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GLIMPSES OF AQUATIC BIODIVERSITY

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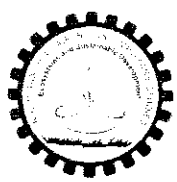

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SUSTAINABLE EXPLOITATION AND CONSERVATION OF LOBSTER RESOURCES IN INDIA - A PARTICIPATORY APPROACH

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Lobsters are one of the most valuable and highly priced crustaceans and an important export commodity of India. Though widely distributed along the entire coast, major fishery is located on the northwest, the southwest and the southeast coasts. Although nine species of spiny lobsters (Palinuridae) have been reported from the Indian coast (Radhakrishnan, 1995), only three littoral and one deep sea form are commercially important. Among the six species reported from the northwest region (Chhapgar and Deshmukh, 1971), two species, the palinurid spiny lobster *Panulirus polyphagus* (Herbst) and the scyllarid *Thenus orientalis* (Lund) predominated the fishery. On the southwest, *P. homarus* (Linnaeus) and the deep sea lobster *Puerulus sewelli* (Ramadan) contributed to the commercially fishery, though *P. versicolor* and *P. ornatus* (Fabricius) are also landed in stray numbers. *P. homarus, P. ornatus* and *T. orientalis* are the major species exploited along the southeast coast. Though occurrence of *Linuparus somniosus* has been reported from the Andaman and Nicobar Islands, this species has never been commercially exploited. All other species such as *P. longipes* and *P. penicillatus* are of non-commercial importance. Incidentally, *Palinustus waguensis* reported by George (1965) as *P. mossambicus* has been appearing again in the fishery along the Chennai coast from 2004 onwards.

Colachel and Muttom in Kanyakumari district on the southwest coast (SW) were the major gill net and trap landing centers on the southwest during fifties and sixties. As lobsters gained importance as a high value seafood in the export market, exploitation of lobsters began in almost the entire SW region. On the southeast (SE), lobsters are caught in almost all the fishing villages from Kanyakumari up to Mandapam, the northernmost border of the Gulf of Mannar. Major lobster landing centers by trawlers in the Gulf of Mannar region are Tuticorin and Pamban and at Kayalpatnam and Tharavaikulam near Tuticorin. Gill nets and trammel nets are the major gear for lobster fishing. Further north, the major trawl landing center for spiny slipper lobsters is Chennai. Lobsters are also landed by gill nets and trammel nets in a few villages, south and north of Chennai. *P. homarus* and *P.ornatus* are the two major species caught both by the trawlers and the gillnets. At Mumbai and Veraval on the NW, lobsters are incidentally caught in the trawl nets operated for shrimp and fish (Radhakrishnan and Manisseri, 2003). As a result of non-enforcement of regulatory measures for the fishery in the State of Maharashtra, the *T.orientalis* fishery in Mumbai collapsed in 1994 (Deshmukh, 2001) and there are no signs of its recovery until 2003. Almost similar situation is prevailing on the south where decline in lobster landing has created serious apprehensions of stock depletion and failure of the fishery. This concern is genuine calling for urgent measures for the proper management and conservation of the resource. The problem is of a complex nature on account of the multi-species fishery spread over the long coastline, and exploited by divergent gears involving both artisanal and mechanized sector.

Though the Ministry of Commerce and Industry, Government of India promulgated the Minimum Legal Size (MLS) law in July 2003 prohibiting export of lobsters below MLS (Table 1), the maritime State Governments are yet to frame regulatory measures on fishing. Further, it is increasingly

Table 1: *Minimum Legal Size for export of lobsters from India* *

Species	Live /Chilled / frozen	Whole cooked	Tail
Panulirus polyphagus	300 g	250 g	90 g
P. homarus	200 g	170 g	50 g
P. ornatus	500 g	425 g	150 g
Thenus orientalis	150 g	-	45 g

