Stock Assessment of Indian oil sardine and Indian mackerel

Final Project Report

Funded
by
M/s Omega Fishmeal & Oil Private Limited

Diploma in Fisheries Engineering, Ratnagiri
(Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli)

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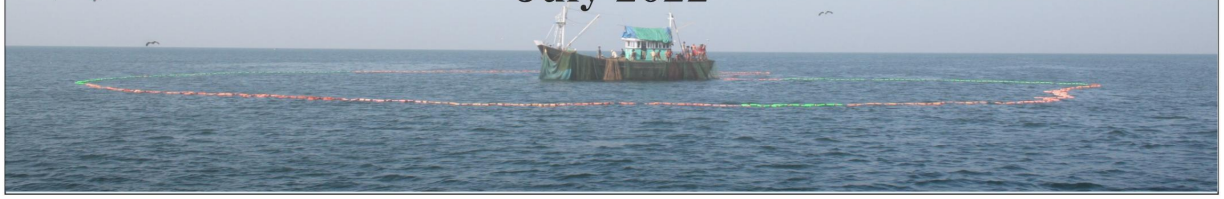

General Information

1.	Project Title	:	**"Stock Assessment of Indian oil sardine and Indian mackerel"**
2.	Funding agency	:	**M/s Omega Fishmeal & Oil Private Limited**
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6	Project period	:	2020-23
7	Sanctioned project cost	:	Rs. 21,37,740/-
8	Actual total grant received	:	Rs. 16,00,410/-
9	Total expenditure	:	Rs. 15,35,336/-
	Name and address of granted University/ Institution	:	**Diploma in Fisheries Engineering, Shirgaon 415629 Ratnagiri, Maharashtra India Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, 415 712 Dist : Ratnagiri, Maharashtra, India**

Title of the Project : **Stock Assessment of Indian oil sardine and Indian mackerel**

Introduction : Fishmeal and oil industry is dependent on the natural marine fisheries resources such as oil sardine, mackerel, pilchard, anchovies etc. These marine resources are over exploited or else are stagnant. These resources are finite, though they are renewable. The aquafeed industries are the main user of fishmeal and oil as the culture of carnivore fish is increased. Thus, they are to be used judiciously, so as to have consistent supply of the same.

M/s Omega Fishmeal & Oil Private Limited is a leading fish meal producer and exporter and has commenced a Fishery Improvement Project (FIP) for two species *viz*. Indian oil sardine and Indian mackerel, as the major raw material used for fish meal production is these two species. The FIP is designed to assist Omega to become certified to the Marin Trust standard, which will have benefits for the company, fishery managers and the implementation of government policy around aquaculture development. Stock assessment studies are aimed to provide the advice on the optimum exploitation of stocks under study. Therefore, stock assessment studies of Indian oil sardine and Indian mackerel was undertaken.

Objectives :

- To collect the required data on fisheries
- To study the biology of fish
- To study growth parameters and mortality rates of stocks
- To study the percentage bycatch in purse seines
- To observe any interactions between fishing operations and protected species

Study area : Altogether three sampling stations from Ratnagiri district of Maharashtra were covered for the present study. Study area is shown in Plate 1.

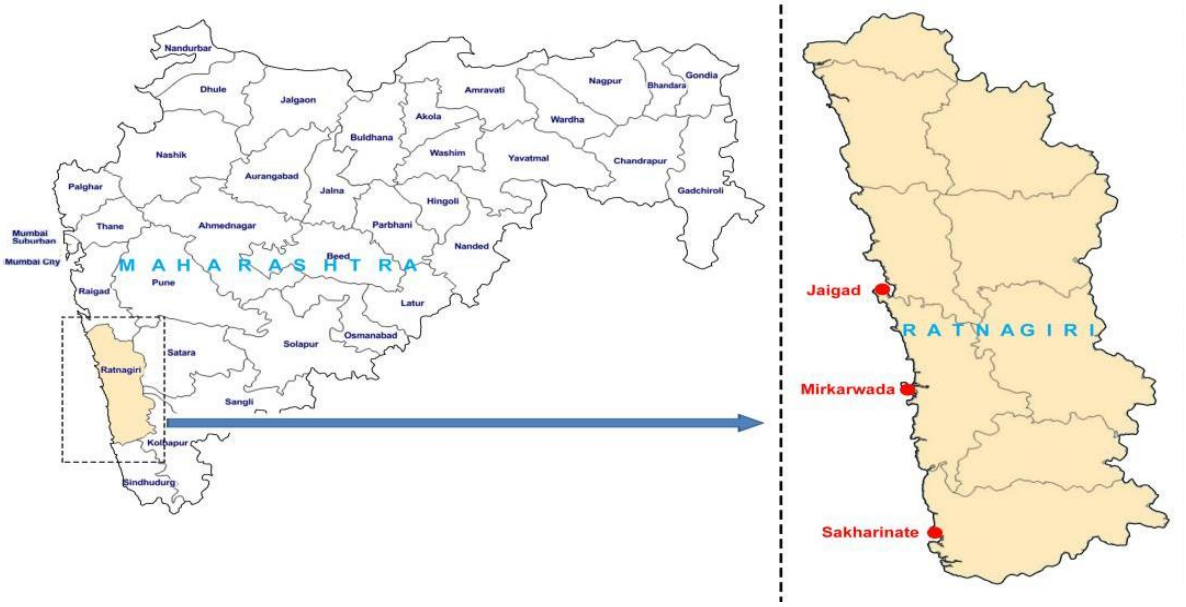


Plate 1 Study area

Methodology & approach :

Length weight relationship

Length weight relationship was estimated by using the logarithmic equation $W=aL^b$ (Zar, 2010).

Gut analysis

The qualitative and quantitative analysis of gut content was carried out for both varieties collected from three landing stations. Variety wise percentage analysis of gut content was carried out for two species at the end of year.

Reproductive Biology

Gonado-Somatic index (GSI)

Gonado somatic index for the species was calculated separately, for which, the total weight of the fish and the weight of gonads were collected carefully. The weight of fish and gonad was recorded with the help of electronic balance after removing the excess moisture using a blotting paper. Following equation (Shamsan and Ansari, 2009) was used for calculations of GSI.

$$GSI = \frac{Gonad\ weight\ (g)}{Total\ body\ weight\ (g)} \text{ X } 100$$

Sex ratio

The samples collected from all three sampling stations were dissected for examining the gonads. The gender of each

specimen was recorded as male, female and indeterminants. Data on sex ratio was analysed by Chi square test to find out, whether dominance of either sex was significant.

Fecundity

For the determination of fecundity, fresh ripen ovaries were used. The excess moisture was removed by using blotting paper and the ovaries were weighed to the nearest milligram. A sub sample of 50 mg mature ovary was weighed with an electronic balance. The sample was then taken in a watch glass and number of mature ova in the sub-sample were counted physically. The fecundity was determined by the formula of (Shamsan and Ansari, 2009).

$$F = \frac{TW}{SW} X \text{ number of ova counted in the sub sample}$$

Where,

F= Fecundity

TW= Total weight of the ovary

SW = Sub-sample weight

Ova diameter

Ova diameter of intra-ovarian ova was measured. Small piece of ovary from the anterior, middle and posterior region was cut and then ova were released on to a glass slide. Ova diameter was measured by using ocular micrometer, which was standardized against stage micrometer. Frequency polygons was drawn.

Maximum Sustainable Yield (MSY) and f_{MSY}

Data of catch and effort for estimation of Maximum Sustainable Yield (MSY) and f_{MSY} was procured from the fish production report of Department of Fisheries, Government of Maharashtra and was estimated as below:

Maximum Sustainable Yield (MSY) was estimated using suitable surplus model by using catch and effort data (Sparre

and Venema, 1998).

Catch composition

Total catch in kilogram of targeted species was recorded onboard. Variety wise quantity in kilogram of other than targeted species was recorded.

$$Percentage\ bycatch = \frac{Volume\ of\ species\ other\ than\ targeted\ species\ (kg)}{Total\ catch\ (kg)}\ X\ 100$$

Expected Result :

- Length-weight relationship
- Food and feeding habits
- Gonado Somatic Index
- Season wise maturity stages
- Ova diameter
- Size at first maturity
- Breeding season
- Maximum Sustainable Yield and f_{MSY}
- Percentage of bycatch
- Species composition and volume of discards (if any)
- Interactions between fishing operations and protected species

Work Done : Stock assessments of Indian oil sardine and Indian mackerel was proposed in this study. In addition to this, reproductive biology, food & feeding, length-weight relationships, percentage of bycatch/discard in purse seine catches and any interactions with protected species was studied. Samples were collected from three sampling stations in Maharashtra. The three stations in Maharashtra were Mirkarwada, Jaigad and Sakharinate as major landing centers for these two species. Weekly sample was collected from Mirkarwada, Jaigad and Sakharinate., from August 2020 to May 2022.

1. Length Frequency Analysis

Altogether 7326 number of samples were collected of Indian mackerel and 1034 number of samples were collected of Indian oil sardine during the entire study study period (August, 2020 to May, 2022) from three selected sampling stations namely, Mirkarwada, Jaigad and Sakharinate for length frequency analysis, out of which 6198 number of samples of Indian mackerel and 506 number of samples of Indian oil sardine were used for biological analysis. Month-wise and station-wise details of samples of Indian mackerel and Indian oil sardine are detailed in Table 1 and 2 respectively.

1.1 Indian mackerel

In the length frequency analysis of Indian mackerel, the average length observed was 17.8 cm throughout the study period whereas, the maximum length recorded was 28.4 cm in the month of May 2022 and a minimum of 5.8 cm in the month of January 2022. Month-wise average total length along with minimum and maximum spread is shown in Table 3 and plotted in Fig. 1. Similarly, month-wise length frequency for Indian Mackerel is shown in Table 4 and plotted in Fig. 2.

Fig 1. Month-wise average total length for Indian mackerel

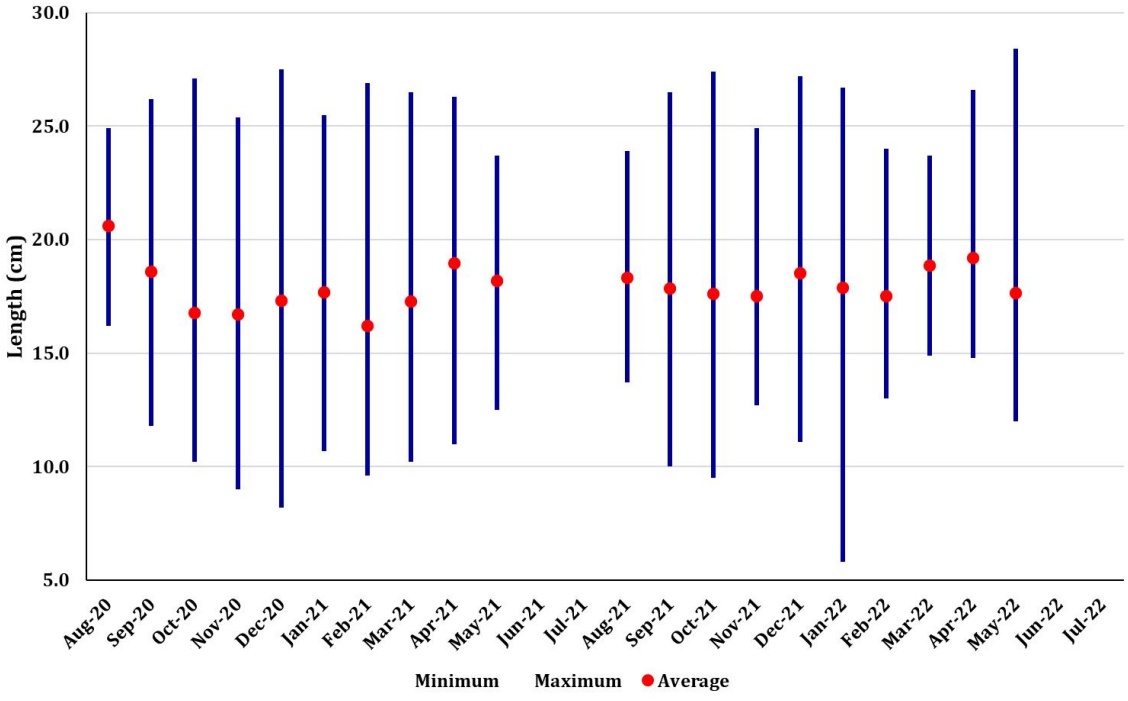


Table 1. Details of month wise samples collected of Indian mackerel according to sampling stations.

Sr. No.	Month	Mirkarwada		Jaigad		Sakharinate		Total	
		Length frequency	Biology	Length frequency	Biology	Length frequency	Biology	Length frequency	Biology
1	**August 20**	46	46	70	20	20	20	**136**	**86**
2	**September 20**	134	134	71	71	111	111	**316**	**316**
3	**October 20**	138	138	148	148	147	147	**433**	**433**
4	**November 20**	247	247	100	100	149	149	**496**	**496**
5	**December 20**	174	174	182	182	197	197	**553**	**553**
6	**January 21**	141	141	102	102	167	167	**410**	**410**
7	**February 21**	138	138	133	133	136	136	**407**	**407**
8	**March 21**	187	187	108	108	172	172	**467**	**467**
9	**April 21**	124	124	21	21	117	117	**262**	**262**
10	**May 21**	98	98	46	46	50	50	**194**	**194**
11	**August 21**	109	87	75	61	77	63	**261**	**211**
12	**September 21**	153	101	136	102	121	101	**410**	**304**
13	**October 21**	148	80	132	81	136	81	**416**	**242**
14	**November 21**	107	82	140	84	133	84	**380**	**250**
15	**December 21**	155	102	132	102	175	100	**462**	**304**
16	**January 22**	124	81	105	80	110	82	**339**	**243**
17	**February 22**	118	80	110	80	116	80	**344**	**240**
18	**March 22**	129	100	145	100	149	100	**423**	**300**
19	**April 22**	97	80	109	80	106	80	**312**	**240**
20	**May 22**	99	80	102	80	104	80	**305**	**240**
Total		**2666**	**2300**	**2167**	**1781**	**2493**	**2117**	**7326**	**6198**

Table 2. Details of month wise samples collected of Indian oil sardine according to sampling stations.

Sr. No.	Month	Mirkarwada		Jaigad		Sakharinate		Total	
		Length frequency	Biology	Length frequency	Biology	Length frequency	Biology	Length frequency	Biology
1	**October 20**	21	21	0	0	0	0	**21**	**21**
2	**November 20**	0	0	19	18	7	7	**26**	**25**
3	**December 20**	19	19	0	0	0	0	**19**	**19**
4	**August 21**	0	0	0	0	0	0	**0**	**0**
5	**September 21**	42	42	0	0	0	0	**42**	**42**
6	**October 21**	0	0	17	17	100	41	**117**	**58**
7	**November 21**	84	20	0	0	108	84	**192**	**104**
8	**December 21**	56	21	55	42	162	43	**273**	**106**
9	**January 22**	0	0	0	0	0	0	**0**	**0**
10	**February 22**	0	0	36	4	0	0	**36**	**4**
11	**March 22**	0	0	0	0	67	10	**67**	**10**
12	**April 22**	105	40	57	57	79	20	**241**	**117**
Total		**327**	**163**	**184**	**138**	**523**	**205**	**1034**	**506**

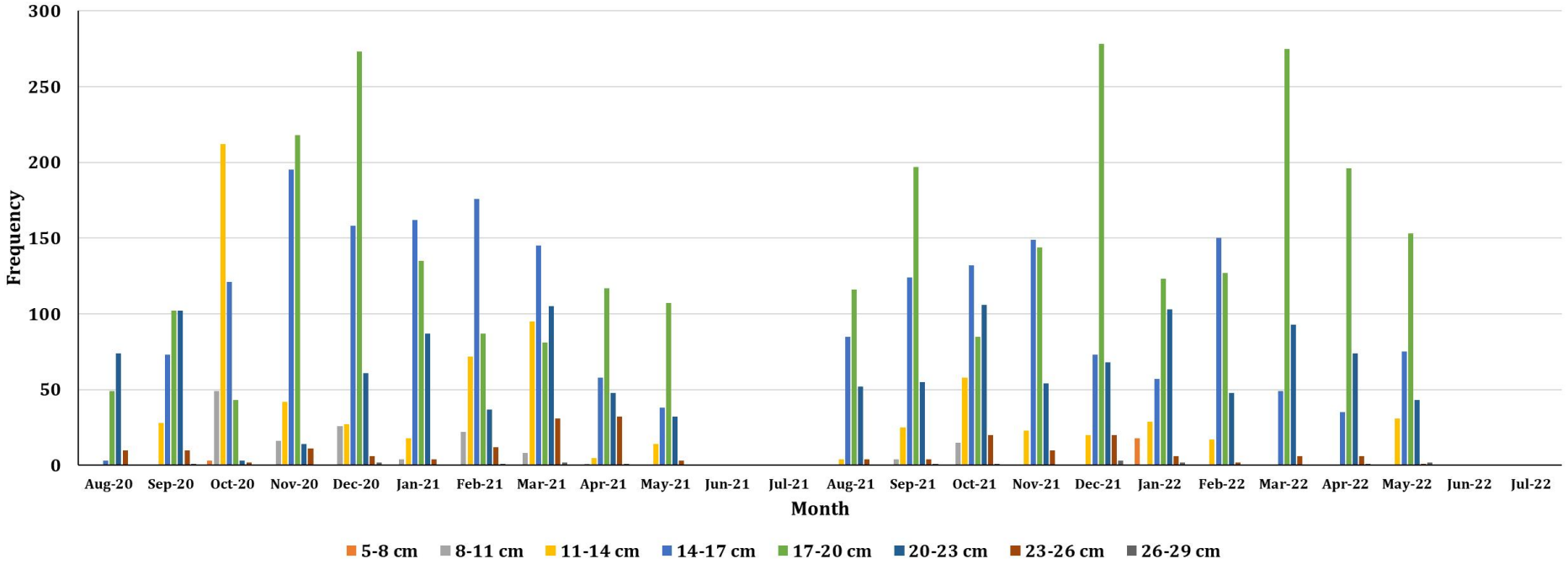
Table 3. Month-wise average total length for Indian mackerel

Month	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22
Minimum	16.2	11.8	10.2	9.0	8.2	10.7	9.6	10.2	11.0	12.5	13.7	10.0	9.5	12.7	11.1	5.8	13.0	14.9	14.8	12.0
Maximum	24.9	26.2	27.1	25.4	27.5	25.5	26.9	26.5	26.3	23.7	23.9	26.5	27.4	24.9	27.2	26.7	24.0	23.7	26.6	28.4
Average	20.6	18.6	16.8	16.7	17.3	17.7	16.2	17.3	19.0	18.2	18.3	17.9	17.6	17.5	18.5	17.9	17.5	18.9	19.2	17.7

Table 4. Month-wise Length Frequency for Indian Mackerel

Class	Aug -20	Sep -20	Oct -20	Nov -20	Dec -20	Jan -21	Feb -21	Mar -21	Apr -21	May -21	Jun -21	Jul -21	Aug -21	Sep -21	Oct -21	Nov -21	Dec -21	Jan -22	Feb -22	Mar -22	Apr -22	May -22	Jun -22	Jul -22	Total
5-8	0	0	3	0	0	0	0	0	0	0			0	0	0	0	0	18	0	0	0	0			**21**
8-11	0	0	49	16	26	4	22	8	1	0			0	4	15	0	0	0	0	0	0	0			**145**
11-14	0	28	212	42	27	18	72	95	5	14			4	25	58	23	20	29	17	0	0	31			**720**
14-17	3	73	121	195	158	162	176	145	58	38			85	124	132	149	73	57	150	49	35	75			**2058**
17-20	49	102	43	218	273	135	87	81	117	107			116	197	85	144	278	123	127	275	196	153			**2906**
20-23	74	102	3	14	61	87	37	105	48	32			52	55	106	54	68	103	48	93	74	43			**1259**
23-26	10	10	2	11	6	4	12	31	32	3			4	4	20	10	20	6	2	6	6	1			**200**
26-29	0	1	0	0	2	0	1	2	1	0			0	1	1	0	3	2	0	0	1	2			**17**
																								Total	**7326**
Min	**16.2**	**11.8**	**10.2**	**9.0**	**8.2**	**10.7**	**9.6**	**10.2**	**11.0**	**12.5**			**13.7**	**10.0**	**9.5**	**12.7**	**11.1**	**5.8**	**13.0**	**14.9**	**14.8**	**12.0**			
Max	**24.9**	**26.2**	**27.1**	**25.4**	**27.5**	**25.5**	**26.9**	**26.5**	**26.3**	**23.7**			**23.9**	**26.5**	**27.4**	**24.9**	**27.2**	**26.7**	**24.0**	**23.7**	**26.6**	**28.4**			
Avg	**20.6**	**18.6**	**16.8**	**16.7**	**17.3**	**17.7**	**16.2**	**17.3**	**19.0**	**18.2**			**18.3**	**17.9**	**17.6**	**17.5**	**18.5**	**17.9**	**17.5**	**18.9**	**19.2**	**17.7**			

