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# SEASONAL VARIATION IN MORPHOMETRIC CHARACTERISTICS OF SELECTED FISHES OF CHENNAI COAST IN RELATION TO HYDROGRAPHIC PARAMETERS

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**Abstract–** Morphometric characteristics are studied in order to identify the species easily. Morphometric characteristics refer to the measurement of length of different parts of the body of fishes. These lengths of different parts vary from species to species and this paper describes the morphometric characteristics of the *Rastrelliger kanagurta,* Mackerel and *Sardinella longicepsis* Oil sardine fishes. The morphometric characteristics include 21 different measurements and 5 derived parameters. The fresh fish after harvest from sea were collected from Kasimedu fish landing centre and brought to the lab, washed thoroughly on the outer surface and then kept on the graph sheet to mark the different points of the fish so that the distance between each part is calculated. The study was conducted in Kasimedu fish landing centre of Chennai. The Kasimedu lattitude and longitude were 13°117′N and 80°293′E. The morphometric characteristics of Oil sardine and Mackerel for 4 different seasons, post monsoon, summer, pre-monsoon and monsoon season for the consecutive 4 years, viz. 2008, 2009, 2010 & 2011 were studied. The morphometric characteristics were correlated with the hydrographic parameters of temperature, salinity, pH, dissolved oxygen, total soluble solids, chlorophyll a, b & c, primary productivity, gross and net and nutrients, nitrate, phosphate and ammonia. The results showed that in the year 2011, temperature shows positive correlation with head length, r=0.02 and with total length,r=0.49 for Mackerel. In Oil sardine, temperature is correlated with total length, r=0.12 and with head length,r=0.04). The correlation of other body parts with that of the hydrographic variables were also made for all 4 years and their seasonal effect were also studied. The total length in the year 2011 is more, 183.47mm among the 4 years tested and among the seasons, the length in the summer season is more in Oil sardine. In Mackerel, in the year 2009 the total length is more, 256.09mm and among the seasons tested, in post monsoon season. The length of the head is more in summer season in Oil sardine in almost all the 4 years tested and in Mackerel the length of the head is more in summer season in 2008 and 2009 and in post monsoon season in 2010 and 2011 the length of the head is more. The values of different lengths of both Mackerel and Oil sardine are significantly different from each other at 5% level of significance.

## INTRODUCTION

Morphometric characteristics are characters of fish that determine the shape of the fish. Seasonal variation refers to the changes in the shape and size of the fish in 4 different seasons. Morphometric study is much needed for the two fishes, namely, Mackerel and Oil sardine to know the behavior and distribution pattern of these along the Chennai coast. These two fishes are most commonly occurring species and are most common in the usual landings of Kasimedu region of Chennai. The morphometric characteristics study gives a detailed picture of the individual fishes, both males and

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females occurring along the Tamil Nadu coast. Morphometric measurement analysis is very much needed to know the impact of environment changes on the distribution shifts in the selected fisheries (Mackerel and Oil Sardine) along the coast. The difference in different parts among the same species of fish in 4 different seasons along with the environmental parameters at 2 different locations are determined. This study helps in determining the seasonal effect on the morphometric characteristics of the two different fishes.

## MATERIALS AND METHODS

Fishes are collected from Ennore(S1) and Chennai fisheries harbor(S2) region along Chennai coast. Different hydrographic parameters were collected from both the stations on monthly basis in a year and recorded. The year is divided into 4 seasons, post monsoon, summer, pre monsoon and monsoon season. 2 different species, viz. Mackerel, *Rastrelliger kanagurta* and Oil sardine, *Sardinella longicepsis* were collected every week in all months from Jan-Dec'08 to 2011. The collected samples were thoroughly cleaned and then kept on a tracing sheet/graph sheet and different parts of the body of fishes were drawn. The morphometric characteristics include 21 different measurements and 5 derived parameters. The parameters that were measured include, the length of lower jaw, P1-P2, length of head, P1-P3 snout to first dorsal, P1-P4, distance between end of the jaw to the start of the pelvic fin, P2-P3, distance between the end of the head to the first dorsal fin, P2-P4, distance between the pelvic fin to the first dorsal fin, P3- P4, distance between the pelvic fin to the start of the anal fin, P3-P5, distance between the first dorsal fin to start of the anal fin, P3-P6, distance between the first dorsal fin to second dorsal fin, P4-P5, distance between the first dorsal fin to the end of the end of the anal fin, P4-P6, distance between the start of the anal fin to second dorsal fin, P5-P6 distance between the second dorsal fin to end of anal fin, P5-P7, distance between second dorsal fin to largest depth of caudal peduncle, P5-P8, distance between the second dorsal fin to largest depth of caudal peduncle, distance between the lower end of anal fin to caudal peduncle, P6-P7, distance between the lower anal fin to caudal peduncle, P6-P8, distance between the upper caudal peduncle to lower caudal peduncle, P9-P10, distance between second dorsal fin to largest depth of caudal peduncle, P7-P8, distance between the second dorsal fin to largest depth of caudal peduncle, P7-P9, distance between the lower anal fin to caudal peduncle, distance between the tip of the fish to the jaw, distance between the snout to pelvic fin. Apart from these measurements using these parameters 5 other derived parameters, standard length P1-P9, snout to anal opening, P1-P6, snout to first dorsal, P1-P5, Total length, snout to first dorsal, P1-P5, snout to second dorsal, P1-P7, depth at caudal peduncle, P9-P10, depth at origin of anal, P6-P7, length of lower jaw, P1-P2 and head length, P1-P3. The fresh fish after harvest from sea were collected and brought to the lab, washed thoroughly on the outer surface and then kept on the graph sheet to mark the different points of the fish so that the distance between each part is calculated. The total length and weight of individual fish were calculated and recorded separately. This observation were done for 4 times in a month, preferably Thursday and then the above parameters measured. The deviation of distance between different points in morphometric truss analysis chart were also calculated both for Mackerel (*Rastrelliger kanagurta*) and Oil Sardine (*Sardinella longiceps*, 2010). Morphometric measurements are widely used to identify differences between fish populations (Tzenz, 2004, Cheng *et al.*, 2005; Buj *et al.*, 2008; Torres *et al.*, 2010). The body parts were measured following standard anatomical reference points (Omoniyi and Agbon, 2004; Al and Kara, 2007). Data on the morphometric measurements (body weight, standard length, total length, head length, body depth, dorsal length and caudal length) of the two fish species were analyzed using univariate analysis of variance (ANOVA) with means separated using the two tailed test and multi variate statistical methods (Yakubu and Okunsebor, 2011) reported that the differences between fish species arose mainly from head measurements.