Notification No. 16 (RE 2003)/2002-07 dated 17 July, 2003, Ministry of Commerce and Industry, Government of India

understood that Government regulations alone may not help in managing a fishery exploited and marketed by various stakeholders along the Indian coast. A programme on education and creation of awareness among the fishermen on the adverse impact of large scale exploitation of egg bearing lobsters and juveniles on the resource, by participating the fishermen community in resource management, was initiated in 2002. The present work is an attempt to review the status of lobster fishery in India in general and the spiny and sand lobster fishery that existed off Mumbai till 1993 in particular. An assessment of the exploited stock of spiny lobster has also been carried out, which would enable to chart a management plan for future exploitation of lobsters on a sustainable basis.

Annual Lobster Landings in India

The estimated annual lobster landings increased from 800 t in 1968 to 3,000 t in 1975 and attained a peak of 4075 t in 1985. Thereafter the fishery showed a trend of decline averaging around 2200 t for nearly 15 years. The landings further declined to 1371 t in 2004 (Fig.1). The NW region contributed to 70%, the SE 16% and the SW 14% of the total landings.

Fishery Along the Southeast Coast

The southeast coast region with prominent lobster fishing encompasses Kanyakumari in the south to Chennai on the north. At Tuticorin, trawlers landed about 41% of the total catches, the rest being landed by gill net and trammel net. In the trawl fishery, lobster catch increased from 37 t in 1993-94 to 51 t in 1994-95 and then reduced to 20 t in 1995-96(Rajamani and Manickaraja, 1997 a; b). Thereafter total landings showed a declining trend and in 2001 the landing was merely 3.8 t. In the gill net fishery at Kayalpatnam, lobster catch increased from 42.2 t with a catch rate of 6.5 Kg/ unit in 1993 to the peak catch of 50.6 t with a catch rate of 5.5 Kg/unit in 1994. However, the fishery declined to 4.4 t with a catch rate of 1.1 Kg/unit in 2002. The two species constituting the fishery were *P. homarus* and *P. ornatus*. At Tharuvaikulam, another gill net landing center, landings decreased gradually from the peak 11.0 t with a CPUE of 1.1 kg/unit in 1993 to 1.1 t with a CPUE of 0.6 kg/ unit in 2002. Though lobsters were landed throughout the year, peak months of fishing at Tuticorin were between October to December and April to May, when 64% of the annual catch is landed. At Kayalpatnam, a change in the relative abundance of *P. ornatus* and *P. homarus* was observed. During 1978-89, *P. homarus* formed 72.3% of the total catch whereas between 1993 and 2002, *P. ornatus* was observed to be the dominant species (60.6%), showing a decline in the availability of *P. homarus* in the gill net fishery. The modal length of *P. homarus* occurring in the fishery was observed to reduce from 245 mm in TL in males during 1978 to 145 mm TL in 2002. In the case of females, also the modal length was reduced from 195 mm TL to 165 mm TL during this period.

However, the modal length of both males and females of *P. ornatus* showed an increase from 175mm TL to 195 mm TL. At Tharuvaikulam, modal length of *P. homarus* increased from 145 to 185 mm TL between 1993 and 2002. During the entire period of study, ovigerous females of *P. ornatus* were never encountered in the inshore gill net fishery. However, adult sizes and spawning females of *P. ornatus* were landed at Nagapattinam by gill nets operated in deeper waters.

