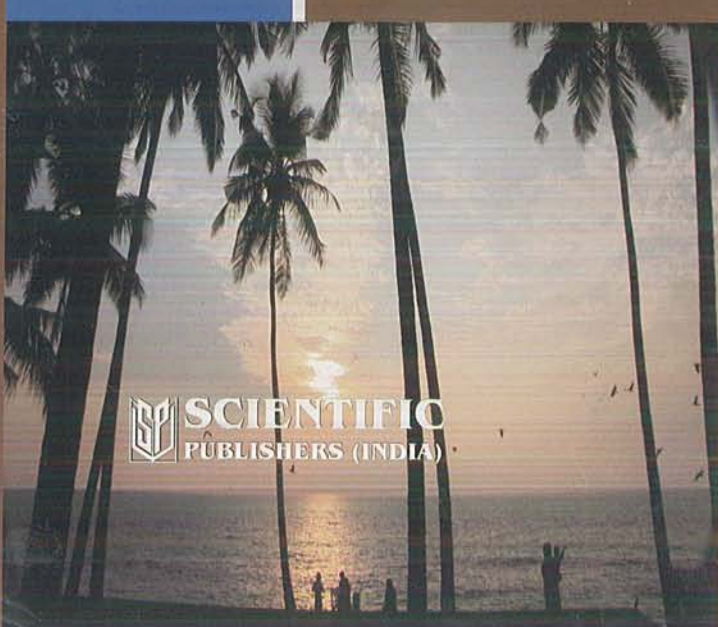
Climate Change and Environment



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Adaptive capacity of the oil sardine *Sardinella longiceps* in the new distributional area with reference to food type

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Introduction

The oil sardine, *Sardinella longiceps* Val., is a major neretic pelagic fishery resource of India. For centuries, there has been a massive fishery for the oil sardine along the southwest coast of India[1]. An average catch of 2.5 lakh tons has been taken annually during the current decade along the Indian coast, and, the oil sardine landings during 2009 was 3,92,486 tones[2]. It is a highly fluctuating fishery and the contribution of oil sardine to the annual marine fish landings in India ranged from 1 to 33%.

The oil sardine is known for its restricted distribution between latitude 8°N and 14°N and longitude 75°E and 77°E [3] (Malabar upwelling zone along the southwest coast of India) where the annual average sea surface temperature ranges from 27 to 29°C. Until the late 1980, almost the entire oil sardine catch was from the southwest coast of India and the catch was either very low or there was no catch from latitudes north of 14°N along the west and east coasts of India. Luther[4] reported the emergence of oil sardine as a new fishery along the east coast in the late 1980s. Vivekanandan *et al.*[5] reported that being a tropical fish, the oil sardine is able to find temperature to its preference along the northwest and southeast coasts in the last two decades. The surface waters of the Indian seas are warming by 0.04°C per decade, and the warmer tongue of the surface waters is expanding to latitudes north of 14°N. In the last two decades, the annual average SST range in the northern latitudes has increased to 27-28.5°C, enabling the oil sardine to extend their distributional range to northern latitudes. They also found that the catches from the Malabar upwelling zone has not decreased indicating distributional "extension" and not distributional "shift".

The extension of distribution and establishment of populations in new areas shows the adaptive capacity of the oil sardine to elevated temperature. However, the hospitality such as availability of right type of food in the new grounds is not known. The oil sardine is a planktivore and one of the few clupeoids in which diatoms form a significant part of the adult diet[6]. The seasonal arrival and abundance of oil sardine is suggested to be dependent on the bloom of the diatom *Fragilaria (=Nitzschia) oceanica*[7]. Dinoflagellates and copepods are also important in the diet from October to January, together with soft organic-rich material re-suspended by the seasonal dispersion of offshore mudbank formation[8]. Thus the distribution and abundance of oil sardine is directly related to the food availability and features along the southwest coast of India.