## RESULTS AND DISCUSSION

### Morphometric truss analysis: (2008-2011)

In Mackerel fish species in the year 2008, post monsoon season, 229.73 mm, total length is the most and least is in monsoon season. This may by due to the temperature effects, lower temperature leads to decrease in total length and the increase in temperature leads to increase in total length. This is true in the years, 2008, 2010 and 2011. Total length at Ennore location is positively correlated to the environmental parameters, temperature, salinity, pH and negatively correlated to the dissolved oxygen,

chlorophyll a, b and c, n-phosphate, n-ammonia and net primary productivity /gross primary productivity. The level of correlation is more with salinity in 2008. At Chennai fisheries harbor location, total length of Mackerel is positively correlated with salinity, pH, chlorophyll a, gross primary productivity, net primary productivity, n-nitrate and negatively correlated with temperature, dissolved oxygen, total soluble solids, chlorophyll b, chlorophyll c, n-phosphate, n-ammonia and net primary productivity /gross primary productivity in the year 2008. In the year 2009, in Mackerel species fish the total length parameter among all morphometric characteristics is positively correlated to temperature, salinity, pH, total soluble solids, chlorophyll a, b and c, n-nitrate, n-ammonia and net primary productivity/gross primary productivity, negatively correlated to dissolved oxygen, gross primary productivity, net primary productivity and n-phosphate at Ennore location. In the year 2009, in Mackerel species fish the total length parameter among all morphometric parameters is positively correlated with temperature, salinity, pH, dissolved oxygen, chlorophyll b and c, net primary productivity, n-phoshate, n-nitrate and net primary productivity /gross primary productivity and negatively correlated with total soluble solids, chlorophyll a and gross primary productivity at Chennai fisheries harbor location. In the year 2010 at Chennai fisheries harbor region, total length is positively correlated with temperature, salinity, dissolved oxygen, pH, chlorophyll a, b and c, net primary productivity, n-ammonia and net primary productivity/gross primary productivity and is negatively correlated with gross primary productivity, n-phoshate and n-Nitrate in Mackerel fish. In the year 2010 at Ennore location, total length is positively correlated with chlorophyll b, gross primary productivity, net primary productivity and n-ammonia and negatively correlated with temperature, salinity, pH, dissolved oxygen, chlorophyll a and c, n-phoshate, n-nitrate and net primary productivity/gross primary productivity in Mackerel species of fish. In the year 2011 at chennai fisheries harbour location, the environmental parameters of temperature, salinity, dissolved oxygen, total dissolved solids, chlorophyll a and c, n-nitrate and net primary productivity/gross primary productivity are positively correlated and pH, chlorophyll b, gross primary productivity, net primary productivity and n-ammonia are negatively correlated with total length of Mackerel fish. In the year 2011 at Ennore location, the environmental parameters of temperature, salinity, dissolved oxygen, total soluble solids, n-nitrate are positively correlated and other parameters of pH, chlorophyll a, b and c, gross primary productivity and net primary productivity, n-ammonia and net primary productivity/gross primary productivity are negatively correlated with total length of the Mackerel fish. In 2008, at Chennai fisheries harbour location, the environmental parameters of total soluble solids, chlorophyll a, b and c, n-phoshate, n-ammonia and net primary productivity/gross primary productivity are positively correlated, temperature, salinity, pH, dissolved oxygen, gross primary productivity, net primary productivity, n-nitrate are negatively correlated in Oil sardine fish. In 2008 at Ennore location the environmental parameters of dissolved oxygen, total soluble solids, chlorophyll a, b and c, n-phosphate, n-nitrate, n-ammonia. and net primary productivity/gross primary productivity are positively correlated and the parameters of temperature, salinity, pH, gross primary productivity and net primary productivity are negatively correlated in Oil sardine fish. In 2009 at Chennai fisheries harbour location, the environmental parameters of temperature, salinity, pH, total soluble solids, chlorophyll c, gross primary productivity, net primary productivity, n-phosphate and net primary productivity/gross primary productivity are positively correlated the other parameters of dissolved oxygen, chlorophyll a, b and n-nitrate are negatively correlated in Oil sardine fish. In 2009 at Ennore location, the environmental parameters of temperature, salinity, pH, total soluble solids, chlorophyll a, b & c, gross primary productivity, net primary productivity, n-phosphate, n- ammonia and net primary productivity/gross primary productivity are positively correlated and other parameters of dissolved oxygen is negatively correlated of Oil sardine fish. In 2010, at Ennore location, the environmental parameters of temperature, salinity, pH, dissolved oxygen, chlorophyll a, b & c , n-phosphate, n-nitrate are positively correlated and other parameters of gross primary productivity, net primary productivity and n-ammonia are negatively correlated of Oil sardine fish. In 2010 at Chennai Fisheries Harbour location, the environmental parameters of temperature, dissolved oxygen, chlorophyll a, gross primary productivity, n-phosphate, n-nitrate are positively correlated and other parameters of salinity, pH, chlorophyll b & c, gross primary productivity, net

