

# **Marine Fisheries Research and Management**

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# 19 Lesser sardines resources of India

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## ABSTRACT

*The lesser sardines comprising ten species form a minor or major fishery in all the maritime states of India during one or the other part of the year. The Central Marine Fisheries Research Institute has taken up a study of the fishery and biology of the important species at some centres and has published the results periodically. The present article reviews the work carried out and highlights the important results pertaining to the fishery, biology and population characteristics along the Indian coast.*

## Introduction

The lesser sardines comprising several species of *Sardinella*, other than the oil sardine, has emerged as an important resource along the Indian coast. Catch data and certain important biological aspects of the dominant species have been studied at the Institute since the late fifties. The catch of lesser sardines has registered a steady increase over the past few years, both along the east and the west coasts of India. In the fifties (1950-'59) the annual average catch was around 28,862 t which increased to 70,751 t in the eighties (1980-'89) and is presently (1990-'94) around 83,749 t. Motorisation/mechanisation of fishing, introduction of innovative fishing gear and gear materials, etc., have greatly contributed to the increase in the landings of the resource. Several species of lesser sardines form an important resource at certain centres. Biology and population characteristics of the dominant species were studied in detail as reviewed below.

### Material and methods

The catch and effort data were collected from all the gears at the landing centres along both the coasts of India. Monthly estimates of catch and effort were made based on 16 – 18 day's observations of the landings each month. Data published by the Institute were also used. To study the length frequency and other biological aspects, random samples from each of the gears operating in the region were collected twice a week together with the landing data. Studies on the total length, weight, sex and maturity condition of the component species were carried out on fresh specimens. Fecundity studies were made both on the fresh and preserved samples by using standard methods. Age and growth parameters were estimated using the von Bertalanffy's growth formula; and the mortality and yield per recruit were estimated using the Beverton and Holt (1957) formula as simplified by Ricker (1975).

### Species composition

The lesser sardine fishery along Indian coast is represented by 10 species (Bennet *et.al.* 1986) viz: *Sardinella gibbosa* (Bleeker), *Sardinella albella* (Valenciennes), *Sardinella fimbriata* (Cuvier and Valenciennes), *Sardinella dayi* Regan, *Sardinella sirm* (Walbum), *Sardinella sindensis* (Day), *Sardinella clupeoides* (Bleeker), *Sardinella melanura* (Cuvier), *Sardinella letogaster* (Valenciennes) and *Sardinella jonesi* (Lazarus). Of these, the first seven species formed the bulk of the fishery at different centres, the remaining occurring sporadically and in stray numbers at certain centres. Studies on the identification and bionomics of lesser sardines have been carried out since the early forties (Chacko, 1946 and Nair, 1953). Raja and Hiyama (1969a) studied the systematics and biometrics of a few Indo-Pacific sardines and later Raja and Lazarus (1975) gave a detailed description of *S. dayi* of Indian seas with remarks on its close similarity with *S. madrasensis* (Lowe) and *S. jussieui* (Valenciennes). *S. melanura* and *S. sindensis* occurring along our coast was re-described by Lazarus (1977b). Lazarus (1983) based on his studies at Vizhinjam described in detail the occurrence of a new species of sardine, *S. (Amblygaster) jonesi* with a key to the species of subgenus *Amblygaster* Bleeker, 1849.

### **Distribution**

The lesser sardines are tropical in distribution and occur along the coasts of Arabia, Red sea, east Africa, Madagascar, India, Sri Lanka, Malaysia, Singapore, Philippines, Australia and China. Along the Indian coast the resource forms a fishery in all the states, but the species exhibit discontinuous distribution with one species being dominant in one region and other species in another region.

