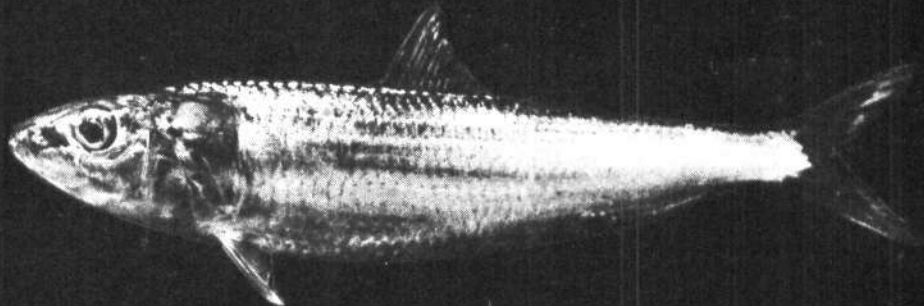




CMFRI SPECIAL PUBLICATION  
Number 48

THE INDIAN OIL SARDINE, *SARDINELLA LONGICEPS*  
VALENCIENNES — AN ANNOTATED BIBLIOGRAPHY



CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

Indian Council of Agricultural Research  
P. B. No. 2704, Dr. Salim Ali Road,  
COCHIN - 682031, INDIA

OCTOBER 1990

**THE INDIAN OIL SARDINE, *SARDINELLA LONGICEPS*  
VALENCIENNES — AN ANNOTATED BIBLIOGRAPHY**

**Girjakumari. S.**

**CMFRI Special Publication  
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**Central Marine Fisheries Research Institute  
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OCTOBER 1990**

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## PREFACE

Research and development efforts on marine fisheries of the country have contributed to a rapid growth of literature. However, no attempt has so far been made to develop bibliographies on commercially important species/groups of marine fishes of India, so that the large community of research workers and fishery managers could be benefited. Therefore, to begin with, the Central Marine Fisheries Research Institute has taken up a programme of compilation of 'Annotated Bibliographies' on commercially important species/groups such as prawns, oil sardine, mackerel, silver-bellies, ribbon-fishes and bombay-duck.

Efforts have been made to include all the relevant literature in these bibliographies. There could be some omissions and so the bibliography is not claimed to be complete in itself. The Institute would welcome information on omissions of any important citations.

Annotations have been done carefully to give at a glance the contents of the original publications. Wherever the authors' abstracts were found sufficient, these were reproduced as such, and in other cases the available abstracts were modified or fresh abstracts were made based on the contents of the original articles.

The present number, entitled 'The Indian oil sardine, *Sardinella longiceps* Valenciennes — An Annotated Bibliography', is the second in the series of bibliographies. The bibliography mainly includes the work done in the Indian region. However, a few references pertaining to the species from the adjacent seas are also referred to. I hope this will be useful for the scientists and others in the field by enabling them to have a rapid survey of relevant literature.

I appreciate the interest taken and efforts made by Smt. S. Girijakumari of the Library and Documentation Section for the compilation of this annotated bibliography.

Cochin - 682031  
9. 10. 1990

P. S. B. R. JAMES  
DIRECTOR

## CONTENTS

1.	SYSTEMATICS AND DISTRIBUTION	1 - 6
2.	FISHERY	7 - 30
3.	BIOLOGY	31 - 44
4.	STOCK ESTIMATE	45 - 47
5.	FISH PROCESSING	48 - 76
6.	AUTHOR INDEX	77 - 80

## 1. SYSTEMATICS AND DISTRIBUTION

1. ANON. 1951. *Preliminary guide to Indian fish, fisheries, methods of fishing and curing*. Agricultural Marketing in India, Marketing Series No.66. Manager of Publications, Delhi, 137 pp.

Oil sardine, under the name *Clupea longiceps*, is listed, giving a figure and description, commercial uses, oil and guano contents, and the prevalent methods of curing, as well as the local names in five languages on page 23 of the monograph.

2. ANON. 1982. Scientific, common and local names of commercially important marine fishes and shellfishes of Maharashtra and Gujarat coasts. *Mar. Fish. Infor. Serv. T&E Ser.*, Central Marine Fisheries Research Institute, Cochin, No.44, p. 18-23.

The local name of oil sardine in Marathi and Gujarathi are given on page 19.

3. ANTONY RAJA, B.T. ; HIYAMA, YOSHIO. 1969. Studies on the systematics and biometrics of a few Indo-Pacific sardines. *Rec. Oceanogr. Works, Japan*, 10:75-105.

The systematics of different species of sardine including the Indian Oil Sardine of the Indo-Pacific region is studied in detail. The morphometric and meristic characters are compared, giving tables and figures. The comparisons are claimed to have shown great variations even within the same species, clearing confusions hitherto existed.

4. BAL, D.V.; VIRABHADRA RAO,K. 1984. Oil sardine. In: *Marine Fisheries*. Tata McGraw Hill Publishing Company Ltd., New Delhi, Chap. 4, p. 51-73.

The article reviews the taxonomy, food and feeding, life history, reproduction, fishery, and utilization of oil sardine. The important types of craft and gear used in the fishery are described. All India catch statistics for the years 1958 to 1979, and regionwise statistics for 1968 to 1979 are furnished.

5. BENSAM, P. 1981. Taxonomic problems in the identification of clupeiform eggs and larvae in the Indian waters. *Rapp. P. V. Reun Cons. int. Explor. Mer.*, 178 : 605-607.

The difficulties that were commonly being encountered in identification of clupeiform eggs because of the overlapping of characters such as size and type of oil globule are explained, particularly with reference to the eggs of *Sardinella fimbriata* and *S. longiceps*, and some suggestions are given to overcome them.

6. CHULLASORN, SOMSAK; MARTOSUBROTO, PURWITO. 1986. Distribution and important biological features of coastal fish resources in South-east Asia. *FAO Fish. Tech. Pap.*, No. 278, 84 pp.

The distribution and biological features of oil sardine are reviewed among other major coastal fishes furnishing countrywise-tables. In the study are included South-east Asian countries bordering Andaman sea to the South China sea. The geographic distributions of the major species are given in schematic illustration. Oil sardine is stated to have predominated in Bali Strait.

7. CMFRI. 1988. Marine fish calendar. 1. Mangalore. *Mar. Fish. Infor. Serv. T&E Ser.*, No. 79, p. 1-23.

Particulars of oil sardine fishery at Mangalore, such as the gears used, seasonal abundance etc, are given along with those of other species. Oil sardine formed 44.3 % of the total marine fish catch during 1981-85.

8. CMFRI. 1988. Marine fish calendar. 2. Visakhapatnam. *Mar. Fish. Infor. Serv. T&E Ser.*, No. 80, p. 1-21.

The local names, catch figures, gear used in the fishery, relative composition of catches, length range of fish in the fishery, sizes at first maturity and spawning seasons of important fishes including oil sardine are presented, based on the data collected at Visakhapatnam from 1981 to 1986.

9. CMFRI. 1988. Marine fish calendar. 3. Calicut. *Mar. Fish. Infor. serv. T & E Ser.*, No. 81, p. 1-9.

Particulars of fishery of oil sardine in Calicut region are given. Figures showing monthwise species composition of clupeids in gillnet catches and seasonal abundance of oil sardine in boat seine and gill net are given. The average annual landings of oil sardine during 1981 - 86 was 3, 288 tonnes.

10. CMFRI. 1988. Marine fish calendar. 6. Tuticorin. *Mar. Fish. Infor. Serv. T & E Ser.*, No. 84, p. 1 - 8.

Oil sardine collected from Tuticorin is described with figure, giving catch data. Sardines are stated to have formed 13.2% of landings during the period of report.

11. CMFRI. 1988. Marine Fish calendar. 9. Vizhinjam. *Mar. Fish. Infor. Serv. T & E Ser.*, No. 87, p. 1 - 15.

Oil sardine is described with figure based on data collected from Vizhinjam from 1981 to 1985. Figures showing monthwise species composition are given, in which sardines are included, which had contributed to 4.89% of the fishery.

12. CMFRI. 1988. Marine fish calendar. 10. Karwar.  
*Mar. Fish. Infor. Serv. T & E Ser.*, No. 88, p. 1 - 3.
- Oil sardine is described with figure. Graph showing seasonal abundance of oil sardine is also given. Sardines formed 60% of the fishery during 1981 - 85, of which oil sardine was a major component.
13. DAY, FRANCIS. 1865 (1981). *The Fishes of Malabar*.  
 Bernard Quaritch, London (Rep. by Bishen Singh Mahendra Pal Singh, Dehra Dun), 293pp.
- Description of oil sardine is given on page 230 under the name *Sardinella neohowii*, providing the distinguishing features, occurrence and habitat.
14. DAY, FRANCIS. 1878 (1981). *The Fishes of India* 2V.  
 William Dawson & Sons Ltd., London (Rep. by Today and Tomorrow Book Agency, New Delhi), 778pp.
- The description and figure (plate CLXI) of oil sardine under the name *Clupea longiceps* is given on page 637 of the Text. The names used by different authors, physical description, colour, occurrence and habitat are also provided.
15. DAY, FRANCIS. 1889 (1963). *The fauna of British India*,  
 Fishes. V. 1. Taylor and Francis, London, 548pp.
- Description of oil sardine under the name *Clupea longiceps* is given on page 373, giving synonyms, identification marks, habitat etc.
16. DAVIDSON, ALAN. 1976. *Seafood of South - East Asia*,  
 Federal Publications, Singapore, 366pp.
- Sardinella longiceps* with figure is dealt with on page 25 of the monograph.
17. DEVANESAN, D. W.; CHIDAMBARAM, K. 1953. The oil sardine.  
 In: *The common food fishes of the Madras state*. Government Press,  
 Madras, p. 14 - 17.
- [See Item No. 193]
18. FISCHER, W.; WHITEHEAD, P. J. P., Ed. 1974. *FAO Species identification sheets for fishery purposes, Eastern Indian Ocean (Fishing Area 57) and Western Central Pacific (Fishing Area 71)*, FAO of the UN, 1, CLUP Sardl .3.
- The identification sheet for *Sardinella longiceps* Valenciennes gives as in other cases the vernacular names, distinguishing characters, geographical distribution and behaviour, existing fishing grounds, catches, main fishing gear and principal forms of utilization.



19. FISCHER, W.; BIANCHI, G. Ed., 1984. *FAO Species identification sheets for fishery purposes, Western Indian Ocean* (Fishing area 51), FAO of the UN, Rome, 1, CLUP. Sardi 3.

The sheet contains the vernacular names, distinguishing characters, geographical distribution and behaviour, current fishing grounds, catches, fishing gear and forms of utilization of oil sardine pertaining to the Western Indian Ocean.

20. FOWLER, HENRY, W. 1956. *Fishes of the Red Sea and Southern Arabia*, V. 1. Weizmann Science Press of Israel, Jerusalem, 240pp.

Taxonomy of *Sardinella longiceps* with an illustrated description is given on page 65.

21. GUNTHER, ALBERT. 1868 (1964). *Catalogue of the fishes in the British Museum*, V. 7. British Museum, London (Rep. by Wheldon & Wesley Ltd., Codicote and Verlag J. Cramer, Weinheim).

Oil sardine is listed (Sl. No. 22) as *Clupea longiceps* on page 428, based on specimen collected from Pondicherry, and again, as *Clupea scombrina* (Sl. No. 56) on page 449, based on specimen collected from Cochin.

22. MISRA, K. S. 1957. An aid to identification of common commercial fishes of India and Pakistan, *Rec. Indian Mus.*, 57, 320 pp.

Identification key to *Sardinella longiceps* is given on page 44. Figure and description are given on page 115. Distribution of the fish and references to literature are also given.

23. MISRA, K. S. 1963 (1976). *Fauna of India and the adjacent countries, Pisces*, V. 2. Zoological Survey of India, Calcutta, 438pp. (Revised second edition of Day, F.; Fauna of British India).

Detailed specific characters of *Sardinella longiceps* Valenciennes is given along with a list of synonyms and vernacular names and with one figure on pages 45 to 47. The then known areas of distribution are also furnished. A field key is given on page 387.

24. MUNRO, IAN, S. R. 1955 (1982). *The Marine and Freshwater Fishes of Ceylon*, Department of External Affairs, Canberra (Rep. by Narendra Publishing House, Delhi). 351 pp.

Brief description with identification keys of *Sardinella longiceps* is given on page 25. A figure is provided at the end (plate 4).

25. MPEDA. 1980. *Indian Fishery Atlas*, Marine Products Export Development Authority, Cochin, p. 18 - 19.

Oil sardine is described with figure, distribution, salient features, different trade names, etc. Map showing distribution of the fish along Indian coast is also given.

26. NAIR, R. VELAPPAN. 1953. Key for identification of the common clupeoid fishes of India. *J. Zool. Soc. India*, 5 (1): 108 - 112.

Key for identification of oil sardine is given as taken from Misra's checklist of fishes, reproducing figures from Day's Fishes of India.

27. NAIR, R. VELAPPAN. 1960. Synopsis on the biology and fishery of the Indian Sardines. In: *Proceedings of the World Scientific Meeting on the Biology of Sardine and Related Species*, 14 - 21 September 1959, Ed. by Rosa, H and G. Murphy, FAO, Rome, 2:329 - 414.

Identity, distribution, bionomics and life history, and population and exploitation of oil sardine along the coast of India is given briefly. Tables are presented giving the vernacular names, size composition, production of sardine oil, landings etc.

28. NAIR, R. VELAPPAN. 1973. *Indian sardines*. (Biology and Fishery). CSIR Zoological monograph No. 2, Publication and Information Directorate, New Delhi, p. 1-36.

[ See Item . No. 226.]

29. RONQUILLO, I. A. 1960. Synopsis of biological data on Philippine sardines (*Sardinella perforata*, *S. Sirm*, *S. longiceps*), In : *Proceedings of the World Scientific Meeting on the Biology of Sardines and Related Species*, 14-21 September 1959, Ed By Rosa, H and G. Murphy, FAO, Rome, Italy, 2: 453 - 495.

Identity, distribution, life history and exploitation of *Sardinella longiceps* in Philippine waters are given briefly along with the other species.

30. SHINDO, SHIGEAKAI; CHULLASORN, SOMSAK. 1980. Economically important marine fishes in the Southeast Asian waters. *SEAFDEC Text Reference Book Series*, No. 17, 443 - 532.

Distinguishing characters, distribution, behaviour, fishing grounds, gears, catches and utilization etc of oil sardine in Southeast Asian region are given, as taken from FAO identification sheets.

31. SIVAKUMARAN, K. P. ; MANICKASUNDARAM, M.; RAMAIYAN, V. 1987. Problems of identification among species of *Sardinella*. National Symposium on Research and Development on Marine Fisheries, 16-18 September 1987, *CMFRI Spl. Publ.*, No. 40, Abstract No. 35 and also paper No. 26 *Bull. Cent. Mar. Fish. Res. Inst.*, No. 44, Pt.I, p. 223 - 226.

The paper argues on the inadequacy of meristic and morphometric characters for the identification of the species of *Sardinella* in general. Of the species cited as examples, oil sardine is, however, stated to be easily identifiable based on its greater head length. The ranges of morphometric and meristic counts of the various species are tabulated for comparison.

32. SOERJODINOTO, R. 1960. Synopsis of biological data on lemuru, *Clupea (Harengula) longiceps* (C. V). In : *Proceedings of the World Scientific Meeting on the Biology of Sardines and Related Species*, 14 - 21 September 1959, Ed. by Rosa, H and G. Murphy, FAO, Rome, 2: 313 - 328.

Identity, distribution, bionomics, life history, and population and exploitation of the oil sardine of Indonesian waters are given briefly under the name *Clupea longiceps*. Figure showing area of distribution and tables showing catches during 1950 - 58 are given.

33. WEBER, MAX; BEAUFORT, L. F. 1913. *The fishes of Indo - Australian Archipelago*, E. J. Brill, Leiden, 2: 82.

*Sardinella longiceps* is described under the name *Clupea (Harengula) longiceps* (C. V. ). Identification characters and habitat are given.

34. WHITEHEAD, P. J. P. 1972. A synopsis of the clupeoid fishes of India. *J. mar. biol. Ass. India*, 14 (1) : 160 - 256.

A synopsis of the clupeoid systematics in general, the paper contains the synonyms, description, figure, distribution and references to literature of oil sardine.

35. WHITEHEAD, P. J. P. 1985. FAO Species catalogue of clupeoid fishes of the world. *FAO Fish. Synop.*, No. 125, V. 7, Pt. 1, p. 104 - 105.

*Sardinella longiceps* is described giving synonyms, diagnostic features, geographical distribution, habitat, biology, fisheries, size, local name etc. A figure is also provided.

## 2. FISHERY

36. ANNIGERI, G. G. 1969. Fishery and biology of the oil sardine at Karwar. *Indian J. Fish.*, 16 (1&2): 35 - 50.

The oil sardine catches at Karwar from 1964 - 65 to 1967 - 68 fluctuated between 4.41t (1964 - 65) and 250.06t (1967 - 68). The fishes were found matured when about 140mm total length, and the spawning season lasted from July- August to November - December. The temperature range of 27° - 29.5° c and low salinity and phosphate contents seemed to cause good fishery.

37. ANNIGERI, G. G. 1987. Present status of oil sardine fishery at Karwar on the west coast of India. National Symposium on Research and Development in Marine Fisheries, *CMFRI Spl. Publ.*, No. 40, Abstract No. 34 and paper No. 25, *Bull. Cent. Mar. Fish. Res. Inst.*, No. 44, Pt.1, p. 214 - 222.

The status of oil sardine fishery after the introduction of purse seines is reviewed and its impact on the traditional fishery is discussed. The average annual yields of traditional gears both before the introduction of purse seines (1967 to 1976) and after (1976 to 1985) are compared. Yield per recruit and MSY are also estimated.

38. ANON. 1947. Marine Fisheries of India. *Proc. Indo-Pacif. Fish. Coun. 1st meet.*, Sec 3, p. 73-81.

It is a report on the activities of the Marine Fisheries Research Stations then established by the Government of India, in which the works done on the oil sardine eggs and larvae at Calicut are included making mention of the laboratory experiments attempted at rearing.

39. ANON. 1960. *Indian Fisheries Bulletin*, Government of India, Ministry of Food and Agriculture, 7 (1, 3)

The bulletin, forming the recommendations made at the first meeting of the Central Board of Fisheries held at New Delhi on 29 December 1959, deals with oil sardine fishery, too, of the west coast of India (on pages 3 and 5).

40. ANON. 1967. Tagging experiment for sardine and mackerel. *Seafood Trade J.*, 2 (11): 35-37.

The article is an appraisal on the importance of tagging experiments particularly of sardine and mackerel, and summarises the steps taken in this by the National Tagging Programme under CMFRI.

41. ANON. 1967. Five year plan of work. *UNDP / FAO Pelagic Fishery Project (IND 93)*, 19pp.

Outlining the past achievements and current programmes of the project, the article proposes, with the help of a chart, a comprehensive five-year programme of work. In all the three aspects considered, oil sardine is dealt with, presenting information in brief on its fisheries, biology, and eggs and larvae.

The past, present and proposed activities on acoustic aerial and vessel surveys to locate shoals and eggs and larvae are also given.

42. ANON. 1969. Marine fish production in India 1960-1968. *Bull. Cent. Mar. Fish. Res. Inst., Cochin*, No. 13, 144pp.

Annual and quarterly amounts of marine fish production, including the production of oil sardine, in the maritime states and Union Territories for 19 years from 1950 to 1968 as estimated by CMFRI are presented and discussed, showing the major influence of oil sardine on the trend of annual production. 114 tables form the main content of the Bulletin, which project the estimated figures statewise, yearwise, groupwise. Data on fishing areas, craft and gear and export of products are also presented.

43. ANON. 1972. *25 years of Marine Fisheries Research*. Central Marine Fisheries Research Institute, Cochin, 72pp.

In this divisionwise review of works done at the Institute, a short account of oil sardine and its fishery is included in the fishery biology section, outlining the trend of production and marketing.

44. ANON. 1973. Results of the first years' survey with the "Sardinella" *UNDP/FAO Pelagic Fishery Project (IND 93) Progress Report No. 2*, 50pp.

The findings on hydrography and plankton are presented, showing that, apart from the normal fishing season for oil sardine and mackerel, which was October to March, fishing could be attempted during August-May also. Figures and tables on the findings are given.

45. ANON. 1973. Hydrographic investigations June 1971 to January 1973. *UNDP/FAO Pelagic Fishery Project (IND 93) Progress Report No. 3*, 35pp.

This was the first summary report on the hydrographic data collected by the project, on which the future programme of environmental work of the project was intended to be based. The water qualities observed - temperature, salinity, dissolved oxygen etc - are illustrated in line graphs.

46. ANON. 1973. Report on aerial survey, 3-10 October 1972. *UNDP/FAO Pelagic Fishery Project, Progress Report. No. 4*, 25pp.

Gives the results of the aerial survey made on surface schools of sardines and mackerel, in combination with surface observations along the coast from Quilon to

Ratnagiri. Tables and figures are given.

47. ANON. 1973. Biological sampling data and catch statistics of mackerel and oil sardine from different fishing centres during the seasons 1971/72 and 1972/73. *UNDP/FAO Pelagic Fishery Project (IND 93) Progress Report, No. 5, 31pp.*

Catch statistics and related data collected from 13 centres on the southwest coast of India are presented discussing the probable causes of fluctuation, namely O-year class contributing to the mainstay of the fishery, rapid growth rate, migration etc. Tables and figures projecting the data are given.

48. ANON. 1974. Survey results. 1972/73. *UNDP/FAO Pelagic Fishery Project (IND 69/593) Progress Report, No. 6, 141pp.*

The abundance and distribution of the pelagic resources including oil sardine and the environmental factors of the project area between September 1972 to August 1973 are presented, discussing the biology and potentials. The data collected onboard are tabulated.

49. ANON. 1975. Results of the 1974 aerial survey. *UNDP/FAO Pelagic Fishery Project (IND 69/593) Progress Report, No. 9, 19pp.*

Combined aerial/vessel survey done in 1974 are reported to have shown that the schools of mackerel and sardine were mainly concentrated south of Mangalore. The estimated stock size were smaller than before. Figures and tables are given.

50. ANON. 1975. Young fish studies. *UNDP/FAO Pelagic Fishery Project, (IND 69/593) Progress Report, No. 10, 36pp.*

The study based on materials obtained from the southwest coast of India from over 800 pelagic trawlings is stated to have shown that the periods of considerable occurrence of young oil sardine were April-August and November-February. Figures are presented.

51. ANON. 1975. Survey of mackerel and sardine schools in 1975. *UNDP/FAO Pelagic Fishery Project (IND 69/593) Progress Report, No. 11, 8pp.*

In 1975, survey was conducted on board R/V Rastrelliger, covering the area from Ratnagiri to Trivandrum. The distribution of schools observed and the density and biomass estimates based on the survey are given.

52. ANON. 1976. Survey results 1973/74. *UNDP/FAO Pelagic Fishery Project (IND 69/593) Progress report, No. 12, 116pp.*

During 1973 to 1974 ten echo surveyings and hydrographic observations were carried out along the southwest coast. The distribution and abundance of biomass as interpreted from the findings are presented geographically. Observations made on

sardine and mackerel are reported to have indicated that these species perhaps never left the shelf. Tables and figures are given for the data.

53. ANON. 1976. Survey results, 1974/75. *UNDP/FAO Pelagic Fishery Project (IND 69/593) Progress Report*, No. 13, 107pp.

The findings based on echo surveyings and fish and plankton samplings and the hydrographic observations from October 1974 to October 1975 along the southwest coast and Gulf of Mannar are reported. The biomasses of mackerel and oil sardine are estimated separately. Main spawning of oil sardine is stated to have been found from April to August. Tables and figures are given.

54. ANON. 1976. Catch statistics, growth and sexual maturity of mackerel and oil sardine as analysed from data collected at fishing centres on the southwest coast of India. *UNDP/FAO Pelagic Fishery Project (IND 69/593) Progress Report* No. 14, 34pp.

Compared to 1972-73, the oil sardine landings are reported to have increased in 1973-74 in Goa, Karnataka and Kerala. The spawning is reported to have started about May and to have continued throughout the monsoon season. Tables and figures on the data are given.

55. ANON. 1976. Physical oceanography of the southwest coast of India based on the investigations of the UNDP/FAO Pelagic Fishery Project. *UNDP/FAO Pelagic Fishery Project (IND 69/593) Progress Report*, No. 16, 36pp.

Reporting the physical features of 200 hydrographic sections from Ratnagiri to Tuticorin during 1971-75 and discussing their relationship with biomass, the paper states that fishes like oil sardine might concentrate below the thermocline during the upwelling period because of low oxygen concentrations and that such studies might lead to predicting fisheries.