At Chennai, lobsters were landed both by trawl nets and gill nets. The average annual catch during 1978-84, was 10.9 t. *T. orientalis* was the major species in trawl catch (Kagwade *et al.*, 1991). Catch and catch rate increased from 59.6 t and 0.14 kg/hr in 1993 to 114.6 t and 0.23 kg/hr in 1994. The catch showed a trend of decline thereafter landing only 8.1 t with a catch rate of 0.01 kg/hr in 1999. In 2002 the catch improved to 33 t but with a poor catch rate of 0.05 kg/hr. Main fishery season generally extended over September to February with maximum catches in October. The mean size of the population landed was 156.9 mm TL for females and 153.6 mm for males. The females attained maturity at 105.5 mm TL (Subramanian, 2004). Maximum spawning activity was observed during January - March and June - July with peak recruitment around October and January. Gill nets landed 3.5 t of lobsters on an average annually comprising 68% *P. homarus*, 18% *P. ornatus*, and 13% *P. versicolor*,. The catch compositions of gill nets and trammel nets operated at Kovalam landing center was examined during 1986-88. The size of *P. homarus* in the trammel net ranged from 23 mm to 100 mm CL with nearly 35% in the range of 23-50 mm CL. On the other hand, length range of lobsters in gill net varied from 38 mm to 100 mm CL with the majority in the size range of 55-80 mm CL (Fig.2). The dominant size class of lobsters in the gill nets decreased from 76-80mm CL in 1979-80 to 61-65 mm CL in 1986-88.

Southwest Coast Fishery

On the southwest, spiny lobster fishery began at subsistence level initially and was gradually transformed into a commercially important fishery, as the importance of lobsters as an export commodity was recognized. Colachel and Muttom were the two important landing centers where traditional traps made of palmyrah frond were used for fishing. Fishermen used to dive and place the traps with baits near the mouth of large crevices in the evening hours and lift the traps next day morning. Later gill nets and trammel nets were introduced and now traps are used only at very few centers. Annual landings gradually decreased from a peak of 301 t in 1966 to 7.6 t in 1996 and were further reduced to 4 t in 2002. About 92% of the catches were constituted by *P. homarus; P. ornatus* and *P. versicolor* constituted the remaining. The fishery was seasonal extending from October to April with maximum landing during November - January. Coincidence of fishing and peak breeding season results in capture of majority of females in egg bearing stage. Nearly, 60% of the females caught during this period were found to be egg bearing. The sizes of *P. homarus* in the catch ranged from 91-280 mm TL and the modal lengths were 121-130 mm TL and 141-160 mm TL.

Deep Sea Lobster Fishery

Major fishing grounds for the deep sea lobster *Puerulus sewelli* are located off Quilon on the southwest coast and off Tuticorin on the southeast coast, at depths ranging from 150 m to 400 m with maximum abundance between 150 m to 250 m. The commercial importance of the resource was recognized in 1959 and subsequent exploratory surveys between 1967 and 1970 revealed existence of potential grounds in these areas (John and Kurian, 1959). The survey during 1969 reported to yield catch rates varying from 15-330 kg/hr on the southwest coast and 200-300 kg/hr on the southeast coast. *P. sewelli* is the only commercially important species found in these grounds. However, in the Andaman and Nicobar islands, the occurrence of another deep sea lobster *Linuparus sominosus* along with *P. sewelli* was reported. The average annual landing of *P. sewelli* at Cochin and Sakthikulangara was 524 t during 1998-2000 (Radhakrishnan and Manisseri, 2003).

The fishing season lasted from October to March. More than 65% of the females were ovigerous. The sizes of *P. sewelli* in the catch ranged from 81-205 mm in total length. A fishery for *T. orientalis*, though of small magnitude (8 t) was reported for the first time from this fishing area.

Northwest Coast Fishery

At Veraval, the estimated annual catch decreased from 315 t during 1987 to 102 t in 2000 and then sharply declined to 22 t in 2002. The spiny lobster *P. polyphagus* and the sand lobster *T. orientalis* constituted the fishery. During 1987-88 189 t of *P. polyphagus* were landed at Veraval. However, the total landing decreased to 3.9 t during 2002. Adults and spawners mainly comprised the trawl catches, while the gill nets and other traditional gears brought more of juveniles. Gill nets were operated on the shallow reefs, which were inhabited by juveniles and subadults. Peak landing of *P. polyphagus* by trawl nets and the breeding season coincided with the onset of winter in the postmonsoon months of October to December. Maximum landing by gill nets was from September to October. The average annual catch of *T. orientalis* at Veraval also showed a trend of decline. *T. orientalis* is exploited mostly by multi-day fishing vessels fishing in deeper waters.