Along the coasts of West Bengal, Orissa and Andhra Pradesh, *S.fimbriata* and *S.gibbosa* support the fishery. Along Tamil Nadu *S.gibbosa*, *S.albella*, *S.dayi* and *S.sirm* are the dominant species. Besides these *S.clupeoides* occurs around the southern most region (Bennet, 1965). Vijayaraghavan (1953) has reported occurrence of *S.melanura* along Madras coast. All the lesser sardine species make their appearance at one time or other along the southwest coast, between Cape Comorin and Quilon; *S.gibbosa*, *S.sirm*, *S.sindensis* and *S.dayi* formed good fishery in the region. Along Karnataka -Goa coast, *S.gibbosa*, *S.fimbriata* and *S.dayi* formed the fishery whereas along Maharashtra and Gujarat, *S.fimbriata* and *S.albella* occur in the fishery. In Andaman waters, *S.albella*, *S.dayi*, *S.melanura* and *S.sirm* form the fishery. Occurrence of *S.leiogaster* also has been reported by Menon and Talwar (1975). At Lakshadweep, *S.melanura* has been reported by Jones and Kumaran (1959) and *S.clupeoides* and *S.fimbriata* by Jones (1969).

### **Fishery**

The various species of lesser sardines together sustain a good fishery especially along Andhra-Tamil Nadu in the east coast and Kerala- Goa in the west coast. Fig. 1 gives the all India estimated annual yield of lesser sardines for the years 1950-1993. Fluctuation in the production, which is an inherent characteristic, observed in most shoaling pelagic groups is discernable in the catches of lesser sardines also. The catch fell from 53,000 t in 1950 to 16,000 t in 1954. Thereafter it rose to 32,000 t in 1959 and then fell to a mere 9,000 t in 1962. A high catch of 11,483 t was obtained in 1963. Similarly good landings were observed in the year 1975, when 1,12,117 t were landed. During the late eighties the catch has fluctuated around 75,000 t and a catch of

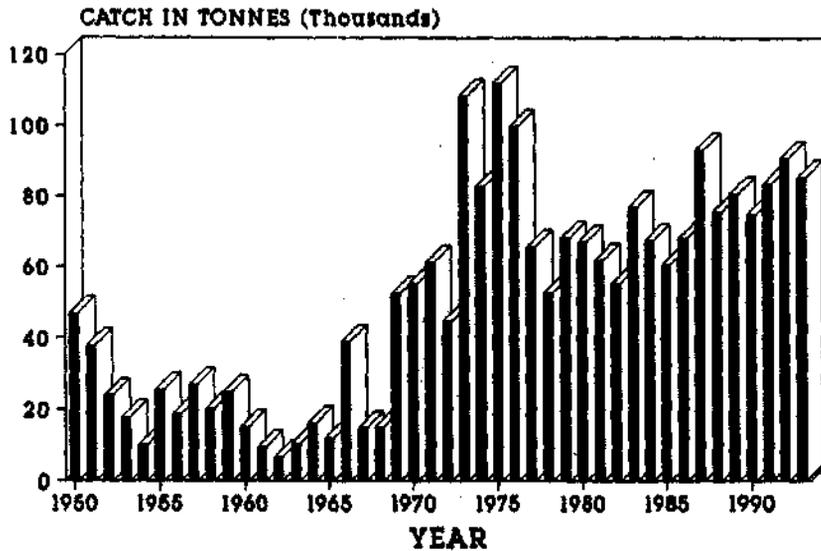


Fig.1. Estimated Annual Yield in Tonnes of Lesser Sardine during 1950-1993

85,473 t was landed during 1993.

