Stock Assessment of Indian oil sardine and Indian mackerel

Annual Report: 2020-21

Funded
by

M/s Omega Fishmeal & Oil Private Limited

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

July 2021

Index

General information

1.	Project Title	:	**"Stock Assessment of Indian oil sardine and Indian mackerel"**
2.	Funding agency	:	**M/s Omega Fishmeal & Oil Private Limited**
3.	Investigator(s) at Collaborating Institutes (s) with address(es)	:	**Dr. Mangesh Madhukar Shirdhankar** Principal Investigator (Pl.) and Professor & Principal, Diploma in Fisheries Engineering, Ratnagiri, 415 629 Maharashtra, India Email ID : mangeshmshirdhankar@gmail.com Mobile No. 091-9422431863
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4	Name and address(es) of Research Fellow	:	**Shri. Prashant Champatrao Lokhande** Diploma in Fisheries Engineering, Ratnagiri, Maharashtra 415 629 India
5	Name and address(es) of Field staff	:	**Shri. Ketan Mahendra Chavan** Diploma in Fisheries Engineering, Ratnagiri, Maharashtra 415 629 India
6	Project period	:	2020-23
7	Total grant	:	Rs. 21,37,740/-
8	Total expenditure till-to-date	:	Rs. 636,679/- (Rs. 4,91,543/- of 2020-21 + Rs. 1,45,136/- of 2021-22)
9	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**

Executive summary

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. Therefore, the Stock Assessment of Indian oil sardine and Indian mackerel was done. Required data on length frequency and biology was collected from 3674 and 3624 specimens of Indian mackerel respectively, whereas required data on length frequency and biology was collected from 66 and 66 specimens of Indian oil sardines. The data collected on biological aspects of Indian mackerel was analysed, but analysis of data on Indian oil sardine was not performed due less sample size.

The length-weight relationships estimated for male, female and indeterminant of Indian mackerel were, $W = 0.0051\ L^{3.2489}$, $W = 0.0081\ L^{3.0965}$ and $W = 0.0046\ L^{3.2833}$ respectively. In general, Indian mackerel feeds on *Pleurosigma sp.,Dinophuysis miles, Copeped, Chaetoceros decipiens, Skeletonema costatum and Thalassiothrix nitzschioides* in all size groups. The average sex ratio of the males to females was found to be 1 : 1.02. The fecundity of Indian mackerel ranged from 3,814 to 2,94,030 with an average of 71,391. The minimum and maximum Gonado Somatic Index (GSI) recorded for male was 0.0861 and 12.49 respectively, while minimum and maximum GSI recorded for female was 0.0436 and 10.6713 respectively. The ova diameter ranged from 175.00 µm - 906.66 µm, whereas the smallest size ova was observed in the month of August and the largest size ova was observed in the month of November. The estimated Maximum Sustainable Yield (MSY) of Indian oil sardine and Indian mackerel together was at 56,142 and 57,008 tonnes by Schaefer and Fox surplus production models respectively. The efforts (f_{MSY}) required at estimated Maximum Sustainable Yield were 41,415 and 52,774 trips by Schaefer and Fox models respectively. Total bycatch observed was 22.63% and other species caught along with Indian mackerel and sardine were scianids, sole fish, croaker, carangid, tuna, seer fish and false travelly. The other fishes caught along with main catch are not discarded, but are marketed for human consumption or by fishmeal industry. Thus, the bycatch discarded is nil. The purse seine fishery for Indian mackerel do not interact with endangered or protected species as none of them were observed in bycatch.

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 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.

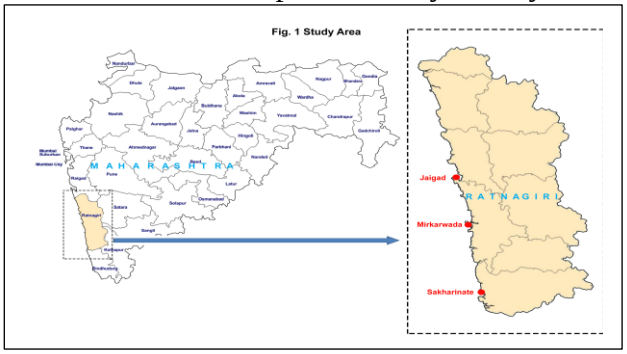


Plate 1 Study area

Methodology & approach : **Length weight relationship**

Length weight relationship was estimated by using the logarithmic equation $W=aL^b$ (Zar, 2005).

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 weighed 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.

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

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.

Maturity and spawning

The sampled fishes were dissected for visual observation of gonads, to understand maturity stage. The maturity stages of Indian mackerel were classified as per Shamsan and Ansari (2009). The stages were I) Immature, II) Maturing, III) Mature, IV) Ripe, V) Spent.

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 micrometre, which was standardized against stage micrometre. Frequency polygons was drawn.

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)

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

Catch composition

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

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

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 was collected from three sampling stations in Maharashtra. The three stations in Maharashtra were Mirkarwada, Jaigad and Sakharinate. Weekly sampling was collected from Mirkarwada, Jaigad and Sakharinate., for ten months from August 2020 to May 2021. Month wise details of sampling are given in Table 1 and Table 2.

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
Total		**1427**	**1427**	**981**	**931**	**1266**	**1266**	**3674**	**3624**

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	August 20	-	-	-	-	-	-	-	-
2	September 20	-	-	-	-	-	-	-	-
3	October 20	-	-	-	-	-	-	-	-
4	November 20	21	21	19	19	7	7	47	47
5	December 20	19	19	-	-	-	-	19	19
6	January 21	-	-	-	-	-	-	-	-
7	February 21	-	-	-	-	-	-	-	-
8	March 21	-	-	-	-	-	-	-	-
9	April 21	-	-	-	-	-	-	-	-
10	May 21	-	-	-	-	-	-	-	-
Total		**40**	**40**	**19**	**19**	**7**	**7**	**66**	**66**

Length-weight relationship

Length-weight relationship of male female and indeterminant was established separately. ANCOVA was performed to compare slopes and elevations. Significant difference was observed in slopes and elevation (P>0.05), thus three equations estimated for male, female and indeterminant are as stated below:

Male	W =	$0.0051\ L^{3.2489}$
Female	W =	$0.0081\ L^{3.0965}$
Indeterminant	W =	$0.0046\ L^{3.2833}$

The correlation coefficient estimated for length-weight relationship of male, female and indeterminant were 0.9856, 0.9750 and 0.9892 respectively(P>0.05). The length-weight relationship established in male, female and indeterminant are given in Fig. 1, Fig. 2 and Fig. 3 respectively. The ponderal index was calculated. The average ponderal index estimated for male, female and indeterminant was 1.0029, 1.0030 and 1.0030 respectively.