Fig. 2. Month-wise length frequency for Indian mackerel

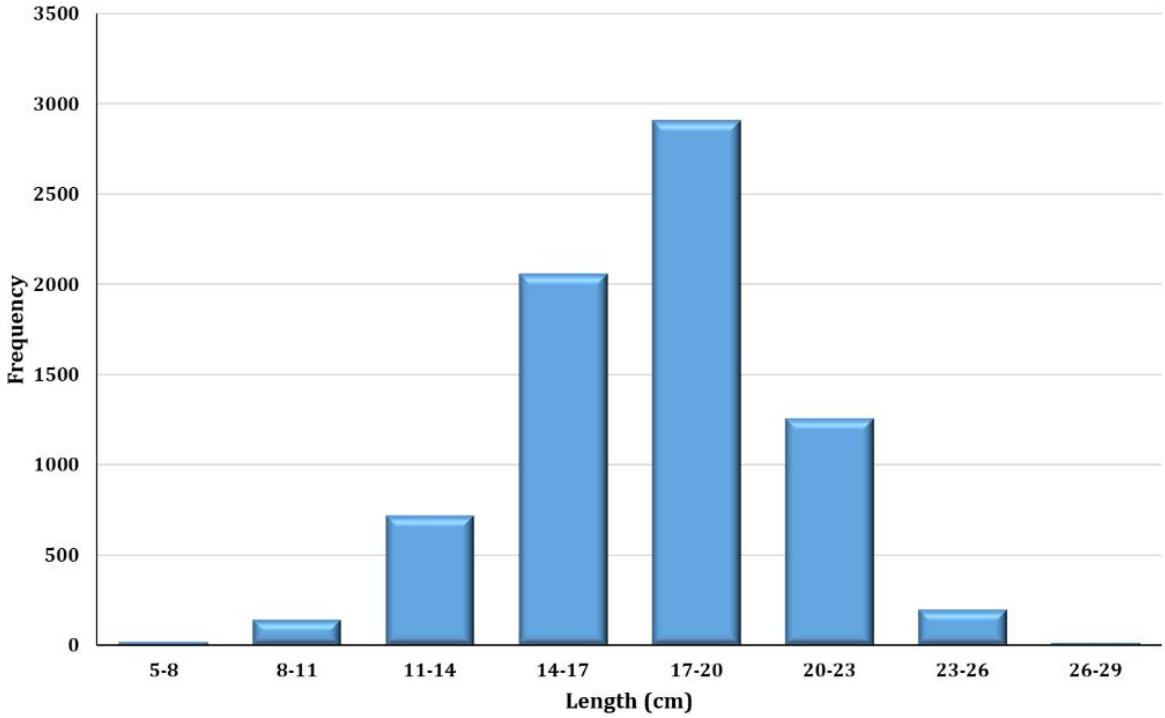


During this analysis, all the samples were classified into eight length classes to apply FiSAT II (FAO-ICLARM Stock Assessment Tools). The dominant length group observed was 17-20 cm which shared 39.67% of the total samples recorded, followed by 14-17 cm (28.09%) and 20-23 cm (17.19%). Different length class and frequencies for Indian mackerel is shown in Table 5 and depicted in Fig. 3.

Table 5. Length classification of Indian mackerel

Length Class	5-8	8-11	11-14	14-17	17-20	20-23	23-26	26-29	Total
Frequency	21	145	720	2058	2906	1259	200	17	7326

Fig 3. Length classification for Indian mackerel



FiSAT analysis to study the various parameters was performed for Indian mackerel and is summarized in Table 6.

Table 6. Estimates of FiSAT for Indian mackerel

Minimum Length	:	5.8 cm
Maximum Length	:	28.4 cm
Average Length	:	17.8 cm
Asymptotic Length (L∞)	:	28.88 cm
Growth Constant (K)	:	0.85
Natural Mortality (N)	:	1.62
Fishing Mortality (F)	:	1.93
Total Mortality (Z)	:	3.55
Exploitation Rate (E)	:	0.54

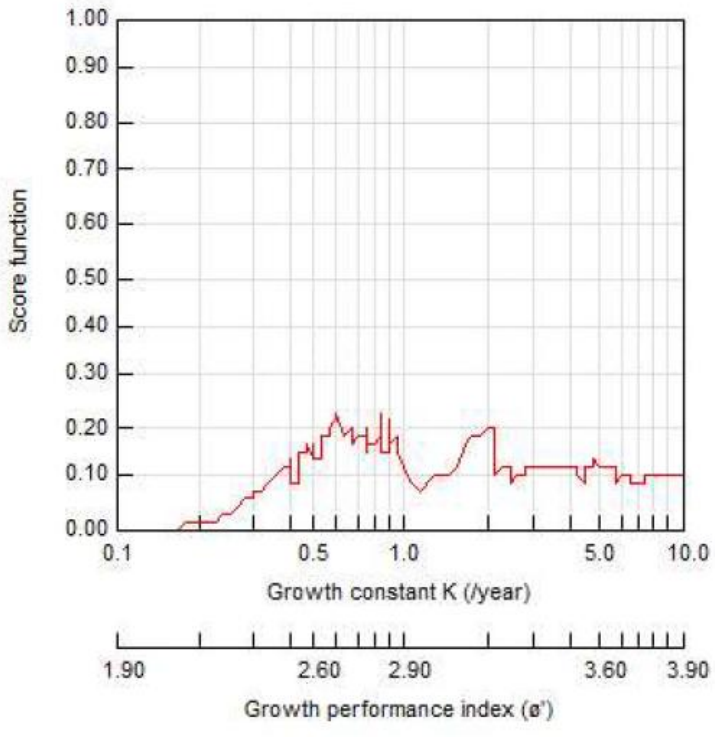
1.1.1 Von Bertalanffy Growth Function Plot and Length Frequencies

The asymptotic length (L∞) and growth rate (K) for the Indian mackerel along Maharashtra coast were estimated at 28.88 cm and 0.85 yr^{-1} respectively.

Parameters ----------

Asymptotic length (Loo):	28.88	Starting Sample:	1
VBGF growth constant (K):	0.850	Starting length:	26.00
Amplitute of oscillation (C):	0.000		
"Winter Point" (WP):	0.000	Score:	0.235

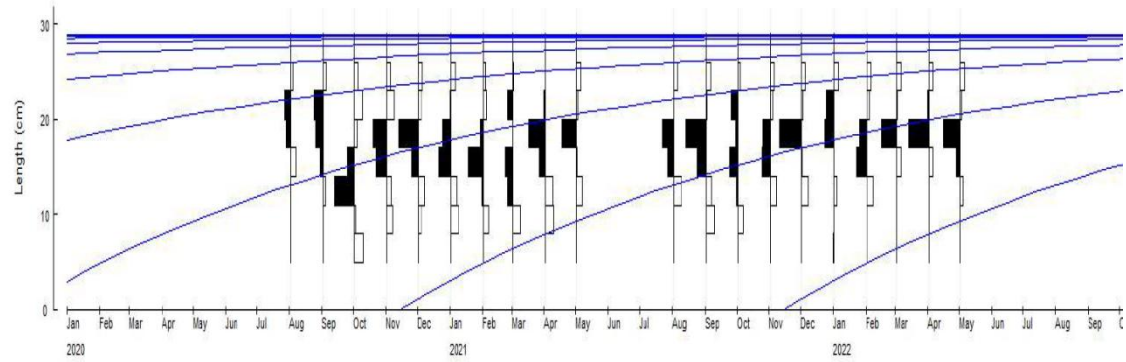
Plot ----------



Parameters ---------

Asymptotic length (Loo):	28.88	Amplitude of oscillation (C):	0.000	Starting sample (SS):	1
VBGF growth constant (K):	0.850	"Winter Point" (WP):	0.000	Starting length (SL):	26.00

Plot ---------



1.1.2 Pauly's Empirical Equation for Natural Mortality (M)

The Pauly's Empirical Equation for Natural Mortality was derived and the estimated natural Mortality (M) is 1.62086 yr^{-1}.

User Defined Inputs ----------

Asymptotic length (Loo; in cm):	28.88
VBGF growth constant (K;	0.85
Mean habitat temperature (°C):	28

Empirical equation:

$$\log(M) = -0.0066 - 0.279 \log(Loo) + 0.6543 \log(K) + 0.4634 \log(T)$$

Natural Mortality Estimate ---------

Estimated natural mortality (M; 1/year): 1.62086

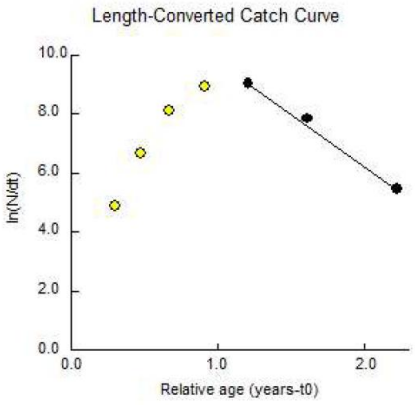
1.1.3 Length-Converted Catch Curve

The total mortality coefficient (Z) from the length converted catch curve estimated from length converted catch curve was 3.55. The values for natural mortality and fishing mortality were 1.62 and 1.93, respectively. The current exploitation ratio (E) was 0.54 which indicated that the fishing pressure is slightly more than optimum exploitation stage.

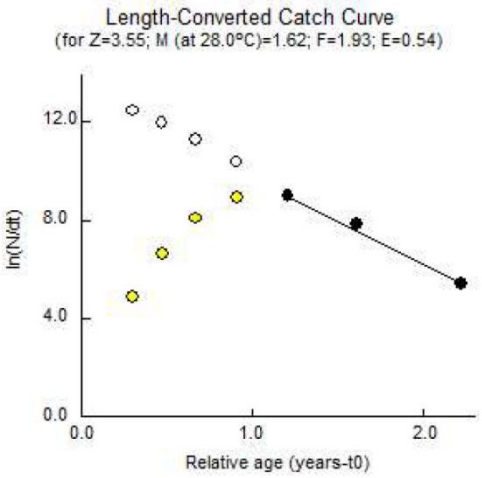
Results ---------

Estimate of Z (/yr.): 3.55 (CI: 0.30 to 6.80)

Plot ----------



Plot ----------



1.1.4 Probability of Capture

Probability of capture calculated from the length-converted catch curve routine was used to estimate the final values of L 25, L50 and L 75 (*i.e.* lengths at which 25%, 50% and 75% of the fish would be vulnerable to the fishing gear. The estimated length sizes for 25% (L25), 50% (L50) and 75% (L75) probabilities of capture would be 15.49 cm, 17.02 cm and 18.55 cm respectively for Indian mackerel indicating high catching probability of the fishes less than 18.55 cm.

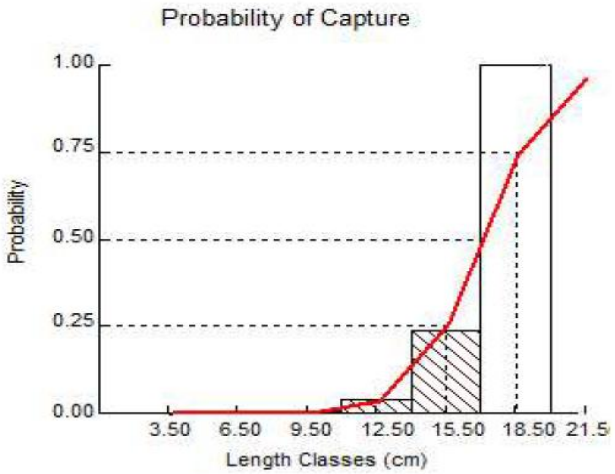
Results ---------

L-25: 15.49 cm

L-50: 17.02 cm

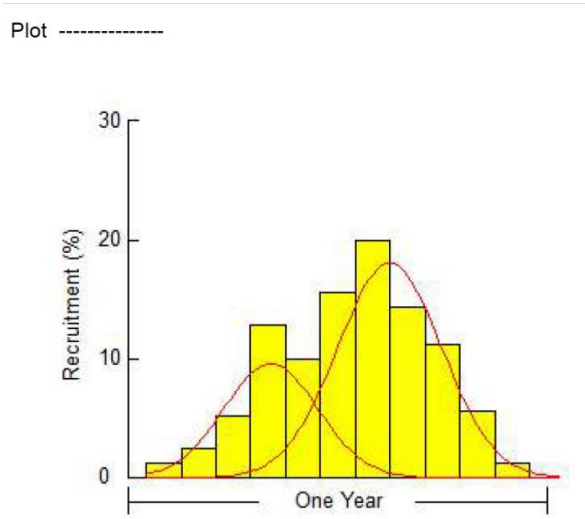
L-75: 18.55 cm

Plot ----------



1.1.5 Recruitment Pattern

The recruitment pattern of Indian mackerel showed that the fish was recruited in the fishery throughout the year with two peaks.



Recruitment Pattern

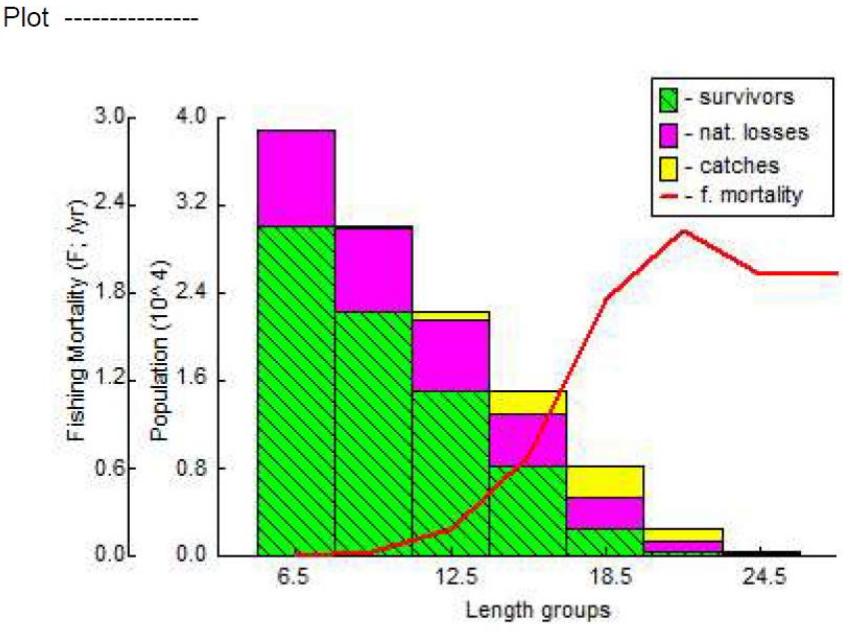
ons | Growth Parameter Inputs & Graph | Numeric Results

Relative Recruitment Values

Relative Time	Percent Recruitment
Month 1	1.33
Month 2	2.40
Month 3	5.36
Month 4	12.75
Month 5	10.01
Month 6	15.63
Month 7	20.15
Month 8	14.46
Month 9	11.17
Month 10	5.47
Month 11	1.26
Month 12	0.00

1.1.6 Length-Structured Virtual Population Analysis

Virtual Population Analysis of length structure showed that the maximum number of fishes were caught between 17-20 cm length. Whereas, length class of 20-23 cm was more vulnerable to fishing having maximum fishing mortality (2.22) among all the length classes.

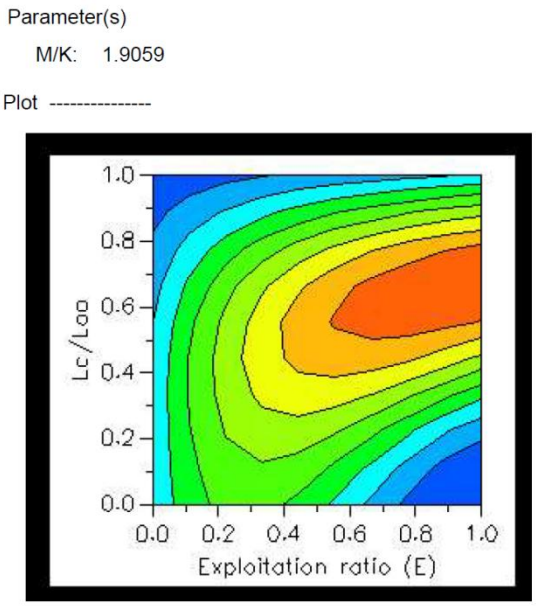


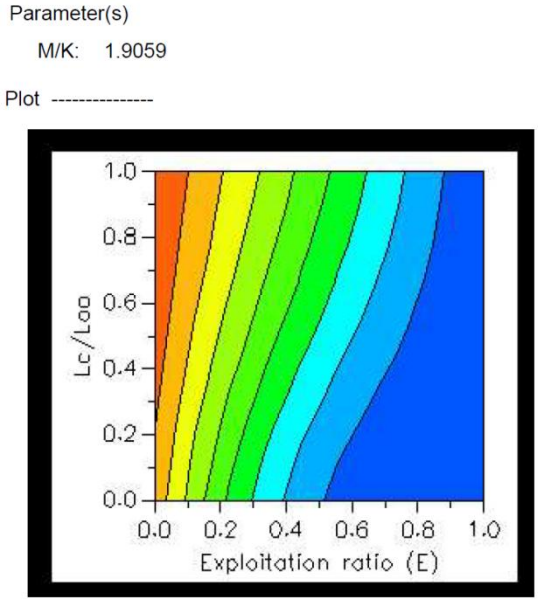
Data and Options | Parameters & VPA Plot | Tabular Results

	Mid-Length	Catch (in numbers)	Population (N)	Fishing mortality (F)	Steady-state Biomass (tonnes)
1	6.5	21.00	38861.47	0.0039	0.00
2	9.5	145.00	30065.88	0.0306	0.00
3	12.5	720.00	22242.96	0.1809	0.00
4	15.5	2058.00	15070.17	0.6893	0.00
5	18.5	2906.00	8172.50	1.7508	0.00
6	21.5	1259.00	2576.08	2.2234	0.00
7	24.5	217.00	399.24	1.9300	0.00
8	27.5	0.00	0.00	1.9300	0.00

1.1.7 Relative Yield/Recruit Analysis (Knife-edge Selection)

From the graph, it can be concluded that E-max 0.947 is an exploitation rate which produces maximum yield E-10 is 0.820 an exploitation rate at which marginal increase of relative yield-per-recruit is 1/10th of its value at zero exploitation and 0.393 (E-50) is a value of E under which the stock is reduced to 50 per cent of its exploited biomass.





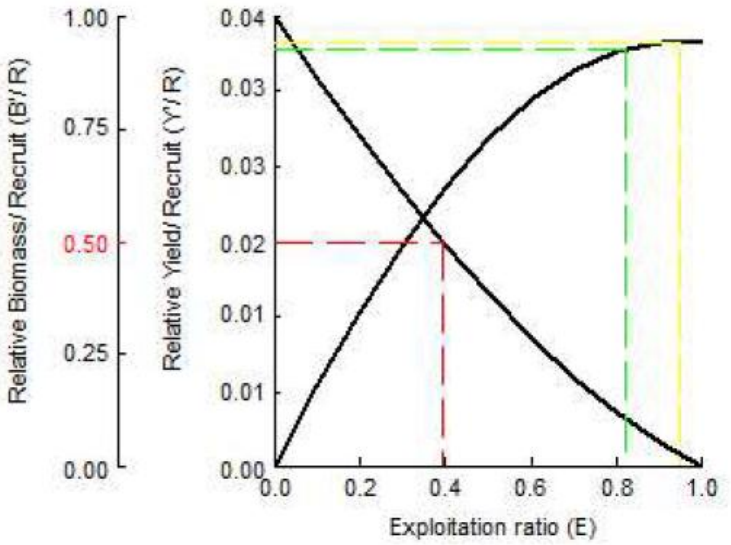
Parameters ---------

Lc/Loo:	0.589	E-max:	0.947	E-50:	0.393
M/K:	1.906	E-10:	0.820		

Table ---------

E	Y/R	B/R	E	Y/R	B/R
0.01	0.007	0.862	0.60	0.033	0.287
0.20	0.014	0.731	0.70	0.035	0.199
0.30	0.020	0.608	0.80	0.037	0.122
0.40	0.025	0.492	0.90	0.038	0.055
0.50	0.029	0.385	0.99	0.038	0.005

Plot ----------



1.2 Indian oil sardine

During the present investigation, average length of Indian oil sardine observed was 15.14 cm with the maximum overall length of 21.2 cm in the month of November 2020 and a minimum of 7.4 cm in the month of November 2021. Month-wise average total length is shown in Table 7 and plotted in Fig. 4. Similarly, month-wise length frequency for Indian oil sardine is shown in Table 8 and plotted in Fig. 5.