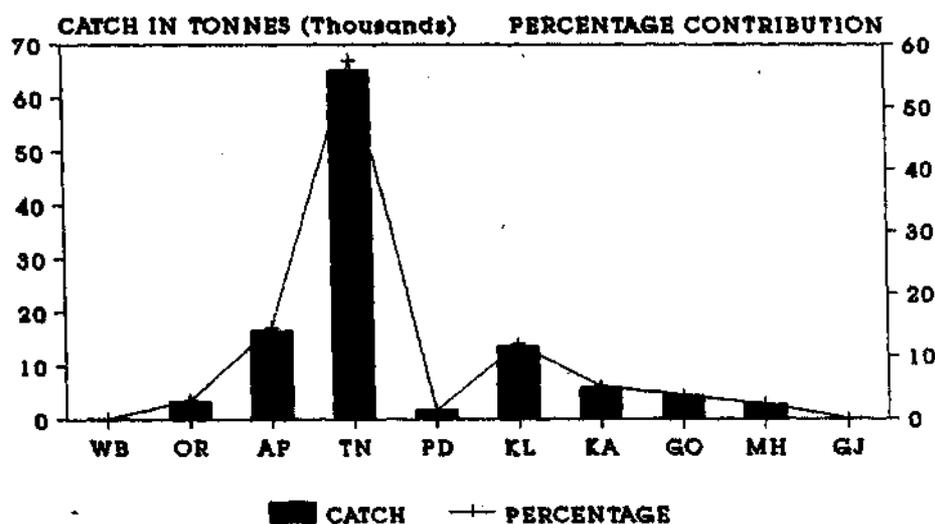
#### Craft and gear

Indigenous, non-motorised, motorised and mechanised crafts are employed in the fishery. Dug-out and plank built crafts are used in the inshore waters whereas purse seiners, gill netters and trawlers are employed for exploiting the resource in the near shore areas upto a depth of 40-60 m. The *catamarans* are popular along the east coast and bring in substantial quantities of lesser sardines.

A variety of fishing tackles are employed in the capture of lesser sardines. The more widely used gears in the west coast are boat seines and purse seines. Purse seines, which replaced the *Rampant* (shore seine) in Karnataka coast, helped to enhance the lesser sardine catch in the region. Sardine gill nets are the main gear in the east and south west coasts landing lesser sardines in good numbers. Cast net and hook and line are also used to catch small quantities of lesser sardines around Vizhinjam (Lazarus, 1984b). The trawlers operating in near shore regions especially below 40 m land sardines in considerable quantities along Karnataka coast.

**Exploitation**

An exclusive single species fishery for lesser sardines does not occur in any region. Two or more species with a dominance of one of them are landed by various gears operating along the coast and it comprises 3 to 6 % of the total fish catch of the country. Regionwise availability of the different species and catch trends for the years 1968 - '78 has been described by Bennet *et al.* (1986). Lesser sardines form an important resource along Andhra Pradesh, Tamil Nadu, Kerala, Karnataka and Goa coasts. Along West Bengal, Orissa, Maharashtra and Gujarat coasts, the resource forms a minor fishery and does not contribute greatly to the catch. The annual average statewise landings of lesser sardines along with the percentage contribution of each state to the total lesser sardine landings of the country during the nine year period of 1985 to 1993 is given in Fig.2.



**Fig.2. Average Statewise Landings of Lesser Sardines (1985-1993)**

Along West Bengal coast, lesser sardines do not form an important resource and comprise only 0.19 % of the total fishery. During most of the years, the catch is meagre and the highest catch of 398 t was observed in 1991.

Lesser sardines are better represented in Orissa with the catch ranging from 959 t in 1992 to 7536 t in 1987. An average of 3478 t was landed annually during 1979-1993 and the resource contributed to 6.8 % of the total

marine fishery of the state. The peak fishing season for the resource along West Bengal -Orissa coasts is during November-April (Dharmaraja and Phillipose, 1975).

Along Andhra Pradesh coast the resource forms 12 % with an average annual (1979-'93) landings of 16,335 t. Highest catch of 28,371 t was observed during 1989 and the lowest of 6,180 t during 1979. The peak fishing season for the lesser sardines at Visakhapatnam extends from October to June with *S.fimbriata* and *S.gibbosa* forming the dominant species at the centre (Ganapathi and Rao, 1957; Rao, 1981; Rao *et al.*, 1980; Luther, 1994 and Luther *et al.*, 1994).

Along Tamil Nadu coast, the lesser sardines sustain a good fishery and forms 10% of the total marine fishery resources of the State. The average annual catch of lesser sardines is around 30,031 t. In spite of the good fishery, fluctuations in the catch associated with this group has been obvious with the catch ranging from 46,366 t in 1987 to 19,611 t in 1990. At Tuticorin the resource is available throughout the year with the peak from September to March. *S. gibbosa* forms the dominant fishery and *S.dayi*, *S.albella*, *S.stm* and *S.clupeoides* are less dominant (Bennet and Arumugham, 1989 & 1991). At Mandapam the fishery lasts from April to October in Palk Bay with *S.albella* as the most dominant species and along the Gulf of Mannar the season extends from November to March with *S.gibbosa* as the dominant one (Bennet *et.al.*, 1986) Along Madras coast, the main fishing season is during March-April (Basheeruddin & Nayar, 1961) with *S.fimbriata* and *S.stm* as the major species.