Year-wise landing of lobsters at Mumbai during 1978-2004 is shown in Fig. 3. The estimated annual average catch during 1978-85 was 402 t at a catch rate of 9.46 Kg/unit. The total annual landings increased from 200 t in 1978 to the peak catch of 700 t in 1986 and thereafter decreased to 75 t in 2002. *P. polyphagus* and *T. orientalis* constituted the fishery, the latter forming 46% during 1978-85 (Kagwade *et al.*, 1991). Commercial landing of the species commenced in 1978 with a catch of 1.5 t, which attained a maximum of 374. 7 t in 1982. Subsequently the catch fluctuated around 250 t for three years and reached another peak (334 t) in 1986. But, thereafter the catch declined rapidly landing only 2.2 t in 1994. Subsequently the fishery collapsed totally with the occurrence of only stray numbers (Deshmukh, 2001).

Though the species occurred in all the months, maximum abundance was during October to March when 62% of the annual catch was landed. Unlike most of the tropical species sand lobster exhibited a single well defined breeding period from October to January with the spawning females forming 60.1% of the total females landed in the catch. Size at 50% of the maturity has been estimated as 107 mm TL and the smallest berried lobster measured was 124 mm TL. The fecundity of a 240 mm TL female was estimated to range from 20,050 to 53,260 (Kagwade and Kabli, 1996 a).

The spiny lobster *P. polyphagus*, also showed a gradual decline in landings. The annual average landing during 1978-85 was 217.5 t at a catch rate of 5.11 kg/unit. The catch declined from 390 t in 1985 to 94 t in 2002 (Fig.3). The average catch per boat trip during 1998-2002 was 2.5 kg (or 0,05 kg per hour of trawling), which did not show any relation with the fishing effort. Month-wise percentage of catch during the five year period show that the abundance of rock lobster was maximum in September and minimum in July. The CPUE of lobsters was also maximum in September (6.18 kg/trip) and minimum in July (1.45 kg/trip). The size of both males and females ranged from 75-385 mm (TL) with the size between 160 mm and 230 mm forming the mainstay of the fishery. The sex ratio showed dominance of females in all the years (1:1:16). The ovigerous females occur throughout the year (23.8%) with the peak occurrence (56.1%) in September. Recruitment of juveniles ranging from 70 mm to 120 mm in TL was generally observed during December-February in shallow nearshore waters.

From the length composition of the two sexes the total mortality coefficient (Z), natural mortality coefficient (M), exploitation rate (U) and the E_{max} were estimated. The Z for the entire five year period for the males was 1.9, which varied from 1.57 in 2001 to 2.57 in 1998 while the same for

the females was 1.63, which varied from 1.57 in 1998 to 2.01 in 2000. With the mean seawater temperature at 28°C the natural mortality coefficients (M) for the males and females were 0.53 and 0.60, respectively (Radhakrishnan *et al.*, 2005).

