

## Resource characteristics and stock assessment of lesser sardines in the Indian waters

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### ABSTRACT

The fishery and biology of commercially important species of lesser sardine resources of India were studied. Detailed gearwise, specieswise and monthwise landings for 1984-88 are presented. In Goa-Karnataka region the main gear was purse seine, whereas in the Kerala region it was gill net. On the east coast, Tamil Nadu-Pondicherry recorded maximum landings through gill nets and Andhra-Orissa through boat seines and gill nets. *Sardinella gibbosa* was the important species in the west and southeast coasts of India, and *S. fimbriata* in the northeast region. Growth parameters for different species were estimated. Stock assessment for *S. gibbosa* showed that the fish is optimally exploited in the Tamil Nadu-Pondicherry region, whereas in the west coast (Kerala and Goa-Karnataka regions) the fishery can be improved with additional effort. In the Andhra-Orissa region, the effort is beyond the MSY level.

The lesser sardines contribute 3.9 to 5.7% annually to the total marine fish landings in India. Because of the small size and low market value of the fish, these are not preferred by industrialists but are consumed as fresh fish. Fishing is done mostly by traditional fishermen using artisanal gears. The industrial trawlers fish them as one of the by-catches.

Lesser sardines are important food fishes among the weaker sections of the coastal states. Because of the small size and cheap price, inputs like refrigeration and freezing are not adopted in lesser sardine trade. Sur-

plus fish is either sun dried or iced and transported to interior markets. Most of the dried product is powdered and used as poultry feed and the rest is sold in interior markets for human consumption.

Lesser sardines comprise all the species of sardines (*Sardinella* spp.) other than the Indian oil sardine. Mostly they are known to inhabit the nearshore waters up to 25-30 m depth zone. Nine species occurring in Indian waters, in the order of abundance, are *Sardinella gibbosa*, *S. fimbriata*, *S. sirm*, *S. albella*, *S. dayi*, *S. sindensis*, *S. clupeoides*, *S. melanura* and *S. jonesi*. Four regions of lesser sardine concentrations are noticed along the Indian coasts, viz., Goa-Karnataka, Kerala, Tamil Nadu-Pondicherry and Andhra-Orissa. The occurrence and abundance of species varied in different regions. In the Goa-Karnataka region four species are identified, namely, *S. gibbosa*, *S. dayi*, *S. fimbriata* and *S. albella*. Locally they are called *boothai*. Three dominant species along Kerala region are *S. gibbosa*, *S. sindensis* and *S. sirm*. Lesser

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known species such as *S. clupeioides*, *S. fimbriata*, *S. melanura* and *S. jonesi* are also noticed in this area occasionally. The local name *chala* is common for all lesser sardine species in Kerala, except for *S. sirm* which is called *keeri chala*. In Tamil Nadu-Pondicherry region, five species are reported, namely *S. gibbosa*, *S. albella*, *S. dayi*, *S. sirm* and *S. clupeioides*. The local names of these species are *chalai* for *S. gibbosa*, *choodai* for *S. albella* and *S. dayi* and *keerimean chalai* for *S. sirm* and *S. clupeioides*. In Andhra-Orissa region, species frequently occurring in the fishery are *S. fimbriata* and *S. gibbosa*, the former being more abundant. These two species are locally called *kavallu*. A comprehensive account of lesser sardine resource in India is given by Bennet *et. al* (1986).

#### MATERIALS AND METHODS

Investigations on the lesser sardine resource were carried out at Karwar in Goa-Karnataka region, Vizhinjam in Kerala region, Tuticorin and Madras in Tamil Nadu-Pondicherry region and Visakhapatnam in Andhra-Orissa region. The gearwise catch and effort data from major fish landing centres were collected during 1984-88 and the annual production was estimated. The composition of the component species was also noted to estimate the abundance of different species in space and time. Biological samples of major species were collected and analysed in the laboratory for length, weight, sex, maturity and food. Based on these data the size composition, food and feeding habits, maturation, spawning, fecundity, size at first maturity and sex ratio of *Sardinella gibbosa*, *S. fimbriata*, *S. sirm* and *S. dayi* were studied. The stock assessment of the most common species, viz., *S. gibbosa* was carried out based on five years data. The length frequency data were converted into 5 mm class intervals and

estimates of the asymptotic length and growth coefficients ( $L_{\infty}$  and  $K$ ) were obtained using the ELEFAN programme (Pauly and David 1981) for fitting the growth curves. Estimates of mortality rates and yield parameters were made using Thompson and Bell long-term forecast model (Sparre 1987). Separate estimates were made for the earlier mentioned four regions.

#### RESULTS

##### Fishery

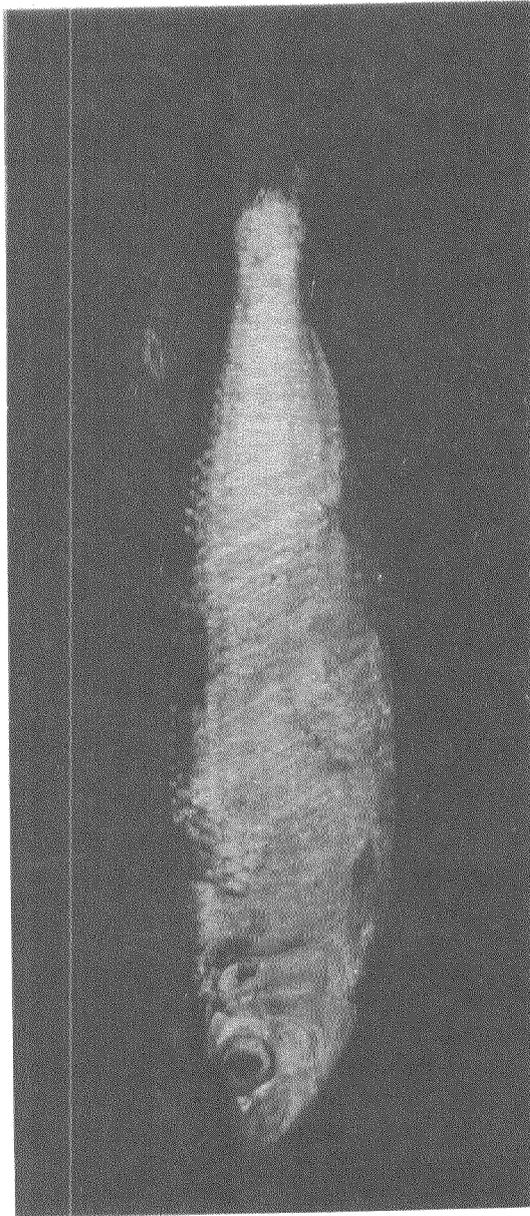
Lesser sardine fishery in India during the past ten years from 1979 to 1988 fluctuated from 3.9 to 5.7% in the total marine fish landings. Average annual catch during the period was 69 550 tonnes. The years 1983, 1987 and 1988 recorded catch well above the annual average (Fig. 1) whereas in other years the annual catch was below the average. Regionwise landings of lesser sardines during 1984-88 are given in Table 1.

