

LARGE MARINE ECOSYSTEMS :

EXPLORATION AND EXPLOITATION
FOR SUSTAINABLE DEVELOPMENT
AND CONSERVATION ON FISH STOCKS

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THE STATUS OF LOBSTER FISHERY IN INDIA AND OPTIONS FOR SUSTAINABLE MANAGEMENT

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ABSTRACT

Lobsters form one of the most valuable crustacean resources, which have been exploited commercially for the past four decades. Annual landings increased from 350 t in 1965 to 4100 t in 1985 but have declined since then. Though lobsters are distributed along the entire coast of India, major fishery grounds are located on the north-western, south-western and south-eastern coasts. Among the twelve species recorded from Indian waters, four species of spiny lobsters (three littoral and one deep-sea) and one species of slipper lobster constitute the commercial fishery. The north-western coast which contributed more than two-thirds of total landings, comprises two species, *Panulirus polyphagus* and *Thenus orientalis*. *Panulirus homarus*, *P. ornatus*, *Puerulus sewelli* and *T. orientalis* are the major species landed in the southern part of the coast.

Lobsters are caught as bycatch in trawl nets in the north-west, whereas bottom-set gill-nets and trammel nets are widely employed for lobster fishing in the southern part. Heavy demand for live and whole cooked lobsters in the export market has triggered regular and organized fishing of all sizes of lobsters, resulting in overexploitation of the resource. Examination of the catch data from 1986-87 to 1995-96 show substantial reduction in annual landings and CPUE of all species of lobsters. The slipper lobster, *T. orientalis*, which formed 45% of the trawl landings of lobsters in Mumbai during 1985-86 disappeared from the fishery in 1994-95. *P. polyphagus* fishery also shows almost a similar trend. In Chennai, sampling of *P. homarus* in trammel nets showed high proportion of individuals below the size at first breeding (60 mm carapace length) than that of the gill nets.

Major problems in resource management of the multi-species lobster fishery in India are discussed. However, regulatory measures need to be strictly enforced to conserve this resource until estimates of maximum sustainable yield and optimum fishing effort can be determined.

Introduction

Lobsters are one of the most valuable crustacean resources of India. The foreign exchange earnings from export of lobsters has exceeded Rs.50 crores and the demand is ever increasing. Total annual landings increased from 365 tonnes in 1965 to 3000 tonnes in 1975, but has sharply declined to 680 t in 1980. The fishery recovered to 4100 t in 1985 and has been fluctuating between 1587 and 2887 tonnes (Fig.1) for the past ten years (1987-1997). Heavy demand and

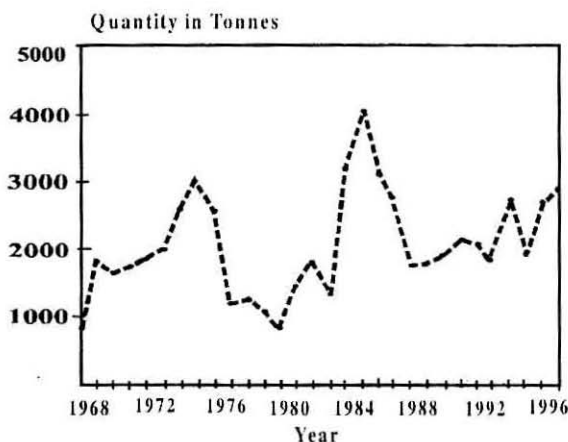


Fig.1 Total annual lobster landings from 1968 to 1998

attractive price for live and whole cooked lobsters in the international market has resulted in increased exploitation of lobsters. In the absence of enforcement of any regulation either on the fishing effort or on the fishing gears, lobsters of all sizes are exploited and exported. Unless new grounds are located, there is limited scope for improvements in the fishery in the coming years. The multi-species nature of the fishery and multi-gear exploitation of the resources in different maritime states poses multitude of problems for management of this resource. An assessment of the current status of lobster fishery in India and various options for sustainable utilisation of the resource is presented in this paper.

Distribution and species composition

Lobsters are widely distributed along the Indian coast. However, major landings come from the north-west (NW), the south west (SW) and the south east (SE). Sector-wise, the NW constituting Gujarat and Maharashtra contributes to an average 76% of the total lobster landings, whereas landings from the SW and SE were, 11% and 13%, respectively. In 1997, while Gujarat contributed 48.7% to the total all India landings, lobster catch from Maharashtra declined from

42.6% in 1996 to 28.3% in 1997. Landings from Tamilnadu and Kerala were 13% and 9.2%, respectively (Table 1). This was followed by Karnataka and

