Beyond the Tsunami

Status of Fisheries in Tamil Nadu, India: A Snapshot of Present and Long-term Trends

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Back cover photo: Boats off Tuticorin beach (Photo credit: A. Sridhar, 2008)
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Executive Summary

This study was conducted along the Tamil Nadu coast over a period of 1 year. It aims to qualitatively and quantitatively characterise the fish landing, various fishing practices along the entire coast, understand the long term trends and dynamics of marine fish landings, its probable impacts on the marine biodiversity and its impact on endangered species of marine organisms.

Specific objectives:

1. To assess the current status of marine fishery from different gears, both artisanal as well as mechanised, along the coast of Tamil Nadu.
2. To study the long term impact of fisheries on various faunal groups being landed along the Tamil Nadu coast for the period 1985 to 2006.
3. To utilise the results of this quantification to formulate measures for conservation of marine habitats and for better management of marine fishery resources along the coast of Tamil Nadu.

Major findings:

1. The present study showed that large quantities of ovigerous (egg-bearing) crustaceans are exploited by gill nets and shrimp trawl nets along the Tamil Nadu coast. The extraction of these ecologically and economically important ovigerous crustaceans could put immense pressure on the natural stock and in future may affect the livelihoods of fisherfolk depending on these resources and have drastic impacts on marine ecosystem processes.
2. Marine ornamental fishery is carried out along the Gulf of Mannar on a very small scale. About 78 species of ornamental fish species are recorded to be exploited for the ornamental fish trade business. Among the various fishing practices recorded in the region, this was the least destructive.
3. Extraction of seaweed is carried out in the Gulf of Mannar region. Currently, exploitation of seaweed is focused on two species of brown algae, which has minimal impacts on the ecosystem. But information about the exploitation of red algae needs to be monitored and culture protocols should be developed and provided to the resource dependent communities in order to reduce stress on natural resources.
4. The present study indicates that there is an increase in percentage of catch of target groups when compared to bycatch. But when considering group-wise composition, it is found that target fishery consists of only three groups but bycatch fishery consists of around 19 groups. This indicates that a large amount of accidental/incidental catch occurs along with the target group fishing activities, which will have considerable long term impacts on marine resources along the Tamil Nadu coast.
5. Long term trend analysis of fish catch for a period of about 20 years (1985-2006) showed that pelagic fish were the most dominant group followed by demersal fish, crustaceans and molluscs. A general increase in total fish catch along the Tamil Nadu coast was observed during 1990s and then the catches showed a decreasing trend. Generally, the Mean Trophic

Level (MTL) of the total trawl catch showed a decreasing trend from 1985 to 2006 and MTL of total catch and pelagic fishery showed significant reduction. This reduction in MTL of pelagic fishery along the Tamil Nadu coast indicates exploitation of organisms lower down in the aquatic food chain (primary and secondary producers).

6. The study shows considerable exploitation of endangered species (Schedule I species) such as marine turtles, sea cucumbers, sea horses, pipefish and windowpane oysters along the Tamil Nadu coast as they form a part of the bycatch.

In general it was seen that the Tamil Nadu coast, especially the Gulf of Mannar and Palk Bay, is very rich in species diversity. Various groups and rare species were found and recorded during the study. Finfish numbering 507 speices were recorded of which one species is new to science and there are many first records in Indian waters. Eighty crab species were also recorded during the study. Given the limited duration of the study, it was not possible to identify and record other invertebrate groups such as molluscs, octocorals, soft corals, hydrozoans, sponges and many other groups of invertebrates. There was a high rate of exploitation of various invertebrates (including endangered species) as bycatch in various gears, especially the bottom set gears.

Long term trend analysis of marine fish landing from 1985 to 2006 showed that in spite of improving techniques and increasing effort invested into catching fish, the fishing yield is declining steadily in recent years along with the already declining trophic level. The trends indicate that there will be a considerable decline in fish catch over the next decade, and improperly managed fishing practices could have considerable ecological and economic repercussions for the future.

1. Introduction

Tamil Nadu is one of the important coastal states on the east coast of India, with a coastline of 1,076 km, 13 coastal districts and 591 fishing villages. It ranks fourth in fish production in the country, has a continental shelf covering 41,412 sq km and an Exclusive Economic Zone (EEZ) spreading over 0.19 million sq km. The Coromandel coast extends 357 km, from Pulicat to Point Calimere, and Palk Bay extends 294 km from Point Calimere to Dhanushkodi. The Gulf of Mannar, rich in biodiversity and hosting a variety of marine species, is a marine biosphere reserve, and extends 335 km from Dhanushkodi to Kanniyakumari. The western and eastern sectors of the Gulf of Mannar, spanning 90 km, comprise the Wadge Bank, and the region from Neerodi to Kootapuzhli. Fish production during 2006-07 was 392,191 tonnes and its value was estimated to be about INR 258,201 lakhs. There are 11,992 mechanised boats, 21,717 *vallams* and 42,825 catamarans presently operating in Tamil Nadu as per the state Fisheries Department records. Nearly 817,832 people in the state are involved in fishing and they target all available marine resources found along the Tamil Nadu coast as well as extending to regions outside the state. To increase the fish catch, 14 artificial reefs have already been created in the in-shore waters of the Tamil Nadu coast that serve as breeding grounds for fish like snappers, groupers and emperors, which have a great market value both domestically and internationally.

Along the Tamil Nadu coast *panchayats* form the central structure of the local fisheries management systems. Though these entities have no connection with the government, they play an important role in solving conflicts concerned with resource management among the fishing communities. After the sudden boom in the mechanised fishing operations, from the late 1980s uptil the mid-1990s, there had been an increase in the number of complaints from traditional fishermen regarding exploitation of fisheries by the trawlers. To address this conflict, the government had introduced the Tamil Nadu Marine Fisheries Act in 1983. The primary objective of this Act was to regulate fishing activities, especially to avoid competition in resource exploitation, as well as to solve problems concerned with the negative impacts of the gears employed by the mechanised sector. This was accomplished by physically separating the fishing grounds of the traditional and mechanised sectors, and by placing regulations on gears, mesh sizes and licensing procedures. The Act also demarcated 3 nautical miles exclusively for traditional fishermen. Mechanised boats were allowed to carry out their fishing operations only beyond this 3 nautical mile limit. Even though this demarcation is applicable to the entire state, some conflicts periodically occur in the Gulf of Mannar and Wadge Bank regions.

Indigenous crafts like canoes and catamarans are used in small numbers along the entire coast mainly employing gill nets, handheld lines, squid jiggings, lobster nets (*kaliral valai*) and crab nets. *Vallams* fitted with motorised engines are the most common crafts used by fishermen along the Tamil Nadu coast. A sudden boom in the number of *vallams* has taken place post-tsunami. A large number of *vallams* were issued to fisherfolk in the name of relief, with no consideration of the ecological repercussions that would follow. *Vallams* can be used for catching all fish resources even though they have less space for cold storage.

Bottom trawling is practiced from 21 landing centres along the Tamil Nadu coast, and most of them employ shrimp and fish trawl nets. Even pair trawling (which is banned because of the large-scale ecological destruction it causes) is practiced in some areas in the Palk Bay region. Trawlers are employed for operating drift nets especially to catch tuna, seer fish and sharks in two landing centres (Tharuvaikulam and Arkatuthurai). At present, longline fishing is carried out with the help of trawlers in five landing centres (Thoothor, Colachel, Chinnamuttom, Tuticorin and Nagappattinam).

Gill nets are also used extensively by fishermen along this coast. Gill nets come in different dimensions and mesh sizes targetted at different species. These nets are used to catch pelagic as well as demersal fish and they are made of multi- and mono-filaments. Some of the common gill nets employed in this region include *chalai valai* (20–25 mm) for catching clupeids; *kanangeluthi valai*, *aiyla valai/pentha valai/pannuvalai* (40–55 mm) for catching Indian mackerels and false trevallys; *mattileesia valai* for catching white sardines; piece *valai* (50–60 mm) for catching scianeids, catfish, pomfrets, carangids, Indian salmons and mackerels; *kala valai* (80–90 mm) for catching Indian salmons and scianeids; *vaval valai* (85–100 mm) for catching silver and black pomfrets; *udu valai, sella valai, paru valai* (drift net, 120 mm) for catching tuna, seer fish, sharks and carangids; *thata valai* (60 mm) for small seer fish; *chengani valai* (45–55 mm) for catching sea perches (*Psammaperca waigensis*); *kellangan valai* (40 mm) for catching *Sillago sigama*; *mural valai* (80 mm) for catching needlefish; and *nethali valai* (15 mm) for anchovy fishing.

Gill nets employed to catch demersal fish include roller nets or *thalencha valai* (75 mm) for catching fish associated with rocks; demersal *paru valai* (110 mm) for catching emperor fish, sweet lips, groupers, parrot fish, monocanthids and carangids; *thiruka valai* for catching rays; disco nets for catching rock lobsters and a variety of fish; *salangai valai/kalralvalai/sadama valai* for catching shrimps, lobsters or cephalopods; and crab nets for catching brachyuran crabs especially blue crabs. Use of gill nets, along with skin diving, is practiced to collect marine ornamental fish in the Gulf of Mannar region.

Shore seines are operated along the coast but the target species vary between ecosystems. In Wadge Bank, they are used to target clupeids, carangids and mackerels. In the Gulf of Mannar they target seer fish, carangids, goatfish, barracudas and clupeids, whereas in Palk Bay they target cephalopods. The duration of deployment of these nets also vary, and it is a seasonal gear involving considerable manpower.

Coral reef fish traps are operated in the Gulf of Mannar for catching fish found in coral reefs. Lobster traps are used in Wadge Bank to harvest lobsters from rocky regions. Fish traps, locally called *adapu valli* (technology transferred from Sri Lanka) are employed along the entire coast of Palk Bay, and these target cephalopods.

Collection of seaweeds (*Sargassum spp.*) is carried out from Wadge Bank to the Gulf of Mannar, and women are employed to exploit *Gelidella acerosa* from rocky and coral ecosystems of the Gulf of Mannar region.

Collection of chank (*Turbinella pyrum*) by skin diving is practiced in the Gulf of Mannar as well as in the Palk Bay region. Collection of chank is done from October to April in the Gulf of Mannar, whereas in Palk Bay it happens from June to November. The collection of jellyfish (*Rhopilema spp.*) using scoop nets is done on a seasonal basis especially from August to November.

Handline and longline fishing are practiced to catch both pelagic and demersal fish. The hook numbers vary from 1 to 18. Handline is used to catch baramundis, catfish and snappers, whereas longlines are used to catch groupers, snappers, jobfish, tuna, seer fish, emperor fish, sweet lips, carangids and sharks. The bait commonly used are clupeids, wings of cephalopods, and flesh of eels, and silk cloth which is mainly used to catch *Decapterus sp.*

Operation of purse seines is banned along the Tamil Nadu coast. In spite of regulations, illegal use of this net continues, especially to target shoaling fish. Spear fishing is practiced rarely, especially to catch Napolean wrasses, grunts and other coral reef associated fish.

Jigs are used to catch squids and fish along the Tamil Nadu coast. Jigs are mainly used to catch cephalopods along the entire TN coast whereas they are used to catch seer fish along the Coromandel coast. The practice is rare in other parts of the state.

Country trawl net, a traditional method of bottom trawling is widely used in the Palk Bay region and this fishing is done purely relying on wind speed, with the use of sails. The unwritten rules of the fishermen here do not permit mechanised engines to be employed in the *vallam*. This fishing mainly targets sea-grass associated shrimps.

The species composition of fish that are caught varies between the ecosystems. In the Wadge Bank, fishermen target rocky shore organisms and the gears are specifically modified and operated to catch these fish. Even in bottom trawling operations, shrimp trawling nets are not used extensively since the area is rich in fish. The dominant forms are carangids, barracudas, groupers, snappers, fusiliers, goat fish and threadfin breams. In addition, cephalopods are also a major catch in this area. Rock lobsters occur here in large quantities when compared to other ecosystems. Populations of rock lobsters have declined dramatically due to over-fishing of berried females. In this fishing ground, red-toothed triggerfish (*Odonus niger*) and half moon triggerfish (*Sufflamen chrysopterus*) form the bulk of the catch and income source for the fishermen. Recently, the population of the green rough-backed puffer fish (*Lagocephalus lunaris*) has increased dramatically.

Fishing in the southern part of the Gulf of Mannar especially targets fish, whereas the northern part targets shrimps. In the southern part of the Gulf of Mannar, triggerfish are landed in considerable quantities. The main catch is composed primarily of fish associated with coral reefs. Sea ponies (*Leiognathus spp.*) are exploited in large quantities along this entire coast. The northern part of the Gulf of Mannar targets mainly shrimp (*Penaeus semisulcatus, P. monodon, Feneropenaeus indicus* and *Parapenaeopsis uncata*). The traditional sector mainly relies on crab fishing. Women also play a role in extracting the crab from the gear. Drift nets (Tharuvaikulam) and hook lines (Threshpuram) are mainly used in the southern part of the Gulf of Mannar, whereas *thirukai valai* (bottom set gill nets) are used in the northern part to catch ray fishes. Shore seines are operated along the entire coast, but fewer fisherfolk are involved in this activity.

In Palk Bay, the artisanal and mechanised sectors mainly target shrimps since this ecosystem has a rich cover of sea-grasses. Chank resources are high in comparison to other ecosystems. The dominant fish in trawl catching are silverbellies (*Geres spp.*), croakers, pomfrets, sea ponies and carangids. Catch using *vallams* mainly comprises pomfrets, croakers, catfish, triple tails and Indian salmons. Artisianal fishing using country trawl nets target shrimps, fish traps (*adapu valai*) target cephalopods and bottom set gill nets mainly exploit crab resources. Specific target fishing of *Sillago sihama* and sand perch (*Psammoperca waigensis*) are also practiced in this ecosystem.

The Coromandel coast has very good sardine resources when compared to other areas. Flying fish fishery is practiced along the entire coast, locally called '*kola*' fishery. The main catch from this coast are the Indian mackerels using traditional gears. Hook fishing is done in the Nagappattinam district. Drift nets are also widely used to catch tuna and seer fish. Collection of shrimp brooders is extensively done in Pazhayar.

2. Occurrence of ovigerous crustaceans in gill nets and shrimp trawl nets along the Tamil Nadu coast

2.1 Introduction

Crustacean fishery is fast developing in India and this fishery earns 60 percent of the foreign exchange with regard to seafood trade. The lucrative prospect of exporting crustaceans has led to unscrupulous extraction of ovigerous (egg-bearing female) forms. This has had considerable impact on fresh recruitment to existing stocks and a reduction in stock size in the wild. Along the Tamil Nadu coast, this is evident in the case of lobsters that have been exploited for the live and frozen trade. This not only has negative impacts on the existing stocks, which is important from a fisheries point of view, but also has many negative consequences on the benthic ecosystem of the coast. Crustaceans are a vital link in the marine food chain. Many of them are predators that help keep herbivore populations in check and also themselves serve as food for other larger carnivore species (especially larger fish) which in turn are of high commercial and nutritional value. After the considerable decline in lobster resources along the coast, the current focus of the seafood industry has turned towards blue crabs for exporting canned meat.

Few studies exist on the extent of exploitation of ovigerous crabs from the region, or its ecological and economic impacts.

2.1.1 Crustacean resources

Various species of economically valuable crustaceans are fished along the entire coast of Tamil Nadu, but shrimps remain the major catch in most of these areas. Exploitation of other crustacean resources along the Tamil Nadu coast are crabs caught from Kulasekarapattinam to Chennai, rock lobsters caught from Muttom to Pamban south as well as from Kovalam region along the Chennai coast, and sand lobster extraction from Nagappattinam to Mudasalodai. Shrimps are mainly considered as the target species in bottom trawling, whereas crabs and lobsters are caught using traditional gears. Currently lobster resources are over-exploited and the state government has imposed a ban on fishing of lobsters weighing less than 250 gm. However, the fishermen do not abide by this rule in all fishing villages because a 150 gm live lobster fetches them INR 200 to 300. Due to the reduction of lobster resources, the seafood industry has turned its focus to the exploitation of blue crabs.

The bottom set gill net is considered as an effective gear to exploit this resource from a commercial point of view (Melville-Smith *et al.* 1999). At present, crab fishing is a major source of income for the artisanal sectors, especially in the Gulf of Mannar and Palk Bay regions, even though it is hampered by money lenders to whom some part of the money (10 perecent) goes from the daily catch. With increasing blue crab extraction, privately owned boiling units for crabs in major crab landing sites have been set up that advance money to fishermen to exploit more resources from the wild. Mostly, two species of blue crabs—*Portunus pelagicus* and *P. sanguinolentus*—are targeted by this industry for the extraction of meat. These crabs are mainly found in sea-grasses, coral reefs and rocky regions. In the case of rock lobsters, the three species *Panulirus homarus*, *P. ornatus* and *P. versicolor*, are caught mainly using trammel nets (*kaliral valai*) and disco nets in rocky and coral reef regions. Sand lobsters (*Thenus orientalis*) are caught while bottom trawling of muddy substratum and the deep sea lobster (*Pulereus swelli*) is harvested from Chinnamuttom to Tuticorin in deep sea bottom trawling, especially during summer.

2.1.2. Materials and methods

Crabs

Bottom set gill nets

Bottom set gill nets catch almost all brachyuran crabs that are found in the habitat where the net is employed. This study is restricted to two species of blue crab: *Portuns pelagicus* and *P. sanguinolentus*. Crab fishing is practiced by artisanal and mechanised methods; even canoes and mechanised *vallams* are used to catch these resources. The crab nets (bottom set gill nets, *nandu valai*) are operated with sinkers attached to the foot rope in most of the fishing villages. Poor fishermen on the other hand use water absorbable foot ropes to take the net to the bottom. Fisherwomen help in employing the net, segregating the crabs caught, as well as removing sea-grass and other debris that get entangled in the nets. After cleaning the net, and in some cases after repairing the torn parts, the net is employed again. The net and the catch are usually extracted in the early morning hours. The retention time of the net varies from 8 to 10 hours. The mesh sizes vary from 70 to 100 mm, and are made of mainly mono-filament twines.

Lobsters

Kaliral valai (trammel nets) and disco nets

The trammel nets (multi-filament) and disco nets (mono-filament) are employed in rocky shore regions especially in regions were sea urchins are found in large numbers. Trammel nets (multi-filament) have an inner and outer mesh size of 120 mm and a middle part with 50 mm mesh size, whereas disco nets have a 75 mm mesh size (mono-filament). The retention period for trammel net varies from 8 to 12 hours, but in the case of disco net it varies from 6 to 8 hours.