##### Craft and gears

Except for small quantities landed by shrimp trawlers at Visakhapatnam, the entire lesser sardine catch in the east coast and the southwest coast is obtained by traditional craft and gears. Recent years have seen many

Table 1. Regionwise landings of lesser sardines during 1984-88

Year	Regionwise landings (tonnes)			
	Goa-Karnataka	Kerala	Tamil Nadu-Pondicherry	Andhra-Orissa
1984	8 414	6 022	27 378	24 388
1985	6 075	2 473	24 124	26 769
1986	7 576	8 934	31 353	20 269
1987	15 998	8 697	48 652	19 884
1988	7 253	12 701	35 385	20 242
Total	45 316	38 827	166 892	111 552
Average	9 063.2	7 765.4	33 378.4	22 310.4
Percentage	12.5	10.7	46.0	30.8



*Sardinella gibbosa*

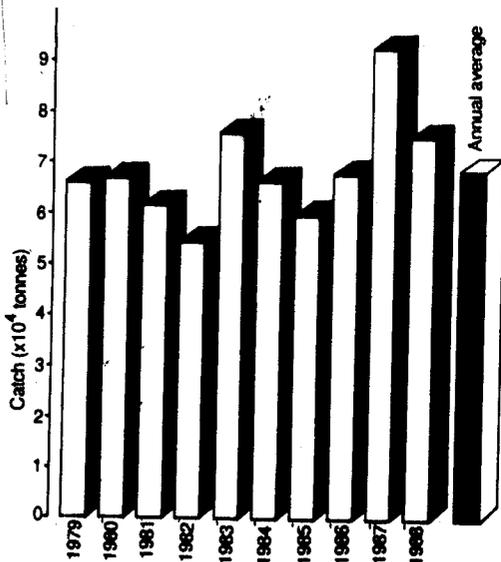


Fig. 1. Annual lesser sardine landings in India during 1979-88.

of the indigenous fishing craft being fitted with motor propellants. In the Goa-Karnataka region, however, the entire lesser sardine catch is brought by purse seiners which have replaced traditional gears *rampani* and *yendi*. The traditional gear, sardine gill net, made of nylon netting, is the popular gear. Other gears operated in the fishery include boat seine, shore seine, and hooks and line. The hooks and line is operated very sporadically to catch *S. sirm* during its abundance. In some areas,

shrimp trawlers also bring lesser quantity of these fishes. Craft and gears employed till 1978 are described in detail by Bennet *et al.* (1986).

*Centrewise, gearwise and specieswise catch:* The monthwise and gearwise total catch of lesser sardines in different centres are given in Table 2 and the species composition in Table 3. September to December is the good season at Karwar centre in Goa-Karnataka region. During monsoon months (May-August) fishing activities come to a stop. Peak catch is obtained soon after the monsoon break (Fig. 2). In purse seines, operated in 21-30 m depth zone off Karwar, lesser sardines formed 2-13% of the total catch of the gear. Four species of lesser sardines formed the catch at Karwar. About 38% of the total lesser sardine catch was formed by *S. gibbosa* followed by *S. fimbriata*. Other species in the fishery were *S. dayi* and *S. albella*. September to November was the peak period for *S. gibbosa*, and October for *S. fimbriata* (Table 3). According to Annigeri (1989b), *S. gibbosa* emerged as a new resource with the introduction of purse seine at Karwar.

Along the coast of Kerala, gill nets are operated throughout the year and good quantities of lesser sardines are landed (Fig. 3). On an average 83.7% of the catch at Vizhinjam in Kerala region was by gill net and the rest by

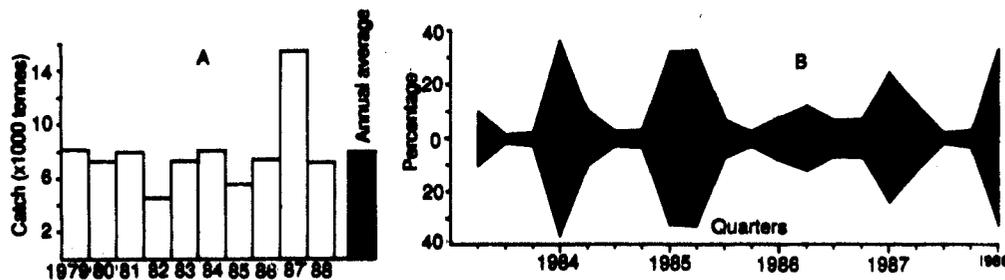


Fig. 2. Estimated annual landings during 1979-88 (A) and quarterly abundance during 1984-88 (B) of lesser sardines in Goa-Karnataka region.

Table 2. Gearwise monthly catch (tonnes) of lesser sardines at different centres during 1984-88 (average) (pooled for all gears)