The objective of the present study is to know how the oil sardine has adapted its feeding habit in the new areas of distribution. For this, a study was initiated to assess the food of *Sardinella longiceps* in the upwelling zone of southwest coast off Kalamukku (near Cochin) and at the new area of distribution namely, off Kovalam (near Chennai) during January-December 2010.

Materials and methods

Specimens of *S. longiceps* were collected from Kalamukku (near Cochin) and Kovalam landing centres (near Chennai) from ring seine and gillnet landings, respectively. During January-December 2010, a total of 348 specimens from Kalamukku and 342 specimens from Kovalam were analysed. The total length and weight of fish were measured, and sex and stage of maturity were noted. The stomachs were removed and after wiping off the moisture, they were weighed in a chemical balance. The stomachs were cut open and the food was removed. Great care was taken to separate the food from the epithelial layer of the stomach wall to which the former was found closely adhering. The stomach fullness was noted as empty, trace, one-fourth full, half-full, three-fourth full and full. The contents were identified under a microscope up to genus level, wherever possible. The food items were identified following Newell & Newell[9], Tomas[10] and www.algaebase.org[11].

As the oil sardine is a plankton feeder, numerical method was followed for determining the relative abundance and importance of various groups constituting the food. For this, each food item was counted in an aliquot sample and its abundance is presented. The number of stomachs in which each food item was represented, was also noted.

Results and discussion

The total length of oil sardine in the samples collected at Kalamukku ranged from 122 to 194 mm, whereas that at Kovalam from 150 to 193 mm. In Kalamukku, fish with empty stomach contributed only 16.95% to the total samples. On the other hand, the contribution of fish with empty stomach was very high at 41.52% at Kovalam (Table 1). The fish with empty stomach and food in trace quantities contributed 60.53% to the samples collected from Kovalam. This is a major difference between the two sets of samples.

Gut content analysis showed that phytoplankton and zooplankton were the major food in the samples from both the locations. There were 25 and 26 genera of phytoplankton at Kalamukku and Kovalam respectively (Tables 2 & 3). The type of food ingested in the two locations was almost similar. Among the phytoplankton, for instance, 22 genera were common between the two locations.

However, the preference of food was different. At Kalamukku, *Thalassiosira* occurred in maximum (50.38%) number of samples and *Pleurosigma* was found in large numbers (52351). *Biddulphia* (44.27%) and *Coscinodiscus* (37.4%) were the other genera that were represented in large number of samples. At Kovalam, *Coscinodiscus* (49.48%) and *Thalassiosira* (43.3%) occurred in a large number of samples.

Table 1. Percentage of food contents in the guts of *Sardinella longiceps* at Kalamukku (n = 348) and Kovalam (n = 342)

Gut condition	Kalamukku (%)	Kovalam (%)
Empty	16.95	41.52
Trace	16.09	19.01
One fourth full	22.99	12.28
Half-full	32.18	19.30
Three fourth full	8.33	5.85
Full	3.45	2.05

Table 2. Gut content analysis of *Sardinella longiceps* collected at Kalamukku (n=131)

S. No.	Food	Frequency (%)	Avg. No.
	Phytoplankton		
1	*Nitzschia*	22.9	6766
2	*Ceratium*	16.79	277
3	*Navicula*	6.87	20
4	*Coscinodiscus*	37.4	366
5	*Thalassiosira*	50.38	3574
6	*Peridinium*	21.37	196
7	*Pleurosigma*	39.69	52351
8	*Rhizosolenia*	9.92	29
9	*Biddulphia*	44.27	704
10	*Chaetoceros*	6.11	120
11	*Thalassionema*	6.11	24
12	*Dinophysis*	20.61	576
13	*Fragilaria*	21.37	123
14	*Gyrosigma*	14.5	312
15	*Melosira*	12.21	3378
16	*Eucampia*	4.58	12
17	*Prorocentrum*	16.79	96
18	*Cyclotella*	5.34	103
19	*Triceratium*	0.76	4