Bottom trawl nets

This net does not target crabs, and they are caught as incidental catch; shrimp and fish trawl nets collect substantial quantity of blue crabs. Live blue crabs (*P. pelagicus*) fetch more money compared to dead ones and the fishermen therefore try to keep the crabs alive. Crab catches are higher along the shallow regions of the coast.

Three stations were fixed in the Gulf of Mannar (Kulasekarapattinam, Vellapatti and Vethalai), six stations in Palk Bay (Tirupalakudi, Devipattinam, Thondi, Passipattinam, Ponnagaram and Katumavadi), two stations along the Coromandel coast (Pazhayar and Annankoil,) and three stations in Wadge Bank (Arockiyapuram, Kottapuzhi and Edinthakarai). Observations of ovigerous female blue crabs in shrimp trawl nets were recorded in Palk Bay (Mallipattinam and Mandapam north) and Nagappattinam, Pazhayar and Mudasalodai along the Coromandel coast, and Mandapam south in the Gulf of Mannar.

2.1.3 Results

Crab fishery

Among the female crabs caught in bottom set gill nets, ovigerous crabs of *P. pelagicus* (29.7–35 percent) and *P. sanguinolentus* (20.3–45.8 percent) were found to be dominant in the catch during the post-monsoon period along the entire coast. Even though ovigerous female crab occurrence had its peak during the post-monsoon period, considerable numbers of ovigerous crabs were caught during other seasons suggesting that these species are continuous breeders. The occurrence of ovigerous females in the catch was higher along the Coromandel coast when compared to other ecosystems. The occurrence of ovigerous female crabs in Wadge Bank was less when compared to other ecosystems mainly because this resource is not targeted in this ecosystem (Figures 2.1 and 2.2).

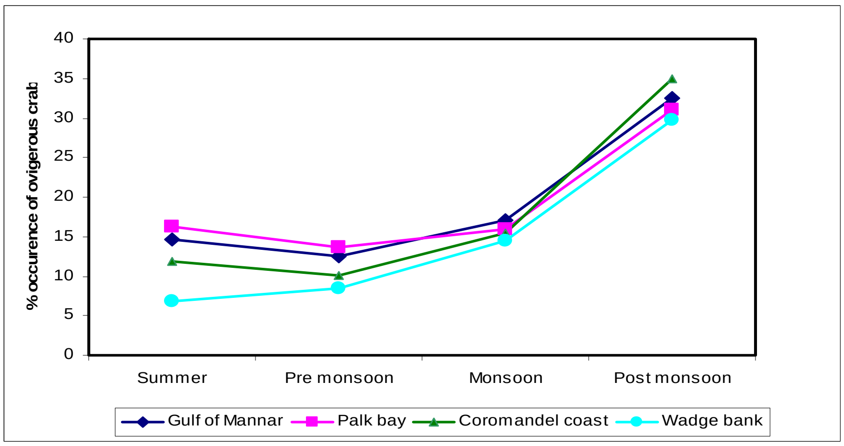

Figure 2.1: Occurrence of ovigerous blue crab *P.pelagicus* in bottom set gill nets in different ecosystems

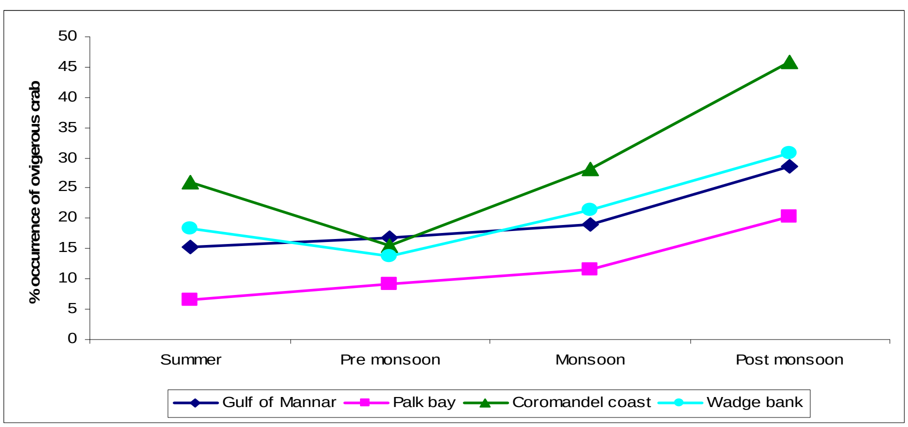

Figure 2.2: Occurrence of ovigerous blue crab *P.sanguinolentus* in bottom set gill nets in different ecosystems

Bottom trawl nets

Among the various nets used, bottom trawl nets recorded the maximum occurrence of ovigerous *P. pelagicus* in the Mallippattinam landing centre (42.7 percent, Palk Bay). During summer the occurrence of ovigerous crabs was lower (Figure 2.3). *P. sanguinolentus* had its peak occurrence in Nagappattinam (Coromandel coast, 36.5 percent) with fewer occurrences during the pre-monsoon period (Figure 2.4).

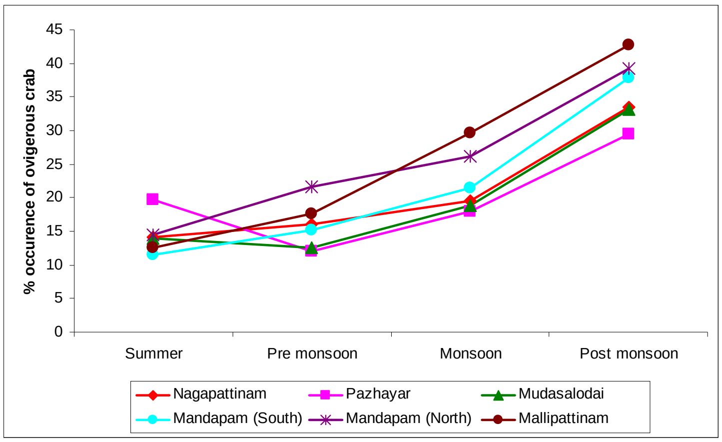

Figure. 2.3: Occurrence of ovigerous blue crab *P.pelagicus* in bottom trawling in different fishing grounds

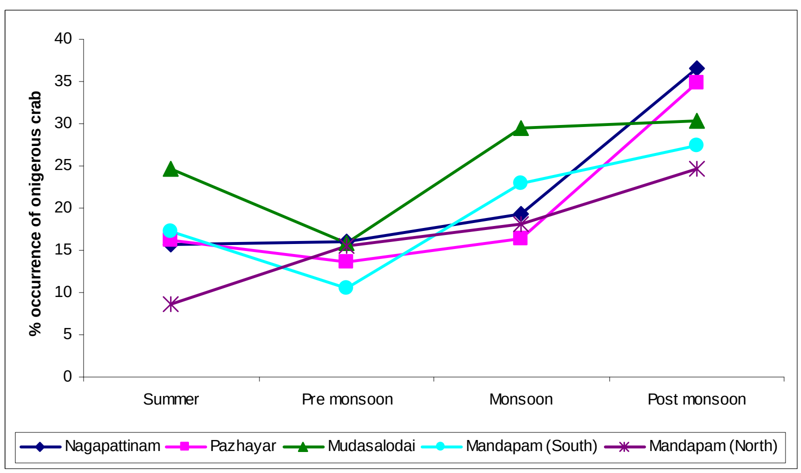

Figure 2.4: Occurrence of ovigerous blue crab *P.sanguinolentus* in bottom trawling in different fishing grounds

Sand lobsters

Even though three species of sand lobsters have been recorded, only the species *Thenus oreientalis* attains marketable size and is exploited from the muddy substratum from Nagappattinam to Mudasalodai. At present demand for frozen rock lobsters has changed to sand lobsters, even though no target fishing is carried out for its exploitation. Ovigerous sand lobsters had thier peak occurrence in the post-monsoon period in all stations (Figure 2.5). In the Nagappattinam landing centre, ovigerous sand lobsters were found in considerable quantities throughout the year, which indicates that this particular area might be an ideal breeding ground for the species.

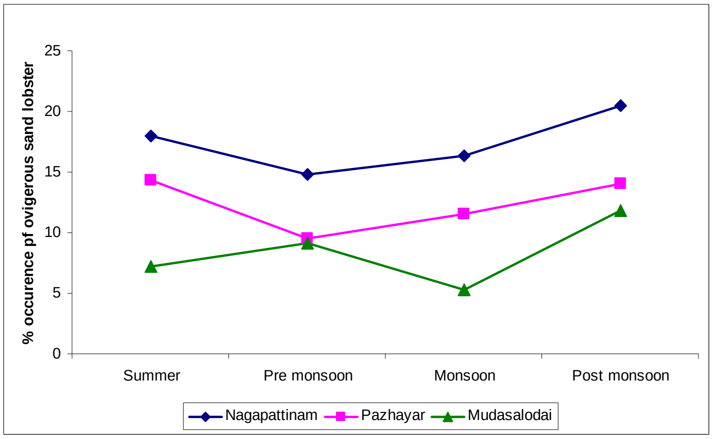

Figure 2.5: Occurrence of ovigerous sand lobster *T. oreintalis* from bottom trawling nets along the Coromandel coast

Rock lobsters

Rock lobsters along the Tamil Nadu coast comprised three species: *Panulirus homarus*, *P.ornatus* and *P.versicolor*. They were mainly caught in gill nets (disco nets and *kaliral valai*) and at present are rarely caught in bottom trawling. In the Wadge Bank region, during the monsoon, the occurrence of ovigerous females was higher (20.3 percent), whereas in the Gulf of Mannar the peak was during the post-monsoon period (17.5 percent) (Figure 2.6). The study reveals that the breeding population of rock lobsters, which was earlier a significant source of income for artisanal fishermen, is declining.

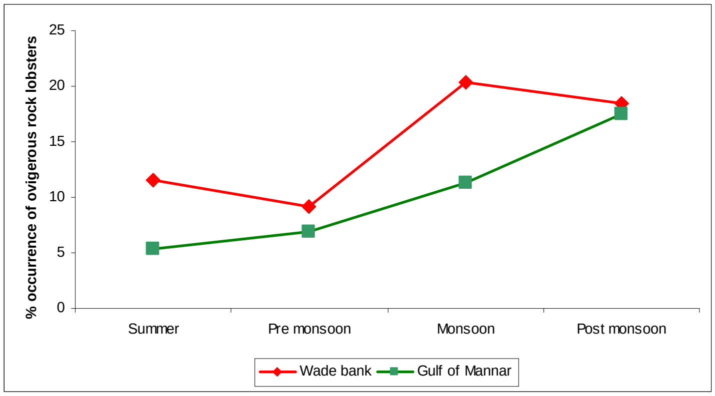

Figure 2.6: Occurrence of ovigerous rock lobsters from gill nets in different ecosystems

2.1.4 Discussion

The blue swimming crab, *Portunus pelagicus* (L.), represents a valuable component of small-scale coastal fisheries in many countries in the tropics (Batoy *et al.* 1980; Joel & Raj 1987; Mgaya *et al.* 1999). Its distribution extends from the southern Mediterranean Sea, to the east coast of Africa and across the Indian Ocean to Japan and the western Pacific Ocean (Smith 1982; Potter *et al.* 1983). These crabs are harvested using traps, beach seine nets and bottom set gill nets (Heath 1973; Bwathondi & Mwaya 1985; Haefner 1985). Along the Tamil Nadu coast, two species of blue crabs are found, namely *P.pelagicus* and *P. sanguinolentus*. *P. pelagicus* is found along the entire coast, whereas *P. sanguinoletus* has a restricted distribution.

P. pelaguicus fetches a higher price (INR 75–100 per kg) when compared to *P. sanguinolentus* (INR 30–40 per kg). The reason behind this, according to the seafood industry, is that the percentage meat content in *P.pelagicus* is higher than in *P. sanguinolentus*. *P. pelagicus* is found both in rocky and muddy regions in shallow waters (Joel & Raj 1987), whereas *P. sanguinolentus* prefers muddy substratum and deeper waters. This might be due to the migration of ovigerous female to deeper waters (Batoy *et al.* 1980). The present study reveals seasonality in catch of *P. sanguinolentus,* and similar trends have been observed in portunid crabs by other researchers (Devi 1985; Mgaya *et al.* 1999; Chande & Mgaya 2003). Even though the *Charybdis* genus is caught in crab nets, they have not been used by the community for exporting as canned meat. This type of target fishing has to be monitored closely so that fisherfolk can utilise this resource sustainably for a longer period of time. Sea ranching of crab nauplii should be done in all crab fishing villages in collaboration with the stakeholders and Fisheries Department with financial support from the stakeholders. The size at maturity for these crabs should be studied and awareness programmes should stress the collection of mature adults, which can be done through mesh size regulation. Muthiga (1986) recommended the release of juveniles, ovigerous females and recently moulted crabs as a way of preventing over-fishing and bringing about sustainable harvesting.

A major problem of operating nets in shallow reef areas is that it traps small pieces of coral, huge amounts of coralline algae, sea-grasses, sponges, molluscs (*Lambis spp.* and *Fasicolaria trapezium*) and gorgonids. They also collect non-target forms like starfish, sea urchins, a variety of fish (like *Siganus spp.*, *Lethrinus spp.*, *Arius spp.* and *Liza spp.*) and other brachyuran crabs (*Calappa spp.*, *Charybdis spp.*, *Thalamita spp.*, *Doclea spp.*, *Dorippe spp.*, *Matuta spp.* and *Platylambrus spp.*) in considerable numbers. Fish caught in the nets are damaged by the crabs as they are consumed by the crabs as food. The crabs nets are segregated in huts on the beach and the non-target species are discarded. Awareness should be created among fisherfolk to conserve the non-target species. If alive, they can be returned to the water, since most of the crabs can tolerate exposure to atmospheric air and they have the capability of regenerating lost swimming or chelate legs. Segregation of resources should be done in the crafts where they anchor so that they can release non-target species immediately.

Though crab fishery is driven by stakeholders, the current focus is on income generated and not on sustainable harvest. If the current rate of exploitation continues, the crab fishery will face the same fate as that of the lobster fishery. Even the state government has not formulated any management plan to stem the decline of blue crab populations, or conserve or increase their stock in the wild. The ontogenetic shift in the habitat preference of blue crabs should be studied so that the fisherfolk get different grounds for fishing these resources, thereby reducing the pressure on fishing in a particular area.

Sand lobster fishery is increasing because of its demand in the international seafood market. Since most of the trawling occurs in sandy or muddy bottoms this resource is getting utilised and even the price (INR 230 per kg) is equal to that of penaeid shrimps. The commercial trade of sand lobsters started in the 1980s and these resources are declining along the Coromandel coast (Subramanian 2004). Developing the culture technology of these species would be a commercially viable and less ecologically damaging alternative to shrimp farming. In addition, it can also be used in stock enhancement of lobsters in the wild to replenish wild stocks.

Though rock lobsters are caught in smaller quantities, this is considered an important crustacean fishery in terms of its value. This fishery has been practiced from the 1950s and its stock size reduced after 2001 mainly because of juvenile and ovigerous female harvest (Radhakrishnan *et al.* 2005). Stock enhancement programmes connected to this resource have been carried out in many countries (Herrnkind & Butler 1997; Gardner *et al.* 2006). Here, there is a law regulating the size of lobsters that can be caught, but it is overlooked by the artisanal fishing sectors. In Wadge Bank and in the Gulf of Mannar, the peak breeding season coincides with the peak fishing period, and this has probably resulted in population decline (George 1965; Vijayanand *et al.* 2007).

Figure 2.7: Exploitation of berried sand lobsters

Figure 2.8: Exploitation of berried blue crabs

3. Marine ornamental fishery in the Gulf of Mannar

3.1 Introduction

Marine ornamental fish trade around the world supports an international trade worth USD 90–300 million in annual retail sales (Sadovy & Vincent 2002). One thousand species from 50 families are targeted for this trade (Wood 2001), and are exported from approximately 80 supplying countries (Sadovy & Vincent 2002). The biological, socio-economic, scientific and aesthetic value of coral reefs and their associated fauna are widely recognised (e.g., Smith 1978; Salm & Kenchington 1984; Munro & Williams 1985; Clark *et al.* 1989; Spurgeon 1992) and the utilisation of this resource in a sustainable and environmentally friendly manner should be promoted. Marine ornamental fishery relates to a cluster of invertebrates and fish attractively coloured, with distinct fin patterns and behaviour. These fish are found in coral reef, sea-grass, mangrove and rocky shore ecosystems. Most of the marine ornamental fish are not of food value, but are of more value than food fish when comparing similar numbers or biomass. These fish are incidentally/accidentally caught in large numbers in shrimp and fish trawl nets. Since dead ornamental fish are of no market value, these otherwise valuable fish are wasted, and end up as poultry feed.

The marine ornamental fish industry in India is very poorly developed despite vast resource availability. The main obstacle in the utilisation of marine ornamental fish resources are the existing legislations and policies. The current blanket strategy of conservation that has been translated from the terrestrial ecosystems to the marine ecosystems (especially to coral reef ecosystems) is a major obstacle in developing the marine ornamental fish trade or its large-scale culture. Poor technology in transportation of live fish and lack of proper packing techniques are another technical hitch in developing the industry. Till date no studies have been conducted by any agency to document and inventorise the available marine ornamental fish resources in the Gulf of Mannar region, in spite of the region being declared as the first marine biosphere reserve in South Asia. It has been reported that the Gulf of Mannar harbours 113 species of fish from 24 families (Venkataramani *et al.* 2005). The initial damage to this resource occurred (especially to damsel fish) when dynamite fishing was done in this region to collect food fish.

Collection of marine ornamental fish is done in two ways: incidental fishing and target fishing. Incidental fishing includes use of traps, shore seine operations and country trawl nets, and target fishing includes skin diving with scoop nets and gill nets. Trap fishing is done in fishing villages like Vembar, Keelakarai and Mandapam. Considerable conflicts arise in the area due to these fishing activities between the Forest Department and the fisherfolk though there is no specific demarcation of a no-take zone by the Forest Department. Shore seine is a seasonal gear operated in villages like Periyapattinam, Mandapam and Rameswaram. This gear is operated in shallow regions of the coral reef ecosystems with minimal impacts on the ecosystem. Country trawl nets operate based on the wind directions and are mainly used in sea-grass beds and sandy bottoms. Target fishing is carried out for the collection of invertebrates during low turbidity and calm periods. Gill netting with skin diving is practiced when the conditions are calm in the reef regions.

