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Marine Fishery Resources Management

SHRIMP FISHERIES IN THE BAY OF BENGAL BOBP/WP/58

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by M. Van der Knaap
Fishery Biologist
(Assistant Professional Officer)
Bay of Bengal Programme

Executing Agency

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This paper describes the marine shrimp fisheries in countries around the Bay of Bengal. It summarizes available information on the fishery, catch data, rates and composition, also or by-catch.

It also reviews the status of exploitation, stock assessment and management in various countries of the region.

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1. INTRODUCTION

Coastal shrimp resources constitute important fisheries in countries around the Bay of Bengal, generating foreign exchange and providing jobs in the fishing and ancillary industries. The artisanal sector contributes about 65% to the total annual production of prawns estimated at 133,000 t in 1984.

Of the Bay of Bengal countries, Bangladesh, Burma, Maldives and Sri Lanka fall entirely within the region studied. Regarding other countries, the west coast of Thailand, the west coast of Peninsular Malaysia, the part of Sumatra above the equator (Indonesia) and the east coast of India including Andaman Islands are within the region (Figure 1). Of these countries, India and Burma did not participate in the FAO/UNDP project RAS/81/051, 'Marine Fishery Resources Management in the Bay of Bengal'.

In this paper, available information on marine shrimp fisheries in various BOBP member countries has been compiled, and the current state of the shrimp stocks discussed.

2. DISTRIBUTION

In this study, scientific names are based on FAO (Holthuis, 1980) terminology. The distribution of penaeid and non-penaeid species occurring in the study area are presented in Tables 1 and 2 respectively. In this segregation, all those species under Superfamily Penaeoidea are treated as penaeids and the others as non-penaeids. Some species which are thought to occur in certain areas are also indicated. Some species mentioned under Malaysia, Thailand and Indonesia may not necessarily be found in the study area.

Of nearly 70 species of penaeid shrimps listed, about 40-45 species occur off India, Malaysia and **Indonesia, 30-35 species off Burma** and Sri Lanka and 20-25 species off Bangladesh and Thailand. They are very poorly represented in the Maldives. The species common to all the seven countries are six: *Penaeus indicus, P. merguiensis, P. semisulcatus, P. monodon, Metapenaeus affinis* and *M. lysianassa.* Those that are common to six countries are another eight: *P. japonicus, M. andamanensis, M. stridulans, M. brevicomis, M. monoceros, Parapenaeopsis hardwickii, Trachypenaeus curvirostris* and *Solenocera crassicornis.*

On the eastern seaboard of the Bay of Bengal, of 36 species occurring in Sri Lanka, all but five are common with India. On the western side, out of about 50 species, nearly 40 appear to be common for three or more countries.

With regard to the non-penaeid species, of the total of nearly 30 species listed, Thailand has the largest number, 18; in the other countries the occurrence of less than 10 has been confirmed. The most common is *Acetes indicus* recorded from all the countries; *Acetus erythraeus, Heterocarpus gibbosus* and *Plesionika martia* are common to five countries. Of the ten species from the eastern Bay of Bengal, occurrence of only three species as common to both India and Sri Lanka has been confirmed. On the western side, some eight species are comparatively more common (at least in three countries) than the others.

Nine penaeid and 13 non-penaeid shrimp species are found on the continental slopes in the Bay of Bengal. A list of these deep sea shrimps is presented in Table 3. Most of the species reported occur on muddy or sandy bottoms and little is known of the species on rocky bottoms, because rocky bottoms are generally avoided by commercial trawlers and research vessels.

3. MARINE SHRIMP FISHERIES IN THE COUNTRIES AROUND THE BAY OF BENGAL

3.1 INDIA

3.1.1 Fishery

Some 3500 small trawlers exploit the coastal prawn resources along the east coast of India. The majority of these vessels measure about 32 feet and have engines of 20 to 80 hp. The cod-end mesh size has been steadily decreasing and has reached a level of 8-10 mm at present. The vessels often operate very close inshore. Fishing trips last one day and the whole catch (including fish) is landed. A different shrimp fishery exists in the upper Bay of Bengal (off the states of Orissa

and West Bengal): 15-25 m outrigger shrimpers fish the offshore prawn resources. There were about 20 shrimpers in 1978, which increased to about 100 in 1985, each making 20-day trips, and landing its catches at Visakhapatnam; nowadays trips of longer duration, 40-45 days are undertaken by some of the largest trawlers. All small and low value fish are discarded. The shrimp fishing grounds along the east coast of India are presented in Figure 2.

In the traditional fishery, the craft used are kattumarams and plank- built boats. The gears used by the kattumarams are small boat seines and gilinets, while the plank-built boats use large stakenets and boat seines. A number of other indigenous shrimp fishing gears are also used (Table 4).

One of the most important fishing gears in West Bengal is the fixed bagnet; other gears include scoop nets, barrier nets, cast nets and small traps.

Artisanal gears used in Orissa are boat seines, lift nets, bottom gillnets and cast nets (Kurian and Sebastian, 1976; Mohapatra, 1980).

There is an intensive trap fishery in the Chilka Lake. Besides, the shrimp culture operations around the Chilka Lake are expanding. The ponds are stocked with *P. monodon* seed caught by scoop nets in the Chilka Lake. After selecting these seeds, the other species are thrown back into the water alive.

The shrimp fishery in Andhra Pradesh employs numerous artisanal gears including fixed bagnets (to catch *Penaeus* and *Metapenaeus* species), very large bagnets to catch *Nematopalaemon tenuipes* from August to November and barrier nets extending over a mile (used in the Kakinada Bay and the Godavary estuary). Other gears used are boat seine, beach seine without bag, drag net, driftnet for large prawns and scoop net. Bamboo box like traps are used in channels, singly or in rows, to catch prawns from July to October (Kurian and Sebastian, 1976).

Boat seines are a popular gear in Tamil Nadu. The mesh size at the mouth is 30 mm and at the cod-end 12 mm.

When prawns are driven to the shore as a result of upwelling or wind, beach or shore seines are used to catch them. Boats lay the net out in a semicircle upto 1 km from the shore and the net is pulled to the coast using ropes. The mesh size at the cod-end is 12 mm.

Other gears used are drag nets, cast nets and net traps (Kurian and Sebastian, 1976).

3.1.2 Catch data

There are two agencies estimating the landings data, the Central Marine Fisheries Research Institute (CMFRI) and the Directorate of Fisheries of the concerned State Government/Union Territory (SG/UT). For the period 1956-1968, CMFRI (1969) is the source of information. Thereafter, upto 1984, the CMFRI data are available in Silas et al. and in Anonymous (1983 Et 1986). The data from the SG/UT are sent to the Ministry of Agriculture, Government of India (GOI), who compile the information and disseminate through occasional publications (Anonymous, 1979 & 1986a). It is this information which is sent to FAQ headquarters and is utilised for the Yearbook of Fishery Statistics published by FAQ.

In this paper, the data as released by GOI for the period 1975 to 1984 (Table 5) are considered. During the first five years of this period, the production of penaeid prawns was oscillating between 18000 and 24000 t; it shot up to 31000 t in 1980 (most probably due to overestimation of the production in West Bengal) but declined thereafter to a level of 23000 tin 1984. The landings of non-penaeid shrimps have also been oscillating rather widely, between 3000 t and 9000 t; recent production shows an increasing trend (probably due to progressive reduction in the cod-end mesh size) and is currently at 13000 t. The total shrimp production registered an all-time high of 40000 tin 1980, dropped heavily thereafter and stands at 36000 t at present. The east coast production of penaeid prawns is about 20% of the all India total, and that of non-penaeid shrimps 15%; together they form 18% of the entire Indian shrimp production.

The state-wise production of penaeid prawn shows that in West Bengal (where the estimation seems to be suspect from 1979), the figures are widely variable between 1000 and 12000 t. It seems almost certain that during the recent five years the estuarine production has been included in the marine catch. The CMFRI data show a drastic decline in the landings of penaeid prawns and an increase in those of non-penaeid shrimps.

In Orissa, there was an increasing trend in penaeid prawn production up to 1980 when it reached about 4000 t; thereafter it started declining with an all-time low of less than 1000 t in 1983.

There seems to have been a partial recovery in 1984. Regarding non-penaeid shrimps, there are records only for the last two years when over 2000 t have been landed.

Among the States/UTs on the east coast, Andhra Pradesh has been recording the highest production (except in 1984) mainly due to the large landings of non-penaeid shrimps. The yield from both penaeid and non-penaeid groups has been fluctuating so widely that no trend of increase or decrease can be discerned. In the case of penaeid prawns the range is from about 6000 t to 11000 t and in the case of non-penaeid shrimps it is from 1000 t to about 7000 t.

More or less the same situation obtains in the adjacent state of Tamilnadu and in Pondicherry. The average production in Tamil Nadu is very close to that of Andhra Pradesh. The penaeid prawn production has fluctuated from 6000 t to 11000 t and the non-penaeid shrimp production from 50 t to 9000 t, the largest landings being registered in 1984.

Pondicherry is a small Union Territory whose total landings of all prawns/shrimps is above 1000 t. The Andaman and Nicobar groups of islands also form a Union Territory. There has been a steady increase in the landings over the years with an annual average of 50 t.

3.1.3 Catch rates

Catch and effort data since 1979 for the Kakinada-based (Andhra Pradesh) small trawlers are presented in Table 6. The total prawn landings in Kakinada had decreased from 2465 tin 1980 to 972 t in 1985, simultaneous with a decrease in total effort. The overall catch rate of prawns for all types of trawlers (9, 10 and 11 m LOA) had also decreased from 51.8 kg/boat/trip to 29.6 kg/boat/trip (Table 6). The reduction in CPUE has been spasmodic, from about 50 kg in 1980-81 to 40 kg. during 1982-84 and then to 30 kg in 1985. The percentage (by weight) of shrimp in the total landings had also reportedly diminished from 30.2 in 1980 to 15.2 in 1985 (Ratnanandaraj, personal communication).

3.1.4 Catch composition

Generally on the east coast the most important penaeid species are *Penaeus indicus, P. monodon, P. semisulcatus, Metapenaeus monoceros, M. dobsoni* and *M. brevicornis.* The important non-penaeid species include *Acetes indicus, Nematopalaemon tenuipes, Exopalaemon styliferus* and *Exhippolysmata ensirostris* (Silas et al., 1980). In Orissa and West Bengal post-larvae of various shrimp species are exploited for culture purposes.