Table 1 : All India and State-wise landing of lobsters from 1988 to 1997

Year	Total Catch	Gujarat	Maharashtra	Tamilnadu	Kerala
1988	1587	837 (52.7)	477 (30.0)	132 (8.3)	112 (7.0)
1989	1590	947 (59.6)	386 (24.3)	164 (10.3)	74 (4.7)
1990	1834	539 (29.4)	787 (42.9)	365 (19.9)	123 (6.7)
1991	2254	923 (40.9)	735 (32.6)	365 (16.2)	195 (8.7)
1992	2095	921 (44.0)	453 (21.6)	502 (24.0)	206 (9.8)
1993	1671	959 (57.4)	237 (14.2)	411 (24.6)	40 (2.4)
1994	2746	1319 (48.0)	405 (14.7)	559 (20.4)	443 (16.1)
1995	1946	1249 (64.2)	288 (14.8)	294 (15.1)	97 (5.0)
1996	2660	1160 (43.6)	1130 (42.5)	253 (9.5)	115 (4.3)
1997	2887	1406 (48.7)	817 (28.3)	375 (13.0)	265 (9.2)

Figures in parentheses indicate percent of the total catch

Andhra Pradesh. Although there are eight species of spiny lobsters distributed along the Indian coast (Fig.2), only four are fished in commercial quantities



Fig. 2 Distribution of spiny lobster landings from 1968 to 1998

(three shallow and one deep) (Radhakrishnan, 1995). Among the slipper lobsters, fishery is constituted by only one species. On the NW, the spiny lobster *Panulirus polyphagus* and the slipper lobster *Thenus orientalis* are the two major species contributing to the fishery. On the SW, *P. homarus* is the dominant species and *P. ornatus* and *P. versicolor* are caught in small quantities. On the SE, *P. homarus* dominates the fishery along the Tirunelveli coast where as *P. ornatus* and *P. homarus* are the main constituents in the Gulf of Mannar and Nagapattinam coast. Along the northern part of Tamilnadu, *T. orientalis* and *P. homarus* form the lobster fishery. The deepsea lobster *Puerulus sewelli* is caught along the south-west and the south east coasts. A new resource of the deepsea lobster *Linuparus somniosus* has been located in the Andaman sea by Fishery Survey of India (Ali *et.al.*, 1991). Other deepsea lobsters recorded from south west coast are *Nephropsis stewarti* and *N. carpenteri*. Reasonable catches of *N. carpenteri* along with deep-sea shrimps have been noticed recently (Radhakrishnan, Personal communication).

Fishing craft and gear

In India, nearly 76% of the lobster catch comes from mechanized trawlers operating for shrimps and demersal fishes. On the NW, *P. polyphagus* and *T. orientalis* are incidentally caught in shrimp trawls. Large quantities of juveniles are caught in indigenous gears from inshore waters. On the SW, indigenous gears such as traps, gill nets, anchor hooks and trammel nets are used for lobster fishing. Traditional trap fishing is gradually being replaced by gill nets and trammel nets. On the SE, traditional fishermen use gill nets and trammel nets and fairly good quantities of lobsters are also landed by trawls at Tuticorin, Pamban and Madras.

Status of the fishery and lobster stocks

North-west coast :

Major mechanized lobster fishing centres on the NW coast are Mumbai and Veraval. Monitoring of the fishery resource characteristics and biology of major species are carried out in these two centres. Average annual catch of lobsters at Veraval during 1980-85 was 270 t with a CPUE of 3.02 kg/U (Kagwade *et.al.*,1991) and between 1987 and 1997, average catch declined to 200 t. In 1996-97, total lobster catch was 200 t with a CPUE of 0.23 kg/U, showing significant decline in the catch rate (Annual report, CMFRI, 1997). *P. polyphagus* constituted 45% of the total lobster catch and the remaining by *T.*

orientalis. Average annual catch of *P. polyphagus* declined from 189 t (1987-88) to 88 t (1996-97) (Fig.3). Similarly, annual average landings of *T. orientalis*

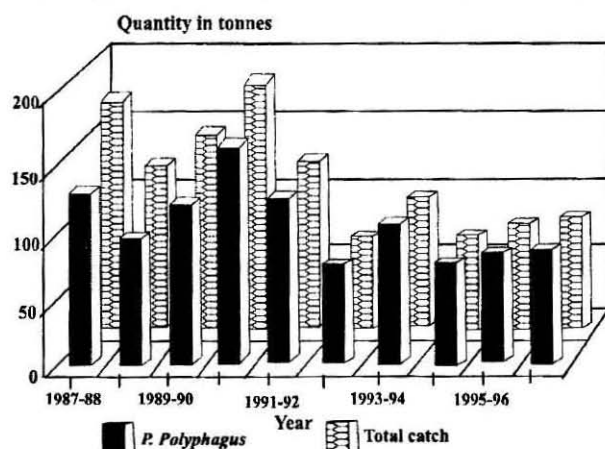


Fig. 3 Average annual catch of *P.polyphagus* during 1987-88 to 1996-97

were also declined from 126 t in 1987-88 to 112 t in 1996-97 (Fig.4).