Centre/Gear	Karwar		Vizhinjam				Tuticorin	Madras	Visakhapatnam			
	Month	PS	GN	BS	SS	H & L	Total	GN	GN	BS	GN	Trawl
Jan	9.5	8.3	0.1	0.1	-	8.5	215.2	38.8	22.9	16.5	-	39.4
Feb	39.2	4.4	-	0.1	-	4.5	244.9	35.2	8.3	18.3	0.3	26.9
Mar	4.3	15.6	0.1	0.1	0.3	16.1	276.3	14.1	4.2	18.9	25.2	48.3
Apr	9.6	6.5	0.1	0.1	-	6.7	231.2	5.7	2.7	3.9	0.2	6.8
May	0.2	26.5	0.6	0.2	0.3	27.6	233.5	5.9	0.8	3.1	0.1	4.0
Jun	-	5.5	5.7	0.1	-	11.3	227.0	34.0	0.9	5.7	1.1	7.7
Jul	-	-	0.8	-	0.1	0.9	262.7	41.0	0.9	1.7	-	2.6
Aug	-	0.1	6.9	-	-	7.0	301.3	62.6	0.6	0.8	0.3	1.7
Sep	116.9	3.1	0.2	0.1	0.1	3.5	358.8	35.5	2.6	0.3	1.6	4.5
Oct	166.5	22.2	1.8	0.1	0.1	24.2	374.0	53.2	3.9	7.4	-	11.3
Nov	73.0	17.8	-	3.8	0.1	21.7	345.1	25.1	11.6	17.5	-	29.1
Dec	35.1	7.3	0.2	0.5	0.2	8.2	300.9	12.2	8.9	31.3	-	40.2
Annual	454.3	117.3	16.5	5.2	1.2	140.2	3 370.9	363.3	68.3	125.4	28.8	222.5
Percentage	100	83.7	11.8	3.7	0.8		100	100	30.7	56.4	12.9	

P S, Purse seine; G N, gill net; B S, boat seine; S S, shore seine; H & L, hooks & line.

Table 3. Specieswise monthly lesser sardine catch (tonnes) at different centres during 1984-88 (average) (pooled for all gears)

Centre/species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual	Percentage
<b>Karwar</b>														
<i>Sardinella gibbosa</i>	2.9	14.9	4.1	3.3	-	-	-	-	57.1	48.9	38.1	2.0	171.3	37.7
<i>S. dayi</i>	4.3	7.6	-	5.3	0.2	-	-	-	6.3	44.3	10.9	6.2	85.0	18.7
<i>S. albella</i>	0.5	1.7	-	-	-	-	-	-	46.7	3.0	13.6	4.8	70.5	15.5
<i>S. fimbriata</i>	1.8	1.2	0.2	0.2	-	-	-	-	6.8	70.3	10.4	3.6	94.5	20.8
Other species	-	13.6	-	0.8	-	-	-	-	-	-	-	18.5	32.9	7.2
<b>Vizhinjam</b>														
<i>S. gibbosa</i>	2.9	-	0.6	5.3	21.6	9.2	0.6	6.9	3.3	23.6	16.2	6.6	96.8	69.0
<i>S. sindensis</i>	0.5	-	0.1	0.7	4.5	0.6	-	-	-	0.6	0.2	0.9	8.1	5.8
<i>S. sirm</i>	4.9	4.5	15.4	0.3	1.0	1.5	0.1	0.1	0.2	-	5.3	0.6	33.9	24.2
Other species	0.2	-	-	0.4	0.5	-	0.2	-	-	-	-	0.1	1.4	1.0
<b>Tuticorin</b>														
<i>S. gibbosa</i>	120.5	110.3	132.8	122.2	167.1	147.5	151.4	170.2	230.3	237.4	163.4	162.1	1 915.2	56.8
<i>S. albella</i>	38.3	32.9	69.1	42.2	30.0	21.2	39.9	33.2	32.4	31.9	31.9	21.9	424.9	12.6
<i>S. dayi</i>	25.5	24.9	46.1	28.6	20.3	14.1	26.6	22.1	21.7	21.4	21.3	14.6	287.2	8.5
<i>S. sirm</i>	26.2	67.4	24.6	32.0	13.8	44.0	39.8	42.2	56.0	77.7	79.7	91.6	595.0	17.7
<i>S. clupeoides</i>	0.2	4.2	0.6	1.6	2.3	0.2	5.0	15.5	1.7	4.9	2.7	9.2	48.1	1.4
Other species	4.5	5.2	3.1	4.6	-	-	-	18.1	16.7	0.7	46.1	1.5	100.5	3.0
<b>Madras</b>														
<i>S. gibbosa</i>	27.6	27.6	11.0	4.3	5.2	24.8	30.3	46.1	28.1	41.8	18.5	10.2	275.5	75.8
<i>S. sirm</i>	4.1	0.3	2.1	1.2	0.6	6.1	2.6	7.0	3.4	7.2	1.4	1.0	37.0	10.2
<i>S. dayi</i>	0.1	-	-	-	-	-	0.1	0.1	0.6	0.1	-	-	1.0	0.3
<i>S. fimbriata</i>	7.0	7.3	1.0	0.2	0.1	3.1	8.0	9.4	3.4	4.1	5.2	1.0	49.8	13.7
<b>Visakhapatnam</b>														
<i>S. fimbriata</i>	32.3	15.5	41.5	4.9	2.7	7.0	1.7	0.8	3.6	10.8	22.0	34.3	177.1	79.6
<i>S. gibbosa</i>	7.1	11.4	6.8	1.9	1.3	0.7	0.9	0.9	0.9	0.5	7.1	5.9	45.4	20.4

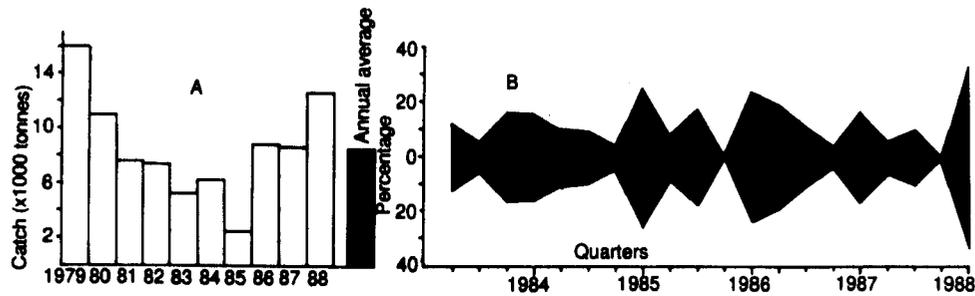


Fig. 3. Estimated annual landings during 1979-88 (A) and quarterly abundance (pooled for all gears) during 1984-88 (B) of lesser sardines in Kerala region.

boat seines and shore seines (Table 2). During certain years small quantities of *S. sirm* were landed in hooks and line. During May and October/November good landings were recorded at Vizhinjam (Table 3) which coincided with good fishery of *S. gibbosa* and *S. sirm*. At Vizhinjam, *S. gibbosa* formed 69% of the catch followed by *S. sirm*. Other species noticed were *S. sindensis*, *S. fimbriata*, *S. melanura* and *S. jonesi*.