Shrimp and fish trawl nets are operated in the Gulf of Mannar region and the fish that are caught in this gear are considered as coral reef fish as they might have spent some part of there life cycle in this ecosystem. This fishing also collects a large number of ornamental fish that are utilised as a protein source in poultry feed. This active mode of fishing is done at depths of 7–45 m and at a distance of 6–30 km off-shore. Here we have quantified the marine ornamental resources exploited for trade mostly from the Keelakarai group of islands.

3.1.1 Materials and methods

Traps (Incidental catch)

Traps, made from *Acacia spp*. barks, are mainly used in the Gulf of Mannar region to collect food fish associated with coral reefs. The bait used to attract the reef fish are shrimp heads, which are purchased from seafood processing plants. The traps are placed in vacant areas between corals, and the retention period of the net varies from 18 to 24 hours. The cost of one trap ranges from INR 300 to 450. The fishing grounds extend as far as 20 km from the shore. Nearly 60 traps are placed every day by three different groups. The trap numbers increase or decrease based on the catch rate.

Gill nets with skin diving (Target fishing)

Gill nets are considered one of the best selective gears in fishery. In order to collect live marine ornamental fish, skin diving is done during gill net operations. In this type of fishing, four to five people are involved in collection, where the ends of the gill net are held by two divers while a third diver disturbs the fish from the coral reef; the whole activity taking about 1 to 2 minutes. The fish caught during this period are kept alive in storage tanks with battery operated aerators. In this type of fishing, fisherfolk are only paid for particular species by brokers.

Shore seines (Incidental catch)

Nearly 20 to 30 people, including women, take part in this fishing activity targeted at fish that display shoaling behaviour. The mesh size in the head portion of the net varies from 15 to 20 mm, whereas the cod end portion ranges from 8 to 6 mm.

3.1.2 Results

Traps

Seventy-eight species of fish belonging to 18 families were recorded from fish traps that were operated in Keelakarai. These fish are traded domestically for the marine aquarium trade based on the demand. Fish belonging to the families Chaetodontidae (16.5 percent) and Labridae (20.5 percent) formed the majority of species. The peak season for marine ornamental fish trade starts from December and ends in March. Trap fishing for food fish is practiced during all seasons and most of the ornamental fish caught are thrown back when there is no demand.

Gill nets

Twenty-five species belonging to 11 families were collected by fishermen using this technique and this is also driven by demand in the domestic market.

Shore seines

Thirty-one species belonging to 14 families were collected by poor fisherfolk. The percentage composition of Syngnathidae was 22 percent, and Chaetodontidae and Tetradonitidae together formed about 12.9 percent of the catch. In this mode of fishing, Tetradontidae were caught in larger numbers, but were rarely used for domestic aquarium trade; these fish were occasionally thrown back or discarded on the beach. Though Sygnathidae have the most occurrences in the species list, their numbers were meagre.

3.1.3 Discussion

The number of fisherfolk employed in the collection of marine ornamental fish is less than 75 families. Despite the small numbers involved in fishing, the use of this resource is not monitored. The present study, carried out for three seasons, recorded 78 species of fish of value in the marine ornamental fish trade from the Keelakarai and Ervadi regions. The approximate number of fish traded during these three season ranges from 7,500 to 10,000 fish. Trawl nets, and hook and line fishing are difficult in coral reef areas and demersal traps are therefore the predominant gear used to harvest reef fish (Dammann 1980). There are no effective alternative gears that can be used during all seasons to utilise this resource.

Exploitation of marine ornamental fish in the Gulf of Mannar region is currently practiced in an environmentally sustainable manner, without the use of destructive fishing practices like dynamite or cyanide fishing. One kilogramme of live ornamental fish produces many times more income than an equal amount of dead food fish. Further, if utilised in a sustainable manner, ornamental fish culture and exploitation from the wild can ease the pressure on other destructive fishing practices and resources in the neritic and oceanic waters.

In many other countries, the collection of marine ornamental fish is done with the help of SCUBA diving equipment, whereas in the Gulf of Mannar no such collection is practiced or permitted. Other South Asian countries are involved in international trade of marine ornamental fish, barring India. Unfortunately, the Keelakarai families are held responsible for the reduction of fish resources and damage to coral reef ecosystems, which may not in fact be true, since these resources have not been properly studied or monitored using SCUBA diving. This study was also based on observations during the collection of ornamental fish.

Alternative livelihood options for the families directly dependant on coral reefs have not been worked out. Even though the United Nations Development Programme-Global Environment Facility project has attempted to reduce the pressure on coral reefs, this goal has not been fully achieved. Also, many fisherfolk are unwilling to consider a full time alternative employment option.

At present, marine fishery is collapsing dramatically in many parts of the world (FAO 1994). It is time to consider marine ornamental fisheries as an alternative source of income. Detailed research needs to be carried out on the ecological and economic viability of marine ornamental fisheries. It is also necessary to formulate policies with regard to the sustainable utilisation of these resources, rather than banning and discouraging the practice. We conclude that this minor fishing activity did not affect the fish community of the coral reefs or affect any of the ecosystem processes in a major way in comparison to the other fishing practices in the region.

Figure 3.1: Marine ornamental fish caught alive and kept in an areator for trade

Figure 3.1: Marine ornamental fish ready for trading

4. Trap fishing of coral reef associated fish from Keelakarai group of islands, Gulf of Mannar

4.1 Introduction

Marine reserves have grown rapidly since the first reserves were established in New Zealand and Australia in the 1970s (Ballantine 1991; Bohnsack 1996). In India, the Gulf of Mannar was the first marine national park that was established in the year 1986, and at present there are five marine parks/sanctuaries that are declared protected by the government. Management mandates of marine parks/sanctuaries are vested with the government. Typically, park managers in these reserves do not possess a marine science background and do not have the expertise to take management decisions based on science and research. Fishery resources have collapsed in almost all countries (FAO 2002), and the reasons attributed to this are greed, ignorance and improper scientific advice, lack of common sense (Kunzig 1995), inadequacy of scientific models, environmental variability, ignorance about natural systems, poor data, inadequate compliance with fishery regulations, and short term economic and environmental considerations leading to fishery collapses (Ludwig *et al.* 1993; Bohnsack & Ault 1996). In addition, there are climate change issues (Koslow *et al.* 1987; Myers *et al.* 1993; Ottersen & Loeng 2000), land-based activities, and pollution (Vitousek *et al.* 1997; Syvitski *et al.* 2005; Halpern *et al.* 2007; Seaman 2007).

Artisanal fishing near coral reefs is often considered to be environmental detrimental. The actual impacts of these artisanal fishing activities have not been monitored properly to understand their impact on coral reefs. Trap fishing is one of the oldest fishing methods and is widely practiced throughout the world in both tropical and temperate regions (Recksiek *et al.* 1991; Slack-Smith 2002). Trapping is a multi-species fishing technique (Garrison *et al.* 1998; Hawkins *et al.* 2007), with low impacts on the habitat. Fish traps are the predominant gear used for the exploitation of reef fish (Appeldoorn *et al.* 1987; Miller & Hunter 1987; Mahon & Rosenberg 1988) especially to collect demersal fish inhabiting coral reefs. Traps typically consist of a bamboo, wooden or steel frame covered with chicken wire with a mesh size ranging from 2 to 5 cm (Stevenson & Stuart-Sharkey 1980). Trap retention rates vary between locations and depend on how long a trap has been soaked, as well as the trap's internal structure (Whitelaw *et al.* 1991; Sheaves 1995). Traps are easy to deploy (Ferry & Kohler 1987), relatively inexpensive to make (Garrison *et al.* 1998) and can be used in areas with rugged substrata (Miller & Hunter 1987). As a fishing method it is effective, but unselective. It produces much unwanted bycatch that is commercially useless and could be a threat to biodiversity (Dayton *et al.* 1995; Alverson & Hughes 1996; Boehlert 1996). Such bycatch can be utilised in the marine ornamental fish trade since most of the non-edible reef resources are of ornamental value. A further problem associated with trap fishing is the damage it causes to corals and other bottom-living organisms when traps are dropped onto the reefs (Yoshikawa & Asoh 2004). Light traps are mainly used to catch invertebrates and juvenile reef fish (Doherty 1987); but in the Gulf of Mannar, this type of fishing is not practiced. Trap entrance size, number of entrances, etc., play a major role in this fishery (Munro 1974; Sugimoto *et al.* 1996)

Artisanal fishing in coral reef ecosystems is an important source of income and food for coastal people (Cesar *et al.* 1997). Gears like drift nets, purse seines, hooks and lines, spear guns, hand spears, traps and gill nets are employed to collect fish from the coral reef ecosystem (Pet Soede *et al.* 2001; Campbell & Pardede 2006). There are relatively few studies that have examined the effects of different gear types on catch composition, species diversity, size and species selectivity in the Gulf of Mannar (Venkatramani *et al.* 2005).

4.2 Materials and methods

Trap fishing in the Gulf of Mannar region is carried out in Vembar, Ervadi, Keelakarai and Mandapam south, and in Keelakarai the total village population depends on coral reef fish both for food and as a source of income.

The study was carried out in the Keelakarai landing centre where the coral reef associated fish were caught mainly from the Keelakarai group of islands. Collection of data on the biomass of coral reef fish caught and species composition were studied in trap fish landing centres on a seasonal basis. The retention period of the trap varied from 8 to 12 hours with shrimp heads being used as bait. The entrance of the trap is ellipse-shaped (oval) with a horizontal diameter of 51 cm and vertical diameter of 35 cm. The funnel-shaped entrance length is about 46 cm and the diameter at the end of the funnel is 20 mm. About 15 fishermen are employed in this practice and around 125 to 250 traps are placed on each fishing trip with the number of traps employed depending on the catch rate. The number of entrances in the trap varied between 1 to 3 . *Acacia spp.* bark is used to construct these traps, which last for 6 months. The traps are placed in the sandy bottom near coral reefs. A wooden structure is placed through the mesh gap at the bottom of the trap and a stone on each side of the trap in order to keep the trap intact. The catch rate of a single trap could not be estimated in the study; however, the catch rate of 15 traps together was recorded.

4.3 Results

Ninety-two fish species were recorded from traps employed in Keelakarai group of islands, which included non-target species from 19 families. All these fish are associated with the coral reefs of Keelakarai group of islands. Further studies should be carried out in the Mandapam and Tuticorin group of islands to estimate the total number of species caught in trap fishing for the whole of the Gulf of Mannar coral reef ecosystem. The food fish comprised 29 species from eight families during the study period, whereas 63 species were considered as bycatch; during the demand period these fish were bought live for the marine ornamental fish trade.

The monsoon period is the peak catching period in terms of biomass whereas the species diversity was low (14 species). The highest species diversity in food fish was recorded during the post-monsoon period (26 species). Summer and pre-monsoon recorded 18 and 17 species in food fish composition respectively. The catch per trap (in kg) varied between seasons from 5.4 to 10.7 kg per trap in the Keelakarai trap fish landing centre (Figure 4.1). Groupers (Serranidae), goatfish (Mullidae) and emperor fish (Lethrinidae) were caught in high biomass during the monsoon. Parrot fish (Scaridae) and rabbit fish (Siganidae) catch peaked during the post-monsoon period (Figure 4.2).

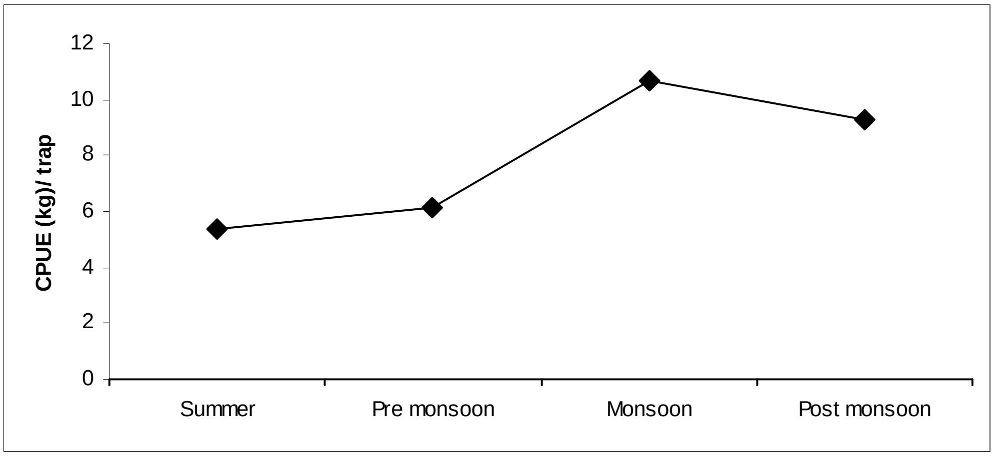

Figure 4.1: Catch per unit effort (CPUE) (kg per trap) during different seasons

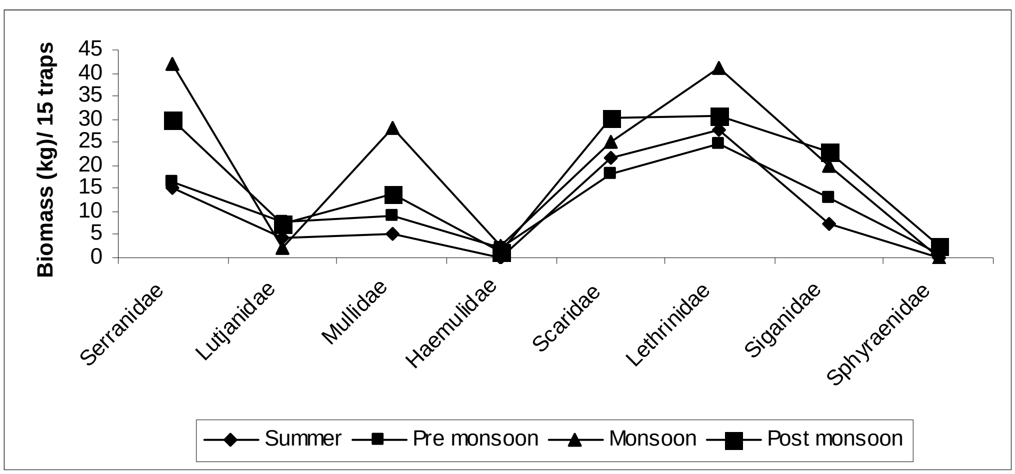

Figure 4.2: Biomass (kg) for 15 traps during the seasons for various fish groups

4.4 Discussion

Over-fishing is one of the most significant threats to coral reefs, as it causes dramatic and lasting negative effects on reef assemblages (Roberts 1995; Jennings & Lock 1996). Only five villages are employed in trap fishing in the Gulf of Mannar, which has a coastline of 140 km with 90 fishing villages. We can conclude that trap fishing in the Gulf of Mannar is done in a sustainable way when compared to other fishing gears.

The establishment of marine protected areas, particularly no-take reserves, is widely recognised as an important conservation and fisheries management tool (Roberts & Polunin 1993; Chape *et al.* 2005). Fishing has a number of direct and indirect effects on reef communities such as reduction in species diversity, alteration in the size structure of target species, and cascading effects on other reef fish species composition, biomass and density (Russ & Alcala 1989; McClanahan & Shafir 1990; Roberts 1995; Ohman *et al.* 1997; Jennings & Kaiser 1998). Though the Gulf of Mannar was the first marine park in Southeast Asia, this protected area still has no properly demarcated core, buffer or no-take zones.

High levels of physical damage to coral colonies caused by fishing gear affect the health of reef ecosystems (Lewis 1997). There is increasing evidence that fishing has facilitated shifts in some reef communities from coral to algal dominated phases (Hughes 1994), which is also evident in the Gulf of Mannar (Diraviya Raj 2006). For this decline, trap fishing alone cannot be blamed since coral reef fish are harvested using different gears. In Kenya, live coral heads are usually removed and used to hold traps at the sea bottom during fishing (Mangi & Roberts 2006), and therefore trapping also has direct effects on the reefs; however, in the Gulf of Mannar this is not done. The ecological impacts of various gear types have not been well studied in the Gulf of Mannar; hence a particular gear cannot be blamed for the decline in fisheries or for loss of biodiversity.

Figure 4.3: Traps drying before being taken out to sea

Figure 4.4: Catch obtained from trap fishery

5. Seasonal exploitation of jellyfish (*Lobonema smithii*) from the Gulf of Mannar region

5.1 Introduction

Jellyfish exploitation started in Asian countries more than a thousand years ago (Omori & Nakano 2001), while commercial harvest from the wild commenced in the 1970s with an estimated catch of 500,000 million tonnes per year. In India, jellyfish exploitation started in 2003 mainly due to international market demands and decline of resources from Japanese waters. China was the first country to utilise this resource (Morikawa 1984), and later the Japanese too started using this resource in large quantities. Jellyfish are in demand mainly for their medicinal value (to treat ailments like arthritis, hypertension and back pain) and as a delicacy (Hsieh & Rudloe 1994; Hsieh *et al.* 2001). At present, Japan is considered as the leading consumer of jellyfish. The distribution of this group is based on environmental and physical parameters; hence huge fluctuation in its catch occurs all around the world (Suelo 1986).

5.2 Materials and methods

Jellyfish are mainly found in large swarms and can be easily targeted; hence dip nets are employed for collection. Fishermen in the Gulf of Mannar spend 2–4 hours a day collecting jellyfish in shallow waters and this is mainly dependent on catch availability. In the Gulf of Mannar, exploitation of jellyfish is carried out in four stations (Tharuvaikulam, Vallinokam, Ervadi and Keelakarai) and the fishing begins during the monsoon and ends during the post-monsoon period. Fishermen consider this as an additional source of income. After selling their main fish catch, they immediately return to sea to collect jellyfish for an additional 2 hours. Some fishermen fish exclusively jellyfish. Motorised *vallams* are used for catching in all the four stations. The data on collection was gathered from fishermen and jellyfish processors.

5.3 Results

Jellyfish collection is done on a seasonal basis especially from July to October; hence the fishermen consider this resource as an additional source of income. Tharuvaikulam had the highest catch when compared to other stations (Figure 5.1). A high variation in catch rates within and between the stations could be observed and this might be due to environmental and physical factors prevailing in the ecosystem.