Overview of the Fishery

Though commercial fishing began in early 1950s, reliable landing data was available only since 1968. The fishery experienced a rapid growth in a span of ten years and the landing touched 3000 t in 1975 as a consequence of intensive exploitation of lobsters. Though suffered a set back for nearly five years, the fishery attained the peak landing of 4075 t in 1985, showing a cyclical pattern in the overall landings. The sharp fall in landings in 2001 and in 2002 is an indication of the growing instability of most of the lobster stocks on both the east and west coast of India. In Kanyakumari district, on the southwest coast of India, fishery for *P. homarus* flourished between 1964 and 1973, during which the average landing was 130 t. Increased effort, introduction of gill net and trammel net for fishing and exploitation of egg bearing lobsters during peak breeding season have been the major factors responsible for reduced catches. Though not a big volume considering the long Indian coast, lobster is an important crustacean resource exploited from Indian seas. On the northwest, lobsters are incidentally caught in trawl nets except for a small quantity landed by gill nets at Veraval in Gujarat. In Mumbai, the slipper lobster *T. orientalis* disappeared from the fishery in just 17 years (Deshmukh, 2000). The high exploitation ratio of 0.83 compared to an E_{max} of 0.55 clearly indicates that the species was grossly overexploited. Such heavy reduction in biomass of the species, certainly could not sustain the stock for long, resulting in total collapse of the fishery. In 1980-86, the species occurred in all the months but the maximum abundance was during October-March when 62% of the annual catch was landed (Deshmukh, 2000). Unlike most of the tropical species slipper lobster showed a single well defined breeding period from October-January. The sex ratio was disproportionate with females outnumbering males, particularly during breeding period. It is also a slow growing species and with relatively low fecundity (Kabli and Kagwade, 1996a). Exploitation of the low fecundity spawning females which formed 60.1% of the total catch might have been detrimental to the recruitment process resulting in rapid decline of the fishery and annihilation of the stock in waters off Mumbai. This is a classic case of recruitment overfishing, which is not precluded by the growth overfishing.

George (1965) suggested minimum legal size of 130 or 140 mm total length for *P. homarus* exploited from the southwest coast even when the fishery was in the growing phase. *P. homarus* is an inshore species with restricted movement (Mohamed and George, 1968) and therefore is highly vulnerable to fishing. Furthermore, peak breeding has been observed to coincide with active fishing and consequently more than 60% of the females caught were ovigerous. Introduction of trammel net brings in large quantities of juveniles and sub-adults, which are supposed to sustain the fishery. Apart from the information available on stock during early 1970s (George, 1971), there is no information on the current biomass and exploitation rate of *P. homarus* occurring along the southwest coast of India. However, based on the current landing data and biological information on mean size of *P. homarus* available in the fishery, it could be deduced that the fishery has been overexploited. Similar situation is prevailing in the gill net fishery at Tuticorin. Reduction in modal length and declining catch of *P. homarus* at Kayalpatnam are indicative of growth overfishing and require immediate remedial measures to protect the juveniles and the breeding females. The *P. ornatus* exploited by gill nets from inshore fishing grounds consists of juveniles and subadults and adults are occasionally caught incidentally in trawl nets. Kagwade *et al.* (1991) expressed surprise of not seeing a single berried specimen of *P. ornatus* either in the gill net or in trawls. Obviously *P. ornatus* breeds in deeper waters and may be migrating to a breeding ground nearer to the northern Sri

Lankan coast through the Palk Strait. Nagapattinam fishermen venturing into lobster fishing in deep waters have been reported to land adult *P. ornatus* and breeding females.

Management

Unlike many lobster fishing countries, trawl fishery for the spiny lobster does not constitute an exclusively targeted fishery. It forms only 0.14% of the total fish landed by the trawlers in Mumbai. Therefore, optimizing the trawling effort for spiny lobster alone is not a practical solution. Observing closed season during peak breeding months (August-September) for the trawler is also not possible as fishing by mechanised boats in the Maharashtra State is banned during monsoon (10th June to 15th August). Therefore, the only management option left is to return the egg bearing females back to the sea, atleast during August-September so that the spawning stock is protected. Heavy recruitment of the juvenile lobsters (40-160 g) takes place in Deember-February and these undersized lobsters do not fetch remunerative price to the fishermen, and therefore they can also be returned to the sea. Recently, there are report of gillnet fishing of mounser lobster at few fishing villages along south Maharashtra coast. These options are possible only if maritime State Government implements fishing regulations so that lobsters above the size at maturity (205 mm in total length or 220 g size) alone is permitted to be caught. Releasing back the egg bearing females back to the sea is to be made mandatory and holding and trading of egg bearing lobsters are to be declared illegal. *P. polyphagus* will be alive after it is brought on board by the trawl net. Therefore, releasing back the undersized and berried lobsters immediately after capture will not affect the eggs and the lobster. This will protect not only the new recruits but the spawning stock as well ensuring future recruitment process.