Fig 4. Month-wise average total length for Indian oil sardine

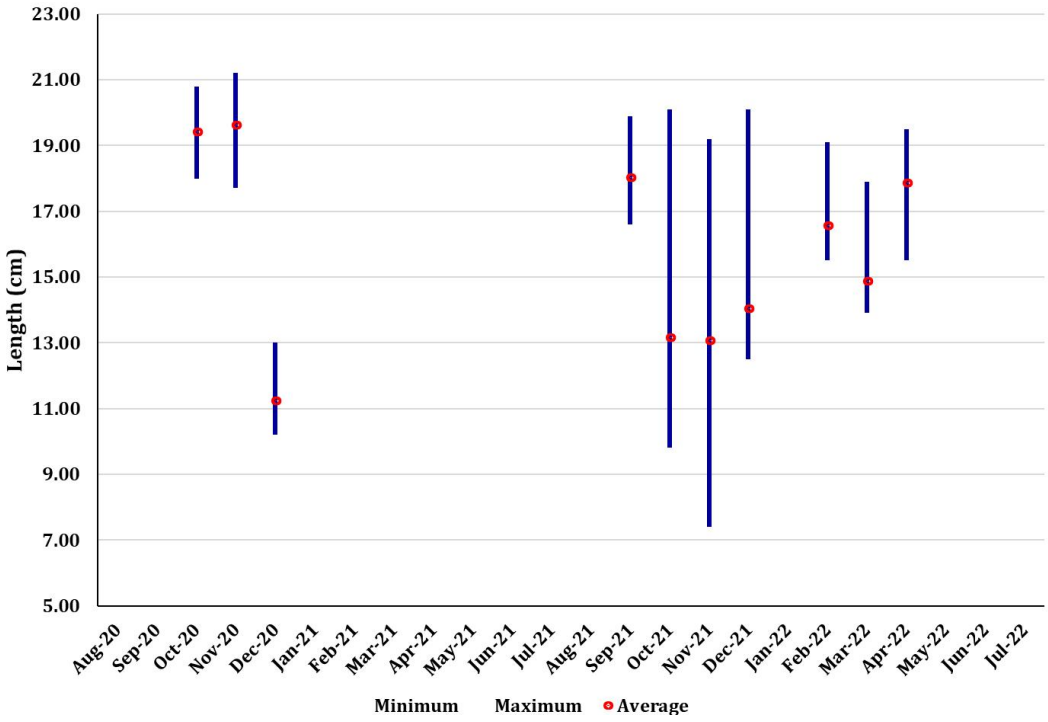


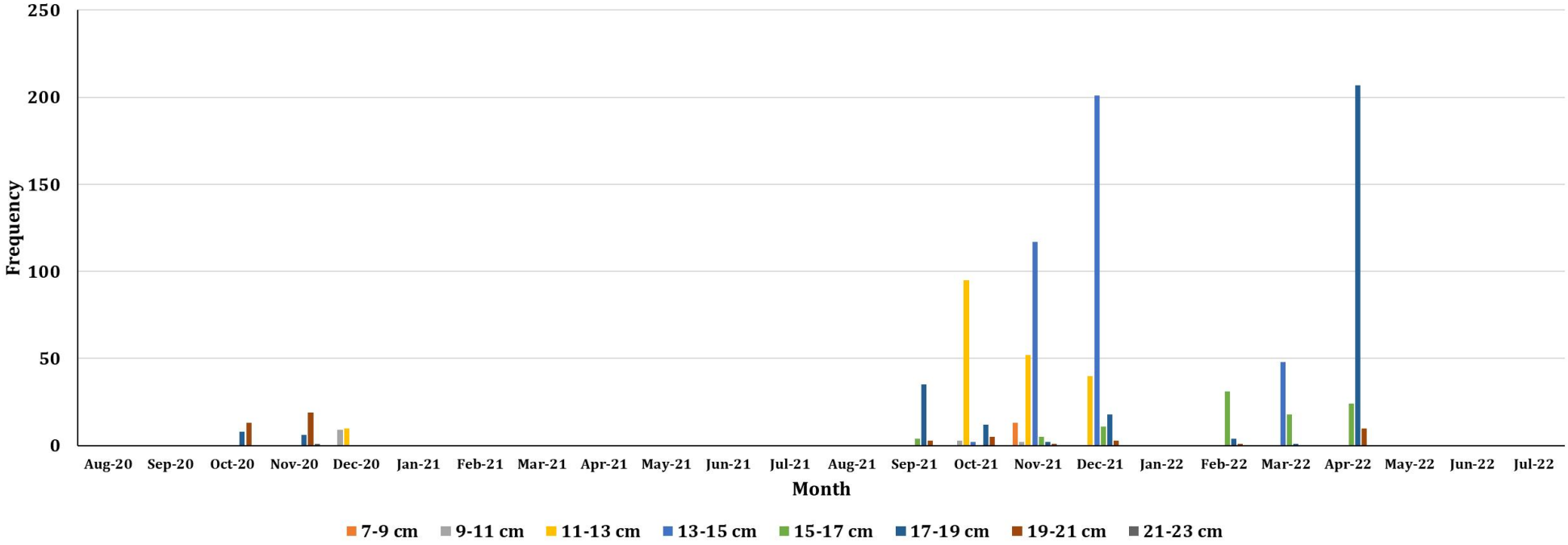
Table 7. Month-wise average total length for Indian oil sardine

Month	Aug -20	Sep -20	Oct -20	Nov -20	Dec -20	Jan -21	Feb -21	Mar -21	Apr -21	May -21	Aug -21	Sep -21	Oct -21	Nov -21	Dec -21	Jan -22	Feb -22	Mar -22	Apr -22	May -22
Minimum	-	-	18.00	17.70	10.20	-	-	-	-	-	-	16.60	9.80	7.40	12.50	-	15.50	13.90	15.50	-
Maximum	-	-	20.80	21.20	13.00	-	-	-	-	-	-	19.90	20.10	19.20	20.10	-	19.10	17.90	19.50	-
Average	-	-	19.41	19.61	11.22	-	-	-	-	-	-	18.02	13.14	13.05	14.02	-	16.56	14.85	17.85	-

Table 8. Month-wise Length Frequency for Indian Oil Sardine

Class	Aug -20	Sep -20	Oct -20	Nov -20	Dec -20	Jan -21	Feb -21	Mar -21	Apr -21	May -21	Jun -21	Jul -21	Aug -21	Sep -21	Oct -21	Nov -21	Dec -21	Jan -22	Feb -22	Mar -22	Apr -22	May -22	Jun -20	Jul -20	Total
7-9	-	-	0	0	0	-	-	-	-	-	-	-	-	0	0	13	0	-	0	0	0	-	-	-	**13**
9-11	-	-	0	0	9	-	-	-	-	-	-	-	-	0	3	2	0	-	0	0	0	-	-	-	**14**
11-13	-	-	0	0	10	-	-	-	-	-	-	-	-	0	95	52	40	-	0	0	0	-	-	-	**197**
13-15	-	-	0	0	0	-	-	-	-	-	-	-	-	0	2	117	201	-	0	48	0	-	-	-	**368**
15-17	-	-	0	0	0	-	-	-	-	-	-	-	-	4	0	5	11	-	31	18	24	-	-	-	**93**
17-19	-	-	8	6	0	-	-	-	-	-	-	-	-	35	12	2	18	-	4	1	204	-	-	-	**293**
19-21	-	-	13	19	0	-	-	-	-	-	-	-	-	3	5	1	3	-	1	0	10	-	-	-	**55**
21-23	-	-	0	1	0	-	-	-	-	-	-	-	-	0	0	0	0	-	0	0	0	-	-	-	**1**
																								Total	**1034**

Fig. 5. Month-wise length frequency for Indian oil sardine

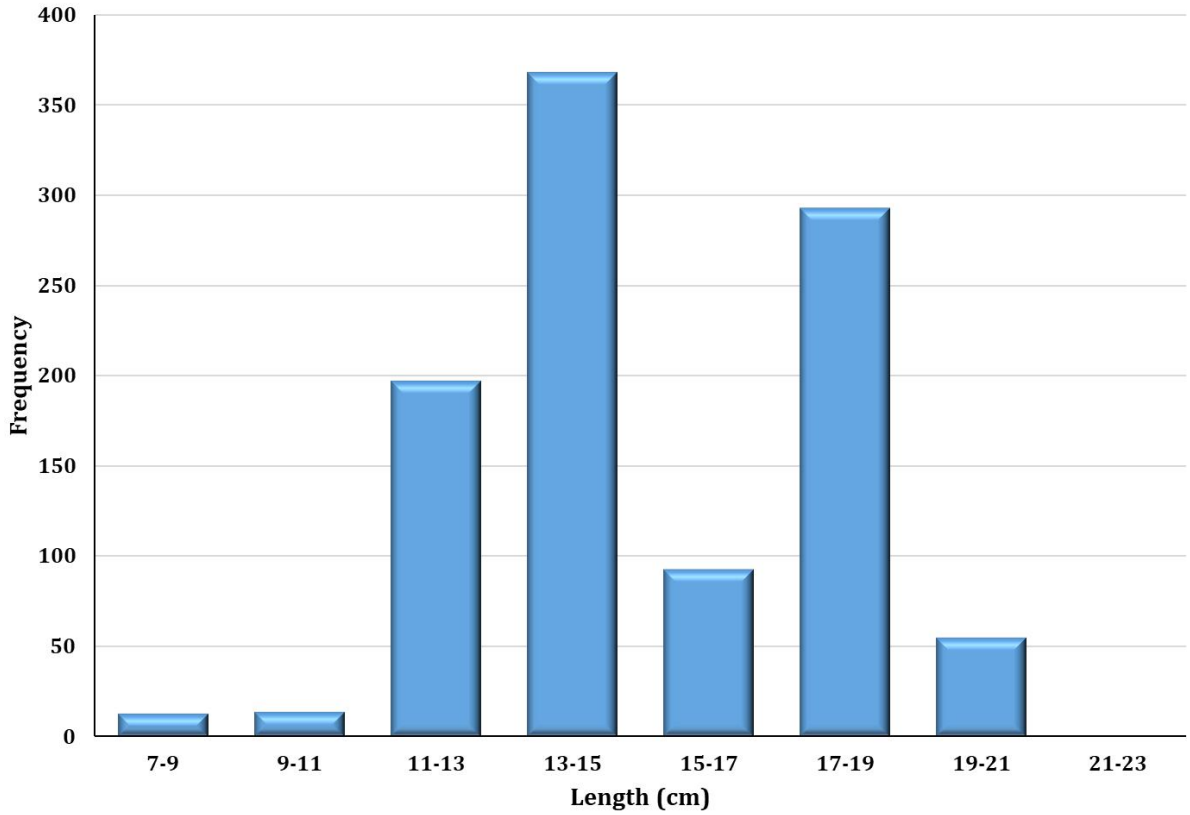


A total of 1,034 specimens of Indian oil sardine were sampled for the length frequency analysis. All the samples were classified into eight length classes and FiSAT II (FAO-ICLARM Stock Assessment Tools) was applied. The dominant length group observed was 13-15 cm with a share of 35.59% of the total samples recorded, followed by 17-19 cm (28.34%) and 11-13 cm (19.05%). Different length class and frequencies for Indian oil sardine is shown in Table 9 and depicted in Fig. 6.

Table 9. Length classification of Indian oil sardine

Length Class (cm)	7-9	9-11	11-13	13-15	15-17	17-19	19-21	21-23
Frequency	13	14	197	368	93	293	55	1

Fig 6. Length classification for Indian oil sardine



FiSAT analysis to study the various parameters related to Indian oil sardine was performed and is summarized in Table 10.

Table 10. Estimates of FiSAT for Indian oil sardine

Minimum Length	:	7.4 cm
Maximum Length	:	21.2 cm
Average Length	:	15.14 cm
Asymptotic Length (L∞)	:	23.10 cm
Growth Constant (K)	:	1.5
Natural Mortality (N)	:	2.50
Fishing Mortality (F)	:	5.11
Total Mortality (Z)	:	7.61
Exploitation Rate (E)	:	0.67

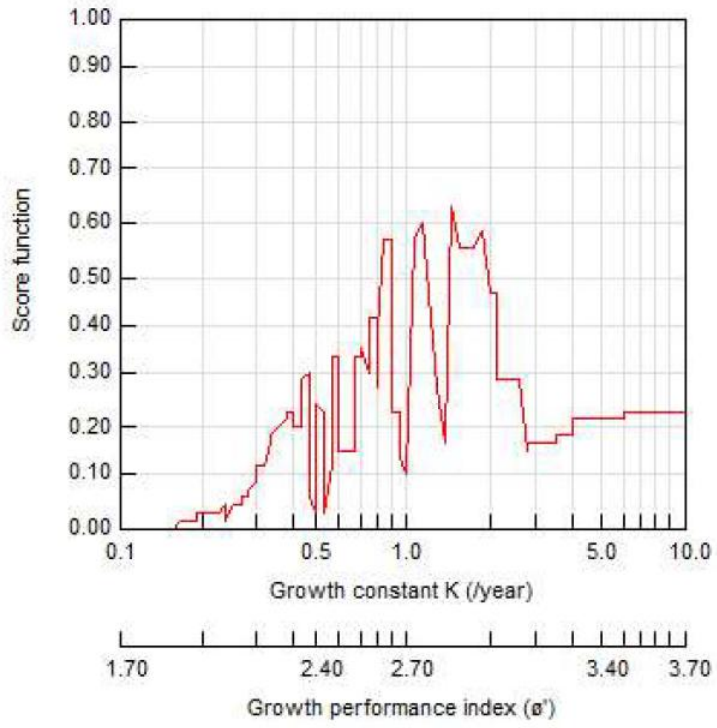
1.2.1 Von Bertallanfy Growth Function Plot and Length Frequencies

The asymptotic length (L∞) and growth rate (K) for the Indian oil sardine along Maharashtra coast were estimated at 23.10 cm and 1.5 yr^{-1} respectively.

Parameters ----------

Asymptotic length (Loo):	23.10	Starting Sample:	16
VBGF growth constant (K):	1.500	Starting length:	13.00
Amplitute of oscillation (C):	0.000		
"Winter Point" (WP):	0.000	Score:	0.631

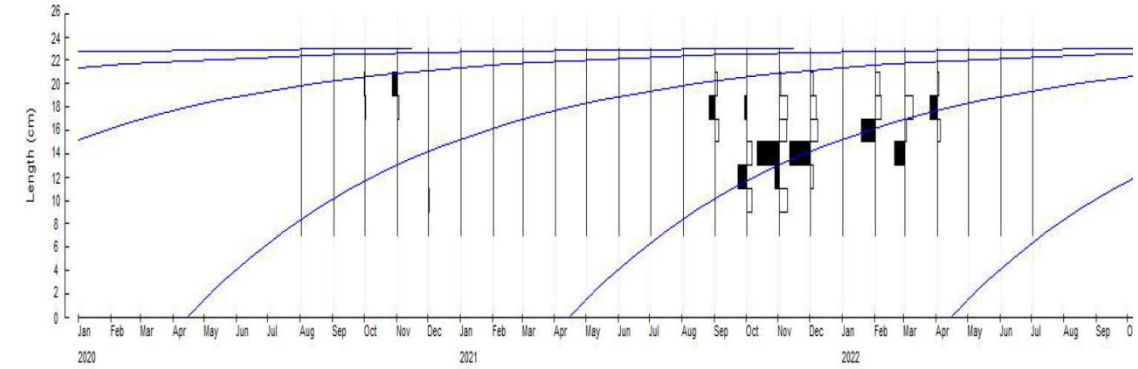
Plot ----------



Parameters ---------

Asymptotic length (Loo):	23.10	Amplitude of oscillation (C):	0.000	Starting sample (SS):	16
VBGF growth constant (K):	1.500	"Winter Point" (WP):	0.000	Starting length (SL):	13.00

Plot ---------



1.2.2 Pauly's Empirical Equation for Natural Mortality (M)

The Pauly's Empirical Equation for Natural Mortality was derived and the estimated natural Mortality (M) is 2.50151 yr^{-1}.

User Defined Inputs ----------

Asymptotic length (Loo; in cm):	23.10
VBGF growth constant (K;	1.5
Mean habitat temperature (°C):	28

Empirical equation:

log(M) = -0.0066 - 0.279 log(Loo) + 0.6543 log(K) + 0.4634 log(T)

Natural Mortality Estimate ---------

Estimated natural mortality (M; 1/year):	2.50151

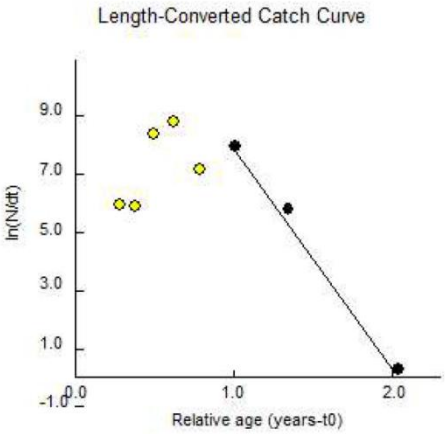
1.2.3 Length-Converted Catch Curve

The total mortality coefficient (Z) estimated from the length converted catch curve was 7.61. The values for natural mortality and fishing mortality were 2.50 and 5.11 respectively. The current exploitation ratio (E) was 0.67 which indicates the fishery is at the over exploitation stage.

Results ---------

Estimate of Z (/yr.): 7.61 (CI: 3.33 to 11.89)

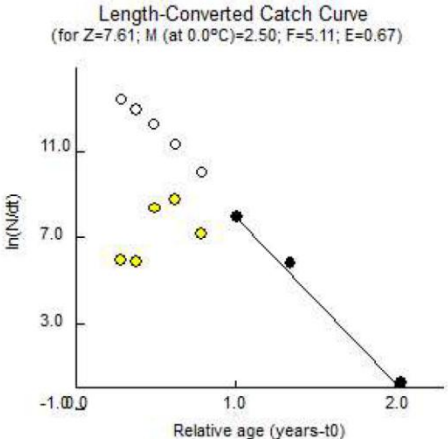
Plot ----------



Results ---------

Estimate of Z (/yr.): 7.61 (CI: 3.33 to 11.89)

Plot ----------



1.2.4 Probability of Capture

Probability of capture calculated from the length-converted catch curve routine was used to estimate the final values of L 25, L50 and L 75 (i.e. lengths at which 25%, 50% and 75% of the fish would be vulnerable to the fishing gear. The estimated length sizes for 25% (L25), 50% (L50) and 75% (L75) probabilities of capture would be 17.22 cm, 18.80 cm and 20.38 cm respectively for Indian oil sardine.

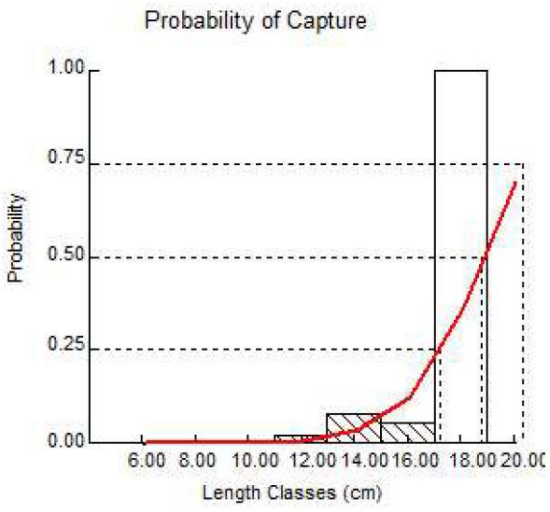
Results ---------

L-25: 17.22 cm

L-50: 18.80 cm

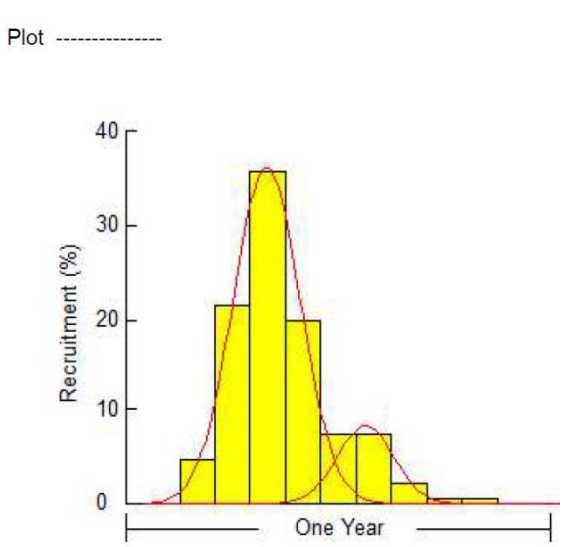
L-75: 20.38 cm

Plot ----------



1.2.5 Recruitment Pattern

The recruitment pattern of Indian mackerel showed that the fish was recruited in the fishery throughout the year with one major peak and other minor peak.