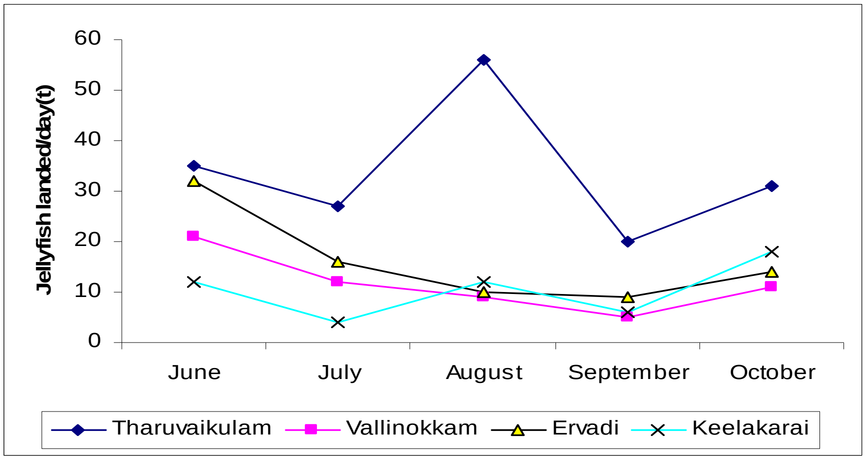

Figure 5.1: Landing of jellyfish along the Gulf of Mannar

Figure 5.2: Exploitation of jellyfish in huge quantities

5.4 Discussion

Jellyfish exploitation in India can be considered as a very good example of fishing down the marine food web, and indicates clearly how there is a reduction in the usual catch of commercial species. The exploitation of new resources reduces fishing pressure on commercially declining stock and it should be encouraged with some management plans in place. In 2007, around 7 million tonnes of jellyfish were harvested from the the Gulf of Mannar using scoop nets. Till now targeted commercial harvest of jellyfish has not yet been undertaken by trawlers. On the other hand, jellyfish are an important food source for endangered species like marine turtles, and this leads to conflicts between the Forest Department and resource utilisers in the Gulf of Mannar region.

Along the Tamil Nadu coast, the biomass of commercial fish caught have reduced dramatically and fish of a lesser value are being caught now in higher quantities. Incidental catch that fishermen are happy to exploit include invertebrates like jellyfish (*Lobonema smithii*), pistol shrimp (*Alpheus malabaricus*), squillas (*Oratosquilla spp.* and *Harpiosquilla spp.*), trigger fish (*Odonus niger*) and puffer fish (*Lagocephalus lunaris*).

6. Cephalopod jigging along the Tamil Nadu coast: A case study

6.1 Introduction

Harvest of the world's cephalopod resources rose rapidly in the mid-1960s following an increase in Japanese domestic landings. Indian cephalopod fisheries depend on cuttlefish, squids and octopus catch, and these resources are exploited in large quantities by bottom trawlers. The cephalopod catch is dominated by cuttlefish (*Sepia pharaonis* and *S.inermis*), squid (*Loligo duvauceli*) and octopus (*Octopus aegina*). Since this resource has good market value and a preference in the domestic market, the artisanal and mechanised sectors are also involved in cephalopod catch using jiggers. Augustyn (1990) established that jigging exploited the concentration of squids in the spawning grounds. Usually jigging is done in the breeding grounds, and breeding grounds are identified using the traditional knowledge of fishermen.

6.2 Materials and methods

The jiggers used around the Tamil Nadu coast have two whorls of hooks, and each whorl consists of 12 hooks. The jiggs have different colours and the employment of colour depends upon the clarity of the water. The jigs are employed using hands, and at any particular time a fisherman will handle two jigs. The fishermen fix a place, anchor the boat and place the jiggers. Jiggers are employed in all ecosystems along the coast. Information regarding the catch in terms of biomass was collected from the landing centres on a seasonal basis. Four stations were fixed along Wadge Bank (Muttom, Colachel, Arockiyapuram and Kootapuzhi), three stations in the Gulf of Mannar region (Manapadu, Tuticorin and Vembar), five stations in Palk Bay (Katumavadi, Ponnagaram, Mallipattinam, Manora and Thondi), and three stations along the Coromandel coast (Chennai, Periyakuppam and Nagappattinam). This fishing activity occurs at depths ranging from 3 to 14 m.

6.3 Results

The cephalopod catch varied between ecosystems. Peak catch using jiggers was observed in the Wadge Bank region with a catch per unit effort (CPUE) of 2.5 kg during the monsoon (Figure 6.1). In Palk Bay, tjigging fisheries for cephalopods had a higher occurrence in all the seasons suggesting that this was a regular fishing activity, whereas the CPUE was less during the monsoon (1.4 per kg). In the Gulf of Mannar and along the Coromandel coast, the CPUE was less than other ecoregions.

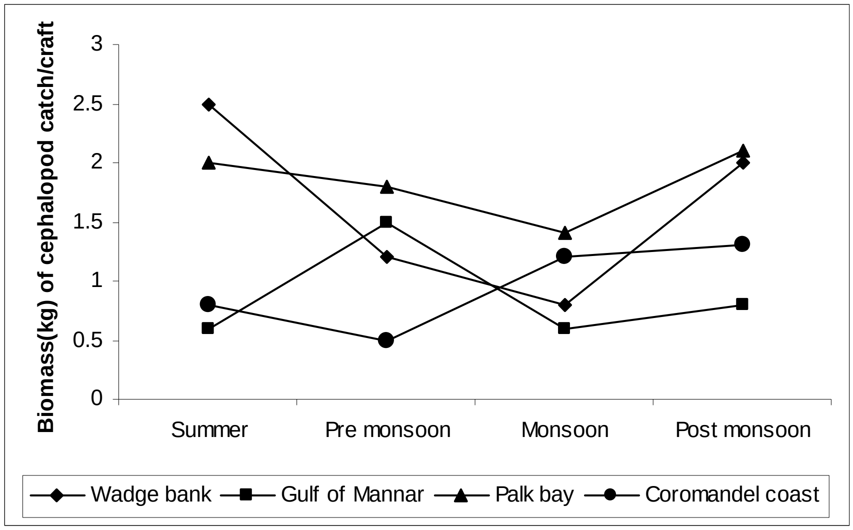

Figure 6.1.: Biomass of cephalopod catch per craft

6.4 Discussion

Even though this fishing practice has started recently, it is well accepted by the fishing community. In Palk Bay, the number of fishermen involved in jig fishing is higher and this might be due to the larger quantity of squid available in this ecosystem. This type of fishery should be encouraged since it is selective and the damage caused to the ecosystem is negligible. At present, jigging for cephalopods are carried out in using traditional methods and promoting this type of fishing in a managed commercial form could be encouraged.

7. Seaweed extraction in the Gulf of Mannar region: A case study

7.1 Introduction

Seaweeds are non-flowering plants found along the inter-tidal and sub-tidal regions of the coast, especially in rocky and coral reef regions. Utilisation of seaweeds in the industrial sector promoted its harvest from the wild, and resulted in the over-exploitation, particularly of red algae. Collection of seaweeds is a seasonal income generating venture in the Gulf of Mannar—for a period of 3 months in the case of brown algae and 8 months in the case of red algae. The collection of brown algae (*Sargassum wightii*) and red algae (*Gelidela acerosa*) is carried out from the Gulf of Mannar region by the fishermen. The exploitation of red algae is carried out in Keelakarai and Ervadi, whereas brown algae are landed in Ervadi but harvested between Mandapam and Keelakarai group of islands.

7.2 Materials and methods

Collection of seaweed is done by plugging or cutting them from their holdfast. Only three to five fishermen are involved in exploiting brown algae, whereas nearly 50 women are involved in the harvest of red algae. Brown algae are harvested till the crafts are full. Red algae are harvested during the low tide period only.

7.3 Results

Brown algae are harvested on a daily basis from the islands. During the 3 month period, it is estimated that around 0.09–0.15 million tonnes of brown algae are landed in Ervadi. In the case of red algae each woman collects around 5–25 kg of red algae; this is dependent on the collection site. Approximately 0.16 and 0.06 million tonnes of red algae is exploited from Ervadi and Keelakarai regions in the Gulf of Mannar.

7.4 Discussion

Exploitation of brown algae is done in a sustainable manner since this harvest happens once a year. Brown algae grow to considerable lengths; wave action results in its getting detached from the holdfast and progressively reaching the shore. It is then utilised as a resource and provides livelihood options to the fisherfolk. Even though seaweeds act as feeding grounds, and as a shelter for juvenile marine forms, the assemblages with regard to these macro-algae are not properly documented. At present in the Gulf of Mannar region, the exploitation of seaweed focuses on two species, which may not have a major impact on the ecosystem. However, the exploitation of red algae needs to be monitored and culture protocols should be developed that provide the dependent communities with some incentives.

Figure 7.1: Seaweeds being unloaded from a boat

Figure 7.2: Seaweeds being dried before processing

8. Analysis of bycatch in trawl fishery along the coast of Tamil Nadu

8.1 Introduction

Trawling has been found to be one of the most efficient methods of catching fish the world over. However, it is also known to be one of the most significant anthropogenic contributors to physical disturbance along continental shelfs, thereby causing considerable physical destruction of ecosystems (Jennings & Kaiser 1998). Discards during fishing operations represent a significant proportion of global marine catch that are generally considered as waste or as sub-optimal use of fishery resources (Chandral 2005). India has a coastline of 8,129 km and 2.02 million sq km of EEZ. Along the Indian coast there are about 3,651 fishing villages and 2,271 fish landing centres (Devaraj & Vivekanandan 1999).

Issues regarding marine bycatch and ecological damage from commercial fishing gear have been discussed widely in many published papers. According to the FAO's report (Alverson *et al.* 1994), it is estimated that 27 million tonnes or approximately 27 percent of the global catches are discarded annually. However, few studies on bycatch have been reported from the Indian coast. Sivasubramanian (1990) stated that shrimp bycatch in Visakhapatnam constituted 85 species. Gordon (1991) estimated that 25–30 percent of discards comprised juvenile shrimps along the Visakhapatnam coast. The Bay of Bengal Programme study indicated that the quantity of bycatch discarded by the east coast trawlers was 100,000–130,000 lakh tonnes during the year 1988 (Bostock & Ryder 1995). The dominant families in the bycatch were Scianedidae, Leiognathidae, Nemipteridaae, Clupeidae, Trichiuridae, Carangidae, Mullidae, Harpodontidae and Meineidae. Menon (1996) has estimated that 6,200 tonnes of juvenile fish and prawns were discarded into the sea during 1980-84. Rao (1998) estimated the discards from Visakhapatnam to be 2 lakh tonnes. Kurup *et al.* (2003) have estimated that the bottom trawl discards along Kerala coast during 2000-01 and 2001-02 was 2.62 and 2.25 lakh tonnes, respectively.

8.2 Single-day fishing trawlers

These are usually small trawlers built of wooden planks extending to a length ranging between 9–11.5 m and a breadth of 3–4 m with a gross tonnage of 9–20 m. These crafts venture out to sea for a maximum period of 6–12 hours and operate two to four hauls. They use shrimp nets with a codend mesh of 10–20 mm and carry a crew of four to six.

8.3 Multi-day fishing trawlers

These are relatively larger trawlers, built of wooden planks with a length of 11–17.1 m and a breadth of 3.5–5 m, with a gross tonnage of 15–40 m. These crafts venture out to sea for a maximum period of 12 days. They operate three to four hauls during the day and two to four during the night. They use both shrimp nets and fish nets; a shrimp net has a codend mesh size of 15–18 mm and a finfish net of 22–24 mm. They carry a crew of five or six persons.

The main objectives of this study were:

- To quantify the target and bycatch species in the catch landed by trawlers along the coast of Tamil Nadu.
- To formulate measures for the conservation of marine habitats and better management of marine fishery resources along the Tamil Nadu coast.

8.4 Materials and methods

The catch details of individual boats were collected along with details such as overall length of boat, codend mesh size, depth of operation and nature of fishing grounds.

The trawl catch composition of trawlers was analysed from 16 major landing centres along the Tamil Nadu coast for a period of 1 year. Samples of bycatch were collected and analysed in the laboratory. Fish were classified into groups such as target and bycatch as per the definitions given by the Commission of European Communities (CEC 1992) and the Food and Agriculture Organization (FAO 1996). The different fish groups were sorted and identified up to the species level. Total bycatch per boat was calculated from the samples from various trawlers. Data on commercial fish was also collected.

8.5. Results

Species composition

Sixteen major trawl landing centres were selected along the Tamil Nadu coast to study the bycatch composition in catch. The target species consisted of finfish, shrimps and cephalopods. Major species of finfish were *Lethrinus sp.*, *Leiognathus sp.*, *Geres sp.*, catfish, barracudas, groupers, *Sillago sp.* and carangids. Cuttlefish and squids were the major species among cephalopods, and non-peneaid and peniad shrimps also constituted target fish species. The bycatch consisted of finfish, windowpane oysters, crabs, cephalopods, sea-grasses, sea urchins, starfish, squillas, sea pens, shrimps, molluscs, jellyfish, seaweed, sea cucumbers, eggmasses, sea urchins, sand lobsters, sea anemones, sand dollars, polycheates, gastropods, sponges, ascidians and bivalves.

8.5.1 Quantification of target and bycatch

Target fishery along different landing centres

The maximum mean catch recorded per trawler during the study was at the Tuticorin landing centre with a mean catch of 2,858 kg and the minimum catch of 620.2 kg was seen at Mudasalodai landing centre. The same trend was seen for the target fish, with a maximum catch of 2,050.9 kg in Tuticorin and the minimum mean catch of 410.1 kg in Mudasalodai. Target trawl fishery catch consisted of three major groups—finfish, cephalopods and shrimp. Maximum finfish were found in Tuticorin and the minimum in Tharangampadi. Shrimp was found to be abundant in Nagappattinam and the minimum record of shrimp was from Cuddalore. Cephalopods were also found to be abundant in Nagappattinam while the minimum catch of target cephalopods was found in Tharangampadi.

Bycatch along different landing centres

Bycatch was found to be maximum in trawlers operating from Nagappattinam with a mean catch of 1,140 kg and minimum bycatch was recorded in Sethubhavachaitram with a mean catch of 168.3 kg. As bycatch, finfish were the major group followed by crabs, gastropods, squillas and bivalves. Finfish were found to be maximum in the bycatch landed at Nagappattinam. Crabs were present in large numbers in the bycatch landed at the Vembar landing centre. Squilla were one of the major constituents of bycatch landed at the Cuddalore landing centre. Shrimp were generally present in large numbers in bycatch landed at the Rameswaram landing centre. The maximum catch of gastropods in bycatch was recorded from the Kottaippattinam landing centre. The maximum catch of bivalves was recorded from Rameswaram landing centre.

Biodiversity studies

Twenty-two groups of different species were found in trawlers that landed at Sethubhavachaitram and a minimum of eight groups were found to be present in trawlers that landed at the Cuddalore landing centre. Poor distribution of various groups of fish were found in Kottaippattinam, Sethubhavachaitram, Cuddalore, Pazhayar, Jegathapattinam, Tharangampadi, Tuticorin and Pambam landing centres. Shannon-Weiner Indices were calculated and the maximum diversity was found in Rameswaram (1.71) and minimum diversity was found in Cuddalore (0.80).

Table 8.1: Species biodiversity along the Tamil Nadu coast

Landing center	Species	Number	Species diversity	Species evenness	Shannon-wiener	1-Lambda'
Kottaipattinam	21	1,164.8	2.8	0.48	1.5	0.62
Sethubhavachaitram	22	920.2	3.1	0.36	1.1	0.44
Kasimedu	10	1,107.6	1.3	0.61	1.4	0.60
Rameswaram	16	1,208.6	2.1	0.62	1.7	0.67
Ervadi	14	1,085.2	1.9	0.56	1.5	0.59
Cuddalore	8	875.5	1.0	0.39	0.8	0.38
Mudasalodi	10	593.4	1.4	0.70	1.6	0.74
Pazhayar	9	935.4	1.2	0.47	1.0	0.46
Vembar	10	1,049.3	1.3	0.534	1.2	0.55
Jegathapattinam	18	853.6	2.5	0.29	0.9	0.36
Mandapam	11	1,052.9	1.4	0.52	1.2	0.55
Nagappattinam	15	1,403.3	1.9	0.53	1.4	0.67
Soliyakudi	14	995.0	1.9	0.51	1.3	0.52
Tharangampadi	11	916.8	1.5	0.41	1.0	0.43
Tuticorin	17	1,014.4	2.3	0.49	1.3	0.54
Pambam	15	883.4	2.1	0.37	1.0	0.40

Cluster analysis

A dendrogram was plotted and it was found that the catch landed at Kottaiappttinam, Pambam, Sethubhavachaitram, Jegathapattinam, Mandapam and Nagappattinam were clustered together showing similarity in species (Figure 8.1).

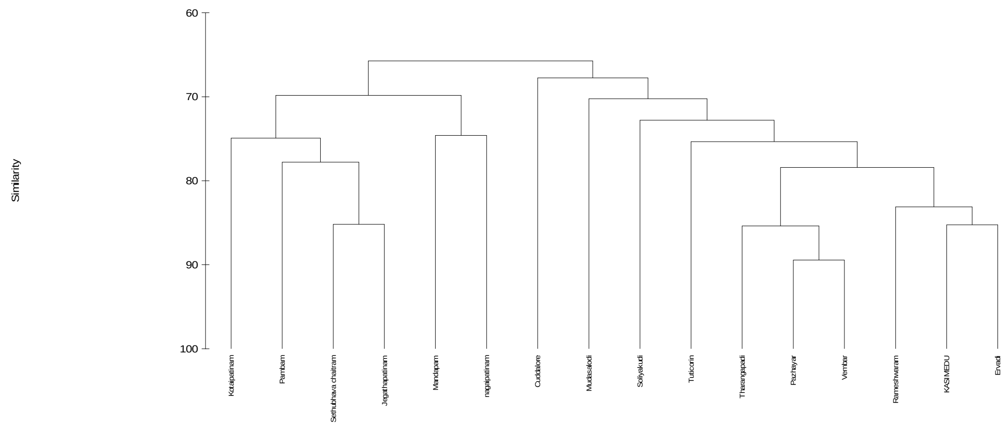

Figure 8.1: Dendrogram of annual fish landings recorded from different landing centres showing grouping of years.

Multi-dimensional scaling plots

The same pattern was also evident from multi-dimensional scaling (MDS) plots. The stress level, which was overlying on the MDS plot (0.16) showed an excellent ordination of the samples collected (Figure 8.2).