56. ANON. 1978, 1979, 1980, 1981, 1982, 1983, 1986, 1989.  
Trends in marine fish production in India. *Mar. Fish. Infor. Serv. T & E Ser.*, Central Marine Fisheries Research Institute, Cochin, Nos. 2; 9; 22; 32; 41; 52; 67; 91.

All the eight numbers of the Series, under reference deal with statistics of marine fish landings in India, respectively for 1977, 1978, 1979, 1980, 1981, 1982-83, 1983-84, 1984-85 and 1985-86. The data including those of oil sardine are projected, comparing with the previous years', statewise, groupwise, gearwise, regionwise and centrewise. The trend of oil sardine landings showed decline from the preceding year in 1977, 1979, 1980, 1982-83, 1983-84, 1984-85 and 1985-86, but increase in 1978 and 1981.

57. ANON. 1979. Calibration of hydroacoustic equipment on board R. V. Rastrelliger (March-April 1977) *UNDP/FAO Pelagic Fishery Project, Phase II: Technical Report* No. 2, 52pp.

The Report discusses the results of calibration experiments conducted on pelagic shoals in March and April 1977 off the southwest coast of India, of which six covers oil sardine. The mortality of oil sardine was found higher with small specimens than with larger ones. Tables and figures are given.

58. ANON. 1979 Aerial frame survey along the southwest coast of India. *UNDP/FAO Pelagic Fishery Project, Phase II: Progress Report*, No. 3, 104pp.

While correlating the results of survey carried out in the project area with distribution of resources, with a view to obtaining a synoptic picture of the fishing efforts and distribution, the paper gives the background information, in a paragraph, pertaining to oil sardine fishery resources between Quilon and Ratmagiri.

59. ANON. *Indian Fishery Handbook*. Marine Products Export Development Authority, Cochin, p. 76. (Revision of Indian Fishery Atlas by MPEDA).

This handbook gives figures of fishes of commercial importance in Indian waters, including oil sardine. Scientific and trade names along with resource potential, area of distribution etc are listed below the figures.

60. ANON. 1980. India-Live fish calibration of hydroacoustic equipment on board R/V *Rastrelliger* (EK system, March 1978 and EK/W system, November-December 1978). A report prepared for the pelagic fishery investigations on the southwest coast, Phase II Project. *FAO FI-DP/IND/75/038*, 37pp.

The paper describes the methods and results of a live-fish calibration experiment conducted on oil sardine with a new acoustic equipment in comparison with the old one. Tables and figures are given.

- 61., ANTONY RAJA, B.T. 1967. Length weight relationship in the oil sardine, *Sardinella longiceps* Val. *Indian J. Fish.*, 14 (1 & 2): 150-170.

The length weight data of oil sardine collected from Calicut Region in the years 1959 to 1964 are studied. A total of over two thousand fish were considered for analysis of covariance, after classifying the fish according to season of capture, and sex and maturity. Attempts were made at converting the weight of fish to number of fish, with a view to obtaining the abundance of stock in space and time. Tables and figures are given.

62. ANTONYRAJA, B. T. 1972. A forecast for the ensuing oil sardine fishery. *Seafood Exp. J.*, 4 (10): 27-33.

An experience paper citing some probable factors that might help in fishery forecast, such as fishing effort, accessibility to population, population size and the rainfall because it might affect the spawning process of the fish.



63. ANTONYRAJA, B. T. 1972. A possible explanation for the fluctuation in abundance of Indian Oil Sardine, *Sardinella longiceps* Valenciennes. *Proc. Indo-Pacif. Fish. Coun.*, 15 (3): 241-252.

Based on the oil sardine landings at Calicut during 1960 to 1969, a relation is worked out between rainfall during the spawning period and abundance of juveniles. It has been claimed that, based on rainfall and gonadial features of the adult during June to August, it was possible to forecast fishery in advance of 2 months. Figures are given for the various aspects studied.

64. ANTONYRAJA, B.T. 1973. Forecasting the oil sardine fishery. *Indian J. Fish.*, 20 (2): 599-609.

Oil sardine landings for the period of 1956-57 to 1972-73 were studied in relation to June-August rainfalls exploring means of forecasting fishery. The study is claimed to have shown that from the intensity of rainfall during the spawning period of forecasting of the fishery would be possible. The extent of atresia in ovaries and the relative abundance of juveniles during the spawning period are also reckoned as pointers. Figures and tables are given.

65. ANTONYRAJA, B. T. 1973. The Indian oil sardine fishery; problems in perspective. *J. mar. biol. Ass. India*, 15 (2) : 735-749.

The problems inherent in the oil sardine fishery are reviewed and discussed. The fluctuation in the fishery is stated to be due to variations in the annual recruit of juvenile broods, which in turn has been linked with the density of southwest monsoon.

66. ANTONYRAJA, B. T. 1973. The oil sardine fishery - a retrospect and a prospect. *Seafood Exp. J.*, 5 (11): 19-20

The oil sardine fishery at Calicut during 1972-73 is reviewed, pointing out some immediate prospects for the fishery.

67. BAL, D. V. ; VIRABHADRA RAO, K. 1984. Oil sardine. In: *Marine Fisheries*. Tata McGraw Hill Publishing Company Ltd., New Delhi, chap. 4, p. 51-73.

[See Item. No. 4]

68. BALAN, V. 1972. Fishery and biology of the oil sardine *Sardinella longiceps* Val off the Cochin coast. *Indian J. Fish.*, 18 (1 & 2): 135-147.

The oil sardine fishery at Manassery, Cochin was studied for its variation from January 1959 to June 1969. The catches were higher in 1960-61, 1966-67 and 1967-68, highest being in 1964-65. Poor fishery was recorded during 1959-60, 1962-63 and 1963-64. Based on length-frequency studies, the juvenile fish are shown to grow faster during the first 12 months. Spawning is inferred, to be intense from June to August. During the study period, the heavier catches consisted more of one-year-olds, with average length 130mm. Tables are given.

69. BALAN, V. 1973. Purse seine and boat seine (Thangu vala) fishery of the oil sardine off Cochin 1968-1971. *Indian J. Fish.*, 20 (1): 70-77.

Catch details, fishing effort, length and sex composition of oil sardine caught in purse seines at Cochin during 1969-71 are presented. A comparison of the fish landed by this gear with that landed by boat seine showed that the length range was similar, and that the sex composition was almost 1:1. Tables are given for the data.

70. BALAN, V. 1984. The Indian oil sardine fishery: a review. *Mar. Fish. Infor. Serv. T & E Ser.*, No. 60, p. 1-10.

This paper highlights the trend in the production, research results and prospects of oil sardine resources. Fishery, annual yields and biology are given. Probable causes for fluctuation in the fishery are discussed. Figures and tables are given.

71. BALAN, V. 1986. The Indian oil sardine. *R. & D. Series for Marine Fishery Resources Management*, Central Marine Fisheries Research Institute, Cochin, 3pp.

A synopsis of the occurrence and distribution, resource, estimation and monitoring of fisheries is presented briefly in the form of a publicity folder.

72. BALAN, V.; REGHU, R. 1979. The Indian oil sardine. *Mar. Fish. Infor. Serv. T & E Ser.*, No. 14, p. 7-13.

The article gives the trends of oil sardine fishery at various places for the past ten years along with length, distribution, growth, age, sex composition, food, mortality rate, stock assessment etc. The different types of gear used and the catch per net at some centres are given. A forecast for 1980 is made, concluding that increase in fishing effort would increase the catch.

73. BALAN, V.; ABDUL NIZAR, M. 1988. Purse seine fishery for oil sardine off Cochin during the year 1980-85. *Indian J. Fish.*, 35 (3) : 131-139.

The study is reported to have shown that oil sardine catch were best in 1984 and poorest in 1985. The highest monthly catch rate was noticed in December 1984 and lowest in November 1985. Mortality rates were estimated by using Beverton and Holt method. Average rates were estimated by using Beverton and Holt method. Average annual stock using purse seine at Cochin was estimated as 10,336t during 1980-85. MSY for Cochin has been estimated as about 12,500t. It is suggested that increasing size at first capture from 125 to 145 mm may yield higher catches. The study revealed that the success of fishery in any year was mainly dependent on the abundance of 0-year class. The 15-40m depth area was found to be most productive. Spawning period was found to be from June to August each year. Application of Chi-square test on sex composition indicated predominance of females during 1980-84. 5 figures and 3 tables showing the various studies are furnished.

74. BENSAM, P. 1970. On the fluctuations of the oil sardine fishery at Cannanore during 1961-1964. *Indian J. Fish.*, 17 (1 & 2): 132-148.

The decrease recorded in oil sardine fishery at Cannanore during 1961 to 1963 followed by a recovery in 1964 is suspected to be due to temperature and salinity playing a major role rather than food or spawning. However, adults were found to have a wider tolerance to these parameters than juveniles. Tables and figures are given for the observations.

75. BLINDHEIM, J. ; CHAKRABORTY, D.; DEVIDAS MENON, M. 1976. The pelagic fishery resources off the southwest coast of India. In: *Fish Processing industry in India*, Symposium held at CFTRI, Mysore, 13-14 February, 1975, p.3-11.

The distribution of sardine and mackerel schools, as had been found in an aerial survey during 1972-74, is presented subarcwise in tables. Based on this, the annual biomass of sardine is estimated to be 280 thousand tonnes. The fishery being mostly dependent on juveniles and the fish having relatively short life span, a higher rate of fishing is suggested for attaining maximum sustainable yield.

76. CHACKO, P.I. 1955. The 1953-54 bumper fishery of the oil sardine (*Sardinella longiceps*) of the west coast of Madras State. *Proc. 42nd Indian Sci. Cong.*, pt. III, p. 307-308 (Abstract only).

The abstract records a bumper fishery of oil sardine, which had occurred after a long decline since 1946. The fishery extended all through the years, with peaks during November, December and January. Shoals even entered estuaries and backwaters. The catch consisted of zero-, one- and two-year olds.

77. CHACKO, P. I. ; MATHEW, M. J. 1956. Programme of oil sardine research in Madras State Fisheries Department in 1954-55. *Proc. 43rd Indian Sci. Cong.*, Pt. III, p. 309-310 (Abstract only).

The status and structure of oil sardine fisheries along the West Coast for the period is reported. Fully matured and spent fish are stated to have occurred during April-August 1954. In September there was recruitment of new broods, which kept contributing to the commercial catches till next year.

78. CHAKRABORTY, D.; VELAPPAN NAIR, R. ; BALAKRISHNAN, G. 1975. Some characteristics of marine fish production in India. *Proc. Symp. Liv. Res. Seas around India*, December 1968, Central Marine Fisheries Research Institute, Cochin, p. 102-113.

Projecting the catch statistics for 1958-67, it is suggested that, since the variation in annual fish production in India was more due to the fluctuation in the catches of important fishes including oil sardine, if this was controlled, the annual landings could be stabilized. Oil sardine index was highest (609) in Kerala. Tables showing total landings, oil sardine landings, seasonal and regional indices of landings are given.

79. CHANDRAMOHAN, K. ; JAMES, P.S.B.R. 1977. Concepts on the fluctuations in the Indian oil sardine fishery-a review. *Seafood Exp. J.*, 9 (2): 9-16.

This is a critique on the concepts of fluctuations of oil sardine fishery, namely, overfishing, availability of food, pressure of overabundant year class, differential gear, differential sea level pressure, pressure of mackerel fishery, southeast monsoon rainfall and scarcity of juveniles in the inshore belt. A future line of work is also indicated.

80. CHIDAMBARAM, K. 1980. Studies on length frequency of the oil sardine, *Sardinella longiceps* Cuv. & Val. and certain factors influencing their appearance on the Calicut Coast of Madras Presidency. *Proc. Indian Acad. Sci.*, 31B(5): 252-282.

The length frequencies, size groups and age groups of oil sardine of Malabar Coast for the period 1936-37 to 1942-43 are presented. The movement, spawning and survival of oil sardine were found to have been in relation with the surface temperature and specific gravity of sea water and availability of food. The need for further investigations on age and on the occurrence of the fish in the offshore waters is pointed out in order to help find the causes of fluctuations of the fishery.

81. CMFRI. 1989. On the emergence of oil sardine fishery along Madras Coast. *Mar. Fish. Infor. Serv. T & E Ser.*, No. 96, p.6-7.

The emergence of oil sardine fishery along Madras Coast since May to September 1987 is reported. Boat seine were used for the fishery. The catch data during the period is given. Biological observations such as size, maturity stages, stomach content etc are briefly given. Regular monitoring and intensive studies are suggested for finding factors responsible for emergence of the sardine fishery along this coast.

82. CMFRI. 1989. Unusual landings of young oil sardine off Madras Coast. *Mar. Fish. Infor. Serv. T & E Ser.*, No. 96, p. 14.

Occurrence of young oil sardine noticed from 10-24 November 1988 in indigenous boat seine catches is reported. Details of catches recorded on the period are given. It is considered that young fishes obtained were probably the result of spawning a few months earlier along the coast.

83. CSIR, 1962. *The wealth of India - Raw materials*, V.4 (suppl.) Fish and fisheries, Council of Scientific and Industrial Research, New Delhi, 132pp.

The oil sardine is included, giving briefly its current distribution, fishing season and other relevant commercial information.

84. DEVANESAN, D. W. 1943. A brief investigation into the causes of the fluctuations of the annual fishery of the oil sardine of Malabar, *Sardinella longiceps*, determination of its age and an account of the discovery of its eggs and spawning ground. *Madras Fish. Bull.* No. 28 (Report No. 1), p. 1-24.

A suspected seasonal migration of oil sardine and the fluctuations in its fishery on the coast of Malabar and South Kanara form the theme of this report, which covers a period of six years. Food of oil sardine was found to be mainly pelagic organisms. The eggs were pelagic. A scale of ovarian stages has been drawn up in the model of Hjort's scale for the herring. The studies did not support the theory of migration in oil sardine. Scale of oil sardine showed 2 rings.

85. DEVANESAN, D. W.; CHIDAMBARAM, K. 1953. The oil sardine. In: *The common food fishes of the Madras state*. Government Press, Madras. p. 14-17.

[See Item. No. 193]

86. DEVARAJ, M. 1979. Management problems in the Indian oil sardine and mackerel fisheries of the southwest coast of India. *India Today & Tomorrow*, 8 (3):126.

A brief popular article on the fishery management problems of sardine and mackerel of southwest coast. It gives information on the catch and effort of traditional as well as modern fishing activities of Karnataka, Kerala and Goa cautioning against overgrowth of purse seines, for preventing social problems to traditional fishermen.

87. DEVIDAS MENON, M. 1973. Pelagic fishery project. *Souvenir* issued on the occasion of the FAO/NORAD training course in acoustic methods, Cochin, 5-23 November 1973, p. 5-8.

Explaining the needs for a correct knowledge on the resource of oil sardine and mackerel, which together formed 50% of India's marine fish production, and for evolving modern processing technologies for them, the article tells about the background against which the Pelagic Fishery Project had been formed. Project was established in 1971 to assess the stock abundance of these two major fishes, to study their life histories, and to conduct fishing experiments to evolve the efficient fishing method and gear. Results of work of the first 2 1/2 years are also briefly presented.

88. DHULKHED, M. H. 1973. Sex-ratio in oil sardine. *Indian J. Fish.*, 20(1): 236-240.

Sex-ratio of oil sardine caught at Mangalore for over eleven years by non-selective gear are said to have indicated that female had a higher rate of growth. The sex-ratios varied in various length groups. Tables and figures giving distribution of sexes are given.

89. DHULKHED, M. H.; MUTHIAH, C.; SYDA RAO, G.; RADHAKRISHNAN, N. S. 1982. The purse seine fishery of Mangalore (Karnataka). *Mar. Fish. Infor. Serv. T & E Ser.*, Central Marine Fisheries Research Institute, Cochin, No. 37, p. 13-15.

This is an appraisal of the purse seine fishery of Mangalore based on landings from 1979 to 1981. Oil sardine formed the major catch, constituting 61%, 55% and 64% of the total catch in 1979, 1980 and 1981, respectively. Most of the fish were used for oil extraction and manure, since there were no facilities for better utilization.

90. DHULKHED, M. H.; RAMAMURTHY, S. 1973. On the occurrence of small sized oil sardine in the Chandragiri Estuary, southwest coast of India. *Indian J. Fish.*, 20 (2): 653-654.

In the Chandragiri Estuary near Kasaragod, small-sized (50-54mm) oil sardine were caught on September 1972, indicating the tolerance of the fish at that size for low salinity. It is also reckoned as a proof to the small-sized oil sardine entering the estuaries, at least of big rivers, on the southwest coast of India.

91. DHULKHED, M. H.; UMA KUMARI, K. 1979. Relative abundance of age groups of oil sardine and its effect on fishery of Mangalore Area. *Indian J. Fish.*, 26 (1& 2): 40-46.

Presenting the data of oil sardine collected from Baikampady near Mangalore from 1965-66 through 1976-77, it is stated that, during the period, 0 and 1 year classes formed the mainstay of the catches. Average rate of mortality was estimated at 1.87. Tables are given showing the catch for different years by different nets.

92. DHULKHED, M. H.; UMA BHAT, K. 1985. The purse seine fishery for oil sardine in the South Karnataka Coast and its effects on the indigenous fishery. *Indian J. Fish.*, 32 (4) : 55-63.

The effect of purse-seine fishery at Mangalore, Malpe and Gangolli on the indigenous fishery is discussed with special reference to shore-seine and Rampan. With the introduction of purse seine in 1979-80, there had been an increase in the catches of oil sardine, but in the subsequent years there was decrease. Growth and mortality rates are mentioned.

93. DWIPONGGO, A. 1972. The fishery and preliminary study on the growth rate of "Lemuru" (oil sardine) at Muntjar, Bali Strait. *Proc. Indo-Pacif. Fish. Coun.*, 15 (3): 221-240.

[See Item. No. 204]

94. DWIPONGGO, A.; UKTOLSEYA, J.C.B. 1972. A lemuru, *Sardinella longiceps*, survey around the western part of the little Sunda Island. *Proc. Indo-Pacif. Fish. Coun.*, 15 (3):212-220.

Results of the survey of oil sardine resources along the coasts of Java and south of the Bali Strait during 12 April-22 May 1972 are given. Though the fishing was poor inspite of three types of gear used, some information about migration of lemuru during the off-season in Bali Strait could be gathered. It is recommended that, for better result, another type of gear like purse seine be used.

95. FAO/UNDP. 1977. Report of the joint mission to plan development of *Sardinella* fisheries in the Bali Strait. IOP/TECH/77/15 *Tech. Rep. Indian Ocean Programme*, No. 15, 51pp.

This report, prepared by FAO/IOP mission of East Java, Indonesia, is on an investigation of development prospects of fisheries for Indian oil sardine in Bali Strait. Some details of the then fishery are dealt with, including the economics of the various operations, and the landing facilities and marketing and processing arrangements available.

96. FOETEDAR, R. K.; SAVARIA, Y.D. 1988. Unusual fishery for oil sardine along the west Saurashtra Coast. *Mar. Fish. Infor. Serv. T & E Ser.*, No. 80, p. 26-27.

Considerable landings of oil sardine noticed during winter months of 1986-87 in West Saurashtra Coast is reported, giving a brief account of the biological features observed of the fish. About 352 tonnes of fish were landed during December to February. The catch belonged to 1 year class, and 96% were females. The shoals are suspected to have been migrated either from southwest coast or from offshore.

97. GOPINATHAN, C. K. 1974. Early stages of upwelling and decline in oil sardine fishery of Kerala. *J. mar biol. Ass. India*, 16 (3): 700-707.

This paper presents the results of a hydrographic survey made in April 1972, covering 26 stations on the shelf between Cochin and Trivandrum. Figures on temperature, salinity and dissolved oxygen determined are given. The fishery was observed to be decreasing during February, for which lack of food and rise in temperature, or the upwelling that had started by then, are cited as possible reasons.

98. ICAR. 1971. *Report of the working party on sardine and mackerel resources*. Indian Council of Agricultural Research, New Delhi, 52pp.

In this report of the working party constituted by Government of India in 1966 a synopsis of the biology and fisheries of sardine is given, and on the basis of this, maps are presented. Also, after having the research works reviewed, a future line of work is suggested.

99. ICAR. 1972 (1985). *Handbook of animal husbandry*. Indian Council of Agricultural Research, New Delhi, Chap. 17, Fisheries, p. 712-756.

A brief account on the resources of oil sardine in India is included, giving details such as the characters and composition of the fishery, the means and methods of exploitation and the statistics on production and marketing.

100. JACOB, T.; ALAGARAJA, K.; DHARMARAJA, S. K.; PANIKKAR, K.K.P.; BALAKRISHNAN, G.; SATYAVAN, U.K.; BALAN, V.; RAO, K.V.N.; 1982. Impact of purse-seine operations on traditional fishery with special reference to oil sardine in Kerala during 1980 and 1981. *Mar. Fish. Infor. Serv. T & E Ser.*, No. 40, p. 8-11.

The study was undertaken to examine the reasons for the decline of oil sardine landings, and the effects of purse seine operations which had started in 1979, on the

traditional fishery. The purse-seining, at the current level of exploitation did not appear to have affected the indigenous fishery off Kerala coast. Tables are given for the catch and effort and age composition in support of the view.

101. JACOB, T.; DHARMARAJA, S. K.; PANIKKAR, K.K.P. 1979. Socio-economic implications of purse-seine operations in Karnataka. *Mar. Fish. Infor. serv. T & E Ser.*, No. 12, p. 1-8.

In Karnataka, the traditional gear used for oil sardine fishery was Rampani. By the introduction of purse seine, though the total catch of fish had increased, hardship arose to fishermen families that depended on traditional gear. Suggestions are given for the rehabilitation of the affected fishermen. Tables projecting the data are provided.

102. JACOB, T.; RAJENDRAN, V.; MAHADEVANPILLAI, P. K.; JOSEPH ANDREWS; SATYAVAN, U. K. 1987. An appraisal of the marine fisheries in Kerala *CMFRI Spl. Publ.*, No. 35, 42pp.

The marine fisheries in Kerala for 10 years from 1975 to 1984 is reviewed, highlighting the status and prospects of the exploited resources including that of oil sardine. Tables are given projecting the annual, quarterwise, specieswise, and districtwise statistics on catches and effort. Average annual catch of oil sardine was estimated at 1.5 lakh tonnes, which was 38% of the total catches of Kerala, and 78% of the total oil sardine catches in India. The all India trend of oil sardine landings over the years was similar to that observed in Kerala. Districtwise figures of marine fishing villages, fishermen population and craft and gear are presented and discussed. Some management measures to maintain the resource are suggested.

103. JADHAV, R. N.; NARAIN, P.; NAIR, P.V.R.; PILLAI, V. K.; PONNAIAH, A.G.; BALACHANDRAN, V. K.; SUBBARAJU, G.; SILAS, E.G.; SOMAVANSHI, V.S.; JOSEPH, K. M. 1989. Oceanographic parameters and their relationship to fish catch estimation : a case study in coastal waters north of Cochin during 1981. *Proc. Seminar on Remote Sensing in Marine Resources*, Central Marine Fisheries Research Institute, Cochin, 17-18 April, p. 4-1 : 4-12.

A study of the oceanic parameters like chlorophyll-a, particulate matter, dissolved oxygen, temperature, salinity etc., made at Cochin during 1981, is presented with an attempt at relating them to fish productivity. The area was observed to have had abundance of oil sardine during the period following the Southwest Monsoon. It is stated that the parameters showed an annual variation pattern that repeated year after year. The sea truth data on the different parameters are given in tables and figures.

104. JAMES, P.S.B.R. 1981. Exploited and potential capture fishery resources in the inshore waters of India. *Bull. Cent. Mar. Fish. Res. Inst.*, No. 30A, p. 72-82.

The oil sardine fishery and its status in Kerala and Karnataka are reviewed along with others for the period 1961-76, giving tables and suggestions for management.



105. JAMES, P. S. B. R.; KURUP, K. N.; RAMAMIRTHAM, C. P.; SADANANDA RAO, D.; SUBBARAJU, G.; KUNJUKRISHNA PILLAI, V. 1987. Distribution and abundance of oil sardine and mackerel in relation to environmental characteristics in the Indian coastal waters. National Symposium on Research and Development in Marine Fisheries, *CMFRI Spl. Publ.*, No. 40, Abstract No. 7 (Abstract only)

The influence of salinity, temperature, dissolved-oxygen content, ocean currents, plankton productivity and marine pollution on the marine fish production for four decades are discussed, with special reference to the increase of production in the early sixties, the fluctuation from the seventies and the subsequent increase due to increase mainly of oil sardine and mackerel in early eighties.

106. JHINGRAN, V. G. 1975 (Rev. Ed. 1982). *Fish and fisheries of India*, Ed.2, Hindustan Publishing Corporation (India), New Delhi, p. 539-541.

The description of the fisheries of oil sardine such as occurrence, landings, gears used, utilization of catches etc. are briefly stated. Annual catch data for 1950 to 1963 are given along with those of others. Classification and figures of fish are also given, on page 9 and 34 respectively.