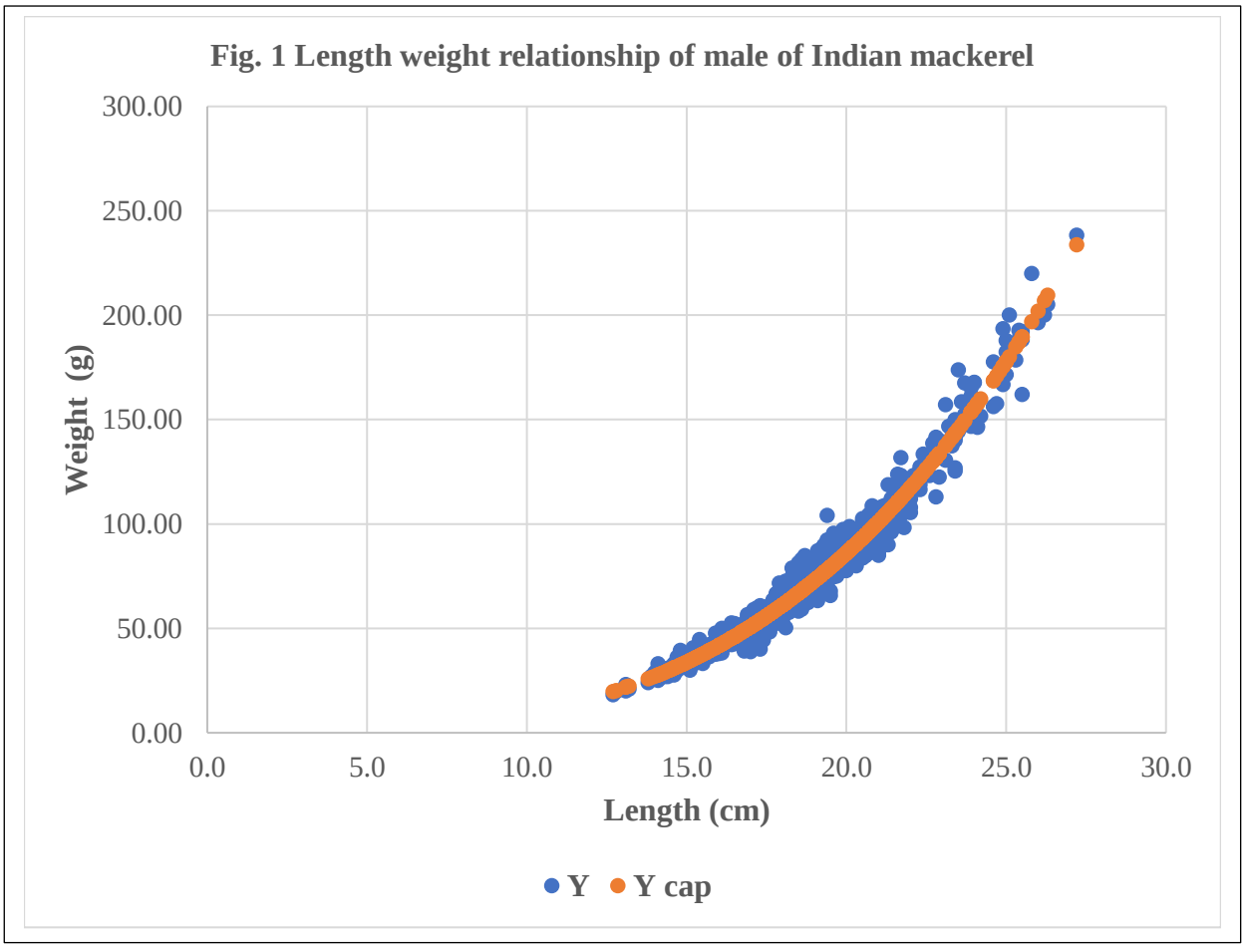


Fig. 2 Length weight relationship of female of Indian mackerel

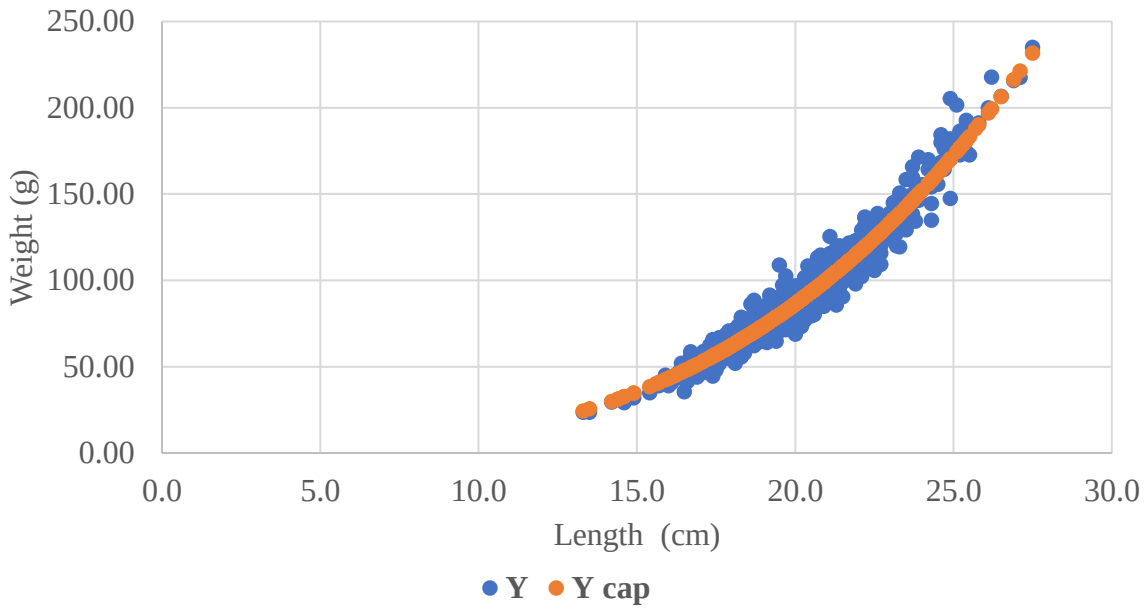
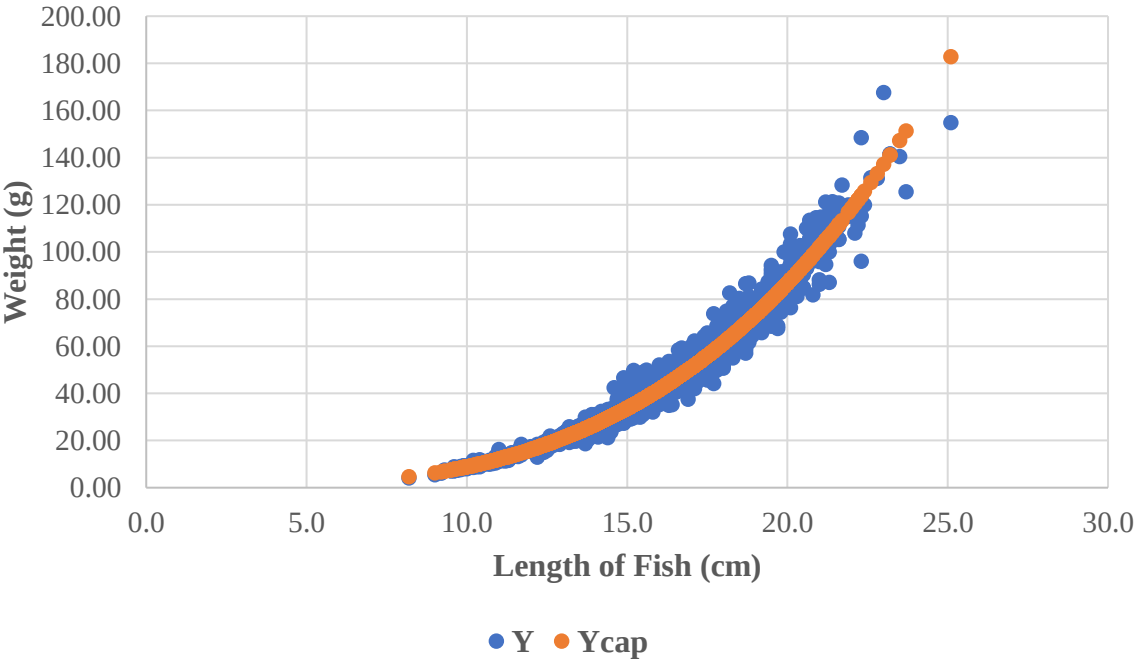


Fig. 3 Length weight relationship of indeterminant of Indian mackerel



Food and Feeding Habit

a. Month wise percentage food item composition in gut of Indian mackerel

The findings of the present study showed that the food items in the gut of Indian mackerel consist phytoplankton, zooplankton, broken appendages & scales of fishes and some small species of crustaceans. Among all the food items, *Copepod, Dinophuysis miles, Pleurosigma sp.* and exoskeleton of small crustaceans and Mollusca were found in highest percentage (More than 30%) in all the months of study period. On the other hand, appendages, *Chaetoceros decipiens* and *Skeletonema costatum* were found in the percentage range of 15 to 30%. In the month of February, exoskeleton (14.95%), *Copepod* (12.32%), *Planktinila sol* (10.54%), *Rhizosolenia hebatata* (7.80%) and *Dinophuysis miles* (4.79%) were the five major food items. Similarly in the month of March, *Dinophuysis miles* (9.89%), *Pleurosigma sp.* (9.24%), *Copepod* (8.75%), appendages (6.77%) and *Chaetocerus decipiens* (4.46%) were dominant food items. In the month of April, *Pleurosigma sp.* (17.09%), *Dinophuysis miles* (10.07%), *Chaetocerus decipiens* (7.40%), exoskeleton (7.25%) and *Copepod* (6.25%) were found in highest percentage among all the food items found, while in the month of May, analysis showed that, *Pleurosigma sp.* (9.24%), was in highest percentage (15.40%) followed by *Copepod* (11.60%), *Dinophuysis miles* (10.20), appendages (6.20%), exoskeleton (5.40%) and *Chaetocerus decipiens* (4.60%). The month wise gut constituents are shown in Fig.4.

b. Size wise percentage food composition of food items in gut of Indian mackerel

The detail compositions of various food items in the gut contents of Indian mackerel in various size groups are shown in Fig. 5. Analysis of the data revealed that, the food items such as phytoplankton, zooplankton, broken appendages, scales of fishes and small species of crustaceans were found in different proportions in all size groups starting from 13-15 cm to 25-27 cm. *Pleurosigma sp., Dinophuysis miles, Copepod, Thalassiothrix nitzschioides, Skeletonema costatum, Chaetocerus decipiens* and pieces of exoskeleton of crustaceans were the most dominant food items in all size groups. Data analysis of the present study showed that in size group 13 to 15 cm, *Pleurosigma sp.* (23.64%), *Skeletonema costatum* (12.73%), *Dinophuysis miles* (10.91%), *Copepod* (7.27%) and *Thalassiothrix nitzschioides* (6.81%) were the major five food items, whereas, in size group of 15 to 17 cm, *Dinophuysis miles* (16.89%) was dominant food

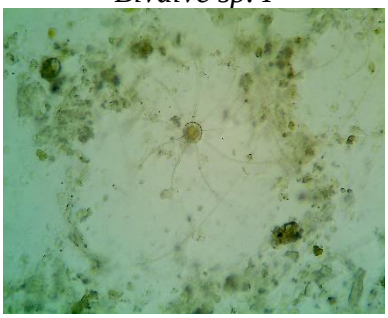
item followed by *Chaetocerus decipiens* (11.17%), *Pleurosigma sp.* (10.35%), *Thalassiothrix nitzschioides* (6.81%) and appendages (6.54%). It was observed that, in size group of 17 to 19 cm, *Pleurosigma sp.* (18.85%), *Copepod* (7.60%), *Skeletonema costatum* (6.04%) and appendages (5.83%) formed major food items, while in size group of 19 to 21 cm, *Pleurosigma sp*. (15.97%), *Skeletonema costatum* (11.69%) *Dinophuysis miles* (9.14%), *Thalassiothrix nitzschioides* (9.14%) and *Rhizosolenia hebetate* (7.29%) were main food constituents. Similarly, *Pleurosigma sp.* (20.41%), was dominant food item in size group 21 to 23 cm, along with *Thalassiothrix nitzschioides* (10.20%), *Copepod* (8.57%), *Chaetocerus decipiens* (8.16%) and *Skeletonema costatum* (6.94%). In gut analysis of size group 23 to 25 cm, *Pleurosigma sp*. (17.72%) and exoskeleton parts of crustacean (16.88%) were most commonly seen along with *Dinophuysis miles* (8.44%), scales (8.02%), *Copeped* (8.02%) and *Chaetocerus decipiens* (8.02%). *Pleurosigma sp.* (17.78%), *Dinophuysis miles* (8.89%), Skeleton (8.89%), *Copepod* (8.89%), *Thalassiothrix nitzschioides* (4.44%) and *Leptocylindrus sp.* (4.44%) were the major food items in the gut content of highest size group (25 to 27 cm).

Thus, it is concluded that, Indian mackerel primarily feeds on *Pleurosigma sp.,Dinophuysis miles, Copeped, Chaetoceros decipiens, Skeletonema costatum and Thalassiothrix nitzschioides* in all size groups. Food items observed in the gut content of Indian mackerel are given in Plate 2 to Plate 5.