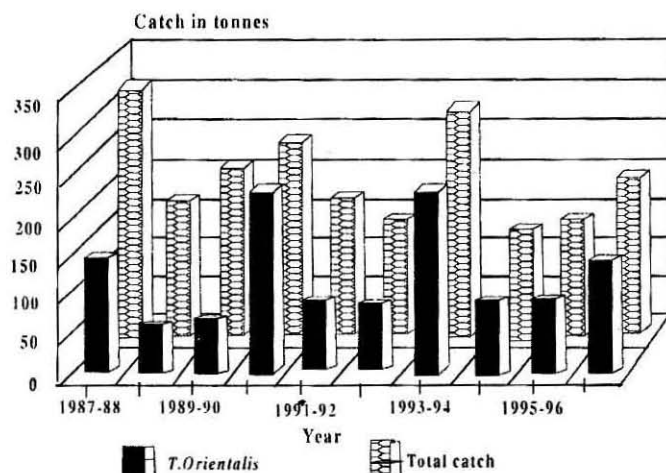


Fig.4 Annual average landings of *T.orientalis* during 1987-88 to 1996-97

Average annual catch of lobsters at Mumbai declined from 402 t in 1978-85 to 113 t in 1987-97. In 1996-97, total lobster catch was only 78 t with a catch rate of 0.05 kg/U. Species-wise, annual average catch of *P. polyphagus* slumped from 123 t during 1987-88 to 76 t during the ten year period between 1987 and 1997 (fig.5). Detailed investigations on the fishery and biology of *P. polyphagus*

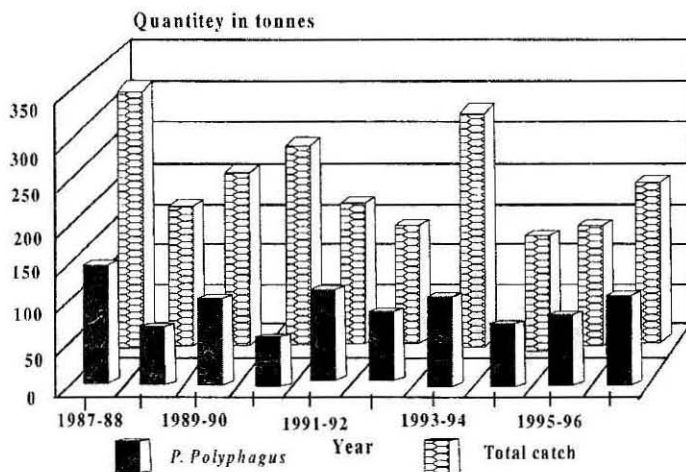


Fig.5 Species-wise average annual landings of *P.Polyphagus* during 1987-88 to 1996-97

have been carried out at Mumbai (Kagwade, 1988, 1995a and b). Females attain first sexual maturity at 175 mm total length (TL) (74.8 mm carapace length). But 50% of females attain maturity at 205 mm TL. Females measuring between 200 and 300 mm TL have been contributing maximum to the fishery *P.polyphagus* reproduces throughout the year but with definite peak spawning in January and September. An average 33.4% of the females caught were ovigerous females during 1976-85, which was reduced to 28.9% in 1986 and 15.3% in 1987 (Kagwade, 1994). High exploitation rates of females may result in low egg production and the consequent recruitment failure. The prolonged larval phase (4-6 months) and the nursery and juvenile phase in near shore habitats probably make them more vulnerable to predation and increasingly susceptible to inshore fishing activities. Intensive fishing of juveniles and sub-adults by indigenous gears and egg bearing lobsters from their breeding grounds during the peak breeding season are presumed to be major reasons for depletion of this resource in Mumbai waters. Adult *P. polyphagus* moves to deeper areas for breeding and are caught by commercial trawlers. Stock assessment studies have indicated high annual exploitation ratio for *P. polyphagus*. Combined average annual stock has been estimated to be low against the yield suggesting cautiousness in exploitation of this species from the trawling grounds off Mumbai (Kagwade, 1993, 1994).

The fishery for the slipper lobster *T. orientalis* was maximum affected at Mumbai. The average annual catch during 1978-85 was 184.9 t at the rate of 4.35 kg/U, forming 46% of the total catch. Sudden slump in catch was reported

in 1987-88, when the landings declined from 203 t in the previous year to 53 t. Decline in catches continued and by 1994-95 the species disappeared from the fishery and reappeared in small quantities in 1996-97 (Fig.6). Size at 50%