107. JONES, S. 1958. Progress of marine fisheries research.  
In: *Fisheries of the west coast of India*, Souvenir issued on the occasion of opening of the new building of the Central Marine Fisheries Research Sub-station at Calicut, CMFRI, p. 8-17.

A souvenir article; the paper primarily stresses the importance of oil sardine as a commercial food fish and points to its potentialities for the manufacture of other products such as oil, guano and meal.

108. JONES, S. 1967. Two decades of marine fisheries research. *Souvenir, 20th Anniv. Cent. Mar. Fish. Res. Inst.*, Mandapam camp, p. 5-21.

An evaluation of the marine fisheries research carried out by Central Marine Fisheries Research Institute for two decades: the article refers to oil sardine's contribution to the economy of India and the achievements made by the Institute in bringing to light the different aspects of biology of this resource that would help manage the fishery better.

109. JOSEPH, K. M. ; SEBASTIAN, A. V. 1964. The effect of mesh size on the fishing efficiency of sardine gill nets. *Fish. Technol.*, 1 (2) : 180-182.

Influence of mesh size on the fishing power of gill nets is studied, using four nets of different mesh sizes. The study showed that there could be difference in the outputs of sardine gill nets of identical design and rigging but of different mesh size. Tables showing the catch details are given.

110. JOSEPH, K. M.; SOMAVANSHI, V. S. 1985. Marine fishery resources survey and role of satellite remote sensing in the assessment of pelagic fishery resources in India. *Proc. Seminar on Remote Sensing in Marine Resources*, Central Marine Fisheries Research Institute, 17-18 April, Cochin, p. 1-2-1 : 1-2-14.

The prospects of satellite remote sensing in the survey and management of marine fishery resources are discussed, reviewing the results of the pelagic fishery survey carried out by research vessels in different parts of the country. Tables and figures showing distribution and landings of pelagic fishery resources as has been observed by these methods are given.

111. KAIKINI, A. S. 1960. The fisheries of Malwan. *Indian J. Fish.*, 7 (2) : 348-368.

Sardine formed an important fisheries of Malwan, a major fishing centre of Konkan Coast. Rampan and drift nets were used. In 1950, *Sardinella longiceps* was the most abundant constituent, but declined in subsequent years. Tables showing landings of sardine from 1950 to 1957 are given.

112. KALAWAR, A. G.; DEVARAJ, M.; PARULEKAR, ARUN, H. 1985. *Report of the committee on marine fisheries in Kerala*, submitted to Government of Kerala. Expert Committee, C/o Central Institute of Fisheries Education, Bombay, 467 pp (mimeographed).

Recommending mainly the measures to be adopted for conservation of shrimp and fish resources of Kerala and for eliminating the existing discord between the traditional and mechanised sectors of the state, the report goes on delving into the nature and probable causes of the fluctuation of the exploited resources including oil sardine, which was being exploited mainly traditionally but, later, in a smaller extent, also by mechanised purse seines. Supporting data are given in tabulated form. Summary recommendations are also given.

113. KESAVANNAIR, A. K.; BALAN, K.; PRASANNAKUMARY, B. 1973. The fishery of oil sardine (*Sardinella longiceps*) during the past 22 years. *Indian J. Fish.*, 20 (1) : 223-227.

A review of the annual landings of the oil sardine during 1950-71 is given, reporting that the oil sardine landings along Kerala coast had been determining the trend of the all India landings. Probable reasons for the fluctuation in oil sardine landings are discussed. Figures are given illustrating the landings during the period.

114. LUTHER, G. 1988. Oil sardine, an emerging new fishery resource along the east coast. *Mar. Fish. Infor., Serv. T & E Ser.*, Central Marine Fisheries Research Institute, Cochin, No. 88 p. 13-19.

A brief account of the newly emerged oil sardine fishery along the east coast is given, tabulating the data of landings at various centres from 1961 to 1986. Distribution, gear, and catch per net and the biological features of the stock are also given.

115. MUKUNDAN, C. 1967. Plankton of Calicut Inshore Waters and its relationship with coastal pelagic fisheries. *Indian J. Fish.*, 14 (1 & 2) : 271-291.

Describing the plankton and its abundance in space and time in the inshore waters of Calicut area for a period of 8 years from 1957 to 1964 in relation to changes in salinity and temperature, the paper attempts to correlate the plankton with the landings of oil sardine and mackerel. It is suggested that, in addition to favourable plankton and temperature, the level of grazing pressure in the offshore regions also might create conditions conducive for the entry of the fish into the nearshore fishing areas in post-monsoon months.

116. MURTY, A. V. S. 1974. The wind drifts off the west coast of India and their influence on the oil sardine fishery. *J. mar. biol. Ass. India*, 16 (2): 520-522.

The paper studies the relationship between wind drifts of the west coast of India during winter and the oil sardine fishery. Oil sardine landings data of 1925 to 1968 are considered for the study. The changes in oil sardine landings are stated to be seemingly related to change in wind drift. The stronger winter monsoon, generating stronger currents, is inferred to be favourable for migration of pelagic fish towards the coast.

117. MURTY, A. V. S. ; EDELMAN, M. S. 1966. On the relation between the intensity of the southwest monsoon and the oil sardine fishery of India. *Indian J. Fish.*, 13 (1&2): 142-149.

Obtaining the July-August data for sea-level pressure for the years 1924 to 1954 from India Meteorological Department, attempts are being made to correlate the sea-level pressure with the landings of oil sardine, the data for the latter having been taken from published material. The sea-level pressure between Cochin and Bombay is stated to bear good relation with the fishery. Figures are given for the studies.

118. MURTY, A. V. S.; VISHNUDATTA, M.N. 1976. The seasonal distribution of some oceanographic parameters off southwest coast of India relevant to pelagic fisheries. *Indian J. Fish.*, 23 (1 & 2) : 97-104.

The behaviour and lipid contents of oil sardine are studied with reference to the temperature, salinity and oxygen distributions associated with the thermocline of the shelf and adjacent waters of southwest coast. The fisheries are found to be in association with high salinity, moderate temperature and deeper thermocline.

119. NAIR, R. VELAPPAN. 1951. Sardine fishery. In : *Handbook on Indian Fisheries*. Ed. Chopra, B. N. Government of India, Ministry of Agriculture, chap.7, p. 55-57.

The structure and composition of the clupeoid fisheries of India are given; and the oil sardine, being the most important among the clupeids, is dealt with in greater details, describing its fisheries, utilization etc.

120. NAIR, R. VELAPPAN. 1952. Studies on the revival of the Indian oil sardine fishery. *Proc. Indo-Pacif. Fish. Coun.*, 4: 115-129.

The Indian oil sardine fishery is studied based on the data collected from South Kanara and Malabar Coasts during 1948-49 to 1951-52 seasons. Regular cyclical changes in the composition of the fishery were noticed during the period. The food of oil sardine was mainly phytoplankton, so the abundance of which influenced the movement of juvenile schools, and which in turn determined the prospects of the fishery.

121. NAIR, R. VELAPPAN. 1973. Indian sardines (Biology and Fishery). CSIR Zoological monograph No.2, Publication and Information Directorate, New Delhi, p. 1-36.

[See Item. No. 226]

122. NAIR, R. VELAPPAN, ; CHIDAMBARAM, K. 1951. A review of the Indian oil sardine fishery. *Proc. Natn. Inst. Sci. India*, 17B (1) : 71-85.

The fishing methods and centres, fluctuation in the fishery, sardine as source of oil and meal, biology, etc are reviewed. The statistics is stated to have revealed that the fluctuation in abundance between 1907 and 1942 had been irregular. Small-sized, immature fish contributed largely to the fishery in the years of abundance. A regulation of fishery for immature sardines in the years of abundance is suggested as a measure for arresting fluctuation to some extent.

123. NAIR, R. VELAPPAN.; SUBRAMANYAN, R. 1955. The diatom, *Fragilaria oceanica* Cleve as an indicator of abundance of the Indian oil sardine, *Sardinella longiceps* Cuv. and Val. *Curr. Sci.*, 24 (2) : 41-42.

The diatom *Fragilaria oceanica* is reported to be the chosen item of food of oil sardine, bearing an indicator value for the abundance of the fish.

124. NAIR, R. VELAPPAN. 1958. The sardines. In: *Fisheries of West coast of India*. Souvenir issued on the occasion of the opening of the new building of the Central Marine Fisheries Research Substation at Calicut, 1st October 1958, p. 31-37.

An overall picture of the then oil sardine fishery along the southwest coast of India is presented, incorporating a short account of the old and primitive methods of fishing. Tables showing landings from 1925-26 to 1949-50 and 1950 to 1957 are given. Food and feeding habits of the fish are also mentioned.

125. NARAYANA KURUP, K.; KRISHNANKUTTY NAIR, G.; ANNAM, V. P.; ABHA KANT ; BEENA, M. R.; LATHA KHAMBADKAR. 1987. An appraisal of marine fisheries of Karnataka and Goa. *CMFRI Spl. Publ.*, No. 36, 104pp.

The marine fisheries in Karnataka and Goa for the period 1975-84 is reviewed highlighting the status and potentials of the exploited resources including oil sardine.

Tables are given projecting the gearwise, specieswise, districtwise and centrewise fish landings and CPUE of major varieties. During the period, 33.45% of total landings in Karnataka and 13.67% in Goa were estimated to be oil sardine. Districtwise figures of marine fishing villages, fishermen population are also tabulated and discussed. So also, some management measures for the resource is given.

126. NATIONAL COMMISSION ON AGRICULTURE (India). 1977. Abridged report-1976. chap.8, Fisheries, p. 389-426.

The importance of oil sardine in the marine fish production between Quilon and Ratnagiri is indicated giving the general characters of its fishery during 1951-72.

127. NOBLE, A. 1971. Development of pelagic fisheries. *Seafood Exp. J.*, 3 (4) : 31-34.

Intended for industry, this article suggests possibilities for further development of pelagic fisheries in general in the Southwest Coast, oil sardine included.

128. NOBLE, A.; NARAYANAN KUTTY, V. A. 1978. Economics of the indigenous fishing units at Cochin - a case study. *CMFRI Spl. Publ.*, No. 4, 24pp.

The 'Ayila vala' and 'Thanguvala' fisheries for oil sardine at Kannamaly for 10 years from 1967 to 1977 is studied with regard to the economics of the traditional coastal fishery of the region.

129. PANIKKAR, N. KESAVA. 1956. *Marine fisheries research in India. In : Progress of fisheries development in India*, Cuttack, p. 20-28.

Overviewing the major research works done on sea fisheries at Central Marine Fisheries Research Institute, the paper points out among other things a serious handicap in the full utilization of oil sardine due to its high fluctuations. A closer study of the fish, its biology and habits, are suggested for facilitating fishery forecasting.

130. PRABHU, M. S. 1967. The oil sardine. *Souvenir, 20th Anniversary*, Central Marine Fisheries Research Institute, p. 41-43.

Oil sardine fishery in India is reviewed. Achievements and activities in the research of oil sardine are stated briefly. Figures of the fish at different sizes are given. Data on the tagging done from various centres are appended.

131. PRABHU, M. S.; DHULKHED, M. H. 1967. On the occurrence of small sized oil sardine, *Sardinella longiceps* Val. *Curr. Sci.*, 36 (15) : 410-411.

In Mangalore Area, very young oil sardine, measuring around 35mm, are reported to have occurred. On a large scale in the fishery from July to October during 1960-66, a phenomenon hitherto unrecorded. Figure showing the size frequency of the fish are given.

132. PRABHU, M. S.; DHULKHED, M. H. 1970. The oil sardine fishery in the Mangalore Zone during the seasons 1963-64 and 1967-68. *Indian J. Fish.*, 17 (1& 2): 57-75.

Oil sardine landings at Ullal were studied in fishing seasons from 1963-64 to 1967-68. The fishery depended on different types of gear, of which cast nets, 'Chala Bale' and 'Rampani' recorded highest CPUE values. The catches were higher during September-December, when temperature and salinity ranged from 25.5° to 28.6°C and from 28.98‰ to 34.36‰ respectively. Length-frequency studies indicated that the fish attained 100-110mm during the first year, 150-160mm during the second year and 175-180mm during the third year. The fishery was supported by different year-classes during different years.

133. PRABHU, M. S.; RAMAMURTHY, S.; DHULKHED, M. H.; RADHAKRISHNAN, N. S. 1971. *Trichodesmium* bloom and the failure of oil sardine fishery. *Mahasagar-Bull. Nat. Inst. Oceanogr.*, 4 (2) : 62-64, and also *NIO Collected Reprints*, 3 Contr. No. 147.

*Trichodesmium* blooms are inferred to be the factor that had affected the fishery at Mangalore during February-March, 1968, when the fishery was poor compared to the previous year. The environmental factors studied simultaneously during blooming are also discussed.

134. RADHAKRISHNAN, N. 1965. Oil sardine investigations at Karwar. *Indian J. Fish.*, 12A (1) : 99-117.

[See Item. No. 231]

135. RAGHUVENDRA PAI; REDDY, M. P.M. 1985. Effect of oceanographic features on the pelagic fisheries along Malpe Coast. *Mysore J. Agric. Sci.*, 19 (3) : 198-204.

One-year data on surface temperature, salinity, plankton, pH and extinction coefficient values of nine stations near Malpe and data on oil sardine for the corresponding period obtained from Fisheries Director's Office, Mangalore, are correlated, and it has been concluded that temperature and salinity influenced the fishery.

136. RAMANA, T. V.; NATHANIEL, D.E.; REDDY, M.P.M. 1988. Distribution of some oceanographic factors in the Arabian Sea off Manjeswar and their possible effect on the oil sardine and mackerel fisheries. *Symp. Trop. Mar. Liv. Res.*, Marine Biological Association of India, Cochin. Abstract No 103, (Abstract only).

Based on studies at eight stations off Manjeswar, it has been concluded that the sea water temperature and salinity might directly influence the fisheries of oil sardine.

137. RAMASOMAYAJULU, K.; DHANARAJU, K. 1985. Confirmation of the occurrence of oil sardine, *Sardinella longiceps* Valenciennes, along the Orissa coast. *Indian J. Fish.*, 32 (4) : 495-496.

Stray catches of oil sardine during 1984-85 are reported from two landing centres, confirming the occurrence reported earlier of the fish along the Orissa Coast.

138. REGHU, R. 1973. Migration of the juvenile oil sardine *Sardinella longiceps* Val. into the backwaters of Cochin. *Indian J. Fish.*, 20 (2) : 655-658.

Juveniles of oil sardine of size 35 to 60mm were caught in stake nets and Chinese dip nets from Thoppumpady and Thevara in the Cochin backwaters during August-September 1972. At Fort Cochin also juveniles were caught. The stomach contents showed poor feeding, thus eliminating the possibility of feeding as the causative factor for the entry of the fish. The entry however, followed a lunar periodicity.

139. RENGASAMY, V. S. 1977. Studies on length-frequency of oil sardine at Calicut during 1970-71 to 1973-74. *Indian J. Fish.*, 24 (1 & 2) : 69-75.

[See Item. No. 232]

140. SADANANDARAO, D.; RAMAMIRTHAM, C. P.; KRISHNAN, T. S. 1973. Oceanographic features and abundance of the pelagic fisheries along the west coast of India. *Proc. Symp. Liv. Res. Seas around India*, Central Marine Fisheries Research Institute, December 1968, Cochin, p. 400-413.

Temperature, salinity, and density of the surface waters of west coast, collected onboard R. V. Varuna and other vessels, are studied monthwise in relation to the pelagic fish landings including oil sardine for the period of 1957 to 1965. The high salinity values in the northern regions appeared unfavourable for oil sardine. The upwelling occurring along the coast during monsoon was found to enrich the waters leading to a high organic production and a good fishery after the monsoon.

141. SALEH, SOETRISNO. 1987. Optimum catch and effective utilization of the Bali Strait oil sardine fishery. *Jurnal Pen. Perikanan Laut*, No. 40, p. 77-88.

Oil sardine fishery is studied as an example while investigating possibilities for improvement in fisheries management in Bali Strait. It is suggested that by using CSW handling system on board, the quality of the fish could be improved, for increasing the price of the fish. This type of fishery management is deemed to be able to adjust the optimum economic yield of the fishery. Table showing landings during 1975-84 and figures based on various studies are given.

142. SAM BENNET, P. 1965. Length and age composition of the oil sardine catch off Calicut Coast in 1964 and 1965. *Indian J. Fish.*, 12 A (2) : 507-529.

Age and size compositions of oil sardine studied during 1964-65 at Calicut are recorded. Stress exerted on the abundant-year-class is cited as a probable cause for fluctuations, for the 1963-year-class had contributed to a bumper fishery during the following two years.

143. SAMBENNET, P. 1973. Fluctuations in the Indian oil sardine fishery - an explanation. *Proc. Symp. Liv. Res. Seas around India*, Central Marine Fisheries Research Institute, December 1968, Cochin, p. 234-240.

A conference paper discussing the causes of the fluctuations in fishery, mainly based on observations on the biology studied at Calicut during 1964-1968. Intensive fishing of an unusually strong year-class rather than general restrictions in fishery is suggested to be a probable solution for stabilizing the fishery.

144. SAMUEL, C. T. 1967. An analysis of the marine fish catch in Kerala from 1957-58 to 1965-66. *Bull. Dept. Mar. Biol. Oceanogr.*, 3 : 61-67.

The paper reports that the oil sardine was constituting 50-60% of the total marine catch of Kerala. Tables and graphs are provided, projecting the fish catch-data in different ways and comparing them with All -India figures.

145. SAMUEL, C. T. 1968. Clupeoid fishes. In : *Marine fisheries in India*. Chap. 5. Oceanographic laboratory, University of Cochin, Cochin p. 86-106.

[See Item. No. 234]

146. SATYANARAYANA, A. V.V.; SADANANDAN, K. A. 1962. "Chala Vala", encircling gill nets for sardines and mackerels of the Kerala Coast with special reference to their design and construction. *Indian J. Fish.*, 9B (2) : 145-155.

From observations made at Chellanam, Southikkal, Narakkal and Azhikode, the relative efficiency of the gill net 'Chala Vala' has been estimated. The nets were of different materials and different types. The take-up, spread of net in water, buoyancy, and weight per unit length of rope were the parameters. Tables are given for the findings.

147. SATYANARAYANAPPA, S. N.; SESHAPPA, D. S. 1985. The design and operational efficiency of a mini-purse seine operated in the inshore waters along the Karnataka Coast. *Mysore J. Agric. Sci.*, 19 (1) : 24-27.

The design, construction and operation of a type of small purse seine, an economical gear, used for oil sardine and mackerel in the inshore waters at Gangolli and Bhindoor, are described, and the net is recommended for a wider application along the Karnataka Coast.

148. SEKHARAN, K. V. 1962. On the oil sardine fishery of the Calicut Area during the years 1955-56 to 1958-59. *Indian J. Fish.*, 9A (2) : 679-700.

The traditional fishery based on 8 types of indigenous gear then prevalent at Vellayil Fishing Centre, Calicut, is dealt with in detail, with special reference to catch and effort, size frequency, surface salinity and temperature. Based on monthly length frequencies it is inferred that one-year olds had formed the recruit age-group in this fluctuating fishery and that there were two broods in an year. 12 tables, for gearwise



monthly catches and effort, size composition, catch-per unit of nets and salinity and temperature etc, and 4 figures depicting the distribution of monthly size frequencies are given.

149. SEKHARAN, K. V.; DHULKHED, M. H. 1963. On the oil sardine fishery of the Mangalore Zone during the years 1957-63. *Indian J. Fish.*, 10A (2) : 601-626.

The routine study of the fishery from Malpe to Kasaragod, later extended also to Ullal, showed that the fluctuation in the fishery was dependent on the fluctuation of year-class strength. Annual rate of decrease of year-class is estimated roughly as 0.81. Fishery, length frequency, age composition, maturity, food, salinity and temperature were studied and the results obtained are tabulated.

150. SEKHARAN, K. V.; VELAPPAN NAIR, R. 1976. The fishery resources of the shelf waters around India. In: *Fish Processing Industry in India*, Symposium held at CFTRI, Mysore 13-14 February 1975. p. 28-35.

Stock estimates and potential catches of oil sardine arrived at by applying different methods on data for the years from 1950 to 1973 are presented and discussed. Supporting figures and tables are given.

151. SHANMUGAVELU, C. R.; MAHADEVAN PILLAI, P. K. 1980. On the result of exploratory purse seining between Cochin and Goa. *Indian J. Fish.*, 27 (1 & 2) : 183-192.

The results of exploratory purse seining conducted at major areas and 37 subareas by the Integrated Fisheries Project at Cochin and Exploratory Fisheries Project at Mangalore and Goa during 1977 to 1978 are given. The catches showed the pelagic species to be dominant and the oil sardine forming 72% of the total catch.

152. SILAS, E. G.; JACOB, T.; ALAGARAJA, K.; BALAN, K. 1986. Exploitation of marine fishery resources and its contribution to Indian economy. *CMFRI Spl. Publ.*, No. 29. 32pp.

The oil sardine are stated to have formed 14% of the exploited marine fishery resources in India during 1981-83, contributing substantially to the Indian economy. Supporting tables are furnished in different projections.

153. SIVAKUMARAN, K. P. 1984. Unusual landings of oil sardine, *Sardinella longiceps* Valenciennes along Parangipettai (Porto Novo), southeast coast of India. *J. mar. biol. Ass. India*, 26 (1&2) : 179:180.

An occurrence of oil sardine in considerable quantities in Parangipettai observed during June-August 1986 is recorded.

154. SIVANKUTTY NAIR, G. 1973. Observations on the oil sardine fishery at Ayiromthengu (Alleppey District). *Indian J. Fish.*, 20 (2) : 417-424.

The structure and biology of oil sardine fishery at Ayiromthengu are studied based on the catches observed from December 1957 to November 1959. Maximum landings were during March-April and minimum in January, juveniles of 13-14cm dominating. Age study is attempted by observing growth checks and preocular bones. Tables are given for the data.

155. SRINIVASARENGAN, S.; CHIDAMBARAM, L. 1985. An unusual occurrence of oil sardine in Pondicherry on the east coast of India. *Mar. Fish. Infor. Serv. T & E Ser.*, No. 61, p. 16-17.

Landings of oil sardine noticed along the Pondicherry Coast during October-December 1983 is reported, giving the catch details and biological features, and citing the underwater drift observed during the period as a possible cause for the occurrence of the fish.

156. STROEMME, T. 1984. Cruise Report R/V Fridtjof Nansen second fisheries resources survey Northeast coast of Somalia 24-30 August 1984. *UNDP/FAO Programme/GLO/82/OOL* 10pp. (Abstract only)

A report on a cruise that had been conducted to do (1) acoustic survey of the small pelagic fish resources of the shelf of North-East Somalia, (2) trawl survey of the demersal fish resources in the 20-200 m bottom depth zone in the same region, and (3) charting the main hydrographic features, at fixed stations. The article gives the distributions of dominant pelagic species observed, including oil sardine.

157. SURESH, K. R.; REDDY, M. P. M. 1980. Variations in oceanographic factors and their possible relation to fluctuations in oil sardine and mackerel catches off Mangalore coast. *Indian J. Fish.*, 27 (1&2) : 1-9.

The effect of seawater temperature, salinity and phytoplankton on the availability of oil sardine and mackerel are studied based on data collected at nine stations off Mangalore. The average surface temperature and salinity remained between 27.7°C and 29.9°C and 32.6‰ and 34.9‰, respectively, during the period of good catches of oil sardine; but no relationship between phytoplankton and oil sardine catch could be observed.

158. VERGHESE, C. P. 1976. Introduction of purse seine fishing in Indian Coasts; operations from 36' and 57' vessels for sardine and mackerel. *Seafood Exp. J.*, 8 (11) : 11-12.

The article states the advantages of purse-seining for sardine and mackerel, giving an outline of the financial estimates. Tables, giving results of operations and figures illustrating the purse seine are given.

159. VIRABHADRA RAO, K. 1973. Distribution pattern of the major exploited marine fishery resources of India. *Proc. Symp. Liv. Res. Seas around India*, Central

Marine Fisheries Research Institute, December 1968, Cochin, p. 18 - 101.  
(earlier as Bull. Cent. Mar. Fish. Res. Inst., No. 6, 1967.)

In this article reviewing the trends of annual landings of marine fish as well as the fishing villages and craft and gear prevalent during 1951-65 for the purpose of demonstrating the distribution pattern of the major exploited resources, the status of oil sardine resource, which then formed 23.88% of the total landings, is also discussed.

160. WAKABI, E. O. 1986. Sardine fishery in Kenya. *Kenya Aquatica, Bull.*, No. 3, p. 22-27.

An overview of the Kenya sardine fishery is given. The *Sardinella* genus was represented on the coast by six species including *Sardinella longiceps*. Catch data for these are furnished with supporting figures.

### 3. BIOLOGY

161. ANNIGERI, G.G. 1978. Studies on variations in the vertebral counts of oil sardine along the North Kanara Coast. *Indian J. Fish.*, 25 (1&2) : 14-22.