At Tuticorin centre in Tamil Nadu-Pondicherry region, lesser sardines contributed on an average 3 371 tonnes per year (Table 2). Though good landings were reported dur-

ing all the months, the peak period was from September to December (Fig. 4). Five species contributed regularly to the fishery. Nearly 57% was formed by *S. gibbosa* and 17.7% by *S. sirm*. Other species in the fishery included *S. albella*, *S. dayi* and *S. clupeoides*.

The fishery at Madras centre of Tamil Nadu-Pondicherry region, though much less in quantity, was similar to that of Tuticorin. Annual average catch was 360 tonnes and the fishery existed almost throughout the year (Table 2). From 1984 to 1988 the average monthly catch showed the peak landings in August, followed by October. Gill net, locally

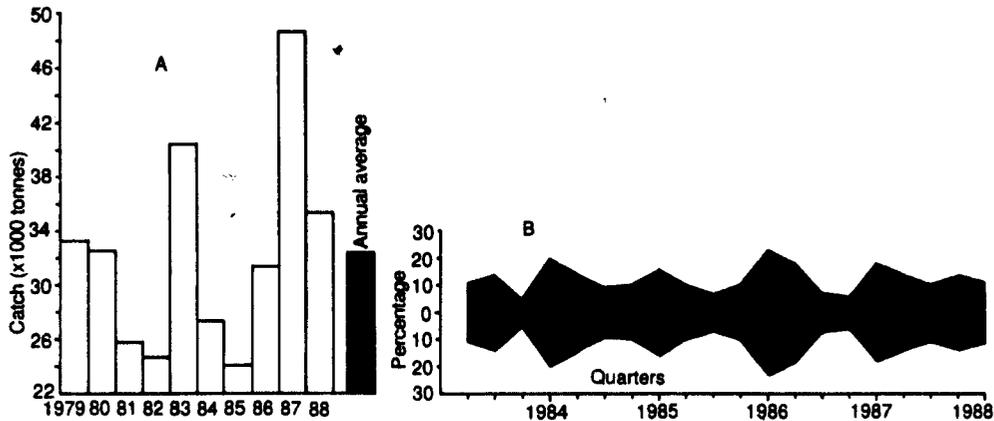


Fig. 4. Estimated annual landings during 1979-88 (A) and quarterly abundance (pooled for all gears) during 1984-88 (B) of lesser sardines in Tamil Nadu-Pondicherry region.

called as *kavala valai* was the only gear used in the fishery. *S. gibbosa* dominated the catch forming 75.8% and the other species in the order of dominance were *S. fimbriata*, *S. sirm* and *S. dayi*. The species composition at Madras differed from that of Tuticorin in the absence of *S. albella* and *S. clupeoides* and in the presence of *S. fimbriata*; the fishery for *S. dayi* was poor here.

The annual lesser sardine landings during 1984–88 at Visakhapatnam in Andhra-Orissa region ranged between 70 tonnes and 382 tonnes with the average at 223 tonnes. They occurred throughout the year with a peak season during October–March accounting for 88% of the annual catch (Fig. 5). Gill net, boat seine and trawl net accounted for 56%, 31% and 13% respectively with a catch rate of 31 kg, 12 kg, and 0.6 kg per unit operation. According to Appa Rao (1981), sardines accounted for about 6% of the total fish catch by shore seine at Waltair area. Recent observations preclude shore seine as a gear for lesser sardines at Waltair. *S. fimbriata* and *S. gibbosa* were the two species in the Visakhapatnam area with the former being dominant forming 79.6%. The relative percentage composition of the two species over the period was 68 : 32

in gill net and 92:8 in boat seine.

### Biology

Observations on the biology of important species of lesser sardines have been made by various authors. In the Goa-Karnataka region, studies were made by Annigeri (1982; 1989a,b) at Karwar on *S. gibbosa* and *S. dayi*. Appa Rao (1981) studied some aspects on the fishery and biology of sardines of Waltair area in the Andhra-Orissa region. All the information available on the fishery and biology of lesser sardine species till 1978 was summarized by Bennet *et al.* (1986).

*Sardinella gibbosa*: Results of study on biological aspects of the species are given below.

**LENGTH COMPOSITION:** In purse seine at Karwar, the size range of *S. gibbosa* was 4.5–20 cm with the 14–16 cm size groups dominating in the commercial fishery (Fig.6). During January–April the pre-monsoon fishery was supported by 4.5 – 19 cm sized fish. Smaller size groups of the range of 4.5–5.5 cm appeared during January 1984. The post-monsoon fishery (September–December) was supported by 10–20 cm size groups.

The length data of *S. gibbosa* from

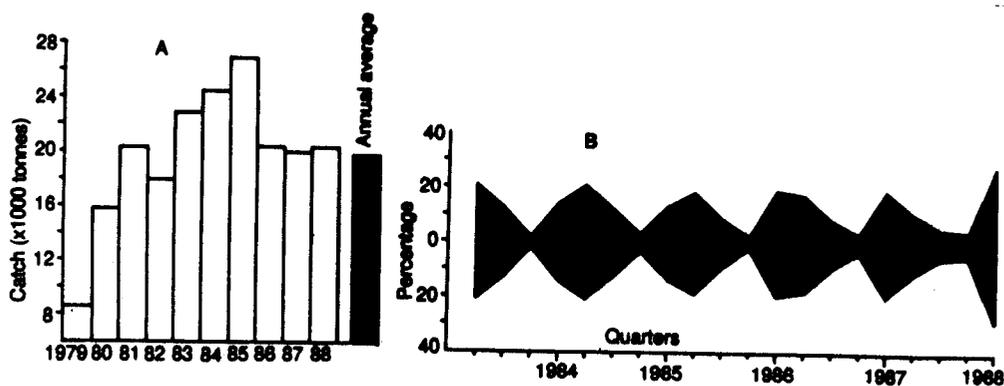


Fig. 5. Estimated annual landings during 1979-88 (A) and quarterly abundance (pooled for all gears) during 1984-88 (B) of lesser sardines in Andhra-Orissa region.