Pondicherry also has a good fishery for lesser sardines with the resource comprising 13.8 % of the total fish catch of the State. The average landings is around 1,762 t. The annual landings ranged from 794 t in 1990 to 3,399 t in 1983.

Along the west coast, Kerala sustains a good fishery especially south of Alleppy with annual average landings of 11,767 t. The resource comprises 8.9 % of the total marine fish catch of the State. The resource exhibited the usual periodic fluctuations with a low catch of 2,473 t in 1985 and a high catch of 22,819 t in 1993. Along Alleppy coast the fishery is good during August to December. At Vizhinjam two peak periods of fishery are observed, the first during April-July and the second during September- December with

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*S.gibbosa*, *S.dayi* and *S.sirm* as principal species. Along Calicut coast, the peak fishing season extends from September to February with *S.gibbosa*, *S.fimbriata* and *S.dayi* as the dominant species.

Karnataka sustains a moderate fishery for lesser sardines with an annual average landing of 5,469 t comprising 3.4 % of the total. High catch of 12,894 t was observed during 1992 and a low catch of 3,151 t during 1982. The fishing season extends from September to November with *S.gibbosa*, *S.dayi* and *S.fimbriata* forming dominant species (Annigeri, 1982 & 1989).

In Goa the lesser sardines form 5.3 % of the state's total marine fish catch with an annual average landing of 3,319 t. The annual landing has been fluctuating between 658 t in 1983 and 10,761 t in 1992. The fishing season extends from September to February with peak in December. *S.gibbosa* and *S.fimbriata* are the important species.

In Maharashtra the resource forms less than 1% of the total marine fish catch. The annual average landing is about 1,846 t with the catch ranging from 254 t in 1984 to 6,935 t in 1993. The resource is caught during September- May with good catches during December to April. *S.fimbriata* and *S.gibbosa* are the chief species.

Lesser sardines do not support a fishery of importance along Gujarat coast and it comprises a mere 0.04 % of the total fish catch of the State and in some years the fishery was non-existent. The highest catch of 543 t was observed during 1987 and the annual average catch is estimated around 103 t.

### **Biological studies**

The biology of the dominant species has been studied at the various Centres of the Institute and information on the size composition, maturity, fecundity, reproduction, spawning grounds, food habits, parasites infesting on them, etc., are available. The results of the studies conducted have been tabulated in Tables 1-3.

Table 1. Results of the fishery and biological studies conducted on lesser sardines at different centres.

	<i>S.gibbosa</i>	<i>S.fimbriata</i>	<i>S.albella</i>	<i>S.sirm</i>	<i>S.dayi</i>
FISHING SEASON	Jan-Dec (a) Nov-Dec. (a)	Mar.-Apr (b) Oct-Nov. &	Jan.-May & Aug.-Dec. (a)	Jan.-Jul. Sep.-Dec. (a)	Jul.-Dec. (b)