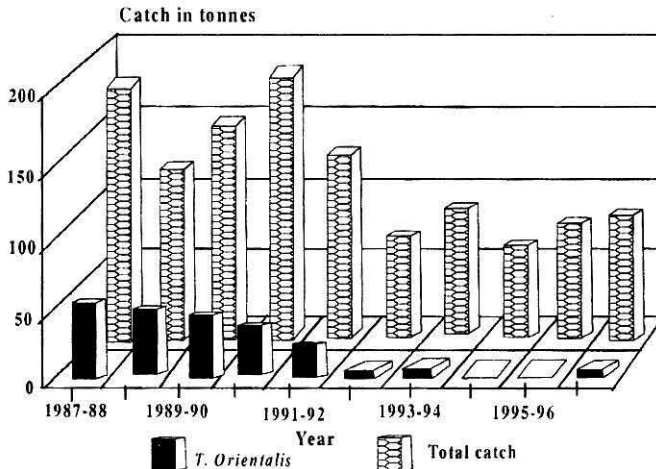


Fig.6 Species-wise average annual landings of *T.orientalis* during 1987-88 to 1996-97

maturity has been estimated at 107 mm TL and the smallest berried lobster was measured at 124 mm TL. Spawning period extends from September to April with high incidence of egg bearing and spend individuals from November to January. Egg bearing lobsters formed 25 to 57% of the total females caught (Kagwade and Kabli, 1996). Peak spawning period is in November and an individual spawns twice an year. Unlike the spiny lobster, *T. orientalis* is low fecund with shorter larval period. The fishery data clearly indicate the necessity for immediate measures to protect the species from complete elimination from the fishery. On the whole, there is an overall reduction in catch and catch rate of the lobster fishery on the NW coast.

South-west coast :

During 1950s and up to 80s, lobster fishery was restricted to only few fishing villages along the coast from Trivandrum to Kanyakumari, which were the most productive lobster fishing grounds in India. Thereafter due to increased export demand, lobsters are fished in almost all the fishing villages. Total landings gradually decreased from 301 t in 1966 to 7.6 t in 1995-96. The dominant species contributing to the fishery is *P. homarus*. The fishery is seasonal and extends from September to April with peak catches from October to January. Mean size of *P. homarus* has been significantly reduced over the years

and especially after introduction of trammel net. Remarkable increase in fishing effort, operation of trammel nets for lobster fishing and catching and marketing of under-sized lobsters are considered to be major reasons for fall in catches. Furthermore, major portion of the females caught are egg bearing as peak fishing period coincides with peak breeding season. Fishing needs to be regulated so that overexploitation of the resource could be prevented. As pointed out by George (1967), regulation of the fishing of small sized lobsters by implementing suitable management measures such as fixation of a minimum size limit or ban on catching and marketing of egg bearing lobsters may be beneficial.

Southeast coast :

The Gulf of Mannar along the Tamilnadu coast is a potential ground for lobster fishery. Substantial catches are also coming from Tirunelveli coast. Tuticorin and Pamban are the major mechanized lobster landing centres in the Gulf of Mannar sector. During 1978-85, annual average landings at Tuticorin was 12 t with a CPU of 4.39 kg/U (Kagwade *et.al.*, 1991). In the trawl fishery, spiny lobster catch increased from 32.5 t with a catch rate of 1.4 kg/U in 1991-92 to 42.6 t with a catch rate of 1.9 kg/U in 1992-93 (Rajamani and Manickaraja, 1997). In the traditional sector, lobster catch increased from 4 t in 1992-93 to a peak catch of 74 t with a catch rate of 3.8 kg/U in 1994-95. However, the landings were declined to 38 t with a catch rate of 2.0 kg/U in 1995-96. The spiny lobster *P. ornatus* is the most important species from the live lobster export point of view. The other species of commercial importance which are also exported in live condition is *P. homarus*, *P. ornatus* constituted nearly 86% of the trawl fishery during 1991-94 but in 1996-97 this species formed only 69.5% of the total lobster catch at Tuticorin. Landings of *P. ornatus* increased from 27 t in 1991-92 to 88 t in 1994-95 but were sharply declined to 35 t in 1995-96. 41% of the *P. ornatus* caught has been estimated to be juveniles and undersized lobsters ranging in size from 111-190 mm TL. Juveniles of *P. ornatus* normally occupy shallow areas around the islands and the sub adults in slightly deeper areas. In the traditional fishery too, *P. ornatus* dominated the landings forming 67% at Tharavaikulam and 47% at Kayalpatnam (Rajamani and Manickaraja, 1997). Smaller sized lobsters measuring less than 130 mm TL form fairly good percentage of the gill net catch during October-November when recruitment takes place. Females of *P. ornatus* have been estimated to attain first sexual maturity at 250 mm TL (90 mm carapace length) (Radhakrishnan and Vijayakumaran, Personal communication). Egg bearing *P. ornatus* is rarely encountered in the trawl catches and in inshore traditional lobster fishery at Tuticorin. However, adult *P. ornatus* measuring above 300 mm TL and occasionally egg bearing lobsters are landed by traditional fishermen fishing in deeper areas south of Nagapattinam. This indicates that *P. ornatus* breeds in