Recruitment Pattern

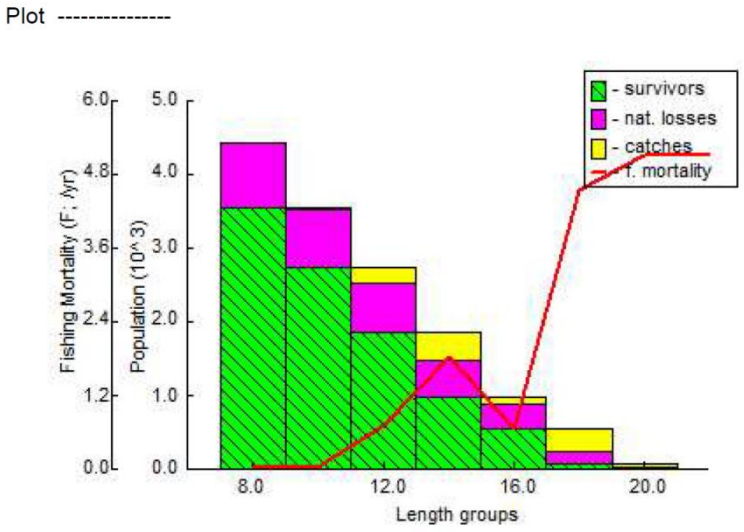
ns | Growth Parameter Inputs & Graph | Numeric Results

Relative Recruitment Values

Relative Time	Percent Recruitment
Month 1	0.00
Month 2	4.91
Month 3	21.28
Month 4	35.64
Month 5	19.68
Month 6	7.34
Month 7	7.57
Month 8	2.30
Month 9	0.78
Month 10	0.42
Month 11	0.07
Month 12	0.00

1.2.6 Length-Structured Virtual Population Analysis

Virtual Population Analysis of length structure showed that the maximum number of fishes were caught between 13-15 cm length, whereas, fishes with 19 cm length were more vulnerable to fishing having maximum fishing mortality of 5.11 among all the length classes.



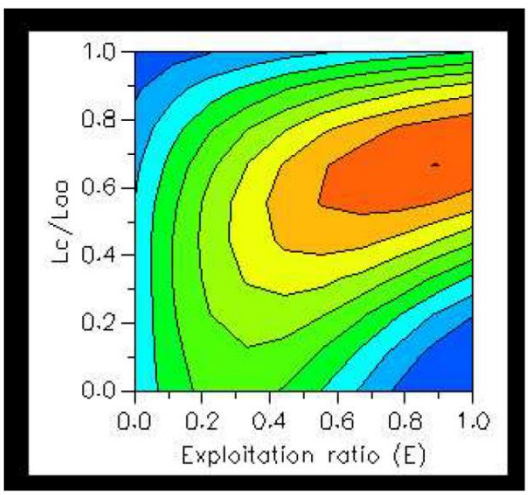
Data and Options | Parameters & VPA Plot | Tabular Results

	Mid-Length	Catch (in numbers)	Population (N)	Fishing mortality (F)	Steady-state Biomass (tonnes)
1	8.0	13.00	4430.05	0.0370	0.00
2	10.0	14.00	3539.29	0.0440	0.00
3	12.0	197.00	2730.08	0.7229	0.00
4	14.0	368.00	1851.42	1.8266	0.00
5	16.0	93.00	979.44	0.6677	0.00
6	18.0	293.00	538.00	4.5361	0.00
7	20.0	56.00	83.41	5.1100	0.00
8	22.0	0.00	0.00	5.1100	0.00

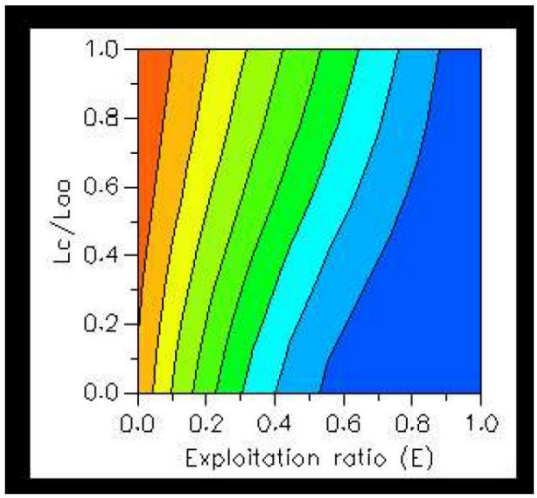
1.2.7 Relative Yield/Recruit Analysis (Knife-edge Selection)

From the graph, it can be concluded that E-max 1.0 is an exploitation rate which produces maximum yield, E-10 is 1.0 an exploitation rate at which marginal increase of relative yield-per-recruit is 1/10th of its value at zero exploitation and 0.455 (E-50) is a value of E under which the stock is reduced to 50 per cent of its exploited biomass.

Parameter(s)
M/K: 1.6667
Plot ----------



Parameter(s)
M/K: 1.6667
Plot ----------



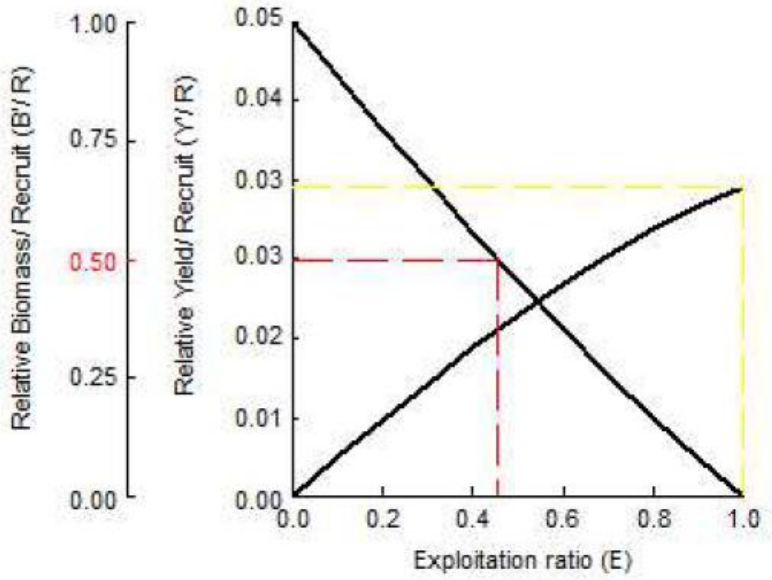
Parameters ---------

Lc/Loo:	0.814	E-max:	1.000	E-50:	0.455
M/K:	1.667	E-10:	1.000		

Table ---------

E	Y/R	B/R	E	Y/R	B/R
0.01	0.004	0.886	0.60	0.022	0.354
0.20	0.008	0.774	0.70	0.025	0.258
0.30	0.012	0.664	0.80	0.028	0.167
0.40	0.016	0.558	0.90	0.031	0.081
0.50	0.019	0.454	0.99	0.032	0.008

Plot ----------



2. Length-weight relationship

2.1 Indian mackerel

Length-weight relationship of male female and indeterminant of Indian mackerel and Indian oil sardine was established separately. The Length–weight relationship was analyzed by using the equation $W=aL^b$. Analysis of covariance (ANCOVA) was performed to compare slopes and elevations. Significant difference was not observed in slopes and elevation ($P>0.05$). Details of Length–weight relationship analysis for Indian mackerel is given in Table 11.

Table 11. The length weight parameter a, b, r for Indian mackerel

Indian mackerel			
	Describe the rate of change of weight with length (a)	**weight at unit length (b)**	**Correlation coefficient (r)**
Male	0.0040	3.3444	0.9809
Female	0.0066	3.1761	0.9683
In-determinant	0.0044	3.3107	0.9882

Three equations estimated for male, female and indeterminant of Indian mackerel are as stated below:

Male $W = 0.0040\ L^{3.3444}$

Female $W = 0.0066\ L^{3.1761}$

Indeterminant $W = 0.0044\ L^{3.3107}$

The correlation coefficient estimated for male, female and indeterminant of Indian mackerel, were 0.9809, 0.9683 and 0.9882 respectively($P>0.05$). The length-weight relationship established in male, female and indeterminant are given in Fig. 7, Fig. 8 and Fig. 9 respectively. The ponderal index was calculated. The average ponderal index estimated for male, female and indeterminant was 0.9912, 0.9951 and 0.9871 respectively.

2.2 Indian oil sardine

Length-weight relationship of male, female and indeterminant of Indian oil sardine shows did not show significant difference in slopes and elevation (P>0.05) in ANCOVA analysis. Details of Length–weight parameters for Indian oil sardine is given in Table 12.

Table 12. The length weight parameter a, b, r for Indian oil sardine

Indian oil sardine			
Male	0.0127	2.9043	0.9686
Female	0.0091	3.0143	0.9738
In-determinant	0.0044	3.2603	0.9933

Equations estimated for male, female and indeterminant are as stated below:

Male $W = 0.0127\ L^{2.9043}$

Female $W = 0.0091\ L^{3.0143}$

Indeterminant $W = 0.0044\ L^{3.2603}$

The correlation coefficient estimated for male, female and indeterminant were 0.9686, 0.9738 and 0.9933 respectively(P>0.05). The length-weight relationship established in male, female and indeterminant are shown in Fig. 10, Fig. 11 and Fig. 12 respectively. The average ponderal index estimated for male, female and indeterminant of Indian oil sardine was 1.0032, 1.0012 and 1.0049 respectively.

Fig. 7. Length weight relationship for male of Indian mackerel

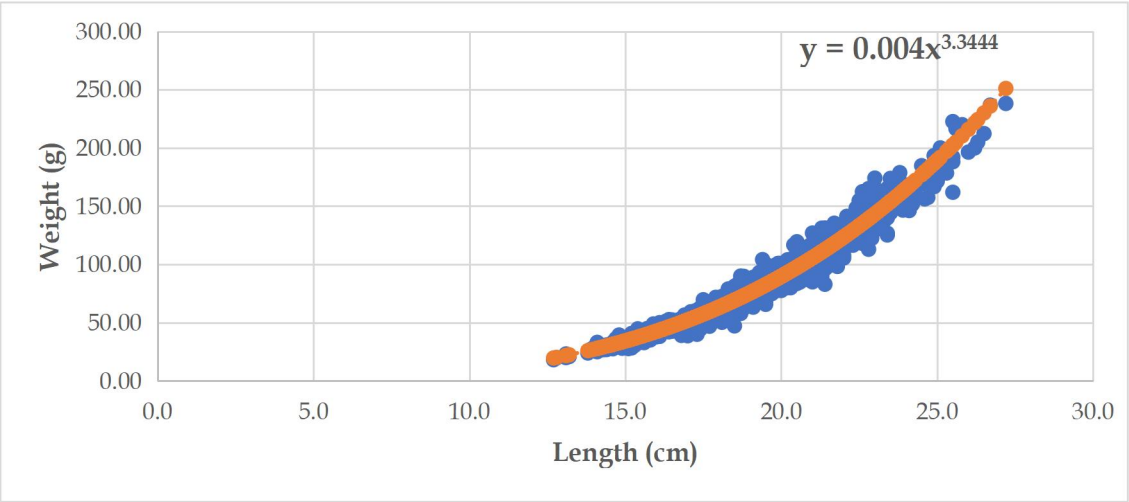


Fig. 8. Length weight relationship for female of Indian mackerel

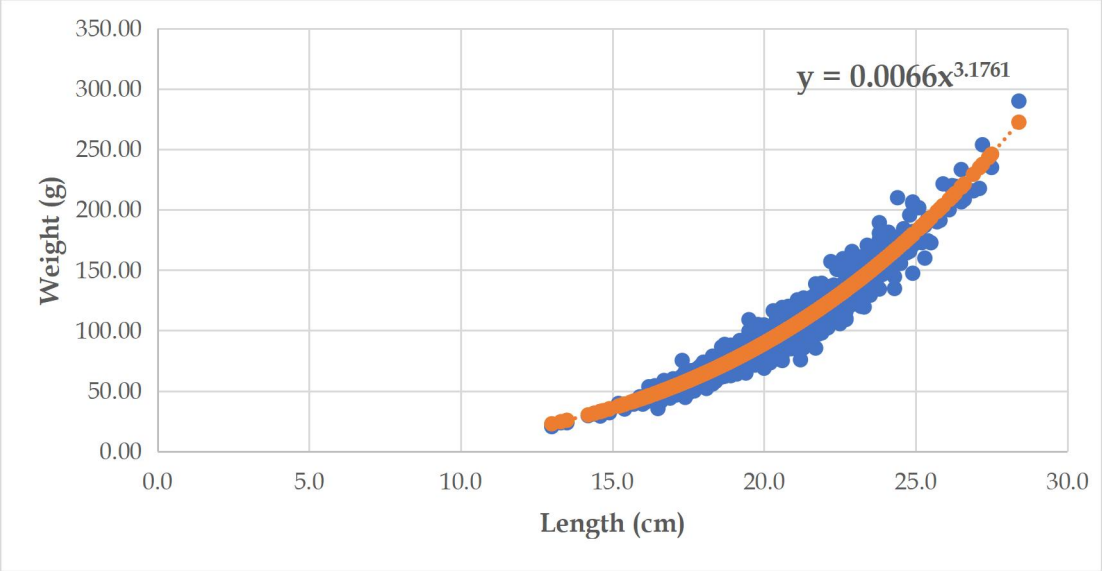


Fig. 9. Length weight relationship for indeterminant of Indian mackerel

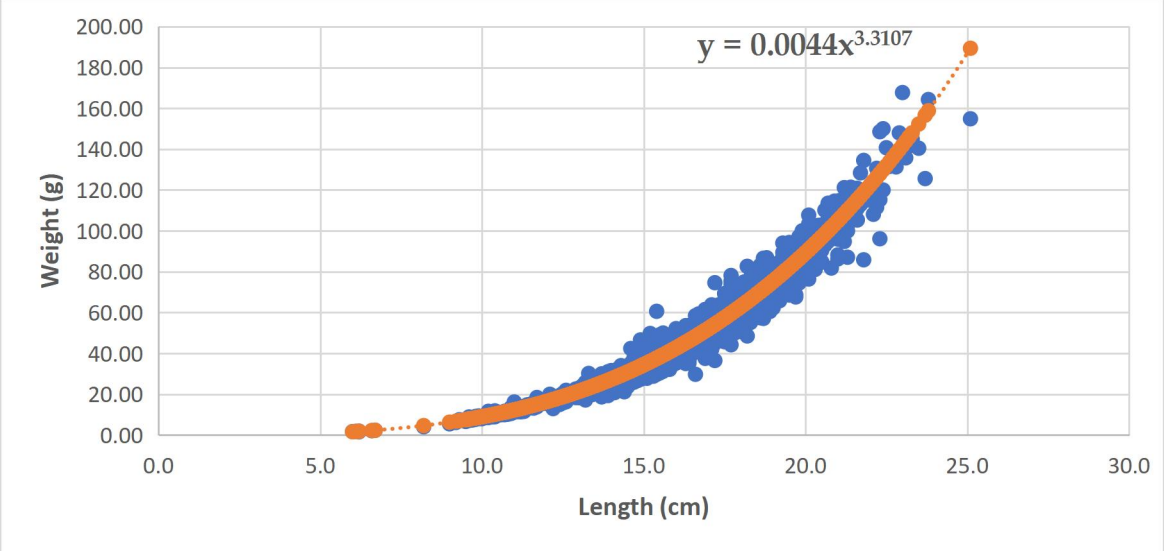


Fig. 10. Length weight relationship for male of Indian oil sardine

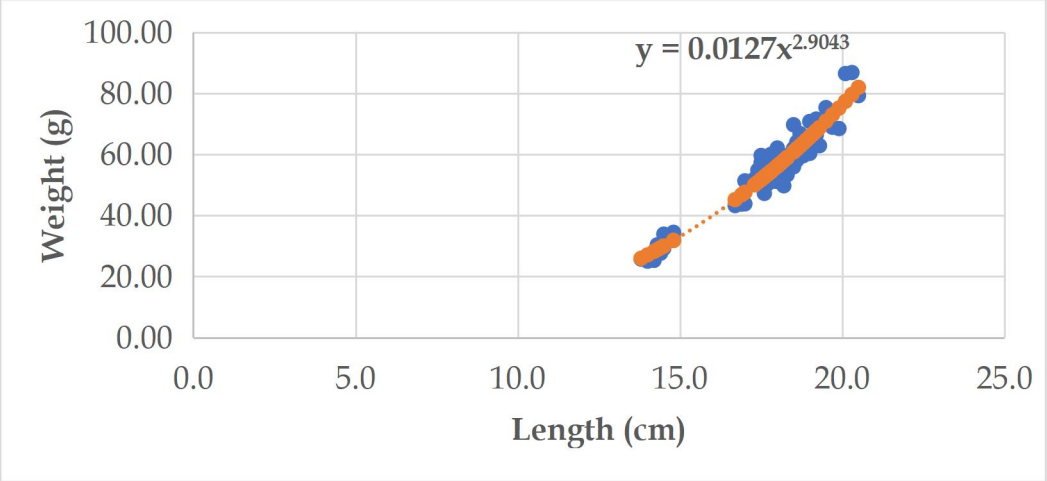


Fig. 11. Length weight relationship for female of Indian oil sardine

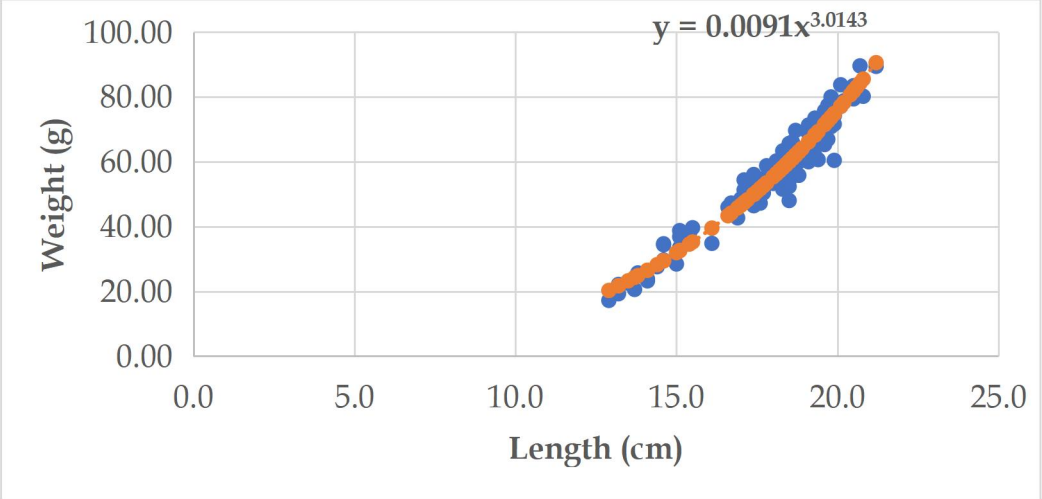
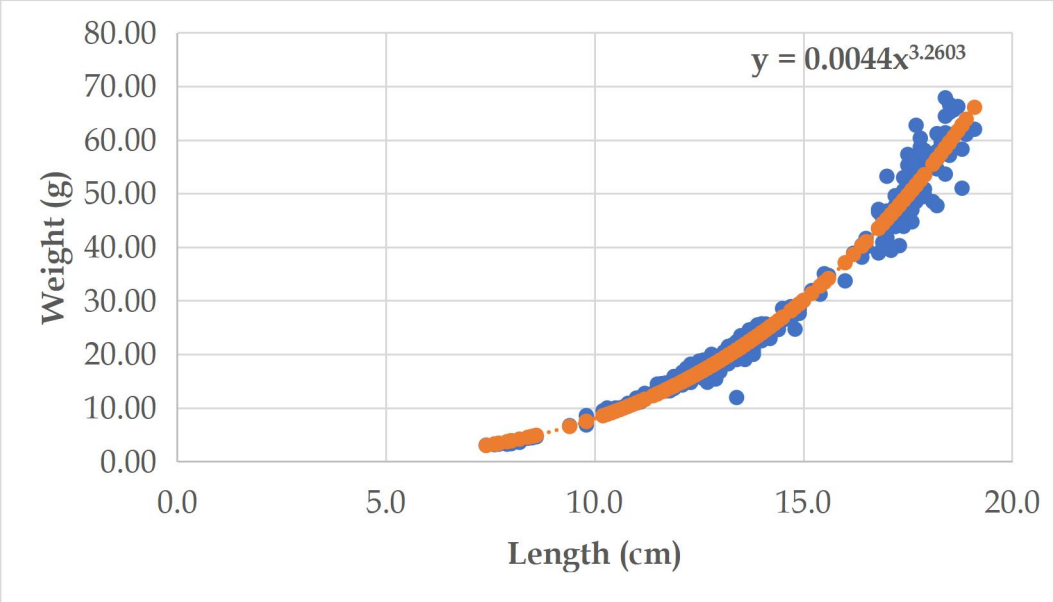


Fig. 12. Length weight relationship for indeterminant of Indian oil sardine



3. Food and Feeding Habit

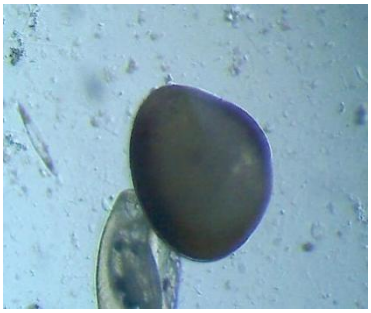
3.1 Indian mackerel

The findings of the present study showed that the food items in the gut of Indian mackerel consist phytoplankton, zooplankton, broken appendages and scales of fishes as well as some small species of crustaceans. Among all the food items, *Copepod* (14.01%) and *Pleurosigma sp.* (15.94%) were dominant during the study period. Apart from this *Dinophuysis miles,* scales, broken appendages and exoskeleton of small crustaceans and mollusca were found in more than 4% among all the food items, whereas, *Ceratium breve*, *Chaetoceros decipiens*, *Cossinodiscus granii*, *Cosinidiscus radiatus*, *Peridinium steinii*, *Rhizosolenia hebetata* and *Skeletonema costatum* were found in the percentage range of 2 to 3%.