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	Feb.Mar. & Jun.-Jul. (b)	May-Jun. (b)	Apr.- Jul. & Sep.- Dec. (a)	Jun.-Dec. (a)	Mar.-Apr. (b)
	Sep.-Mar.(b)	Nov.-Mar. (b)	Sep.-Mar. (b)	Nov.-Mar. (b)	
	Nov.-Mar. (b)		Apr.-Oct. (b)		
	Sep.-Non. (b)				
	Dec.-Apr (b)				
Size range (cm) in Fishery	4-21.3 (b)	6-18 (b)	6-23 (b)	9-17 (b)	2-15.5 (b)
Commercial size (cm)	5-10 (b)	10-12 (b)		14-20 (b)	12-14 (b)
	12-14 (b)				
Age group (yr)	0-2	0-2		0-2	0-1
Maturity	10.7-18.4	13.5-18.5(b)	14.6-15.5 (c)	20.7 (d), 19.7	14 (e)
Size (cm)	(a,g,h)	12(g), 15(f)	10.7 (g)		
Spawning season	Mar.-Apr. (a)	Aug.- Sep. (g)	Feb.-Jul. (a)	Feb.-Jul. (b)	
	Feb.-Jul. (b)	Apr.-Jun. (f)	Mar.-Apr- (a)	Oct.-Dec. & Jan.-May (e)	
	Jul.-Feb. (b)	Jan.-Apr. (c)	Mar.-May(g)		
	Aug. - Feb (b)	Oct.- Nov. (g)			
Fecundity	12,786-41,326 (b)	17,974-34,545 (a)	10,000-13,500 (c)	121,500-132,900 (b)	14,000-66,280 (e)
		5,500-41,700 (b)			

a. Shekaran, b. Bennet *et.al.*, c. Radhakrishnan, d. Lazarus, e. Annigeri, f. Chidambaram, g. Chacko & Mathew, h. Ganapathi & Rao.

Table. 2. Important food components of lesser sardines.

<i>S.gibbosa</i>	<i>S.albella</i>	<i>S.fimbriata</i>	<i>S.dayi</i>	<i>S.sirm</i>	<i>S.clupeoides</i>	<i>S.melanura</i>
Zoea larvae	<i>Fragilaria</i>	Dinophysis	Calanid	Calanid	Calanid	<i>Pseudodiaptomus</i>
<i>Eucalanus</i>	<i>Rhyncalanus</i>	<i>Acartia</i>	Metanauplius	<i>Euterpina</i>	<i>Euterpina</i>	<i>omus</i>
<i>Euterpina</i>	<i>Labidocera</i>	<i>Temora</i>	<i>Labidocera</i>	nauplii	<i>Acartia</i>	<i>Paracalanus</i>
<i>Oncaea</i>	<i>Eucalanus</i>	<i>Pseudodiaptomus</i>	Other	<i>Eudadne</i>	<i>Mysis</i>	<i>Eucalanus</i>
<i>Corycaeus</i>	<i>Euterpina</i>	<i>omus</i>	crustaceans	<i>Acetes</i>	<i>Alima</i>	Ostracods
<i>Acartia</i>	<i>Microsetella</i>	<i>Euterpina</i>	prawn larvae	<i>Mysis</i>	Phyllosoma	Decapod larvae

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Macrosetella	Other copepods	Evadne	Acetes	Prawn larvae	Porcellosoma	Vegetable
Pseudodiaptomus	Lucifer	Copepod eggs	Molluscan larvae	Cocsinodiscus	Thenus	matter
Prawn larvae	Mysis	Mysis	Fish tissue	Trichoceratium	Acetes	Acetes
Megalopa	Megalopa	Acetes	Thalassiothrix	Foraminifera	Cocsinodiscus	
Lucifer	Bivalve larvae	Other	Cocsinodiscus		Bivale larvae	
Mysis	Pteropods	crustaceans	Trichodesmium		Trichodesmium	
Crustacean remains	Fish larvae	Prawn larvae	Rhizosolenia		Ceratium	
Fish eggs	Bacteriastrum	larvae	Foraminifera			
Fish larvae	Rhizosolenia	Cocsinodiscus				
Molluscan larvae	Pleurosigma	Fragilaria				
Trichodesmium	Triceratium	Nitzschia				
Cocsinodiscus	Trichodesmium	Ceratium				
Rhizosolenia	Cocsinodiscus	Biddulphia				
Bacteriastrum	Foraminifera	Trichodesmium				
Chatosigma	Oithona	Navicula				
Pleurosigma	Corycaeus	Thalassiothrix				
Thalassiothrix	Acartia	Planktoniella				
Copepods	Sagitta	Pleurosigma				
Foraminiferans	Fish eggs	Acanthometon				
Sagitta		Dinophysis				
Acetus		Peridium				
Alpheus						