deeper waters. In Tuticorin, *P. homarus* is landed both by trawls and gill nets. Average annual catch for the period 1978-85 was 8 t at the rate of 2.84 kg/U (Kagwade *et.al.*, 1991). In 1994, the estimated catch was 16.4 t and the catch was reduced to 7.3 in 1995. *P. homarus* caught in trawls are mostly undersized, 46.2% of which are in the size range of 101-130 mm TL (Rajamani and Manickaraja, 1997). Traditional fishermen operate trammel nets, which also brings in undersized lobsters in large quantities. Though lobsters are caught through out the year at Tuticorin, larger quantities are landed between May and February. Large-scale incidental catch of undersized lobsters in trawl catches and fishing by trammel nets are probably the reasons for declining lobster fishery in this sector.

At Mandapam, an average 3 to 4 t of lobsters are landed of which 75% is constituted by *P. ornatus*, 20% by *P. homarus* and the rest by other species such as *P. versicolor*, *P. longipes* and *P. penicillatus*. Fairly good quantities are also landed at Yerwadi and Valinokkam lying between Tuticorin and Mandapam. Fishery commences in October and extends up to May. Peak fishing season is from December to March.

In Chennai, lobsters are landed both by trawls and artisanal gears. During 1978-85 average annual catch was 10.9 t (Kagwade *et.al.*, 1991). An average 76% of the lobster catch from trawlers is constituted by *T. orientalis* and the remaining is by *P. homarus*, *P. ornatus* and *P. versicolor*. The catch of *T. orientalis* declined from 114 t with a catch rate of 0.51 kg/hr in 1994-95 to 36 t with a catch rate of 0.15 kg/hr in 1995-96. In the traditional sector, gill nets land an average 3 to 4 tonnes of lobsters annually, of which *P. homarus* constitutes 68%, *P. ornatus*, 18% and *P. versicolor*, 13%. Trammel nets are also widely used for lobster fishing and 50% of the catch in trammel net is constituted by immature lobsters (<55 mm CL), compared to 25% in gill nets. Large-scale destruction of young lobsters by trammel nets and fishing of egg bearing lobsters have been observed from this sector (Radhakrishnan and Vijayakumaran, 1988).

Deepsea lobsters :

Deepsea lobster is an important resource and has high export value. *P. sewelli* is the only species commercially exploited and other potential species are *L. somniosus* and *N. carpenieri*. *P. sewelli* occurs off the southern coasts at depths ranging from 150 to 400 m with maximum abundance between 150 and 250 m. Exploratory surveys during 1969 and 1970 have recorded catch rates of 15-330 kg/hr and 200-300 kg/hr on the south west and south east coast of India, respectively. The Fishery Survey of India conducted deepsea fishery resources surveys upto 500 m depth along the south-west coast, Wadge Bank and Gulf of

Mannar since early eighties. The distribution pattern of deepsea crustaceans based on these surveys is presented by Sulochanan *et.al.* (1991) and Sivaprakasam (1992). During 1990, new deepsea lobster grounds were located by Fishery Survey of India around Andaman and Nicobar Islands (Ali *et.al.* 1991). During 1993-94, landings from Gulf of Mannar was 90 t with a CPUE of 15 kg/hr and in 1997-98 total catch was 56 t with a CPUE of 29 kg/hr. This species is very vulnerable to fishing, especially during the breeding period when the breeding population migrates to upper areas, resulting in heavy exploitation of the breeding females. Fishing of berried females and immature lobsters might be the possible reasons for wide fluctuation in deepsea lobster catches. There is a need to adopt a comprehensive management policy for exploitation of the deepsea lobster resource in order to ensure a sustained fishery.

Export of lobsters :

Lobster is an export commodity and 99% is exported to the major market, Japan. Export of lobster fetches on an average Rs.55 crores in foreign exchange annually. There is an overall decline in export of lobsters from India, during the past five years. Total exports decreased from 1629 t in 1992-93 to 1312 t in 1996-97. However, value-wise, exports increased from 44 crores in 1992-93 to 55 crores in 1996-97 (Marine Products Export Review, 1996-97). India has been exporting lobster in different forms such as live, chilled, whole cooked, frozen and as frozen tails. The major market for frozen lobster is Japan. Export of live lobsters began in 1990-91 and since then there is a steady increase in export of live lobsters, both in quantity and value in 1998-99, 160 t of live lobsters valued at 11.5 crores were exported. Live lobsters are mostly exported to Hong Kong. On the other hand, export of whole cooked lobsters suffered a set back. Export increased from 1065 t in 1990-91 to 1260 t in 1995-96, and drastically declined to 825 t in 1996-97. In 1998-99, 951 t were exported, which clearly indicates only marginal increase in arrival of *P. polyphagus* for export, as the main component in the whole cooked form. Export of frozen sand/slipper lobster tails has also been stagnant in 1996-97, compared to the previous year. Stagnation in lobster exports may probably be indicative of general decline in lobster landings.