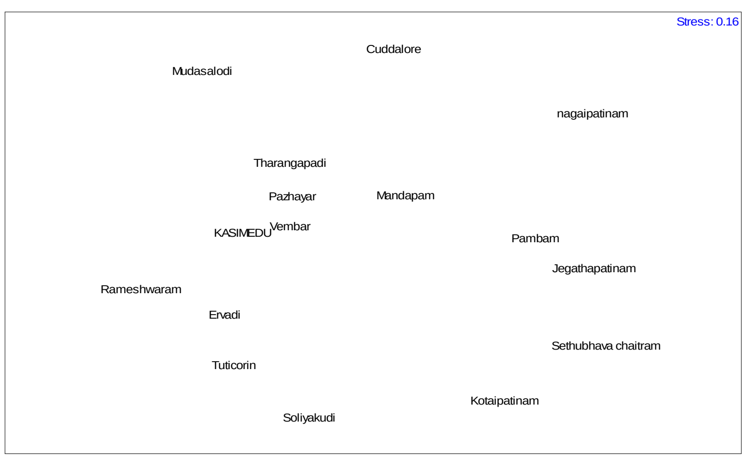

Figure 8.2: Multi-dimensional scaling ordination plots of catch obtained along the Tamil Nadu coast from different stations

8.6 Discussion

The impacts of fishing gear on the marine environment have been a matter of great concern for the sustainable management of oceanic resources. Trawl nets are used to catch economically valuable target species, but as non-selective gears, bottom trawl nets collect every organism in their path. The increase in commercial fish production all over the world in the last five decades has been accompanied by an increase in the landings of bycatch and discards. The marine fish landings in India have increased from 0.5 million tonnes in 1954 to 2.54 million tonnes in 2004 (Vivekanandan *et al.* 2005). The significant increase in marine fish landings during this period is primarily due to the introduction of fishing methods such as trawling. About 50 percent of the total marine capture fisheries in India are from trawlers.

In the present study, a total of 22 groups were recorded from various landing centres along the Tamil Nadu coast. Target fish comprised three groups , while bycatch comprised 19 groups. The results indicate that the number of groups being landed as bycatch is very high. According to Kurup *et al.* (2003), the discard in Kerala by bottom trawlers was 103 species of finfish, 65 species of gastropods, 12 species of bivalves, eight species of shrimp, two species of stomatopods, 12 crab species, five species of cephalopods, three species of echinoderms and three species of jellyfish.

Finfish were found to be abundant in both target as well as bycatch groups that were landed along the Tamil Nadu coast. Crabs, squillas, gastropods and bivalves were the other major groups present. The increase in number of bycatch groups along the Tamil Nadu coast can be attributed to reduction in the codend size of trawlers. Rao *et al.* (1980) have reported the increase in prawn landings in Kakinada, Andhra Pradesh, during the 1970s due to the gradual reduction in the codend mesh size of trawl nets. This reduction in mesh size has ultimately resulted in the reduction of the average size of prawns.

Maximum mean catch was recorded from the Tuticorin landing centre and minimum mean catch was recorded from the Mudalasodai landing centre. Tuticorin is a large landing centre and usually, most trawlers that operate are multi-day trawlers. Therefore, the catch was generally high here. The average percentage shows that target fish are more abundant than bycatch in most of the landing centres.

The present study indicates that there is an increase in percentage of catch from target groups when compared to bycatch. But when we compare group-wise composition, it is found that target fishery consists of only three groups while bycatch consists of 19 groups. This indicates that a large amount of invertebrates are exploited along the Tamil Nadu coast.

The present study was based on harbour surveys, so the most important component, namely discards at sea by trawlers, was excluded. Had it been incorporated, the fish catch composition would have changed. A detailed study on discards has been carried out in Kerala by Kurup *et al.* (2003) and it was found that the quantity of discards thrown back into the sea during 2000-01 and 2001-02 were 2.62 and 2.25 lakh tonnes respectively. The study has stated that this could be attributed to the fact that the entire quantity of bycatch is discarded into the sea in Kerala. This is not the case in the Tamil Nadu trawl fishery where there are reports of large quantities of bycatch being landed and sold for making fertiliser, thereby providing an additional source of income. In Gujarat, the largest producer of marine fish in India, bycatch is utilised in the production of fish meal and fish manure (Zynudheen *et al.* 2004). In countries like India, where per capita protein utilisation is very low, the complete utilisation of discards is important as they are found to be a good source of protein and minerals (Zynudheen *et al.* 2004).

Vivekanandan *et al.* (2003) has reported that the catch from in-shore waters (<50 m depth) reached the cacheable potential during 1995-2000 and resources such as eels, catfish, sciaenids, pomfrets, Indian mackerel and cephalopods were over-exploited from the Indian waters. The rise in fish catch in the southwest coast has been attributd to a rapid increase in fishing efforts, particularly in the coastal areas. It is well established that large meshed trawl nets perform better in Indian coastal waters without much reduction in catch.

Many endangered species were also disturbed, including corals, sponges, gastropods and bivalves. This will have a direct impact on the ecosystem of Tamil Nadu's coastal waters. Shanker *et al.* (2004) reported the death of nearly 100,000 olive ridley (*Lepidochelys olivacea*) turtles since 1994 along the Orissa coast, mainly due to fishery related mortality, resulting in the possible decline in this population. According to Hanfee (1996), the landings of elasmobranches as bycatch in India are high, but the absence of reliable data on the levels of bycatch, survival rate of discards, and on the populations of deep sea sharks handicap their conservation in Indian waters, even though many of these species are protected under the Indian Wild Life (Protection) Act, 1972.

In summary, the results of the study show that the amount of target fish removed is more compared to bycatch. But it was also seen that bycatch consisted of 19 groups of various marine organisms compared to three groups of target catch. Therefore, the damage caused to the ecosystem in terms of destruction is mainly due to the removal of large groups of bycatch.

Urgent measures have to be taken to reduce the bycatch/discard to reduce the wastage of marine living resources and to sustain marine fisheries. Studies on survival rate of the discards are needed in tropical waters to assess the survival rate of organisms in nets and onboard before being discarded into the sea (Alverson & Hughes 1995). Bycatch reduction approaches include technical systems, such as selectivity, deterrence and avoidance devices; regulatory systems such as discard bans and bycatch utilisation; and social systems involving understanding trade-offs, engaging the fishing sector in finding solutions, etc. A major portion of bycatch could be reduced if fishing fleets could match the performance of experimental gear (between the minimum and median performance) reported in various studies. The addition of further legislative and social approaches would also have strong benefits.

Figure 8.3: Anchovies landed by trawlers

Figure 8.4: Presence of bivalves and sea horses in bycatch landed by trawlers

9. Tamil Nadu marine fisheries: Long term trends

9.1 Introduction

Fishing has been an important occupation for humans since at least the Paleolithic period, some 90,000 years ago (Yellen *et al.* 1995) and fishing has gradually improved and diversified over millennia. The impacts of fishing did not receive attention until John Cleghorn's 1854 term 'over-fishing' became a highly debated issue in the scientific community (Smith 2002). The environmental or ecosystem impacts of bottom fishing in the sea are two-fold. One is the impact of the removal of large quantities of biomass (fish populations) from the food web of 'food poor' or low energy environments characteristic of the deep sea. The other is the physical impact of fishing on ocean bottom ecosystems, comprising primarily of corals, sponges and other filter feeding species that often provide the basic structure of the ecosystems associated with seamounts, and which are also found along continental slopes, canyons and ridges throughout the world's oceans (Froese 1998; Pauly 1998). The three major gear types used in deep sea bottom fishing—gill nets, longlines and bottom trawls—are all believed to have some degree of impact on corals and other bottom dwelling organisms. Bottom trawling, which consists of dragging heavy chains, nets and steel plates across the ocean bottom, is considered by far to be the most damaging, and is the most common gear used in deep sea bottom fishing throughout the world. Its destructive impact has been clearly documented in a number of areas of the northeast Atlantic and southwest Pacific Oceans, both on seamounts as well as along the continental slope (Froese 1998; Pauly 1998).

In India, fish and fisheries have always played an important role in nutrition and livelihood. However, concentrated efforts at development of Indian fisheries began only after India gained independence (Bensam 1999). Over a span of 50 years, marine fish catch increased considerably from 0.6 to 3.3 million tonnes. Presently, there are many fishing vessels involved in excessive fishing in various areas, especially where valuable species occur (Somavanshi 2001). The first formal step towards the development and management of marine fisheries was the enactment of the Indian Fisheries Act 1897, delegating various erstwhile provinces with the responsibility of fisheries administration and management (BOBP 1982; Chidambaram 1982; Bensam 1999). However, in pre-Independence times, regulations regarding fisheries were essentially revenue oriented and expressed little interest in the development of fisheries. By the end of 1991, it was realised that marine fisheries was reaching the maximum limits of extraction in the in-shore areas and were over-exploited at various locations. Thus, no substantial increase in production could be expected. The emphasis of fisheries development therefore shifted towards expansion of the inland sector and aquaculture, and towards off-shore and deep-sea fisheries.

9.2 Fishing and the food web

A simple model that illustrates the relationships between sea organisms is the marine food chain: single-celled algae are the primary producers that make use of sunlight to form the complex molecules they need for growth and reproduction. The next link in the chain feeds herbivorously on these primary producers, becoming prey for the next meat-eating or carnivorous group, and so on.

In reality, it is rare for multi-layered marine communities to consist of a simple, single-stranded chain of individual species, each feeding on the next species down the chain (i.e., on a lower trophic level). Often, the feeding habits of a species changes in the course of its development to maturity: a young herring consumes phytoplankton while the adult fish feeds on a wide range of prey animals. Hence, the feeding relationships of sea animals are better characterised as a marine food web with complex inter-connections between individual members of the community.

Recently, Tamil Nadu commercial marine fisheries have experienced a period of rapid growth and structural changes, and its characteristics are markedly different from what they were a decade ago. Some of these changes are the result of government and private sector decisions on fishery development in India, but many have occurred because of increasingly competitive pressures, particularly as they have affected mainland commercial fishing fleets. Further changes are anticipated as diverse fishing interests (large-scale, small-scale, commercial, indigenous, as well as non-consumptive marine resource interests) are worked out in fisheries, marine and coastal zone management processes. This chapter concentrates on the economic development of the in-shore and off-shore commercial fisheries, and places a somewhat greater emphasis on large-scale fisheries.

9.3 Description of the study area

Tamil Nadu's marine fisheries can be divided into three geographical areas:

1) Gulf of Mannar (The surrounding reefs and off-shore banks)

2) Palk Bay

2) Coromandel coast

Tamil Nadu fishing fleets can also be divided into three partially overlapping or interconnected segments:

1) Large-scale commercial fishing

Although termed 'large-scale' in Tamil Nadu, almost all the vessels in this segment would be considered small as most of these vessels are less than 60 feet in total length. They include the older *aku* boats (pole-and-line sampans for fishing skipjack tuna) and tuna longline boats (also wooden, but of a different design), as well as modern tuna and swordfish longline vessels, distant-water bottom trawlers, and multi-purpose vessels which fish for bottomfish (deepwater snappers, groupers and jacks), shrimps and lobsters in the Gulf of Mannar. These vessels operate from Tamil Nadu throughout the southern Bay of Bengal. The list of fish frequently caught along the Tamil Nadu coast by different gears, which are commercially important are listed below (Table 9.1).

2) Small-scale commercial fishing

The vessels in this segment include a wide variety of moored boats between 12 and 45 feet in length. These vessels primarily use gill netting and handline techniques, although some traps and surrounding nets are also used. The target species include tunas, carangids, croakers and bottom fish for the trawlers and handliners; bottom fish, reef fish and crustaceans for the trap vessels; and small mid-water scads for the surrounding net fishery.

Table 9.1: List of common and scientific names of frequently caught commercial species

Sharks	Other carangids	Bombay duck	Other tummies
Skates	Silverbellies	Lizardfish	Billfishes
Rays	Big-jawed jumpers	Half beaks and full beaks	Barracudas
Eels	Black pomfret	Flying fishes	Mullets
Catfish	Silver pomfret	Rock cods	Unicorn cods
Wolf herrings	Chinese pomfret	Snappers	Halibuts
Oil sardines	Indian mackerel	Pig-faced breams	Flounders
Other sardines	Other mackerels	Threadfin breams	Soles
Hilsa shads	*S. commersoni*	Other perches	Penaeid prawns
Other shads	*S. guttatus*	Goatfish	Non-penaeid prawns
Coilia	*S. lineolatus*	Threadfins	Lobsters
Setipinna	*Acanthocybium spp.*	Croakers	Crabs
Stolephorus	*E. affinis*	Ribbon fish	Stomatopods
Thrissina	*Auxis* spp.	Horse mackerels	Bivalves
Thryssa	*K. pelamis*	Scads	Gastropods
Other clupeids	*T. tonggol*	Leather-jackets	Cephalopods

The objectives of the present study were:

- To study the quantity of pelagic, demersal, crustacean and mollusc species being landed along the Tamil Nadu coast for the period 1985-2006.
- To determine the effect of fishing on various groups and calculate the Mean Trophic Level (MTL) of catch along the Tamil Nadu coast.
- To study the trend in landing of sensitive species along the Tamil Nadu coast.

9.4 Materials and methods

The study was carried out to see the changes that have occurred after the tsunami along the coast of Tamil Nadu. The Central Marine Fisheries Research Institute (CMFRI) estimates the annual marine fish landing in India by employing the stratified multi-stage random sampling design (Srinath 2003) and maintains a database of the same. The yearly estimated marine fish landings (1985–2006) for Tamil Nadu were obtained from CMFRI Special Publication No. 89. The data was further analysed for demersal and pelagic fish. The MTL of all the species recorded in the catch was calculated for the period 1985–2006 as explained below.

9.5 Data analysis

a) Calculation of biodiversity indices

Biodiversity indices based on the abundance data of fish collected from the marine landings of Tamil Nadu were calculated using the PRIMER (Plymouth Routines in Multivariate Ecological Research) software package developed at the Plymouth Marine Laboratory, United Kingdom (Clarke & Warwick 1994); the methodology is explained below. A number of standard univariate statistics were used to summarise the fish community data at each site, including calculation of both total and average abundance per site, total and average number of taxa, and the percentage breakdown of abundance by both major taxonomic groups and species. Additional analyses were performed to calculate species richness, diversity and evenness index values for each station (sample), using PRIMER.
Species richness was determined using Margalef's index (d), which provides a measure of the number of species (S) present for a given number of individuals (N) according to the following equation:

$$d=(S-1)/\log 2\ N$$

Diversity was calculated using the Shannon-Weiner (H') index:

$$H'=-\Sigma\ (pi)(\log 2\ pi)$$

where pi is the proportion of the total count arising from the *ith* species.

Equitability—the evenness of species distribution—was determined using Pielou's evenness index (J'):

$$J'=H'\ (\text{observed})/H'\ \text{max},$$

where H' max is the maximum possible diversity which would be achieved if all species were equally abundant [=log2 (S)].

Over the last decade, a variety of different biodiversity measures have been devised to measure the degree to which species are taxonomically related to each other, such as 'variations in taxonomic distinctness' (VarTD) and 'average taxonomic distinctness' (AvTD) (Clarke & Warwick 2001). AvTD is the measure of mean path length through the taxonomic tree connecting every pair of species in the list, while VarTD is simply the variance of these pair-wise path lengths, and reflects the unevenness of the taxonomic tree (Clarke & Warwick 2001). These two indices are not dependent on sampling methods, sample size or habitat types and are widely used for broad-scale geographical comparisons of biodiversity, environmental impact assessment and evaluation of surrogates for biodiversity estimation (Clarke & Warwick 2001). All indices were determined using the DIVERSE routine within the PRIMER software package.

The Taxonomic Distinctness (TD) was calculated for total species, target species and non-target species from the presence/absence data using the PRIMER software (Clarke & Warwick 2001). The significance test for the departure of TD for any sample of *m* species from overall value of TD for 'global' species list for the region was calculated (funnel test). The test is based on the theoretical mean and variance of TD values obtained by random sampling of *m* species from the total list of *S* species. Although the theoretical mean remains constant, the variance naturally increases as *m* decreases, and so the approximate 95 percent confidence intervals take the form of a 'funnel'. The value of TD for any particular set of samples can then be related to this confidence funnel, to gauge the extent to which their TD falls significantly below (or above) that which is expected. Assuming a null hypothesis that each sample is a random selection from the total species list, all values of TD should fall within the confidence funnel.

Mean trophic level

The MTL of fish is taken from FishBase and Vivekanandan *et al.* (2005). The MTL of the fish recorded from landings of marine fisheries along Tamil Nadu and Puducherry coasts were combined and calculated. To understand the trend in fishing on the marine food web, the above two data sets were analysed as follows:

i) The MTL (TrL_i) for a given year i was estimated by multiplying the landings (Y_i) by the trophic levels of the individual species/groups *j*, then taking a weighted mean (Pauly *et al.* 1998), that is,

ii) $$TrLi = \frac{\sum_{ij} TL_j Y_{ij}}{\sum Y_{ij}}$$

Where TL_j is the trophic level of the individual species/group *j*, Y_{ij} the landings of that species/group, $\sum Y_{ij}$ the summation of all values of (TL_j X Y_{ij}) is the total landings of all species/groups. The decline, if any, in the TrLi over the years is considered as 'fishing down the marine food web'.

This analysis did not consider the discards at sea. The fishing gears discard low-value juveniles for which proper estimates are not available. Had all those catches been included in the analysis, one should expect fishing down the food web to have been even more visible. However, the magnitude of the effect of discard on the catch versus mean TrL signature could not be evaluated without data on the species/group composition in the discard along the TN coast.

9.6 Results

Species composition

Landing by various gears in the marine waters off the Tamil Nadu coast during 1985–2006 consisted of 65 species, out of which 29 species were pelagic fish and 36 species were demersal fish. Among pelagic fish, the major species were oil sardines, lesser sardines, mackerels, horse mackerels, tunas and billfish. Among demersal fish, the major species belonged to groupers, snappers, silverbellies, catfish, etc.