In the early 1970s exploratory trawling done off the Rushikulya river in Orissa at 10 and 20 m depth revealed that of the 13 species of marine prawns *Penaeus monodon* was overwhelmingly dominant (73%), followed by P. indicus (13%), *P. merguiensis* (4%), *Metapenaeus monoceros* (2%), *P. semisulcatus* (1%) and other species (7%) (Mohanty et al., 1979).

Rao et al. (1980) have presented the species composition of the shrimp landings by trawlers in Kakinada for the period 1967-79. In general, up to 1976, *Metapenaeus* spp (mostly *M. dobsoni, M. affinis* and *M. monoceros)* dominated to the extent of 55% to 75%; thereafter the extent of their dominance declined to a level of 24% in 1979. Simultaneously, the non-penaeid shrimps surfaced very strongly, forming 31% to 55%. The authors attributed this change to the reduction in the cod-end mesh size of the trawl. The share of *Penaeus* spp was erratic, averaging about 12% of the landings. The picture during the subsequent year upto 1985 was more or less similar (Table 7), presuming that the class "others" relates to non-penaeid shrimps.

3.1.5 By-catch

According to George et al. (1981), the by-catch of commercial shrimp trawlers of Orissa consisted of croakers (67%) and of threadfins (9%). Other contributors were catfish, sharks and rays.

Information is available on the fish species composition of Kakinada-based trawlers. The sciaenids (20%) form the major component of the by-catch. Other important components are hairtails (9%) and clupeids (8%); as is customary in reporting of the by-catch, 'others' form a very high proportion – about 54% (Table 8) (Ratnanandaraj, personal communication). A comparison of the above information with that given by George et al. (1981) for 1979 for the different States/UT on the east coast, reveals a rough similarity in so far as Andhra Pradesh is concerned. However, the relative importance of the species is different in the other areas; in Orissa, the sciaenids are dominant, followed by threadfins and catfishes; in Tamil Nadu, the ponyfishes form the bulk followed by the sciaenids, and in Pondicherry the perches and ponyfishes are the main components.

3.1.6 Stock assessment

The standing stock of shrimps off West Bengal has been estimated as 10000 to 13000 t on an area of 28000 km 2 to a depth of 75 m (Sudarsan, 1977).

Application of Schaefer's production model to the catch and effort of small trawlers at two centres in Tamil Nadu, Madras and Mandapam for the period 1972-79, yielded MSY values of 920 and 363 t with corresponding effort values of 94000 and 23800 boat-days respectively (Silas et al., 1984). According to the latter authors, no fit to production model was possible for the Kakinada data for the period 1970-80 because the catch rates were increasing with effort. However, it was seen subsequently that the catch, effort and the catch rates have declined significantly (Table 6). Rao et al. (1980) pointed out that since 1977 there was a considerable reduction in the mesh size at the cod-end coupled with significant increase in effort. The extra pressure on the shrimp stock due to reduction in cod-end mesh size was not reflected in the fishing effort values, which were used in the assessments. The shrimp resources in the Kakinada region are almost certainly overexploited.

Apart from the above, the available statistics do not allow proper stock assessment for the eastern states of India. The traditional non-mechanised fishing sector is concerned about the adverse impact on its catches and earnings due to the increased entry of motorized boats on the one hand and the growing operations of these boats in the inshore waters on the other. As prawns are the target species of both the motorized and the non-motorized fleets, the shrimp resources are believed to be overexploited in various fishing areas. In addition, the average mesh size in the cod-end of trawis decreased sharply during the second half of the seventies, which led to landings of huge amounts of small shrimp including juvenile penaeids and adult non-penaeid shrimp species. The use of small mesh sizes has been defended as necessary to prevent small adult shrimps (mainly non-penaeids) from being lost to the fishery (Rao et al., 1980).

3.1.7 Management

The management of shrimp resources in India is required to cater to a wide range of objectives – increasing production, maximising economic return, increasing employment, etc. Silas et a). (1984) have discussed the available options for management and observed as follows

Enforcing larger mesh sizes might not be particularly helpful as adults of small-sized non-penaeid shrimps might then be lost to the fishery. Mesh size regulation would, however, be necessary in estuarine areas were large numbers of juveniles are now caught.

Limitations on fishing effort through a licensing system, catch quotas and restrictions on the number of fishing hours may help restrict catches to optimal levels. Diversification of fishing methods during certain seasons would also help. A package of incentives and subsidies might be required to achieve this.

Nursery areas are best protected by a total ban on fishing. It is, however, doubtful whether such an intervention is possible in Indian conditions. Measures that are possible would include restrictions (or a total ban) on the operation of fixed gears and small-mesh nets in nursery areas. Banning the export of shrimps with counts below some fixed minimum could also be tried out.

A committee of the Government of India recommended the following measures for conservation of shrimp resources (Silas et al., 1984):

- each state should obtain reliable statistics on the number of mechanised boats in operation;
- inshore fisheries should be monitored intensively;
- total allowable catch off Orissa and West Bengal should be prescribed;
- fishing zones should be prescribed for different categories of vessels and these should be strictly adhered to;
- mangrove swamp areas must be demarcated as reserved areas;
- fixed gears with mesh sizes smaller than 20 mm must be phased out and fishermen affected by this provided alternative employment in aquaculture;
- necessary steps must be taken to implement existing regulations; and
- steps must be taken to prevent large-scale domestic and industrial effluents from reaching estuaries.

The states of Tamil Nadu and Orissa have enacted a Marine Fishing Regulation Act to reserve a distance upto 5 km (or 3 miles) from the shore for the exclusive use of traditional non-mechanised fishing vessels; small mechanised boats should operate only beyond 5 km, and large shrimpers and deep sea fishing vessels should operate beyond 10 km from the shore.

As far as is known, no regulations for the shrimp post-larval fishery have been enacted.

The Government of India has decided not to allow import of any more shrimping vessels of 20 m and above in length, and not to recommend soft loans for indigenous construction of similar sized vessels. On the other hand, entrepreneurs find it more economical to operate 14 m shrimpers. The increasing fishing pressure thus goes unabated.

3.2 BANGLADESH

3.2.1 Fishery

Commercial shrimping on the continental shelf of Bangladesh started after the Mitsui Tayo survey in 1976-77 (Rashid, 1983). The number of shrimp trawlers operating in Bangladesh waters increased from 8 in 1980/81 to 31 in 1985/86; the fish trawls which also exploit the shrimp resources, however, started decreasing from 46 in 1983/84 to 14 in 1985/86 (Shahidullah, 1986). During 1979-81, more than 100 Thai trawlers were in operation under a joint venture programme. The trawler fleet strength is given in Table 9 and the shrimp trawling grounds are shown in Figure 3.

Artisanal fishermen who exploit the prawn resources operate dragnets, seine nets, fixed pursenets, stakenets, trammelnets, framed or dipnets and castnets (Kibria, 1985). The use of trammelnets, common in neighbouring Burma, was reportedly spreading towards the north (ODA/PPFC, 1983); it has apparently become popular in Bangladesh also, after its introduction in Cox's Bazar (Shahidullah, 1986). Van Zalinge (1986) noticed a shift from seine nets, cast nets, dragnets and other artisanal gears towards set bagnets and trammelnets.

A very important behundi net (set bagnet) fishery for juvenile fish and prawns exists in the tidal zone of Bangladesh (Ahmed, 1981 & 1984). According to Shimura (1984), there were 13039 nets in the estuarine area and 3086 in the offshore area, the latter from November to February. Shahidullah (1986) found some increase in the number of set bagnets, 11379 in the estuarine and inshore waters and 4775 in the offshore waters. Three categories of bagnets are distinguished; their areas of operation are indicated in Figure 3.

Intensive cultivation of prawns is also practised in Bangladesh. About 20,000-28000 ha of land in the intertidal zone is used to trap and raise postlarvae of *Penaeus monodon, P. indicus* and *Metapenaeus monoceros.* The stocking rate of post larvae of *P. monodon* in ponds is of the order of 25000- 40000 seed/ha (Kibria, 1985; Larsson, 1986). Three different gears are used in the postlarval fishery: set bagnet (behundi jal), push net (thela jal) and dragnet (baksho jal). The mesh size used is 1 mm (Larsson, 1986). Kibria (1985) and Larsson (1986) made some rough estimate of the seed production in Satkhira district as about 0.80 billion and 1.12 billion respectively; the difference *was* due to difference in the area reckoned for culture of *P. monodon* per year. According to Larsson (1986), less than 1% of the catch consists of *P. monodon,* the balance consists of fry of various other shrimp and fish and is discarded on the river banks.

According to Penn (1982) and Rashid (1983), the period of recruitment to the fishing grounds for the different species is as follows : tiger prawn from September to January; white prawn during January to May.

3.2.2 Catch data/Catch rates

According to Shahidullah (1986), the estimated shrimp production of the trawler fleet was about 700 tin 1980/81 and then sharply increased to 4500 tin 1983/84. In the next season the production dropped sharply to 3140 t and remained at the same level in 1985/86. The average shrimp catch rate has been fluctuating between 337 kg/day/trawler in 1982/83 and 660 kg/day/trawler in 1985/86 (Table 10). However, according to Van Zalinge (1986), the estimated production and catch rate for 1985/86 were 4031 t and 626 kg/day/trawler respectively. Similarly, there are differences in the reported number of trawlers. For 1983/84 Shimura (1984) has estimated the total shrimp catch as 3000 t from 31 shrimp trawlers and 1500 t from 64 finfish trawlers. However, the number of vessels (95) differs considerably from those (73-74) given by White and Kahn and Shahidullah (Table 9).

While there are estimates of total production from the set bagnet fishery (Shahidullah, 1983 and 1986; Shimura, 1984), the proportion of shrimps in the production is not known. According to Akerman (1986), the offshore bagnet catches consisted of 21% of shrimp. If a conservative proportion of 10% is applied to the total set bagnet production (60000 to 62500 t), then around 6000 t of shrimp is produced by this fishery. The combined production from the trawl and set bagnet fishery would be then about 10000 t.

Seasonal differences in catch rates of crustaceans were observed during the brief resources surveys by R/V Dr. Fridtjof Nansen in November/December 1979 and in May 1980 (Saetre, 1981). In general, it was seen that the catch rates were higher during the latter period.