P. ornatus is the major component of live lobster export (56%) followed by *P. homarus* (38%), *P. polyphagus* (5%) and *P. versicolor* (1%). There are no restrictions on size of live lobsters exported from India and therefore, even lobsters weighing as small as 50 g are exported (Vijayakumaran and Radhakrishnan, 1997). Among the whole cooked form, lobsters weighing 200-250 g is in maximum demand in 1999 and the highest price is paid for this grade (US \$ 12.5 per kg). In 1998, maximum price was offered for the 250-300 g

grade. India is currently exporting whole cooked lobsters from 80 g onwards. Price for 80 to 150 g varies from US \$ 4.60-7.60/kg. This shows that it is highly uneconomical to export small lobsters. However, the quantum of exports of each grade is necessary to evaluate how much percentage of undersized lobsters contribute to the total export of whole cooked and live lobsters in each year.

Management of lobster fishery

The value of spiny lobsters on world markets is high and, in general, lobster stocks are heavily exploited. Thus, practical management decisions are required so that exploitation will be sustainable. Management regulations, which are normally applied to lobster fisheries are, closed season, gear restrictions, minimum legal size and protection of berried females. In India, nearly 76% of the lobster catch comes from trawlers and therefore fishing is not targeted for lobsters alone. Lobsters are incidentally caught along with other demersal resources such as shrimps, crabs and fishes and therefore no direct regulations can be enforced to control fishing of lobsters alone. In the traditional sector, it may be easier to impose restrictions, as fishermen venture exclusively for lobster fishing in certain months. Therefore, some management measures will have to be implemented to regulate the fishery. Potential earnings of the fishermen can be maintained or even enhanced with proper management and enforcement of fishing regulations. Juveniles of lobsters generally inhabit inshore areas until they attain sexual maturity and where they could be easily fished with minimum effort. Similarly, high exploitation of egg bearing females during peak breeding season can bring in negative impact upon the breeding stocks, and, hence, egg production. Seasonal closures around the time of breeding have been effectively used as a regulatory measure in single species fishery of the subtropical seas. How far this measure could be applied under Indian condition needs to be examined. On the SW as well as SE coasts, operation of trammel nets brings in substantial quantities of juvenile *P. homarus* and *P. ornatus*. Trammel net is a destructive gear for lobsters. With the beginning of live lobster and whole cooked lobster export, export of undersized lobsters has been on the increase, as the overseas demand is higher for smaller lobsters in certain categories. India is a potential exporter of smaller sized lobsters, as other countries have strict regulations on size of lobsters fished. This situation has affected the lobster resource of the country to a great extent.

Current management measures

The current landing of lobsters in India is about 71% of the peak catch in 1985. In Mumbai, the present harvest and CPUE of *P. polyphagus* is only just 22% and 46% of the 1985 catch, respectively. Decline in landings has also been reported from Veraval. The status of *T. orientalis* fishery is still alarming. In Mumbai, this species disappeared from the fishery in 1996-97 and has recurred again in small quantities in 1998. This situation warrants immediate implementation of management measures so that further decline is contained.

Currently, no management regulations are strictly implemented to regulate fishing of lobsters in India. There are no restrictions on minimum size of capture, type of gears used, number of crafts engaged in lobster fishing and on the fishing seasons. Unlike the single species fishery of the temperate and sub-tropical countries, the lobster fishery in India is multi-species and exploited by divergent gears involving both traditional and mechanized sectors. The fishermen lured by the high prices for lobsters are exploiting the resource indiscriminately, in the absence of any regulation or control on fishing activity. There are no restrictions on size of lobsters exported. Therefore, framing and implementation of management measures will have to take into account the biological, economic and the social aspects.

Future management measures

In an effort to increase egg production, reduce exploitation rates of juveniles and conserve the resource for sustainable utilisation, several management measures are suggested.

Protection of egg bearing lobsters

Available research information indicates that a substantial portion of the females harvested during major peaks in breeding season is egg bearing. Since tropical species of lobsters are continuous breeders, berried lobsters may be present in small quantities in the catches through out the year. However, high percent of females with eggs are encountered in certain months and this period is considered as the peak-breeding season. Heavy exploitation of berried females could affect egg production and consequently low level of recruitment. The larval cycle of spiny lobsters is prolonged and highly complex and therefore, the percent of larvae finally metamorphosing into the post larvae (Puerulii) will be very minimal. The adverse effect of high exploitation rates of ovigerous females on the recruitment and the stock will not be immediate. So, protection of egg

bearing females from overexploitation would be necessary for sustenance of the resource. In other lobster fishing nations, capturing of egg bearing lobster is prohibited and it is mandatory to release the berried females back into the sea. This will be the major regulatory measure that can be implemented practically for the management of the NW lobster fishery. Co-operation of the fishermen is very essential for successful implementation of this regulation. Other management measures that can be considered for implementation are :

V-notching of berried females : This will be easier to implement in the traditional sector. Berried females have to be purchased from fishermen initially by paying the market price, V-notched and released immediately. 'V' notching is cutting a 'V' shaped mark on the uropod for identification of the lobster. If the lobster is caught again, the fishermen are expected to release the lobster voluntarily. A task force involving local youths under the supervision of village panchayat or fishermen co-operative society has to be formed for implementation of this programme. This programme may be initiated on a pilot basis in selected villages on the SW and SE coasts. Once the fishermen are convinced of the importance of this programme, they may carryout this conservation measure by themselves.