primary productivity and n-ammonia are negatively correlated of Oilsardine fish. In 2011 at chennai fisheries harbour location, temperature, salinity dissolved oxygen, chlorophyll a b and c, n-nitrate and n-ammonia are positively correlated and other parameters of ph, total dissolved solids, gross primary productivity , net primary productivity and net primary productivity /gross primary productivity are negatively correlated of Oil sardine fish. In 2011 at Ennore location, the environmental parameters of temperature and n.nitrate are positively correlated and other parameters of salinity, pH, dissolved oxygen, total soluble solids, chlorophyll a, b and c, gross primary productivity, net primary productivity, n-ammonia and net primary produc tivity/gross primary productivity are negatively correlated for Oil sardine species of fish. Fig.2 represents the morphometric characteristics of Mackerel fish. The depth at caudal peduncle P9- P10 is the smallest in Mackerel when compared to Oil sardine by 2.46% the depth at origin of anal fin P6-P7 of Oil sardine is lower compared to Mackerel by 21.56%. The distance between the first dorsal fin to second dorsal fin P5-P7 is larger in Mackerel than Oil sardine by 62.95%, the length of lower jaw of Mackerel is larger compared with Oil sardine by 13.60%, P1-P2. The distance between the end of the jaw to the start of the pelvic fin (P2-P4) of Mackerel is larger than Oil sardine by 29.17%. The distance between the end of the head to the first dorsal fin P3- P5 is larger in Oil sardine by 23.31% than Mackerel. The distance between the lower anal fin to caudal peduncle P8-P10 is larger in Mackerel by 9.31 % than in Oil sardine. The distance between the P6-P7 start of anal fin to the second dorsal fin is larger in Mackerel by 21.56% than Oil sardine. The distance between the end of the head to the start of the pelvic fin P3-P4 is larger in Mackerel than Oil sardine by 14.97%, the distance between the first dorsal fin to start of anal fin P5-P6 is larger in Mackerel by 51.98% than Oil sardine. The distance between the lower end of anal fin to caudal peduncle P8-P9 is larger in Mackerel by 2.24% than Oil sardine. The distance between the start of anal fin to end of anal fin P6-P8 is larger in Oil sardine by 18.99% than Mackerel. The distance between the end of the jaw to the end of the head P2-P3 is larger in Mackerel by 2.63% than Oil sardine. The distance between the pelvic fin to the start of the anal fin P4-P5 is larger in Mackerel by 13.86% than Oil sardine. The distance between the second dorsal fin to end of anal fin is (P7-P8) is larger in Mackerel by 12.56% than Oil Sardine. The length of head in Mackerel (P1-P3) is larger by 5.08 % than Oil sardine. The distance between the snout to first dorsal is larger in Mackerel by 22.63% than Oil sardine. The distance between the P3-P6 end of the head to the start of the anal fin is larger in Mackerel than Oil sardine by 38.84%. the distance between P5-P8 the first dorsal fin to end of the anal fin is greater in Mackerel by 40.24% than Oil sardine. The distance between the second dorsal fin to largest depth of caudal peduncle P7-P9 is larger in Mackerel than Oil sardine is 4.29%, the distance between the second dorsal fin to largest depth of caudal peduncle (P7-P10) is larger in Mackerel than Oil sardine by 5.11%. Among the 4 years tested in post monsoon season in the year 2011, head length is more in 39.834 mm and total length is 182.95 mm, head length is more, 42.67 mm and total length is 183.47 mm in the year summer, 2011, pre-monsoon in the year 2009, 41.06 mm and total length is 173.05 mm, in monsoon head length is 41.56 mm and total length is 169.58 mm. In Oil sardine, among the years tested, 2009 year has more of P1-P2 length, 22.43 mm. Total length is more in the year, 2011, 176.32 mm and less in the year 2008, 156.13 mm. Among the seasons tested, summer season has a larger total length, 172.03 mm and least is in post monsoon season, 144.78 mm. (Fig.1). The head length in pre monsoon season, 24.11 mm is more while in post monsoon season, 19.76 mm is less. The head length is attributed to higher temperature effect. Snout to first dorsal fin distance is most correlated with total length r=0.99. The largest being the distance between the largest depth of caudal peduncle is the largest, 69.64mm, followed by distance between second dorsal fin to largest depth of caudal