In samples of oil sardine studied from 7 centres on the North Kanara Coast during 1973-75, the number of vertebrae ranged from 43 to 48, with the mode at 47. The overall data on vertebral counts showed an indication that the samples drawn were from different subpopulations. Tables for the different analysis of vertebral counts are given.

162. ANON. 1951. *Report on marketing of fish in the Indian Union*. Ed.2. Agricultural marketing in India Marketing Series, No. 65, Manager of Publications, Delhi, 165pp.

Data on marketing of oil sardine for the period 1936-37 to 1946-47 are included in the monograph.

163. ANON. 1974. Plankton fish eggs and larvae studies. *UNDP / FAO Pelagic Fishery Project IND 1593 Progress Report*, No. 7. 52pp.

In the plankton collected from shallow waters off Kasaragod in July 1972 and off Cochin in July 1973, both during the peak of southwest monsoon, as part of a survey, oil sardine eggs as well as larvae of a few hours old are reported to have occurred. In the absence of evidence of wide spread spawning despite the extensive survey in 1973, the spawning is assumed to have been taking place in "isolated local patches." The juveniles (6- 8cm) that are reported to have appeared in "noticeable numbers" from July onwards at different places and in "commercial abundance" from August/ September onwards are stated to be the product of an earlier spawning of considerable magnitude, apart from that indicated by the two isolated observations stated above. The sampling stations and the dates of sampling are tabulated and maps are given showing the isopleths of plankton and larval densities and positions of plankton samplings.

164. ANON. 1976. Oil sardine larvae. *UNDP/ FAO Pelagic Fishery Project IND/ 593 Progress Report* No. 15, 18pp.

The report is on the plankton study conducted from September 1971 to September 1975 primarily as an egg and larval survey programme for oil sardine and mackerel. Regular oblique hauls were made using "Bongo Net" and special collections were made using single-cone-nets, both of mesh size 0.50, mostly in shallow waters during southwest monsoon.

Some eggs have been identified as those of oil sardine, which are stated to have been taken within latitude 9°30'-12°30' N from grounds less than 25 meter deep. Eventhough the eggs are being encountered in all the years, they were caught in significant quantity only once, in July 1972, off Kasaragod.

The larvae, segregated on the basis of myotome numbers, pigmentation and localities and time of occurrence, are described and illustrated stagewise. Figures indicating the localities from where the larvae were collected, and the various larval characters as described by different authors are given. Also given is a table showing the known seasons and localities of spawning of the different sardines including oil sardine.

165. ANON. 1976. Plankton fish eggs and larvae studies. *UNDP/FAO Pelagic Fishery Project IND 69/593 Progress Report No. 17, 27pp.*

The oil sardine larvae were the most important among the 9 species of sardine collected in the plankton samples taken from hydrographic stations from Ratnagiri to Tuticorin. Tables showing the number of plankton stations and samples, densities of larvae at different sections, and figures showing average distribution of sardine larvae in the project are given.

166. ANON. 1977. Fisheries research. In: *Indian Fisheries 1947-77, Marine Products Export Development Authority, Cochin p. 7-29.*

In this article, reviewing the achievements of 30 years of fisheries research in the country, the current status of the exploited resources are given, of which oil sardine is mentioned as the most important one, and so the knowledge achieved on this resource has been emphasised, including that on ecology, biology and movements.

167. ANON. 1983. Meet your fish. *Seafood Exp. J.* 15 (11): 32-33.

A note on oil sardine, its distinguishing characters, distribution, biology, fishing season and method, and utilization are given for popular information.

168. ANTONY RAJA, B.T. 1963. An instance of hermaphroditism in the Indian oil sardine, *Sardinella longiceps* (Cuv and Val). *J. mar. biol. Ass. India*, 5 (1):148-150

A case of hermaphroditism noticed in an oil sardine measuring 175mm, taken from Vellayil (Kozhikode) on 23-3-1960 is recorded. Externally though the fish resembled a female, one gonad was an ovary and the other an ovotestis. Figure of the gonads are given.

169. ANTONYRAJA, B.T. 1964. Some aspects of spawning biology of Indian oil sardine, *Sardinella longiceps* Valenciennes. *Indian J. Fish*, 11A (1) : 45-120.

The maturity and spawning habits are given based on the ova-diameter frequency of samples collected during 1959-63. The spawning season is stated to be from July-August. 17 tables and 9 figures are given.

170. ANTONYRAJA, B.T. 1966. On the maturity stages of Indian oil sardine, *Sardinella longiceps* Val. with notes on incidence of atretic follicles in advanced ovaries.

Based on a study covering the period 1959-62 description of seven maturity stages of oil sardine are given together with field keys. External appearance, extent of gonads, gonad-bodyweight ratio, maximum and modal sizes of ova and their general appearance under microscope are considered. Tables showing the various factors characteristic of the different stages of maturity, and figures showing stages of maturity, for male and female fish are given.

171. ANTONYRAJA, B.T. 1969: Patterns of sex ratio in the oil sardine, *Sardinella longiceps* Val. at. Calicut. *Indian J. Fish.*, 16 (1&2): 99-102

A statistical analysis of samples collected from Calicut during 1959-60 to 1965-66 showed that there was no significant change in sex ratio. Among adults, males were more in May, which is suspected to be due to males maturing earlier. The fecundity estimates are given.

172. ANTONY RAJA. B.T. 1969. The Indian oil sardine. *Bull. Cent. Mar. Fish. Res.Inst.* No.16, 128pp. (Mimeograph)

This is a review of the work so far done on *Sardinella longiceps* giving the salient findings on the fishery and biology of the species in detail. Elaborate tables and figures are given.

173. ANTONYRAJA, B.T. 1970. Estimation of age and growth of the Indian oil sardine, *Sardinella longiceps* Val. *Indian J.Fish.*, 17 (1&2): 26-42

Based on length-frequency on samples collected during 1961-62 to 1965-66 at Calicut a growth curve is derived. The normal life span of the fish is estimated to be  $2\frac{1}{2}$  years. The success in fishery in any year is stated to depend upon the spawning success and survival rate in the same year. Influence of rainfall on spawning is indicated. 9 figures and 5 tables are given.

174. ANTONYRAJA. B.T. 1971. Comments on the reported method of employing greater magnification for the ova-diameter studies in fishes. *Indian J. Fish.*, 18 (1&2): 174-176.

The note, citing oil sardine as an example, tries to prove that the method of using high magnification for the study of ova-diameter in fishes, hardly had any advantage over using low magnification, for technical reasons.

175. ANTONY RAJA, B.T. 1971. Fecundity fluctuations in the oil sardine, *Sardinella longiceps* Val. *Indian J. Fish.* 18 (1&2): 84-95.

Based on samples collected at Calicut during 1960-65, fecundity-length and fecundity-weight relations are studied using scatter diagrams. The relationship showed that, for a given length or weight, the fecundity varied considerably even within the

same season. Fecundity-age relation is stated to have shown older fish to have higher values of fecundity. The average number of ova per fish and the total number of ova per tonne of adult fish are worked out. 11 tables and 5 figures are given.

176. ANTONYRAJA, B. T. 1973. Oil sardine in the estuaries of North Kanara. *Indian J Fish.*, 20 (2) : 651-653.

Occurrence of juveniles of oil sardine with modal sizes 90mm and 110mm in the Kakinada estuary during October 1972 is recorded. Comparing the water qualities of the estuary and Karwar Bay, where oil sardine shoals occurred at this time, it is concluded that the entry into the estuary might be passive.

177. BAL, D. V.; VIRABHADRA RAO, K. V. 1984. Oil sardine. In: *Marine fisheries*. Tata McGrawHill Publishing Company Ltd., New Delhi, chap.4, p. 51-73.

[See Item. No. 4]

178. BALAN, V. 1959. Age determination of the oil sardine, *Sardinella longiceps* Val. by means of scales. *Curr. Sci.*, 28 (3) : 122-123.

Based on a study of scales taken from just above pectoral fin of 1370 specimens collected from Calicut during 1957-58, it is concluded that in oil sardine the scales are useful in estimation of age.

179. BALAN, V. 1961. Some observations on the shoaling behaviour of the oil sardine, *Sardinella longiceps* Val. *Indian J. Fish.*, 8 (1) : 207-221.

Based on spot observations in the inshore waters of Calicut during 1957-58, different types of oil sardine shoals are described, giving their visual and odoriferous diagnostic characters helpful in spotting. The characters are tabulated.

180. BALAN, V. 1964. Studies on the age and growth of the oil sardine, *Sardinella longiceps* Val. by means of scales. *Indian J. Fish.*, 11A (2) : 663-686.

The age and growth of oil sardine is estimated from the scales taken from a selected body area as well as from the length-frequency distribution of samples collected during 1955-1965 at Calicut and Cochin. Scale measurements are claimed to have shown that the fish had attained average lengths of 14.3, 16.4 and 18.4cm at the age of one, two and three years, respectively. Those below 12.0cm had no ring in their scales. Figures and tables showing results and observations are given.

181. BALAN, V. 1965. The fecundity and sex composition of *Sardinella longiceps* Val. along the Cochin Coast. *Indian J. Fish.*, 12A (2) : 473-491.

The monthly distribution of sex and maturation are presented. The egg counts made of 52 mature oil sardines collected from Cochin Coast are stated to have shown that mature ovary contained on an average 48119 ripe eggs. Relations between fish

length and number of eggs and fish weight and fecundity are worked out.

182. BALAN, V. 1972. Fishery and biology of the oil sardine *Sardinella longiceps* Val. off the Cochin Coast. *Indian J. Fish.*, 18 (1&2) : 135-147.

[See Item. No. 68]

183. BALAN, V.; REGHU, R. 1979. The Indian oil sardine. *Mar. Fish. Infor. Serv. T & E Ser.*, No. 14, p. 7-13.

[See Item. No. 72]

184. BENSAM, P. 1964. Growth variations in the Indian oil sardine, *Sardinella longiceps* Valenciennes. *Indian J. Fish.*, 11A (2) : 699-708.

Based on a study on samples collected from Cannanore during 1961-64, it is inferred that the fish had grown to about 40mm in the first year, and to about 20 mm in the second year. During the phase ending first maturity, the fish is reckoned to have grown to about 47mm in about 6 months; during the second maturity the growth was only about 10mm. During November-April, no growth was seen.

185. BENSAM, P. 1964. The pharyngeal pockets in the Indian oil sardine, *Sardinella longiceps* Valenciennes and a few other clupeiformes from Indian Waters. *Indian J. Fish.*, 11A (1) : 175-180.

A preliminary account of the morphology and internal structure of the pharyngeal pockets in the Indian oil sardine is given, along with the variations observed from other species. Pharyngeal pockets in different species are illustrated for comparison.

186. BENSAM, P. 1964. Difference in the food and feeding adaptations between juveniles and adults of the Indian oil sardine, *Sardinella longiceps* Valenciennes. *Indian J. Fish.*, 11A (1) : 377-390.

Juveniles were carcinivorous whereas adults were mostly phytoplankton feeders. Gill rakers were less developed in juveniles. Figures and tables are given.

187. BENSAM, P. 1965. Regeneration of caudal fin in the Indian oil sardine, *Sardinella longiceps* Valenciennes. *J. mar. biol. Ass. India*, 7 (1) : 102-107.

Based on a few specimens with caudal fins in various stages of regeneration, the process of regrowth of fin is explained. Five stages of regeneration are described. Figures are also given.

188. BENSAM, P. 1969. Further instances of gonadal peculiarities in *Sardinella longiceps* Valenciennes. *J.mar. biol. Ass. India*, 10 (1) : 172-174.



Some gonadal peculiarities noticed in oil sardine at Cannanore are recorded, such as a female with intergonadal loop, a female with divided right gonad, a female with bilobed right gonad, a female with intergonadal fusion, and males with intergonadal connective tissue.

189. DAYARATNE, P.; GJOSAETER, J. 1986. Age and growth of four *Sardinella* species from Sri Lanka. *Fisheries Research*, 4 (1) : 1-33

Studies on four species of *Sardinella*, including *Sardinella longiceps*, collected by gillnet in Sri Lanka are reported. Ageing was attempted by the study of otoliths, and it was observed to reach 14cm at the end of one year, when the fish also attained maturity. Two spawning seasons were observed - one each during the southwest and northeast monsoons. Tables and figures are given.

190. DELSMAN, H. C. 1926. Fish eggs and larvae from Java Sea. 7. The genus *Clupeia*. *Treubia*, 8 (3-4) : 219-239.

Illustrated description of the eggs and larvae of oil sardine is given, under the name *Clupea longiceps*.

191. DEVADOSS, P. 1973. On the occurrence of juvenile oil sardine *Sardinella longiceps* Val. in the inshore waters of Bombay. *Indian J. Fish.*, 20 (1) : 234-236.

Based on samples collected from the dolnet catches of mechanised boats, occurrence of young oil sardine, of 0-year class, in the inshore waters of Bombay during January and February 1971 is recorded.

192. DEVANESAN, D. W. 1943. A brief investigation into the causes of the fluctuations of the annual fishery of the oil sardine of Malabar, *Sardinella longiceps*, determination of its age and an account of the discovery of its eggs and spawning ground. *Madras Fish. Bull.* No. 28 (Report No. 1) : 1-24.

[See Item. No. 84]

193. DEVANESAN, D. W.; CHIDAMBARAM, K. 1953. The oil sardine. In: *The common food fishes of the Madras State*. Government Press, Madras, p. 14-17.

This is a popular article, giving the distinguishing characters, bionomics (habits, habitats etc.), method of capture and economic importance. The statistics of the fishery of west coast from 1929-30 to 1938-39 are also presented.

194. DHULKHED, M. H. 1962. Observations on the food and feeding habits of the Indian oil sardine, *Sardinella longiceps* Val. *Indian J. Fish.*, 9A (1) : 37-47.

Based on samples collected at Mangalore during February 1957 to January 1960, the volumes of stomachs were determined by displacement method and the dietary elements were determined by number method. It is concluded from the observations

that the sardines feed mainly on diatoms and dinoflagellates. Figures showing the fluctuation of different food items observed during 1957 to 1960 are given.

195. DHULKHED, M. H. 1963. The length-weight and volume relationships of the Indian oil sardine, *Sardinella longiceps* Val. *Indian J. Fish.*, 10A (1) : 40-47.

The study was at Mangalore between October 1959 and November 1960 on specimens ranging from 90mm to 210mm in total length, segregating them into intermediate male and female groups. Volume of fish was studied by displacement method. The difference in regression coefficients tested are stated to have been non-significant. Tables and figures for the results are given.

196. DHULKHED, M.H. 1964. Observations on the spawning behaviour of the Indian oil sardine, *Sardinella longiceps* Valenciennes, determined by ova diameter studies. *Indian J. Fish.*, 11A (1) 371-376.

The oil sardine occurred in different degrees of spent condition in the samples collected from the catches of various gears between Malpe and Kasargod during 1960-62, indicating the possibility of the fish releasing eggs in batches. The ova-diameter studies are stated to have shown that 3 to 4 batches of eggs might be released during spawning. Minimum size at first maturity is found to be 165-169mm. Figures are given showing size at first maturity and frequency of ova diameter.

197. DHULKHED, M.H. 1966. On an unusual ovary of the Indian oil sardine *Sardinella longiceps* Val. *J. mar. biol. Ass. India.* 7 (1) : 210-212.

A fish of 174mm, caught by cast net at Ullal, is reported to have had two dissimilar lobes in the gonads, one small lower lobe and one large upper lobe.

198. DHULKHED, M.H. 1968. Sex ratio and maturity stages of the oil sardine *Sardinella longiceps* Val. from the Mangalore Zone. *Indian J. Fish.*, 15 (1&2) : 116-126.

The paper presents the sex and maturity of oil sardine based on study during 1960-67. Hardly any difference is stated to have been noticed in the ratio of sexes. Spawning time was from June to September. Various degrees of spent stages were found from July to September, indicating the possibility of being released in batches. 6 tables are given.

199. DHULKHED, M.H. 1970. The food of small sized oil sardine of the Mangalore Area. *Indian J. Fish.*, 17 (1&2): 111-115.

The study was based on fish caught at Mangalore, of 40-79mm in length. The food mainly consisted of diatoms, dinoflagellates and copepods, without any noticeable consistency.

200. DHULKHED, M.H. ; SEKHARAN, K.V. 1976. Experimental cage rearing of oil sardine. *Proc. 63rd Indian Sci. Congress, Pt.4. Discussions: Zoology, Entomology and*

Fisheries section. Abstract No.23, 115-116.

A feasibility experiment is recorded. Oil sardine having been kept in suspended cages near shore at Mangalore, remained for more than a month without incurring mortality.

201. DHULKHED, M.H. 1977. Determination of mean length of oil sardine at different ages based on the annual size-frequency distribution. *Indian J. Fish.*, **24** (1&2):195-198.

Studies were done at Mangalore during 1960 to 1973. The average lengths of fish at ages of six, twelve, eighteen and twentyfour months were 87.9mm, 124.4mm, 156.9mm and 172.7mm respectively, the first three groups predominating in the fishery in most of the years.

202. DUTT, S. 1968. On the spawning season and juveniles of oil sardine, (with comments from M.S. Prabhu). *Curr. sci.* **37** (14) 411-412.

Different monthly modes in the lengths of juveniles in certain years are shown to indicate the different broods in an extended spawning season of oil sardine.

203. DUTT, S. 1981. A comparison of some ecological features of the populations of clupied fishes of cold and tropical waters. *Proc. Symp. Ecol. Anim. Popul. Zool. Surv. India*, Pt.1:149-154.

A comparison is made between oil sardine and herring. Whereas oil sardine was having an extended spawning, the herring had a single and short one. Oil sardine had no distinct migratory path but herring had a consistent migratory circuit.

204. DWIPONGGO, A. 1972. The fishery and preliminary study on the growth rate of 'Lemuru' (oil sardine) at Muntjar, Bali Strait. *Proc. Indo. Pacific. Fish. Coun.*, **15** (3): 221-240.

Length-frequency study is used to assess the growth rate and population structure of oil sardine (Lemuru). The selectivity of the fishing gear also is studied. It is observed that the size varied annually and the rate of growth during the Lemuru season was higher than in the offseason period.

205. EDWARDS, R.R.C.; SHAFER, S. 1987. Biometrics of *Sardinella longiceps* Val. in relation to upwelling in the Gulf of Aden. *J. Fish. Biol.* **30** (1): 67-73.

The seasonally oscillating water temperatures in the Gulf are correlated with the growth rates, body condition factor and gonad index of female oil sardine. Upwelling in the Gulf, resulting in nutrient enrichment and plankton blooms, is found to control the fishery. An annual fluctuating pattern, with weight loss of fish, is reported to have been observed in the non-upwelling period.

206. GRORGE,K.C. 1959. A method for distinguishing the sex of the oil sardine, *Sardinella longiceps* Val. in the field. *Indian J.Fish.*, 6 (2) : 322-326.

An externally visible muscular papilla in the cloaca of the male oil sardine and a corresponding membraneous structure in the female are described, stating that these are useful in segregating the sexes in the field. The method was, however, not found applicable in juveniles below 130mm in total length.

207. GEORGE,K.C. 1976. Ichthyoplankton surveys along the south west coast of India by UNDP/FAO Pelagic Fishery Project, Cochin, 1971-75. In: *Book of Abstracts of Papers presented at the Joint Oceanographic Assembly*, Edinburgh, U.K. 13-24 Sept. 1976, FAO,Rome.

The abstract is on an attempt made to establish the time and locality of spawning of oil sardine based on a comparative review. Peak period of spawning of oil sardine appeared to be from April to August, relatively close to shore, and mainly in the area between 11° 30' N and further 15° 30' N.

208. GEORGE,K.C. 1980. Studies on the distribution and abundance of fish eggs and larvae off the south-west coast of India with special reference to scombroids. (Ph.D.thesis) In: *Abstract of Theses 1973-89*, Cochin University of Science and Technology, Abstr. No.M.S.19, p.222-223.(Abstract only)

The ichthyoplankton collected by UNDP/FAO pelagic fishery project from 1409 stations mostly located on shelf waters of the area from Ratnagiri to Tuticorin during September 1971 to December 1975 formed the basis of the study. Sporadic large collections of eggs of *Sardinella longiceps* were made in July and August. Larvae of *Sardinella* spp. dominated by *S. longiceps* occurred throughout the year, but predominantly during March to September period with peak abundance in July and restricted to shelf areas.

209. GJOSAETER,J.; DAYARATNE,P.; BERGSTAD,O.A.; GJOSAETER,H.; SOUSA,M.I.; BECK,I.M. 1984. Ageing tropical fish by growth rings in the otoliths. *FAO Fish. Circ.*, No. 776, 54pp.

A report on the results of the attempts made at ageing fish in general from otoliths, the paper gives the observations made on oil sardine, which was one of the 29 species selected for case studies. In oil sardine, however, no functional relationship could be established between the fish and the otolith size.

210. GNANAMUTTU,J.C.; GIRIJAVALLABHAN,K.G. 1984. A note on the occurrence of mature oil sardine, *Sardinella longiceps* Val., off Madras coast. *Indian J. Fish.*, 31 (3) : 378 - 379.

The note records some mature oil sardine collected from Madras Coast during January - March 1978. The size ranges observed in different months are given. The presence of the mature fish has been deemed to suggest an imminent spawning in the areas around Madras.

211. HORNELL, JAMES; RAMASWAMI NAYUDU, M. 1924. A contribution to the life history of the Indian sardine with notes on the plankton of the Malabar Coast. *Madras Fish. Bull.*, 17 (Report No. 5) , 129 - 197.

The report gives the results of investigations carried out in Malabar and South Kanara Coast on oil sardine and plankton in the early 1920 s. The then physical and climatic characters of Malabar are described. Details of plankton recorded in the area are presented in tabular statements and figures. Specific characters, food, rate of growth and age limit, sex and sexual maturity, fat content and parasites are all dealt with in detail.

212. ICAR. 1971. *Report of the working party on sardine and mackerel resources*, Indian Council of Agricultural Research, New Delhi, 52pp.

[See Item No. 99]

213. JOHN C. C.; MENON, M. A. S. 1942. Food and feeding habits of oil sardine and mackerel. *Curr. Sci.*, 11 (6): 243 - 244.

The oil sardine is recorded mainly to be a phytoplankton feeder based on stomach - content analysis. Common items of food noticed were diatoms and dinoflagellates.

214. KAGWADE, P. V. 1964. The food and feeding habits of the Indian oil sardine, *Sardinella longiceps* Valenciennes. *Indian J. Fish.*, 11A (1) : 345 - 370.

The stomach contents of oil sardine from the inshore waters of Calicut are studied for feeding intensities of different age groups. Samples were collected during November 1959 to October 1962. The occurrence method, number method and weight method are followed. The main item of food is reported to be diatoms and dinoflagellates, zooplankton forming the third in importance. 5 tables and 6 figures are given.

215. KUTHALINGAM, M. D. K. 1959. Temperature tolerance of the larvae of ten species of marine fishes. *Curr. Sci.* 28 (2) : 75 - 76.

Based on a few parameters, such as length of fish and temperatures of air and sea water, it is attempted to find the optimum temperature for the early development of a few fishes including the oil sardine, which was found to thrive better in low temperature from the time of hatching up to post - larval period. Data are tabulated.

216. KUTHALINGAM, M. D. K. 1960. Observations on the life history and feeding habits of the Indian sardine, *Sardinella longiceps* (Cuv. & Val.). *Treubia*, 25 : 207 - 213.

Eggs and larvae of *Sardinella longiceps* are described based on studies conducted at Madras University during 1953 - 58. Description of larvae from the day of hatching to 40th day is given along with figures. Feeding habits of adult and post larvae are also mentioned.

217. KUTHALINGAM, M. D. K. 1961. Observations on the feeding habits of some sardines together with key to the identification of the young ones of the genus *Sardinella*. *Rec. Indian Mus.*, 59: 455 - 470.

The stomach contents of 1502 specimens of sardines belonging to eight species including *Sardinella longiceps* are studied with special reference to sex and maturity. The young sardines are stated to have been observed to feed on zooplankton while the adult fed mainly on phytoplankton.

218. KUTHALINGAM, M. D. K.; LUTHER, G.; SRINIVASAN, P.V.; LAZARUS, S. 1983. Preliminary experiments in the rearing of the oil sardine, *Sardinella longiceps* and Indian mackerel *Rastrelliger kanagartha* in floating cages. *Proc. Natl.Sem. Cage and pen Culture*, 18 - 19 March, 1983, Fisheries College, (Tamil Nadu Agricultural University) Tuticorin, p. 87 - 88.

A report on an attempt made to rear some fishes in cages in the inshore waters of Vizhinjam; the note claims that the results had indicated the feasibility of growing oil sardine in cages.