3.2 Indian oil sardine

Gut content analysis of Indian oil sardine revealed that, *Pleurosigma sp.* was candidate food item found in more than 21% among all the food items found in gut content analysis during the present study. Aside *Pleurosigma sp.*, Copepod, *Cosinodiscus Asteromphalus, Cossinodiscus granii* and crustacean appendages were also found in the range of 5 to 10%. While, *Skeletonema costatum, Chaetoceros decipiens, Cosinidiscus radiatus, Ceratium tripose var pulchellum, Dinophuysis miles, Grammatophora undulata, Peridinium steinii* and exoskeleton of small crustaceans were also major food items in the gut of Indian oil sardine.

Food items observed in the gut content of Indian mackerel and Indian oil sardine are given in Plate 2 to Plate 5 and Fig. 13 and 14 for Indian mackerel and Indian oil sardine respectively.

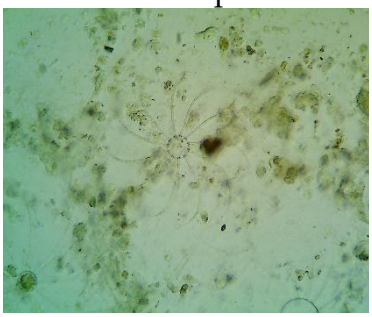


Bivalve sp. I

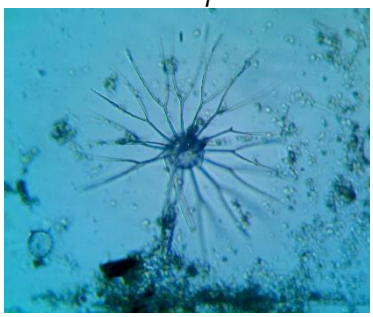
Bivalve sp. II

Bivalve sp. III

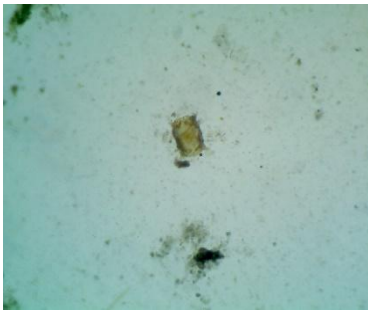
Bacteiastrum comosum



Bacteiastrum varians



Bacteriastrum hyalinum



Biddulphia heteroceros

Biddulphia sinensis

Ceratium fusus

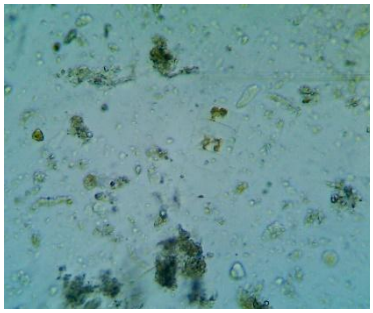
Ceratium breve

Ceratium trichoceros

Ceratium contrarium

Ceratium tripose var pulchellum

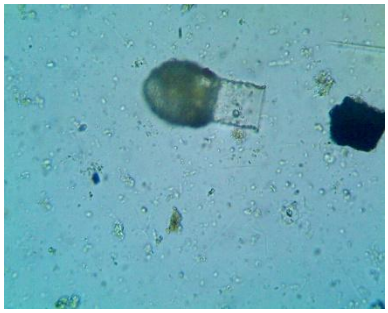
Chaetoceros coarctatus

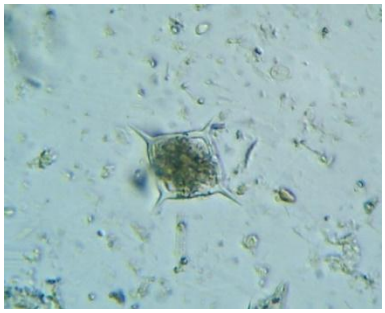


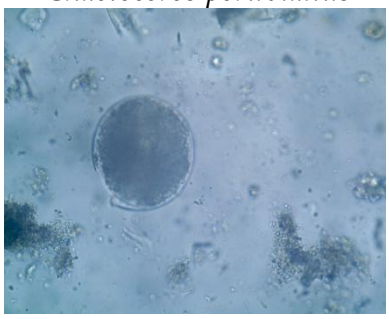
Chaetoceros decipiens

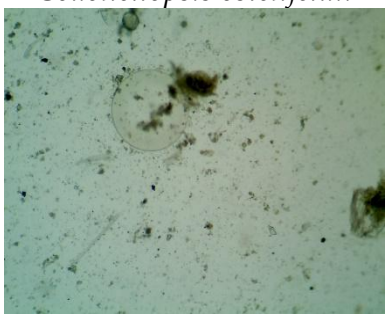
Plate 2 Food components in gut content of Indian mackerel and Indian oil sardine


Chaetoceros peruvianus


Codonellopsis ostenfeldii


Dictyocha fibula


Coscinodiscus asteromphalus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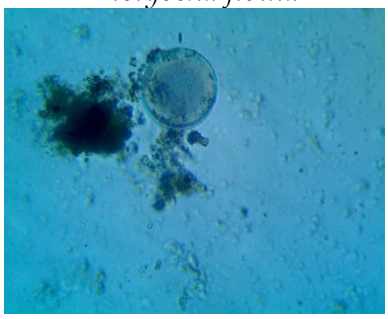
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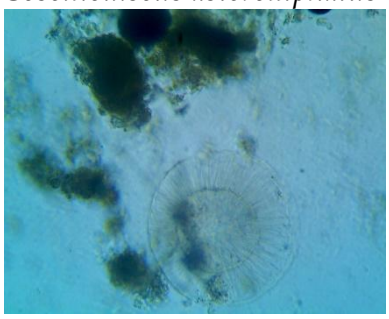
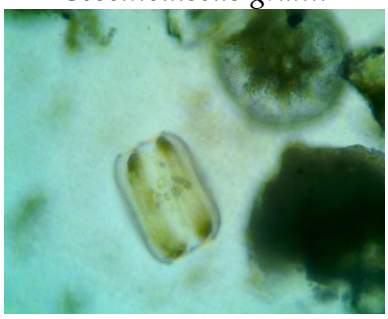
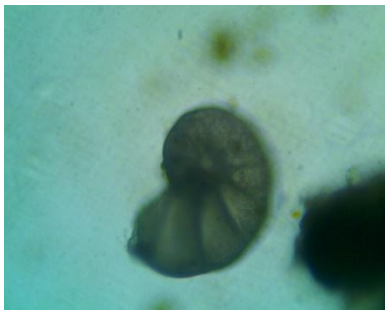

Cyclotella striata


Grammatophora undulata

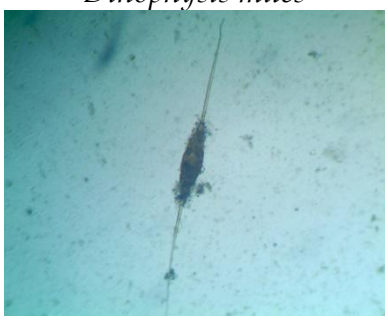

Limacina sp


Dinophysis caudata


Dinophysis miles


Ornithocercus steinii


Macrosetella sp.


Nitzschia longissima

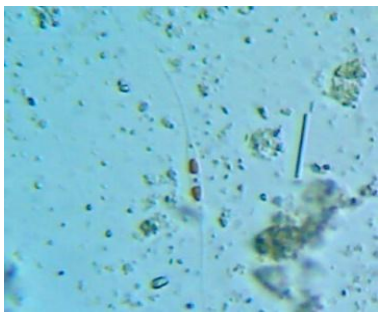
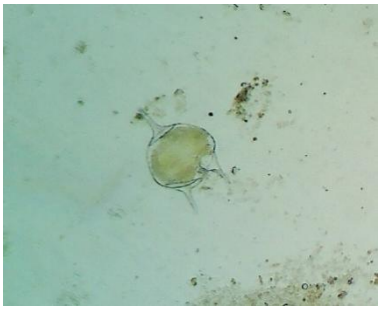