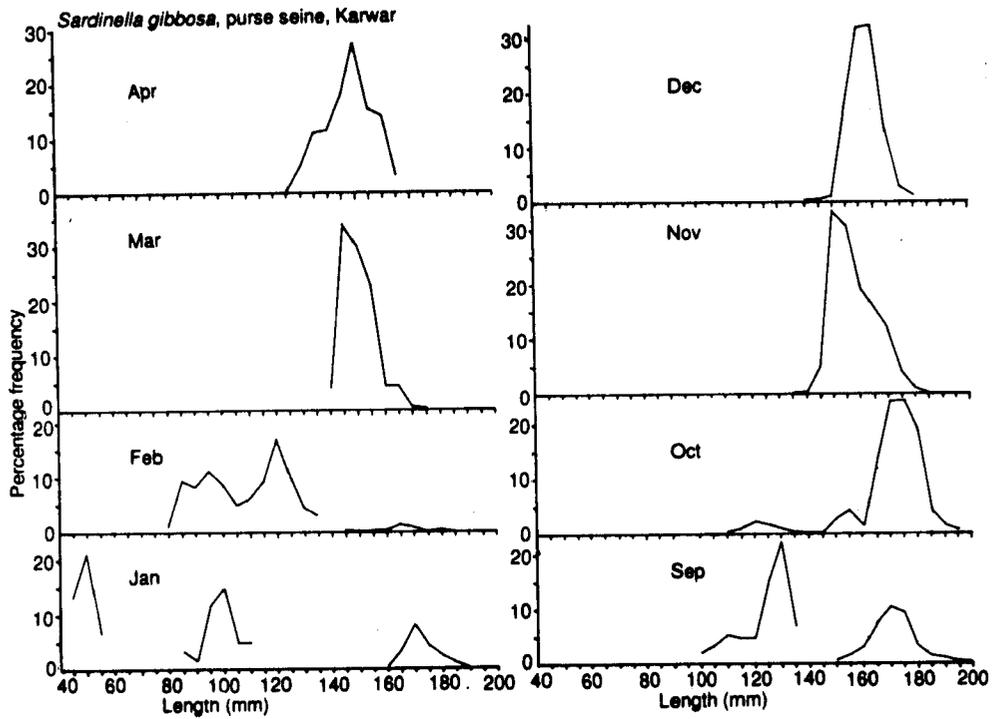


Fig. 6. Length frequency distribution of *Sardinella gibbosa* at Karwar during 1984-88 (average).

Vizhinjam showed the range from 11.5 cm to 18.5 cm in gill net and from 8.5 cm to 19.5 cm in shore seine (Fig. 7). Maximum number of fish was caught in gill net and the length range of commercial fishery was 13–16 cm. Smaller fishes of the length range 8.5–10 cm were available during May 1984 in shore seine.

At Tuticorin, in gill net, the length range of *S. gibbosa* was 9.5–18 cm with modal sizes between 13 and 14 cm (Fig. 8). The commercial fishery mostly depended on the 12.5–14 cm size range which occurred in almost all the months.

The length range of *S. gibbosa* in gill net at Madras was 8.5–16 cm with modal sizes at 12 or 13 cm during different years. The size was around 11.5–14 cm in commercial fishery.

At Visakhapatnam, *S. gibbosa* was in the

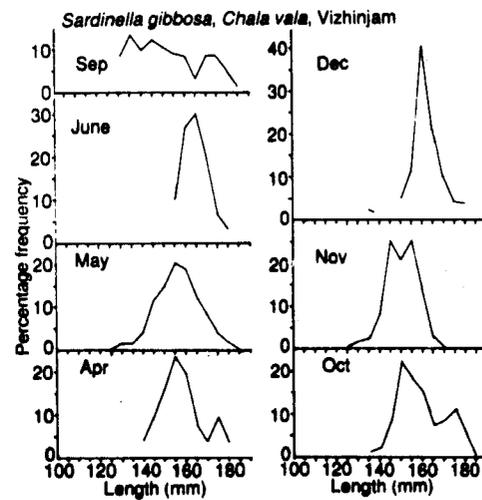


Fig. 7. Length frequency distribution of *Sardinella gibbosa* at Vizhinjam during 1984-88 (average).

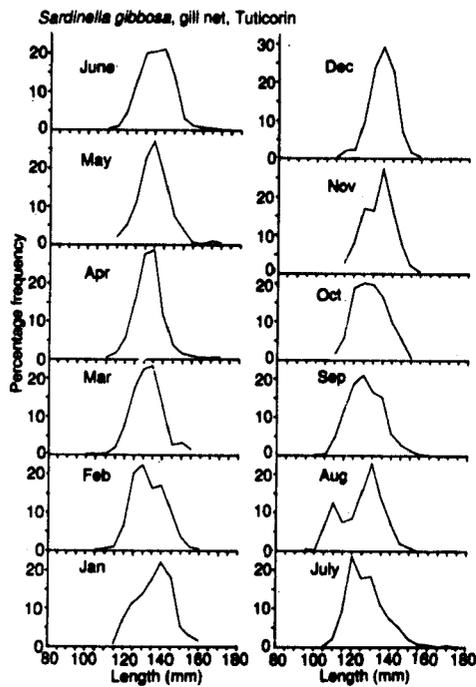


Fig. 8. Length frequency distribution of *Sardinella gibbosa* at Tuticorin during 1984-88 (average).

length range of 3.5–18 cm (Fig. 9). In boat seine, smaller sized fish of the range 3.5–13 cm were common, but in gill nets the length

range was 7.5–18 cm, and bulk of the catch was in the range of 10–16.5 cm. Larger fish measuring 17–18 cm occurred mostly during February to April.

Following Annigeri ((1989b), three age groups could be identified in the fishery of *S. gibbosa* at different regions. Commercial gill net fishery was mostly supported by 1st and 2nd year fish with a few fish in 3rd year of growth. In other gears also the pattern was almost similar.

**FOOD AND FEEDING:** Lesser sardines in general are plankton feeders. *S. gibbosa* was found to be a zooplankton feeder. The food items include copepods, *Lucifer*, prawn larvae, *Acetes*, Mysids, crab larvae, etc. Fish caught in the boat seines and shore seines were with 1/2 - full stomach and those in gill nets mostly had empty stomach.