At Veraval, the drastic decline in lobster fishery from 271 t in 1999 to 22 t in 2002 (81.2 % decline) is of serious concern. Intensive exploitation of juveniles of *P. polyphgus* from the inshore reef area by gill nets is to be banned if the lobster fishery is to sustain. Legal ban on fishing of juveniles by the gear is to be enforced by the State Government. As there is no stock of the sand lobster left in the sea off Mumbai, total conservation of the remaining residual population by returning it to the sea and legal ban on landing of the species are the only options until the stock is revived. Searanching of hatchery produced seeds to augment the resource may not be feasible from the economical point of view.

On the southwest coast, closure of fishery during the peak breeding months of November will protect the spawning stock temporarily and this may allow the actively breeding population to release the larvae. There is no data on the level of spawning stock required to sustain the fishery. Ban on operation of trammel net on the entire southwest and southeast coast will prevent exploitation of the recruiting juveniles and subadults, which constitute nearly 35% of the trammel net catch. At Tuticorin, the gill net fishery of *P. ornatus* juveniles may be detrimental to the stock though the extent of negative impact was not assessed. However, the declining catches and catch rate in the gill nets and trawl nets between 1993 and 2002 is an indication of the unstable nature of the stock. *P. homarus*, being a shallow water species having limited movement, is highly vulnerable to fishing. The spawning females and the juveniles are equally vulnerable as they occupy almost nearby habitats.

Spiny lobster fishery is an open access low volume fishery limited to specific areas and any restrictions imposed on fishing will be desisted by the fishermen. Apart from legal implementation of fishing regulations, education and creation of awareness among the various stakeholders on negative impact of fishing and marketing of egg bearing lobsters and juveniles may bring a subtle change in their mindset. Establishment of Marine Protected Areas (MPAs), artificial habitats, lobster sanctuaries / reserves in identified locations can also help in rejuvenation of the lobster populations.

A participatory management project initiated by CMFRI and funded by MPEDA is making slow progress in changing the mindset of fishermen and traders and may inculcate the sense of responsible fishing and trade. Village level meeting, distribution of educative posters, stickers and pamphlets, video film shows, 'V' notching and releasing of egg bearing lobsters involving the fishermen and distribution of lobster traps to wean the fishermen away from using the destructive fishing methods are some of the activities implemented under the programme. Enforcement of minimum legal size for export is a positive step from the Ministry of Commerce and Industry, Government of India. However, implementation of a minimum legal size for fishing, closure of fishery during peak spawning in the southern rock lobster fishery and ban on trammel nets are regulatory measures recommended for management of this vulnerable fishery. Lobster fishing being a socio-economic activity involving the local fishermen, any regulatory measure shall consider the socioeconomic view point so that the fishermen are not adversely affected.

Recommendations for sustainable exploitation and management of lobster resource:

- Strict enforcement of Minimum Legal Size (MLS) for fishing by the State Governments.
- Ban on operation of destructive fishing gear (Trammel nets) and fishing by divers. Traps with escape gaps to be promoted.
- Partial closure of the fishery during peak breeding season or ban on fishing of egg bearing lobsters.
- Establishment of Marine Reserves or Lobster Sanctuaries to maintain and protect breeding stock.
- Establishment of Artificial habitats to provide additional substrate for young lobsters (increase food production and protection from predators)
- Creation of awareness among the lobster fishermen on good fishing practices and sustainable exploitation.
- Allot research funding for development of breeding and hatchery technology for spiny and slipper lobster and sea ranching for stock enhancement.