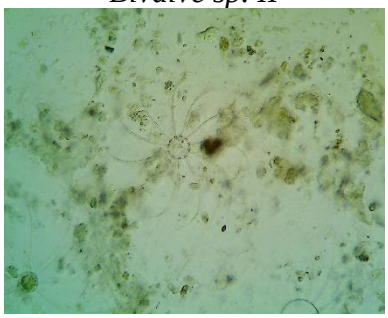
Bivalve sp. I

Bivalve sp. II

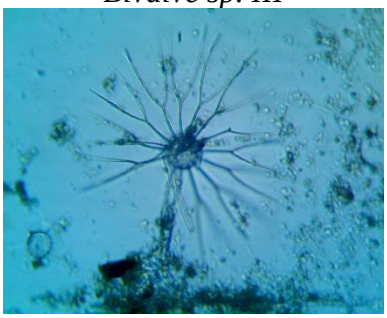
Bivalve sp. III



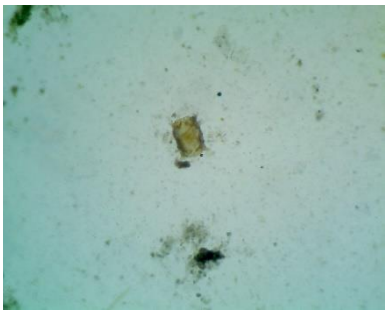
Bacteiastrum comosum



Bacteiastrum varians



Bacteriastrum hyalinum



Biddulphia heteroceros

Biddulphia sinensis

Ceratium fusus

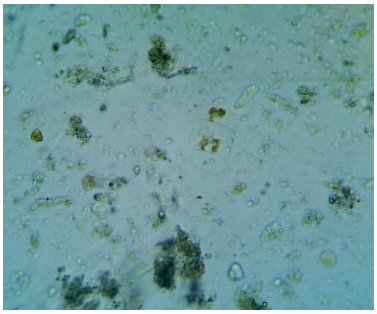
Ceratium breve

Ceratium trichoceros

Ceratium contrarium

Ceratium tripose var pulchellum

Chaetoceros coarctatus

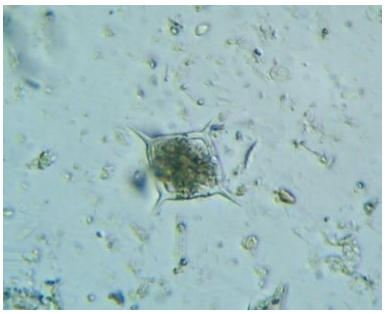


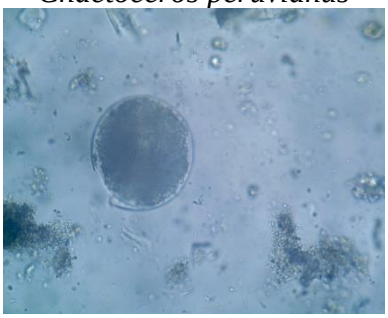
Chaetoceros decipiens

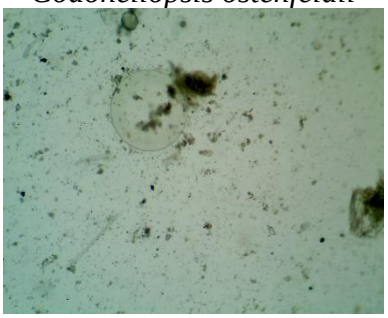
Plate 2 Food components in gut content of Indian mackerel

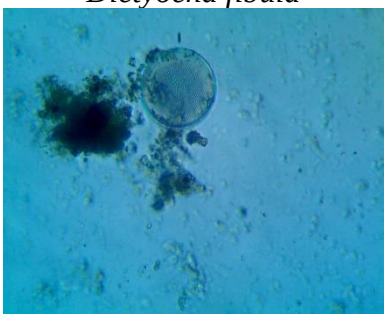

Chaetoceros peruvianus

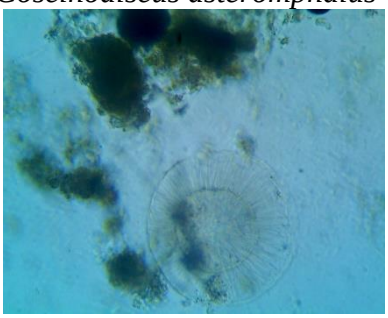

Codonellopsis ostenfeldii

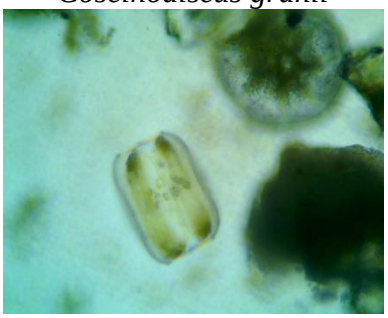

Dictyocha fibula

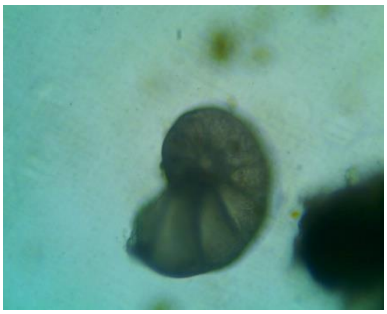

Coscinodiscus asteromphalus


Coscinodiscus granii


Coscinodiscus radiatus


Cyclotella striata


Grammatophora undulata

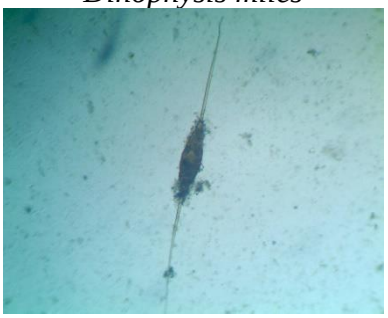

Limacina sp


Dinophysis caudata


Dinophysis miles


Ornithocercus steinii


Macrosetella sp.


Nitzschia longissima

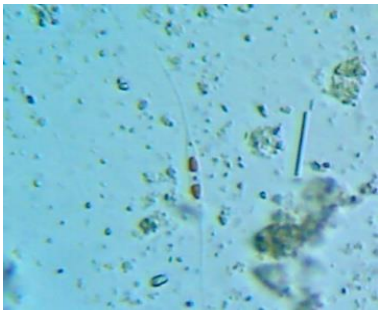
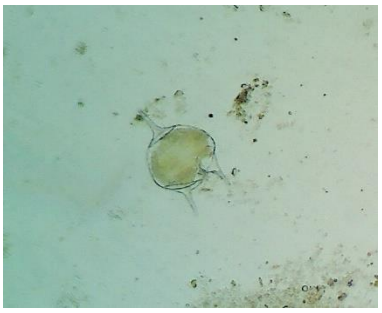

Nitzschia closterium

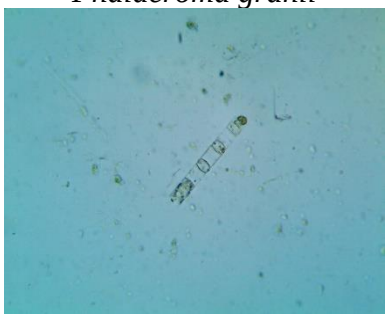
Plate 3 Food components in gut content of Indian mackerel