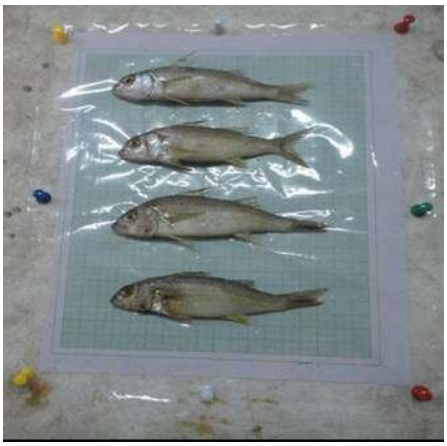

**Fig. 1.** Graph sheet and the selected fishes for morphometric measurements (5.2) Oil sardine:

peduncle, 68.25mm followed by distance between the first dorsal fin to end of anal fin, P5-P8 56.94 mm followed by snout to first dorsal fin, P1-P4, 47.85mm, followed by length of head P1-P3, 47.13mm followed by distance between the second dorsal fin to end of anal fin, P7-P8 43.28 mm, followed by distance between the pelvic fin to the first dorsal fin, P4-P5, 42.64 mm, followed by P2-P3 distance between the end of the jaw to the end of the head 38.95 mm, followed by distance between the start of anal fin to the end of anal fin, 38.33mm, followed by distance between the lower end of anal fin to caudal peduncle, P8-P9, 37.16mm, followed by P5-P6 distance between first dorsal fin to start of anal fin followed by P3-P4 distance between the end of the head to the start of the pelvic fin, followed by P6-P7 distance between the start of the 35.06mm start of the anal fin to the second dorsal fin, followed by P8-P10 distance between the lower anal fin to caudal peduncle 32-140 mm followed by P3-P5, distance between the end of the head to first dorsal fin 25.08 mm, followed by distance between the end of the jaw to the start of the pelagic fin P2-P4 24.74 mm followed by length of lower jaw P1-P2, 24.21mm followed by distance between the firstdorsal fin to second dorsal fin P5- P7, 19.03 mm followed by distance between the upper caudal peduncle to lower caudal peduncle P6-P10, 12.17 mm.

**Mackerel**

Among the 4 years tested, head length is more in 2010, in post monsoon season, 54.86 mm and total length is 257.84 mm, head length is more in summer season, 53.12 mm in 2009, total length is more in 249.91 mm, head length is more in pre monsoon season, 51.07 mm in 2009 and total length is 247.31 mm, head length is more in monsoon season, 52.84 mm in 2009 and total length is 256.09 mm. Interaction between Mackerel, 2007 and 2008 is significant, Mackerel, 2007 and 2011, Mackerel, 2008 and 2009 ($p<0.05$), Mackerel, 2008 and 2011, $p<0.05$, Mackerel, 2009 and 2010, 0.04, ($p<0.05$), Mackerel, 2010 and 2011, 0.02 ($p<0.05$). Interaction between Oilsardine, 2007 and 2011, $p<0.05$,the other years are non significant. The observed/ measured distances are total length of the fish, 244.00mm, followed by the standard length, P1-P9, 205.71mm, distance between the snout to upper caudal peduncle followed by P1-P7, distance between the tip of the fish to second dorsal fin,185.31mm followed by P1-P6, distance between the tip of the fish to the start of the anal fin, 133.27 mm, followed by P1-P5, distance between snout to first dorsal fin, 124.58 mm. The length of dorsal fin base, P5-P8, 95.27 mm is the largest, followed by P3-P6, distance between the end of the head to the start of the anal fin 83.24mm, followed by P5-P6, distance between the first dorsal fin to start of anal fin, 74.41 mm, followed by P7-P10, distance between the second dorsal fin to largest depth of caudal peduncle, 73.39 mm, followed by P7-P9, distance between the second dorsal fin to the largest depth of caudal peduncle,71.31mm, followed by P4-P6, distance between the pelvic fin to the start of anal fin 63.00 mm followed by P1-P4, snout to first dorsal fin distance being 61.85 mm, followed by P5-P7 distance between the first dorsal fin to second dorsal fin, 51.35 mm, followed by P1-P3, length of head, 49.65 mm, followed by P4-P5, 49.50 mm, distance between the pelvic fin to the first dorsal fin, followed by P7-P8, distance between the second dorsal fin to the end of the anal fin, 49.50mm, followed by P6-P7 distance between the pelvic fin to the first dorsal fin, followed by P7-P8 distance between the second dorsal fin to the end of the anal fin, 49.50 mm, followed by P6-P7, distance between the start of anal fin to second dorsal fin, 43.29 mm, followed by P3-P4, distance between the end of the head to the start of the pelvic fin, 41.23 mm followed by P2-P3, distance between the end of the jaw to the end of the head followed by P8-P9, distance between the lower end of anal fin to caudal peduncle, 38.01 mm followed by P8-P10, distance between the lower anal fin to caudal peduncle, 35.44 mm followed by P2-P4, distance between the end of the head to the start of the pelvic fish 34.93 mm followed by P6-P8, 31.05 mm, distance between the start of the anal fin to end of the anal fin followed by P1-P2, length of lower jaw, 28.02 mm, followed by P3- P5, 19.24 mm distance between the end of the head to first dorsal fin, followed by P9-P10, 7.00 mm distance between the upper caudal peduncle to lower caudal peduncle. Graphs were plotted for the morphometric parameters for the total length and head length. Morphometric regression equations were worked out (Table 1).