9.6.1 Trends in landings of different groups

The landings of various groups and the mean catch landing along the Tamil Nadu coast for the period 1985 to 2006 are shown in Table 9.2. The mean catch landing for the period 1985-2006 was 366,748 tonnes with a minimum catch of 217,031 tonnes in 1985 and a maximum catch of 493,787 tonnes in 1997, in general the total catch showed an increasing trend. The mean catch landing for pelagic fish was 195,976 tonnes with a minimum catch of 103,592 tonnes in 1985 and a maximum catch of 284,092 tonnes in 1997, again showing an increasing catch trend over the years. The mean catch landing for demersal fish was 125,409 tonnes with a minimum catch of 87,752 tonnes in 1985 and a maximum catch of 163,432 tonnes in 1995, also showing an increasing trend. The mean catch landing for crustacean fish was 33,509 tonnes with a minimum catch of 19,977 tonnes in 1985 and a maximum catch of 44,868 tonnes in 1994, with an increasing trend. The mean catch landing for molluscs was 11,854 tonnes with a minimum catch of 5,653 tonnes in 1986 and a maximum catch of 18,228 tonnes in 1996, also with an increasing trend.

Table 9.2: Group-wise composition in tonnes during different years from 1985 to 2006

Year	Pelagic	Demersal	Crustaceans	Molluscs	Total
1985	103,592	87,752	19,977	5,710	217,031
1986	131,839	95,346	23,464	5,653	256,302
1987	157,614	121,278	28,058	10,139	317,089
1988	152,468	123,481	25,863	6,856	308,668
1989	153,856	109,900	23,844	6,060	293,660
1990	161,267	119,380	27,764	10,384	318,795
1991	198,910	126,975	30,777	11,312	367,974
1992	216,806	120,273	30,730	16,594	384,403
1993	173,727	133,302	31,877	8,842	347,748
1994	193,739	157,535	44,868	15,787	411,929
1995	213,835	163,432	42,559	15,660	435,486
1996	244,483	153,824	39,144	18,228	455,679
1997	284,092	156,494	41,414	11,787	493,787
1998	254,402	129,011	44,445	8,511	436,369
1999	221,502	119,199	36,640	12,962	390,303
2000	232,683	125,008	38,607	9,752	406,050
2001	204,569	114,923	33,293	9,937	362,722
2002	231,675	128,110	41,038	17,302	418,125
2003	208,864	110,186	34,944	16,137	370,131
2004	225,566	135,324	33,099	17,180	411,169
2005	143,997	109,044	27,394	10,349	290,784
2006	201,979	119,231	37,394	15,647	374,251

9.6.2 Mean tropic level

The MTL of various groups are shown in Figures 9.1 to 9.5. Generally, the MTL of all the marine fish landed along the Tamil Nadu and Puducherry coast decreased from 3.30 to 3.23 from 1985 to 2006 with a mean of 3.26. The minimum was 3.16 in 1998 and the maximum was 3.35 in 1989. The MTL generally showed a decreasing trend over the years (Figure 9.1). The MTL of pelagic fish decreased from 3.41 to 3.24 from 1985 to 2006 with a mean of 3.25. The minimum was during 1997 with a MTL of 3.07 and maximum was during 1988 with a MTL of 3.44. The MTL of pelagic fish showed a gradual decrease over the period (Figure 9.2). But the MTL of demersal fish caught was reversed, showing an increase from 3.33 in 1985 to 3.40 in 2006 with a mean of 3.44. The maximum was in 2003 with an MTL of 3.53 in 2003 and minimum was in 1986 with a MTL of 3.33 (Figure 9.3). The MTL of crustaceans caught was somewhat constant over the period, at 2.60 in 1985 and 2006 with a mean MTL of 2.59. The maximum was 2.62 in 2003 and the minimum was 2.57 in 1994 (Figure 9.4). The MTL of molluscs caught increased from 3.26 to 3.51 from 1985 to 2006 with a mean of 3.39. The maximum was in 1993 with a MTL of 3.59 and the minimum was 2.65 in 1987. The MTL generally showed an increasing trend over the years (Figure 9.5). Statistically, no significant changesz were seen in the MTL along the Tamil Nadu coast for the period 1985 to 2006.

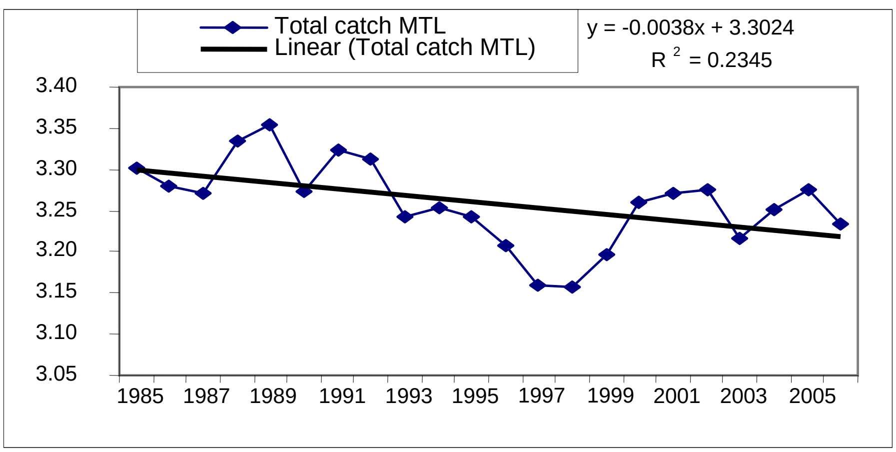

Figure 9.1: Mean Trophic Level of total fish landed along the Tamil Nadu coast

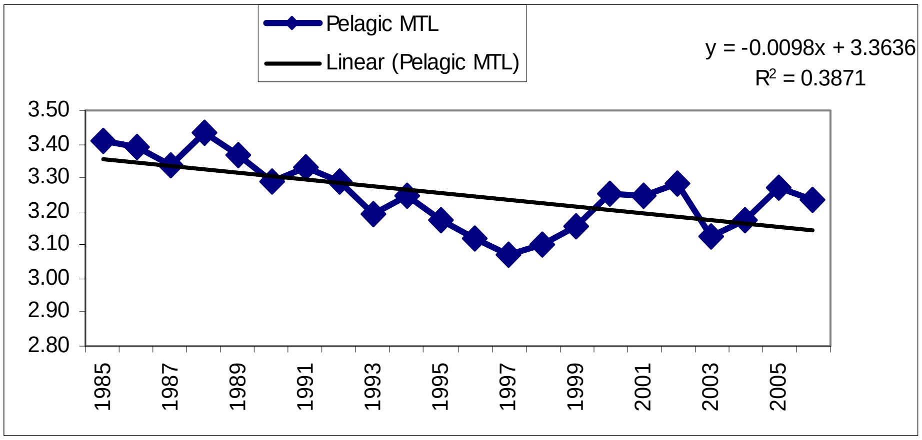

Figure 9.2: Mean Trophic Level of pelagic fish landed along the Tamil Nadu coast

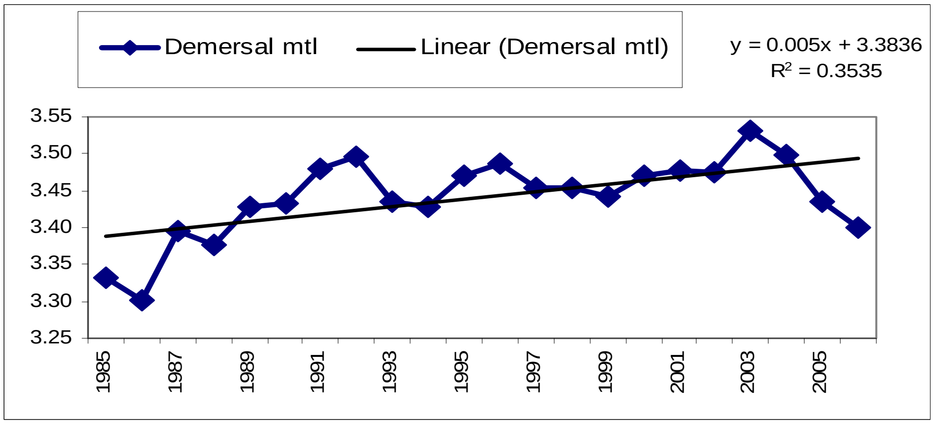

Figure 9.3: Mean Trophic Level of demersal fish landed along the Tamil Nadu coast

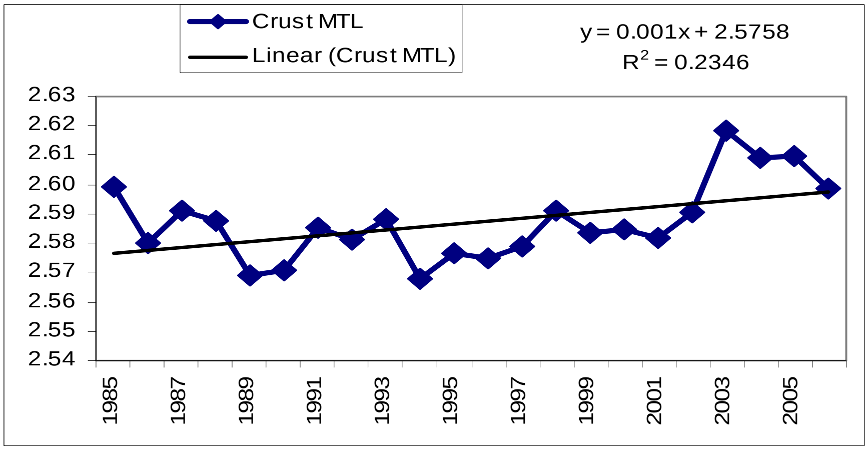

Figure 9.4: Mean Trophic Level of crustaceans landed along the Tamil Nadu coast

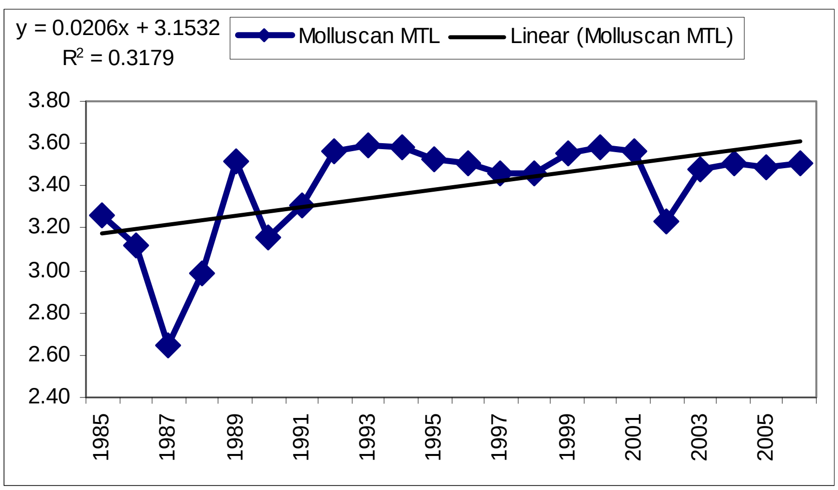

Figure 9.5: Mean Trophic Level of molluscs landed along Tamil Nadu coast

9.6.3 Biodiversity studies

Sixty-four species were recorded from 1985 to 2006 along the Tamil Nadu coast. The minimum number of species (58) was recorded in 1985 and 2005, and the maximum (64) was recorded in 1991. The various biodiversity indices for total fish species were calculated and are shown in Table 9.3. In the total catch, the richness varied from 4.52 in 2006 to 4.95 in 1991, species evenness ranged from 0.74 in 1997 and 1998 to 0.80 in 2002, Shannon Weiner index ranged from 3.05 in 1986 to 3.28 in 2002, AvTD ranged from 62.98 in 1996 to 65.24 in 1985 and VarTD ranged from 527.72 in 2001 to 567.62 in 2003 (Table 9.3).

Table 9.3: Biodiversity indices for marine fish landing along Tamil Nadu coast from 1985 to 2006

Year	Species	Numbers	Species diversity	Species evenness	Shannon -Weiner	Average Taxonomic Distinctness	Variation Taxonomic Distinctness
1985	58	199,187	4.671366	0.77	3.12	65.24	550.65
1986	59	240,399	4.681174	0.75	3.05	64.94	549.02
1987	60	299,896	4.678384	0.76	3.13	64.56	553.62
1988	59	286,333	4.61603	0.77	3.15	65.23	542.42
1989	61	269,452	4.798409	0.79	3.24	64.78	539.59
1990	60	285,715	4.696424	0.77	3.17	64.89	543.97
1991	64	334,074	4.953174	0.79	3.27	63.79	546.75
1992	62	353,776	4.774421	0.77	3.19	64.14	554.24
1993	62	319,247	4.813109	0.77	3.16	64.51	537.71
1994	61	370,344	4.679389	0.76	3.13	64.78	539.59
1995	61	400,255	4.651214	0.77	3.18	64.51	549.03
1996	61	424,962	4.629717	0.76	3.13	62.98	531.21
1997	63	461,562	4.753737	0.74	3.06	64.15	542.14
1998	62	410,244	4.719716	0.74	3.07	64.15	553.51
1999	62	364,512	4.763275	0.76	3.13	64.41	544.27
2000	63	371,680	4.834011	0.78	3.24	64.15	542.14
2001	60	336,249	4.636321	0.79	3.24	63.39	527.72
2002	60	396,578	4.576969	0.80	3.28	64.46	560.64
2003	59	356,010	4.537378	0.78	3.19	64.54	567.62
2004	61	362,353	4.687363	0.78	3.21	64.51	549.03
2005	58	284,722	4.538481	0.79	3.21	64.95	561.36
2006	59	366,676	4.526923	0.78	3.19	64.99	549.49

9.6.4 Cluster analysis

Cluster analysis was carried out for the period 1985-2006 of the total marine fish landed along the Tamil Nadu coast as seen in Figure 9.6. It can clearly be seen that the catches from 1985 to 1990 are clustered together, as are those from 1991 to 2006.

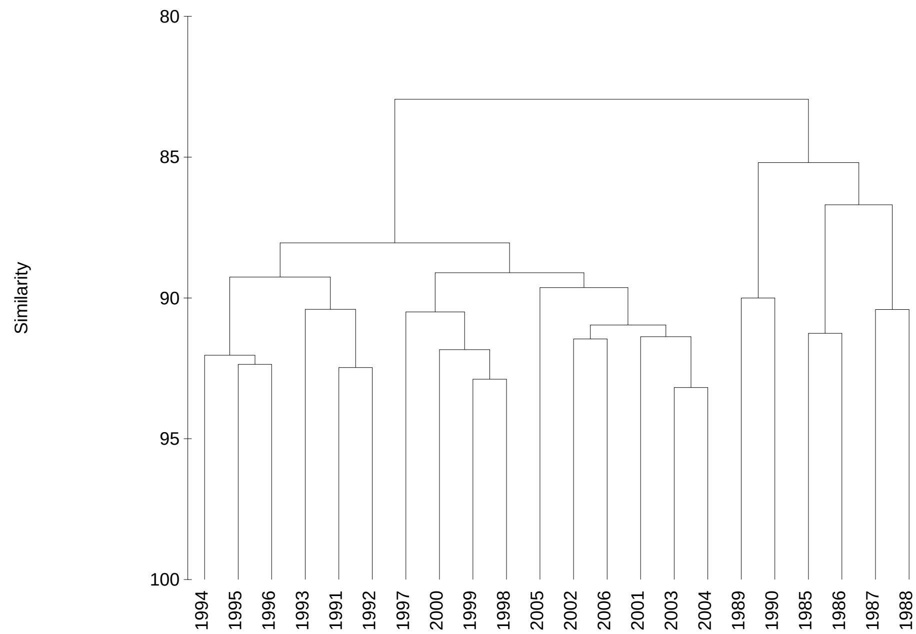

Figure 9.6: Dendrogram of annual fish landings recorded during different years showing grouping of years

9.6.5 Multi-dimensional scaling plots

The same pattern was also evident from MDS plots, where the catch from 1985 to 1990 fell on one side, and those after 1990 fell on the other side of the map, demonstrating a closer similarity in species composition in the 1985-90 period than in the 1991-2006 period. The stress level overlying the MDS plot (0.1) showed an excellent ordination of the samples collected (Figure 9.7).

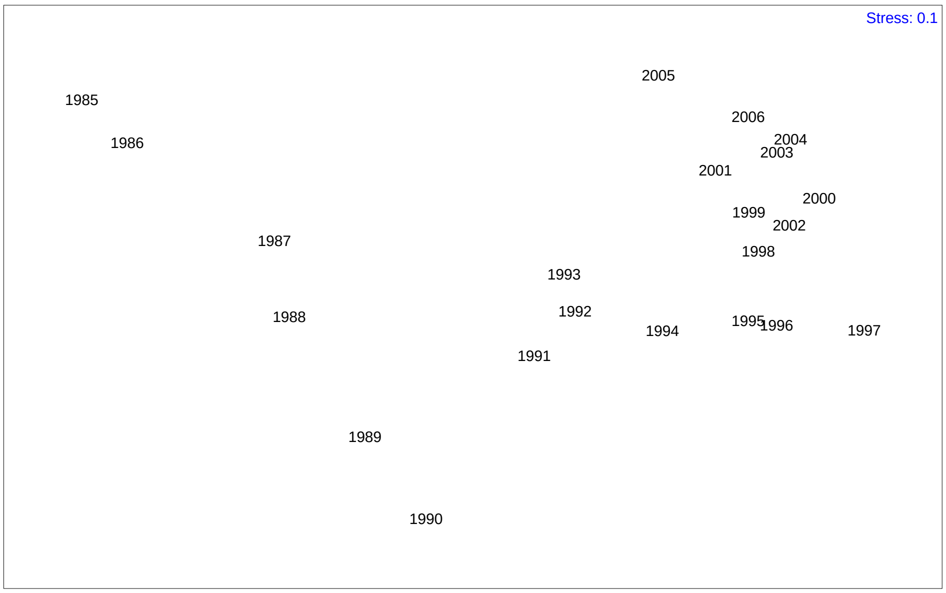

Figure 9.7: Multi-dimensional scaling ordination plots of catch obtained along the Tamil Nadu coast during 1985-2006

9.6.6 Taxonomic distinctness–average and variation

The departure from theoretical mean AvTD (Delta +) and VarTD (Lambda /+) and 95 percent confidence funnel of all individual samples of bottom dwelling fish species calculated using presence/absence data from marine fish landings along the Tamil Nadu coast is shown in Figures 9.8 and 9.9. All values of TD should fall within the confidence funnel assuming null hypothesis that each sample contains species randomly selected from the total species list.

The 95 percent confidence funnel generated for the VarTD values of all the stations is shown in Figure 9.8. Except in 1985, 1991 and 2005, all other years fell within the confidence level, showing no deviation from the normal deviation. Only 1985, 1991 and 2005 fell on the funnel line indicating some stress from fishing pressure during these years. But when we compare the 95 percent confidence funnel generated from the AvTD, a marked difference can be found.

