management (v)TAC & ITQ	Chikuni, 1985; Wada, 1997

PS: Purseseine; TR:Trawl; RS: Ringseine; TAC: Total Allowable Catch; ITQ: Individual Transferable Quota

Table 13. Human activities (other than regular fishing) in the coastal areas and their possible effects on the small pelagics.

Types of activities		Possible effects
(i)	Dense human population and discharge of large quantities of untreated domestic waste water	Faecal coliform and BOD levels high leading to eutrophication; incidence of red tide often causes fish mortality
(ii)	Runoff of agrochemicals and industrial discharge	Hazardous chemicals are lethel beyond certain level
(iii)	Heavy phosphorous loading in estuaries	- do -
(iv)	Removal of mangroves for wood; mining of coral reefs for lime	Destruction of nursery grounds
(v)	Oil pollution by ships and fishing vessels	Shadowing effect and reduction in DO leading to mass mortality
(vi)	Unplanned tourism development	Beach erosion and habitat disturbance
(vii)	Terrestrial runoff of silt due to land reclamation and deforestation	Change in marine environment effects juvenile population
(viii)	Fishing by using cyanide & other lethal chemicals	Detrimental to a whole range of organisms in the area