Education of fishermen on breeder protection : Education of the fishermen by distribution of pamphlets and educative materials on lobster conservation may be initiated through village Panchayat and fishermen cooperative society. Articles in local newspapers and advertisements through mass media also can be attempted. Extension workers have to visit the fishing villages periodically and convey the message of protection of 'mother' lobsters and the benefits the fishermen will get on a long term.

Establishment of sanctuary/lobster parks : The establishment of sanctuary areas, provided they are sufficiently large and enforcement is effective, has been reported to be extremely useful in lobster management. This will provide valuable information on fishery characteristics of an unfished population for comparison with the fished stock. This will be highly useful for taking management decisions. A National Marine Biosphere Reserve is already existing in The Gulf of Mannar, on the SE coast. Fishing is permitted now but in the lobster sanctuary fishing of lobsters should not be allowed by the concerned authorities. A suitable area where lobster fishery is existing should be identified for establishing the reserve.

Protection of juvenile lobsters : In India, non-enforcement of management measures in regulating the lobster fishery has resulted in intensive exploitation of juveniles. On the NW, the quantum of juveniles appearing in the trawl fishery is

within limits. However, intensive exploitation of juveniles of *P.polyphagus* by stake nets and cast nets operating in the inshore waters where the juveniles inhabit until they recruit into the fishery will be highly detrimental to the fishery on a long term basis. On the SW and the SE, traditional fishermen catch undersized lobsters using trammel nets. The exploitation is continuing, as there is an export market for small live lobsters in Taiwan where they fatten and sell the product at higher price. On the NW, *P. polyphagus* lobsters weighing even up to 80 g are exported in whole cooked form.

Minimum size for export : In India, it may be easier to implement a minimum size for export rather than introducing size limits for exploitation, as lobsters are primarily an export oriented seafood. Implementation of a minimum size for export will automatically deter the fishermen from intentional exploitation of juveniles and undersized lobsters, as there will be no export market. But, in situations where lobsters are caught along with another important resource as in the case of trawl fishery of *P. polyphagus* and *T. orientalis* of the NW coast, and *P. ornatus* and *P. homarus* of the SE coast, it may not be possible to enforce higher size limits. However, a minimum size for export will have to be enforced so as to restrict intentional exploitation of juveniles and undersized lobsters. Currently, the minimum size of whole cooked lobster exported from India is 80 g, which is far below the size at maturity of the two species constituting the whole cooked product. The size at first maturity for *P. polyphagus* is 275 g (175 mm total length, 74.8 mm carapace length) and 135 g (165 mm TL, 55 mm CL) for *P. homarus*. Historically, size limits are set at the acceptable market size with only secondary consideration to the reproductive capacity of the stock. But, the countries adopting this strategy have strict regulatory measures such as effective control on the effort and maximum allowable catch in a particular season. Under the Indian conditions, especially when lobsters are mostly landed as a bycatch, this may not be practical. The current market demand for whole cooked lobsters is for lobsters weighing 200-300 g and the highest price is offered for this size (US \$ 11.5 to 12.0/kg). Lobsters of smaller grades fetch only very low price and exporting of undersized lobster is economically wasteful. By restricting the minimum size of export to the size of maximum demand, export and thereby exploitation of smaller lobsters can be prevented. On the NW, juveniles and undersized lobsters form only a small percent of the total catch in the trawl fishery, but major landing of juvenile lobsters is by indigenous gears operating in near shore areas. This measure will prevent intentional fishing of juveniles, as there will be no export demand for smaller lobsters.

As far as live lobster export is concerned, live lobsters of all sizes are exported. *P. ornatus* is the main component of live export. Highest demand is for lobsters weighing above 1000 g and the grade, next in demand is that ranging

from 400 to 1000 g. In the trawl fishery, 41% of the catch is in the size range of 111-190 mm total length (100-300 g). *P. ornatus* of these sizes are juveniles and fetch very low price. A fairly good percent of gill net catch from inshore waters also consists of smaller size lobsters (<500 g). Catch from deeper waters consists of lobsters above 800 g, but the quantity is less. Mature *P. ornatus* (700-800 g) moves to deeper waters for breeding. Rare occurrence of egg bearing lobsters in the fishery shows that *P. ornatus* spawning stock is naturally protected. By restricting the minimum size of export to 400 g, exploitation and wastage of juveniles can be prevented without disrupting the export market. But the fishermen will have to voluntarily release back the lobsters below 400 g and the economic and social implications on implementation of the recommended minimum size for exploitation needs to be examined.