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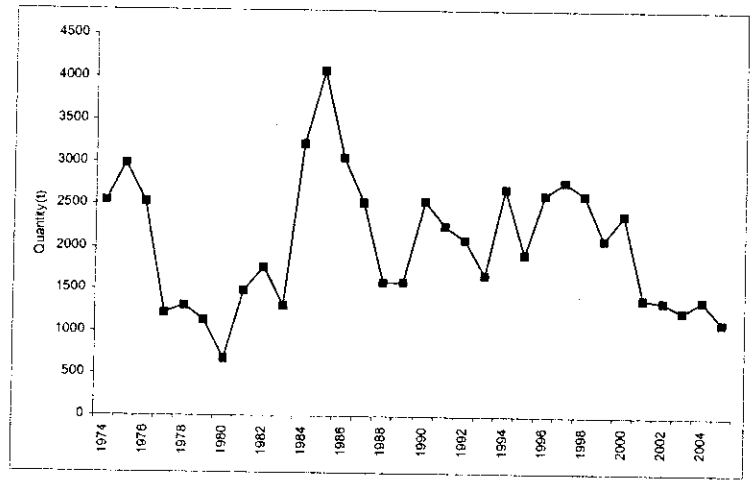

Fig.1: *Total annual landing of lobsters in India*

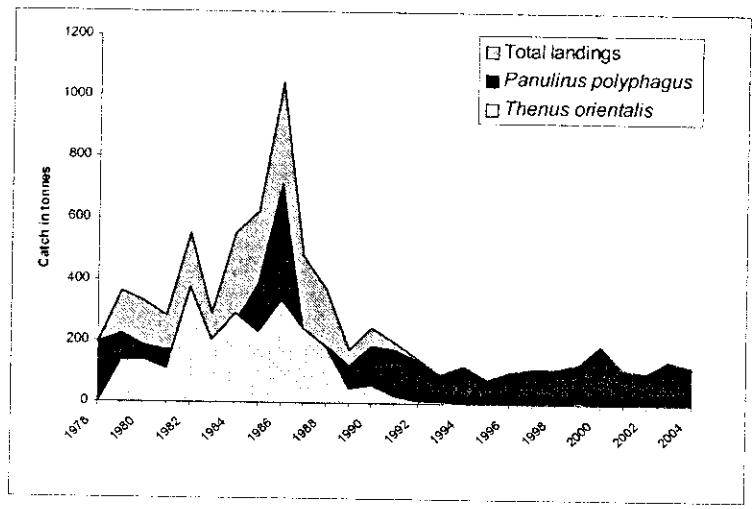

Fig. 2: *Species-wise and total landing of lobsters in Mumbai*

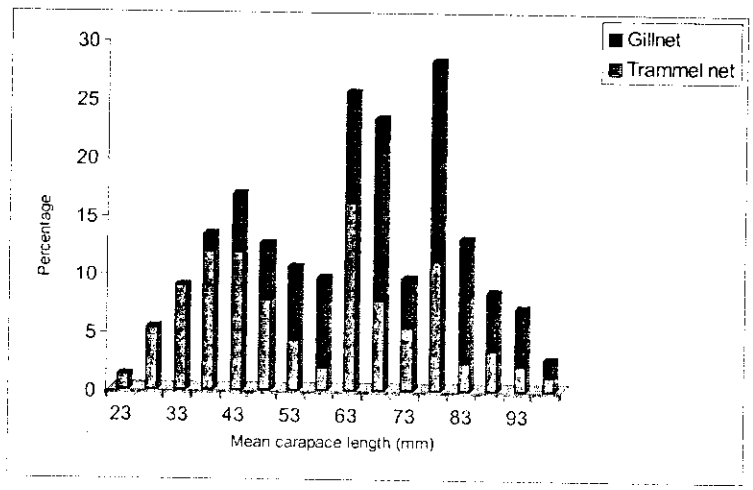

Fig. 3: *Length composition of lobsters in gillnet and trammel net at Kovalam, Chennai.*