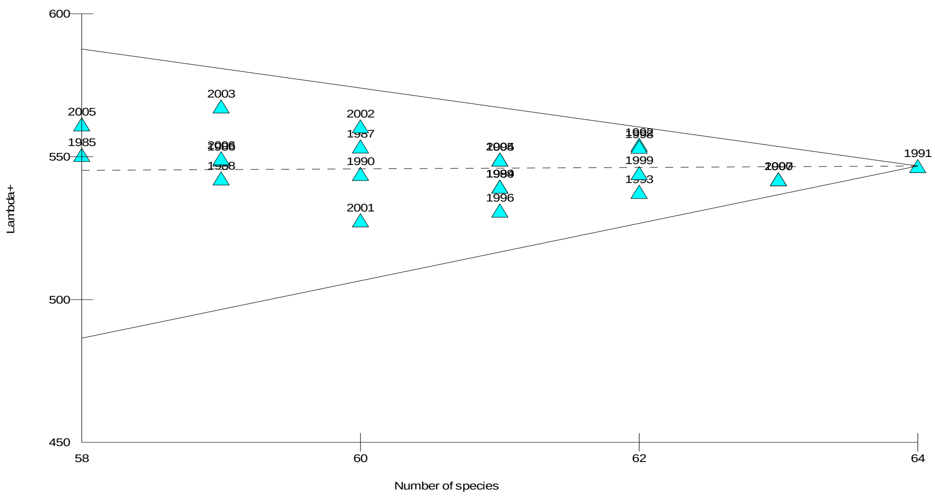

Figure 9.8: The departure from theoretical mean of Variation Taxonomic Distinctness (Lambda +) and 95 percent confidence funnel of all individuals of fish species calculated using presence/absence data from along the Tamil Nadu coast

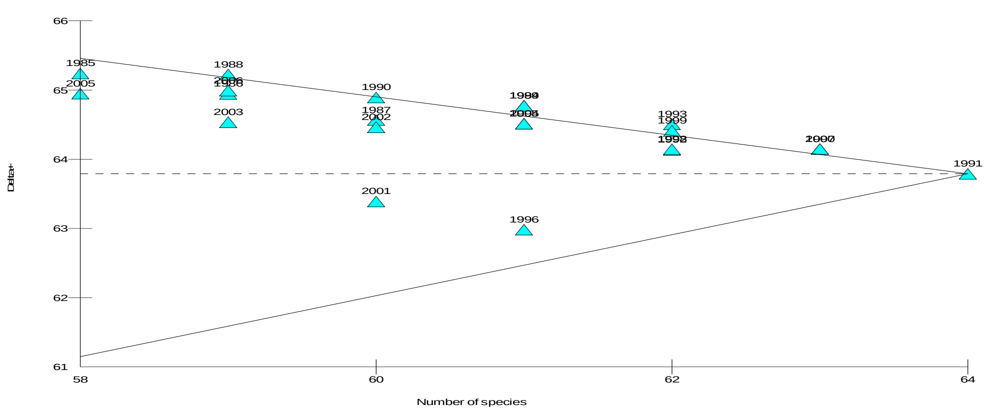

Figure 9.9: The departure from theoretical mean of Average Taxonomic Distinctness (Delta +) and 95 percent confidence funnel of all individuals of fish species calculated using presence/absence data from along the Tamil Nadu coast

9.7 Discussion

Long term variation in trawl fishery landing from the in-shore waters by various fishing gears along the Tamil Nadu coast were studied for a period of 21 years. Landings by the various gears along Tamil Nadu coast during 1985-2006 consisted of 66 species, out of which pelagic fishery consisted of 29 species and demersal fishery consisted of 36 species.

Along the Tamil Nadu coast, lesser sardines were the most dominant group (11.1 percent), followed by oil sardines (10.12 percent). The mean pelagic fish catch constituted 53.09 percent of total catch, demersal finfish were 34.61 percent, crustaceans 9.12 percent and molluscs 3.12 percent. A rapid transformation in fisheries during the 1990s impacting marine fish landings along the Tamil Nadu coast was observed. The annual total landing increased from 217,031 tonnes in 1985 to 374,251 tonnes in 2006. Peak landing was seen in 1997 with a catch of 493,787 tonnes. In the long term, landing of various fish showed a significant increase along the Tamil Nadu coast during the 1985-2006 period. Along the Indian coast, there has been an unprecedented expansion of fishing fleets in the last half century and fish landings have increased more than five-fold (Devaraj & Vivekanandan 1999; Srinath 2003). The sudden rise in trawl catch in the mid-1990s can be attributed to the introduction of the larger trawl boats, with decreased codend mesh size along the Tamil Nadu coast. Such an explosive increase in catch and gears has enabled expansion of fishing operations towards deeper and more distant areas. Additional resources have been incorporated, giving new complexion to the catch This was seen from the catch data during 1985-2006, both in number of boats and total catch of marine fish landings along the Tamil Nadu coast.

The annual catch composition of marine fish landings showed a peak in catch in 1997 and then a decreasing trend during the later years. Thangaraj (2002) has reported that the shrimp catch increased during 1990 and then decreased sharply due to fishing pressure along the Chennai coast. Considerable decrease in shrimp catch during the 1980s, then an increase during the mid- 1990s, followed by a decline over recent years has also been reported by Nandakumar *et al.* (2001) along the Kerala coast and by Deshmukh *et al.* (2001) along the Bombay coast. The finfish also showed a similar trend with increase in catch in the mid-1990s and then a gradual decrease over recent years in Cochin, in Kerala and Kakinada, in Andhra Pradesh (Sivakami 1995; Sivakami & Ramalingam 2003). The present study also shows similar trends for finfish, crabs, cephalopods and stomatopods (Table 9.3). The percentage of demersal fish landed at the Tamil Nadu coast by various fish gears was less than that compared to the landings of pelagic fish. Generally, a decrease in codend mesh size, (10 mm for shrimp nets and 12 mm for fish nets) of trawlers was observed along the Tamil Nadu coast. Kurup *et al.* (2003) have carried out a detailed study on the catch composition of total trawl catch along the Kerala coast and have reported the usage of smaller codend mesh size up to 10 mm. They have also reported a decrease in catch as a whole during the mid-1990s together with constant levels of discards in the catch. The decreasing trend in the mesh size of the net is a serious concern and would have contributed to the greater catch of juveniles and non-targets resulting in considerable decrease in fish catch during the recent years along the Tamil Nadu coast. Greenstreet and Hall (1996) studied the long term changes in the structure and species composition of the ground fish assemblages, and also reported explicit trends in the non-target component of the assemblages.

In the present study, changes in the MTL of catch were investigated. One of the arguments against the use of MTL of the catch as a reliable indicator of fisheries impact is that the food web model is not static, but is variable with time due to diet switching and variable prey preferences of fish (McCann *et al.* 1998; Kondoh 2003). It is possible that variability in the food web model may be due to fisheries impact, but this needs to be validated further. Nevertheless, this analysis provides a good picture of the components of the ecosystem targeted by fisheries. The MTL of total catch was

3.16, for pelagic fish 3.07, demersals 3.30, crustaceans 2.57 and molluscs 3.39. The continuous removal of top predators like sharks and rays over the years might have adversely affected the MTL of the trawl catch along the Tamil Nadu coast. Significant changes were observed in the long term trends of MTL for total catch and pelagic fish. The MTL of total fish catch and pelagic fish catch showed significant reduction. This is indicative of 'fishing down the food web' along the Tamil Nadu coast, especially for pelagic groups. Due to high fishing intensity *vis-à-vis* low productivity, fisheries in this area is unable to sustain the MTL. It appears that fishing may decline along with the already declining trophic levels along the Tamil Nadu coast in the next few decades. Similar trends in trophic levels were reported by Vivekanandan *et al.* (2005) from the southwest coast of India. Pauly *et al.* (1998) examined the FAO capture fisheries production database from 1950 to 1994 in terms of trophic levels of the catch which showed that the landings from global fisheries have shifted from larger piscivorous fish towards small invertebrates and planktivorous fish at an estimated a rate of about 0.1 per decade. Caddy and Garibaldi (2000) have also reported the gradual decline in the MTL of fish landings in the eastern, northern and central Atlantic Ocean, the southeast Pacific Ocean, the Mediterranean Sea and the Black Sea. In the tropical belt, this trend is not very clearly marked but does occur, as evidenced in the Gulf of Thailand (Christensen 1998).

The recently introduced biodiversity indices TD is a function of species present/absent data (Clarke & Warrick 1993). Two taxonomic related measures such as AvTD and VarTD were computed from simple species lists with the additional knowledge of the linear classification. Results indicate that significant changes in the AvTD and VarTD were observed during the period 1985-2006. The statistical test for the null hypothesis for AvTD and VarTD (funnel test) also indicates that there is significant impact on total fish catch.

The general decline in annual total fish catch along the Tamil Nadu coast may be attributed to habitat damage due to trawling (James 1994) and damage caused to benthic communities (Bensam *et al.* 1994). As the shallow coastal waters serve as nursery grounds for a number of finfish and shellfish species, large-scale trawling in these regions might be responsible for mass removal of juveniles and sub-adults of several commercially important pelagic and demersal fish. There are reports on the adverse impacts on demersal communities of the Mauritanian continental shelf facing fishing at increasing levels over several decades (Jouffre 1998).

In summary, pelagic fish were the most dominant group followed by demersals, crustaceans and mollucs. A general increase in total fish catch along the Tamil Nadu coast was observed during 1990s, post which catches showed a decreasing trend. Generally, the MTL of the total trawl catch showed a decreasing trend from 1985 to 2006, and MTL of total catch and pelagic fishery showed significant reduction. This reduction in MTL of pelagic fishery along the Tamil Nadu coast indicates the exploitation of smaller fish such as plankton feeders. It also indicates that fishing yield may decline in addition to the already declining trophic level along the Tamil Nadu coast over the next decade. Marine fisheries may adversely affect the habitat of bottom dwelling fish like flatfish, sharks and rays. A gradual decrease in landing of pelagic species from Tamil Nadu coastal waters has been noticed due to the higher rate of exploitation of these fish.

10. Exploitation of endangered species along the Tamil Nadu coast

10.1 Introduction

Indian fisheries are multiple species fisheries; during target fishing non-target species are caught incidentally or unintentionally and this has severely impacted the marine ecosystem, its biodiversity and also the yield from the natural system. Due to the use of non-selective gears, coupled with over-fishing and habitat destruction, some marine species stocks have drastically reduced over recent years. The impacts of removal of non-target organisms from the ecosystem through incidental catch or bycatch remain largely unstudied around the world (Pettovello 1999; Milton 2001). Many species in the marine ecosystem have thus become endangered or threatened. One approach to conserving these species is by promoting them to the elite group of species (i.e., including them in wildlife protection schedules) and declaring them as threatened/vulnerable/endangered. While such a status of untouchability offered to species is effective to a certain extent in the terrestrial ecosystem, this is not the case in the marine ecosystem.

Target fishing of marine resources are driven by stakeholders who drive the industry with their financial strength. Target fishing, like skin diving, is employed to exploit species inhabiting shallow waters up to a depth of 3 m; species caught includes molluscs, sea cucumbers, seaweeds, sea anemones, echinoderms, pipefish and sea horses. The resource status of endangered species has not yet been studied and the standing stock still remains to be quantified. Resource dependent communities must recognise the need for and the aims of resource management, since management regimes rely strongly on the support and compliance of the people who utilise these resources.

Most of the endangered species are caught in bottom trawl nets in mammoth volumes, especially molluscs, which also have a huge demand in domestic and international trade as curios. Sea cucumbers, locally called '*attai*', is exploited for local consumption as well as for export of these value-added products to other Asian countries (Conand 1990). There are around 20 species of sea cucumbers in the Indian waters and not all species are traded (James 2001). Sea cucumbers are also caught in considerable numbers and fetch around INR 10–28 per animal, the price depending upon species availability and the season. Even though the government placed sea cucumbers, as well as other marine organisms, under Schedule I of the Indian Wild Life (Protection) Act 1972, the fishermen continued with their protests. This was because the resource provided a livelihood option to many poor fisherfolk in the Gulf of Mannar, Palk Bay and Nagapattinam (Coromandel coast) regions. Even though community-based management of sea cucumber resources was carried out in Palk Bay, the resources could not be protected in terms of exploitation.

In 1992 when sea cucumber resources declined the spotlight turned towards sea horses (Marichamy *et al.* 1993) and molluscs (*Strombus canarium*). Sea horses are sluggish fish inhabiting sea-grass ecosystems. Fishermen started collecting sea horses and pipefish as they had a very good market in China where they are used as ingredients in traditional Chinese medicine. The exploitation of syngnathid fish reached its peak in 1995 with the trade broadening along the entire coast (Murugan *et al.* 2008), and this resulted in them being accorded Schedule I status in the Indian Wild Life Protection Act since 2001. However, the diversity and wild stock of syngnathid fish occurring in Indian waters is still not known and efforts to estimate diversity should be initiated by the scientific community.

Marine turtles are caught in bottom trawling, gill nets and shore seines. Even though many awareness programmes have been carried out with regard to conservation of marine turtles, there is still a lot that needs to be done. Some communities consider turtle meat a delicacy and also of medicinal value, especially green turtles (*Chelonia mydas*) in the Tuticorin region and olive ridleys in the Keelamanakudy region.

The windowpane oyster (*Placenta placenta*) commonly known as '*kapis*' is commercially and economically important because of its translucent shell. Windowpane oysters occur in large numbers in the Palk Bay region since this bivalve prefers sea-grass habitats with muddy substratum. Their shells are utilised for producing shell lime. The status of this endangered species should be periodically evaluated to estimate its stock size in the wild. Stock enhancement programmes also need to be considered in India.

10.2 Materials and methods

Sea cucumbers

This fishery is done with skin diving as well as using bottom trawl nets. During the study period, the exploitation of sea cucumbers was recorded from Mandapam (south) to Nagappattinam in bottom trawling nets. The data on catch was collected from fishing crews, since collecting data from the auction place is both difficult as well as unsafe. Information on numerical catch for different seasonal periods was collected from 15 bottom trawlers.

Marine turtles

Even though the Gulf Mannar is not a a breeding ground for marine turtles, they inhabit this region mainly because it serves as a good feeding ground for them. Turtles that are caught are primarily used for consumption during the weekend, and the meat is shared among the villagers as it is considered to be of medicinal value. They are commonly encountered in bottom trawl nets, and rarely in gill nets and shore seines. Information regarding their occurrence was collected from fishing crews of trawlers (*n*=15) and other crafts (gill nets, *n*=20; shore seines, n=3) on a seasonal basis.

Sea horses and pipefish

These syngnathid fish were found in bottom trawling, shore seines and country trawl nets. In bottom trawling, small sized sea horses (7–10 cm) were observed from bycatch discards. Those of > 10 cm length were sold to chank purchasers. Sea horses caught in country trawl nets and shore seines are sold to people in a dried form on a weekly basis. In the case of pipefish, only the alligator pipefish (*Syngnathoides biaculeateus*) is valued in trade, and it is usually found in bottom trawling, shore seines and country trawl nets. Other species of pipefish along with other fish species are utilised as an ingredient in poultry feed. Visual observation was made to estimate the incidental occurrence of this fish on a seasonal basis (trawl nets, *n*=20; country trawl nets, *n*=45; shore seines, *n*=12).

Windowpane oysters

The occurrence of the windowpane oysters (*Placenta placenta*) was observed from Rameswaram to Mallippatinam in shrimp trawl nets. In gill nets—targetting Indian salmon, Indian mackerel and pomfrets—they occur in huge qunatitites from Kodiakkari to Arkatuthurai. In these regions, their shells act as substratum for gorgonids (another scheduled group of organisms). The gorgonids get entangled with the gill nets, which in turn leads to displacement of the oyster shells from the substratum. The occurrence of windowpane oysters is considered as a problem in this region as it reduces the fish catch. Biomass of windowpane oysters was collected on a seasonal basis from trawl nets (*n*=10) and gill nets (*n*=16) in the Palk Bay region.

10.3 Results

Sea cucumbers

Four species of sea cucumbers (*Holothuria scabra*, *H. spinifera*, *H. atra* and *Stichopus spp.)* were found to be auctioned both openly and discretely. Among the four species, *H. scabra* fetches a higher price; the price varied from INR 22 to 28 per animal. At present target fishing (skin diving) is not carried out in the Gulf of Mannar and Palk Bay. This livelihood option of the dependent community has neither been documented by the policy makers, nor an alternative option provided. This resource occurs in bottom trawl nets as incidental catch. Due to its demand and good price offered by the stakeholders, the fishermen are interested in its harvest. The average number of sea cucumbers caught in different seasons is shown in Figure 10.1. During the post-monsoon and summer periods the catch rate was high in all stations except Mandapam north (Palk Bay), whereas peak catch in Mandapam north was recorded during the monsoon period (Figure 10.1).

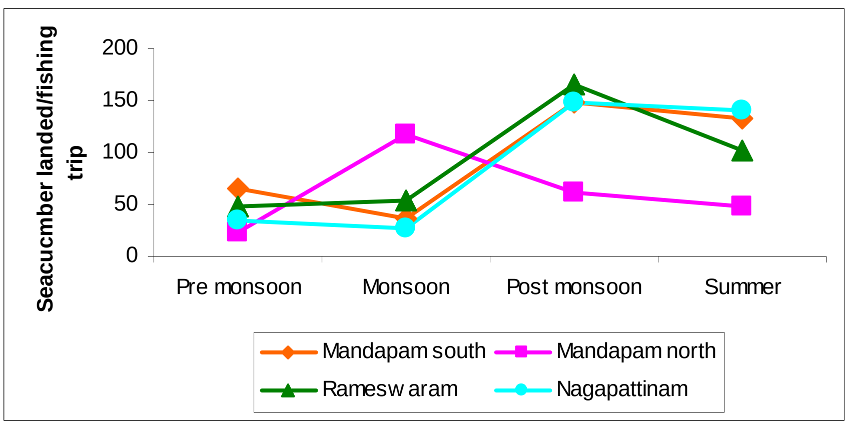

Figure 10.1: Landing of sea cucumbers at different landing centres seasonally

Marine turtles

Since no bottom trawlers employ Turtle Excluding Devices, marine turtles are mostly thrown back into the sea. However, turtles caught in gill nets and other gears are utilised for human consumption. As per information provided by the fishing crew of several trawl vessels, the Coromandel coast accounts for more turtle catch when compared to other ecosystems (Figure 10.2). In the case of gill nets, Wadge Bank recorded a higher incidence of turtles followed by the Coromandel coast (Figure 10.2). All the turtles caught in Wadge Bank were used for food, whereas along the Coromandel coast most of the turtles were thrown back into the sea.