From the south, fairly good quantities of *P. homarus* are exported in whole cooked form, mostly in the size range of 100-300 g. Live *P. homarus* of this size range is also exported, depending upon the demand. In the case of *P. homarus*, the size at first sexual maturity is 135 g (55 mm CL), but spawning intensity is maximum in the size range of 60-70 mm CL (175 to 275g) during the peak-breeding season. By limiting the size of export to 200 g, fishing and export of juveniles and undersized lobsters will be curtailed. Since this weight falls above the size at first sexual maturity and the first breeding size, automatic protection will be assured for the early breeding females.

Operation of trammel nets : Gill nets and trammel nets are considered as destructive gears for lobster fishing in other lobster fishing nations. In India, traditional fishermen in the south are mainly using gill nets for lobster fishing. The use of traps by southwest coast fishermen are diminishing as operation of gill nets is much more easier, compared to traps. Percentage of juveniles and undersized lobsters (<55 mm CL) entangled in gill nets is around 25%, where as in trammel nets 50% of the lobsters caught are below the maturity size. On the SW coast, juveniles of *P. homarus* move towards the inshore areas during October for settling and feeding as food (mainly mussels and the associated fauna) will be abundant in this area. Soon after the *P. indicus* fishing season, which also coincides with the movement of juveniles, fishermen use old trammel nets for juvenile lobster fishing. Large quantities of juveniles and undersized lobsters will be caught during this period.

Conservation and protection issues

Artificial shelters for lobster fishery enhancement : Artificial shelters have greatly enhanced the catches from the tropical spiny lobster fisheries associated

with shallow bays and reef lagoons in Cuba and Mexican Caribbean. They have now become widespread in the Caribbean region and there are plans to introduce them into other countries such as Australia, Sri Lanka and Seychelles. In Cuba, artificial habitats called 'pesqueros' contribute 50% of the total lobster catch. The ecological effects of the use of artificial shelters are uncertain, but it is clear that they accumulate fishable-size lobsters and ease fishing operations. Their use is becoming more widespread. Establishment of reefs and their management in Indian conditions will have to be studied on an experimental basis before taking decisions on large-scale establishment of artificial shelters.

Breeding and sea ranching of lobsters : A viable hatchery technology is essential for mass production of juveniles. Spiny lobster hatchery technology is still in experimental stage. The sand lobster *T. orientalis* has a shorter larval cycle and the hatchery technology for this species is yet to be perfected.

Research for management : The value of lobsters on world markets is high, and in general, stocks are heavily exploited. Therefore, effective management decisions are required, their formulation relying upon detailed knowledge of both the fishery and the biology of the animal. While fairly good data on the characteristics of lobster fishery in India is available, more biological information on growth, mortality, fecundity, spawning, stock exploitation and recruitment is required on commercially important species. This information is crucial, as sound management, decisions will be based on the validity of the data collected on these aspects. Research projects on detailed investigations on reproductive biology of commercially important lobsters will have to be taken up to provide reliable information such as impact of fishing upon population fecundity and the stock-recruitment relationship.

Discussion

Lobsters are a low volume high value resource exploited intensively from the Indian seas. Though lesser in magnitude, this is a very important resource, which brings in foreign exchange for the country. Demand for lobsters has increased dramatically in recent years. Consequently, exploitation levels have also been enhanced considerably. Lobster fishery in some of the countries is well managed. Combinations of conventional management approaches such as input (fishing effort) controls, output (catch) controls and other regulatory measures such as size limits and seasonal/or area closures are in operation in different spiny lobster fisheries around the world. In India, a suitable management system is yet to be developed, though the fisheries has been existing for the past five decades. Non-enforcement of management regulations has

resulted in overexploitation of the resource, leading to fall in catches and reduction in mean size of lobsters occurring in the fishery. Therefore, wise management decisions have to be formulated and the fishery regulated for continued sustenance. Enforcement of management recommendations may result in reduced returns at first, but subsequent years should show enhanced income. Total earnings will decline drastically if regulations are not enforced and the fishery is allowed to continue to decline. If the population declines beyond a critical point, recovery will be difficult as has happened in lobster fisheries of some of the countries, where the fishery is not managed. Fisheries research on lobster reproductive biology should be intensified so as to provide valuable and reliable data to fisheries managers to take appropriate decisions on management. Wide fluctuations in lobster catches and in recruitment may also result from varying environmental conditions. Therefore, a realistic approach to lobster resource management is required for long-term sustenance of the resource.

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