**MATURATION AND SPAWNING:** Fish in all stages of gonadal maturity were met with during this study (Table 4). Though running ripe fish (stage VI) were rare in the commercial fishery, the gravid fish were abundant at Karwar and Visakhapatnam forming 13.4% and 24.6% respectively. At Vizhinjam and Tuticorin, fish with developing gonads were noticed abundantly. At Madras a major per-

Table 4. Specieswise and centrewise composition of different maturity stages of lesser sardines during 1984-88 (pooled)

Species/Centres	Maturity stage (%)					Sample size
	Indeterminate	II Resting	III & IV Developing	V & VI Gravid	VII Spent	
<i>Sardinella gibbosa</i>						
Karwar	1.9	11.7	35.6	13.4	37.4	1 502
Vizhinjam	7.2	3.0	65.5	15.9	8.4	1 185
Tuticorin	23.3	12.7	40.2	16.6	7.2	6 002
Madras	nil	46.9	35.7	8.4	9.0	3 468
Visakhapatnam	38.5	5.3	21.0	24.6	10.6	1 837
<i>S. fimbriata</i>						
Visakhapatnam	81.4	5.7	11.8	0.8	0.3	5 045
<i>S. sirm</i>						
Vizhinjam	9.1	11.8	36.5	29.0	16.6	773

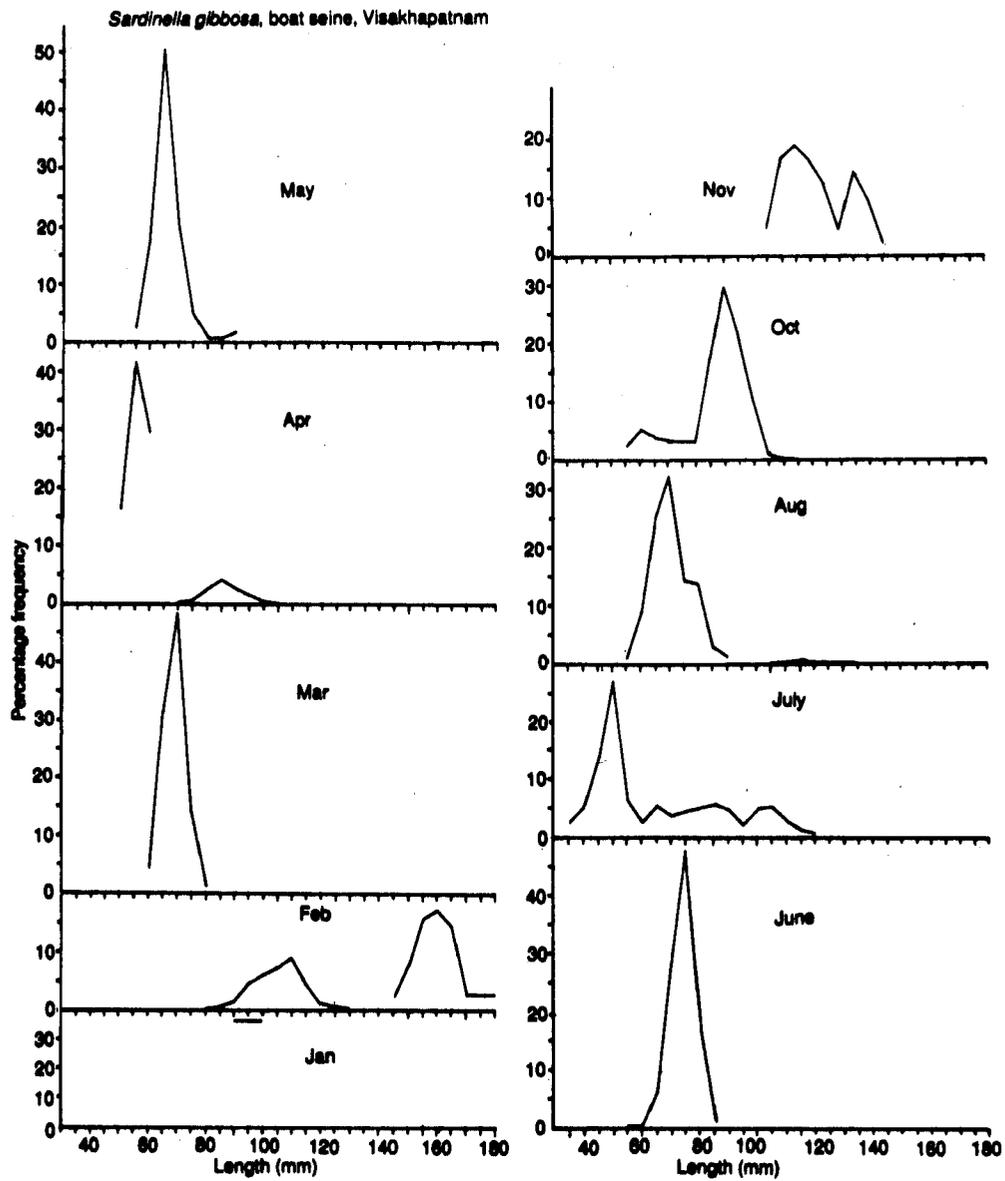


Fig. 9. Length frequency distribution of *Sardinella gibbosa* at Visakhapatnam during 1984-88 (average).

centage of the landings was in resting stage.

The season for the appearance of fish in different stages of maturity was not same at all the regions. Different maturity stages of fish

appeared in different months at different regions. Gravid fish were dominant during December at Karwar, whereas these were dominant in June at Vizhinjam, in April-July

at Tuticorin, in May and October at Madras and in January–April at Visakhapatnam. The results indicated differential spawning periodicity in different areas. *S. gibbosa* spawned during September–April at Karwar, May–June and October–November at Vizhinjam, December to March at Madras and January to April at Visakhapatnam. The trend of spawning at Tuticorin presented a differential pattern, with the broods of ripe eggs being released periodically when they mature.

**FECUNDITY:** According to Appa Rao (1981), fecundity of *S. gibbosa* varied between 12 786 and 41 326 ova. Present study indicated that most advanced groups of ova in fish of the length range 14–18.5 cm were between 26 000 and 73 000 in ovaries of stage V and between 14 000 and 58 000 in partly spent ovaries.

**SIZE AT FIRST MATURITY:** The size at first maturity of *S. gibbosa* at different centres is given in Fig. 10. The minimum size of matu-

rity was noticed as 115 mm at Karwar and Vizhinjam. As the spawning season approaches, percentage of mature fish gradually increases and reaches 50% level at a length of 135.5 mm at Karwar and Vizhinjam, 138.3 mm at Tuticorin, 139 mm at Madras and 136 mm at Visakhapatnam, indicating these as the size at first maturity.