**Comparision between Mackerel and Oil sardine**

Fig.1 shows the different lengths of Mackerel in Monsoon season 2011 and Fig. 2 shows the different lengths of Mackerel in post monsoon season 2011. The depth at caudal peduncle P9- P10 is the smallest in Mackerel when compared to Oil Sardine by 2.46% the depth at origin of anal fin P6-P7 of Oil Sardine is

lower compared to Mackerel by 21.56%. The distance between the first dorsal fin to second dorsal fin P5-P7 is larger in Mackerel than Oil sardine by 62.95%, the length of lower jaw of mackerel is larger compared with Oil sardine by 13.60%, P1-P2. The distance between the end of the jaw to the start of the pelvic fin P2-P4 of Mackerel is larger than Oil sardine by 29.17%. The distance between the end f the head to the first dorsal fin P3-P5 is larger in Oil sardine by 23.31% than Mackerel. The distance between the lower anal fin to caudal peduncle P8-P10 is larger in Mackerel by 9.31% than in Oil sardine. The distance between the P6-P7 start of anal fin to the second dorsal fin is larger in mackerel by 21.56% than Oil sardine. The distance between the end of the head to the start of the pelvic fin P3-P4 is larger in Mackerel than Oil sardine by 14.97%, the distance between the first dorsal fin to start of anal fin P5-P6 is larger in Mackerel by 51.98% than Oil sardine. The distance between the lower end of anal fin to caudal peduncle P8-P9 is larger in Mackerel by 2.24% than Oil sardine. The distance between the start of anal fin to end of anal fin P6-P8 is larger in Oil sardine by 18.99% than Mackerel. The distance between the end of the jaw to the end of the head, P2-P3 is larger in Mackerel by 2.63% than Oil sardine. The distance between the pelvic fin to the start of the anal fin P4-P5 is larger in Mackerel by 13.86% than Oil sardine. The distance between the second dorsal fin to end of anal fin is P7-P8 is larger in Mackerel by 12.56% than Oil sardine. The length of head in Mackerel P1-P3 is larger by 5.08% than Oil sardine. The distance between the snout to first dorsal is larger in Mackerel by 22.63% than Oil sardine. The distance between the P3-P6 end of the head to the start of the anal fin is larger in Mackerel than Oil sardine by 38.84%. the distance between P5-P8 the first dorsal fin to end of the anal fin is greater in Mackerel by 40.24% than Oil sardine. The distance between the second dorsal fin to largest depth of caudal peduncle P7-P9 is larger in Mackerel than Oil sardine is 4.29%, the distance between the second dorsal fin to largest depth of caudal peduncle P7-P10 is larger in Mackerel than Oil sardine by 5.11%. Fig. 2 represents time series plot of total Length in 5 consecutive years and Fig. 3 represents time series plot of P1-P6 in 5 consecutive years.

**Interaction effect between mackerel and oil sardine**

Among the treatments tested in both the species, the P3-P6, P5-P8, P7-P9 and P7-P10 are significantly higher when compared with other parameters both in Mackerel and Oil Sardine fishes, followed by P1-P3, P1-P4, P4-P5, P4-P6 and P5-P6 are next higher group followed by P5-P6 and P7-P8, followed by P2-P3 followed by P8-P9 followed by P3-P4 followed by P6-P7, P6-P8 and P8-P10, followed by P5-P7 followed by P2-P4 followed by P1-P2 followed by P3-P5 followed by P9-P10 when statistically analysed. The interaction effect is non-significant both at 5% and 1% level of significance. Both parts effect and species effect when separately analysed are significant both at 5% and 1% level of significance. Among the varieties tested, Oil Sardine is the higher than Mackerel in all the distances calculated when compared with least square deviation. Fig. 2 represents Mackerel morphometric characteristics in a graph sheet. Table 1 represents the relationship between weight and length of Mackerel and Oil sardine fish. The combination of distance between the pelvic fin to the first dorsal fin, P4-P5 in Oil sardine and Mackerel, distance between the start of anal fin to end of anal fin P6-P8 of Oil sardine, distance between the second dorsal fin to largest depth of caudal peduncle P7-P9 of Mackerel, distance between the lower end of anal fin to caudal peduncle of Mackerel, P8-P9, distance between the lower anal fin to caudal peduncle P8-P10 of Oil Sardine are the highest/largest occurring distances. Fig. 4 represents the different lengths of Mackerel in monsoon season and Fig.5 different lengths of Mackerel in poat monsoon season. The distance between P5-P6 the first dorsal fin to start of anal fin of Oil sardine and the distance between the upper caudal peduncle to lower caudal peduncle of Mackerel are the smallest occurring distances. The interaction effect between 2 varieties and 21 parts are significantly different. Among the parts, P4-P5 is the largest distance followed by P5-P6, P9-P10, P6-P8, P8-P9, P3-P4, P7-P8, P6-P7, P7-P9, P1-P4, P8-P10, P5-P7, P7-P10, P4-P6, P5-P8, P1-P2, P3-P5, P2-P4, P1-P3, P3-P6 and P2-P3. Among the varieties tested, Oil Sardine is the largest distance variety when compared with Mackerel. The parts differences among each other are significantly different both at 5% and 1% level of significance and the varietal differences are non-significant both at 5% and 1% level of significance. Table 2 represents the equations for the regressions of variable characters(Y) on standard length(X) for different variables.