**Table 3. Parasites of lesser sardines**

Name of fish	Name of parasite	Mode of infection	Effect on host
<i>Sardinella gibbosa</i>	<i>Aponurus</i> spp.	Stomach parasite	
	<i>Heminurus</i> spp.	Stomach parasite	
	<i>Caligus</i> spp.	Buccal cavity	
	<i>Cymothoa</i> spp.	Opercle, head	
<i>Sardinella albella</i>	<i>Peroderma</i>	Burried within the body of host at lateral side	Gonad retarded, never attains maturity

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	<i>Bomolocus sardinellae</i>	Eye parasite	Gonad development
	<i>Pumillopsis sardinellae</i>	One parasite on each eye	retarded
<i>Sardinella sirm</i>	<i>Pumillopsis sathopedes</i>	Eye parasite(on the eyeball)	Gonad retarded, never attains maturity
	<i>Cymothod spp.</i>	Sides of the body	
<i>Sardinella fimbriata</i>	<i>Pseudopetalus formmicoides</i>	Buccal cavity	
	<i>Lernanthropus oblongus</i>	Gill	
	<i>Cymothoa spp.</i>	Sides of the body	

**Population structure**

Studies on the population of important/dominant lesser sardine species have been carried out at some of the centres. Estimation of the length-weight relationship,  $L_{\infty}$ ,  $K$ ,  $t_0$ , mortality, yield, exploitation rate, etc., have been worked out for some of the species to make an assessment of the long term effect of changes in fishing on catch trends (Rao et al. 1980; Annigeri 1985 & 1989) (Table 4). Lazarus and Thiagarajan (1994) made an assessment of the exploitation of sardine stock off Vizhinjam using Schaefer and Fox models separately on three species. The boat seine was taken as the standard effort. The results showed a need for the reduction in effort to get the MSY of individual species. However studies at Karwar indicated that there is no great pressure on the resource at present

Table 4. Important population parameters of lesser sardines

Parameter	<i>S.gibbosa</i>	<i>S.albella</i>	<i>S.daji</i>
Length-weight relationship	$W=5.0660+3.0434$ Log L (Female) $W=-6.9909+3.0780$ log l (Male) (a)	$W=-6.8950+3.1757$ Log L (Female) $W=-5.1458+3.0518$ Log L (Male) (a)	$W=-4.3525+2.3591$ Log L (Female) $W=-6.0753+3.4081$ Log L (Male) (b)
$L_{\infty}$ (mm)	96.36(a), 183 (b) 144.26 (b) 0.32 (a), 1.61(b),0.75 (b)	78.65 (a) 0.3(a)	150.39 (b) 0.3(b)

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to	-0.16(b),-0.43(b)	-0.7413 (b)
M	0.8212(b),0.8218(b)	0.7961 (b), 0.7961 9b)
F	0.09 -0.38 (b)	0.7961 (b),0.7961 9b)
Z	1.31(b)	0.54 (b)
Exploitation rate U	0.1224 (b)	0.54 (b)
Total annual stock Y/U	159231 (b, All India)	50514 (b, All India)
	10701 (b, Karwar)	653(b,Karwar)
Average standing stock	87399(b, All India)	21311 (b,All India)
Y/F	5873 (b,Karnataka) 1535 (b,Karnataka)	
	1435 (b,Karwar)	275 (b,Karwar)
a-sekharan	b-Bennet	

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**Management options**

The studies show that the resource is available throughout the year at one Centre or the other. Studies on the stock assessment of some species conducted at Karwar indicated that there is no great pressure on the resource at present and there is further scope for increasing the catch along that region. However, as stock assessment estimations on all the species of lesser sardines along the entire range of distribution is lacking and as they co-exist in the same grounds, it is desirable to conduct further studies on these lines for proposing some conclusive management measures for the resource.

**Economics and marketing**

The lesser sardine, forming a source of cheap protein, is available almost throughout the year and fetches about Rs.3-6/- per kg at the landing centres. The fluctuations and the steep decline in the catches of oil sardine during the recent years have resulted in increased demand for lesser sardines. The fish is consumed fresh in the coastal places and is transported with ice flakes to nearby states by road and train. The resource has a great demand in the dried form also and the salt dried products are sent to interior States of India and adjacent countries. The smaller fishes, which do not fetch a good price in local markets, are dried and used as an important protein mix for the preparation of cattle/poultry/ fish feed.