3.2.3 Catch composition

Four commercial shrimp categories are recognised in the trawler landings: tiger, brown, white and small shrimps. The tiger shrimps are mainly Penaeus monodon and P. semisulcatus; the white, P. indicus and P. penicillatus, and the brown, Parapenaeopsis sculptilis The small shrimps Consist largely of Metapenaeus monoceros, M. brevicornis and other Metapenaeus species (Rashid, 1983). The various species compositions as reported at different points of time are summarized in Table 11. It appears that the percentage species composition has changed considerably over a period of about 10 years. The percentage of white has declined considerably but on the other hand, the percentages of brown and small prawn categories have increased. This transition appears to have occurred in 1980-81. The operations of Thai trawlers in Bangladesh waters might have had an impact on the species composition after 1979/80.

There is some mix-up in the identity of shrimp categories. Rashid (1983) has categorised *Parapenaeopsis sculptills* under brown shrimp and classified Metapenaeus as "small". Van Zalinge 11986) used the name 'small' for *P. stylifera* and the term 'brown' for *Metapenaeus monoceros.* However, since in the trade circles there is no confusion about the identity, it is presumed that the classification of Rashid might have been an inadvertent error.

3.2.4 By-catch

During the Mitsui Tayo survey, the by-catch of the two trawlers consisted of jew fish (33%), eel (17%), sole (17%), snapper (7%), mackerel (4%), pomfret (4%), Chinese herring (3%) and mixed fish (15%) (Rashid, 1983). There is no information on the utilization of the present day by-catch.

3.2.5 Stock assessment

Table 12 presents the estimates of standing stock made by different authors. Using the swept area method, West (1973) estimated for the total continental shelf area a standing stock between 3400 t and 5700 t assuming no escapement, and between 6800 t and 11400 t (average 9000 t) assuming 50% escapement. In the grounds of Cox's Bazaar, which are the main shrimping grounds, the standing stock was estimated by him as between 1900 and 2700 t (50% escapement). Based on the data obtained during the Mitsui Tayo survey in 1976-77, Rashid (1983) estimated the standing stock of marine shrimp as 4400 t or 8800 t depending whether the escapement was zero or 50% and suggested a potential annual yield between 2000 t (zero escapement) and 4000 t (50% escapement) for the surveyed area of 4200 nm^2.

Penn (1982) obtained different levels of standing stock per year which he attributed to differences in the intensity of recruitment. The average values of standing stock obtained by him over four years were 2094 t (no escapement) and 4165 t (50% escapement). Following Boerema (1974), he considered the standing stock values as estimates of the maximum potential yield with M = 2.0. Although a comparison of the stock densities (Table 12) might suggest an increase in biomass in 1978-79 over that in 1968-71, it should be noted that Penn considered in his study only the areas with the highest density. On the basis of the day-time results of the shrimp cruises by R/V Anusandhani from November 1985 to July 1986, the standing stock was estimated between 60 and 2293 t (Van Zalinge, 1986).

Some potential yield and MSY values obtaining from Bangladesh waters were cited by Sivasubramaniam (1985). These include a potential yield of shrimps between 3400 and 5700 t obtained by Tiews (1966) through the swept area method; an MSY value of 4000-5000 t estimated by FAO (1972b) applying production models to the available catch and effort data; and a potential yiedl of 2500 t using catch and effort data upto 1981 (George, 1982).

3.2.6 Management

In order not to overexploit the shrimp resources on the trawlable grounds, a minimum mesh size of 45 mm in the cod-end of the shrimp trawl has been prescribed in the Marine Fisheries Ordinance of 1983. Trawling operations are permitted only in waters deeper than 40m. The ordinance has also prescribed a minimum mesh size of 30 mm to be used in the cod-end of set bagnets (Shahidullah, 1986). Ahmed (1981 & 1984) studied the behundi net fishery and concluded that intensive growth overfishing takes place in the estuarine areas. He sugested banning of behundi net operations. According to him (1984), enlargement of the mesh size would be senseless due to the absence of larger fish vulnerable to the gear and hence resulting in poor catches. However, in the inshore waters where bigger fishes are available, increasing the mesh size at the cod-end may be rewarding both from the economical and biological points of view. Although the mesh selectivity experiments conducted by Akerman (1986) were insufficient to draw definite conclusions, they indicated of the readiness of the fishermen to shift to bigger mesh sizes at the cod-end, provided the cheaper polyethylene netting material of desired ply was made available to them. Reverting to the estuarine fishery, White and Khan (1985) **also expressed their concern about the possible** impact of behundi nets upon both shrimp and fish larvae and juveniles and their interaction with the offshore fisheries. Van Zalinge (1986) also concluded that growth overfishing occurs in the artisanal fishery where the catches consist of postlarval, juvenile and pre-adult shrimps. As thousands of fishermen depend on this fishery, it needs a great deal of attention from researchers before the desired regulatory measures are introduced Such studies should also take into consideration, the destruction of prawn seeds other than those of tiger prawn by the seed collectors engaged in shrimp culture operations and the alarming decrease in the contribution of white shrimp to the trawl fishery.

Considering the size of the standing stock (between 2000 t and 4200 ton an average), Penn (1982) suggested a trawl fleet not exceeding 20 to 30 vessels, depending on size, to exploit the available resources. White and Khan (1985) recommended that the trawler fleet should not be expanded beyond 31 fish trawlers and 30 shrimp trawlers (the fleet's strength at that time.) Further import of trawlers was banned by the Government in September 1984 (Shahidullah, 1986). **Van Zalinge** (1986) thought it advisable to postpone decisions on changes in the industrial fleet (45 vessels in 1986) until proper stock assessment becomes feasible.

3.3 BURMA

3.3.1 Fishery

Along the Tenasserim and Arakan (or Rakhine) coasts (Figure 4), there are substantial artisanal prawn fisheries which use trammelnets from small boats and canoes. The trammelnets, set on the sea-bed during daylight at depths of 10-30 m, are selective in catching especially *P. merguiensis* and *P. penidilatus,* which account for 80% of the catch. Canoes usually carry about 10 nets, each mounted to 30 m x 20 m with an inner mesh size of 4.5 cm and an envelope with 25 cm mesh (ODA/PPFC, 1983). The number of such trammelnets used along the Arakan coast was around 5000 in 1978/79; it increased to 16500 in 1982/83, but decreased to 15000 in 1983/84. Along the Tenasserim coast the number of trammelnets oscillated between 3750 in 1978/79 and 16000 in 1982/83; it dropped to 9000 in 1983/84 (Table 13).

The fishing season starts in August/September and ends in December on the southern coast but continues till February or March further north. The bathymetry of the seabed is such that the depths (10-30 m) which contain the mature prawn populations are close to the shore and easily accessible to the artisanal fishery. Areas where prawns are known to concentrate, e.g., in the vicinity of freshwater outflows, are heavily fished (ODA/PPFC, 1983; Price and Kyaw Htin, 1984).

Substantial quantities of marine (and freshwater) shrimps are also caught by the antisanal shrimp fishery from the delta area by means of floating bamboo shrimp traps and fixed nets, the latter being hauled four times a day (Price and Kyaw Htin, 1984).

Trawlers have been exploiting the shrimps since the 1960s. Fishing records, however, are available only from 1977/78. The composition of the trawl fleet over the years is presented in Table 14. The number of freezer trawlers declined in the period 1977-1982 from 12 to 8 while the smaller stern trawlers up to 200 GRT and boom trawlers increased from 16 in 1977/78 to 40 in 1981/82 (Price and Kyaw Htin, 1984).

3.3.2 Catch data/Catch rates

Along the Tenasserim coast the artisanal production registered an increasing trend from 505 t in 1977/78 to 909 tin 1979/80; thereafter it steadily declined to 670 tin 1982/83. On the Arakan coast, except for a decline in 1980/81, the production increased steadily from 226 tin 1978/79 to 582 tin 1982/83. The data on production, effort and catch per effort presented in Table 13 show that on the Tenasserim coast the catch/effort has declined drastically whenever the effort was hiked up about three times or more; on the Arakan coast, although the catch/eftort was low, it did not decline so sharply as on the Tenasserim coast.

The only production figure available for marine shrimp in the Delta area is 1440 tin 1953/54 being the production of 909 floating bamboo traps, set in tidal creeks (Ba Kyaw, 1956, cited in Price and Kyaw Htin, 1984). The number of traps operated at present is not known.

Regarding the industrial trawl fishery, Price and Kyaw Htin (1984) reconstructed shrimp catch and effort data for the trawl fleet for the period 1977/78 to 1981/82, based on the information available from logbooks. Their studies indicated that the production by trawlers in Burmese waters increased from 52.2 tin 1977/78 to 90.2 tin 1981 /82 (with a slight drop in 1979/80). The adjusted production, effort and catch rate figures are presented in Table 15.

From the survey records of research vessels it is seen that generally better catch rates were obtained during the post-monsoon period. During these surveys the dominant species were *Metapenaeus* spp; in addition, *P. monodon, P. merguiensis* and *P. semisulcatus* were also caught (Stromme et al .. 1981; ODA/PPFC, 1983; Price and Kyaw Htin, 1984; FAO/UNDP, 1984).

3.3.3 Catch composition

Large fluctuations between years were observed in the percentage composition of the industrial shrimp catches. A significant feature was the transition of dominance from *Metapenaeus* spp to *Penacus* spp during 1980-82 as compared to the earlier three seasons, 1977-80 (Table 16). Even among *Penaeus* spp, the tiger prawn *(P. monodon* and *P. semisulcatus)* dominated to such an extent as to almost totally eliminate the white prawns *(P. merguiensis* and *P. pendilatus).* This transition may be due to changes in natural mortality or fishing mortality; or it may reflect changes in the fishing grounds or changes in the selectivity of the industrial fishing gear (Price and Kyaw Htin, 1984). On the other hand, for the artisanal fisheries sector, principally employing trammelnets, the catches were dominated by the white prawns to the extent of 80% of the total catch (ODA/PPFC, 1983; FAO/UNDP, 1984).

3.3.4 By-catch

During the trawl surveys along the Arakan coast, (ODA/PPFC, 1983), rays, clupeids, sciaenids, pomadasyids, ariids and lutjanids were the main contributors to the by-catch. Their contribution, however, varied with depth and season. Generally, the by-catch was fully utilized.

3.3.5 Stock assessment

The standing stock of shrimps in the trawlable grounds off the Arakan coast was estimated as 4370 t (ODA/PPFC, 1983). It was assumed that the optimal annual catch could be equal to the standing stock or virgin biomass of shrimp. Consequently, the optimum yield for the Arakan coast was placed at 4870 t, the additional 500 t coming from the artisanal fishery. It was also assumed that the artisanal production would increase to about 1000 t following its expansion in the northern part of the Arakan coast, leaving about 3900 t for the trawl fishery. During the trawl operations of R/V Linshu in 1981 /82 it appeared that the prawn catches consisted of 46-48% *Penaeus* spp, which led to the conclusion that the optimum yield of *Penaeus* spp may be around 2560 t (47% of 4370 t plus an additional 500 t from the artisanal fishery), and that of the other prawn species, mainly *Metapenaeus affinis* and *M. monoceros,* about 2300 t (ODA/PPFC, 1983).