**SEX RATIO:** Monthly variations in sex ratio between males and females were noticed in *S. gibbosa*. Sex compositions in different centres are given in Table 5. Indeterminate formed a major portion at Tuticorin and Visakhapatnam. Marked difference in the percentage occurrence of sexes was noticed at Karwar, Vizhinjam and Visakhapatnam.

*Sardinella fimbriata:* Studies on the biology of *S. fimbriata* were made at Visakhapatnam. The length range in the fishery was 4–19.5 cm (TL). Smaller fishes of the size 4–13 cm, with modal length varying from 5 cm to 10 cm, were caught in boat seine

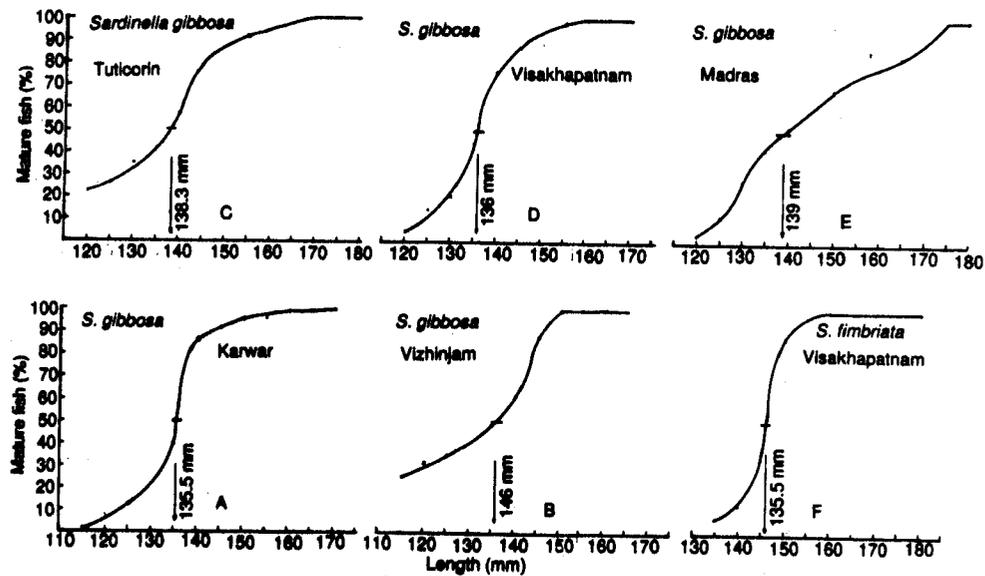


Fig. 10. The size at first maturity of *Sardinella gibbosa* at different centres and *S. fimbriata* at Visakhapatnam.

Table 5. Specieswise and centrewise sex ratio of lesser sardines during 1984-88 (pooled)

Species/Centres	No. of fish	Indeterminates	Adults	Sex ratio of adults	
				Male (%)	Female (%)
<i>Sardinella gibbosa</i>					
Karwar	1 502	29	1 473	46.3	53.7
Vizhinjam	1 185	25	1 100	47.6	52.4
Tuticorin	6 002	1 398	4 604	50.2	49.8
Madras	3 468	nil	3 468	49.1	50.9
Visakhapatnam	1 837	707	1 130	44.7	55.3
<i>Sardinella fimbriata</i>					
Visakhapatnam	5 045	4 107	938	46.3	53.7
<i>Sardinella sirm</i>					
Vizhinjam	773	70	703	56.2	43.8

during October to April. In the gill net, the size range was 4.5–19.5 cm, with 7.5–13 cm size fish forming the major component in the commercial fishery. Larger fish of the length range 18–19.5 cm occurred in May–August. Appa Rao (1981) observed that certain size groups of *S. fimbriata* suddenly disappeared from the fishing grounds during some months, and other size groups appeared in the catches, indicating that different broods enter the population.

Food comprised mainly of zooplanktons. Phytoplanktons occurred in small quantities. According to Appa Rao (1981), the fish measuring less than 50 mm fed mainly on diatoms, whereas those of 51–100 mm fed on both diatoms and copepods. Larger fish above 100 mm fed mainly on copepods and other zooplanktons.

The growth parameters were estimated as:  $L_{\infty}$ , 217.4 mm; K (annual), 1.3;  $t_0$ , -0.0647 (annual); and  $L_{max}$ , 196 mm. Based on these parameters the growth of *S. fimbriata* was estimated and the fish attained the lengths of 75, 115, 145 and 165 mm at the end of 3, 6, 9 and 12 months respectively.

The length-weight relationship was estimated as:

$$\log W = -4.9208 + 2.90826 \log L \quad (r = 0.995)$$

Juveniles occurred in large numbers at Visakhapatnam. Adults with spent, resting and developing gonads formed the main catch at Visakhapatnam. Fish in advanced stage of maturity was rarely met with. Smallest fish with developing gonad was 135 mm long. At total length of 146 mm, 50% fish became mature (Fig. 7.F). Adult fish occurred mainly in July and August, indicating the spawning season.

*Sardinella sirm*: Gill net catches at Vizhinjam landed *S. sirm* of the length range 13.5–22.0 cm. Modal size group of the younger fish which occurred in May was 15.5 cm. Larger fish measuring 17.5–22 cm with a mode at 20 cm were available from January to April, June and November. In shore seines, three size groups were landed, viz., the younger fishes of the range of 6–7.5 cm with a mode at 7 cm, the second group of 10–13 cm with a mode at 12.5 cm, and the larger fish of 19–21.5 cm with a mode at 20 cm.

Estimate of sex ratio for *S. sirm* is given in Table 5. The indeterminate ones formed 9.1%. Among the adults, the sex ratio M:F was 46.2:53.8. During spawning season, over 50% of the fish attained maturity at the length of 17 cm. Fecundity of *S. sirm* ranged from 121 500 to 132 900 (Lazarus 1984).