219. KUMAR, K. ; BALASUBRAMANYAN, K. 1987. Fishery and biology of oil sardine, *Sardinella longiceps* from coastal waters of Parangipettai. National Symposium on Research and Development in Marine Fisheries, 16 - 18 September 1987; *CMFRI Spl. Publ. No.*, 40, Abstract No. 8 and paper No. 6 *Bull. Cent. Mar. Fish. Res. Inst.*, No.44, p. 42 - 45.

Oil sardine fishery was about 70.5 tonnes during July - September '86 at Parangipettai. By von Bertalanffy's method, it was found that *S. longiceps* had a growth of 147.72 mm for the first year, 172.53mm for the second year and 187. 71mm for the third year. The size at first maturity was 156mm for the females and 158.5mm for males. Spawning was to be from July to September.

220. LAZARUS, S. 1976. On the occurrence of oil sardine in the spawning stage off Vizhinjam . *Indian J. Fish.*, 23 (1 & 2) : 249 - 252.

An occurrence of ripe and spawning oil sardine off Vizhinjam is reported, claimingly for the first time. Ova - diameter studies and fecundity estimate of primary and secondary modes are attempted.

221. LAZARUS, S. 1985. On the spawning season and early life history of oil sardine *Sardinella longiceps* (Cuv. & Val.) at Vizhinjam. *Indian J. Fish.*, 32 (2) : 236 - 247.

Oil sardine in spawning and spent conditions were recorded at Vizhinjam during May 1976, from farther off the usual fishing grounds. Illustrated descriptions of egg and different stages of larva collected are given.

222. MENEZES, MARIA. R. 1975. A morphometric study of *Sardinella longiceps* (Cuv. & Val.) and *Sardinella fimbriata* from the Goa Region. *Mahasagar - Bull. Nat. Inst. Oceanogr.*, 8 (1 & 2): 67 - 79.

Morphometric and meristic characters of *Sardinella longiceps* based on sample collected from Panjim during December 1974 to February 1975 are studied and compared with the earlier findings. The length frequency, sex - ratio, morphological characters etc, are tabulated.

223. NAGARAJA RAO, S.; SAMUEL, W.C. *A student's guide to fisheries*. V. 2. 136p.

The guide contains a brief description of oil sardine fishery, including its extent, nature and status of the fishery and the marketing of the fish.

224. NAIR, R. VELAPPAN. 1949. The growth rings on the oil sardine, *Sardinella longiceps*, (Cuv. & Val.). *Curr. Sci.*, 18 (1): 9 - 11.

It is reported that three growth rings were observed in the otoliths of a few oil sardine, 2 rings in some and no rings in a few. It is concluded that the rings were formed annually when food was scarce. Photomicrographs of otoliths are given.

225. NAIR, R. VELAPPAN. 1959. Notes on the spawning habits and early life history of the oil sardine, *Sardinella longiceps* (Cuv. & Val.). *Indian J. Fish.*, 6 (2): 342 - 349.

Description of egg and notes on the early life history, spawning season and spawning habits of oil sardine are given based on the observations at Calicut from 1948 to 1957. The study is stated to have indicated that the spawners entered the coastal waters during June & July, and that the spawning took place during August and September. It is also concluded that the fish spawned only once during a spawning season. Fecundity was estimated to be 78,000 eggs. Eggs, ovary and larva are described with illustrations.

226. NAIR, R. VELAPPAN. 1973. Indian sardines. (Biology and Fishery). CSIR Zoological monograph No. 2. Publication & Information Directorate, C. S.I. R., New Delhi. p. 1 - 36.

The monograph describes the biology, fishery and utilization of oil sardine. Other sardines are also dealt with. Taxonomy, distribution, shoaling habits, seasonal variation in the landings etc. are given. Fishing crafts and gear are described with diagrams.

227. NOBLE, A. 1965. The food and feeding habits of the Indian oil sardine *Sardinella longiceps* Valenciennes at Karwar. *Indian J. Fish.*, 12 A (1): 77 - 86.

Based on study of the stomach contents of fish landed at Karwar during 1961 -

64, the abundance and types of food of oil sardine are presented. Diatoms is listed as the major food item, stating that it had dominated in the stomach contents during July - September and December - February. Copepods were also important, as they had dominated during other times. Figures showing percentage of stomach contents are given.

228. PRABHU, M. S.; VENKATARAMAN, G. 1970. Mackerel and oil sardine tagging programme 1966-67 to 1968-69. *Bull. Cent. Mar. Fish. Res. Inst.*, No.17, 38pp.

The bulletin gives the method followed and the results obtained of the tagging of oil sardine and mackerel attempted at several centres in India. Plastic tags were used for which figures are given. Tables giving details of tagging and recoveries made during different seasons in different centres along the west and east coast are given.

229. PRABHU, M. S. : DHULKHED, M. H. 1972. On two new varieties of the Indian oil sardine, *Sardinella longiceps* Val., Mahasagar - *Bull. Nat. Inst. Oceanogr.*, 5 (1) :27-30 .

Some of the oil sardines collected from Baikampady near Mangalore on October 1966 were found to be different from normal fish as their body was broader and head shorter. The fishes obtained were classified into three types and the characteristics found are given in tabular form. For comparison, the morphometric and meristic characters of the normal fish as reported by different authors are given in a table.

230. PRAKASAM, V. R. ; PIUS JOHNSON. 1988. Scale morphology of three teleosts (*Etroplus suratensis*, *Anabas testudineus*, *Sardinella longiceps*) with reference to function. *Indian J. Fish.*, 35 (3): 221 - 225.

Morphological study showed that the scale of oil sardine were cycloid. The circuli of sardine scales were found to be either concentric or parallel, continuous or discontinuous and serrations were absent . Functions of these scale structures are also evaluated in this note.

231. RADHAKRISHNAN, N. 1965. Oil sardine investigations at Karwar. *Indian J. Fish.*, 12A (1) : 99 - 117.

The fishing seasons, maturity and spawning, and length frequency distribution of oil sardine observed at Karwar during January 1955 to March 1964 are presented. The season in general commenced during September - November and terminated in March - April with November - January the best period of fishery. Maturity of the fish was followed for the entire fishing season. Length - frequency is stated to have shown that the growth varied in the different year classes. Figures and tables are given.

232. RENGASAMY, V. S. 1977. Studies on length - frequency of oil sardine at Calicut during 1970 - 71 to 1973 - 74. *Indian J Fish.*, 24 (1 & 2) : 69 - 75.

The length frequency distribution at Calicut is reported to have shown that oil



sardine attained a total length of 125 - 130mm at the end of one year, 165 - 175mm at the end of two years and 180 - 190mm on completion of three years. The rate of growth appeared fast among the smaller size groups, and the fishery was mainly supported by 0 - year, 1 year and 2 year classes.

233. RITTERBUSH, S. W. 1975. An assessment of the population biology of the Bali Strait lemuru fishery. *Mar. Fish. Res. Rep.*, *Mar. Fish Res. Inst.* No.1, p. 1 - 38.

This paper presents certain biological aspects of lemuru (*Sardinella longiceps*) of Bali Strait. The life span of the fish is estimated to be 4 to 4.5 years. Spawning season is mostly June to July. The fish mainly feed on copepods. Recruitment of juveniles are apparently in correlation with the catch rate.

234. SAMUEL, C. T. 1968. Clupeoid fishes. 1: *Marine Fisheries in India*. Chap.5, Oceanographic Laboratory, University of Cochin, Cochin, p. 86 - 106.

A brief description of biology, occurrence, fishery, uses, etc. of oil sardine is given along with that of other clupeoid fishes. Table showing total landings in India during 1950 - 1965 is given.

235. VENUGOPALAPILLAI, S. 1968. A note on the morphological irregularities in the Indian oil sardine, *Sardinella longiceps* Val. *J. mar. biol. Ass. India*, 9 (1): 195 - 196.

Some morphological abnormalities, namely curvature in the region of caudal peduncle, absence of anal fin and absence of upper caudal fin, noticed in oil sardine are recorded.

#### 4. STOCK ESTIMATE

236. ANNIGERI, G. G. 1971. Estimation of mortality rates of the oil sardine, *Sardinella longiceps* Val. *Indian J. fish.*, 10 (1& 2): 109 - 113.

Mortality rates of oil sardine at Karwar as obtained by applying Beverton and Holt method on age composition are presented. The rates show variations from year to year, both in the total and in the fishing mortalities, which have been attributed to short term annual changes in available stocks.

237. ANON. 1974. Results of the 1973 aerial survey. *UNDP / FAO Pelagic Fishery Project, IND 69 / 593, Progress Report No. 8, 19pp.*

Based on aerial survey carried out in 1972 and aerial survey combined with vessel scouting in 1973, distributions of sardine and mackerel along the Southwest coast are presented. The school sizes and shapes, and abundance are estimated from combined aerial pictures and sonar findings. Tables and figures showing flights and cruise tracks and distribution of sardine and mackerel schools are given.

238. ANON. 1976. A synopsis of the information on pelagic resources along the south west coast of India. *UNDP / FAO Pelagic Fishery Project, IND 69 / 593, Progress Report, No.18, 31pp.*

The results of surveys made during 1971 - 75, using acoustic methods, are reported to be indicative of the standing stocks of pelagic fishes including sardine confining to the shelf region all through the year. Figures showing cruise tracks, distribution of schools sighted are given.

239. BANERJI, S. K. 1973. An assessment of the exploited pelagic fisheries of the Indian Seas. *Proc. Symp. Liv. Res. Seas around India*, Central Marine Fisheries Research Institute, Cochin, p. 114 - 135.

Assessments of oil sardine and other pelagic stocks are made with a view to estimating the probable magnitude of potential yields derivable from them. Tables are given for average annual landings (1958 - 67) and optimum yield. Annual mortality and effort calculated are presented in tables.

240. CORPUZ, A.; SAEGER, J.; SAMBILAY, V. 1985. Population parameters of commercially important fishes in Philippine waters. *Tech. Rep. Dept. Mar. Fish.*, No.6, 99pp.

Population parameters of 41 commercially important fish species including *Sardinella longiceps* in Philippine waters are estimated using length - frequency based computer programmes ELEFAN 1 and 11. Tables showing summary results of the analysis are given.

241. INGLES, J.; PAULY, D. 1984. An atlas of growth, mortality and recruitment of Philippine Fishes. *ICLARM Technical Report*, No.13, 127pp.

Results of analysis of the length - frequency data collected from 1957 to 1981 of different species from Philippines, including *Sardinella longiceps*, are given. The name of fish, sampling location and date, a graphic representation of length - frequency data with superimposed growth curve, length converted catch curve, recruitment pattern, and a graph with probabilities of capture plotted against length, are given for each fish separately.

242. LAZARUS, S. ; THIAGARAJAN, R. 1988. An assessment of the exploitation of the sardines at Vizhinjam, India. *Symp. Trop. Mar. Liv. Res.*, Marine Biological Association of India 12 - 16 January 1988, Cochin. Abstract No. 131, p. 67 - 68.

An assessment of sardine resources at Vizhinjam is attempted based on biweekly observations, and the level of exploitation is estimated using surplus production models. Annual landings of seven species of sardines including *Sardinella longiceps* (23.1%) are estimated at 272 tonnes. Gill nets, boat seines, shore seines and hooks and line are the gears observed for the study.

243. PANICKER, P. A. 1985. Pelagic fishery resources and its exploitation along Karnataka Coasts - an assessment. In : *Harvest and Post harvest Technology of fish*, Ed. by Ravindran, K, etal. Society of Fishery Technologists (India) , Cochin, p. 28 - 30.

The paper presents the data and results of analysis of commercial purse - seining from 1977 to 1981, using the method of surplus production model and taking catch - per - unit effort as the index of relative abundance of fish. The economic level of exploitation and maximum sustainable yield are discussed. The possibility of the purse - seining overexploiting the stock, leading to depletion is pointed out.

244. SANDERS, M. J.; BOUHIEL, M. 1984. Stock assessment for the Indian oil sardine *Sardinella longiceps* inhabiting the eastern waters of the People's Democratic Republic of Yemen. *FAO / UNDP Project Dev. Fish. areas of the Red Sea and Gulf of Aden*, FAO / UNDP RAB / 81 / 002 / 18, 62pp.(Abstract only).

An assessment of the oil sardine stock off the coast between Mukalla and Ras Fartak is reported. Estimates have been made for the growth constants with the aid of von Bertalanffy Equation, showing the growth to be seasonal, mostly during the months of July through August. Length - weight relationship is also studied. Spawning is shown to occur in August - September. Estimates are made for the natural and total mortality coefficients in the inshore and offshore parts of the stock. It has been concluded from the yield per recruit estimates that the annual catch of about 18 thousand tonnes could be increased to about 21 thousand tonnes following an annual increase in the fishing effort.

245. SEKHARAN, K.V. 1984. Estimates of the stocks of oil sardine and mackerel in the present fishing ground off the westcoast of India. *Indian J. Fish.*, 21 (1): 177 - 182.

The annual exploitation rate (U) is estimated; and the annual total stock is calculated by dividing total catch (Y) by U, and the annual average standing stock by dividing the annual catch by F - the annual fishing mortality coefficient. In the oil sardine fishery of the West Coast, M - natural mortality coefficient has been estimated as 1.12, F as 0.54 and U as 0.26. The Annual average catch for 1960 - 70 was 210,000 tonnes, based on which the annual total stock in the fishing ground could be 810,000 tonnes.

246. SRINATH, M. 1987. Trend of major exploited marine fishery resources of India during 1961 - 85. National Symposium on Research and Development in Marine Fisheries, Mandapam Camp 16-18 September, 1987. *CMFRI Spl. Publ.*, No. 40, 1987, Abstract No. 123, and paper No. 33 *Bull. Cent. Mar. Fish. Res. Inst.*, No. 44, 1989, p. 272 - 283.

In the trends worked out of the various exploited species by means of the Multistaged Stratified Random Sampling for the period 1961 - 85, the trend of oil sardine is shown as a gaining one on the South east Coast while it was a fluctuating one on the Southwest.

## 5. FISH PROCESSING

247. AGGARWAL, J. S. 1968. Processing of sardine fish oil. *Paintindia*, 18 (4) : 43-45.

Five samples of sardine oil from different dealers were studied and, based on the observation, the method of using it for different purposes such as hydrogenation and surface coatings are discussed.

248. AMES, G. R. ; GOPAKUMAR, K.; VJAYAN, P. K. 1987. Histamine formation in Indian oil sardine, *Sardinella longiceps*. *Infofish Marketing Digest*, 2/87, p. 41.

It was examined whether harmful histamine would be formed in oil sardine during storage by keeping it in ice at a constant temperature and analysing it at intervals. In the fish that had been kept at temperature above 10-15°C, histamine was found to have formed, though the fish appeared edible. Icing of fish as soon as possible is suggested as a remedy.

249. AMES, G. R.; POULTER, R. G. 1987. Frozen storage life of tropical fish species. *Infofish International*. 6/87 p. 39-41 also *FAO Fish. Tech. Pap.*, No. 317, p. 155-161.

Reviewing the works done so far on the subject the paper points out that in the freezing of oil sardine, the main factors affecting quality was formation of rancidity: but glazing with water before freezing could increase the storage life.

250. AMMU, K.; JOSE STEPHEN ; ANTONY; P. D. 1986. Nutritional evaluation of fish solubles. *Fish. Technol.*, 23 (1): 18-23.

Nutritional qualities of the solubles from oil sardine and pink perch were studied by feeding trials on albino rats. During 4-7 weeks of growth, fish soluble had no effect on growth, but during 7-10 weeks of age higher growth rate was observed. The sardine solubles were found poor in essential amino acids but were rich in other amino acids.

251. AMMU, K.; VISWANATHAN NAIR, P. G. ; DEVADASAN, K. 1986. Carbonyls from some commercially important fishes and shellfishes of tropical waters. *Fish. Technol.*, 23 (2) : 134-139.

A study on hexane-extractable carbonyl from three fishes including oil sardine and prawn is presented, which showed wide variations in the contents of different carbonyls in different fishes. Carbonyls distilled from muscle of oil sardine show difference from those extracted with hexane.

252. ANON. 1951. *Preliminary guide to Indian fish, fisheries, methods of fishing and curing*. Agricultural Marketing in India. , Marketing series No. 66, Manager of Publications, Delhi. 137pp.

[See Item. No. 1]

253. ANON. 1967. Utilization of sardine oil - preparation of ready-mixed paints. *Seafood Exp. J.*, 1 (10) : 25-26.

Stearine separated fraction of the oil after polymerisation under controlled conditions is reported to be usable in the preparation of ready mixed paints. The method of separation and the test for quality of the product are given.

254. ANON. 1976. Canning sardine - natural pack. *Souvenir* issued on the occasion of inauguration of permanent building of Central Institute of Fishery Technology, Cochin, p. 93.

A simple and cheap method of canning oil sardine with the fish packed in its own juice is presented.

255. ANON. 1976. Extraction of sardine oil. *Souvenir* issued on the occasion of inauguration of permanent building of Central Institute of Fishery Technology, Cochin, p. 101-102.

A new method of extraction of oil from oil sardine, claiming it to be an improved one, is presented, giving the physical and chemical qualities of the oil thus produced.

256. ANON. 1980. India, Salting oil sardine (*Sardinella longiceps*) by Mediterranean method and production of non-sterilized canned fish products. (A report prepared for the Pelagic Fishery Investigations on the Southwest Coast Phase II project). *FAO-FI-DP/IND/75/038*, 43pp.

Prepared based on the work and findings of a fish processing consultant in collaboration with the staff of the IFP, the document examines in detail among other things the possibility of industrial application of the most economic ways of processing and marketing of pelagic fish, including oil sardine, which was by far the most prominent. Different types of fish handling and transportation, processes of salting and maturation, and the salted fish products that were existing or developed in India and other countries are detailed and compared, pointing out the advantages and disadvantages of each. The salting experiments conducted on oil sardine in IFP are described in greater detail and the results obtained are compared with those recorded of the Mediterranean Sardines. And based on these experiences, a flow-sheet depicting the various factors that are to be followed in the order before and after salting is presented. Tables are given projecting and comparing the different data collected in the course of the study, and illustrations are given of the equipments, containers etc. that are used in the salt-curing of the fish.

257. BAL, D. V.; VIRABHADRA RAO, K. 1984. Oil sardine. In: *Marine Fisheries*. Tata McGraw Hill Publishing Company Ltd., New Delhi, chap. 4, p. 51-73.

[See Item. No. 4]

258. BHOJ RAJ NAIDU, N. 1976. Synthesis of sardine fish oil alkyd polymers. In: *Fish Processing Industry in India*, Symposium held at CFTRI, Mysore, 13-14 February 1975. p. 103-107.

The possibilities of partial or whole replacement of the costlier vegetable drying oils by the cheaper Indian sardine fish oil in the commercial production of alkyd resins are examined. The properties of the fish oil alkyds are studied by the synthesis of Glycerol sardine oil alkyds with or without modifications by maleic anhydride and of Glycerol sardine oil-castor oil blended alkyd polymer (66% oil length) and compared with a similarly synthesized straight castor oil alkyd of 66% oil length.

The composition of the long oil maleic modified sardine oil alkyds/straight sardine alkyds, and that of LO/sardine oil castor oil blended and straight castor oil alkyds prepared by the diacid-oil glycerolysis method, in comparison with DCO and sardine oil alkyds prepared by the conventional method are presented in tables.

259. BOSE, A. N. 1969. Freezing of tropical fish. (with addendum - Refrigerated sea water in preservation of tropical fish) In: *Freezing and Irradiation of fish*, Ed. by Kreuzer, Rudolf. Fishing News (Books) Ltd., London, p. 179-188.

This is a review of the works that had been carried out in India on the technology of freezing fish, in which the findings on sardine are also included. It is stated that, during the storage of individually quick frozen (IQF) oil sardine, slow increase of  $\alpha$  amino-nitrogen had been noticed. Bacterial flora of frozen fish kept up to two days in ice decreased continuously in storage. However, the count of those fresh fish kept more than two days in ice increased after an initial fall. Shelf life of frozen fish produced and packed in different conditions are presented in tables.

260. CHANDRASEKHAR, T. C.; KAVERIAPPA, K. M. 1985. A process for reduction of benzopyrene content in smoked oil sardine. *FAO Fish. Rep.*, No. 317, p. 262-266.

Samples of oil sardine were subjected to varying conditions of smoking such as reduction in combustion temperature, use of smoke filters etc. The products were analysed for 3, 4 benzo (a) pyrene content using spectro fluorometer-203, and found that, by certain conditions, the content of benzo (a) pyrene was reduced to the safe level fixed by International Union of Pure and Applied Chemistry. The process is said to have also yielded a product of desired colour, taste and acceptability.

261. CHANDRASEKHAR, T. C.; RUDRASHETTY, T. M.; UDUPA, K. S.; 1979. Studies on smoke curing and preservation of oil sardine (*Sardinella longiceps*.) *Fish. Technol.*, 16 (1): 47-52.

The paper gives a method for smoke-curing of oil sardine. Salted sardine (with salt-fish ratio 1:6) is smoked in traditional smoke chambers in 2 stages with smoke generated from coconut husk, wood shavings and saw dust in 2:2:1 ratio. The product thus obtained is said to have good odour, flavour, golden yellow colour and a shelf life

of 8 weeks at room temperature. Tables are given showing effect of smoking and storage characteristics of oil sardine.

262. CHINIVASAGAM, H. N.; ETOH, S. 1985. Vacuum pouch product development in Sri Lanka. Part I. Processing, *FAO Fish. Rep.* No. 317, suppl. p. 249-254.

Trial processings done of herring, sardine (*Sardinella longiceps*) tilapia, milkfish, tuna and flying fish in chilli/tomato sauce and brine are described. The packing was done in vacuum pouches. The product was tested for acceptability. In sardine, however, disintegration as well as yellowing of oil and development of rancidity was observed on storing.

263. CHINNAMMA GEORGE; VIJAYAN, P. K.; PERIGREEN, P. A. 1985. Utilization of frozen stored oil sardine for canning. In: *Harvest and Post-harvest Technology of Fish*. Ed. by K. Ravindran, et al, Society of Fishery Technologists (India), Cochin. p. 539-542.

The suitability of frozen oil sardine for canning was studied by chemically analysing the frozen fish stored at -23°C before and after canning. Fresh sardines when frozen were found suitable for canning up to 10-24 weeks, depending on season and initial quality. Tables are given for the analytical results.

264. CSIR, 1957. The wealth of India - Industrial products. Part IV: F-H, Council of Scientific and Industrial Research, New Delhi, p. 70.

A short note on oil sardine and the method of extraction of its oil is given.

265. CYRIAC MATHEN; CHOUDHURI, D. R.; PILLAI, V. K. 1966. Use of different glazes in frozen oil sardines. *Fish. Technol.*, 3 (1): 30-37.

The seasonal variation in the fat content of oil sardine, its frozen storage life at - 18°C and on treatment with various chemicals as coating materials for extending storage life are studied. The storage life of fresh oil sardine was found to extend, by dipping in hydroquinone solution prior to freezing or by coating with agar agar after freezing. Tables are given for changes in peroxide value, free fatty acids, moisture, drip and organoleptic characteristics during frozen storage.

266. DAMODARAN NAMBUDIRY, D. 1980. Lipid oxidation in fatty acid fish: The effect of salt content in the meat. *J. Food Sci. Technol.*, 17 (4): 176-178.

The effect of salting on the development of oxidative rancidity in frozen sardine was studied. Though salt imparts no effect on free fatty acid (FFA) formation at lower concentrations, as the concentrations increased it was found to inhibit formation of FFA. It is suggested that the adverse effect of higher concentrations of salt on lipid oxidation might be due to the inhibitive effect of salt on the catalyst of lipid oxidation in fish.



267. DEVADASAN, K. 1983. A comparative study of the muscle proteins of fishes and shell fishes of tropical waters. (Ph. D Thesis) In: *Abstract of Theses 1973-89*, Cochin university of Science and Technology. Abstract No. M. S. 35, p. 238-239. (Abstract only)

The distribution of major nitrogen fractions in several species of fishes including oil sardine was studied in detail. The changes in these fractions during storage in ice were also followed. Changes in the muscle protein fractions of oil sardine during quick freezing and subsequent storage at - 18°C were also studied by direct extraction with appropriate buffers. With progressive storage, total salt soluble proteins registered a regular fall.

268. DEVADASAN, K.; RAJENDRANATHAN NAIR, M. 1970. Observations on changes in the major protein nitrogen fraction of prawns and sardines during ice storage. *Fish. Technol.*, 7 (2): 195-197.

Changes in major protein nitrogen fractions such as sarcoplasmic myofibrillar and stoma were studied in two species of prawns and in oil sardine kept in ice storage. Myofibrillar proteins were denaturated rapidly but sarcoplasmic proteins were not denaturated. Extraction of myofibrillar protein was inhibited in the uniced condition in oil sardine due to fatty acids.

269. DEVADASAN, K.; MURALIDHARAN, V.; GEORGE JOSEPH. 1977. Influence of fat content on the quality and shelf life of cured sardines. *Fish. Technol.*, 14 (1) : 73-77.