Phalacroma granii

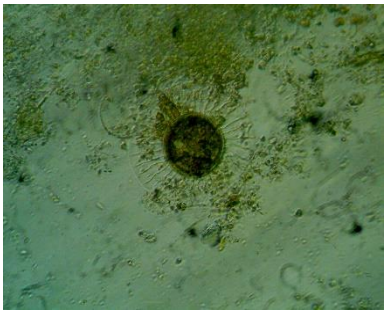


Peridinium steinii

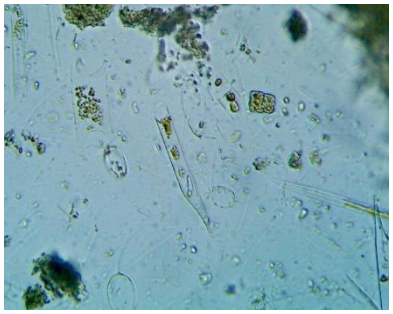
Peridium oceanicum



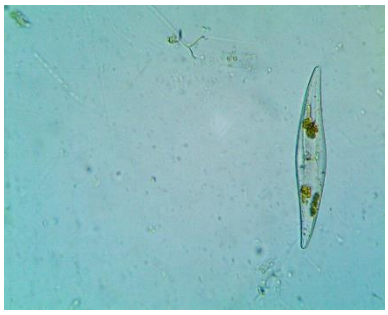
Skeletonema costatum



Planktoniella sol



Rhizosolenia hebetata

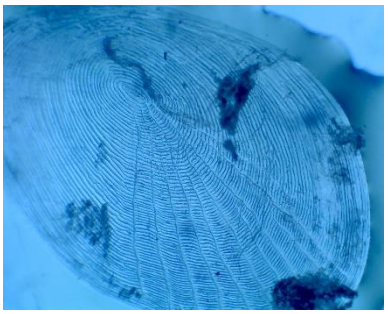


Pleurosigma

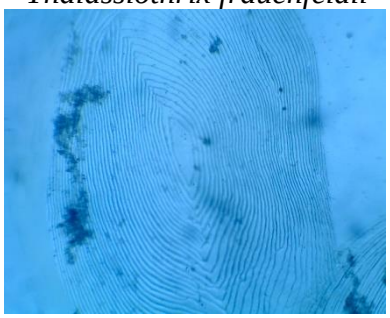
Thalassiothrix nitzschioides

Thalassiothrix frauenfeldii

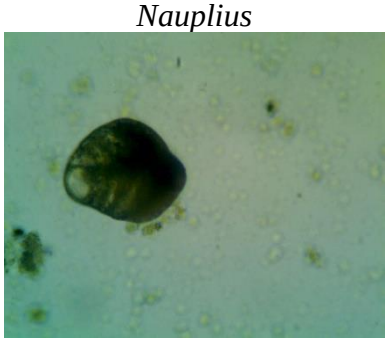
Nauplius



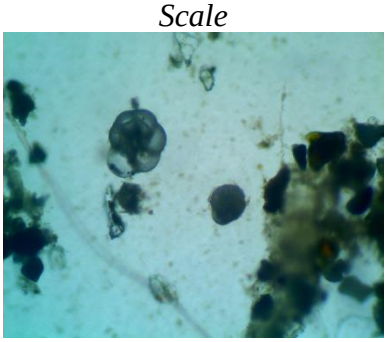
Scale



Exoskeleton



Unidentified I



Unidentified II

Unidentified III

Plate 4 Food components in gut content of Indian mackerel

Unidentified IV

Unidentified V

Unidentified VI

Unidentified VII

Unidentified VIII

Unidentified IX

Unidentified X

Unidentified XI

Plate 5 Food components in gut content of Indian mackerel

Fig. 4 Monthwise food components in gut of Indian mackerel

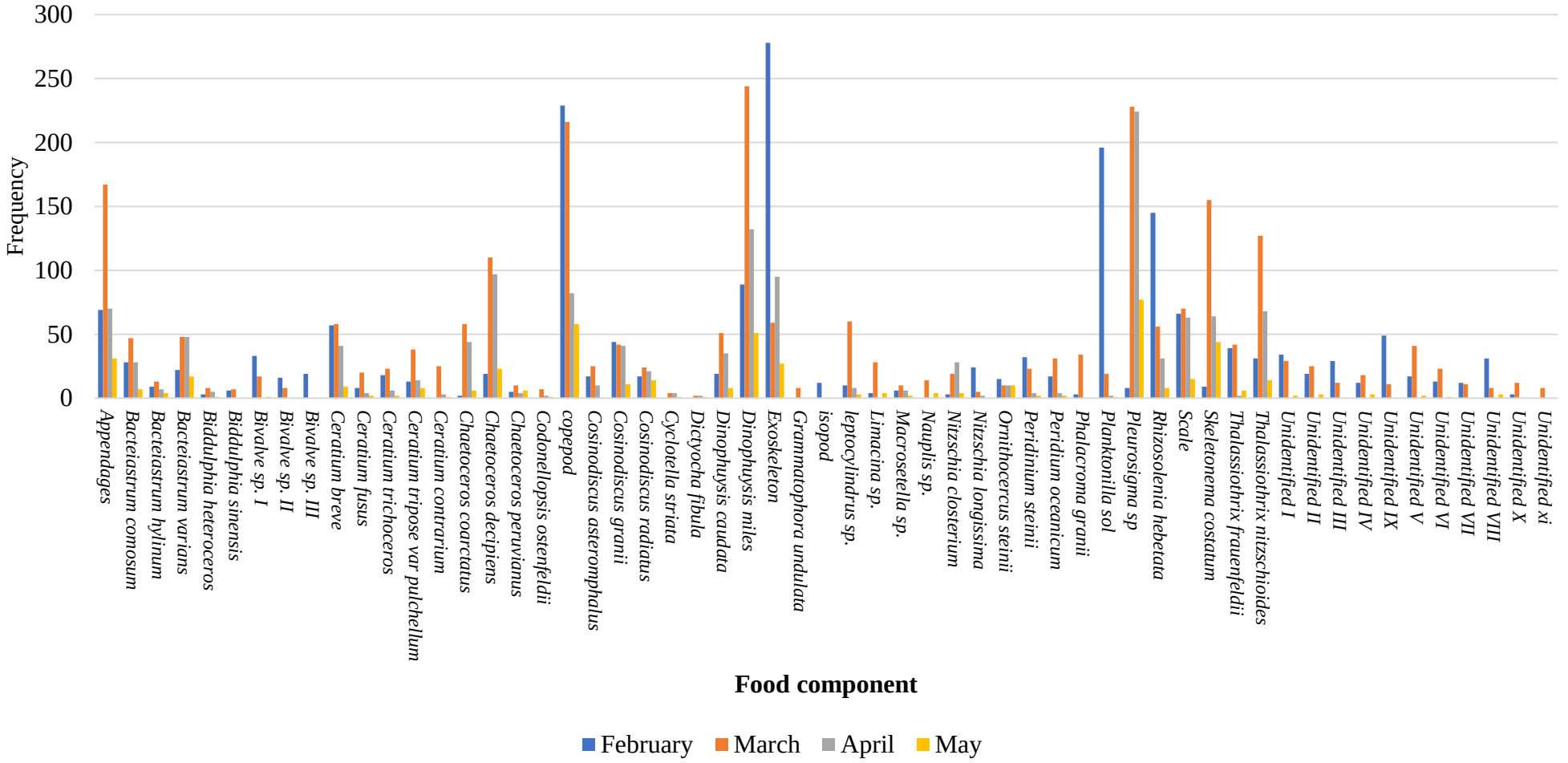
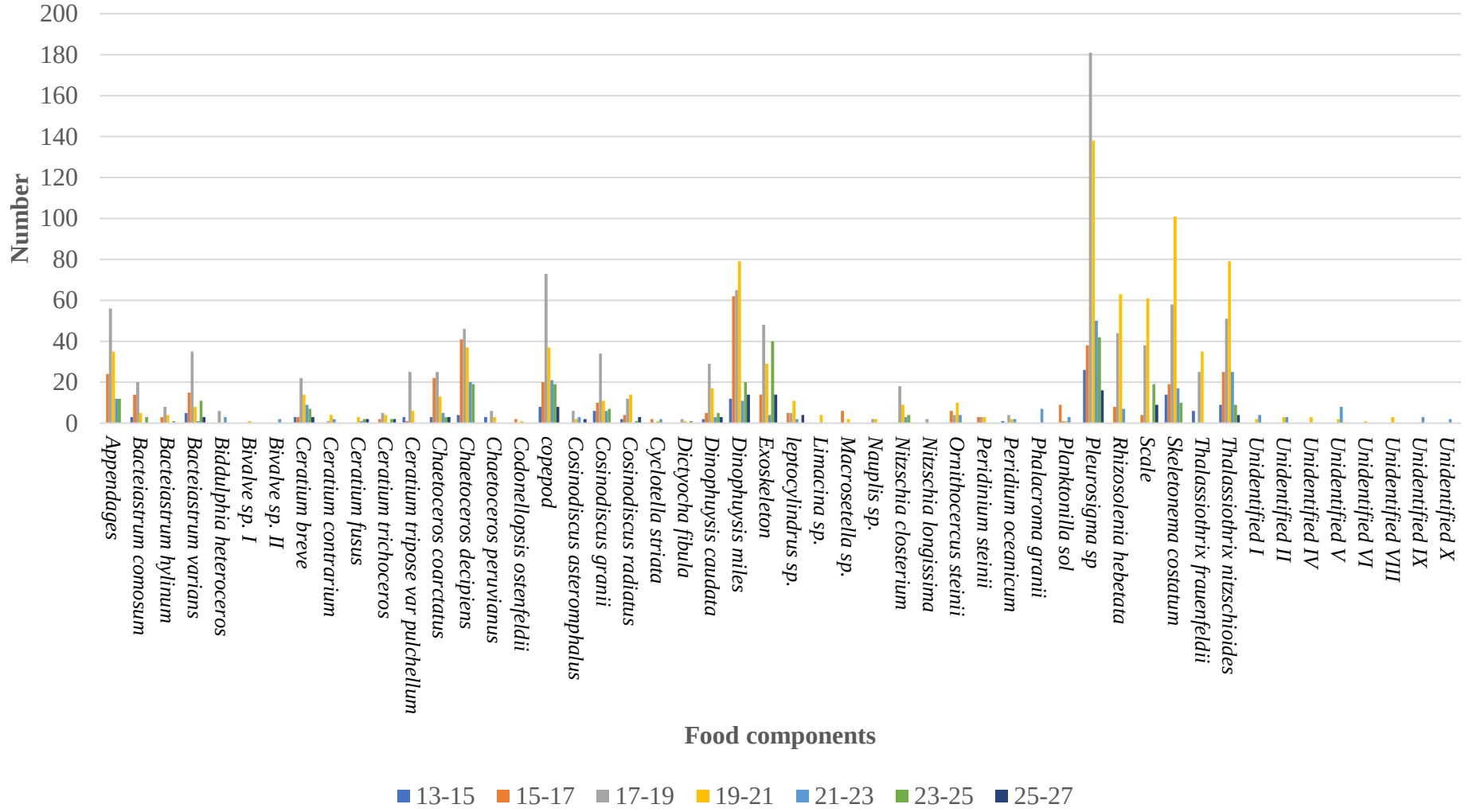


Fig. 5 Lengthwise food components in gut of Indian mackerel



Reproductive Biology

a. Sex Ratio

To study the sex ratio of Indian mackerel a total of 3624 specimens were examined (Plate 6) during August 2020 to May 2021, of which, 714 were male, whereas, 728 were female and 2182 were indeterminant. Sex ratio was tabulated for each month. The average sex ratio of the males and females was found to be 1 : 1.02 for the entire period of study (Table 3). The females dominated in the months of August 2020 and December 2020, while the males dominated in the month of October 2020 and February 2021.

Table 3. Month wise sex ratio of Indian mackerel

Month	Male	Female	Total	Sex ratio (M:F)	Significance at 5% level
Aug-2020	32	48	80	1 : 1.50	$p < 0.05$
Sep-2020	98	91	189	1 : 0.93	$p < 0.05$
Oct-2020	88	53	141	1 : 0.60	$p > 0.05$
Nov-2020	62	49	111	1 : 0.79	$p < 0.05$
Dec-2020	45	66	111	1 : 1.47	$p < 0.05$
Jan-2021	86	78	164	1 : 0.91	$p < 0.05$
Feb-2021	67	42	109	1 : 0.63	$p > 0.05$
Mar-2021	101	131	232	1 : 1.30	$p > 0.05$
Apr-2021	81	110	191	1 : 1.36	$p > 0.05$
May-2021	54	60	114	1 : 1.11	$p < 0.05$
Total	**714**	**728**	**1442**	**1 : 1.02**	**$p < 0.05$**

Male Female

Plate 6 Male and female of Indian mackerel

b. Fecundity

The fecundity ranged from 3,814 (19.8 cm, 77.3 g) to 2,94,030 eggs (26.5 cm, 206.59 g) with an average of 71,391.

c. Gonado Somatic Index

Gonado Somatic Index (GSI) for male and female was calculated separately. The minimum and maximum GSI recorded for male was 0.0861 and 12.49 respectively, while minimum and maximum GSI recorded for female was 0.0436 and 10.6713 respectively. GSI of male and female is depicted in Fig. 6 and Fig. 7 respectively. It can be observed from Fig. 6 that the higher GSI value of male in more percentages were available during August to November and January to April. Similarly, it can be seen from Fig. 7 that the higher GSI value of female in more percentages were available during August to November and January to May. This clearly indicated that the Indian mackerel breeds throughout the year except December with major peak in post-monsoon season and minor in other part of the year.

The month wise average GSI values were plotted and same is depicted in Fig. 8. The Fig. 8 also 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 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.