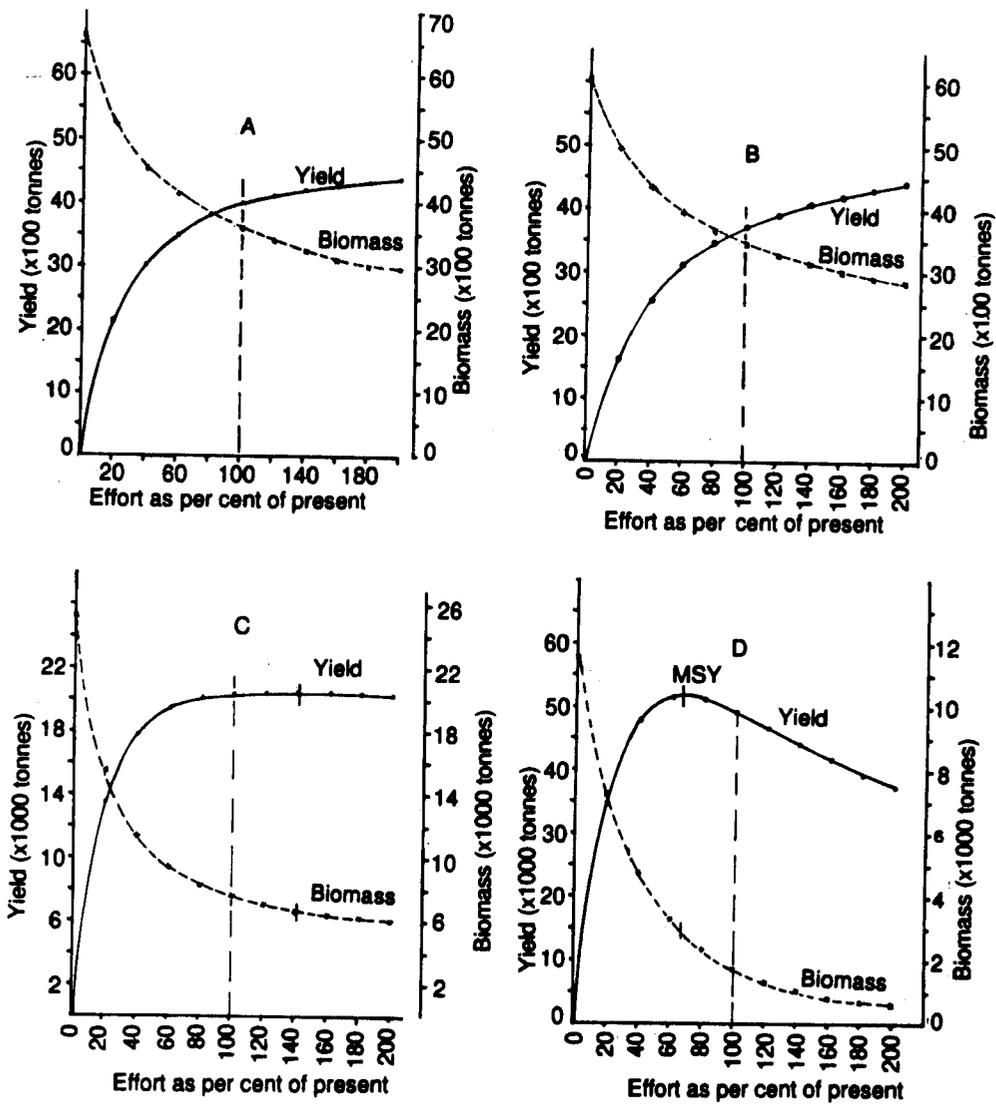


Fig. 11. Yield and biomass of *Sardinella gibbosa* at different levels of effort at A. Goa-Karnataka, B. Kerala, C. Tamil Nadu-Pondicherry and D. Andhra-Orissa regions.

*Sardinella dayi*: Biological studies of the fish were mostly confined to Karwar, where it forms a minor fishery in the purse seine. 11–18 cm fish contributed to the fishery. According to Annigeri (1982), three to four broods

are manifested in the fishery.

The spawning biology of *S. dayi* was studied by Annigeri (1989a). According to him the size at first maturity was around 140 mm. October–December was the peak spawn-

Table 6. Growth parameters, mortality rates and yield parameters of *Sardinella gibbosa* at different regions

Parameters	Goa-Karnataka	Kerala	Tamil Nadu-Pondicherry	Andhra-Orissa
$L_{\infty}$ (mm)	211	197	191	191
K (annual)	1.4	1.2	1.5	1.5
$t_0$ 0.0	0.0	0.0	0.0	
$L_{max}$ (mm)	195	190	170	175
Length (mm) at age				
Ist year	157.9	140.6	148.4	148.4
IInd year	197.6	180.8	181.5	181.5
IIIrd year	204.5	188.3	186.5	186.5
Size (mm) at first maturity	135.5	135.5	138.3	136.0
M 1.976	1.888	2.140	2.100	
F 1.208	2.053	4.687	4.180	
Z 3.184	3.941	6.827	6.280	
MSY	4 561.936	at X>50	20 455.860	5 166.186
X 5.0156	**	1.4125	0.6625	
Biomass MSY	1 986.028	**	6 667.823	2 825.728

\*\*Not estimated since MSY is realizable only at an exorbitantly high level of F.

ing season, with a second spawning of a smaller scale during January–May. The average fecundity was 66 000 ova.

#### Stock assessment

*Sardinella gibbosa*: The values of growth parameters, mortality rates and yield parameters of *S. gibbosa* are presented in Table 6.

The yield at present along the regions on the west coast is considerably lower than the maximum sustainable yield (MSY). A considerable increase in effort is needed to reach the MSY in these regions, especially in the Kerala region where more than 50 times increase in the present effort is needed to achieve the MSY (Fig 11.A,B).

On the other hand, in the Tamil Nadu-Pondicherry region, the present yield from the fishery is more or less steady, reaching almost the MSY level (Fig. 11.C).

Along the Andhra-Orissa region the stock is subjected to more fishing pressure than required for a balanced fishery. Here the yield has crossed the optimum level (Fig. 11.D) and

any further increase in effort may not necessarily give increased catch at the present stock levels.

#### DISCUSSION

The study on the total catch, effort and catch per unit of effort of lesser sardines and the stock assessment of the most abundant species in the group (*S. gibbosa*) showed that in the stock levels, existing during 1984–88, the catch could be increased to some extent in the west coast, provided the effort by exclusive gears like gill net was increased, aiming the lesser sardines as the target fishes. The gears employed in this area do not aim at the lesser sardines and hence, a sizeable quantity escapes from the fishing effort.

In the Tamil Nadu-Pondicherry region, the fishery was providing maximum yield during 1984–88. Relatively good fishery was recorded throughout the year because it was a targeted nearshore fishery in this area. The effort inputs during the study period were close to the optimum level, and sufficient for