Nitzschia closterium

Plate 3 Food components in gut content of Indian mackerel and Indian oil sardine

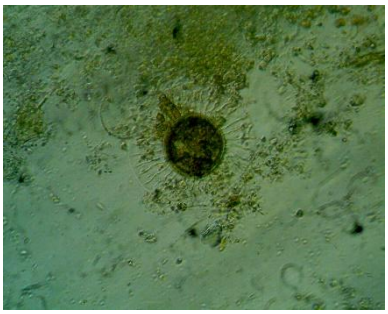
Phalacroma granii



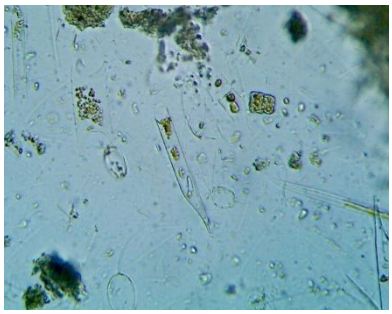
Peridinium steinii

Peridium oceanicum

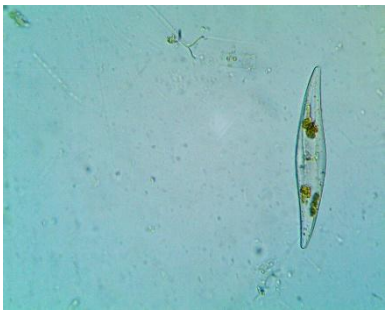
Skeletonema costatum



Planktoniella sol



Rhizosolenia hebetata

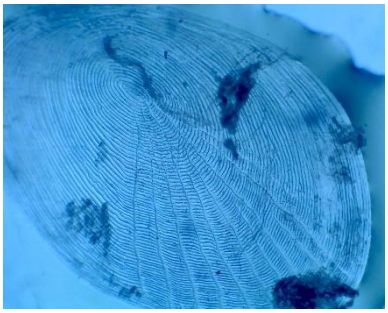


Pleurosigma

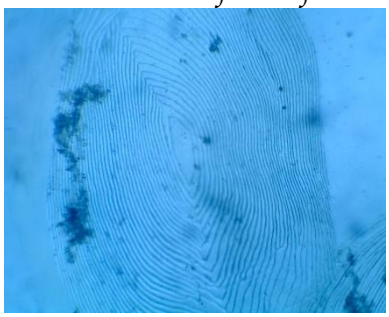
Thalassiothrix nitzschioides

Thalassiothrix frauenfeldii

Nauplius

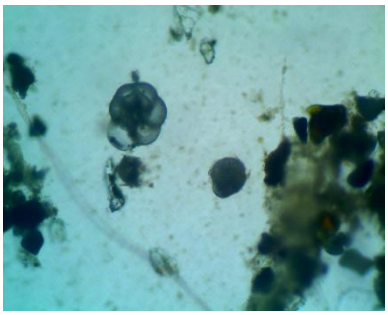


Scale

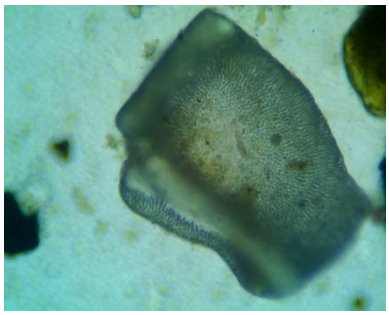


Exoskeleton

Unidentified I



Unidentified II



Unidentified III

Plate 4 Food components in gut content of Indian mackerel and Indian oil sardine

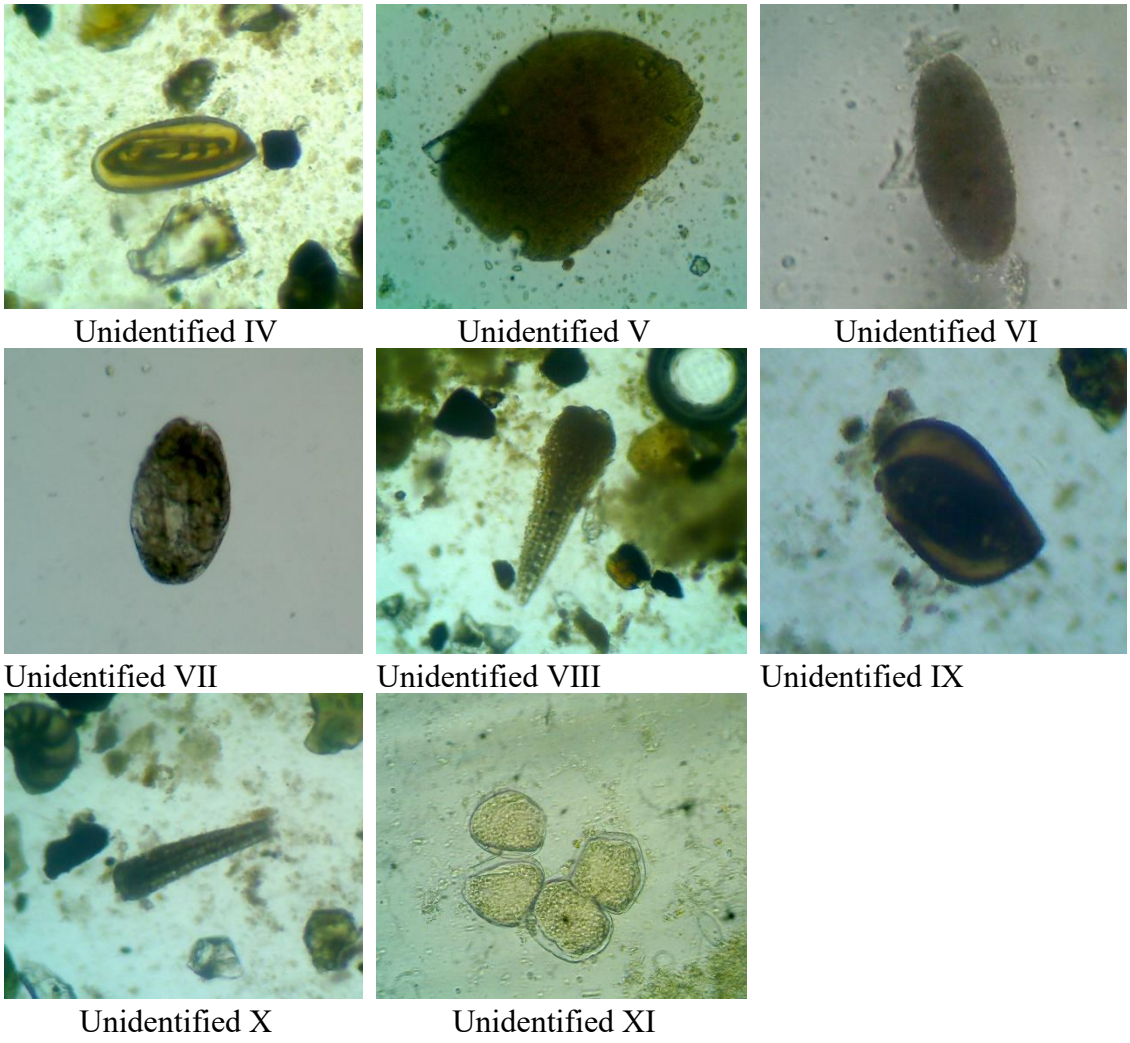


Plate 5 Food components in gut content of Indian mackerel and Indian oil sardine

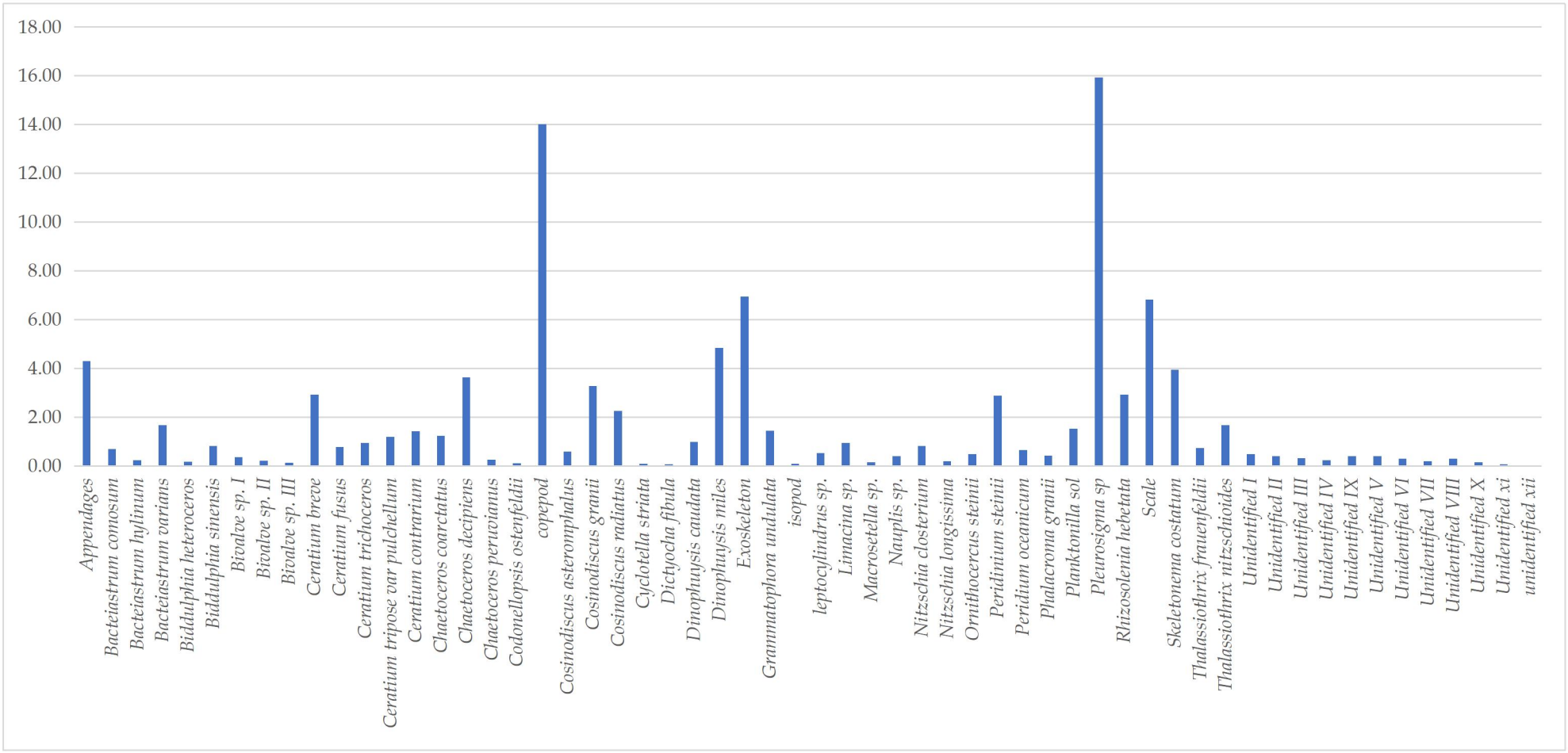


Fig. 13. Overall percentage of feed component in gut of Indian mackerel

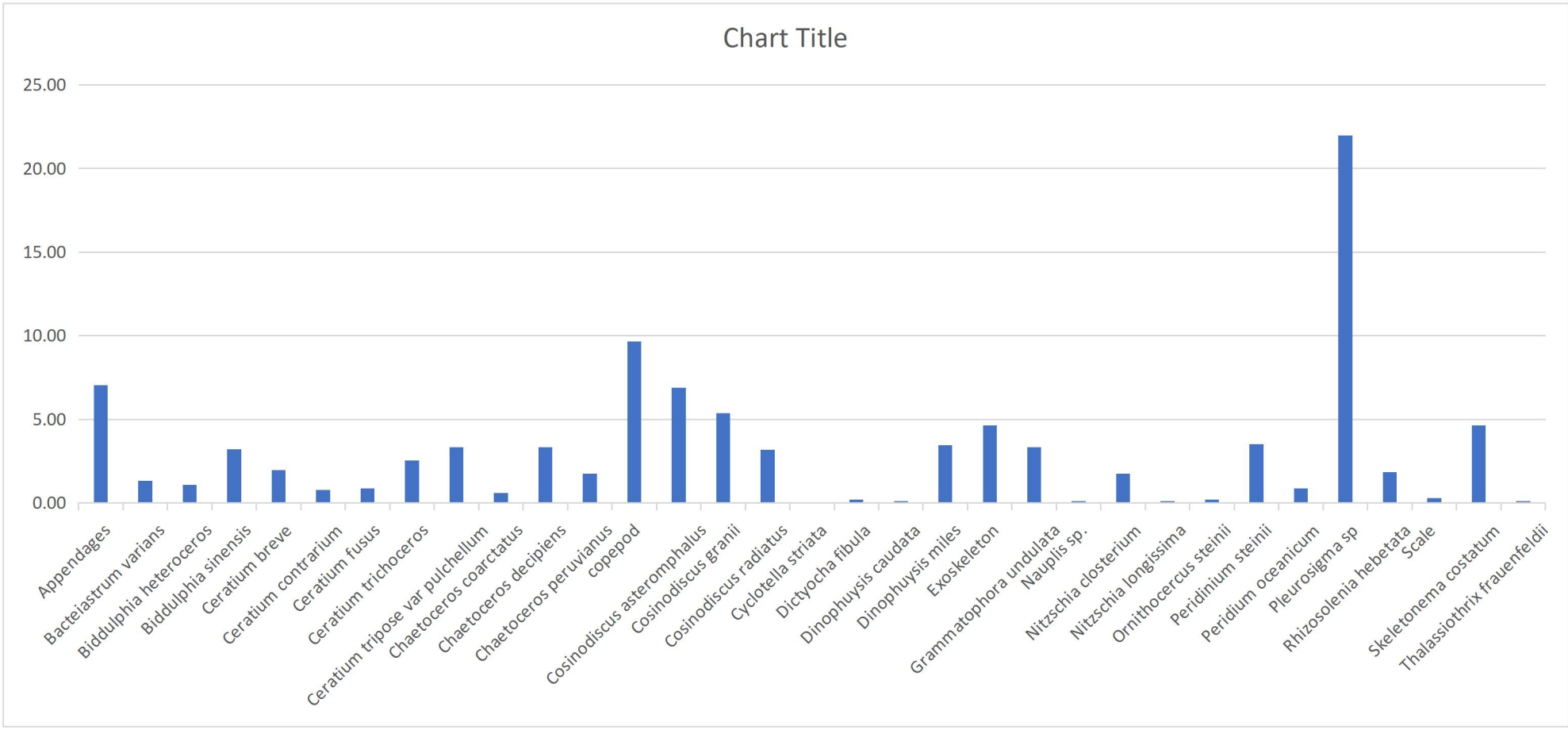


Fig. 14. Overall percentage of feed component in gut of Indian oil sardine

4. Reproductive Biology

4.1 Sex Ratio

To study the sex ratio of Indian mackerel a total of 6198 specimens were examined (Plate 6) during August 2020 to May 2022, out of which, 1312 were male, whereas, 1484 were female and 3402 were indeterminant. Sex ratio was estimated for each month. The month wise sex ratio of the male and female for the entire period of study of Indian mackerel and Indian oil sardine is shown is Table 13 and 14 respectively. For Indian mackerel, the study reveled that, the females dominated in the months of August and December in year 2020 ($P<0.05$), while the males dominated in the month of October 2020 and February 2021 ($P<0.05$) whereas, in the second year of study showed that, except the moth of September and October, 2021 the females were dominated throughout the year ($P<0.05$). Similarly, for Indian oil sardine, study showed that, females were more in all the months of study except April, 2022 but the difference was non-significant ($P>0.05$).

Table 13. Month wise sex ratio of Indian mackerel

Months	2020-21			2021-22			Pooled			Sex ratio	
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
August	32	49	**81**	59	92	**151**	91	141*	**232**	1.00	**1.55**
September	98	90	**188**	114	68*	**182**	212	158*	**370**	1.00	**0.75**
October	88	53*	**141**	71	60*	**131**	159	113*	**272**	1.00	**0.71**
November	62	49	**111**	39	45	**84**	101	94	**195**	1.00	**0.93**
December	45	66	**111**	58	105*	**163**	103	171*	**274**	1.00	**1.66**
January	86	78	**164**	63	97	**160**	149	175	**324**	1.00	**1.17**
February	67	42	**109**	33	35	**68**	100	77*	**177**	1.00	**0.77**
March	101	131	**232**	43	85*	**128**	144	216*	**360**	1.00	**1.5**
April	81	110*	**191**	69	91	**160**	150	201	**351**	1.00	**1.34**
May	54	60	**114**	49	78	**127**	103	138	**241**	1.00	**1.34**
Total	**714**	**728**	**1442**	**598**	**756**	**1354**	**1312**	**1484**	**2796**	1.00	**1.13**

*** Numbers are significantly different P<0.05**

Table 14. Month wise sex ratio of Indian oil sardine

Months	Male	Female	Total	Sex ratio	
				Male	Female
Nov-20	18	28	**46**	1.00	1.56
Sep-21	19	22	**41**	1.00	1.16
Oct-21	7	7	**14**	1.00	1.00
Nov-21	2	5	**7**	1.00	2.50
Dec-21	11	31	**42**	1.00	2.82
Feb-22	0	1	**1**	-	-
Apr-22	15	14	**29**	1.00	0.93
Total	**72**	**108**	**180**	1.00	1.50

All numbers are non-significant at 5 % level of significance

4.2 Fecundity

The fecundity in Indian mackerel ranged from 3,814 (Weight of female: 77.3 g) to 3,70,607 eggs (Weight of female: 139.15 g) with an average of 72,569 whereas, in Indian oil sardine it ranged from 15,836 eggs (Weight of female: 33.50 g) to 1,82,237 eggs (Weight of female: 89.43 g) with 56,975 eggs.

4.3 Gonado-Somatic Index

Gonado Somatic Index (GSI) for male and female was calculated separately for both Indian mackerel and Indian oil sardine. For Indian mackerel, the minimum and maximum GSI recorded for male was 0.04 and 14.56% respectively with an average of 2.83%, while minimum and maximum GSI recorded for female was 0.05 and 16.13% respectively with an average of 3.07%. On the other hand, for Indian oil sardine the minimum and maximum GSI registered was 0.64 and 15.74% respectively with an average of 5.26% for male and for female, minimum GSI was 0.14 and maximum GSI was 13.50% with an average of 5.01%. GSI of male and female of Indian mackerel and Indian oil sardine tabulated in Table 15. Month-wise frequency of GSI value for male and female of Indian mackerel and Indian oil sardine is plotted and shown in Fig. 15 to Fig. 18 respectively. Frequency graph of male and female reveled that, frequency of occurrence of higher GSI values were more in the month of August to October for Indian mackerel and in the month of September to November for Indian oil sardine. These graphs clearly indicated that the Indian mackerel and Indian oil sardine breeds throughout the year with major peak in post-monsoon season and minor in other part of the year.

Table 15 Gonado-Somatic index (GSI) for Indian mackerel and Indian oil sardine

	Indian mackerel		**Indian oil sardine**	
	Male	**Female**	**Male**	**Female**
Minimum	0.04	0.05	0.64	0.14
Maximum	14.56	16.13	15.74	13.50
Average	2.83	3.07	5.26	5.01

The month wise average GSI values for male and female of Indian mackerel were plotted and same is depicted in Table 16 and Fig. 19. The Fig. 19 clearly indicated that the highest GSI values were observed during the

month of August to October and February to May. The availability of higher GSI value of individuals in the month of August to October and February to May also clearly indicated that the India mackerel undergoes prolonged breeding season along the coast of Maharashtra.

Similarly, month wise average GSI values for male and female of Indian oil sardine were depicted in Table 17 and Fig. 20. It was observed that GSI values were higher in the month of September for both male and female and gradually decreased up to the month of December and again increase in GSI can be observed from the month of February.

Fig. 15 GSI of male Indian mackerel

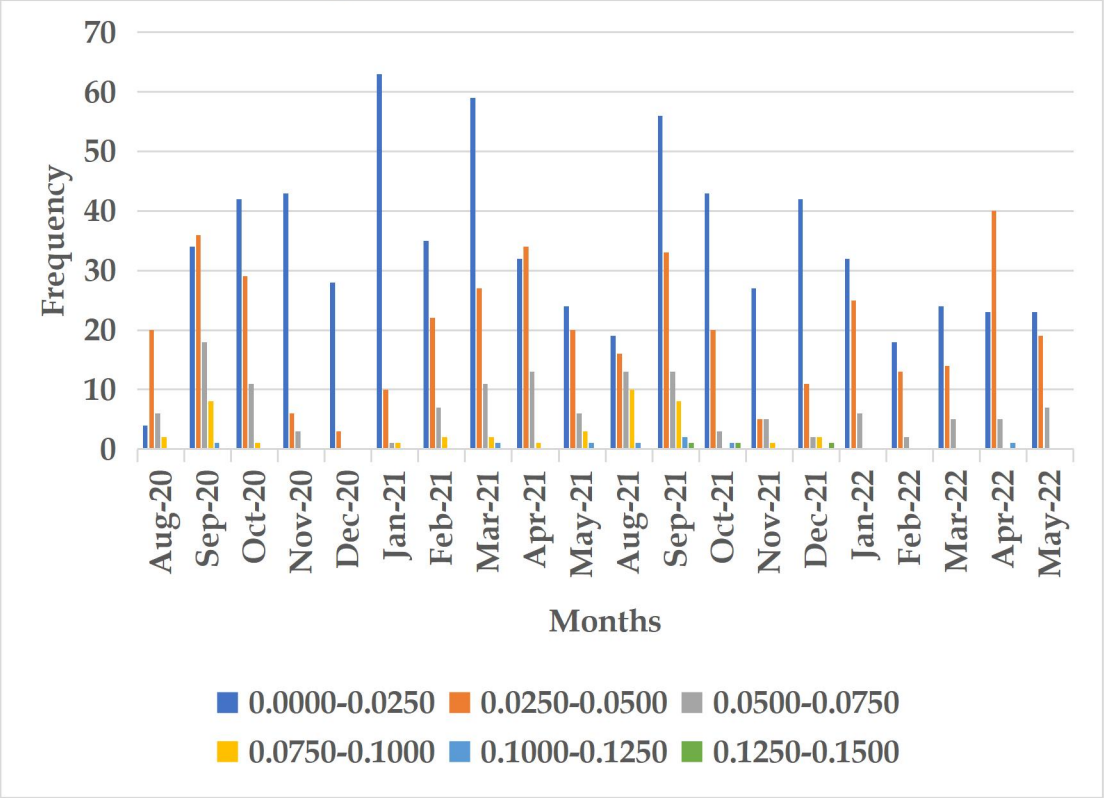


Fig. 16 GSI of female Indian mackerel

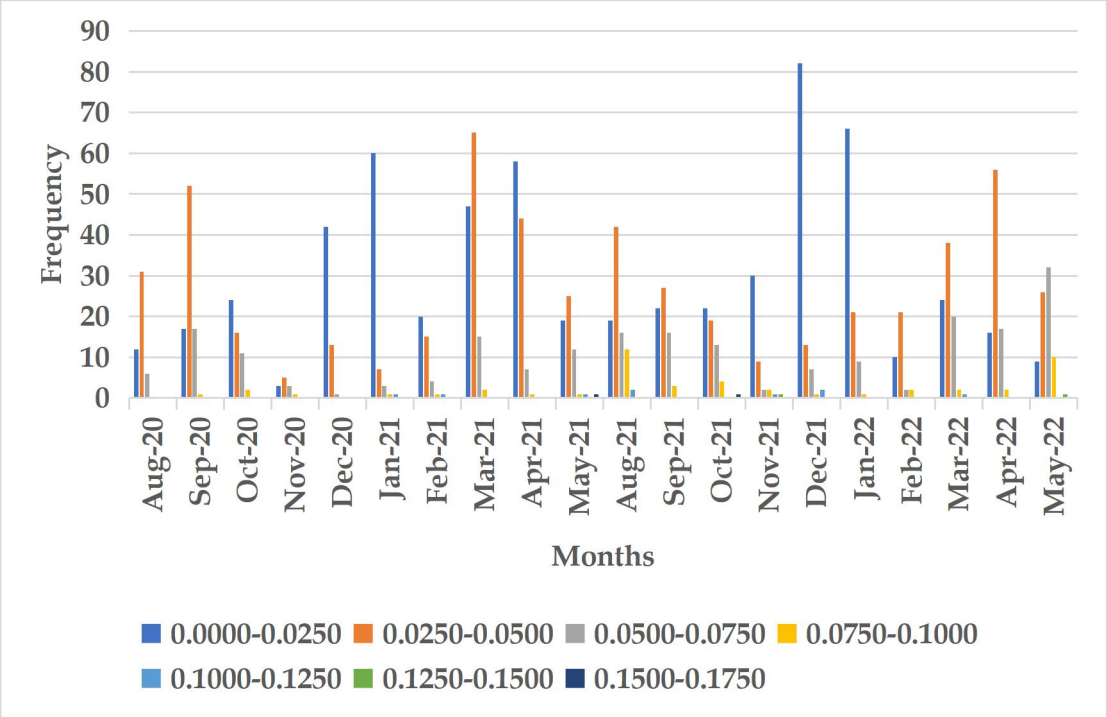


Fig. 17 GSI of male Indian oil sardine

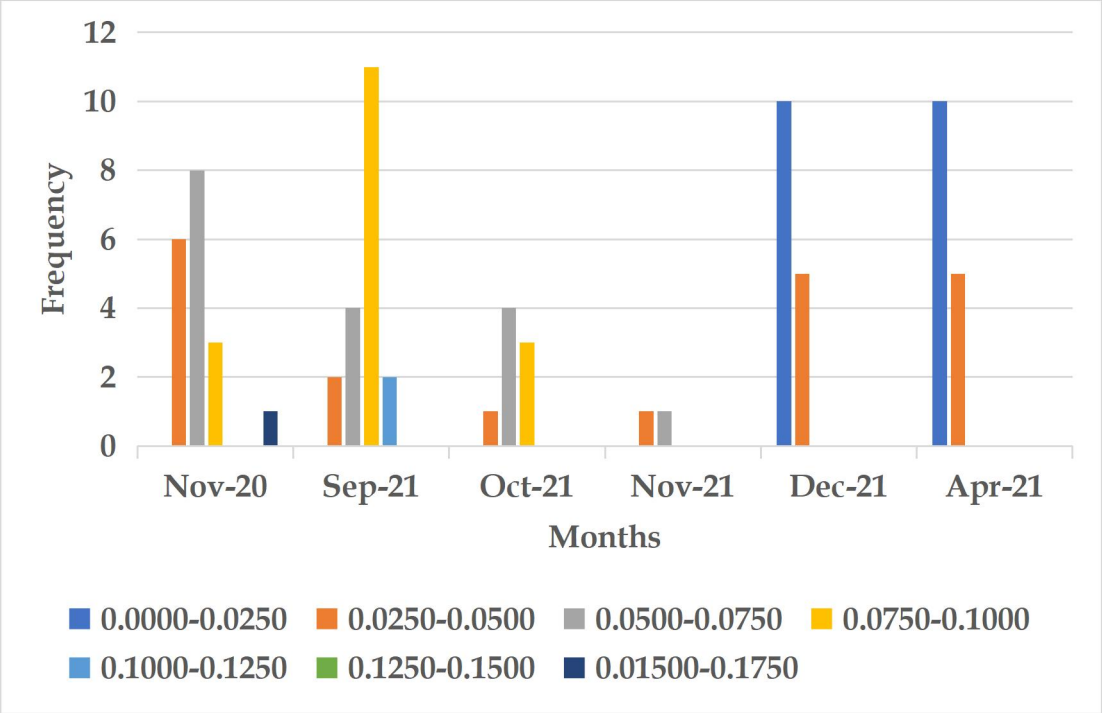


Fig. 18 GSI of female Indian oil sardine

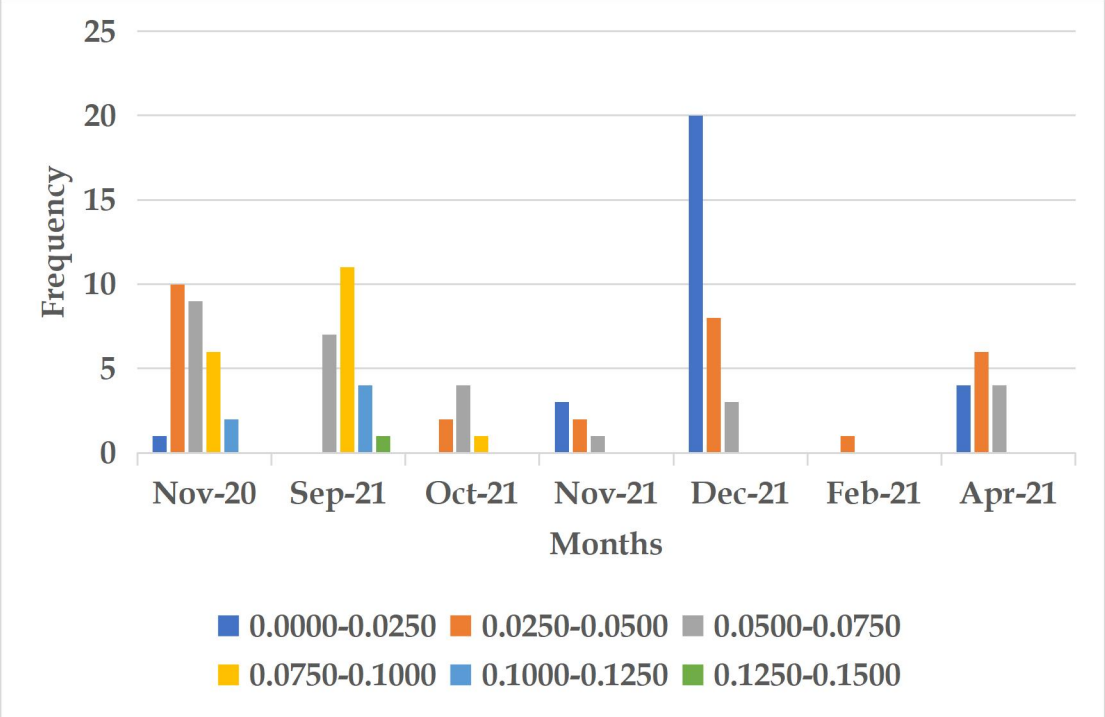


Fig. 19 Month-wise average GSI for Indian mackerel

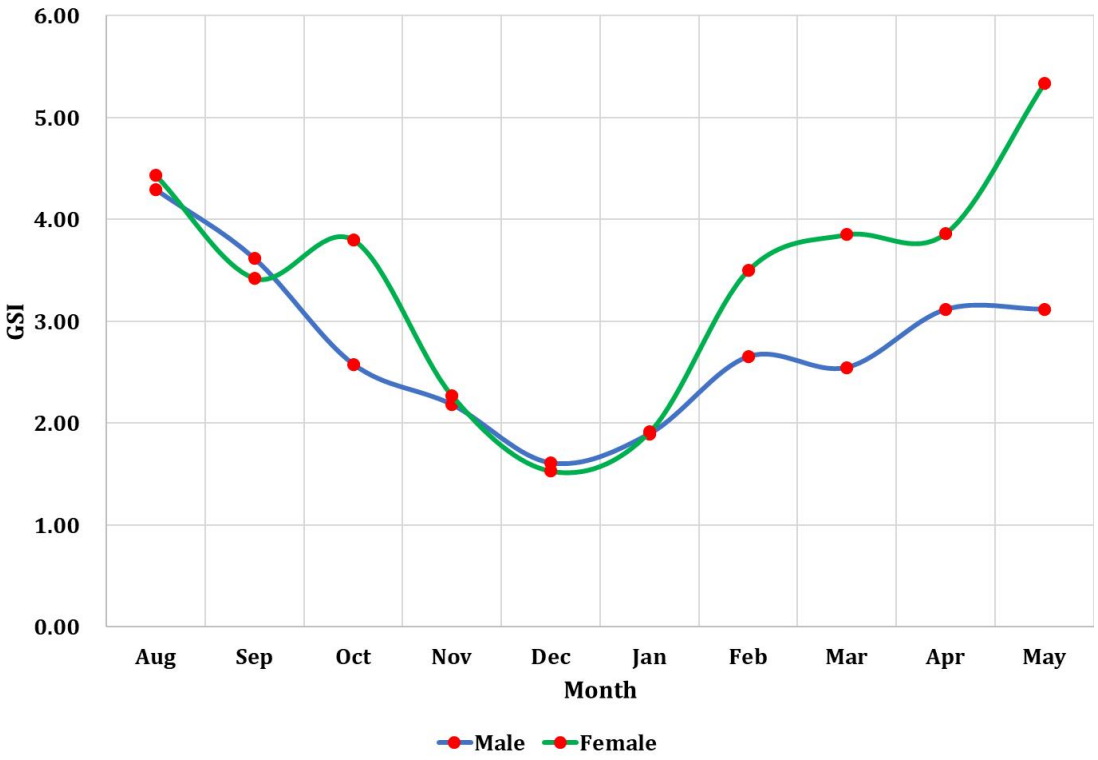


Table 16. Month-wise average GSI for Indian mackerel

Months	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Male	4.29	3.62	2.58	2.18	1.61	1.90	2.65	2.55	3.12	3.12
Female	4.43	3.42	3.80	2.27	1.53	1.91	3.50	3.85	3.86	5.34