Fig. 6 Month-wise percentage male fish according to GSI value

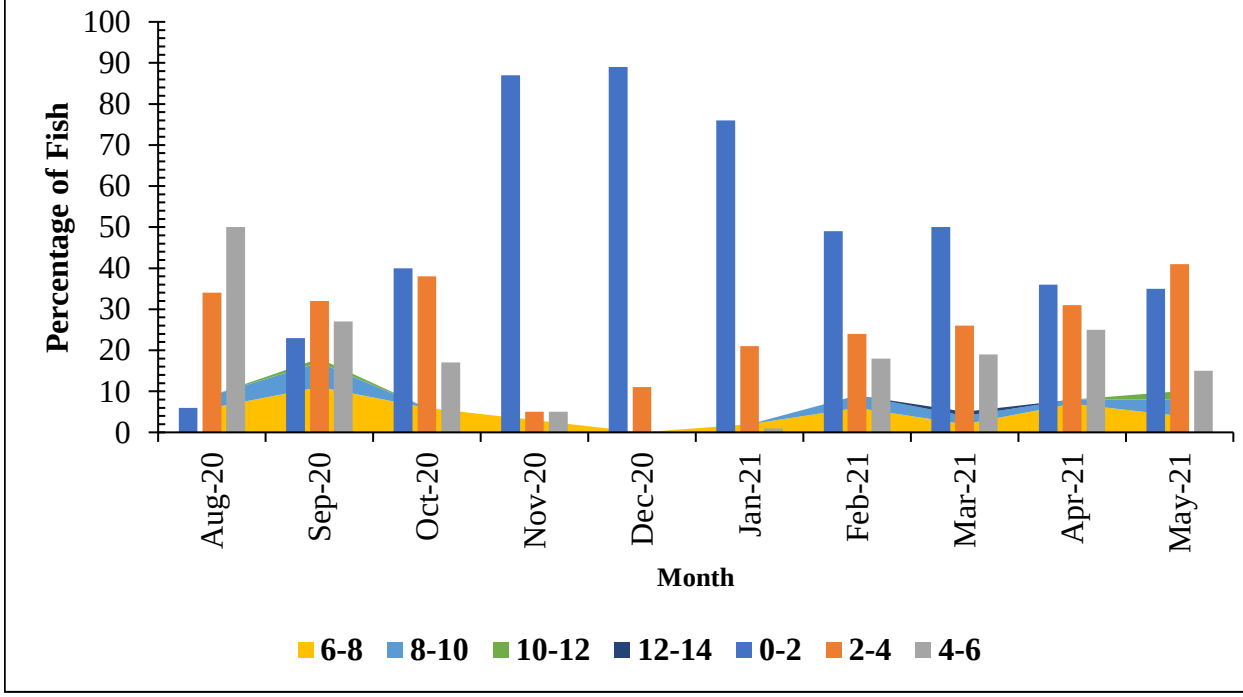


Fig. 7 Month-wise percentage female fish according to GSI value

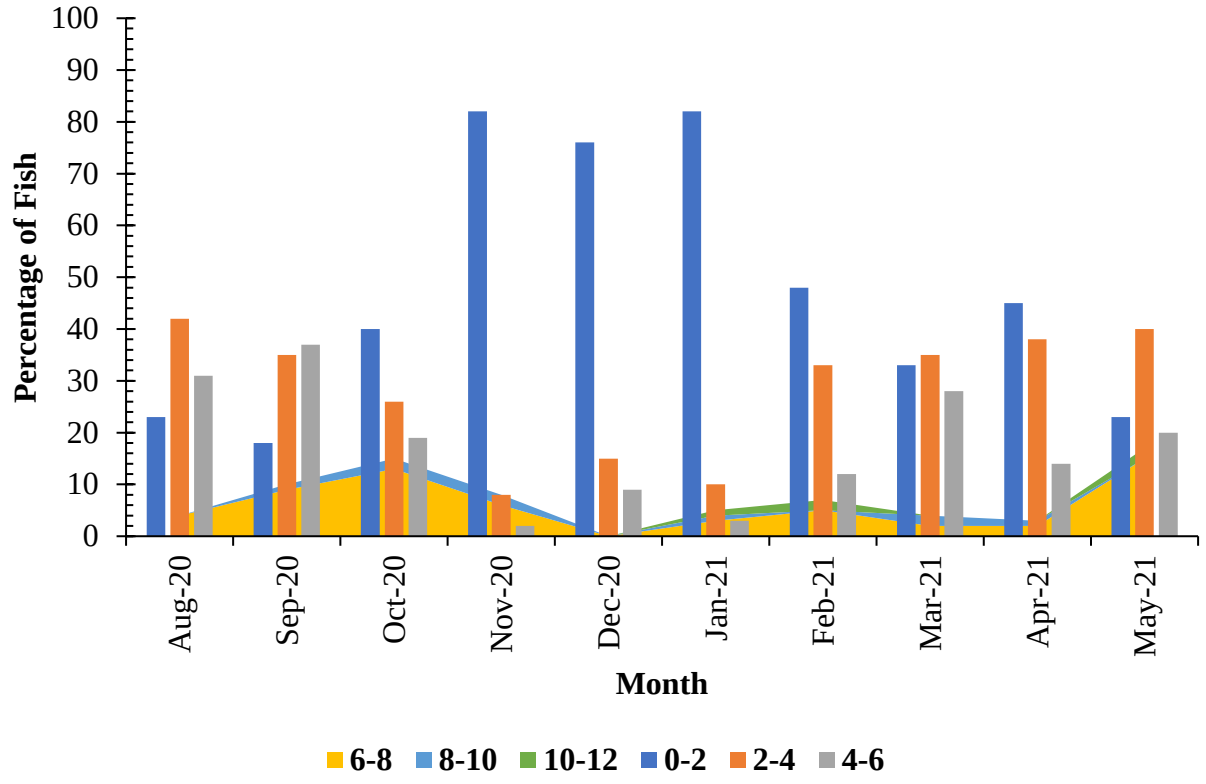
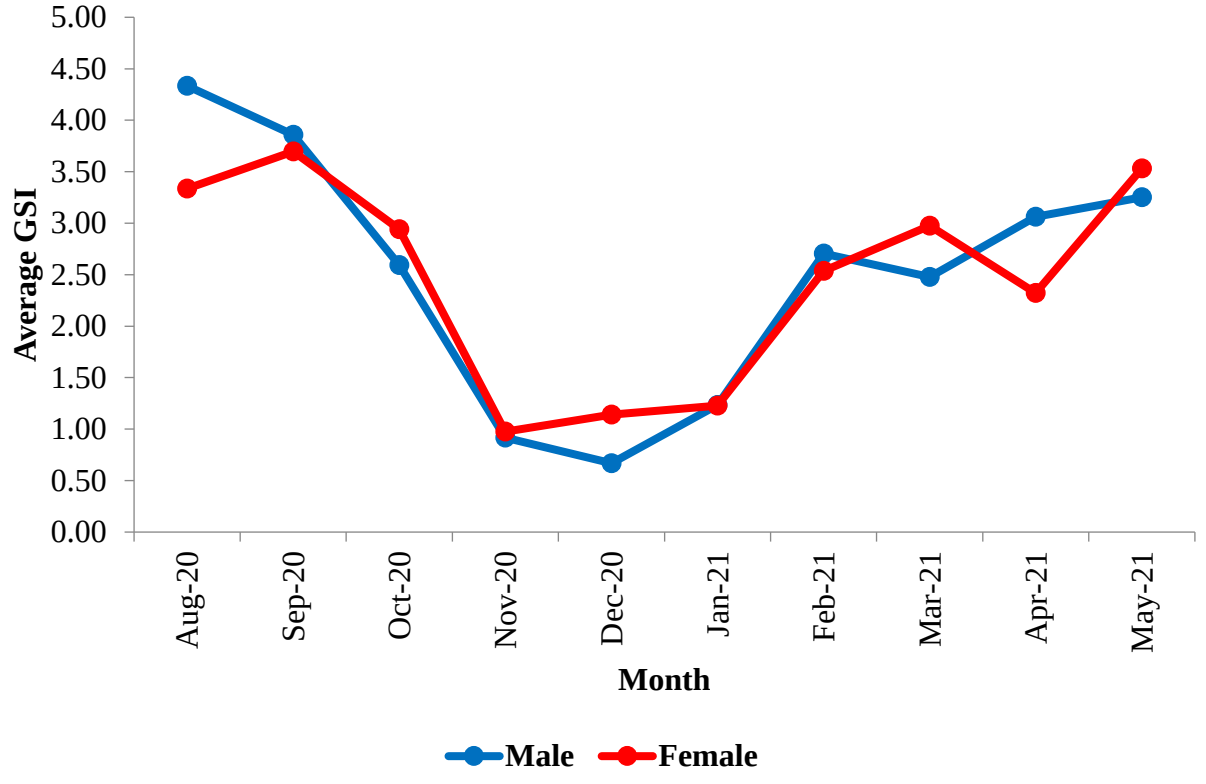


Fig. 8 Month-wise average GSI



d. Maturity stages of ovary

The ovaries of Indian mackerel were observed from August to May. Depending upon the size of ovary, colour of ovary and size of ova the six stages of ovaries have been identified. The stages identified along with the photograph of ovary are given in Plate 7.