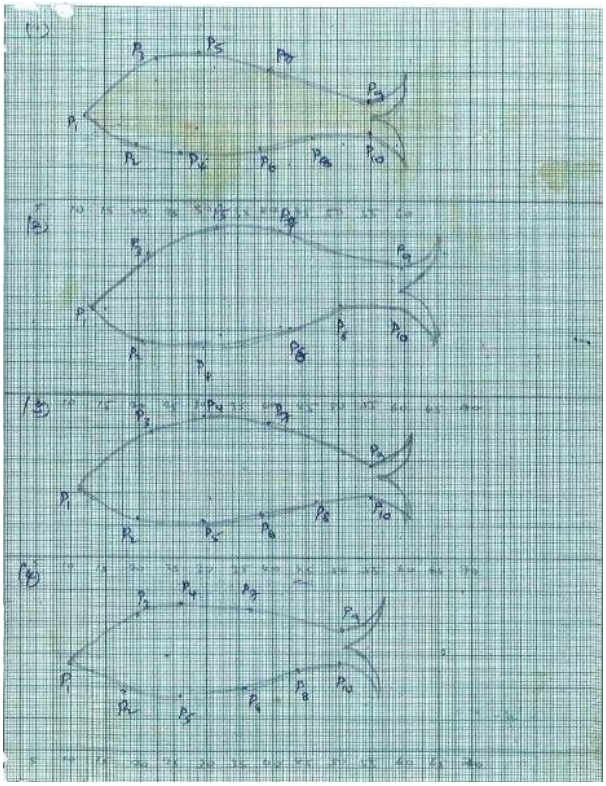

**Fig. 2.** Mackerel morphometric characteristics in a graph sheet

**Overall data analysis**

**Mackerel**

1) P9-P10 – P1-P9 the difference between these 2 is non significant within group and significant between groups at 5% level of significance.
2) P6-P7 – P1-P9, the difference between these 2 is significant within and between groups.
3) P1-P3 – P1-P9, the difference between these 2 is significant within and between groups.
4) P1-P2 & P1-P9, P1-P6 & P1-P9, P1-P7 & P1-P9 and P1-P12 and P1-P9, significant between groups and within groups.

**Oil sardine**

1) P9-P10 and P1-P9, P6-P7 and P1-P9, P1-P3 and P1-P9, P1-P2 and P1-P9, P1-P6 and P1-P9, P1-P7 and P1-P9, P1-P12 and P1-P9 – Within group – non significant, between groups significant.
2) Regression Analysis: TL versus P 1 - P2, P 1 - P3, P1 -P4 The regression equation is TL = 78 + 0.23 (P1 - P2) + 2.44 (P1 - P3) - 0.29 (P1 -P4)

| Predictor | Coef | SE Coef | T | P |
|---|---|---|---|---|
| Constant | 78.30 | 145.20 | 0.54 | 0.61 |
| P 1 - P2 | 0.23 | 1.74 | 0.13 | 0.90 |
| P 1 - P3 | 2.44 | 2.42 | 1.01 | 0.35 |
| P1 -P4 | -0.29 | 1.81 | -0.16 | 0.88 |

S - 11.50 R-Sq - 18.70% R-Sq(adj) - 0.00%
PRESS - 1392.26 R-Sq(pred) - 0.00%

Analysis of Variance

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Regression | 3 | 183.00 | 61.00 | 0.46 | 0.72 |
| Residual Error | 6 | 794.20 | 132.40 | | |
| Total | 9 | 977.10 | | | |

| Source | DF | Seq SS |
|---|---|---|
| P 1 - P2 | 1 | 40.10 |
| P 1 - P3 | 1 | 139.40 |
| P1 - P4 | 1 | 3.50 |

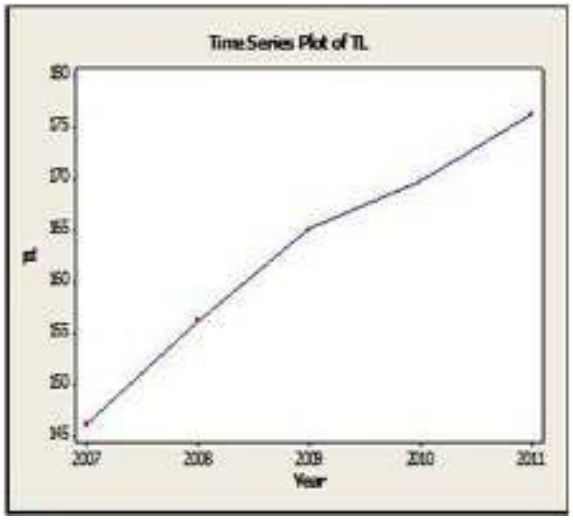


**Fig. 3.** Time series plot of Total Length in 5 consecutive years

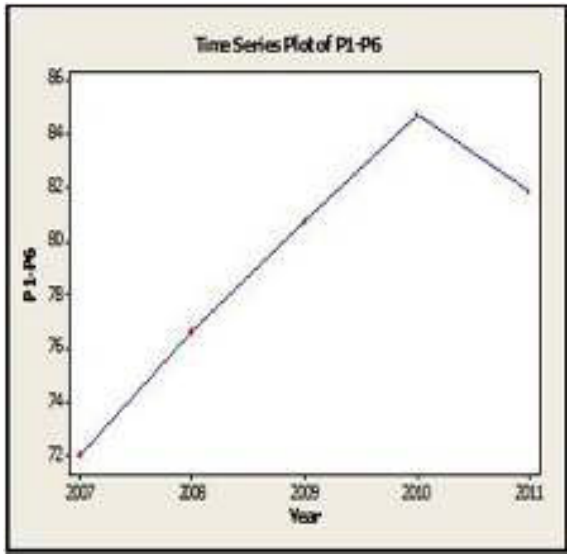


**Fig. 4.** Time series plot of P1-P6 in 5 consecutive years

**Table 1.** Relationship between weight and length of Mackerel and Oil sardine fish

| SN. | parameters | size | a | b | r2 | r |
|---|---|---|---|---|---|---|
| 1 | Mackerel | 176.77X60.01 | 1.93 | 0.06 | 0.002 | 0.05 |
| 2 | Oil Sardine | 232.80X137.40 | 117.17 | 53.88 | 0.001 | 0.03 |