Application of Schaefer's and Fox's production models to the data of Price and Kyaw Htin (1984) (Table 13) resulted in MSY values of 547 t and 612 t respectively for the artisanal fishery along the Arakan coast ($r = -0.70$ and $r = -0.94$); and of 1186 t and 974 t respectively for the Tenasserim coast ($r = -0.73$ and $r = -0.97$). The corresponding maximum effort values were respectively 16500 and 24800 trammelnets for the Arakan coast and 10000 and 8800 trammelnets respectively for the Tenasserim coast. According to the Schaefer model, the shrimps were already fully exploited on the Arakan coast. On the Tenasserim coast the fishing pressure on the shrimp resources was very often beyond the optimum level.

The analysis of the data by means of Fox's model indicated that on the Arakan coast, while there is room for a sizeable increase in effort, the production has almost reached the MSY level. On the Tenasserim coast the optimum effort had been exceeded twice, in 1979-80 and in 1982-83, and the production had almost reached MSY level in 1979-80 but thereafter, irrespective of increase or decrease in effort, the catches had been declining. Price and Kyaw Htin (1984) pointed out that the production figures for the Tenasserim coast are under-estimates.

Price and Kyaw Htin (1984) concluded from information on size categories, that for the period 1979-80 – 1982-83, the amount of small shrimp processed had increased. In 1979-80 only 6% of the shrimps processed were smaller than 7.5 cm (total length), but this proportion increased to 36% in 1982/83. They attributed this phenomenon to the effects of increased fishing pressure. This observation was in accordance with the low catch rates obtained at high levels of fishing effort along the Tenasserim coast. They also observed that catch rates for the trawl fleet were low and that the catch per unit of effort decreased at high levels of fishing effort. They felt that further expansion of the trawl fleet would certainly be unprofitable, due to the limited stock size on the grounds currently exploited. Even otherwise the data available (Tables 14 & 15) do not indicate that the trawlers could have ever operated economically.

3.3.6 Management

Price and Kyaw Htin (1984) recommended that the sale of trammelnets may not be increased, along both the Arakan and Tenasserim coasts.

It was recommended that all fishing activities be carefully monitored in order to collect data for future analysis and management decisions (ODA/PPFC, 1983; Price and Kyaw Htin, 1984).

3.4 THAILAND

3.4.1 Fishery

The main gears operated in the traditional sector in Thailand are shrimp gillnets, tidal traps and pushnets. The trammelnet is less important. The catches consist of small-size *Penaeus merguiensis* and *Acetes spp.* Regarding the industrial sector, the trawlers were already active in Thai waters in 1967 (Anonymous, 1976) and the number of trawlers in 1972 was estimated between 300 and 500. The size of the vessels was generally between 9 and 18 m, very few vessels had a length over 21 m. The mesh sizes in the cod-end of the trawis varied between 25 and 30 mm. Fishing is carried out throughout the year, but with less intensity during the south-west monsoon season (FAQ, 1972a).

From the SEAFDEC fishery statistical bulletins it is seen that the number of otter and pair trawlers had increased considerably since 1976. In 1982, while the number of pair trawlers remained at the same level as it was in 1981, the number of otter trawlers increased sharply by 80%. The fleet composition by GRT class for otter and pair trawlers is presented in Table 17 and the number of craft operating different gears in Table 18. The number of boats operating shrimp glllnets increased considerably up to 1979. After 1980 it decreased sharply. The shrimp fishing grounds are shown in Figure 5.

3.4.2 Catch data

The total landings of shrimps along the west coast of Thailand for the period 1967-74 are presented in Table 19. The shrimp production which was about 2000 tin 1967 rapidly increased and peaked in 1979 to about 24000 t. There was a sudden slump in 1980 and the present status is that it has recovered to a level of 18000 t. The landing of penaeid prawns was about 3821 tin 1976 but increased to 21090 t in 1979. It is very likely that this sudden spurt in landings was due to catches taken from non-Thai waters, because under joint venture arrangements with Bangladesh and India, a large number of trawlers were operating in the upper Bay of Bengal during that period. A sharp drop in the landings was observed in 1980 and according to FAQ (1985) this drop might have been caused by the termination of fishing outside Thai waters. The production figures for penaeid and non-penaeid prawns, according to the Thai Sample Survey, are presented in Table 20, while the figures from the FAQ Yearbook of Fishery Statistics (FAQ, 1987) are presented in Table 21.

Between the data in Tables 20 and 21 there is an anomaly. According to the Thai Sample Survey (Table 20), non-penaeids form a very high portion of shrimp catch since 1980, but FAQ statistics (Table 2) indicate the reverse. The difference is so large that it may not be due to inclusion of

Parapenaeopsis spp alone in non-penaeid catches, as mentioned in Table 20. The only year the data are comparable between the two sources is 1979.

Figure 6 presents the shrimp landings by size class (LOA) of otter board trawlers. It may be observed that the landings by vessels shorter than 14 m have decreased gradually since 1972. On the other hand, boats longer than 25 m started operating in 1973 and their landings increased significantly until 1979 (a drop was observed, however, in 1978) (Vibhasiri and Roongratri, 1983)

3.4.3 Catch rates

For the period 1968-70, although the catch rate of all prawns increased (from 4.7 to 5.2 kg/hour), the catch rate of the commercially valuable species decreased (from 2.8 to 1.9 kg/hour) (Sribhibhadh, 1972, Table 23).

From the records of Vibhasiri and Roongratri (1983) relating to the trawler fleet operating in the Andaman Sea, it is noticed that the catch rates of all prawns varied considerably between 4.1 and 15.8 kg/hour during the years 1971 to 1979. SEAFDEC (1982, 1983 a & b) reported catch rates of 8.6, 7.0 and 7.7 kg/hr for the trawler fleet operating in the Andaman Sea in 1979, 1981 and 1982 respectively. The catch rates seem rather low, probably due to the fact that not all the effort reported had been directed towards shrimps.

MacNae (1974) reported high catch rates in the night (more than 300 kg/hr) from January to April, off Phuket and in the northern part of Thailand, close to the Burmese border. During the rest of the year the catch rates were less than 50 kg/hr except in some inshore areas.

3.4.4 Catch composition

It is seen from the report of Sripayat et al. (1971) that in 1968-69, the trawler catches consisted mainly of *Metapenaeus spp, Penaeus merguiensis* and *P. semisulcatus; P. monodon* and *P. latisulcatus* were also available but a high percentage – nearly 50% – of prawns belonged to unsorted species. Comparing the species composition in 1968-69 with that obtained during the Landing Place Survey in 1979-83, we observe a slight decrease in the share of the two categories of tiger prawns *(Penaeus monodon* and *P. semisulcatus),* from 18.0 to 12.0%. The shares of *P. merguiensis* and *Metapenaeus spp* fluctuated too much to draw any firm conclusions.

3.4.5 Stock assessment

During the deliberations of the Special Working Party on stock assessment of shrimps in the Indian Ocean in 1972, the average optimum yield was provisionally estimated at 6000 **t** and optimum effort at about 400 vessels. The production of the motorized fleet in 1970 was approximately equal to that estimate, while the artisanal fleet captured an additional 2200 **t** (FAO, 1972a).

The Workshop on the Fishery Resources of the Malacca Strait in 1976, however, estimated the potential annual catch as at least 8000 **t;** a figure of 10000 **t** would probably be a conservative estimate of MSY for the entire west coast. These values are based on the catch figures; no detailed catch and effort data were available at that time (Anonymous, 1976).

During the Workshop on the Biology and Resources of Penaeid Shrimps in the South China Sea Area, an MSY value of 14191 **t** (Fox's model) was presented, based on data from the otter trawl fleet operating in the Andaman Sea. It was noted that in 1978 the catch rates as well as total landings were much higher than in previous years, probably due to expansion of the fishing grounds outside the EEZ of Thailand (Vibhasiri, 1980). Vibhasiri used the 14-18 m trawler as a standard for effort. The effort and catch rate figures presented by SEAFDEC (1983a & b and 1984) are specified by GRT classes and not by LOA classes. This makes it difficult to compare the results and to extend the data series for production model analysis. According to Hongskul (personal communication), otter board trawers of 14-16 m LOA belong to the 10-20 GRT class, while 16-18 m LOA vessels belong to the 20-30 GRT class. The SEAFDEC statistics distinguish between the 10-20 GRT and the 20-50 GRT classes for trawlers. Catch and effort data for these classes were pooled, and their common catch rate was applied to the total production to calculate the theoretical total effort. The results obtained were added to Vibhasiri's data series and an attempt was made to assess the MSY and optimum effort values for the Thai trawler fleet operating in the Andaman Sea. Fox's and Schaefer's production models were applied to catch and effort data for the period 1971-1982 (Table 22). This gave an MSY value of 16427 **t** with an optimum effort value of 7505690 hours trawling (Schaefer's model) and an MSY and optimum effort values of 15781 **t** and 8985540 hours

trawling (Fox's model) (r = -0.4260 and -0.5158 for Schaefer's and Fox's model respectively). Repetition of the analysis without the data for 1978 and 79 (when considerable quantities of shrimp were caught outside Thai waters) resulted in a better correlation coefficient, but in unacceptably high optimum effort values; these results should, therefore, be dealt with carefully.

Bhatia et al. (1983) reported an MSY of 10000 t for large shrimps *(Penaeus* and *Metapenaeus);* another 10000 t for small shrimps *(Metapenaeus, Metapenaeopsis, Parapenaeopsis* etc) and 7800 t for planktonic shrimps *(Acetes erythraeus, A. indicus, A. japonicus, A. vu/garis, Lucifer hanseni, Mesopodopsis orientalis, Acanthomysis hogarti* and *Rhopalophthalmus spp).* These estimates are probably based on total landing figures, including the catches outside Thai waters.

3.4.6 Management

Under the Fisheries Act of 1947, the Ministry of Agriculture and Co- operatives promulgated a series of rules and regulations among which the following are applicable to shrimp fisheries:

– Prohibition of the use of mesh size smaller than 20 mm in block nets and bamboo screen block traps.

– Prohibition of trawling within three kilometres from the shoreline (Bhatia et al., 1983).