The effect of seasonal variations in the fat content on the quality of dry cured, pickled and smoke cured oil sardine is reported. The fish collected from landing centre were cured and analysed for moisture, nitrogen, sodium chloride etc., according to A.O.A.C. method. Results obtained are given as tables. Comparative merits and defects of curing are also given.

270. DEVARAJU, A. N.; SHETTY, T. M. R. 1985. Comparative study of fish bacteria from tropical and cold/temperate marine waters. *FAO Fish. Rep.*, No. 317-Suppl. p. 97-107.

Oil sardine, mackerel, pink perch and croaker caught off Mangalore were studied for fish bacteria, and these were compared with the cold/temperate fish bacterial cultures obtained from Torry Research Station, U.K. Growth and bio-chemical activities of both bacteria were compared. Cold/temperate bacterial genera grew better at lower temperatures and showed better biochemical activities.

271. DHULKHED, M. H.; NAGESH, C. N. 1976. Serological studies on oil sardine (*Sardinella longiceps*) and mackerel (*Rastrelliger kanagurta*). *Fish. Technol.*, 13 (1) : 9-12.

Serological studies attempted on oil sardines at Mangalore is reported to have shown the presence of blood types A, AB and O, indicating the existence of genetically different groups of oil sardine in the region.

272. DHULKHED, M.H.; NARASIMHA RAO, S. 1976. Electrophoretic studies on serum proteins of oil sardine (*Sardinella longiceps*) and mackerel (*Rastrelliger kanagurta*) *Fish. Technol.*, 13 (1) : 16-19.

The serum protein electrophoretic studies attempted on oil sardine is reported to have shown A negative, A positive and B negative, from which the existence of genetically different groups of oil sardine at Mangalore is inferred.

273. DORA, K. C.; HIREMATH, G. G. 1987. Effect of chilled sea water storage of oil sardine (*Sardinella longiceps*) on quality changes during frozen storage. *Fish. Technol.*, 24 (2) : 109-111.

The study on the difference in quality and frozen shelf life of oil sardine preserved in chilled sea water and in ice prior to freezing is reported. The sardine preserved in seawater was found to be suitable for freezing up to 5 days while that in ice only up to 2 days.

274. DORA, KRUSHNACHANDRA, 1982. Effect of CSW storage on sardine fish *Sardinella longiceps* on the quality changes during frozen storage. (M.F.Sc. Thesis) 84 pp. In: *Catalogue of Theses 1976-85*, University of Agricultural Sciences, Mangalore (Abstract No. 40).

The efficacy of chilled sea water as the storing medium for freezing and handling of oil sardine is studied, taking bacterial growth as the index, and comparing the results with those of the prevailing traditional methods.

275. GEDAM, P. H.; AGGARWAL, J. S. 1967. Sardine fish oil. Part III. Refining of high acidity oil. *Painiindia*, 17 (4) : 19-20, 37.

The possibility of the raw sardine oil of high acidity and colours to be refined first by submitting it to urea adduct treatment and then by usual alkali refining is described. The yield of the thus refined oil, having very low acid value and pale colour, was much higher than that obtained by the two-stage alkali refining process.

276. GEDAM, P. H.; SUBBARAMAN, M. R.; AGGARWAL, J. S. 1971. Consecutive chromatographic techniques in the component fatty acid analysis of sardine oil. *Feete Seifen. Anstrichm.*, 73 (12) : 748-573 (Abstract only).

The method of analysis used in this investigation is stated to be supplementing the procedures developed by Ackman with the use of an internal standard method of Gunstone and Padley and is recommended for the component acid analysis of fish oils.

277. GEORGE, MANGALY, K. 1984. A critique of serological and electrophoretic studies

on the Indian oil sardine and mackerel. *Indian J. Fish.*, 31 (3) : 396-399.

A critical examination of some recent reports on electrophoretic and serological studies on Indian oil sardine is claimed to have shown that the authors of the report had ignored the basic procedures and had arrived at wrong conclusions which were misleading.

278. GIRIJAVARMA, P. R.; CHOUDHURI, D. R.; PILLAI, V. K. 1970. Effect of varying water contents in oil packed sardine and mackerel. *Fish. Technol.*, 7 (1) : 95-96.

The effect of water content on the shelf life of sardine and mackerel canned in oil are studied by examining the changes in physical and biochemical properties of samples of fish having less than 5% and above 25% water. The samples having higher percentage of water is stated to have developed black stain and showed less shelf-life. Table showing properties of canned fish with various water contents are given.

279. GOPAKUMAR, K. 1965. Seasonal variations in lipid composition of oil sardine (*Sardinella longiceps*). *Indian J. Fish.*, 12B (1) : 1-15.

Using oil sardine landed at two fishing villages of Cochin during 1964-65, oil was extracted from weighed quantities of muscle. Lipid was separated by chromatographic method. The components of lipid was estimated. The total lipid content, amount of tryglycerides and phospholipids thus recorded are represented graphically.

280. GOPAKUMAR, K. 1974. Fatty acid make up of lipids of oil sardine (*Sardinella longiceps*) in relation to seasons. *J. mar. biol. Ass. India*, 16 (3) : 830-834.

The paper gives the result of experiments conducted to find the seasonal variations in the total lipid and corresponding iodine values of lipids in oil sardine. Gas-liquid chromatography was used for fatty acid analysis. Tables are given for the fatty acid composition and iodine values.

281. GOPAKUMAR, K.; RAJENDRANATHANNAIR, M. 1966. Studies on fish lipids. II Fatty acid composition of lipids of oil sardine (*Sardinella longiceps*). *Fish. Technol.*, 3 (1) : 21-25.

The muscle and skin of fish chilled in ice, descaled and deboned were blended in mechanical blender and samples were analysed, and gas-liquid chromatography was employed for qualitative and quantitative analysis. The results are presented and discussed.

282. GOVINDAN, T. K. 1967. Saliience of sardine. *Sci. Rep.* 4 (12): 562-564. (Abstract only)

The abstract mentions the importance of oil sardine from the food and industrial points of view, and gives the different types of processing of this fish and preservation of products.

283. GOVINDAN, T. K. 1972. Oil sardine: an energetic food and potent industrial raw material. *Seafood Exp. J.*, 4 (8) : 37-41.

Commercial methods of preservation of the fish by freezing and canning and the method of extraction of oil are discussed.

284. GOVINDAN, T. K. 1973. Application on technology in optimum utilization of the fishery resources of India. *Proc. Symp. Liv. Res. Seas around India*, Central Marine Fisheries Research Institute, Cochin, p. 725-736.

The methods of handling, transportation, freezing, canning, curing and utilization of byproducts of the fish including oil sardine, are described.

285. GOVINDAN, T. K. 1974. Oil sardine : a rich marine resource. *Economic Times*, 15th December, p. 5 (Abstract only).

In this popular article, the economic importance of oil sardine is given. Though three lakh tonnes were landed annually, marketing of fish was a problem owing to lack of proper methods of preservation. Salting and drying could not be applied as the fish had high oil content which got easily rancid on drying and rendering the product inedible in a fortnight's time. Nevertheless, the oil had immense potentialities for industrial application and so new methods of extracting oil and preparing other products are introduced.

286. GOVINDAN, T. K. 1985. *Fish. Processing Technology*. Oxford IBH publishing Company, New Delhi. 252 pp.

Giving the fundamentals of preservation of tropical fishes, the book acquaints the beginners with commercially important fishes of India, including oil sardine. Freezing preservation of oil sardine, canning of smoked sardine, preparation of oil etc. are described in different chapters.

287. GOVINDAN, T. K.; SIBASANKAR GUPTA. 1977. Investigations on long distance transportation of fish. 1. Transportation of frozen fish from Cochin to Calcutta. *Fish. Technol.*, 14 (2) : 109-115.

Oil sardine, among a few other species of fish, were frozen after glazing and were sent to Calcutta from Cochin, along with an unglazed sample. Though all the other fish were qualitatively acceptable the oil sardine could only be fair-graded at the end of transportation. The chemical and bacteriological observations made at the destination are given in tables.

288. HIREMATH, G. G.; FRANS TEUTSCHER; ANDRES NORDHEM. 1982. Experiments on storage of fish in chilled sea water. *Mysore J. Agric. Sci.*, 16 (3) : 329-339.

Results of trials done on storage of sardine and mackerel in chilled sea water are

presented. The fish chilled in CSW immediately after catch and stored at 0°-5° were rated 'good' for 3 days, 'fair' up to 6 days, and 'acceptable' up to 8 days. Tables and figures for the data are given.

289. HIREMATH, G. G.; SUDHAKARA, N. S.; SHETTY, H.P.C. 1985. A new method for utilization of oil sardine for human consumption. In: *Harvest and Post-harvest Technology of Fish*, Ed. by K. Ravindran et al. Society of Fishery Technologists (India), Cochin, p. 573-576.

Fresh fish were salted and pressed and were stored in different temperatures. The pressed fish remained acceptable for 3 weeks at ambient temperature and 2 months at chilled room temperature.

290. HIREMATH, G. G.; SUDHAKARA, N. S.; SERRAO, A. 1986. Salted and pressed sardine. *Infofish Marketing Digest*, No. 2, p. 21-22.

A method of curing oil sardine by salting and pressing is presented, claiming that the cured products could be preserved at ambient temperature.

291. ISI, 1970. *Indian Standard Specifications for sardine oil*. IS:5734-1970 Indian Standard Institution, New Delhi, 7pp.

Standards for grades, requirements, packing and marking, sampling and tests of sardine oil are prescribed. Method of determination of free fatty acid is given as appendix.

292. JACOB, P. G.; RAJAGOPAL, M. D. 1980. Variation in chemical contents and biochemical composition of tissues in some marine fishes. *Indian J. Mar. Sci.*, 9 (3) : 207-211.

Of the various fish chemically studied, oil sardine is reported to have the lowest ratio of food cal. - body cal.: of 0.3, indicating its being the most efficient energy converter of all. The results are presented in tables and figures.

293. JAFFAR, M.; ASHRAF, M. 1988. Contents of selected macronutrients in various marine fish from the Arabian Sea. *Pak. J. Sci. Ind. Res.* 61 (1) : 23-25. (Abstract only)

Twelve marine fishes, including oil sardine were selected for the estimation of Calcium, Sodium, Potassium and Magnesium by atomic absorption method. The estimation was performed in the edible muscle to check their nutritional quality on the basis of recommended dietary allowances laid down internationally. On the whole, almost all the fish were found to be potential sources of the macronutrients.

294. JAFFAR, M.; ASHRAF, M. 1988. Selected trace metal concentrations in different tissues of fish from coastal waters of Pakistan (Arabian sea). *Indian J. Mar. Sci.* 17 (3) : 231-234.

Trace metal concentrations in edible muscle, kidney and liver of twelve species of fish including oil sardine were analysed by atomic absorption spectrophotometry. The levels of these trace metals were minimum in muscle, while in kidney and liver they were higher. The study revealed that the trace metal levels in Indian Oil Sardine, pomfrets and longtail tuna were higher as compared to other fish. Tables giving concentration of various metals in muscle, liver and kidney of different fish are furnished.

295. JAFFAR, M.; ASHRAF, M. 1989. Arsenic concentrations in the edible muscle of commercial marine fish species from Arabian Sea. *Fisheries Research*, 7 : 11-16.

Twelve species of marine fishes including oil sardine, in 78 samples collected along the coast of Karachi between 1986 and 1987 were studied for chemical contamination using atomic-absorption method, and the results are presented and discussed. Figure showing the locations of sampling sites and a table giving the observed concentrations of arsenic in the different species are furnished.

296. JOSHI, VITHAL, R. 1978. Studies on the effect of pre-cooking in the fish (*Sardinella longiceps*) canning. (M.F.Sc Thesis) 108 pp. In: *Catalogue of Thesis 1976-85*, University of Agricultural Science, Mangalore.

The results of experimental pre-cookings done for four different durations at three temperatures in three types of cans are reported. Cooking the fish on grills and cans in upright and inverted positions are comparatively examined. The results are claimed to have shown that anaerobic plate counts were reduced to one-thousandth of the original, and the non spore forming bacteria, yeast and moulds were completely destroyed.

297. JOSHI, V. R.; SARALAYA, K. V. 1981. Studies on the effect of precooking in sardine canning. I. Effect on microflora of fish. *Mysore J. Agric. Sci.*, 15 (2) : 322-326.

Oil sardine precooked in 1lb jam can in steam at 100°C is studied for its effect on counts of bacteria, yeast moulds etc.

298. JOSHI, V. R. ; SARALAYA, K. V. 1981. Studies on the effect of precooking in fish (*Sardinella longiceps*) canning. II. On major chemical components. *Mysore J. Agric. Sci.* 15 (1) : 142-150. (Abstract only).

While studying the effect of precooking in the canning of sardines by using containers at different temperatures for various durations, it was found necessary to analyse the losses of chemical constituents of fish in relation to the total weight loss. In general, moisture content and fat content were decreased while protein was increased on cooking. The losses were higher with higher temperature, larger can and longer cooking time.

299. JOSHI, V. R.; SARALAYA, K. V. 1982. Studies on the effect of precooking in

sardine canning: V. Factors influencing the precooking effect. *Mysore J. Agric. Sci.*, 16 (3) : 338-345.

The effects of freshness, fattiness and different methods of precooking on the canned product are studied. Precooking was found less effective on fresh sardines than on iced ones. Very fatty fish was 15 min. ahead of moderately fatty fish in reducing product exudate to the required 1.5 percent level. Cooking outside of can and packing them later into can was found to affect the final product adversely.

300. JOSHI, V. R.; SARALAYA, K. V.; NAGARAJ, A. S. 1983. Studies on the effect of precooking in sardine canning. III. On weight loss and exudate. *Mysore J. Agric. Sci.*, 17 (2) : 177-181.

Sardines experimentally precooked at three different temperatures for different periods and canned, showed that greater the precook, larger was the weight loss and smaller the quantity of exudate in the cans. It was found that precooking, which resulted in weight loss of 23-26%, reduced the exudate to below critical level of 1.5 to 1.7 per cent of packed fish weight.

301. KAIMAL, M.N.N.; MADHAVAN, P. 1967. Utilisation of sardine oil for industrial purposes. I. Factice for use as a filler in rubber compounding. *Res. Ind.*, 12 (4) : 251-252. (Abstract only)

The possibility of using sardine oil as a raw material for the preparation of dark factice has been studied. It is found that a product similar to commercial factice could be prepared by treating sardine oil at 180-200°C with 20 per cent by weight of elemental sulphur.

302. KAIMAL, M. N. N. ; GOPALAKRISHNA PILLAI, A. G. ; MADHAVAN, P. 1968. Utilisation of sardine oil for industrial purposes. II. Surface coating material from sardine oil. *Res. Ind.*, 13 (1) : 24-26. (Abstract only)

The possibility of preparing surface coating material from sardine oil is examined. On heating at 200°C in the presence of cobalt oxide catalyst for 2 hours, the drying characteristics changed and odour was also removed. The paint prepared using this oil conformed to the Indian Standard Specifications for ready mixed paints.

303. KAIMAL, P.N.R. 1969. Freezing of oil sardines. *Indian seafoods*, 7 (2) : 21-24.

The paper describes a method devised for freezing, in which, treatment of fish by brine solution for a specific period is claimed to have prevented belly bursting.

304. KALAIMANI, N.; MURALEEDHARAN, V.; JOSEPH, K. G.; UNNIKRISHNAN NAIR, T. S. 1984. Antioxidant effect of betel leaf extract on dry-cured fish. *Fish. Technol.*, 21 (1) : 37-40.

Oil sardine was treated with 5% betel leaf extract in water at different stages of

salt-curing. The fish dipped in the extract immediately after salting, and then drying, was found to have better keeping qualities.

305. KALLOLI, B. N. 1978. Storage studies on oil sardine fish meal with special reference to its fat content. (M.F.Sc. Thesis) 112 pp. In: *Catalogue of Thesis 1976-85*. University of Agricultural Sciences, Mangalore. (Abstract No. 48).

The thesis listed is reportedly based on an 8 month observation of the protein and fat contents in sardine fishmeal experimentally stored in polythene bags and comparing them with those of the fresh fish.

306. KALLOLI, B.M.; SHAMASUNDER, B.A. 1983. Effect of fat content on protein quality of fish meal during storage. *Mysore J. Agric. Sci.*, 17 (1) : 66-70.

Fish meal prepared by standard wet reduction method was tested for difference in rates of fat content by solvent extraction method. The samples were stored at room temperature and tested at intervals of one month, for eight months. The reduction in pepsin digestibility and available lysine content of fish meal during storage was found to be in direct relationship to its fat content. Increase of TBA values is stated to have been rapid in high fat samples and gradual in low fat samples.

307. KALLOLI, B.M.; SHAMASUNDER, B.A.; BHANDARY, C.S. 1984. Efficiency of different solvents for estimation of fat content in sardine fish meal during storage. *Mysore J. Agric. Sci.*, 18 (1) : 52-57.

It is reported that, of three solvents studied, acetone was found to be the most efficacious and petroleum ether the least, throughout the storage period. In the extracted fat, the Iodine Value and TBA Value were determined. The reduction in the fat extractability are argued to be mainly due the oxidation and polymerisation changes.

308. KAMASASTRI, P.V.; RAMANANDARAO, D. 1962. Studies on Indian fish meals. I. Chemical composition and storage characteristics of fish meals prepared from different types of fishes. *Indian J. Fish.*, 9B (2) : 108-117.

Of the fish meals prepared from fresh caranx, jewfish, sardine and mackerel landed at Cochin, sardine meal was found to have had low protein value. Changes in nitrogenous fractions and fat during storage period are described, giving tables.

309. KAMASASTRI, P.V. 1960. Studies on the Indian sardine oil. *Indian J Fish.* 7 (2) : 443-447.

The deterioration in the quality of the commercial sardine oil during storage was studied, comparing it with oil prepared under controlled conditions. The comparison was done by AOAC methods. The value of the various parameters such as specific gravity, refractive index, acid value, peroxide value, saponification



value etc. obtained in both the cases are given comparatively in tables.

310. KAMASASTRI, P.V.; PRABHU, P.V.; RAMANANDA RAO, D. 1962. Further studies on the Indian sardine oil. *Indian J. Fish.*, 9B (1): 84-90.

The qualities of the sardine oils obtained from different places on the West Coast are studied in comparison with laboratory extracted oil. The probable reasons suspected for the higher rates of deterioration observed in the commercial products are discussed, suggesting remedial measures.

311. KARTHIAYANI, T.C.; MAHADEVA IYER, K. 1967. Quantitative and qualitative studies on the bacterial flora of fresh sardines. *Fish. Technol.*, 4 (2): 89-97.

Bacterial counts at room temperature and at 8°C on the skin with muscle and the gut content of fresh sardines made for a year are reported to have seasonal variations. The counts were similar in the gut content and the skin with muscle. Qualitatively, the analysis revealed a high occurrence of Gram-negative rods and low occurrence or nil of Gram-positive rods in fresh sardines.

312. KARTHIAYANI, T.C.; MAHADEVA IYER, K. 1971. Seasonal variations of bacterial flora of fresh oil sardines (*Sardinella longiceps*). *Fish. Technol.*, 8 (1): 69-79.

Seasonal variations were found in the total bacteria and their characters. During monsoon, the total count was high. During summer, mesophiles predominated and the phosphorescent bacteria were less, and during winter, the less active groups were common. Tables and figures are given.

313. KARTHIAYANI, T.C.; MAHADEVA IYER, K. 1971. Temperature influence on the biochemical characteristics of fresh sardines (*Sardinella longiceps*). *Fish. Technol.*, 8 (1): 100-101

The paper is on the study of bio-chemical activities on 460 bacterial cultures associated with fresh sardines landed by country boats.

314. KOTWAL, K.F.; PAI, V.M. 1968. Fatty acid from sardine oil. *Pain India*, 18 (4): 54-55.

The body of oil sardine was first deacidified in a vacuum distillation plant and the oil was split into fatty acids and glycerol. The quality of glycerol thus obtained was acceptable. The results showed that if oil with less odour was produced, the quality of products could be improved.

315. KRISHNAKUMAR, S. 1983. Studies on handling and preservation of oil sardines (*Sardinella longiceps*) in chilled sea water. (M.F.Sc Thesis) 92 pp. In: *Catalogue of these s 1976-85*. University of Agricultural Sciences, Mangalore (Abstract No. 50).

The advantages of using CSW as the medium of storage of oil sardine over the traditional method are examined.

316. KRISHNAKUMAR, S.; HIREMATH, G.G.; MENON, N.R.; SHETTY, H.P.C.

1985. Preservation of *Sardinella longiceps* in iced and chilled sea water. Part I. Changes during storage with particular reference to bacterial load and nitrogenous compounds. *Fish. Technol.*, 22 (2): 126-131.

Four samples prepared on board - 2 in chilled sea water, one iced and one uniced - were studied. All were stored in chilled room. By studying the bacterial count and nitrogen compounds, it was seen that chilling in CSW enhanced the shelf life by 2 to 4 days. Figures and tables for the observations are given.

317. KRISHNAKUMAR, S.; HIREMATH, G.G.; MENON, N.R. 1986. Preservation of Indian Oil Sardine *Sardinella longiceps* in ice and chilled sea water Part II -Changes during storage with particular reference to deterioration during CSW holding. *Fish. Technol.*, 23 (1): 1-6.

Studying the weight changes, salt penetration into meat and rancidity development in 4 samples - 2 chilled, one iced and one uniced - kept in chilled room, it was found that sardines in CSW, kept better quality for the first 4-5 days after which the quality deteriorated.

318. LALITHA, K.V.; MAHADEVA IYER, K. 1985. Use of catalase value as an index of quality of oil sardine (*Sardinella longiceps*) in ice storage. In: *Harvest and Post-harvest Technology of Fish*, Society for Fishery Technologists (India), Cochin, p. 678-679.

The study is reported to have shown that the muscle catalase values were in such correlation with organoleptic quality of oil sardine, that the catalase value could be used as an index of quality.

319. LISAC, H. 1974. Upgrading and adapting fishery products of lower market value. In: *Fishery products* Ed. by Kreuzer Rudolf, Fishing News (Books) Ltd., England, p. 156-160.

Giving some selected achievements in upgrading the fishery resources of low market value in different parts of the world, the article refers to the condition of the large stock of *Sardinella longiceps* found in Yemen. As it was difficult to market the fish locally, research was being made for utilizing the fish for converting into other products.

320. MADHAVAN, P.; KAIMAL, M.N.N. 1968. Utilisation of sardine oil. *Paintindia*, 18(4): 50-53.

Traditional and improved methods of extraction of oil from sardine and its industrial utilisation, such as manufacture of factice, surface coating materials, printing ink and additive to lubricating oil etc. are reported.

321. MADHAVAN, P.; UNNIKRISHNAN NAIR, T. S. 1973. Utilization of sardine fish. *Fish. Technol.*, 10 (1): 44-51.

The problems and prospects of processing sardine into canned or frozen products, and of distributing the fish in fresh condition by quick transport are dealt with. Utilization of sardine body oil for production of factice and paints, and as additive in lubricating oil and base for printing ink are also discussed.

322. MADHAVAN, P.; BALACHANDRAN, K.K.; CHOUDHURI, D.R. 1970. Suitability of ice stored mackerel and sardine for canning. *Fish. Technol.*, 7 (1): 67-72.

Effect of storage prior to canning on the quality of canned product is studied, comparing the physical and chemical properties during ice storage with those of the finished product. Organoleptic analysis is stated to have shown that the fish stored in ice up to two days were suitable for canning, but storage for larger period affected the appearance. Supporting data are given in tables.

323. MADHAVAN, P.; UNNIKRISHNAN NAIR, T. S.; BALACHANDRAN, K.K. 1974. A review on oil sardine I. Distribution, preservation and transportation. *Fish. Technol.*; 11 (2): 88-92.

Reasons for the fluctuation of oil sardine are reviewed, briefly stating the utilization of catches and the problems faced by the industry.

324. MADHAVAN, P.; UNNIKRISHNAN NAIR, T.S.; BALACHANDRAN, K. K. 1974. A review on oil sardine II. Preservation by canning, curing and smoking. *Fish. Technol.* 11(2): 93 -101.

The paper reviews the methods of processing of oil sardine into different products and their preservation. Packing of sardine for export is also described.

325. MADHAVAN, P.; UNNIKRISHNAN NAIR, T.S.; BALACHANDRAN, K.K. A review of oil sardine III. Oil and meal industry. *Fish. Technol*, 11 (2): 102-107.

An improved method of oil extraction that would give a yield of about 12% oil is suggested. A brief account of the salient features of the fish meal and fish- protein concentrate extracted from oil sardine are also given. Tables comparing the qualities of sardine oil with similar oils and the commercially produced oil with the oil produced by suggested method are furnished.