Mackerel: $W=1.93XL^{0.06}$ Oil sardine: $W=117.17XL^{53.88}$

### Correlation of head length with environmental parameters

In Chennai fisheries harbor region, head length varies with total soluble solids, r=0.53, chlorophyll b r=0.41, chlorophyll c, r=0.38, n-phos, r=0.35, n-ammonia, r=0.74 and net primary productivity/gross primary productivity, r=0.04 in Oil sardine. In Ennore, head length varies with dissolved oxygen, r=0.05, total soluble solids, r=0.67, chlorophyll a, r=0.35, chlorophyll b r= 0.65, chlorophyll c, r=0.47,n-phosphate, r=0.42, n-nitrate R=0.33, n-ammonia, r=0.5 and net primary productivity/gross primary productivity, r=0.64 in Oil sardine in the year 2008.In Ennore, head length varies with temperature, r=0.15, salinity, r=0.58, pH, r=0.14, total soluble solids, r=0.14, chlorophyll a, r=0.28, chlorophyll b, r=0.37, chlorophyll c, r=0.34, gross primary productivity, r=0.52, net primary productivity, r=0.58, n-phosphate, r=0.61, n-ammonia, r=0.31, net primary productivity/gross primary productivity, r=0.46 in Oil sardine. In Chennai fisheries harbor region, head length varies with temperature, r=0.20, salinity, r=0.62, pH, r=0.02, chloro phyll.a, r=0.01, chlorophyll-c, r=0.10, gross primary productivity, r=0.34, net primary productivity, r=0.66, net primary productivity/gross primary productivity, r=0.49 in Oil sardine in the year 2009. In Ennore, head length varies with temperature, r=0.31, salinity, r=0.31, pH,

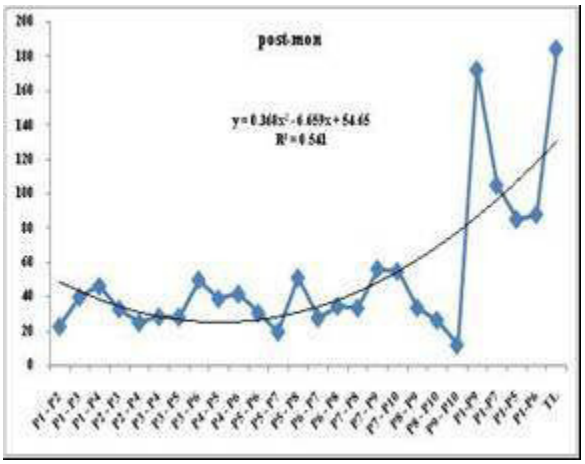


**Fig. 5.** Different lengths of Mackerel in Monsoon season-2011

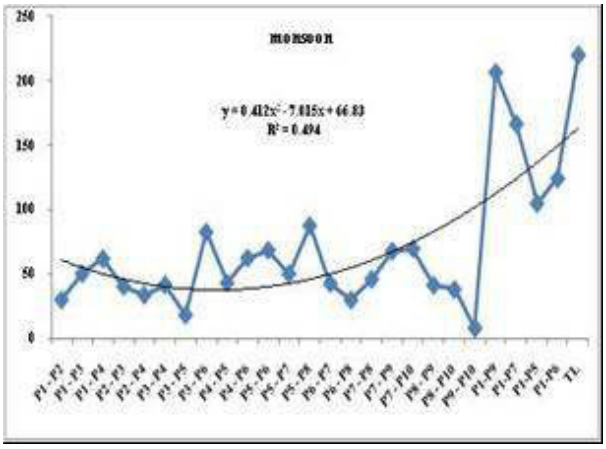


**Fig. 6.** Different lengths of Mackerel in post monsoon season – 2011

r=0.24, dissolved oxygen, r=0.08, chlorophyll.a, r=0.41, n-phosphate, r=0.15 and n-nitrate, r=0.01 in Oil sardine. In Chennai fisheries harbor region, head length varies with temperature, r=0.18, salinity, r=0.18, dissolved oxygen, r=0.06, n-nitrate, r=0.15 in Oil sardine in the year 2010. In 2011, Chennai fisheries harbor region, head length varies with temperature, r=0.24 and dissolved oxygen, r=0.14, chlorophyll.a, r=0.27, chlorophyll.b, r=0.51, chlorophyll.c, r=0.28, n-nitrate, r= 0.59 and n-ammonia, r=0.23 in Oil sardine. In 2011, Ennore, head length varies with temp er ature, r=0.04 and n-nitrate., r=0.11 in Oil sardine. In Mackerel, head length varies with salinity, r=0.64, pH, r=0.05, chlorophyll.a, r=0.35, gross primary productivity, r=0.46, net primary productivity, r=0.40 and n-nitrate, r=0.06 in 2008 at Chennai fisheries harbor region. In Mackerel, head length varies with temperature, r=0.02, salinity, r=0.64, pH, r=0.05, chlorophyll a, r= 0.35, gross primary productivity, r=0.32, net primary productivity, r=0.40, net primary productivity/gross primary productivity , r=0.15 at Ennore at 2008. In Mackerel, head length varies with temperature, r=0.29, salinity, r=0.29, pH, r=0.24, dissolved oxygen, r=0.02, chlorophyll -b, r=0.07, chlorophyll. c, r=0.14, net primary productivity, r=0.07, net primary productivity/gross primary productivity, r=0.19 at Chennai fisheries harbor