Fig. 20. Month-wise average GSI for Indian oil sardine

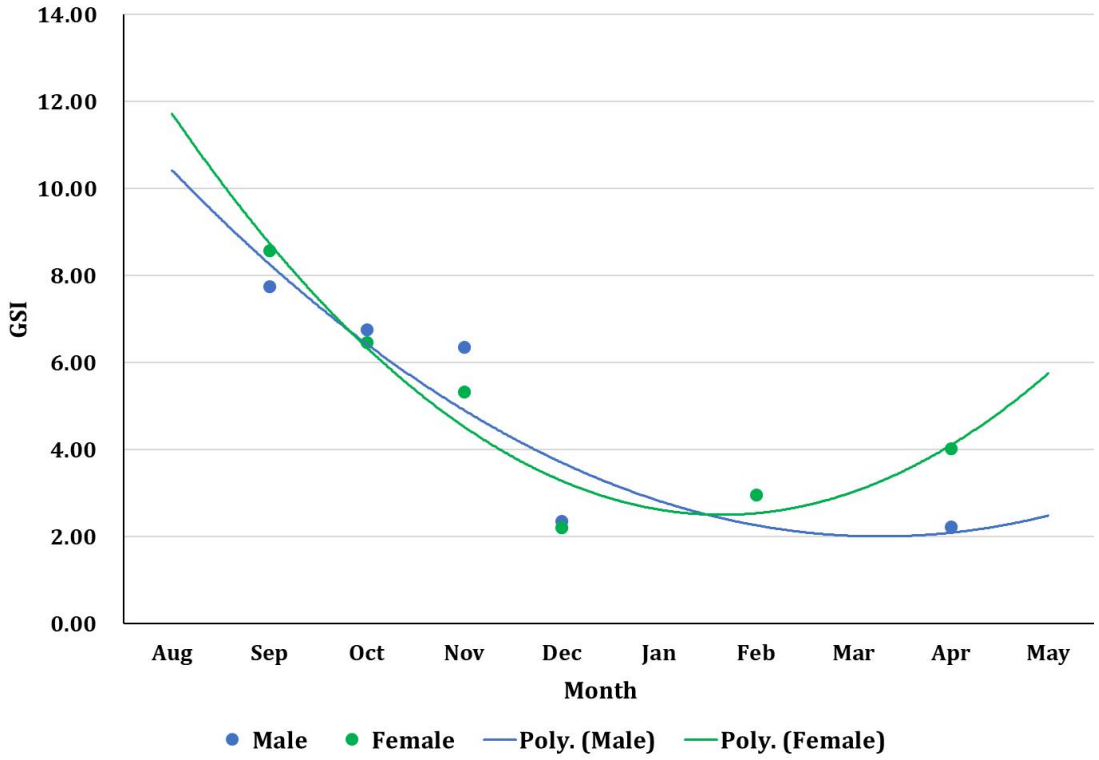


Table 17. Month-wise average GSI for Indian oil sardine

Months	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Male	-	7.74	6.75	6.35	2.34	-	-	-	2.21	-
Female	-	8.57	6.46	5.33	2.21	-	2.95	-	4.02	-

4.4 Ova diameter

The ovaries of Indian mackerel were studied for 20 months from August, 2020 to May, 2022 and for Indian oil sardine it was studied for 7 months from November, 2020 to April, 2022 as per sample availability. The size wise frequency analysis is depicted in Fig. 21 for Indian mackerel and in Fig. 22 for Indian oil sardine. In Indian mackerel, the measured ova diameter ranged from 17.5 µm - 906.66 µm, whereas, it ranged from 112.00 µm - 670.40 µm in Indian oil sardine. The smallest size ova was observed in the month of August, 2020 and December, 2021 for Indian mackerel and Indian oil sardine respectively and the largest size ova was observed in the month of November for both the studied fish species.

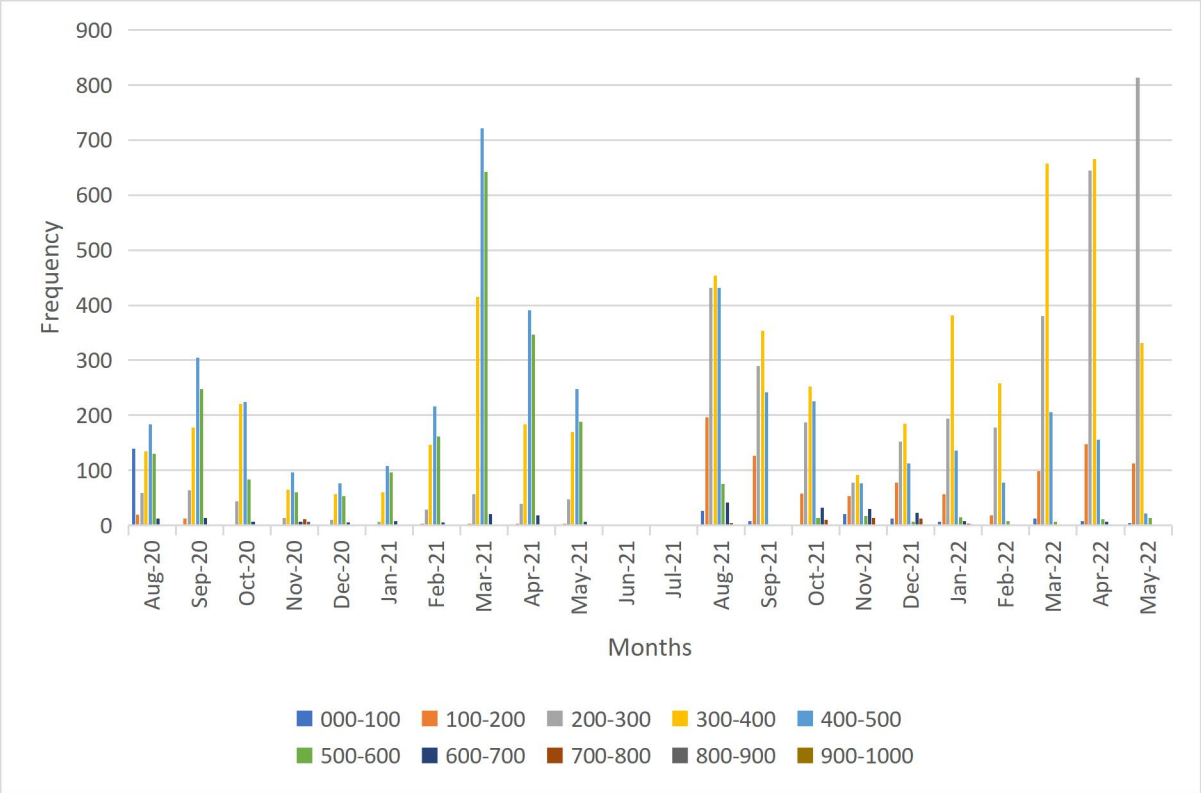


Fig. 21 Frequency distribution of ova diameter (µm) from August 2020 to May 2022 for Indian mackerel

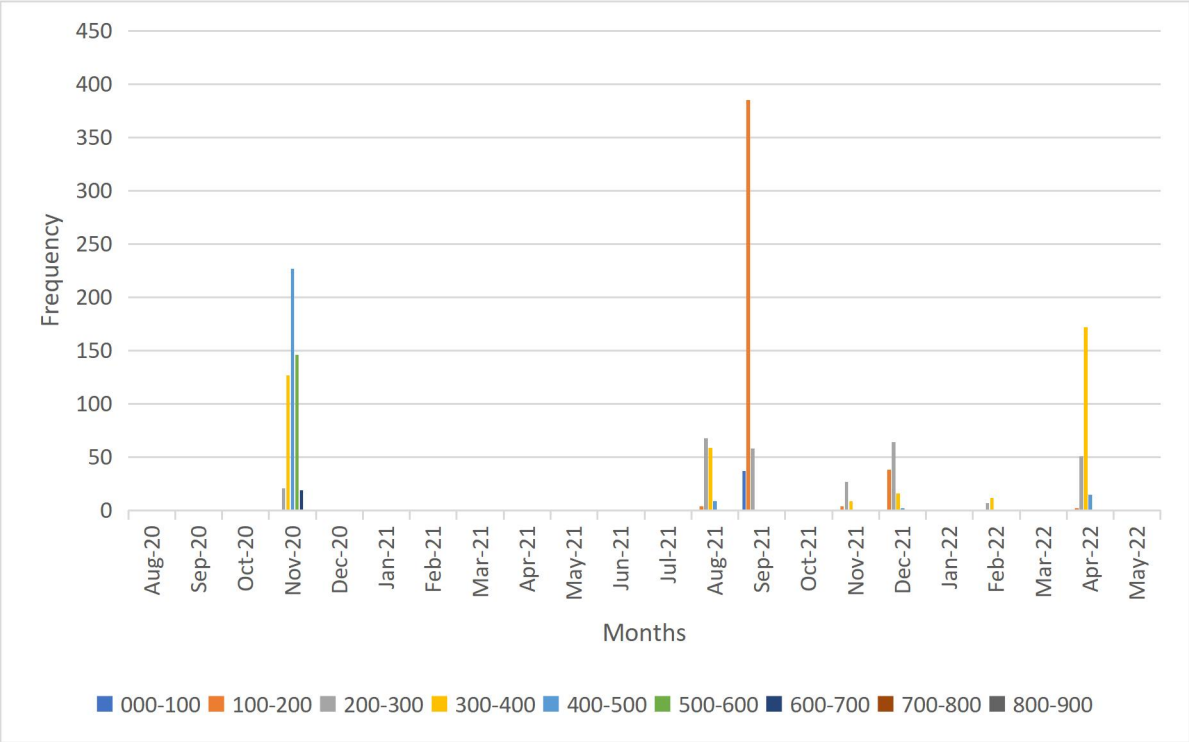


Fig. 22 Frequency distribution of ova diameter (µm) from August 2020 to May 2022 for Indian oil sardine

4.5 Size at first maturity

The length wise average GSI values for Indian mackerel and Indian oil sardine are shown in Table 18 and 19 respectively and the same values were plotted and is shown in Fig. 23 and 24 for Indian mackerel and Indian oil sardine respectively and these figures and values clearly indicated that the Indian mackerel fish starts maturing after 12 cm overall length while in Indian oil sardine maturity begins after 13 cm overall length.

Table 18. Length-wise average GSI of Indian mackerel

Length (cm)	Average GSI (Together)	Average GSI (Male)	Average GSI (Female)
11-14	1.39	1.78	0.34
14-17	1.52	1.76	0.78
17-20	2.37	2.37	2.37
20-23	3.58	3.64	3.55
23-26	4.10	3.80	4.30
26-29	4.55	2.00	5.53

Table 19. Length-wise average GSI of Indian oil sardine

Length (cm)	Average GSI (Together)	Average GSI (Male)	Average GSI (Female)
12-14	2.61	2.08	2.78
14-16	2.82	2.68	2.90
16-18	5.19	5.55	4.69
18-20	5.58	5.87	5.41
20-22	6.25	3.91	6.83

Fig. 23 Length-wise average GSI of Indian mackerel

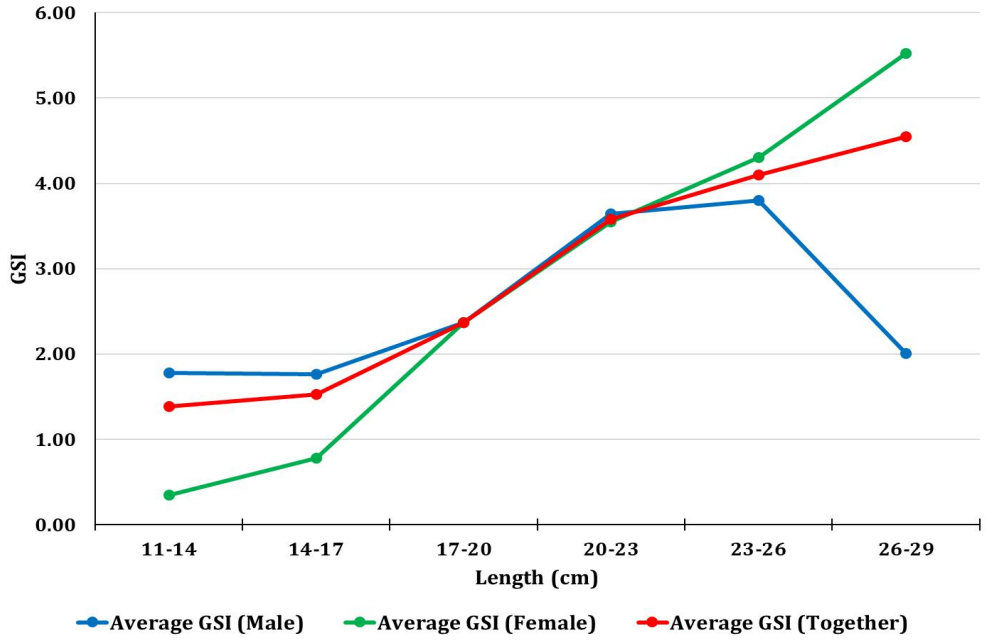
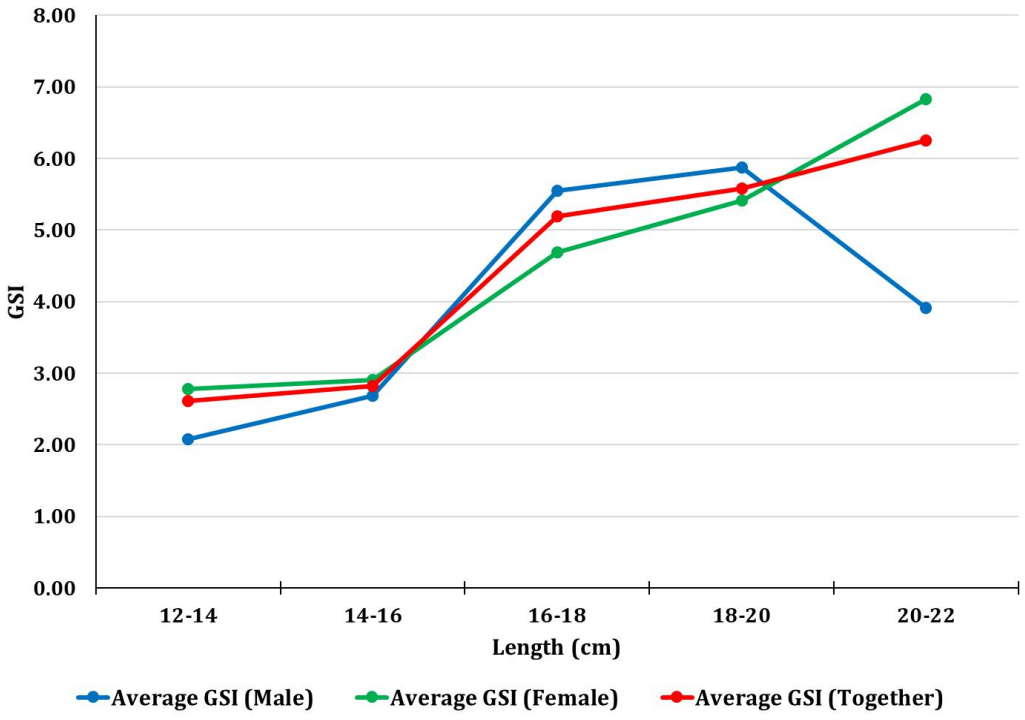


Fig. 24 Length-wise average GSI of Indian oil sardine



5. Maximum Sustainable Yield and f_{MSY}

The catch and effort data for the present study was acquired from Fish Production Report of Department of Fisheries, Government of Maharashtra. The year-wise fishing efforts by the purse-seines and total catch of Indian oil sardine plus Indian mackerel are shown in Fig 25. The highest efforts were recorded in the year 2003-04 whereas lowest from the year 2018-19. The drastic decline in the efforts were observed from the year 2018-19 and also in 2019-20 may be because only four months were allowed by the Government to operate the purse-seiners for fishing.

Year-wise Catch Per Unit Effort is depicted in Fig. 26. The maximum CPUE was observed in the year 2017-18, while lowest in the year 2019-20.

In the present study, the catch and effort data of Indian oil sardine plus Indian mackerel was analysed with surplus production models. The Maximum Sustainable Yield and efforts were estimated by surplus production models such as Schaefer and Fox models. The Maximum Sustainable Yield of Indian oil sardine plus Indian mackerel together was estimated at 54,570 and 56,732 tonnes respectively by Schaefer and Fox surplus production models. The efforts required for the MSY were 41,545 and 56,916 trips by Schaefer and Fox models respectively. The yield curve by Schaefer and Fox for both the species together is depicted in Fig. 27.

The catch and effort data from the year 2000-01 to 2020-21 showed that, the efforts undertaken by the purse-seiners were within the f_{MSY} estimated by both the surplus production models as shown in Fig 28. Till the year 2009-10, only once the catch was recorded more than the estimated MSY and since year 2010-11 to 2017-18, the catches were found exceeding the estimated MSY values, but after 2018-19 catches were much more less than MSY values as given in Fig. 29.