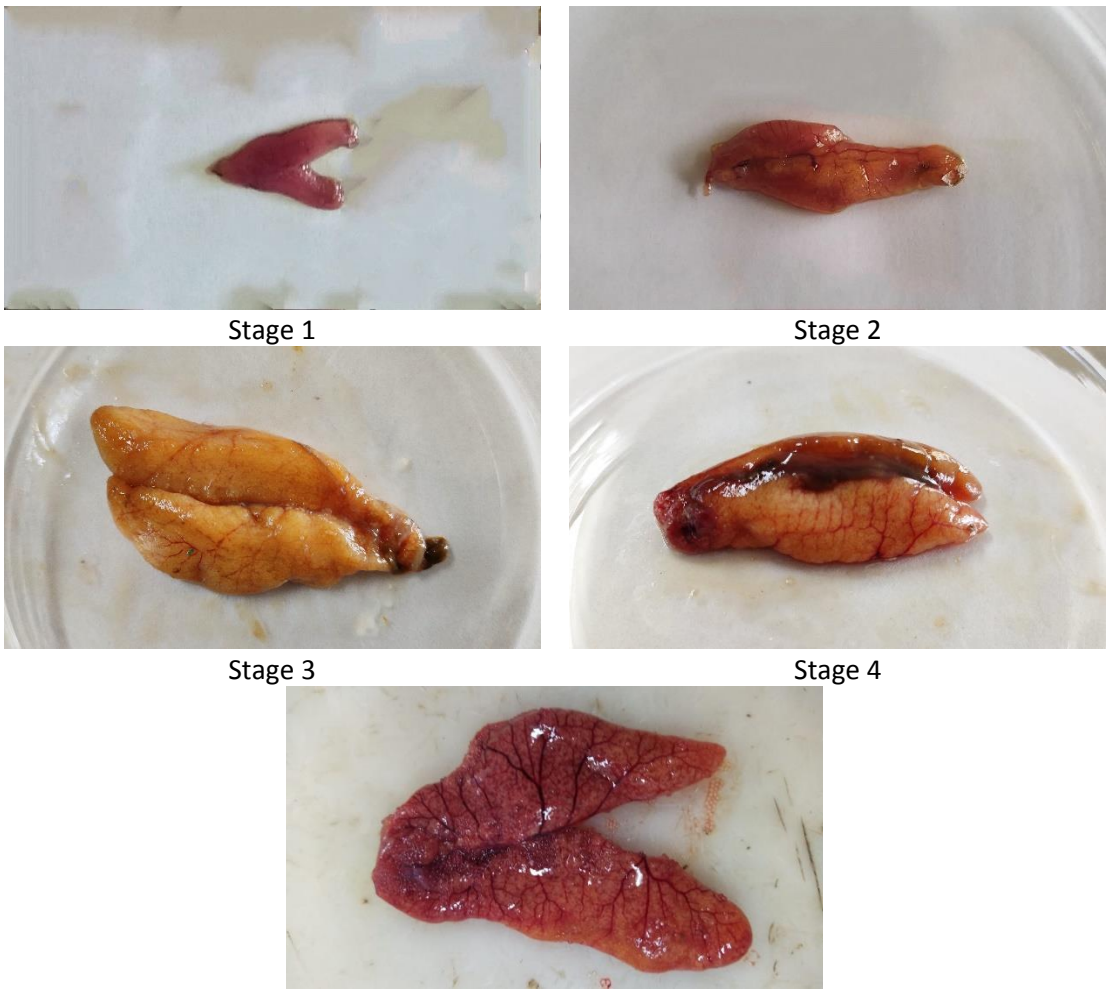


Plate 7 Various development stages of ovary

e. Ova diameter

The ovaries of Indian mackerel were studied for 10 months form August 2020 to May 2021 and the size wise frequency analysis is shown in Fig. 9. The ova diameter measured, ranged from 175.00 µm - 906.66 µm, whereas the smallest size ova was observed in the month of August 2020 and the largest size ova was observed in the month of November 2020.

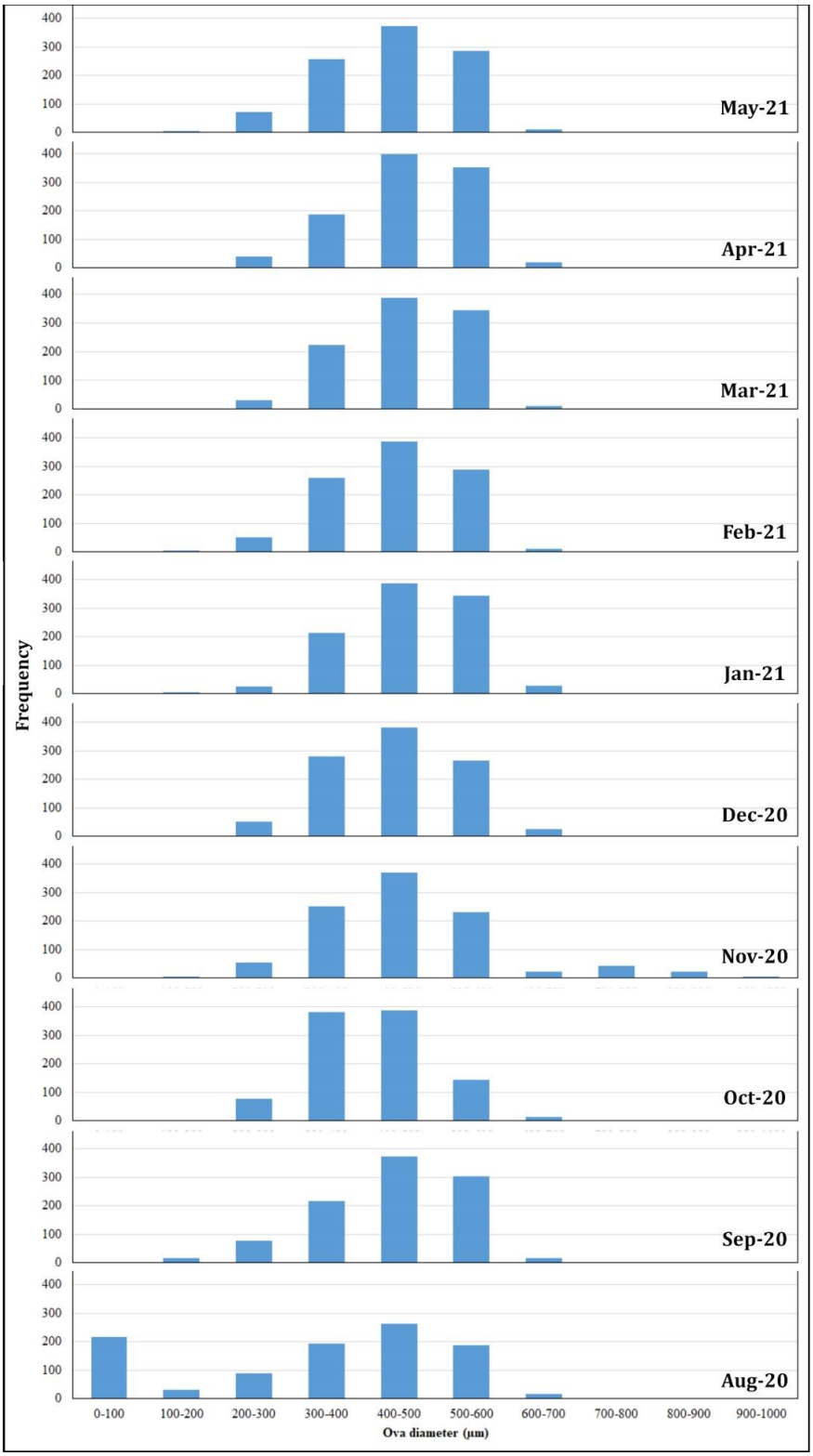
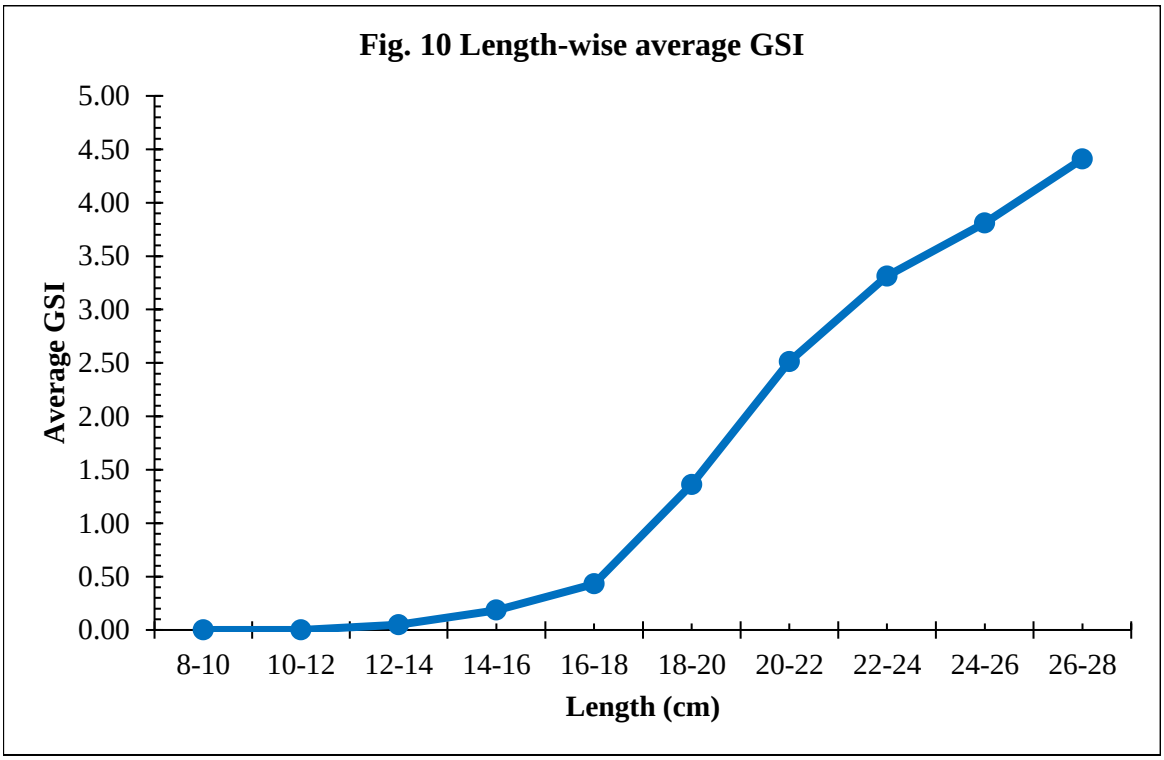


Fig. 9 Frequency distribution of ova diameter (µm) durng August 2020 and May 2021

f. Size at first maturity

The length wise avarage GSI values were plotted and is shown in Fig. 10. The Fig. 10 clearly indicated that the fish starts maturing after 12 cm overall length.



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 11. The highest efforts were recorded in the year 2003-04 whereas lowest in the year 2018-19. The drastic decline in the efforts were observed in the year 2018-19 and 2019-20. This may be because of restriction on purse seine fisherman to fish only during four months *i.e.* September to December by the regulation made by Government of Maharashtra. In addition to this, deep depression and cyclones like Daye, Luban as well as Titli in the fishing year 2018-19 and deep depressions as well cyclones as Kyarr, Maha and Pawan in fishing year 2019-20 has affected the fishing, intern has resulted in reduced fishing effort. This has resulted in reduction in catches and same is observed in Fig. 11.

Year-wise Catch Per Unit Effort (CPUE) is depicted in Fig. 12. The maximum CPUE was observed in the year 2017-18, while lowest in the year 2003-04.

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. The Maximum Sustainable Yield of Indian oil sardine and Indian mackerel together was estimated at 56,142 and 57,008 tonnes by Schaefer and Fox surplus production models respectively. The efforts required to fish at MSY were 41,415 and 52,774 trips by Schaefer and Fox models respectively. The yield curve by Schaefer and Fox for both the species together is depicted in Fig. 13.