20	*Skeletonema*	2.29	95
21	*Pyrophacus*	5.34	37
22	*Globigerina*	0.76	0
23	*Asterionella*	1.53	4
24	*Radiolarian*	0.76	1
25	*Ornithoceros*	1.53	8
26	*Coccosphere*	0.76	0
	Total		69176
	Zooplankton		
1	Copepod	25.95	219
2	Mysid	3.05	11
3	Tintinnids	32.06	234
	Total		464

Table 3. Gut content analysis of *Sardinella longiceps* collected at Kovalam (n=97)

S. No.	Food	Frequency (%)	Avg. No.
	Phytoplankton		
1	*Nitzschia*	30.93	26375
2	*Ceratium*	7.22	47
3	*Navicula*	15.46	38
4	*Coscinodiscus*	49.48	184
5	*Thalassiosira*	43.3	327
6	*Peridinium*	25.77	68
7	*Pleurosigma*	29.9	66
8	*Rhizosolenia*	5.15	16
9	*Biddulphia*	30.93	201
10	*Chaetoceros*	5.15	1
11	*Thalassionema*	9.28	3
12	*Dinophysis*	7.22	21
13	*Fragilaria*	38.14	226
14	*Gyrosigma*	11.34	36
15	*Melosira*	10.31	170
16	*Eucampia*	7.22	21
17	*Prorocentrum*	22.68	172
18	*Cyclotella*	3.09	5
19	*Triceratium*	6.19	36
20	*Skeletonema*	20.6	294

21	*Pyrophacus*	4.12	26
22	*Globigerina*	1.03	4
23	*Noctiluca*	1.03	0
24	*Bacteriastrum*	3.09	1
25	*Pseudonitzschia*	3.09	29
	Total		28367
	Zooplankton		
1	Copepod	40.21	184
2	Mysid	12.37	32
3	Tintinnids	34.02	149
4	Ostracod	1.03	0
5	Cladocera	3.09	1
6	Fish egg	4.12	11
	Total		377

Among zooplankton, tintinnids and copepods were dominant in the two sets of samples, but the number of zooplankton in the gut was relatively low than that of phytoplankton.

This observation has brought out three important differences in the food of the oil sardine collected from two locations. (i) The large number of empty stomach off Kovalam may not be unusual as samples with more than 50% empty stomach are often encountered in the catches of several fish species[12]. Hence, it could not be concluded that oil sardine are unable to get adequate quantities of right type of food. However, the striking difference between the two sets of samples needs to be investigated further. (ii) There appears to be a definite difference in the type of food ingested by the oil sardine inhabiting the two localities. It is not clear whether the difference is due to difference in the type of food available to the fish or difference in the food preference of the fish. Perhaps more samples spread over several seasons may provide better information. The oil sardine has established huge population and emerged as the single largest fishery along the Tamil Nadu coast in the last two decades[5]. Hence, availability of food could not be a constraint to the growth and proliferation of the fish in the new distributional grounds. It may be tentatively concluded that the oil sardine has adapted to the type of food available in the new area of distribution. (iii) In the two sets of samples, phytoplankton forms the major share of food of *S. longiceps*. Zooplankton is found in more samples at Kovalam than at Kalamukku even though their number is meager.

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J. Sundaresan, S. Sreekesh, A.L. Ramanathan, Leonard Sonnenschein & Ram Boojh (Editors)

The scientific community has now widely accepted climate change as a reality. It is the most dynamic existential threat to be faced by the humanity. Changing climate is bringing about rapid changes in the environment. This book presents authoritative contributions from national and international researchers on pattern of change in climate variables and their environmental consequences. Book covers the consequences of change in climate variables both to physical and biological environments. It also discusses the possible impact on livelihood options of the people and identifies the feasible mitigation and adaptation options available to the planners and administrators. The book presents the specific case studies carried out in different environmental and ecological conditions to demonstrate the signs of climate change impact on environment and methodological approach that can be adopted to address these issues scientifically. This book is a baseline reference for researchers, environmentalist, planners, policy makers as well as administrators who are concerned with the future of the planet Earth.

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