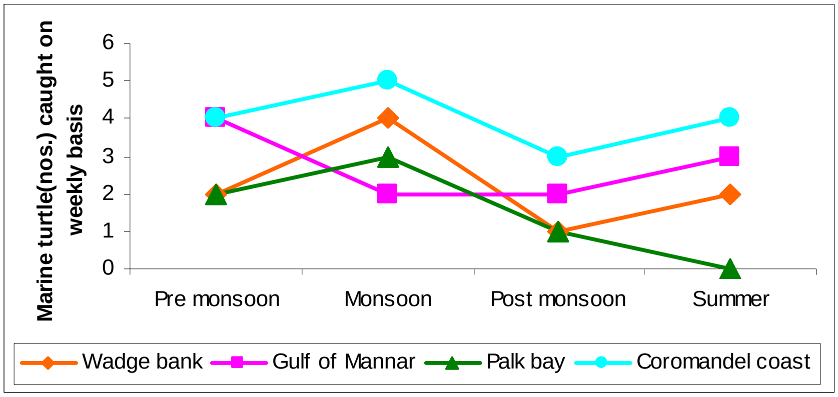

Figure 10.2: Marine turtles caught on a weekly basis

Sea horses and pipefish

Five species of sea horses (*Hippocampus trimaculatus*, *H. fuscus*, *H. spinosissimus*, *H. kuda* and *H. kelloggi*) were observed during the study period along the entire Tamil Nadu coast. Occurrence of sea horses in bottom trawlers in the Gulf of Mannar was found to be highest during the monsoon period (35 per fishing day), whereas only 11 per fishing day were observed during the monsoon period. In Palk Bay, during the post-monsoon period, the occurrence was high (73 per fishing day), but the catch did not vary much during the monsoon and pre-monsoon periods, with a catch rate of 65 and 56 per fishing day respectively. Along the Coromandel coast, the occurrence was high during the pre-monsoon period (29 per fishing day) when compared to other seasons (Figure 10.3).

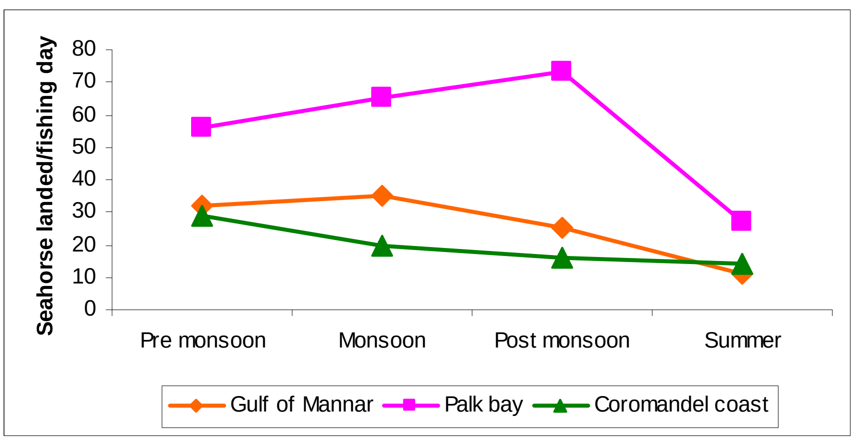

Figure 10.3: Season-wise landing of sea horses by trawlers

Since fishermen are aware about the ban on this species, sea horses are separated from the haul and kept in a safe place to later form a part of the illegal trade. The study finds differences in peak catching period in the three different ecosystems; this might be due to climate change, however, further studies in this regard are needed. Country trawl nets recorded more catch in Palk Bay when compared to the Gulf of Mannar and this is due to the exclusive operation of this gear in Palk Bay as well as the abundance of sea-grasses when compared to the Gulf of Mannar. High numbers of sea horses were recorded in both the regions during the monsoon period, with an occurrence of 12 and 56 per fishing day in the Gulf of Mannar and Palk Bay respectively (Figure 10.4).

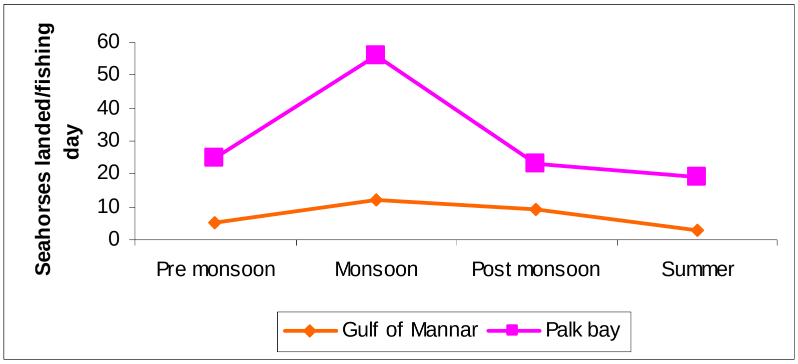

Figure 10.4: Season-wise landing of sea horses by country trawlers

Shore seine catches all species of fish during the encircling period. The highest catch of sea horses was recorded during the post-monsoon period (28 per fishing day) in the Gulf of Mannar whereas the pre-monsoon period had peak occurrence (37 per fishing day) in Palk Bay (Figure 10.5).

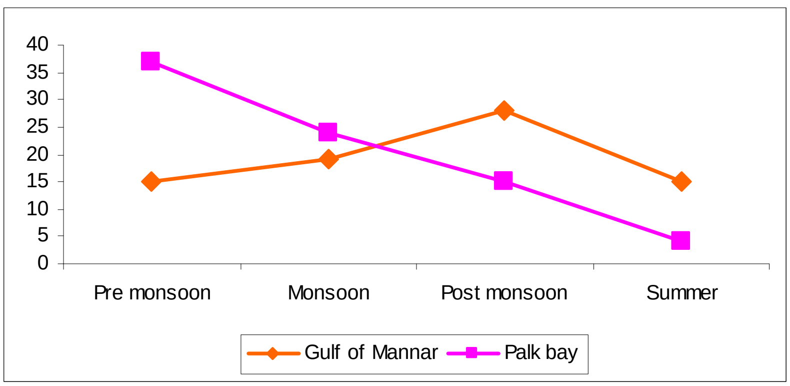

Figure 10.5: Season-wise landing of sea horses by shore seines

Windowpane oysters

The windowpane oysters (*Placenta placenta*) are mainly found in sea-grass ecosystems and the muddy substratum. Windowpane oysters caught by bottom trawl nets varied between seasons and even the biomass varied between stations (Figure 10.6). During the monsoon period the biomass was less when compared to other seasons. The winged oyster beds in the wild ecosystem should be identified for conservation.

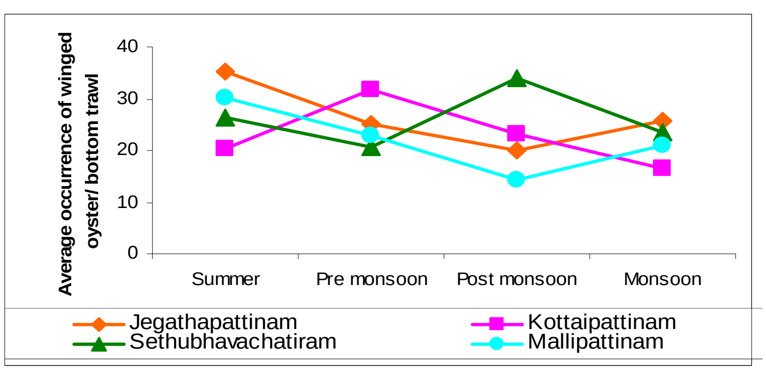

Figure 10.6: Average occurrence of winged oysters in bottom trawl nets

10.4 Discussion

Marine turtle catch is reducing as their populations in the wild are facing increasing threats. Catch and consumption of marine turtles in Keelamanakudy has been reported by Sivakumar (2005). Turtles are also frequently caught and auctioned openly in Vizhinjam, Kerala. Most of the turtles are caught from the Wadge Bank region and therefore conservation measures should be taken to conserve its population here. The occurrence of tagged turtles from the Orissa coast has been found in Keelamanakudy (Sivakumar 2005).

Due to lack of available trade data on sea cucumbers from both exporting and importing countries, it is difficult to quantify the international trade of these species accurately in terms of volume or value (Ferdouse 1996). Improved processing and cooking methods and increased awareness of the anti-viral, anti-tumoral, anti-cancerous and pro-fertility properties of this product could also increase demand (James 2001). Though scientists say that over-exploitation has occurred along the Tamil Nadu coast, no proper documentation on its exploitation and stock size has been done, nor has any stock enhancement programme ever been carried out. Government research centres possess the technology to rear this unique fish; however, these organisations have not yet made any attempt to restock them in the wild.

Bivalves are exploited because they are very productive, abundant in shallow coastal waters, and are tasty and nutritious. Though winged oysters are more abundant along the west coast, they are also found in the Gulf of Mannar and Palk Bay regions. They produce pearls that are exploited commercially (Dharmaraj *et al.* 2004). Attempts to slow the decline of this valuable resource include fisheries regulations to control harvesting and aquaculture (Madrones-Ladja *et al.* 2002; Dharmaraj *et al.* 2004).

Sea horses are mainly caught in bottom trawl nets whereas pipefish are caught in larger numbers in shore seine nets. This suggests the different ecological niches preferred by these species. Though sea horse catch is declining, pipefish catch has not yet declined much when compared to sea horses. In the catch composition, sea shores and pipefish are found in the ratio of 1:8 in the Palk Bay region (Murugan *et al.* 2008).

Figure 10.7: Heaps of sea cucumbers harvested in trawl nets

Figure 10.8: Landing of coral as bycatch in crab nets

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Appendix

Species of finfishes caught in different traditional gears and status of their populations

S. No.	Name of species	Gear Used			Status
		Trap	Gill net	Shore seine	
1.	*Abudefduf vaigiensis*	Common	Common	-	No threat
2.	*Acanthurus leucosterNon*	Rare	Common	-	No threat
3.	*Acanthurus lineatus*	Rare	-	-	No threat
4.	*Acanthurus mata*	Rare	-	-	No threat
5.	*Acanthurus nigrofuscus*	Rare	-	-	No threat
6.	*Acanthurus triostegus*	Common	-	-	No threat
7.	*Amphiprion sebae*	-	-	Common	No threat
8.	*Apogon fasciatus*	-	-	Rare	No threat
9.	*Apogon fraenatus*	-	-	Rare	No threat
10.	*Apolemichthys xanthurus*	Common	-	-	No threat
11.	*Arothron immaculatus*	Common	-	Common	No threat
12.	*Arothron stellatus*	Common	-	Common	No threat
13.	*Balistapus undulatus*	-	-	Rare	No threat
14.	*Canthigaster solandri*	Common	-	-	No threat
15.	*Centropyge multispinis*	Common	-	-	No threat
16.	*Cephalopholis formosa*	Rare	-	Rare	No threat
17.	*Chaetodon auriga*	Common	-	Common	No threat
18.	*Chaetodon collare*	Common	-	Common	No threat
19.	*Chaetodon falcula*	Rare	Rare	Rare	No threat
20.	*Chaetodon gardineri*	Rare	-	-	No threat
21.	*Chaetodon lineolatus*	Rare	Rare	-	No threat
22.	*Chaetodon melanNotus*	Rare	Rare	-	No threat
23.	*Chaetodon octofasciatus*	Common	-	Common	No threat
24.	*Chaetodon plebeius*	Rare	-	-	No threat
25.	*Chaetodon trifasciatus*	Rare	Rare	-	No threat
26.	*Chaetodon vagabundus*	Common	-	Common	No threat
27.	*Chaetodon xanthocephalus*	Rare	-	-	No threat
28.	*Cheilinus chlorurus*	Common	-	-	No threat
29.	*Cheilinus undulatus*	Rare	-	-	Not known
30.	*Cheilnus trilobatus*	Common	-	Common	No threat
31.	*Chilomycterus orbicularis*	-	-	Common	Not known
32.	*Chiloscyllium griseum*	-	-	-	Not known
33.	*Chlorurus oedema*	Common	-	-	Not known
34.	*Chromis spp.*	Rare	-	-	Not known
35.	*Coris dorsomacula*	Common	-	-	No threat
36.	*Dascyllus melanurus*	Rare	-	-	No threat

37.	*Dascyllus reticulatus*	Common	-	-	No threat
38.	*Dascyllus trimaculatus*	Common	Common	Rare	No threat
39.	*Diodon holocanthus*	-	-	Common	No threat
40.	*Diodon hystrix*	-	-	Common	No threat
41.	*Diploprion bifasciatum*	Rare	-	-	Not known
42.	*Epinephelus coioides*	Common	-	-	Not known
43.	*Epinephelus fuscoguttatus*	Common	-	-	Not known
44.	*Epinephelus longispinis*	Common	-	-	Not known
45.	*Epinephelus malabaricus*	Common	-	-	Not known
46.	*Epinephelus bleekeri*	-	Common	-	Not known
47.	*Gomphosus caeruleus*	Rare	Rare	-	Not known
48.	*GymNothorax favagineus*	Common	-	-	Not known
49.	*GymNothorax flavimarginatus*	Common	-	-	Not known
50.	*GymNothorax meleagris*	Rare	-	-	Not known
51.	*Halicampus grayi*	-	-	Rare	Endangered
52.	*Halichoeres marginatus*	Rare	Rare	-	Not known
53.	*Halichoeres nigrescens*	Common	-	-	No threat
54.	*Halichores hortulanus*	Common	-	-	No threat
55.	*Heniochus acuminatus*	Common	Common	-	No threat
56.	*Heniochus pleurotaenia*	Rare	Rare	-	No threat
57.	*Hippichthys cyaNospilos*	-	-	Rare	Endangered
58.	*Hippocampus fuscus*	-	-	Rare	Endangered
59.	*Hippocampus kuda*	-	-	Common	Endangered
60.	*Hippocampus spiNosissimus*	-	-	Rare	Endangered
61.	*Hippocampus trimaculatus*	-	-	Common	Endangered
62.	*Labroides dimidiatus*	Rare	Rare	-	Not known
63.	*Lactoria cornuta*	Common	-	Common	Not known
64.	*Lagocephalus lunaris*	-	-	Common	No threat
65.	*Lalmohania velutina*	-	-	Common	No threat
66.	*Lutjanus bengalensis*	Common	Common	-	No threat
67.	*Lutjanus decussatus*	Common	Common	-	Not known
68.	*Lutjanus ophuysenii*	Rare	-	-	Not known
69.	*Lutjanus quinquelineatus*	Rare	-	-	Not known
70.	*Myripristis botche*	Common	-	-	Not known
71.	*Myripristis kuntee*	Rare	-	-	Not known
72.	*Neopomacentrus nemurus*	Rare	-	-	Not known
73.	*Paramonacanthus nipponensis*	-	-	Rare	No threat
74.	*Parupeneus bifasciatus*	Rare	-	-	No threat
75.	*Parupeneus indicus*	-	Common	Common	No threat
76.	*Plectorhinchus orientalis*	Rare	Rare	-	Not known
77.	*Pomacanthus annularis*	Common	Rare	-	Not known

78.	*Pomacanthus imperator*	Common	Common	-	No threat
79.	*Pomacanthus semicirculatus*	Common	Common	-	No threat
80.	*Pomacentrus caeruleus*	Rare	Common	-	No threat
81.	*Pteragogus flagellifer*	Common	-	-	No threat
82.	*Pterois ruselii*	Common	Common	-	No threat
83.	*Pterois volitan*	Common	Common	-	No threat
84.	*Sargocentron rubrum*	Common	-	-	No threat
85.	*Scarus ghobban*	Common	-	-	No threat
86.	*Scarus quoyi*	Common	-	-	Not known
87.	*Scarus rivulatus*	Common	-	-	Not known
88.	*Scarus rubroviolaceus*	Common	-	-	Not known
89.	*Siganus lineatus*	Common	-	-	Not known
90.	*Stethojulis interrupta*	Common	-	-	Not known
91.	*Syngnathoides biaculeateus*	-	-	Common	Endangered
92.	*Takifugu oblongus*	-	-	Rare	No threat
93.	*Tetrosomus gibbosus*	-	-	Common	No threat
94.	*Thalassoma hardwicki*	Common	-	-	No threat
95.	*Thalassoma lunare*	Common	-	-	No threat
96.	*Xiphocheilus typus*	Rare	-	-	No threat
97.	*Xyrichtys bimaculatus*	Rare	-	-	No threat
98.	*Xyrichtys cyanifrons*	Rare	-	-	No threat
99.	*Zanclus cornatus*	Common	Common	-	No threat
100.	*Zebrasoma veliferum*	Rare	Rare	-	No threat

Our Post-Tsunami Environment Initiative publications:

- Beyond the Tsunami: Social, Ecological and Policy Analyses of Coastal and Marine Systems on the Mainland Coast of India
- Trends and Patterns in Hydrology and Water Quality in Coastal Ecosystems and Upstream Catchments in Tamil Nadu, India
- Macro and Mega Faunal Communities of Intertidal Ecosystems on the Tamil Nadu Coast, India
- Status of Fisheries in Tamil Nadu, India: A Snapshot of Present and Long-term Trends
- Environmental Law Guide - An Analytical Guide for Deciphering Content of Laws in India
- Community Perceptions of Resources, Policy and Development, Post-Tsunami Interventions and Community Institutions in Tamil Nadu, India
- Current Status of Mangroves in Kerala and Tamil Nadu, India, with regard to Vegetation, Community Perceptions and Policy
- Coastal Sand Dunes of Tamil Nadu, India - An Overview
- A Protocol for Ecological Monitoring of Sandy Beaches and Intertidal Fauna on the Indian Coast
- Sand in my Hands! An Activity Book on Sandy Beaches and Sand Dunes for Children
- Policy Brief: Bioshields
- Policy Brief: Sand Dunes
- Policy Brief: Sea Walls

United Nations Team for Tsunami Recovery Support

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The Coastal and Marine Programme at ATREE is interdisciplinary in its approach and applies skills in the natural and social sciences to its research and conservation interventions.