326. MENEZES, MARIA, R. 1975. Electrophoretic studies of eye lens serum proteins of *Sardinella fimbriata* (Valenciennes) and *Sardinella longiceps* (Valenciennes). *Mahasagar, Bull. Natn. Inst. Oceanogr.* 8 (3&4): 117 - 121.

The protein components of eye lenses and blood sera of two species of sardines studied, are compared. While the protein components in lenses were similar, the sera are stated to have shown the difference in that the number and position of the protein

components differed.

327. MENEZES, MARIA R. 1975. A morphometric study of *Sardinella longiceps* (Cuv. & Val.) and *Sardinella fimbriata* from the Goa region. *Mahasagar, Bull. Natn. Inst. Oceanogr.*, 8 (1&2):67-79.

Some marked deviations in the metric and meristic characters observed in the *S. longiceps* from the Goa Region, collected from December 1974 to February 1975, from those recorded by earlier workers are studied. The difference in characters is suspected to be due to the two stocks being from two different subgroups. Tables are given presenting the observed differences.

328. MENEZES, MARIA, R. 1980. Immunochemical analysis of soluble lens proteins in some marine fishes. *Indian J. Mar. Sci.*, 9 (1): 63-65.

Soluble eye lens proteins of 10 fishes belonging to different families were studied by immunoelectrophoresis using the lens antiserum of *Sardinella longiceps*. Method of preparation of antiserum is described. Figures illustrating the reaction of the antiserum is given.

329. MENEZES, MARIA. R. 1980. Soluble lens proteins polymorphism in the oil sardine, *Sardinella longiceps* Val. *Mahasagar, Bull. Natn. Inst. Oceanogr.*, 13(2):183-185.

In the cellogel electrophoretic studies of soluble eye lens proteins of the oil sardine, two band patterns are stated to have been observed, irrespective of sex or size, suggesting the samples analysed to have come from two different populations.

330. MOELJANTO, R. 1985. The role of the fat content on the processing of Bali Strait sardines. *FAO Fish. Rep.*, No.317 suppl. p.267-270.

In the oil sardine, or lemuru, the most important species in the Bali Strait, there was correlation between fat content and fishing season. The range of fat content was 5-25%, thus making the fish ideal for extracting oil. Results of processing experiments done by better handling of fresh fish are also presented and discussed.

331. MOHITE, R.R. 1977. Studies on the effect of time of storage of oil sardines on the yield, quality and changes during storage of sardine oil. (M.F.Sc. Thesis) 118pp. In: *Catalogue of Theses 1976-85*, University of Agricultural sciences, Mangalore. (Abstract No.54)

The effects of different durations and methods of storing the raw material on the product quality are studied.

332. MOHITE, R.R. 1979. Studies on the effect of time of storage of oil sardine on the yield, quality and changes during storage of sardine oil. *Mysore J. Agric. sci.*, 13 (1): 122-123.

It is concluded from the results obtained in the experiments to produce grade 1 and grade 2 sardine oil (as per IS: 5734: 1970) fish should not be stored for more than 8, 24, 14 hr. and 32, 138, 60 hr. respectively in uniced, iced in anteroom and iced condition.

333. MOORJANI, M.N.; SELVARAJ, A.; IMAM KHASIM. 1976. Reducing water/oil ratio in sardine fish canned in oil. In: *Fish Processing Industry in India*, symposium held at CFTRI, Mysore 13-14 February 1975, p.52-53.

The paper discusses a few methods involving a little change in the processing line to overcome the problem of water in canned oil sardine. The modifications needed in the existing canning lines are given.

334. MOORJANI, M.N.; VASANTHA, M.S. 1972. Hot smoking of oil sardines and mackerels. *Seafood Exp. J.*, 4(3): 25-27.

A combined process of salting, boiling and smoking as a short-term preservation as applied to oil sardine and mackerel is reported along with the observed quality of the finished product.

335. MUKUNDAN, M.K.; GOPAKUMAR, K.; NAIR, M.R. 1985. Purification of a lipase from the hepatopancreas of oil sardine (*Sardinella longiceps* Linnaeus) and its characteristics and properties. *J. Sci. Food Agric.*, 36 (3): 191-203

Lipase was purified from the hepatopancreas of oil sardine by defatting, water extraction, ammonium sulphate fractionation and chromatography on DEAE Sephadex and Sephadex G-100. The preparation was homogenous on polyacrylamide disc gel electrophoresis and on gel filtration through Sephacryl S-200. The pH and temperature optima of purified sardine lipase were 8 and 37°C respectively. Sardine lipase remained stable up to 45°C and in the pH range 5 to 9.5. Tables and figures are given.

336. MUKUNDAN, M.K.; GOPAKUMAR, K.; NAIR, M.R. 1985. Preparation and properties of immobilised sardine lipase. In: *Harvest and Post-harvest Technology of Fish*, Ed by Ravindran, K. et al, Society of Fishery Technologists (India), Cochin, p.429-439.

The preparation of sardine lipase from hepatopancreas of oil sardine and immobilisation by polymerisation in acrylamide gel followed by lyophilisation is described. Properties of the natural and immobilised lipase such as pH, temperature optima and the rate of hydrolysis of various tryglycerides are also given.

337. MUKUNDAN, M.K.; RADHAKRISHNAN, A.G.; JAMES, M.A.; NAIR, M.R. 1985. Nutritive value of red and white meat of oil sardine (*Sardinella longiceps*). In: *Harvest and Post-harvest Technology of Fish*, Ed. by Ravindran, K. et al. Society of Fishery Technologists (India) Cochin, p-426-428.

The study was made by experimentally feeding albino rats with dried red and white meat of oil sardine separately, along with a protein-free basal diet. The result indicated that the white meat was superior to red in protein content, while the red meat was better for nutrition.

338. MURALEEDHARAN, V.; VALSAN, A.P. 1976. Preparation of smoke cured fillets from oil sardine. *Fish Technol.*, 13(2) : 146-152.

A method of preparation of smoke-cured fillets of oil sardine is described, with suggestions useful to enhance storage life. Tables for the studies are given.

339. MURALEEDHARAN, V. 1980. Ready to serve products from oil sardine. *Seafood Exp.J.*, 12 (2) : 29-30.

Methods, claiming to be simple, economic and efficient, to process diversified products like fillets, pickles and chutney powder out of smoked sardine are given.

340. NAIR, P. G. V.; ANTONY, P. D.; GOPAKUMAR, K. 1979. Oxidative rancidity developed in the skin and muscle lipids of oil sardine (*Sardinella longiceps*). *J. Food Sci. Technol.* 16 (4): 151 - 154.

Oxidative rancidity developed in the skin and muscle lipids of oil sardine during frozen storage (-18° c) is studied by measuring peroxide value, thiobarbituric acid number and polyene indices and determining fatty acid compositions. Increase in peroxide and thiobarbituric acid values and fall in polyene indices are stated to be faster in skin lipids. The peroxide value reached a maximum after 4 weeks of storage, indicating rapid autoxidation.

341. NAIR, R. VELAPPAN. 1973. *Indian sardines (Biology and fishery)* CSIR Zoological monograph No. 2, Publication and Information Directorate, New Delhi, p. 1. - 36.

[See Item. No. 226]

342. NARAYANAN NAMBIAR, V.; SURENDRAN, P. K.; MAHADEVA IYER, K. 1974. Morphological, biochemical and growth characteristics of *Serrata* strains isolated from sardine (*Sardinella longiceps*). *Fish. Technol.*, 11 (2) : 129 - 136.

Two aerobic gram-negative bacterial strains from fresh sardines were studied for morphological, biochemical and growth characteristics. The strains were found to resemble *Serratia plymuthica*. Effect of temperature and certain carbohydrates on the pigmentation was also studied. Iron was found to inhibit pigmentation and mannitol or sorbitol to remove inhibition. Tables are given for the studies.

343. NARASIMHA RAO, S.; DHULKHED, M. H. 1976. Electrophoretic characteristics of oil sardine (*Sardinella longiceps*) and mackerel (*Rastrelliger kanagurta*) eye lens proteins. *Fish. Technol.*, 13 (1) : 13 - 15.

Electrophoretic treatment on eye lens proteins is reported to have separated the proteins into three and four components, which is taken as a sign of an heterogeneous nature of the fish population.

344. NIGAM, B. P. 1974. Canning oil sardine in oil (summary report on the development of proposed commercial manufacturing process). *Seafood Exp. J.*, 6(6): 15 - 34.

A procedure of canning oil sardine in oil on a commercial scale is reported, giving the physical features of the plant, raw materials needed, sanitation and packaging, process and equipment, operation procedure etc. Flow charts for machinery and operation are presented. Cost of estimated production is also given.

345. NIRMALA THAMPURAN ; MAHADEVA IYER, K. 1979. Studies on the growth temperature ranges of bacteria isolated from fresh sardine at different primary incubation temperatures. *Fish. Technol.*, 16 (1) : 15 - 18.

An experiment was conducted by isolating 296 bacterial cultures from sardine, employing streak plate technique. At 8° c psychotrophs were recovered, where as at 37°c mesophiles were recovered. At 30° c both were recovered.

346. PERIGREEN, P. A. ; GOVINDAN, T. K. 1969. Transportation of fish in India - problems and prospects. *Fish. Technol.*, 6 (2) : 74 - 78.

Susceptibility to spoilage during transportation of fish including oil sardine is examined. Belly - bursting was the problem associated with oil sardine. In some cases, it was 25% to 30%, depending on the maturity. Dipping in 15% brine for 30 minutes prior to freezing is suggested as a possible remedy. Tables comparing the storage lives of fish in different containers are given.

347. PERIGREEN, P. A. ; GOVINDAN, T. K. ; PILLAI, V. K. 1969. An effective method for reducing belly - bursting in frozen oil sardines. *Fish. Technol.*, 6 (1) : 55 - 58.

Of the different concentrations of NaCl and the different durations of dippings tested, a 30 minute dip in 15% solution prior to freezing was found to reduce belly - bursting of frozen oil sardine. Results obtained in all other tests are also presented.

348. PERIGREEN, P. A. ; AYYAPPAN PILLAI, S. ; SURENDRAN, P. K. ; GOVINDAN, T. K. 1975. Studies on preservation of fish in refrigerated sea water. *Fish. Technol.*, 12 (2) : 105 - 111.

Comparing storage of oil sardine in refrigerated sea water and in crushed ice, it was found that RSW was inferior to crushed ice. Comparative tables are given for the peroxide value, free fatty acids, total bacterial count and organoleptic characteristics noted in both the cases.

349. PEROVIC, V. ; SAMUEL, G.E. 1978. The canning of Indian pelagic fish in a Yugoslavian canning plant. *Proc. Indo-pacif. Fish. Commission*, 18 (3): 272-287.

This is a report on a trial canning done in a Yugoslavian canning plant in 1977 of 4 species of Indian fish including oil sardine to find if the method used for mediterranean fish could also be applied to Indian species. The trial is reported to have shown that it was applicable for good results but with a little change in the canning lines and technological processes adopted there. Flow chart for sardine canning and a table showing product and yield are given.

350. PILLAI, V. K. 1974. Utilization of *Sardinella* resources in India. In : *Fishery products*, Ed. by Kreuzer, R. Fishing News Ltd., England, p - 212 - 225.

The paper gives in length the prospects of freezing, canning and curing of oil sardine. The uses of sardine oil for different purposes are also pointed out. Tables comparing sardine oil with similar oils and the commercially prepared oil with that prepared by the improved methods suggested are given.

351. PRABHU, P. V. ; MADHAVAN, P. ; RAMACHANDRANNAIR, K. G. 1978. Fishery byproducts and utilization of fishery wastes in India. *Proc. Indo - Pacif. Fish. Coun.* , 18 (3) : 515 - 519.

The commercial production of fishmeal, fishoil, sharkfins and fishmaws in India are reviewed. The improvement in quality of byproducts the modern extraction units had made possible over the traditional ones, particularly in the production of sardine oil, is emphasized.

352. PUTRO, SUMPENO. 1986. Better on board handling of oil sardines in the Bali Strait using chilled sea water. *Infofish Marketing Digest*, No. 1, p. 33 + 35.

The oil sardine which used to form about 89% of total fish caught in the Bali Strait used to be mainly auctioned causing improper returns. Better returns are stated to have been possible if the fish were stored in Chilled Sea Water onboard the purse seiners soon after catching. A plan of a CSW tank to be carried onboard purse seiners is given.

353. RADHAKRISHNAN, A. G. ; ANTONY, P. D. ; NAIR, M. R. 1985. Changes in major fractions of oil sardine (*Sardinella longiceps*) and mackerel (*Rastrelliger kanagurta*) during frozen storage. In : *Harvest and Post - harvest Technology of Fish*. Ed. by Ravindran, K. et al., Society of Fishery Technologists (India), Cochin, p. 433 - 435.

Oil sardine were frozen-stored for 6 months at  $-18^{\circ}\text{C}$  and the changes in their protein fractions were noted. The myofibrillar fraction showed decrease with rise in the denaturated fraction as the duration of storage increased. The sarcoplasmic protein showed only mild decrease. Table is given showing the protein fractions as observed.

354. RAJENDRANATHAN NAIR, M. 1962. A preliminary study of the changes associated with lipid breakdown in oil sardine (*Sardinella longiceps*) stored at refrigerated temperatures. *Indian J. Fish.*, 9B(1) : 126-132.



The effects of storage at 10°C and at the temperature of ice on the course of breakdown of lipids, and the changes brought out by the proteolytic action in the tissue during storage are studied. Rapid proteolysis is stated to have occurred at higher temperature. Volatile acid number increased after 4th day at 10°C. Free fatty acid production was found to be influenced by increased proteolytic rate. Figures are given for the findings.

355. RAMADASS,V.; AGGARWAL,J.S.1967. Sardine fish oil.  
Part II. Alkyd resins. *Paintindia*, 17 (3) : 26-27.

Long, medium and short oil length alkyds were prepared separately from linseed oil and sardine fish oil, and from their mixtures in the ratios 70:30 and 50:50. The colour of the alkyds is stated to have darkened as the amount of sardine oil in the alkyd formulations increased. The acid values of the product also increased gradually. It is therefore concluded that the substitution of 30 percent linseed oil by sardine oil would not lead to much of alkyd deterioration. Tables are given for the results.

356. RAO,K.N.A.;STEPHEN,S.; AGADI,B.M.; NAGESWAR,B.; SUBRAMANYAM,Y.;  
BALIGA, N. 1975. Investigation into the source of epidemics of infantile  
gastroenteritis in Coondapur. *Aq. Sci.Fish. Abstr.*,7(4), Code No.7Q3454, p.8.

This is an abstract of a paper appeared in *Indian J. Pediatr.*, 42: 319-325, stating that the source of epidemics that occurred since 1972 causing 23 deaths was traced to sardines among other marine finfishes and shell fishes.

357. RAO, S.N.; PAI,,M.P.; SEN, D.P.; MATHEW,G. 1977.  
Effect of sardine oil on the serum cholesterol level: a study in normal human  
volunteers. *Aq.Sci.Fish. Abstr.*, 7 (11), Code No.7Q 15113, p.255.

This is an abstract of a paper published in *Indian J. Nutr. Diet.*, 14 (1) : 1-7. The investigation which was meant to see the effect of sardine oil on humans, and to see how far the observations made with rats are applicable, was made on human volunteers, giving sardine oil to some, sunflower oil to some and a mixture of the two to some. The results indicated that the sardine fish can be included in the diets of cases with hypocholesterolemia and cardiovascular diseases.

358. SANTHANA KRISHNAN,G. 1987. Export potential of sardines.  
*Seafood Exp. J.*, 19 (1-2) : 31-33.

As the existing methods of preserving oil sardine such as canning, freezing etc. were ineffective to prevent spoilage, suggestion is made in this paper to process it in dried form, as well as looking for its potential for export.

359. SARALAYA, K.V.; NAGARAJ, A.S. 1986. Influence of physical characteristics and  
chemical composition on the canning yield of mackerel and sardines.  
*Mysore J, Agric. Sci.*, 20 (3): 216-224.

The influence of size and weight and of moisture and fat contents in oil sardine on the canning yield is studied. Charts and tables are prepared in the light of the findings to help processors to maximize yields in canning.

360. SARALAYA, K. V.; PARASHURAM, P. 1971. Studies on the canning yield of some important fishes of the west-coast of India. *Seafood Exp. J.*, 3(1):125-129.

The results of studies conducted on the dressing ratio, percentage yields and yield rates obtained in the canning of five kinds of fishes including sardine in different types of pack, using suitable containers, are presented and discussed.

361. SATISH, M.S. 1983. Production, utilization and storage studies of minced meat of oil sardine (*Sardinella longiceps*). (M.F.Sc. Thesis) 72pp. In: *Catalogue of Thesis 1976-85*. University of Agricultural Sciences, Mangalore (Abstract No.63).

The advantage of preserving oil sardine in minced condition are studied experimentally, and the results are discussed.

362. SEN, D.P. Use of sardine oil in oil sardine packs and as a hypocholesterolemic agent-a review. In: *Fish Processing Industry in India*, Symposium held at CFTRI, Mysore 13-14 February 1975, p. 89-91.

The experiments since conducted on packing sardine in sardine oil are stated to have shown that properly extracted sardine oil could be used for packing and that the blend of sardine oil and refined groundnut oil was having high acceptability. Also, it is stated that from a similar review of the experiments so far done both on rats and on human volunteers, the hypocholesterolemic effect of both the fish and the oil was confirmed.

363. SEN, D.P.; CHALUVAIAH. 1968. Sardine oil; its extraction and properties. *Painindia*, 18(4) : 39-41.

The sardine oil from whole fish was found to vary in colour from greenish yellow. Freshly extracted oil was bland but developed rancid and fish oil odour.

364. SEN, D.P.; DANIL, N.P. 1968. A techno-economic study of oil sardine (*Sardinella longiceps*) for meal and oil. *Indian Seafoods*, 6(3) : 7-14.

Properties of sardine oil and the indigenous and modern methods of preparing it are given. There are also suggestions to produce oil and meal with improved qualities.

365. SEN, D.P.; GRACY MATHEW. 1975. Present status of research on sardine oil in India - a review. *Seafood Exp. J.*, 7(7) : 9-14 and 7(8) : 9-16 also in: *Fish Processing Industry in India*, Symposium held at CFTRI, Mysore, 13-14 February 1975, p. 87-89.

An account of the works done on sardine oil is presented. Tables are furnished,

giving synoptic view of the current status of knowledge.

366. SEN,D.P.; REVANKAR,G.D. 1968. Processing of sardine oil for certain industrial uses. *Painindia*, 18(4) : 42

Certain processings such as hydrogenation of the oil for industrial uses are presented, giving the qualities of the processed materials.

367. SEN,D.P.; REVANKAR,G.D. 1972. Seasonal variation in the amount of oil of oil sardine (*Sardinella longiceps*)fish. *J.Food Sci. Tech.*, 9(2): 93.

Fresh oil sardine captured at Mangalore and adjacent areas showed that October-December was the period of maximum fat content and January was the period when fat content started falling. Fat and moisture contents were also found to be interrelated.

368. SEN,D.P.; REVANKAR,G.D. 1973. Use of sardine oil in oil sardine packs. *Seafood Exp. J.*, 3 (12) : 13 - 17.

Properly extracted sardine oil, was almost bland, which was found to be useful for packing oil sardine. A blend of sardine oil and refined ground nut oil is stated to have had acceptability, too as packing medium.

369. SEN, D. P.; PADIVAL, R. A. 1970. Effect of certain proteins on the stabilisation of fish oil. *J. Food Sci., Technol.*, 7 (3) : 153 - 158.

The stabilising effect of Fish Protein Concentrate, Ground Nut Protein Isolate and Leaf Protein are studied and compared. It was observed that the nature of stabilising effects of these materials were different from that of Butylated Hydroxy Anisole.

370. SEN, D. P. ; SRIPATHY, N. V. 1968. Sardine meal and oil units for South Kanara District : some considerations. *Seafood Exp.*, 2 (10) : 9 - 12.

The factors which are to be taken into consideration for the establishment of fish meal and oil factory on modern lines are discussed.

371. SEN, D. P. ; BHANDARY, C. S. ; MURTHY, I. A. S. ; NARASIMHARAO, S. ; PAI, M.P. 1974. Hypocholesterolemic effect of sardine oil and oil sardine (*Sardinella longiceps*). *J. Food. Sci; Technol.*, 11 (3); 113 - 117.

Experiments conducted on rats are reported to have shown that neither the oil sardine nor the oil had significant effect on cholesterol content of heart or liver.

372. SHAMASUNDER, B. A. 1978. Prevention of quality deterioration of sardine oil in press liquor. ( M. F. Sc. Thesis) 115pp. In: *Catalogue of Theses 1976 - 85*, University of Agricultural sciences, Mangalore (Abstract No. 64).

An experimental study conducted on the preservation of fish press liquor by

formaldehyde treatments and high temperature applications is described giving the results.

373. SHAMASUNDER, B. A.; BHANDARY, C. S. 1985. Effect of sodium chloride treatment on the quality of sardine oil in press liquor at room temperature. In: *Harvest and Post-harvest Technology of fish.*, Ed. by Ravindran, K. et al., Society of Fisheries Technologists (India), Cochin. p. 631 - 637.

The efficiency of sodium chloride treatment to prevent quality deterioration of sardine oil in press liquor was investigated. Three different concentrations of sodium chloride, namely 5, 10 and 15 per cent were used. It was found that 10 and 15 percent NaCl treatment were effective in retaining the quality of oil in press liquor for 10 days. The quality of oil was tested by odour, colour, acid value and test for rancidity. Figures and tables for the test results are given.

374. SHAMASUNDHER, B. A. ; BHANDARY, C. S. 1985. Studies on the effect of formaldehyde treatment on the quality of sardine oil in press liquor during storage at room temperature . *Mysore J. Agric. Sci.*, 19 (2) : 109 - 114..

On adding formaldehyde in well - mixed press liquor and cooked water, the deterioration of press liquor was found retarded. Tables giving oil quality and bacterial count on addition of formaldehyde are presented.

375. SRIKAR, L. N.; HIREMATH, G. G. 1972. Fish preservation.  
1. Studies on changes during frozen storage of oil sardine. *J. Food Sci. Tech.*, 9 (4) : 191 - 193.

The effect of various glazes in suppressing rancidity during frozen storage of oil sardine was studied. No significant difference in the effect of antioxidants was found. However, the storage life was extended in the fish frozen in blocks after filling the air space with glazing solution.

376. SRIPATHY, N. V. 1974. Marine fish processing industries in the coastal districts of Mysore. *Seafood Exp. J.*, 6 (6): 35 - 45.

Fish landing trends of the two coastal districts of North and South Kanara and the prevailing means and methods of disposal of fish, including conversion of excess oil sardine into meal and oil are discussed with the aid of tables.

377. SRIPATHY, N. V. 1979. Fish and fish products. In : *Food Industries*, Chemical Engineering Education Development Centre, Indian Institute of Technology, Madras, p. 15. 1 - 15.8.

Various aspects of fishery and fishery products in India are mentioned . Methods of preservation of oil sardine fish and oil extraction are given, along with those for other possible products like fish meal, flour, hydrolysates etc.

378. SRIPATHY, N. V. ; AHMED, S. Y. 1978. Improvements in quality of fish meal and oil - pilot plant efforts. *Seafood Exp. J.*, 10 (9) : 25 - 33.

The fish meal - fishoil plant based on sardine, initiated on a pilot plant basis by CFTRI in late sixties is described, comparing the quality of the oil obtained with that of the traditionally produced oil. The quality of fish meal from the plant also is given.

379. SRIVASTAVA, N. B. ; BHOJRAJ NAIDU, N. 1976. Upgrading of sardine fish oil by various physical and chemical methods. In: *Fish Processing Industry in India*, Symposium held at CFTRI, Mysore. 13 - 14 February, 1975, p. 100 - 103.

Sardine oil as generally marketed was usually deep brown in colour and possessed a putrid smell with high acidity. The attempts made to upgrade the oil by refining and deodourisation, involving solvent extraction, acidolysis and maleinisation, are described.

380. SUDHAKARA, N. S. ; NAGARAJ, A. S. , SHETTY, T. M. R. 1986. Economics of a batch type wet - reduction method for oil sardines. *Seafood Exp. J.*, 18 (9): 10 - 13.

Describing the capital investment, workings and layouts of the batch - type wet - reduction method practiced in the Dakshina Kannada for production of fish meal and oil, the paper lists the advantage of the batch type method in the context of the prevailing highly erratic oil sardine landings. The layouts of the two common types of units found in Dakshina Kannada , one for handling less quantities of raw materials and the other for larger quantities are presented.

381. SUDHAKARAN, R. ; SUDHAKARA, N. S. 1985. Studies on the preparation of the salted and dried minces from Threadfin bream (*Nemipterus japonicus*) and Indian oil sardine (*Sardinella longiceps*). *FAO Fish. Rep.* No. 317 Suppl., p. 338 - 347.