**Future studies**

Although several species contribute to the fisheries, the biology and stock assessment studies of only a few have been carried out. Efforts have to be made to collect detailed information on all the species of commercial importance so as to forecast the fishery and give appropriate management measures for sustaining the resource. The introduction of improved and innovative gears and gradual shift in the fishing grounds has resulted in catching more of lesser sardines and also in the exploitation of certain new stocks hitherto not observed in certain regions. The catch has to be continuously monitored for racial studies on the available population in the distributional range in order to understand the existence of more than one stock in any given region.

**References**

- Annigeri, G.G. 1982. On the fishery and biology of *Sardinella dayi* (Regan) at Karwar, India. *J. mar. biol. Ass. India*, **24**(1&2): 133-140.
- Annigeri, G.G. 1985. Estimation of yield per recruit and stocks of lesser sardines, *Sardinella gibbosa* (Bleeker) and *S.dayi* Regan in the Karwar waters (West coast of India). *J. mar. biol. Ass. India*, **27**(1&2): 175-182.
- Annigeri, G.G. 1989. On the age and growth and mortality of *Sardinella gibbosa* (Blkr) of Karwar waters (west coast of India). *Indian J. Fish.*, **36** (3):199-203.
- Bennet, P.S. 1965. On *Sardinella clupeioides* (Bleeker) from the coasts of India. *J. mar. biol. Ass. India*, **7**(1): 208-210.
- Bennet, P.S. 1971. Some observations on the fishery and biology of *Sardinella fimbriata* (Val.) at Vizhinjam. *Indian J. Fish.*, **14**(1&2):145-158.
- Bennet, P.S. and G.Arumugham. 1989. The present status of small scale traditional fishery at Tuticorin. *Mar.Fish. Infor. Serv. T&E Ser.*, **99**:1-15.
- Bennet, P.S. and G.Arumugham. 1991. The present status of small scale traditional fishery at Tuticorin. *Mar.Fish. Infor. Serv. T&E Ser.*, **113**:1-16.
- Beverton, R.J.H. and S.J.Holt. 1957. On the dynamics of exploited fish populations. *Fish. Invest. Minist. Agric. Fish.G.B. (2 Seafish)*, **19**:533p.
- Chacko,P.I. 1946. On the bionomics of the Indian sprat *Sardinella gibbosa* (Cuv.&Val). *J.Bombay nat. Hist. Soc.*, **46** (2):407-408.

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- Chacko, P.I. and M.J.Mathew. 1956. Biology and fusheries of the sprat *Sardinella Albella* (Cuv &Val) in the west coast of Madras coast. *Fish.Sta.Rep.Year b., Madras April 1954- March 1955* :103-108.
- Chidambaram. K. And R.S.Venkataraman.1946. Tabular statements on the natural history of certin marine food fishes of Madras Presidency. Madras Government press, 26 p.
- Dharmamba, M. 1967. On the juveniles of *Sardinella fimbriata* (Valenciennes) and *Sardinella gibbosa* (Bleeker). *Indian J.Fish.*, **10A**(1): 167-181.
- Dharmaraja, S.K. and Varughese Phillipose. 1975. Trends in the yields of major exploited fisheries of the east coast of India. *Indian J.Fish.*, **6**: 374-388.
- Ganamekalai, A.G. 1962a. Studies on the age and growth of the karimeen chalai, *Sardinella sirm.* *Madras J. Fish.*, **1**: 25-39.
- Ganapati, P.N. and K.S.Rao. 1957. On the bionomics of *Sardinella gibbosa* (Blkr) off Waltair coast. *J.Zool. Soc. India.* **IX**(2): 162-182.
- Jones,S. 1969. Catalogue of fishes from the Laccadive archipelago in the reference collections of the Central Marine Fisheries research Institute. *Bull. Cent. Mar. Res. Inst. Mandapam Camp*, 8:32p.
- Jones,S. and M.Kumaran. 1959. The fishing industry of Minicoy Island with special reference to the tuna fishery. *Indian J. Fish.*, **6**(1) : 31-57.
- Lazarus,S. 1977a. Observations on the food and feeding habits of *Sardinella gibbosa* from Vizhinjam. *Indian J. Fish.*, **24**(1&2): 107-112.
- Lazarus,S. 1977b. A redescription of *Sardinella melanura* (Cuvier) (Clupeidae:Pisces) with remarks on the species *Sardinella nigricaudata* Chan. *Indian J. Fish.*, **24** (1&2) :220-222.
- Lazarus,S. 1983. A new species of sardine *Sardinella (Amblygaster) jonesi* from Vizhinjam, south west coast of India with a key to the species of subgenus *Amblygaster* Bleeker 1849. *J.mar. biol. Ass. India*, **20** (1&2): 80-87.
- Lazarus,S and R.Thiagarajan. 1994. An assessment of the exploitation of the sardine stock off Vizhinjam, south west coast of India. *J.mar. biol. Ass. India*, **36** (1&2): 100-105.