3.5 MALAYSIA

3.5.1 Fishery

In the traditional shrimp fishery the main gears used are seines, bagnets, pushnets, gillnets and fishing stakes. The present shrimping grounds are shown in Figure 5.

In the northern part of Malaysia (from Perlis to Selangor), trawling was introduced in 1964/65 and in the southern part (Johor) in 1968 when the estimated number of trawlers exploiting the demersal resources in the Malacca Straits was 1024; this number increased to 3909 in 1974. The statutory minimum mesh size by that time was 25 mm, although numerous trawlers used 19 mm mesh in the cod-end (Anonymous, 1976).

The strength of the trawler fleet seemed to have peaked in 1976 with 5967; thereafter it has been reduced to the present level of about 3400-3500. The trawlers are up to 100 GRT but the largest number, more than two-thirds, are in the category of 10-50 GRT (SEAFDEC, 1978 to 1984).

Around full moon the landings of trawlers consist mainly of fish. During the rest of the month the trawlers fish for shrimp during the night and for fish during the day. (Mahyam, personal communication).

3.5.2 Catch data

In 1965 and 1966 traditional fisheries produced 13194 and 13797 t of penaeid prawns respectively. The annual production of penaeid prawns for 1967 to 1984 is presented in Table 23. The amount landed in 1967 increased to 21573 t, of which an unknown part was caught by trawlers. Since 1967 the prawn production by trawlers has increased considerably – upto 65% of the total production of 46703 tin 1971 (Pathansali, 1976). In 1974 the share from the artisanal sector improved to a level of 41%. The major contributions were made by bagnets and seines (Anonymous, 1976).

From 1967 to 1977 the total landings of shrimp oscillated between 24000 t and 51000 t and peaked in 1978 with 63000 t. Thereafter the total production started to decline. In 1983, the contribution from the trawlers to the total landings stood at 46%; from the artisanal sector the bulk of production came from seines (34%), relegating what was an equally important gear ten years ago, the bagnet, to a poor second with 9%.

The production of non-penaeid shrimps of the genus Acetes increased from 4557 tin 1965 to 6753 t in 1969, but decreased to 4805 tin 1971 (Pathansali, 1976). The annual production has been fluctuating thereafter and the latest available figure is 9895 tin 1983.

3.5.3 Catch composition

Lee (1972) has recorded six genera consisting of 28 species of penaeid prawns during 1968-69. Of the total number of prawns sampled, 64% belonged to the genus *Metapenaeus,* 27% to *Parapenaeopsis* and 4% to *Penaeus.* Of these, only *Metapenaeus lysianassa, M. brevicornis, M. affinis, Parapenaeopsis coromandelica, P. hardwickii* and *Penaeus merguiensis* occur in such abundance as to be considered species of commercial interest.

3.5.4 Stock assessment

Pathansali (1976) found it impossible to use catch and effort data to estimate the maximum yield of prawns, as the prawn production at that time was still showing an increasing trend. He estimated a maximum yield in the region of 35000 to 40000 t, which is comparable with the 35000 t of penaeid prawns estimated by Gulland (1971) who also estimated the potential for non- penaeid shrimps at 7500 t.

The 1976 Workshop on the Fishery Resources of the Malacca Straits (Anonymous, 1976) calculated potential yield values for several areas along the west coast of Peninsular Malaysia: Perlls, Kedan, Penang, 12500 t; Perak, Selangor, 37500 t; Negeri Sembilan, Malacca 250 t and Johor 3000 t, totalling 53250 t.

The workshop considered the catches in the area from Perlis to Selangor to be close to the maximum sustainable yield. This MSY was exceeded in 1978 and 1979 but subsequently the production was around the value of MSY.

The production in 1983 was distributed thus : Perlls, Kedan, Penang, 14097 t; Perak, Selangor, 32795 t; Negeri Sembilan, Malacca, 144 t and Johor 3485 t, totalling 50521 t, and thus approaching the calculated MSY. For 1984, data were available only for the provinces Perlis, Kedan, Penang, Perak and Selangor. The production was 34394 t – a sharp fall. Considering that the production in the other provinces has never exceeded 5000 tin the earlier years, the decrease is of the order of 10000 t. This might have been due to the banning of trawlers from inshore waters.

The analysis of length frequencies of *P. monodon* (from Kuala Kedah) through the ELEFAN I and II programs, resulted in exploitation rates of E = 0.48 and E = 0.52 for males and females respectively (Alais bin Man, under preparation). The fishing mortality for shrimps at the MSY level is usually lower than the natural mortality which would indicate that the stock, at an exploitation rate of E = 0.5, is at least fully exploited and is likely to be overfished (Garcia, personal communication).

3.5.5 Management

After 1978 the prawn landings by trawlers started to decrease; this was probably the result of strict enforcement of the ban on trawl fishing in inshore waters (Anonymous, 1982a). The minimum permitted mesh size in the cod-end is 38 mm. Fishing zones were allocated to several types of vessels; only vessels operating traditional gears are allowed upto 5 miles from the shore, while 40 GRT trawlers are allowed in the 5-12 miles zone and vessels larger than 40 GRT beyond 12 miles (Sivasubramaniam, 1985).

3.6 INDONESIA

3.6.1 Fishery

Traditional gears like bottom gillnets, beach seines, liftnets, pushnets and tidal traps have been operated in the shrimp fisheries in the Malacca Strait's coast of Indonesia for many years.

The bottom gillnets are of monofilament nylon with a mesh size of 25- 50 mm, and are operated in the intertidal zone in combination with other units, resulting in nets of 25-200 m length which are set parallel to the shore. In the 1950s, before trawlers were introduced, the annual production of the traditional gears was of the order of 7000 t of penaeid prawns. In the early 1960s exploratory trawling was initiated, and in 1966 eight vessels were operational. From then the trawl fishery developed rapidly; 830 vessels in 1971 and 1600 in 1974. The capacity of the stern trawlers (Chung King) ranged from 5 to 35 GRT, with the majority between 5 and 10 GRT with the engine power ranging from 33 to 120 hp. The trawls used were made of polyethylene; the head rope measured 12 to 16 m (Anonymous, 1976; Unar, 1973). Naamin and Farid (1980) reported the number of trawlers operating in the Malacca Straits in 1978 as 1310.

Intensive trawling in the inshore zones gave rise to conflicts between the traditional inshore fishery and the trawl fishery. Trawling was banned in October 1980. After the trawl ban, gillnetting for shrimp increased in the Malacca Straits. The locations of shrimp fishing grounds before the trawl ban are indicated in Figure 5.

3.6.2 Catch data

Several series of production figures appear to exist; however in this review, only the figures available in Anonymous (1976) for the period 1969 to 1974 and in Ahmad bin Adnan and Tampubolon (in press) for the subsequent period up to 1984 are taken into consideration, unless otherwise stated.

Annual production figures from these sources for the Malacca Straits are presented in Table 24. The annual production was increasing steadily, with some minor fluctuations, from a level of about 14000 tin 1969 to 21000 tin 1975. Thereafter, the production doubled the very next year and galloped to a peak of 52440 tin 1978 only to decline sharply in 1980, – due most probably to the ban on trawling. However, the production rose sharply to 47,382 tin 1981, only to slump to a level of 33-36000 tin the following years. It would appear that the sudden doubling of production in 1976 was due to capture of large quantities tf 'other shrimps' which included non-penaeid shrimps and juveniles of penaeid prawns (Dwiponggo, 1987) and also perhaps due to increased fishing effort, which registered an increase of 68% in the strength of the trawler fleet as seen from the figures provided by Naamin and Farid (1980). It is, however, not possible to trace the reason for the sharp increase in 1981.

On the Indian Ocean side of Sumatra the prawn production was estimated at 1,000 t by Hall (cited in Gulland, 1971). Unar and Naamin (1984) presented figures of the same order of magnitude for the period 1975-1979.

3.6.3 Catch composition

The penaeid shrimps consist mainly of *Parapenaeopsis spp., Penaeus merguiensis, Metapenaeus brevicornis* and *M. ensis* (Anonymous, 1976). Other important species are *P. indicus, P. monodon, P. semisulcatus, P. latisulcatus, M. monoceros* and *Solenocera crassicornis* (Unar and Naamin, 1984). The non-penaeid shrimps consist of small atyids, caridean species and Acetes spp. (Gulland, 1971).

3.6.4. By-catch

Unar and Naamin (1984) reported that more than 60 species of fish were caught during shrimp trawling or by other gear catching shrimp. The main species or groups of species were sharks and rays, Bombay duck, pomfrets, croakers, Spanish mackerels, catfish, hairtails, snappers, groupers, squid and swimming crab. The estimate of fish by-catch for trawlers varied from 1.1 to 1.8 t/trawler/day for the Malacca Straits and from 1.5 to 2.5 t/trawler/day for the east coast of Sumatra. According to Venema (personal communication), pony-fishes (Leiognathidae), threadfin breams (Nemipteridae) and goatfishes (Mullidae) were also very common in trawl catches.

3.6.5 Stock assessment

Due to the fact that the number of trawlers that operated in Aceh Province and North Sumatra more than doubled in three years, without any significant increase in total landings, it was assumed that the shrimp stocks were fully exploited and that the production in 1973 and 1974 was close to the MSY which was estimated at 20000 t (Anonymous, 1976).

Using catch and effort data, Tampubolon and Sutedjo (1983), cited by Sivasubramaniam (1985), estimated an MSY of 17597-25734 t.

Table 25 is a reproduction of catch and effort data from Ahmad bin Adnan and Tampubolon (in press) relating to penaeid shrimps from the Indonesian waters of the Malacca Straits. Applying Schaefer's production model, they obtained an MSY of 14484t and as per Fox's model, the MSY was 13884 t. The only year these limits were exceeded was 1983. The optimum effort was also exceeded that year; such a situation had arisen in 1976 and 1977 also, but the production was much lower. These results must be considered with caution because the CPUE employed was that of shrimp gillnet whereas up to 1980, the trawl contributed to most of the total landings in the Malacca Straits. Furthermore, the question remains whether the unit of effort used is really representative of the total fishing mortality.

3.6.6 Management

Unar and Naamin (1984) have summarised the management measures taken by the Indonesian government before it was decided to ban trawling. The following extracted features are relevant to the study area.

In 1976, regulations were introduced to prohibit trawlers from fishing within three miles from the shore line. In the inshore area an enormous competition for the shrimp resources had developed between the Chung King trawlers and the traditional fishermen.