Salted and minced meat, a better alternative to the traditional salting of whole fish was tried both with threadfin bream and with oil sardine. Different saltmince ratios and drying conditions were tried to get an acceptable product. Shelf lives of the product, their acceptability and economics are discussed. The method of salting and mince is stated in detail along with the observations made on chemical and microbial changes during storage.

382. SUDHAKARAN, R. 1984. Studies on preparation and shelf life of salted fish mince. (M. F. Sc. Thesis) 75pp. In: *Catalogue of Theses 1976 - 85*, University of Agricultural sciences, Mangalore (Abstract No. 66)

The feasibility of minced fish as an alternative to traditional salting of whole fish was studied in the case of thread fin bream and oil sardine, examining the shelf life.

383. SURENDRAN, P. K. ; GOPAKUMAR, K. 1981. Selection of bacterial flora in the

chlortetracycline treated oil sardine (*Sardinella longiceps*) Indian mackerel (*Rastrelliger kanagurta*) and prawn (*Metapenaeus dobsoni*) during ice storage. *Fish. Technol.*, 18 (2): 133 - 141.

The succession of bacterial groups at various stages of spoilage of fish, including oil sardine, treated with the antibiotic are studied. In the treated oil sardine, *Pseudomonas*, *Moraxella* and *Acinetobacter* groups were found to decrease initially, but later on the *Pseudomonas* group increased, and after 21 days, 80% of flora on the samples consisted of this group only.

384. SURENDRAN, P. K. ; GOPAKUMAR, K. 1982. Bacterial flora of EDTA treated oil sardine (*Sardinella longiceps*) Indian mackerel (*Rastrelliger kanagurta*) and prawn (*Metapenaeus dobsoni*) in ice storage. *Fish. Technol.*, 19 (1) :33 - 39.

The flora of fresh oil sardine had consisted mainly of *Pseudomonas*, *Moraxella*, *Acinetobacter* and *Vibrio*. During spoilage in ice, *Pseudomonas* alone was found to constitute 75%. Treatment with EDTA before storing in ice reduced the *Pseudomonas* considerably. Tables showing percentage composition of bacterial flora isolated are given.

385. SURENDRAN, P. K. ;GOPAKUMAR, K. 1982. The bacteriology of oil sardine (*Sardinella longiceps*) and mackerel (*Rastrelliger kanagurta*) caught from tropical waters off Cochin. I. Quantitative aspects. *Fish. Technol.*, 19 (2) : 89 - 96.

The total aerobic viable plate counts of skin, gills and intestine of newly caught oil sardine at four different temperatures are compared, showing that the bacterial density was the highest in intestine and lowest on skin. Comparative tables are provided.

386. SURENDRAN, P. K. ; GOPAKUMAR, K. 1982. The bacteriology of oil sardine (*Sardinella longiceps*) and mackerel (*Rastrelliger kanagurta*) caught from tropical waters off Cochin. II. Qualitative aspects. *Fish. Technol.*, 20 (1): 45 - 52.

The skin, gills and intestine of oil sardine were found to consist, to about 90%, of gram negative bacteria belonging to genera *Vibrio*, *Pseudomonas*, *Moraxella*, *Acinetobacter* and *Cytophaga*. The remaining 10% was constituted by gram positive *Micrococcus* and *Arthrobacter*. Significant seasonal changes in the relative distribution of different genera were observed.

387. SURENDRAN, P. K.; GOPAKUMAR, K. 1985. Preservation of oil sardine with propyl paraben dips. In: *Harvest and Post-harvest Technology of Fish*, Ed. by Ravindran, K. et al, Society of Fishery Technologists (India), Cochin, p.373- 376.

Fresh oil sardine were dipped in 500ppm and 1000ppm propyl paraben solutions and stored in crushed ice. The fish were examined bacterjologically, chemically and organoleptically to determine the storage life. The storage life of 1000ppm propyl paraben treated fish extended 5 days over that of the control. Tables showing shelf life

and changes in bacterial flora of treated fish are given.

388. SURENDRAN, P. K. ; JOSE JOSEPH; SHENOY, A. V. ; PERIGREEN, P. A. ; MAHADEVA IYER, K.; GOPAKUMAR, K. 1989. Studies on spoilage of commercially important tropical fishes under iced storage. *Fisheries Research*, 7: 1 - 9.

Iced - storage characteristics of 5 species of fishes including oil sardine were studied. Oil sardine was found to have a storage life of 5 - 6 days. With increase in days of storage, the percentage of *Pseudomonas* spp. also increased, and the fish was spoiled. Tables showing fish size and pattern of changes in the bacterial flora, and a figure showing changes in average sensory scores during iced storage are given.

389. SURENDRAN, P. K. ; MAHADEVA IYER, K. 1973. Experimental preservation of sardines (*Sardinella longiceps*) using chlortetracycline. *Fish. Technol.*, 10 (2) : 110 - 115.

The effect of dips in 10ppm and 50ppm chlortetracycline on storage life of oil sardine in ice are studied. The antibiotic treatment though caused a decrease in the bacterial count, did not control the rancidity, indicating the lack of efficacy of the antibiotic in preservation.

390. SURENDRAN, P. K. ; MAHADEVA IYER, K.; GOPAKUMAR, K. 1985. Effectiveness of EDTA dips on the shelf life of oil sardine (*Sardinella longiceps*) mackerel (*Rastrelliger kanagurta*) and prawn (*Metapenaeus dobsoni*) in ice storage. *Fish. Technol.*, 22 (1) ; 28 - 34.

In the sardine, mackerel and prawn which had been dipped in Na EDTA and stored in ice, the total plate count (TPC) and Trimethylamine Nitrogen content (TMAN), though decreased, the EDTA absorbed by the muscle was not completely removed. Also, rancidity was not prevented. Tables showing the results are given.

391. SUSAMMA CHERIAN.; RAJENDRANATHAN NAIR. M. 1969. Preliminary observations on changes in nucleotides in oil sardine and certain penaeid prawns during chill storage. *Fish. Technol.* , 6 (2): 36 - 41.

The course of nucleotide degradation during ice storage in oil sardine and two species of prawns is studied. The patterns of nucleotide changes in block - frozen fish and in individually quick - frozen fish stored at -23°C are compared, providing tables and figures.

392. SUSAMMA JACOB; KARTHIAYANI, T. C.; RAJENDRANATHAN NAIR, M. 1964. Effect of aureomycin on the behaviour of certain free amino acids in oil sardine (*Sardinella longiceps*) held in ice storage. *Fish. Technol.*, 1 (2) : 164 - 167.

Oil sardine treated with aureomycin solution and packed in polythene bags were

stored in crushed ice, along with untreated ones for a period of 26 days, studying bacteriological counts and estimation of amino acid during intervals. Bacterial counts showed reduction in the antibiotic treated fish, but the amino acid content increased during the storage period both in the treated and in the untreated ones. Table showing bacterial counts and figures for amino acid estimations are furnished.

393. UNNIKRISHNAN NAIR, T. S.; BALACHANDRAN, K. K. ; MADHAVAN, P. 1977. Canning of smoked sardine. *Fish. Technol.*, 14 (1) : 49 - 52.

The experiment is said to have indicated that cold blanching of dressed fish in 15% brine and smoking followed by drying in hot air or cooking in steam before canning would yield good organoleptic qualities in canned oil sardine. In the experiment coconut husk was used for generating smoke. Tables are given.

394. UNNIKRISHNAN NAIR, T. S. ; MADHAVAN, P; BALACHANDRAN, K. K. PRABHU; P. V. 1974. Canning of oil sardine (*Sardinella longiceps*) natural pack. *Fish. Technol.* 11 (2): 151 - 155.

A method of canning oil sardine in its own juice instead of oil is suggested, which consists of dipping cleaned sardine in brine containing potash alum and citric acid, packing in cans, exhausting and seaming, and heat processing.

395. VASANTHA, M. S. ; MOORJANI, M. N. 1970. Some aspects of canning of oil sardine (*Sardinella longiceps*) . *Indian Food Packer*, 24 (4) : 11 - 14.

The size of fish to be preferred for canning, the most suitable levels of water and fat contents of fish, and the brining time are given in order for obtaining a canned product of delicacy.

396. VASANTH SHENOY, A. ; PILLAI, V. K. 1971, Freezing characteristics of tropical fishes. I. Indian Oil Sardine. *Fish. Technol.*, 8 (1) : 37 - 41.

The influence of pre - freezing ice - storage period on the shelf lives of individually quick - frozen and block - frozen oil sardine kept in storage at -12°C and -23°C was examined by studying biochemical and organoleptic qualities. The shelf life of sardines varied between 24 and 2 weeks for samples iced for 0 to 5 days prior to freezing. Block - frozen sardines were better in biochemical quality.

397. VENKATESWAR RAO, M. ; GEDAM, P. H. 1976. Fatty acid compositions of sardine oil. In: *Fish Processing Industry in India*, Symposium held at CFTRI, Mysore, 13 - 14 February 1975. p. 91 - 93.

The method and result of a fatty acid analysis done on three samples of sardine oil produced at the pilot plant at CFTRI are given. Fatty acids ranging in chain lengths from C<sub>12</sub> to C<sub>22</sub> and in unsaturation from 0 to 6 double bonds were found in these oils. A few odd numbered fatty acids were also detected.



398. VIJAYAN, P. K. ; BALACHANDRAN, K. K. 1986. Development of canned fish curry. *Fish. Technol.*, 23 (1) : 57 - 60.

The methods of canning sardine in two types of curry media are described with tables showing the recipe, storage characteristic etc. The sample with less chilli is claimed to have remained in good condition for 18 months at room temperature, whereas that with more chilli remained so only for 15 months.

399. VISWANATHAN NAIR, P. G. ; ANTONY, P. D. ; GOPAKUMAR, K; RAJENDRANATHAN NAIR, M. 1978. Lipid breakdown in oil sardine (*Sardinella longiceps*) during frozen storage. *Fish. Technol.*, 15 (2) :81 - 84.

The course of phospholipid breakdown, production of free fatty acids and the changes taking place in major unsaturated fatty acids during frozen storage of oil sardine are described. The rate of free fatty acid production was faster. The hydrolysis of lipids and accumulation of free fatty acid and development of rancidity were the major problems in frozen storage.

400. VISWANATHAN NAIR, P. G. ; RAJENDRANATHAN NAIR, M. 1985. Fatty acid composition of muscle and skin lipids of oil sardine. In: *Harvest and post-harvest Technology of Fish*. Ed by Ravindran, K. et al, Society of Fishery Technologists (India), Cochin, p. 441 - 444.

Oil sardine samples collected from Cochin during 1980 - 1982 were studied for monthly variations in the fatty acid composition of muscle and skin lipids. Seasonal variations in the proportion of the various acids in the lipids were noticed. Tables are given showing the distribution of acids.

401. VISWESWARAIAH, K. 1969. Chemical preservation of oil sardine fish to obtain a good grade fish oil: *J. Food. Sci. Tech.*, 6 (2): 103 - 105.

Different chemicals and antibiotics were tested for preserving oil sardine individually and in combination at room temperature (27 - 30°C) for more than 24 hours prior to processing; but none gave desired result. The fish dip - treated in saturated NaCl solution containing formaldehyde was, however, found to give quality improvement in product.

402. VISWESWARAIAH, K. 1969. Chemical preservation of oil sardines (*Sardinella longiceps*) to obtain a good oil. *J. Food Sci. Tech.*, 6 (3) : 173 - 178.

The oil obtained from minced oil sardine packed with NaCl containing formaldehyde was compared with the oil obtained from freshly caught fish, and the results are presented. The economics and advantages of the operation are discussed. Tables giving different qualities of oil and a flow chart for processing fish meal and oil from oil sardine are also given.

## 6. AUTHOR INDEX (Item Numbers given)

- Abdul Nizar, M 73  
 Abha Kant 125  
 Agadi, B. M 356  
 Aggarwal, J. S. 247, 275, 276, 355  
 Ahmed, S. Y 378  
 Alagaraja, K. 100, 152  
 Ames, G. R. 248, 249  
 Anmu, K. 250, 251  
 Andres Nordhem 288  
 Annam, V. P. 125  
 Annigeri, G. G. 36, 37, 161, 236  
 Anon. 1, 2, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48,  
 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60,  
 162, 163, 164, 165, 166, 167, 237, 238,  
 252, 253, 254, 255, 256  
 Antony, P. D. 250, 340, 353, 399  
 Antonyraja, B. T. 3, 61, 62, 63, 64, 65, 66, 168,  
 169, 170, 171, 172, 173, 174, 175, 176  
 Ashraf, M 293, 294, 295  
 Ayyappan Pillai, S. 348  
 Bai, D. V. 4, 67, 177, 257  
 Balachandran, K. K. 322, 323, 324, 393, 394, 398  
 Balachandran, V. K. 103  
 Balakrishnan, G. 78, 100  
 Balan, K. 113, 152  
 Balan, V. 68, 69, 70, 71, 72, 73, 100, 178, 179, 180,  
 181, 182, 183  
 Balasubramanian, K. 219  
 Baliga, N. 348  
 Banerji, S. K. 239  
 Beaufort, L. F. 33  
 Beck, I. M. 209  
 Beena, M. R. 125  
 Bensam. P. 5, 74, 184, 185, 186, 187, 188  
 Bergstad, O. A. 209  
 Bhandary, C. S. 307, 371, 373, 374  
 Bhojraj Naidu 258, 379  
 Bianchi, G. 19  
 Blindheim, J. 75  
 Bose, A. N. 259  
 Bouhiel, M. 244  
 Chacko, P. I. 76, 77  
 Chakraborty, D. 75, 78  
 Chaluvaiiah 363  
 Chandramohan, K. 79  
 Chandrasekhar, T. C. 260, 261  
 Chidambaram, K. 17, 80, 85, 122, 193  
 Chidambaram, L. 155  
 Chinivasagam, H. N. 262  
 Chinnamma George 263  
 Choudhuri, D. R. 265, 278, 322  
 Chullasorn, Somsak 6, 30  
 CMFRI 7, 8, 9, 10, 11, 12, 81, 82  
 Corpuz, A. 240  
 CSIR 83, 264  
 Cyriac Mathen 265  
 Damodaran Nambudiry, D 266  
 Dani, N. P. 364  
 Davidson, Alan 16  
 Dayaratne, P. 189, 209  
 Day, Francis 13, 14, 15  
 Deisman, H. C. 190  
 Devadasan, K. 251, 267, 268, 269  
 Devadoss, P. 191  
 Devanesan, D. W. 17, 84, 85, 192, 193  
 Devaraj, M 86, 111  
 Devaraju, A. N. 270  
 Devidas Menon, M. 75, 87  
 Dhanaraju, K. 137  
 Dharmaraja, S. K. 100, 101  
 Dhulkhed, M. H. 88, 89, 90, 91, 92, 131, 132, 133,  
 149, 194, 195, 196, 197, 198, 199, 200,  
 201, 229, 271, 272, 343  
 Dora, Krushnachandra 273, 274  
 Dutt, S. 202, 203  
 Dwiponggo, A 93, 94, 204  
 Edelman, M. S. 117  
 Edwards, R. R. C. 205  
 Etoh, S. 262  
 FAO/UNDP 95  
 Fischer, W 18, 19  
 Foetedar, R. K. 96  
 Fowler, Henry, W 20  
 Frans Teutscher 288  
 Gedam, P. H. 275, 276, 397  
 George, K. C. 206, 207, 208  
 George Joseph 269  
 George, Mangaly, K. 277  
 Girijavallabhan, K. G. 210  
 Girija Varma, P. R. 278  
 Gjosaeter, H. 209  
 Gjosaeter, J. 189, 209  
 Gnanamuttu, J. C. 210  
 Gopakumar, K. 248, 279, 280, 281, 335, 336, 340,  
 383, 384, 385, 386, 387, 388, 390, 399.  
 Gopalakrishnapillai, A. G. 302

- Gopinathan, C. K. 97  
 Govindan, T. K. 282, 283, 284, 285, 286, 287, 346, 347, 348  
 Gracy Mathew 365  
 Gunther, Albert 21  
 Hiremath, G. G. 273, 288, 289, 290, 316, 317, 375  
 Hiyama, Yoshio 3  
 Hornell, James 211  
 ICAR 98, 99, 212  
 Iman Khasim 333  
 Ingles, J 241  
 ISI 291  
 Jacob, P. G. 292  
 Jacob, T. 100, 101, 102, 152  
 Jadhav, R. N. 103  
 Jaffar, M. 293, 294, 295  
 James, M. A. 337  
 James, P. S. B. R. 79, 104, 105  
 Jhingran, V. G. 106  
 John, C. C. 213  
 Jones, S. 107, 108  
 Jose Joseph 388  
 Joseph, K. G. 304  
 Joseph, K. M. 103, 109, 110  
 Joseph Andrews 102  
 Jose Stephen 250  
 Joshi, V. R. 297, 298, 299, 300  
 Joshi, Vithal, R. 296  
 Kagwade, P. V. 214  
 Kaikini, A. S. 111  
 Kaimal, M. N. N. 301, 302, 320  
 Kaimal, P. N. R. 303  
 Kalaimani, N. 304  
 Kalawar, A. G. 112  
 Kalloli, B. M. 305, 306, 307  
 Kamasastri, P. V. 308, 309, 310  
 Karthiayani, T. C. 311, 312, 313, 392  
 Kaveriappa, K. M. 260  
 Kesavan Nair, A. K. 113  
 Kotwal, K. F. 314  
 Krishnan, T. S. 140  
 Krishnakumar, S. 315, 316, 317  
 Krishnankutty Nair, G. 125  
 Kumar, K. 219  
 Kurup K. N. 105, 125  
 Kuthalingam, M. D. K. 215, 216, 217, 218  
 Lalitha, K. V. 318  
 Latha Khambadkar 125  
 Lazarus, S 218, 220, 221, 242  
 Lisac, H. 319  
 Luther, G. 114, 218  
 Madhavan, P. 301, 302, 320, 321, 322, 323, 324, 325, 351, 393, 394  
 Mahadeva Iyer, K. 311, 312, 313, 318, 342, 345, 388, 389, 390  
 Mahadevan Pillai, P. K. 102, 151  
 Manickasundaram, M 31  
 Martosubroto, Purwito 6  
 Mathew, M. J. 77  
 Mathew, G. 357  
 Menezes, Maria, R. 222, 326, 327, 328, 329  
 Menon, M. A.S. 213  
 Menon, N. R. 316, 317  
 Misra, K.S. 22, 23  
 Moeljanto, R. 330  
 Mohite, R. R. 331, 332  
 Moorjani, M. N. 333, 334, 395  
 MPEDA 25  
 Mukundan, C. 115  
 Mukundan, M. K. 335, 336, 337  
 Munro, Ian. S. R. 24  
 Muraleedharan, V. 304, 338, 339  
 Muralidharan, V. 269  
 Murty, A.V.S. 116, 117, 118  
 Murthy, I. A. S. 371  
 Muthiah, C 89  
 Nagaraj, A. S. 300, 359, 380  
 Nagarajarao, S. 223  
 Nagesh, C. N. 271  
 Nageswar, B. 356  
 Nair, M. R. 335, 336, 337, 353  
 Nair, P. G. V. 340  
 Nair, P. V. R. 103  
 Nair, R. Velappan 26, 27, 28, 78, 119, 120, 121, 122, 123, 124, 150, 224, 225, 226, 341  
 Narain, P. 103  
 Narasimharao, S. 272, 343, 371  
 Narayanan Kutty, V. A. 128  
 Narayana Kurup, K. *See* Kurup, K. N.  
 Narayanan Nambiar, V. 342  
 Nathaniel, D.E 136  
 National Commission on Agriculture (INDIA) 126  
 Nigam, B. P. 344  
 Nirmala Thampuran 345  
 Noble, A. 127, 128, 227  
 Padival, R. A. 369  
 Pai, V. M. 314  
 Pai, M. P. 357, 371  
 Panicker, P. A. 243  
 Panikkar, K. K. P. 100, 101  
 Panikkar, N. Kesava 129

- Parashuram, P. 360  
 Parulekar, Arun, H 112  
 Pauly, D. 241  
 Perigreen, P. A. 263, 346, 347, 348, 388  
 Perovic, V. 349  
 Pillai, V. K. 265, 278, 347, 350, 396  
 Pillai, V. Kunjukrishna 103, 105  
 Pius Johnson 230  
 Ponnaiah, A. G. 103  
 Poulter, R. G. 249  
 Prabhu, M. S. 130, 131, 132, 133, 228, 229  
 Prabhu, P. V. 310, 351, 394  
 Prakasam, V. R. 230  
 Prasannakumari, B. 113  
 Putro, Sumpeno 352  
 Radhakrishnan, A. G. 337, 353  
 Radhakrishnan, N. 134, 231  
 Radhakrishnan, N. S. 89, 133  
 Raghuvendra Pai 135  
 Rajagopal, M. D. 292  
 Rajendran, V. 102  
 Rajendranathan Nair, M. 268, 281, 354, 391, 392, 399, 400  
 Ramachandran Nair, K. G. 351  
 Ramadass, V. 355  
 Ramaiyan, M. 31  
 Ramana, T. V. 136  
 Ramamirthan, C. P. 105, 140  
 Ramamurthy, S. 90, 133  
 Ramanandarao, D. 308, 310  
 Ramasomayajulu, K. 137  
 Ramaswami Nayudu, M. 211  
 Rao, K. N. A. 356  
 Rao, K. V. N. 100  
 Rao, S. N. 357  
 Reddy, M. P. M. 135, 136, 157  
 Reghu, R. 72, 138, 183  
 Rengasamy, V. S. 139, 232  
 Revankar, G. D. 366, 367, 368  
 Ritterbush, S. W. 233  
 Ronquillo, I. A. 29  
 Rudrashetty, T. M. 261  
 Sadanandarao, D. 105, 140  
 Sadanandan, K. A. 146  
 Saeger, J. 240  
 Saleh, Soetrisno 141  
 Sam Bennet, P. 142, 143  
 Sambilay, V. 240  
 Samuel, C. T. 144, 145, 234  
 Samuel, G. E. 349  
 Samuel, W.C. 223  
 Sanders, M. J. 244  
 Santhanakrishnan, G. 358  
 Saralaya, K. V. 297, 298, 299, 300, 359, 360  
 Satish, M. S. 361  
 Satyanarayana, A. V. V. 146  
 Satyanarayanappa, S. N. 147  
 Satyavan, U. K. 100, 102  
 Savaria, Y. D. 96  
 Sebastian, A. V. 109  
 Sekharan, K. V. 148, 149, 150, 200, 245  
 Selvaraj, A. 333  
 Sen, D. P. 357, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371  
 Serrao, A. 290  
 Seshappa, D. S. 147  
 Shafer, S. 205  
 Shamasunder, B. A. 306, 307, 372, 373, 374  
 Shanmugavelu, C. R. 151  
 Shenoy, A. V. 388  
 Shetty, H. P. C. 289, 316  
 Shetty, T. M. R. 270, 380  
 Shindo, Shigeaki 30  
 Sivasankar Gupta. 287  
 Silas, E. G. 103, 152  
 Sivakumaran, K. P. 31, 153  
 Sivankutty Nair, G. 154  
 Soerjodinoto, R. 32  
 Somavanshi, V.S. 103, 110  
 Sousa, M. I. 209  
 Srikar, L. N. 375  
 Srinath, M. 246  
 Srinivasan, P. V. 218  
 Srinivasarengan, S. 155  
 Sripathy, N. V. 370, 376, 377, 378  
 Srivastava, N. B. 379  
 Stephen, S. 356  
 Stroemme, T. 156  
 Subbaraju, G. 103, 105  
 Subbaraman, M. R. 276  
 Subramanyan, R. 123  
 Subramanyam, Y. 356  
 Sudhakar, N. S. 289, 290, 380, 381  
 Sudhakaran, R. 381, 382.  
 Surendran, P. K. 342, 348, 383, 384, 385, 386, 387, 388, 389, 390  
 Suresh, K. R. 157  
 Susamma Cherian 391  
 Susamma Jacob 392  
 Syda Rao, G. 89  
 Thiagarajan, R. 242  
 Udupa, K. S. 261  
 Uktolseya, J. C.B. 94

Uma Bhat, K. 92  
Uma Kumari, K. 91  
Unnikrishnan Nair, T. S. 304, 321, 323, 324, 325,  
393, 394  
Valsan, A. P. 338  
Vasantha, M. S. 334, 395  
Vasanth Shenoy, A. 396  
Velappan Nair, R. *See* Nair, R. V.  
Venkataraman, G. 224  
Venkateswar Rao, M. 397  
Venugopala Pillai, S. 235  
Verghese, C. P. 158  
Vijayan, P. K. 248, 263, 398  
Virabhadra Rao, K. 4, 67, 159, 177, 257  
Vishnudatta, M. N. 118  
Viswanathan Nair, P. G. 251, 399, 400  
Visweswaraiyah, K. 401, 402  
Wakabi, E. O. 160  
Weber, Max 33  
Whitehead, P. J. P. 18, 34, 35

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