Fig. 25 Catch and Effort of purse-seiners according to year

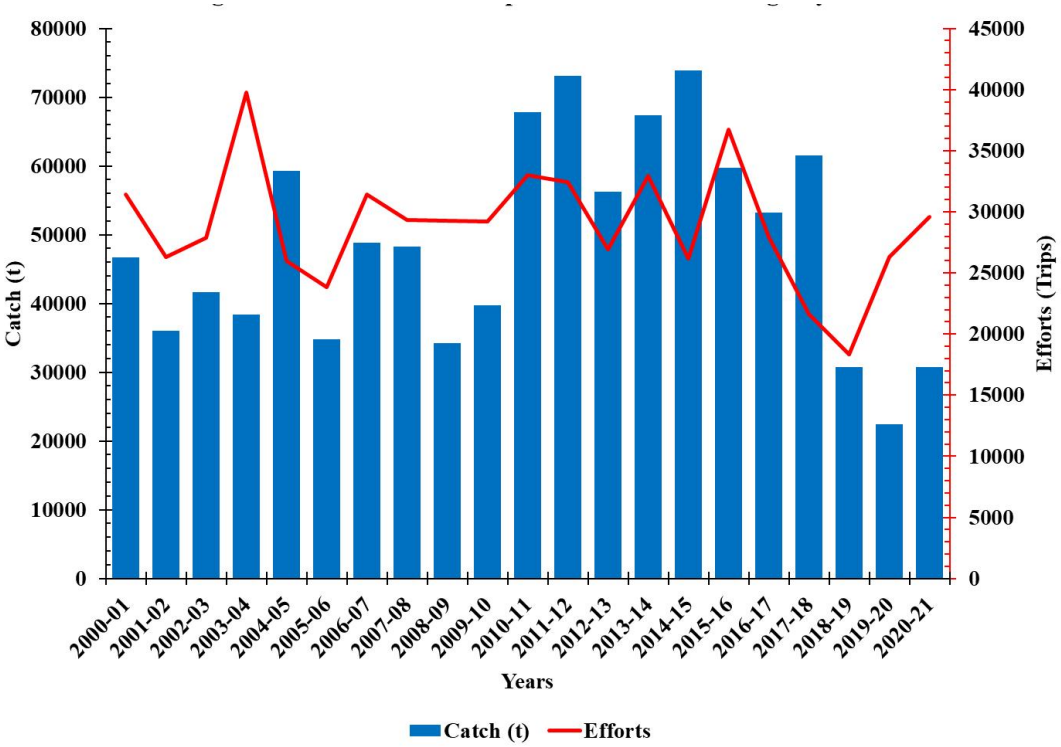


Fig. 26 Catch Per Unit effort of purse-seiners according to year

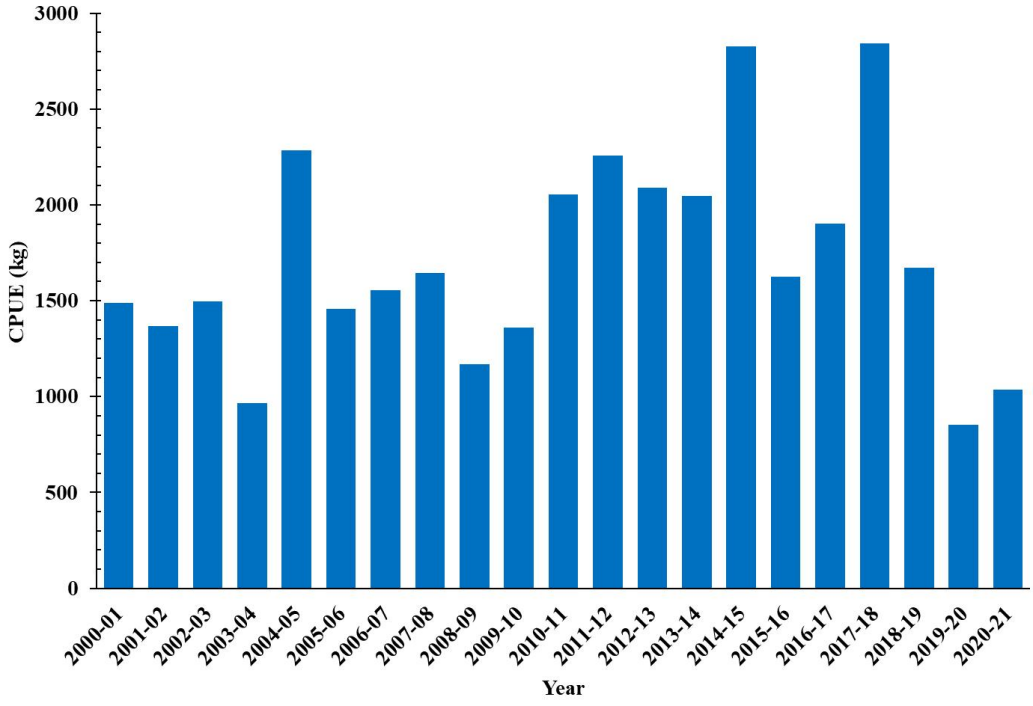


Fig. 27 Schaefer and Fox model curve

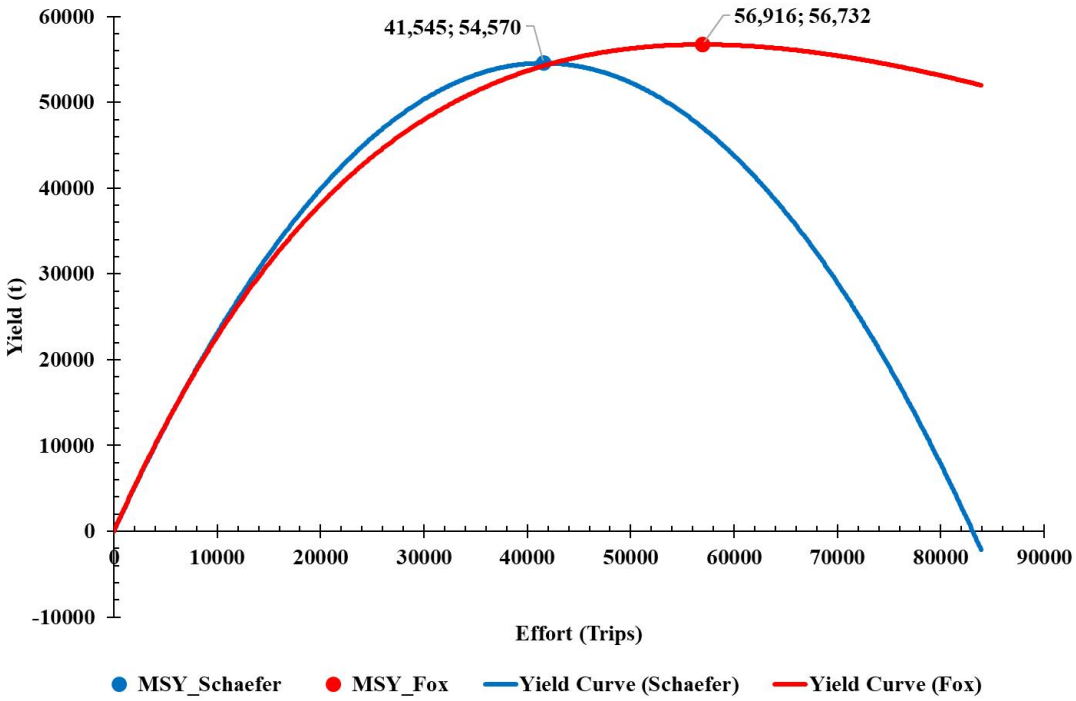


Fig. 28 Year-wise Efforts

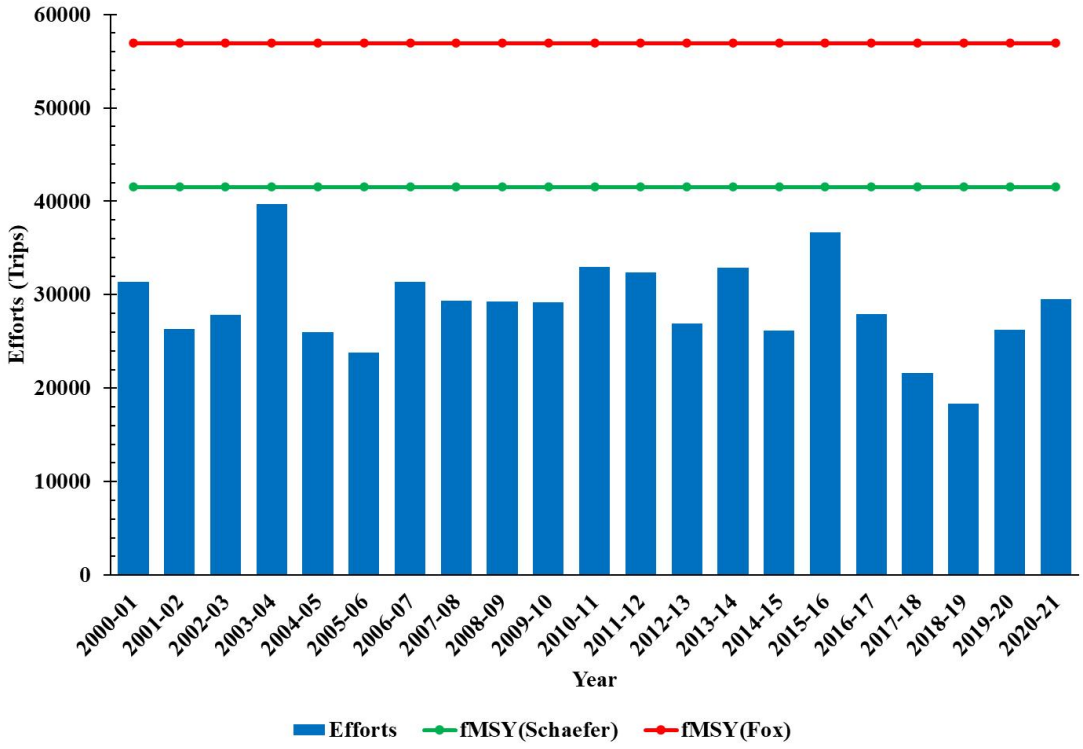
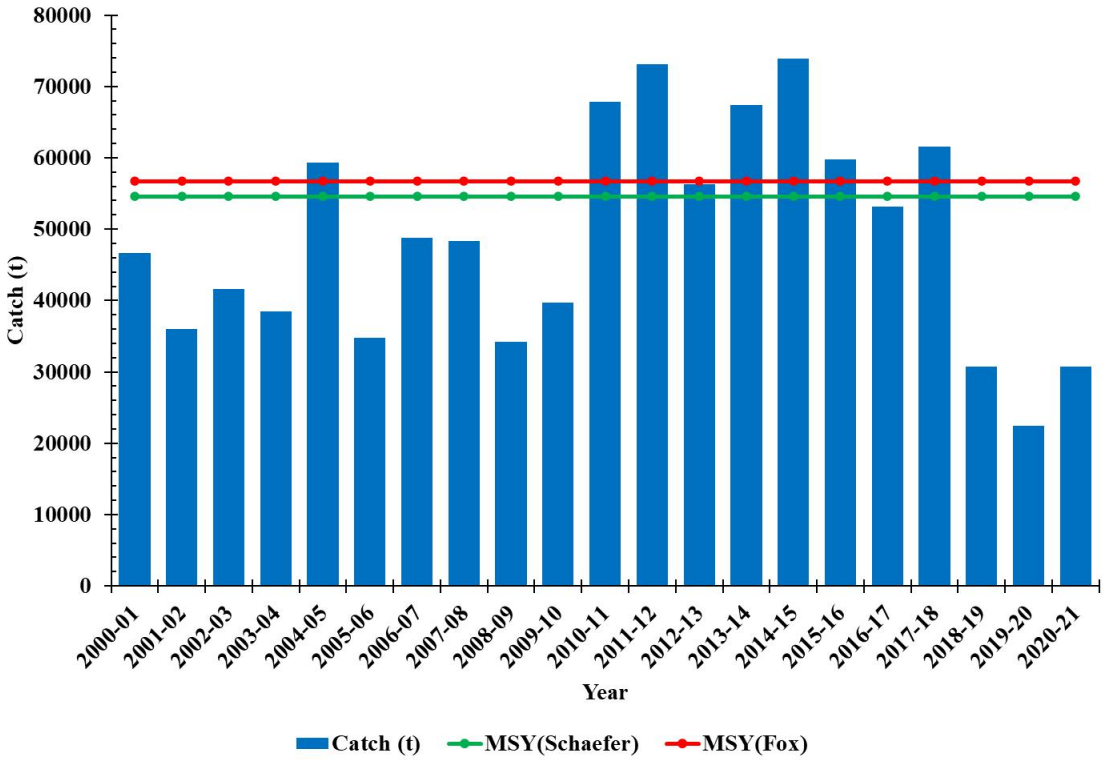


Fig. 29 Year-wise Catch



6. Percentage of bycatch, species composition and volume of discards

Quality and quantity wise catch composition of purse seine was collected. Indian mackerel and Indian oil sardine was taken separately and rest all fishes were grouped together. The catch composition of purse seine haul for Indian mackerel is shown in Fig. 30, while catch composition of purse seine haul for Indian oil sardine is shown in Fig. 31. Total bycatch observed in purse seine haul for Indian mackerel was 21.45%. Other species recorded along with Indian mackerel were tuna, carangid (two species), seer fish, sole fish, croaker (two species) and false trevally. The other fishes caught along with main catch are not discarded, but are marketed for human consumption or to fish meal industry. Thus the by catch discarded is nil. Catch recorded in purse seine haul for Indian oil sardine was with 100% of Indian oil sardine and no other fishes were caught, thus no bycatch is recorded.

Fig. 30 Catch composition of purse seine for Indian mackerel

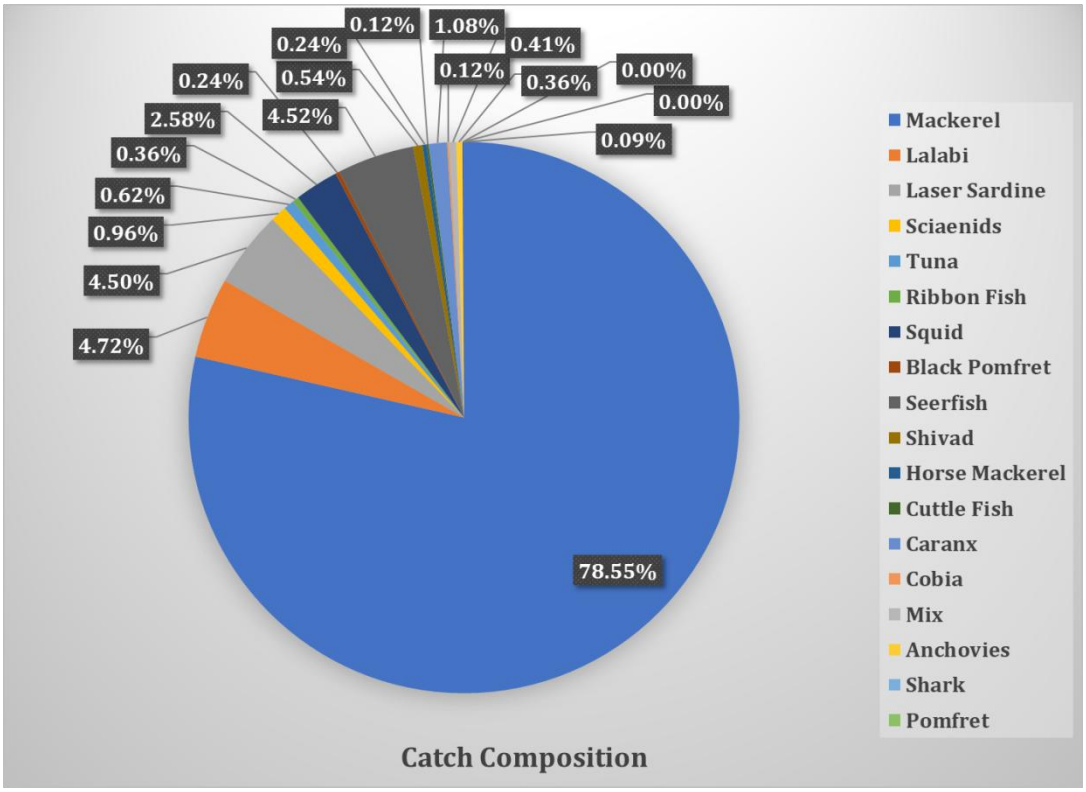
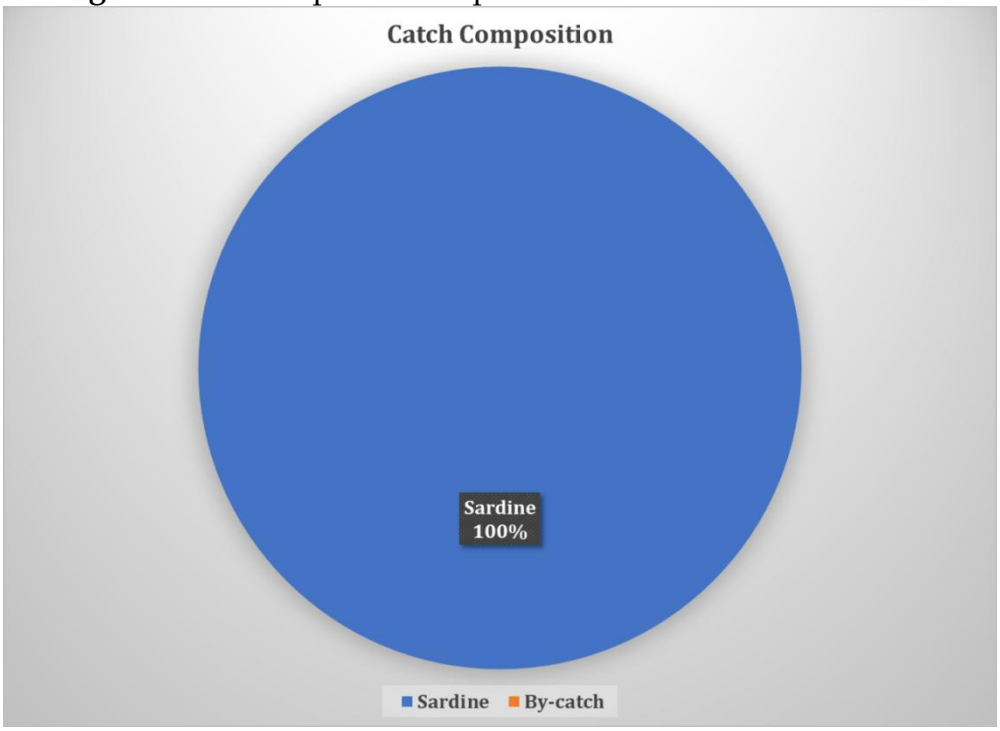


Fig. 31 Catch composition of purse seine for Indian oil sardine



7. Interactions between fishing operations and protected species

The species caught along with main catch are listed in bycatch and species composition section. In which none of the endangered species was recorded. Thus it can be concluded that the purse seine fishery for Indian mackerel do not interact with endangered or protected species.

Acknowledgement

We are very much thankful to the university authorities as Hon'ble Vice Chancellor and Director of Research, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli for giving required permission to undertake research on Stock assessment of Indian oil sardine and Indian mackerel at Diploma in Fisheries Engineering, Shirgaon, Ratnagiri. We express our sincere thanks to M/s Omega Fish meal and Oil Private Limited for funding the project. Last but not least we express sincere gratitude to Department of Fisheries, Government of Maharashtra for providing the required data for the assessment of stock.

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Financial Statement
(Year 2020-21 to 2022-23)

Project Title : Stock Assessment of Indian oil sardine and Indian mackerel

Principal Investigator: Dr. Mangesh M. Shirdhankar

Participating Agency, Address : Diploma in Fisheries Engineering, Shirgaon, Ratnagiri.

Certified that an Amount received from M/s Omega Fish meal & Oil Private Limited as above for the sub – Project (Title mentioned above) Has been spent for the purpose for which it was Sanctioned as under :

Sr. No.	Expenditure Head	2020-21	2021-22	2022-23
1	Expenditure up to beginning of the year	NA	4,91,543	13,18,281/-
2	Opening balance at Beginning of year	NA	2,77,137/-	90,399/-
3	Amount Received From Funding Agency	7,68,680/-	6,40,000/-	1,91,730/-
	Total	7,68,680/-	9,17,137/-	2,82,129/-
A	Manpower			
1	Senior Research Fellow	1,59,068/-	3,83,716/-	78,430/-
2	Field Staff	61,936/-	1,36,967/-	47,613/-
3	Material and Services	30,165/-	38,552/-	9,710/-
Total - A		2,51,169	5,59,235	1,35,753/-
B	Travel and DA			
1	Travel Allowance (TA)/DA	2,550/-	2,900/-	800/-
2	Vehicle hiring	1,18,600/-	1,80,608/-	53,072/-
3	Contingencies Expenditure	49,344/-	19,995/-	10,000/-
Total - B		1,70,494	2,03,503/-	63,872/-
C	Institutional Charges	69,880	64,000/-	17,430/-
Total - C		69,880/-	64,000/-	17,430/-
Total (A+B+C)		4,91,543	8,26,738	2,17,055/-
Refund to Funding Agency		-	-	65,074/-
Balance at the end of the Year		2,77,137/-	90,399/-	-

The expenditure as above has been incurred as per rules and procedures of the work centre and has been property accounted for in the books of accounts. The relevant records are retained in this organization and are audited/subject to audit by the auditors.

(M. M. Shirdhankar)
Principal investigator,
Omega Project &
Principal, Diploma in Fisheries Engineering, Shirgaon, Ratnagiri

Pay and Accounts officer- II
Pre Audit Unit,
K.K.V. Ratnagiri