An interdepartmental regulation was established in 1978 to control and slow down the construction of trawlers, especially where the boatyards in the provinces bordering the Malacca Straits were involved.

In some areas the number of trawlers appeared to be in excess and an attempt was made to spread out the fishing effort. This attempt largely failed as the alternatives offered were less profitable fishing grounds and inadequate landing facilities.

In 1980, trawling was banned from the waters around Bali, Java and Sumatra. Vessels licensed in these areas were not allowed to shift to other fishing grounds. Before and after the ban, fishermen were encouraged to start operating other gears, like purse seines, gillnets and pole and line.

The authors suggested a mesh size regulation in the tidal trap fishery. Commonly, mesh sizes smaller than 1 cm are used in the cod-end. Consideration has also been given to the introduction of a levy on the export of shrimps to control the fishing effort.

It has been observed that, after the ban on trawling, the number of other fishing units and their production (both fish and shrimp) have increased significantly. In the absence of trawlers, the fishing grounds available to the small-scale or traditional fishermen have increased. Since the gears used in the shrimp fishery are to a certain extent tied to the inshore area, the high fishing effort may also be directed at small shrimp species and juveniles of bigger species. If this is the situation at present and if the production has been correctly estimated, the fishery might have an enormous effect on the shrimp stocks. It might even exert a heavier fishing pressure than a trawl fishery (also because the numbers of such gears are still increasing). The subject deserves further attention; in particular, the size and species composition of the catches by different gears and the value of the catches need to be examined.

3.7 SRI LANKA

3.7.1 Fishery

In the lagoons and estuaries along the Sri Lankan coastline, prawns are exploited by several indigenous gears, namely, cast net, trap, set bagnet, stake or wingnet and dragnet. Stake or wingnets are widely used in the northern part of the island. Set bagnets are used close to mouths of lagoons (Jayakody, 1984).

On the continental shelf, the available prawn resources are exploited by trawls, gillnets and trammelnets. Trawling is conducted by 9 m boats (3.5 tonners) with 30 hp inboard engines and by outrigger canoes using sail. The mesh size used in the trawl cod-end is between 12 and 17 mm. Mechanised trawling started around 1962. Gillnets and trammel nets are operated from 6 m fibreglass boats with outboard motors (Siddeek, 1978 & 1986; Jay3kody, 1984). Major trawl fishing grounds are found off Chilaw and Negombo. In practically all lagoons and estuaries, artisanal gears exploit the shrimp resources (Figure 7).

3.7.2 Catch data/Catch rates

The annual production of penaeid prawns from lagoons and inshore waters was estimated at 1000-1500 t annually (De Bruin, cited in Siddeek, 1978). The production trend (Table 26) is an oscillating one reaching the highest level in 1982 with 7614 t. Thereafter it has declined to a level of 4000 to 4600 t, most likely because of the reduced fishing effort resulting from the disturbed political situation in the north. The catch and effort data given by Jayakody (1984) for the trawl fisheries off Chilaw and Negombo indicate that the catch rate has been affected to some extent under increasing effort.

3.7.3 Catch composition

In the trawl catches off Chilaw during the period January/February 1977, the shrimps were mostly *M. dobsoni* (72%), followed by *P. indicus* (10%). The other species were *Parapenaeopsis coromandelica, P. uncta, P. sytlifera, Penaeus semisu/catus* and *M. monoceros* (Siddeek, 1978).

The studies of Jayakody (1984) on the trawl catches in Chilaw and Negombo during 1979 and 1980 indicate that the highest species at both places were *M. dobsoni* and *P. stylifera.* The percentage of *P. indicus* in Negombo was almost twice as that in Chilaw during both years.

3.7.4 By-catch

According to Sachithananthan and Thevathasan (1970), shrimps and crabs accounted for 8% of the catch by stakes or wingnets in the northern part of Sri Lanka in 1968. Other contributors were *Ctenochaetus* **(23%),** *Caranx* (17%), cuttlefish (14%) and *Sphyraena* (13%).

Jayakody's 1984 study showed that in 1979-81, the main components of the by-catch were sciaenids, silver bellies, solefish, catfish, elasmobranchs, ribbonfish, perches, cephalopods and other crustaceans. The shrimp/by-catch ratios were 1.3:1 and 1:1.65 (1979-80) and 1.3:1 and 1:1.8 (1980/81) for Negombo and Chilaw respectively.

3.7.5 Stock assessment

Siddeek (1978) estimated the standing stock of several penaeid shrimp species in the area around Chilaw, by applying De Lury's method, which compares the average catch per unit effort with the accumulated catch. The standing stocks in January 1977 obtained by the method were *M. dobsoni,* 9601 kg, *P. stylifera* and *P. coromandelica,* 3257 kg and P. cornuta, 158 kg, totalling 13016 kg. (The original values were reported in pounds and converted into kg (1 lb = 0.4536 kg).

Jayakody (1984) applied Schaefer's production model to the catch and effort data from Chilaw and Negombo and obtained MSY values of 233t and 178 t for the respective places.

Standing stocks of five species on 34.7 km2 of trawling grounds off Chilaw were calculated for February 1984 by Siddeek and Jayakody (1984) using the swept area method. They took 50% and 66% escapement from the path of the trawl into account and obtained estimates of standing stock of 8914 and 14691 kg respectively. They compared the February 1984 results with those of January 1977 (Siddeek, 1978) and concluded that *M. dobsoni* and *P. stylifera* stocks were substantially over exploited.

Siddeek (1986) used the monthly CPUE estimates for the period January June 1984 to calculate the biomass of *Penaeus semisulcatus* and the by- catch on the trawling grounds in Palk Bay by the swept area method. The biomass of *P. semisulcatus* varied between 40.8 and 88.0 t resulting in densities of 1.10 and 0.51 kg/ha (the surface of the shrimp trawling grounds was estimated at 80000 ha). The by-catch biomass was estimated between 232.8 and 582.4 t.

Yield per recruit curves were constructed by Siddeek (1986) for *P. semisulcatus* caught in the Palk Bay for 30 and 40 mm mesh in the cod- end. He concluded that there is room for a slight increase in the fishing effort without fear of growth overfishing in case a 30 mm mesh is used in the trawl cod-end.

Production models were applied to the catch and effort data of Jayakody(1984). Schaefer's model resulted in MSY values of 217 and 179 t coinciding with effort values of 47596 and 27310 trips for Chilaw and Negombo respectively (r^2values 0.6887 and 0.9676 respectively). Using Fox's model the following MSY values were obtained : 253 and 185 t with effort values of 72731 and 33045 boat days for Chilaw and Negombo respectively (r^2values 0.6898 and 0.9622 respectively). It may be concluded from the analyses that in Negombo the resources are fully exploited according to Schaefer's model, while a significant increase in effort would result in a relatively small increase in landings following Fox's model. According to both models there would be room for expansion of fishing effort in Chilaw. It should be noted that Siddeek and Jayakody (1984) concluded that several species were already overexploited in the Chilaw area. Jayakody (1984) obtained an exploitation rate of 0.31 for *P. indicus* in the Chilaw/Negombo area, based on the ELEFAN analysis of length frequencies. This figure would allow an increase in fishing effort directed towards this species. These results, should, however, be viewed with caution, because only the trawl fishery was dealt with, while artisanal fishermen also contribute significantly to the shrimp production in that area.

3.7.6 Management

Mesh selectivity experiments were carried out in Palk Bay in 1984 by operating fish-cum-prawn trawls with three different mesh sizes in the cod-end – 25, 30 and 40 mm (stretched mesh). The 50% retention length (carapace) values of *Penaeus semisulcatus* were found to be 1.96 and 2.27 cm for the 30 and 40 mm cod-ends respectively. It was recommended that a mesh size larger than 25 mm be introduced in the cod-end to enhance prawn yields. The yield per recruit values of *P. semisulcatus* for the 30 mm cod-end were higher than those for the 40 mm cod-end (Siddeek, 1978).

The National Environment Act, the Coast Conservation Act, and the NARA Act contain legislation for conservation, preservation and management of Sri Lanka's marine and coastal resources on a broad basis (Sivasubramaniam, 1985).

In 1986, the collection of shrimp seed from lagoons and estuaries was prohibited.

3.8 MALDIVES

3.8.1 Fishery

Hardly any shrimp fishery exists in the Maldives. Munch-Petersen (1978) mentions a penaeid shrimp *(Penaeusjaponicus)* which is said to be used as food in the Addu Atoll. This species is hand picked during night time. (Hassan Maniku, personal communication). The total production is believed to be very low.

4. DEEP SEA SHRIMP RESOURCES

As there is no commercial activity to tap the continental slope resources of the Bay of Bengal, the only information on deep sea shrimp resources originates from exploratory surveys. During an exploratory survey by R/V Anton Bruun in 1963, it was found that a large part of the continental slope in the area covered by the survey (Thailand, Burma, Bangladesh and India), was too precipitous for effective trawling. The bottom at depths greater than about 900 m was usually flat and muddy and suitable for trawling. However, the ocean floor in the Bay of Bengal seemed to be barren of life (Hida and Pereyra, 1966). A list of deep sea shrimps reportedly occurring in the Bay of Bengal is given in Table 3.

4,1 India

Holthuis (1980) mentions the potential interest to the fishery of the deep sea shrimps, *Solenocera hextii* and *Plesionika martia.* He cites Kurian and Sebastian (1976) who stated that during deep water explorations at 150 to 200 fathoms, these species occur in varying numbers, but never in large quantities and that they would be attractive commercially because of relatively large sizes (males upto 55 mm and females 109 to 138 mm, total length). Several other species were mentioned to be of commercial interest also, but it is not certain whether they all occur along India's east coast.

From plankton samples taken during the International Indian Ocean Expedition (1960-65), it appeared that shrimp larvae were present, especially those of *Penaeopsis rectacuta* and *Metapenaeopsis andamonensis* off the Andaman islands and, sometimes in abundance, off the east coast of India. The abundance of *P. rectacuta* larvae was suggestive of exploitable stocks in the waters south of the Andamans and around the Nicobar islands (Paulinose and George, 1976).

Exploratory fishing cruises of the vessels Matsya Jeevan and Matsya Shikari revealed the occurrence of deep sea lobsters and prawns in appreciable quantities. *Aristeus spp.* was observed between 200 and 425 m depth between 110 and 13°latitudes. Catch rates varied between 7.5 kg/hr at 10°N 80°Eand 96 kg/hr at 11°N80°E. *Solenocera hextii* was found at an average catch rate of 5 kg/hr between 18°N 85°Eand 20°N88°E(Somvanshi and Joseph, 1983).