The catch and effort data from the year 2000-01 to 2019-20 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 14. Till the year 2009-10, only once the more catch was recorded than the estimated MSY and since year 2010-11 to 2017-18, the catches were found exceeding the estimated MSY values as given in Fig. 15.

Fig. 11 Catch and Effort of purse-seiners according to year

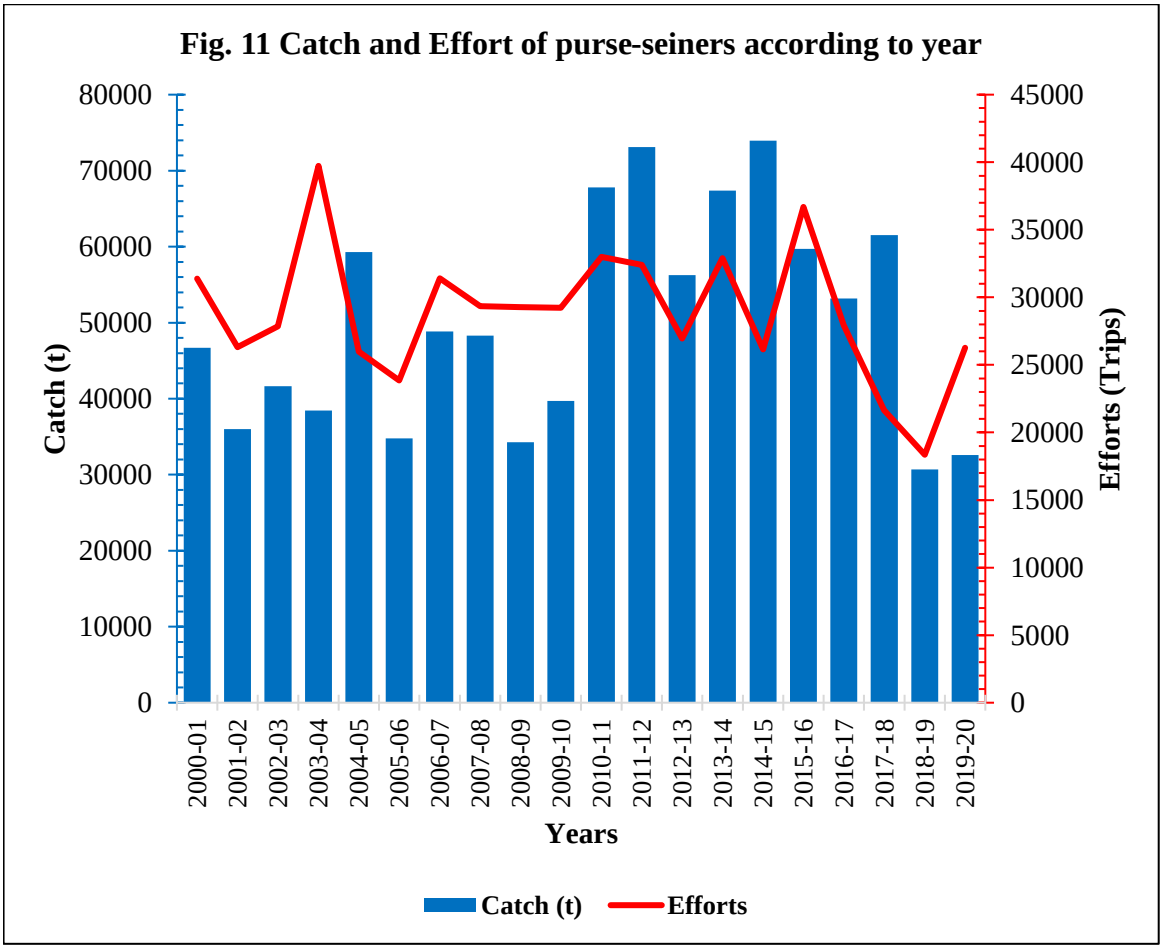


Fig. 12 Catch Per Unit Effort of purse-seiners according to year

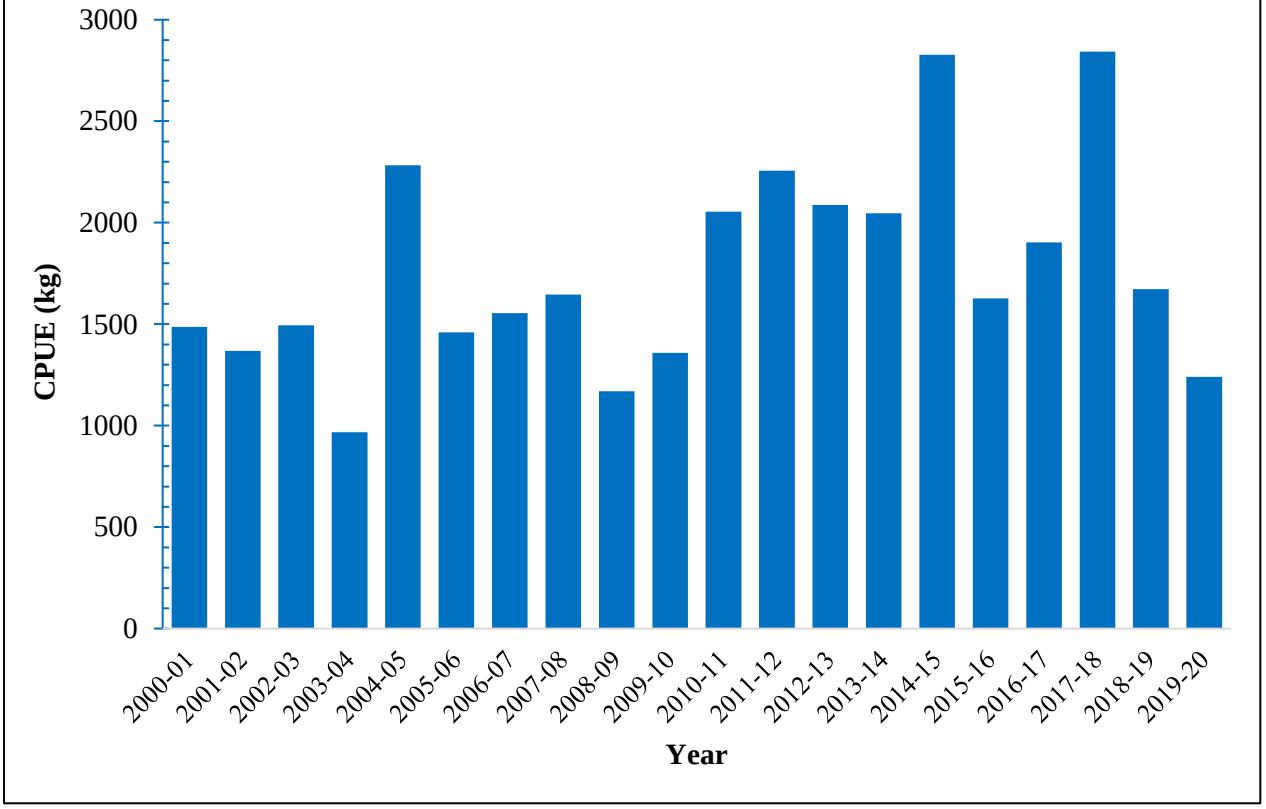


Fig. 13 Schaefer and Fox model curve

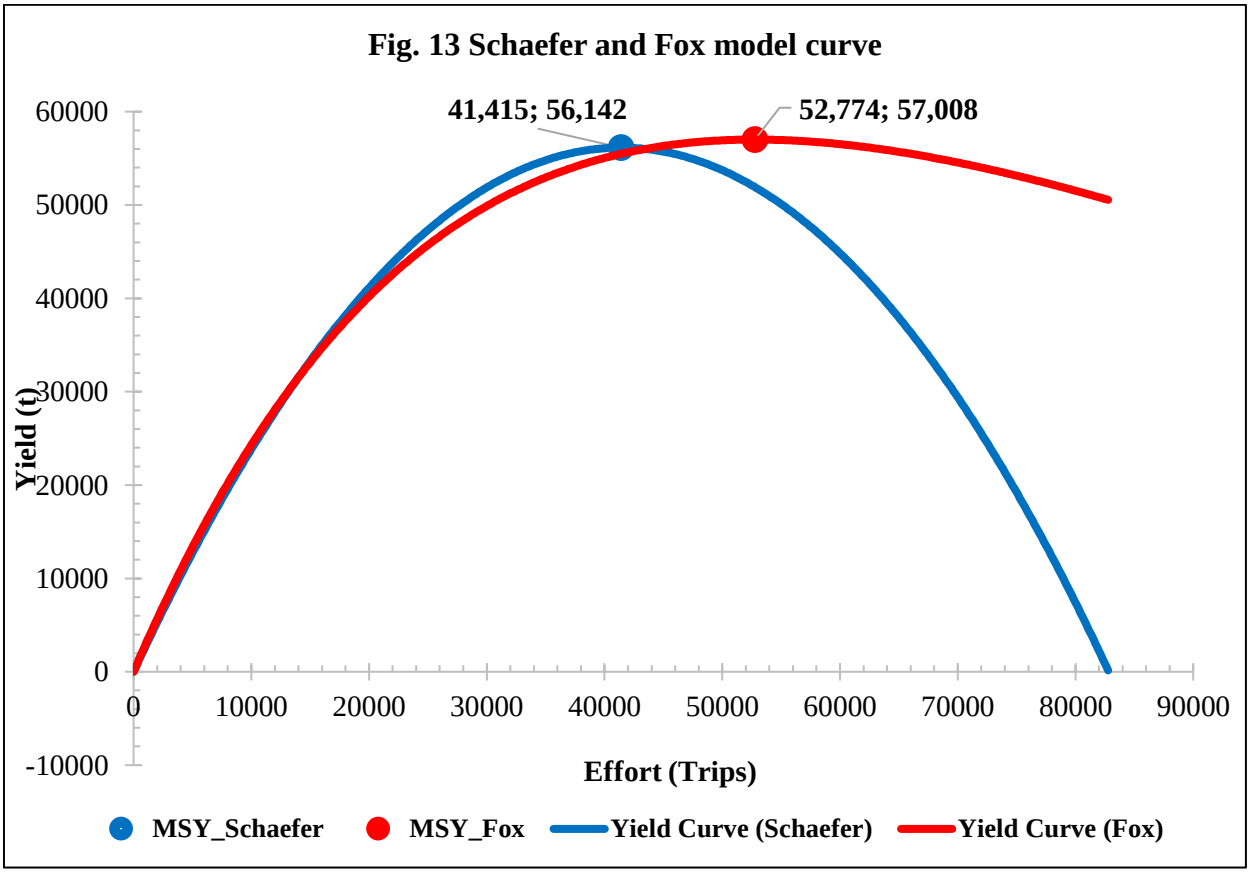


Fig. 14 Year-wise Efforts

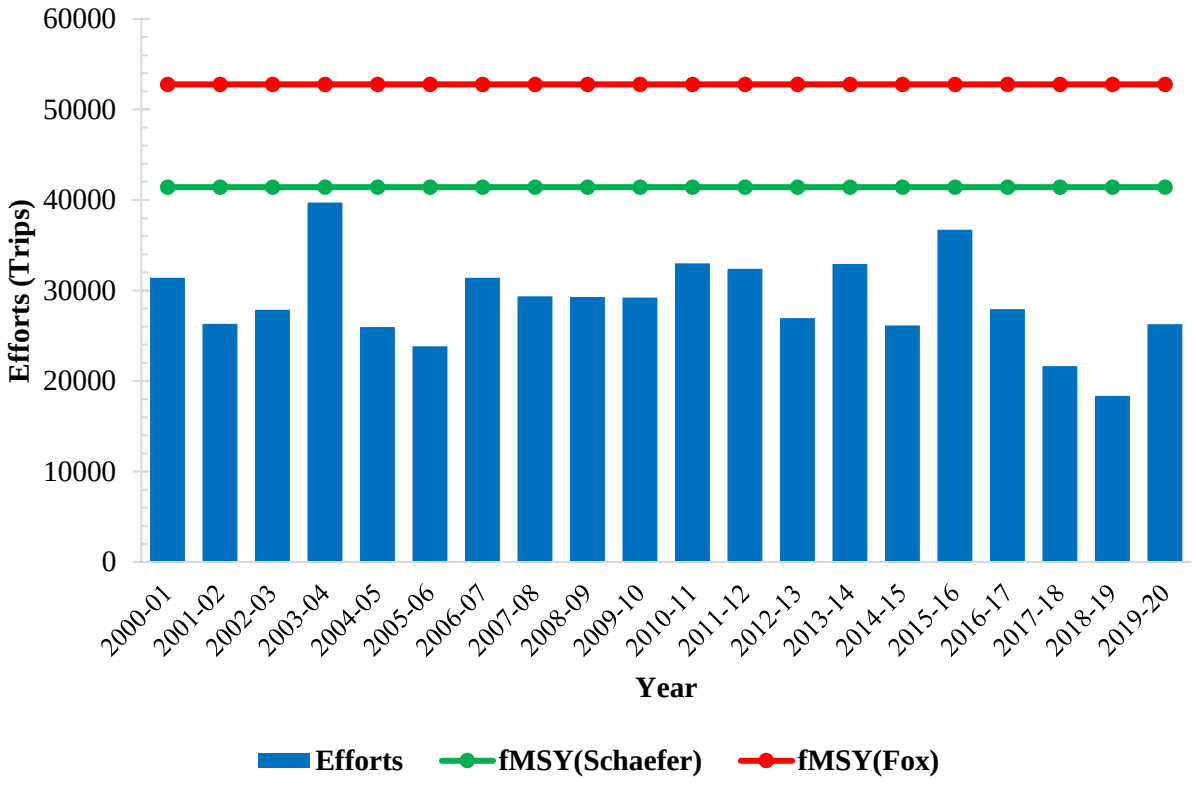
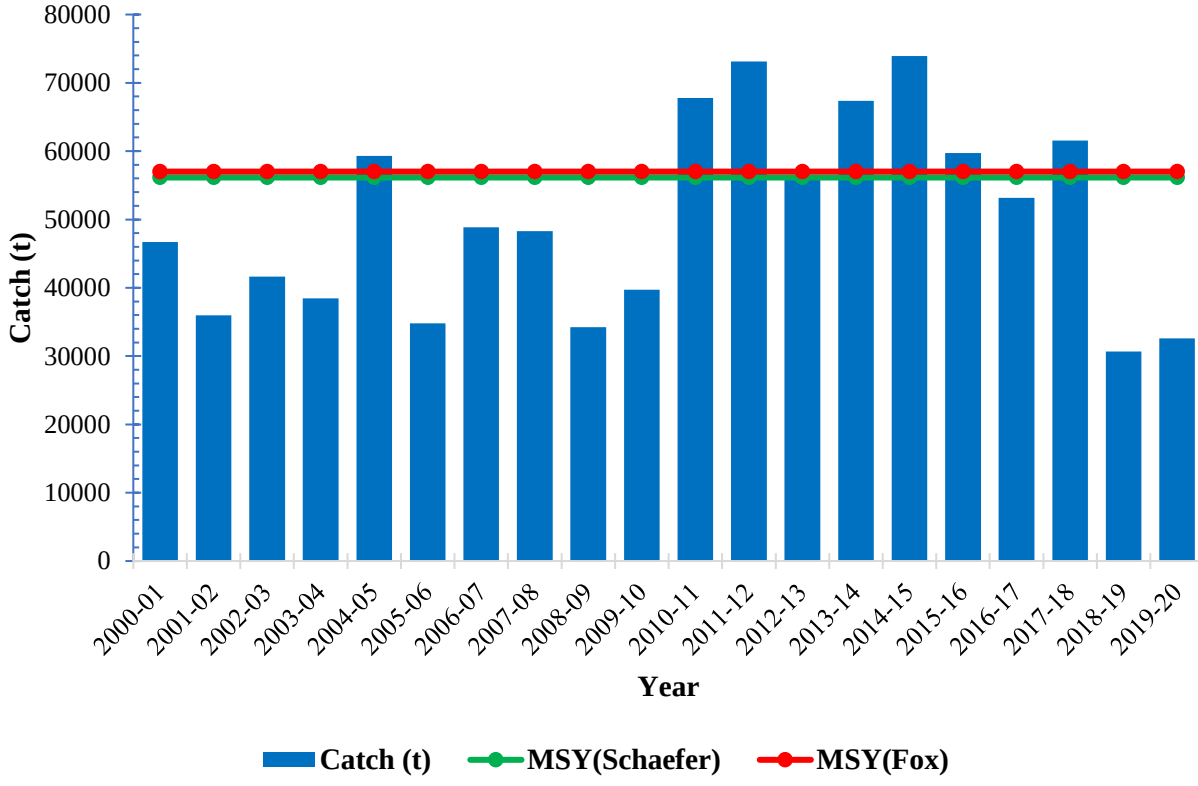
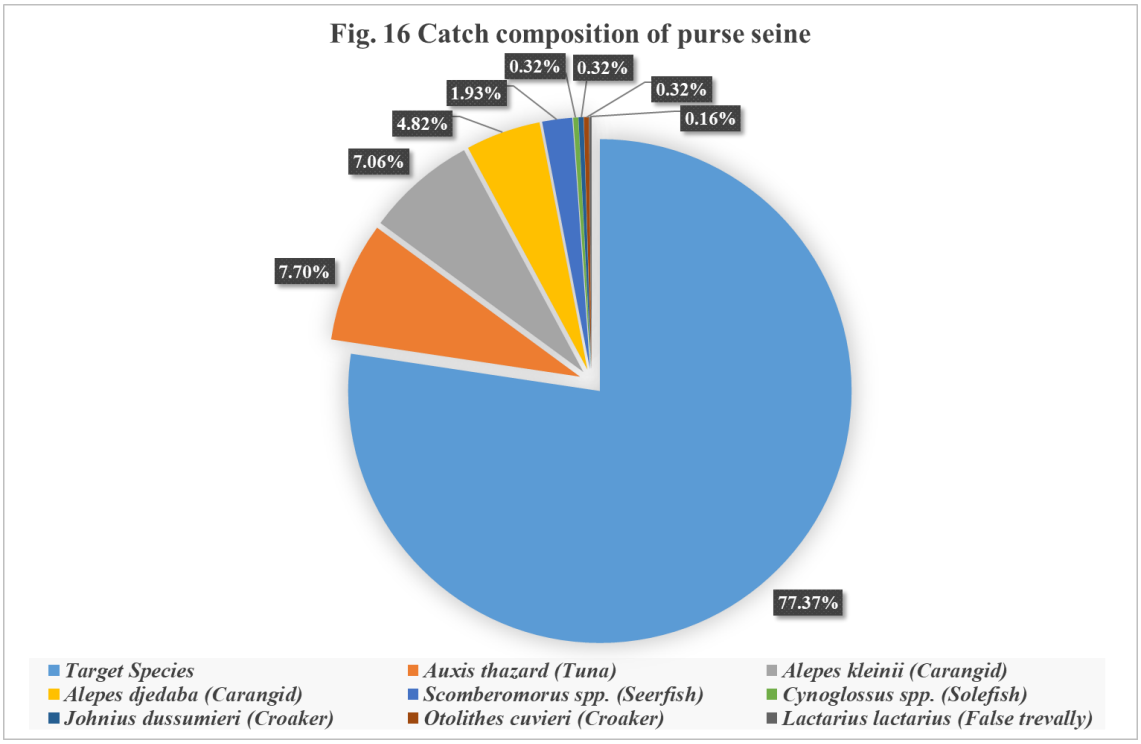


Fig. 15 Year-wise Catch



Quality and quantity wise catch composition of purse seine was collected. Mackerel and saride was taken together and rest all fishes were grouped together. The catch composition of purse seine is shown in Fig. 16. Total bycatch observed was 22.63%. Other species recorded along with Indian mackerel and sardine were tuna, carangid (two species), seerfish, solefish, croaker (two species) and false trevally. The other fishes caught along with main catch are not discarded, but are marketed for human consumption or by fishmeal industry. Thus the by catch discarded is nil.

Fig. 16 Catch composition of purse seine



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 is recoded. Thus it can be concluded that the purse seine fishery for Indian mackerel do not interact with endangered or protected species.

Very few samples of Indian oil sardine were collected during the 2020-21. Thus, anlysis was not performed. The collected data will pooled in the samples of next fishing season and then anlysis will be performed. Similarliy, the length frequency anlysis will be performed in the FiSAT after collecting the second year length frequency data.

Acknowledgement

We are very much thankful to the university authorities as Hob'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 Fishmeal 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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