- Luther, G. 1994. Status of sardine fishery at Visakhapatnam, *Mar. Fish. Infor. Serv. T&E Ser.*, **133**:10-14.
- Luther, G., C.V.Seshagiri Rao and M.S.Sumithrudu. 1994. The role of gill net in the exploitation of lesser sardines. *Mar. Fish. Infor. Serv. T&E Ser.*, **133**:10-14.
- Nair, R.V. 1953. Key for the identification of the common clupeoid fishes of India. *J. Zool. Soc. India*, **5**(1):108-138.
- Radhakrishnan, N. 1964. Notes on some aspects on the biology of the fringe scale sardine, *Sardinella fimbriata* (Cuvier & Valenciennes). *Indian J. Fish.*, **XI** (1):127-134.
- Raja, B.T.A. and Y.Hiyama. 1969a. Studies on the systematics and biometrics of a few Indo-Pacific sardines. *Rec. Oceanogr. Works Japan*, **10**(1): 73-103.
- Raja, B.T.A. 1969b. On *Sardinella stirm* (Walbaum) from Okinawa. *Rec. Oceanogr. Works Japan*, **10**(1): 150-157.
- Raja, B.T.A. and S.Lazarus. 1975. A description of *Sardinella dayi* Regan (Pisces:Clupeidae) of Indian seas with remarks on the close similarity with *Sardinella madrasensis* (Lowe) and *Sardinella jussieu* (Valenines). *Indian J. Fish.*, **22**(1&2): 113-125.
- Rao, K.V.S., V.R.Rao, P.Mojumder, T.Appa Rao, S.Reuben, S.S.Dan and B.Narayana Rao. 1980. Pelagic fishery resources of Lawson's Bay, Waltair. *Indian J. Fish.*, **27**(1&2): 35-53.
- Rao, T. Appa. 1981. On some aspects of the fishery and biology of sardines of Waltair area. *Indian J. Fish.*, **28**: 96-103.
- Ricker, W.E. 1975. Computaton and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Board Can.*, **101**: 382p.
- Sekaran, K.V. 1968. Growth rates of the sardines, *Sardinella albella* (Val.) and *S.gibbosa* (Bleek.) in the Mandapam area. *Indian J. Fish.*, **15**(1&2): 68-80.
- Sekaran, K.V. 1973. On the food of the sardine *Sardinella albella* (Val.) and *S.gibbosa* (Bleek.) in the Mandapam area. *Indian J. Fish.*, **13**(1&2): 96-141.
- Sekaran, K.V. 1973. Length weight relationship in *Sardinella albella* (Val.) and *S.gibbosa* (Bleek.) in the Mandapam area. *Indian J. Fish.*, **15**(1&2): 166-174.
- Talwar, P.K. 1974. A note on the *Sardinella letogaster* Val. (Pisces:Clupeidae) from India. *Indian J. Animal Sci.*, **44**(12):1025-1026.
- Vijayaraghavan, P. 1953. Food of sardines of Madras coast. *J. Madras Univ.*, **23**(1): 29-39.