4.2 Bangladesh

As far as known, no exploratory fishing has been conducted on the continental slope of Bangladesh. During the surveys of R/V Dr. Fridtjof Nansen, no bottom trawling was carried out deeper than 145 m (Saetre, 1981).

4.3 Burma

During the survey of R/V Anton Bruun in 1963, the catches on the continental slope between 367 and 549 m consisted mainly of unidentified berycoid fish and shrimp, the latter in fair quantities although probably not of commercial interest (Hida and Pereyra, 1966).

Exploratory trawling was undertaken in deep waters (250-350 m) off the Tenasserim coast. The catch rates of shrimp ranged from 3 to 40 kg/h (average 21 kg/h). Of the four species collected, the most abundant were the Indian nylon shrimp *(Heterocarpus woodmasoni)* and the Oriental narwal shrimp *(Parapandalus spinipes)* (Price and Kyaw Htin, 1984).

In 1979 and 1980, R/V Dr. Fridtjof Nansen carried out some trawling operations on the continental slope of Burma. The shrimp catches consisted of *Heterocarpus spp, Arisreus semidentatus* and some unidentified species. Shrimp catch rates recorded were in the range of zero to

155 kg/h in October 1979 and between zero and 65 kg/h in March/April 1980 (mean catch rates of 34 and 18 kg/h respectively). Catches were relatively small, and it was concluded that insufficient quantities were present for a viable commercial fishery (Stromme et al., 1981).

The presence of *Penaeopsis rectacuta* larvae in samples taken from Burmese waters during the International Indian Ocean Expedition implied the occurrence of this species on the Burmese continental slope (Paulinose and George, 1976).

4.4 Thailand

In November 1981 trap fishing experiments were conducted off Phuket island in the Andaman Sea by the vessel Nagasaki Maru. Traps were set at 85, 130 and 280 m. No prawns were caught at 85 m; at 130 m *Parapandalus spinipes, Plesionika assimi/is* and *Heterocarpus spp* were caught. While at 280 m depth *parapanda/us spinipes, Plesionika longirostris, P. ensis, P. alcocki* and Heterocarpus spp were trapped (Okawara et al., 1983).

During the same survey, some trawling operations were carried out on the continental slope where *Plesionika martia, Heterocarpus lepidus, H. sibogae, Parapandalus spinipes* and *P. escati/is* were cught (Lumubol, 1982).

During the resources survey by R/V Dr. Fridtjof Nansen, some unidentified shrimps were caught on the continental slope, the catch rates being too low to be of commercial interest (Aglen et al .. 1981a).

4.5 Malaysia

The EEZ of West Peninsular Malaysia does not reach the continental slope in the Bay of Bengal.

4.6 Indonesia

Longhurst (in Gulland, 1971) reported the possibility of a commercial fishery for *P/esionika martia* on the continental slope of North Sumatra.

Some unidentified shrimps were caught (mean catch rate of 27.1 kg/hr) in some trawl hauls taken by A/V. Dr. Fridtjof Nansen on the continental slope (Aglen et al .. 1981b).

4.7 Sri Lanka

During a survey of the Soviet vessel SRTM *Optimist* from March to December 1972, trawlable grounds of 12 nm2 were discovered on the continental slope rich in prawn and lobster (Demidenko 1972, cited in Hapuarachchi and Jayakody, 1980) (Figure 7).

Blindheim et al. (1979) mentioned the occurrence of Acetes species on the continental slope of Sri Lanka. According to Holthuis (1980) this genus does not occur in waters deeper than 55 m. Subsequently Acetes was listed by Nishida and Sivasubramaniam (1986) as a genus occurring on the Sri Lankan continental slope.

During the survey of R/V Dr. Fridtjof Nansen in the Gulf of Mannar in August 1978, 27% of the catches on the continental slope consisted of shrimp, 64% of fish and 8% of lobster. The shrimps were identified as *Aristeus semidentatus, Parapandalus spinipes, Heterocarpus gibbosus* and *H. woodmasoni* (Saetersdal and De Bruin, 1979). In January/February 1980, only 2% of the catches on the slope consisted of shrimps. During this survey, *Metapenaeopsis andamanensis* was caught instead of *H. woodmasoni;* the other three species caught in 1978 were again present in 1980 (Blindheim and Foyn, 1980). Nishida and Sivasubramaniam (1986) have mentioned *A. semidentatus* and *H. gibbosus* only as deep sea prawns occurring on Sri Lanka's continental slope (besides *Acetes spp.)*

4.8 Maldives

During the resources survey in August 1983 by R/V Dr. Fridtjof Nansen, catch rates of shrimp (except for small penaeids) ranged between zero and 48 kg/h. The average catch rate was 12.5 kg/h. The shrimps caught belonged mainly to Penaeidae, Pandalidae and Solenoceridae. *Heterocarpus ensifer, Aristaeomorpha fo/iacea, Aristeus mabahissae, Hadropenaeus lucasii and Penaeopsis baissi* were captured at locations deeper than 200 m. The shrimp resources were assessed at 3000 t for an area of 3600 nm2 shallower than 500 m, south of Male (Stromme, 1983; De Bruin, 1984). According to Holthuis (1980), *Hererocarpus sibogae* also occurs in Maldivian waters.

5 SALIENT FEATURES OF THE SHRIMP FISHERIES IN THE BAY OF BENGAL

The annual shrimp production in the entire Bay of Bengal is presented in Figure 8. It may be seen that the total prawn production increased steadily to peak in 1978 at about 170000 t. A serious drop occurred in 1980 to a level of about 140000 t, when the production in all the countries except India declined. This was the year when a ban on trawling was promulgated in Indonesia and when Thailand's joint venture operations with some Bay of Bengal countries was terminated. There were partial recoveries in 1981 and 1983 but the trends in general appear to indicate that the fishery may not recover to the 1978 level. The current annual shrimp production in the region may be about 130-140000 t.

Table 27 gives various estimates of potential yield or MSY in the countries of the region. A comparison of these figures with the catch data of the recent 5 years suggests in general that in all countries in the study area the penaeid prawn resources are heavily exploited. For instance in India, the motorized and non-motorized sectors compete for the resources in the inshore waters, where it is apprehended that the resources are over exploited. In Bangladesh, the marine penaeid shrimps, whose life cycles are linked to the estuaries, are sought by fishermen at all stages. Postlarvae of all species except *P. monodon* are unfortunately and unwillingly destroyed, while juveniles and pre-adults are heavily exploited in the inshore area by the set bagnet fishery. Adults, in turn, are fished by a well established trawl fleet and by a rapidly developing trammelnet fishery. There are signs that the shrimp resources available to the Burmese trawl fishery are over-exploited. In Malaysian waters, a high fishing effort was reported in earlier years; the effort at present is not known. If no reduction in effort has occurred, the stocks would seem to be in serious danger. The Indonesian statistics showed an increase in the number of gears other than trawl, most of them probably are operated close to the shore where the juveniles are exploited. The production in Indonesia has remained stable after the trawl ban in 1980, at a reduced level. However, there is an enormous increase in the effort of the traditional gears. In Sri Lanka, the resources seem to be fully exploited, although it should be noted that the production models applied did not take the artisanal catches into account. Considering the fishery situation in the countries around the Bay of Bengal, it seems that any expansion of the shrimp fishing grounds may have to be found in deeper continental shelf waters or on the continental slope; however, the economics of exploiting them remains doubtful.

A summary of the shares of the artisanal (= non-motorized) and industrial (= motorized, in India and Sri Lanka; partly so and partly motorized in Thailand and Malaysia) sectors in the total prawn production is presented in Table 28. The information for each country was not available for the same year. The contribution of the artisanal and industrial sectors to the total prawn production differs considerably from country to country. The artisanal sector produces about 29% of the total prawn production on the east coast of India and at the other extreme, 100% in Indonesia. In between we have Bangladesh, Thailand and Malaysia whose artisanal sector accounts for 55-65% and Burma and Sri Lanka, about 90%.

From Figure 9 it may be seen that the species composition of the landings in the various countries is quite different. The high percentage of tiger prawns in the Burmese trawl catches is striking; this may be due to the fact that the majority of the white prawn is caught by the trammelnet fishery, although it should be noted that the species composition varied considerably in the period 1977-82 (Table 16). Another interesting observation is that about a half of the production in Thailand, Malaysia and Indonesia Consists of "other" shrimps, mainly Solenocera, Parapenaeopsis, Metapenaeopsis (and perhaps the juveniles of penaeid prawns and other small species of sergestids), while in Sri Lanka, India and Bangladesh their share is 30% or less.

It may be observed that in India, Bangladesh, Malaysia and Sri Lanka, the trawl catches mainly comprise *Metapenaeus* species; *Ponaeus spp* form less than 30%. In Burma and Thailand, *Penaeus spp* are more important. With regard to Indonesia, the picture is not clear; *Penaeus* may be more important than *Metapenaeus* or vice versa but *Parapenaeopsis* and *Solenocera* may perhaps be quantitatively more abundant.

As regards the by-catch of the trawlers, as we proceed clockwise around the Bay of Bengal, it is seen that in Sri Lanka the dominant components are the croakers and ponyfishes. In the contiguous area of Tamil Nadu on the east coast of India, the same two groups are dominant with the difference that ponyfishes are more abundant that the other. Further north in Andhra Pradesh and Orissa, while croakers reappear as the most important group, the threadfin breams, hairtails, ponyfishes (only in Andhra Pradesh), lizard fish, scads, sharks and rays, are represented in sizeable quantities.

A more or less similer picture is obtained in the by-catch of Bangladesh trawlers. However, in Burma, the croakers are relegated to a minor role, where sharks and rays and clupeids are reported to be the main elements. While there seems to be no information for Thailand and Malaysia, sharks and rays continue to be a major component in Indonesia, where in addition, Bombay duck, pomfret, croakers, catfish etc, constitute the by-catch; their relative importance, however, is not known. Generally, the croakers seem to form the most important group common in all the countries. The importance of the other groups depends on their relative abundance in the demersal fishery resources of the region.

A composite pictorial representation of the shrimp fishery in each country is given in Figures 10 to 12, bringing out the contribution of artisanal and industrial sectors to the total prawn production, and the different types of gear employed in the estuaries, lagoons, and on the continental shelf. The same figures indicate whether or not potential trawling grounds exist on the continental slope.

In India (Figure 10), the shrimp resources in estuaries, lagoons and on the continental shelf are heavily exploited by all kinds of gears. It may be seen that the small trawlers come very close inshore and compete with the other fishing gears for the shrimp. In some parts of the continental slope there may be some scope for expansion of the fishing grounds for deep-sea prawns.

Postlarvae are heavily exploited in the estuaries in Bangladesh (Figure 11), and the shrimp that escape are being exploited by set bagnets at the mouths of creeks and in the inshore waters of the continental slope. Pre-adults and adult prawns are being fished by a well equipped trawler fleet.

Trammelnets are the main gears used in Burma (Figure 11), where they exploit the adult stocks, like the trawlers; but the dominant species are different between the two sectors. At a small scale, bagnets are used in the estuaries.

In Thailand and Malaysia (Figure 12), the shrimp in the estuaries and on the continental shelf are fully exploited by a great variety of artisanal gears and by trawlers.

Shrimps at present are being exploited only by artisanal gears in Indonesian waters (Figure 12) because of the ban on trawling. However, the number of artisanal gears has increased considerably and they fully exploit all stages in the shrimp's life cycle.

Figure 10 presents the situation in Sri Lanka, where many varieties of artisanal gears are operated in lagoons and estuaries and on the continental shelf. Also in inshore waters, small trawlers operate. Some parts of the continental slope appear to have some potential for trawling deep-sea shrimps and lobsters.

Several working groups on the study of shrimp resources have been constituted in the past and each of them has made its own recommendations at the regional level. Sometimes, as in India, a committee was set up at the national level by the government for advice on management measures.

In general it may be concluded that more data of various kinds (catch and effort, biological, economic, sociological) should be collected in future so as to provide necessary inputs for proper management of the valuable shrimp resources. It is recommended that resource assessments be carried out, based on data provided by the existing shrimp fisheries (and not by survey activities).

Despite all the recommendations of the past, the follow-up has been meagre. The impression is that too many recommendations were formulated and that not enough support was given to the countries to implement them, making the recommendations unrealistic and inapplicable to these countries. Therefore it is recommended that the possibility of regional support through a "Shrimp Resources Assessment and Management Programme in the Bay of Bengal" be explored in order to fill gaps in the knowledge of shrimp biology in relation to the environment, to carry out mesh selectivity experiments, to improve the methodology of collection of related fishing effort data for the various gears, to determine the species composition of the catches taken by different fishing methods, and to obtain more knowledge on the seasonality of the catches. Although the problems are national in character, they are the same in all the countries, in some countries less severe than in the others. A regional support mechanism therefore appears to be much more cost-effective than several separate national ones.

6. SUMMARY

6.1 Status of exploitation

The exploited marine shrimp stocks belong mainly to two groups— the penaeid species (mostly *Metapenaeus* and *Penaeus)* and the non- penaeid species (mostly Acetes).

The annual shrimp production in the region was about 133000 tin 1984 and comprised 115000 t of penaeid prawns and about 18000 t of non-penaeid shrimps. Malaysia is the largest producer of penaeid shrimp (36% of the total) and India contributes most of the recorded non-penaeid catch (72%). Total penaeid shrimp production of the region peaked in 1977 and has slumped since then. The production of non-penaeid shrimp peaked in 1980, declined somewhat thereafter but then recovered to record an all-time high of 18000 t in 1984.

In India, the highest production of penaeid prawns was 31000 tin 1980; thereafter it appears to have stabilized around 25000 t but in 1984, as was the case in Malaysia, the production fell below this level.

In Bangladesh, the production dropped during 1981-83 because joint ventures with Thailand were discontinued; it however picked up during the subsequent years to a level of 3,000 to 4,000 t. The reason is not clear; the domestic trawler fleet expanded initially, but its strength was subsequently reduced.

In Burma, the production has been practically stagnant at a relatively low level of about 1000 t.

The catches of Thailand peaked in 1979 at about 21000 t, but this was due to catches from outside Thai waters — from the upper Bay of Bengal in Bangladesh and India through contractual joint ventures. In the 1980s, the catches have fluctuated, the average being 12 500 t.

In Malaysia, after the 1978 peak of 63 000 t, the yield has more or less stabilized around 50 000 t; reasons for the decline in 1984 are not known.

The catches in the Malacca Straits waters of Indonesia declined in 1980 from 50 000 t to 32 000 t owing to the ban on trawling; although for unknown reasons the production in 1981 reached the level of the pre-ban period, in subsequent years, it has remained around 33-36000 t.

In Sri Lanka, the highest catches were obtained in 1982, nearly 8000 t; subsequently, the production has declined, perhaps due to reduced fishing effort in the northern part of the island consequent to disturbed political conditions.

The proportion of the non-motorized and motorized and mechanised sectors to the total production differs considerably from country to country. In general, the former sector accounts for the entire catch in Indonesia; the other extreme is India where its share is only about 29%. In between are Burma and Sri Lanka recording about 90%, Thailand, Bangladesh and Malaysia, 50% to 60%.

Regarding the principal species in the penaeid group, it is seen that *penaeus* spp are dominant in Thailand and Burma. In India, Malaysia, Bangladesh and Sri Lanka, the major contribution is from *Metapenaeus* spp. In Indonesia, the 'other shrimps' dominate, among which *Parapenaeopsis* spp. may be an important element; otherwise, *Penaeus* spp may be more important than *Metapenaeus* spp.

The only two countries from where separate data are available on the contribution of non-penaeid shrimps are India and Thailand. In India, the production has increased rather rapidly in recent years, from about 6000 tin 1979 to 13000 t in 1984. This has been largely due to progressive reduction in the cod-end mesh size of the trawl net. In Thailand, the reason for the current increased yield of about 5000 t in the production of sergestid shrimps *(Acetes)* is not known; earlier it used to be around 3000 t. In Indonesia, the sergestids, which may be quite substantial, have not yet been quantified.

There are no commercial fisheries in the region to exploit the deep sea shrimp resources located by exploratory surveys, because their economic viability is yet to be established.

6.2 Stock assessment

In India stock assessment studies have been inadequate; except for an attempt at applying Schaefer's production model to catch and effort data of three landing centres and estimation of potential yield of 10-15000 t off West Bengal waters, no serious attempt has been made to assess the stock levels.

In Bangladesh, it appears that at the virgin state, the potential annual yield would have been around 4000 t in commercially fishable grounds. Subsequently, after intensive exploitation by Thai vessels, the standing stock appeared to have been reduced to 2500 t.

A trawl survey in 1981-82 indicated that off the Arakan coast of Burma, the optimum yield would be about 4900 t, of which about 1000 t was reported to be available for the artisanal fishery. However, application of production models for the artisanal fishery showed an MSY of 500-600 t, which corresponded to full exploitation of the stocks. On the Tenasserim coast, the production models showed an MSY of 1000 t. The arrival of increasing amounts of small-size shrimps in the processing plants and the diminishing catch rates under increased fishing effort, indicate that further expansion of the fishing effort would not be advisable along the Tenasserim coast.

There are problems in correctly estimating the stock size on the west coast of Thailand, especially since 1978, because of the inclusion in the catch statistics of catch and effort data from areas outside the Thai waters. Thus the estimated MSY of 14000 and 20000 t for penaeid shrimps may be too high. The estimate of 10000 t based on fishing data from Thai waters only, may be closer to the actual MSY, which would, in turn, mean that the current state is one of over-exploitation.

Although the catches in Malaysian waters have occasionally exceeded or declined below the estimated potential annual yield of about 50000 t, they were more or less around this level for over a decade. The most recent figures (1984), however, indicate a sudden decline; whether this is due to natural causes or fishery-dependent factors is not known.

Two estimates of MSY have been made earlier for the Indonesian waters of Malacca Straits, 18-26000 t and 14500 t; these relate to the more important of the penaeid species. While the methodology of collection and treatment of data requires to be refined, provisionally it would appear that the present production of *Penaeus spp* (15-17000 t) may be at the borderline between optimum and over-exploitation.

In Sri Lanka, different approaches have been employed and somewhat varying opinions have been expressed. The present restricted fishing activity in the northern part of the island makes it difficult to evaluate the status of the exploited stocks.

6.3. Management

In India, the states of Tamil Nadu and Orissa have enacted laws meant to keep small motorized trawlers beyond 5 km from the shore; and large shrimpers and other deep sea fishing vessels beyond 10 km from the shore. Executive orders to the same effect have been passed in Andhra Pradesfi.

A committee set up by the Government of India had made the following salient recommendations:

- total allowable catch off Orissa and West Bengal to be prescribed;
- prescribed fishing zones for different types and categories of vessels to be adhered to;
- mangrove ecosystem to be demarcated as reserved areas;
- fixed gear with mesh size smaller than 20 mm to be phased out, and the affected fishermen rehabilitated through other programmes such as aquaculture.

Although the Government of India does not allow import of any more shrimping vessels of 20 m and above in length, and does not encourage soft loans for indigenous construction of similar sized vessels, enterpreneurs have found it more economical to operate 14 m shrimpers.

In Bangladesh a minimum cod-end mesh size of 45 mm had been prescribed for the shrimp trawls, and their operation is permitted only in areas deeper than 40 m. A minimum cod-end mesh size of 30 mm for the set bagnets which are operated in the estuaries and coastal areas has also been prescribed. The Government has also stopped further import of trawlers.

In Burma, there are no management measures. It has been recommended that the sale of trammelnets should not be allowed to expand. Data collection and monitoring of fishing activities have also been urged to facilitate management decisions.

There are only two regulatory measures in Thailand

(i) Mesh size smaller than 20 mm is prohibited in block nets and bamboo screen block traps and
(ii) Trawling is prohibited within 3 km from the shore line.

In Malaysia, only fishing with traditional gears is permitted within 5 miles from the shore; 40 GAI vessels are allowed in the 5-12 mile area and larger vessels beyond 12 miles. The minimum permitted mesh size at the cod-end of trawl is 38 mm.

Consequent to the threat posed to traditional fishermen by the rapidly developing trawl fisheries, trawling was totally banned in Indonesia in 1980/1981. But whether the legislation has helped manage the shrimp fishery to the desired level of exploitation cannot be answered with conviction.

Collection of shrimp seed from lagoons and estuaries is prohibited in Sri Lanka. There are three broad-based acts containing legislation for conservation, preservation and management of marine and coastal resources.

6.4 Future action

There has been some meagre follow-up to several recommendations made at various forums on the need for collecting catch, effort and length frequency data, and on resource management. A regional support mechanism could be a cost-effective arrangement for assistance in improving the collection and analysis of data, in assessing the stocks, and in specifying and implementing management measures.

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