region in 2009. In Mackerel, head length varies with temperature, r=0.05, salinity, r=0.21, pH, r=0.11, total soluble solids, r=0.19, chlorophyll a, r=0.32, chlorophyll b, r=0.55, chlorophyll c, r=0.42, n-nitrate, r=0.38, n-amm, r=0.06 and net primary productivity/ gross primary productivity, r=0.04 at Ennore region in the year 2009. In Mackerel, head length varies with temperature, r=0.22, dissolved oxygen, r=0.31, pH, r=0.35, chlorophyll a, r=0.08, chlorophyll c, r=0.20, net primary productivity, r=0.48, n-ammoniar=0.54 and net primary productivity /gross primary productivity, r=0.08 at Chennai fisheries harbor region. In Mackerel, head length varies with chlorophyll a., r=0.10, gross primary productivity, r=0.03 and net primary productivity, r=0.05 at Ennore region. In Mackerel, head length varies with temperature, r=0.02, total soluble solids, r=0.19, chlorophyll a, r=0.09, chlorophyll b, r=0.05, chlorophyll c, r=0.07 and net primary productivity / gross primary productivity, r=0.10 at Ennore region in 2011. In Mackerel, head length varies with temperature, r=0.10, total dissolved solids, r=0.04, chlorophyll-a, r=0.28, chlorophyll.b, r=0.21, chlorophyll.c, r=0.14, net primary productivity, r=0.01, n-nitrate., r=0.56, n-ammonia, r=0.37 and net primary productivity/gross primary productivity, r= 0.60 at Chennai fisheries harbor region.

**Correlation of total length with environmental parameters**

In Mackerel in Ennore region, total length varies with dissolved oxygen, r=0.05, total soluble solids, r=0.70, chlorophyll.a, r=0.26, chlorophyll.b, r=0.50, chlorophyll c, r=0.28, n-phosphate, r=0.27, n-Nitrate, r=0.16, n-ammonia r=0.57 and net primary productivity / gross primary productivity, r=0.32 in the year 2008. In Mackerel in Chennai fisheries harbor region, total length varies with total soluble solids, r=0.48, chlorophyll.a, r=0.03, chlorophyll b, r=0.43, chlorophyll c, r=0.43, N-phosphate, r=0.29, n-ammonia, r=0.76 and net primary productivity / gross primary productivity, r=0.11. In Mackerel in Chennai fisheries harbor region total length varies with temperature, r=0.36, salinity, r=0.53, pH, r=0.10, total soluble solids, r=0.20, chlorophyll c, r=0.09, gross primary productivity, r=0.28, net primary productivity, r=0.49, n-phosphate, r= 0.004, net primary productivity/gross primary productivity, r=0.28. In Mackerel in Ennore region, total length varies with temperature, r=0.47 salinity, r=0.55, pH, r=0.19, total soluble solids, r=0.04, chlorophyll a, r= 0.13, chlorophyll b, r=0.35, chlorophyll c, r=0.31, gross primary productivity, r=0.55, net primary productivity, r=0.61, n-phosphate, r=0.46, n-ammonia, r=0.44 and net primary productivity/gross primary productivity, r= 0.43 in 2009. In Mackerel in Ennore region, total length varies with temperature, r=0.42, salinity, r=0.46, pH, r=0.43, dissolved oxygen, r=0.45, chlorophyll. a, r=0.40, chlorophyll b, r=0.29, chlorophyll.c, r=0.39, n-phosphate, r=0.53 and n-nitrate, r=0.16. In Mackerel in Chennai fisheries harbor region, total length varies with temperature, r=0.03, dissolved oxygen, r=0.00, chlorophyll.a, r=0.37, gross primary productivity, r=0.09, n-phosphate, r=0.26 and n-nitrate. r=0.37 in 2010. In Mackerel in Ennore in 2011 total length varies with temperature, r= 0.12 and n-nitrate, r=0.12. In Mackerel in Chennai fisheries harbor region, total length varies with temperature, r=0.27, salinity, r=0.07, dissolved oxygen, r=0.23, chlorophyll.a,

**Table 2.** Equations for the regressions of variable characters(Y) on standard length(X) for different variables

| Locality/ Type of fish | TL Vs SL | Snout to anal opening (Y) on std. length (X) | Snout to I dorsal (Y) on std. length (X) | Snout to II d orsal(Y) on std. length (X) | Depth at caudal peduncle (Y) on std. length (X) | Depth at origin of anal (Y) on std. length (X) | Length of lower jaw (Y) on std. length (X) | Head length(Y) on std. length (X) |
|---|---|---|---|---|---|---|---|---|
| Marina (nochi kuppam) | | (P1-P6) | (P1-P5) | (P1-P7) | (P9-P10) | (P6-P7) | (P1-P2) | (P1-P3) |
| a) Oil sardine | $y=0.14x^2$ -1.32x+ 179.73 | $y=0.17x^2$ +2.03X +83.03 | $y=0.13x^2$ +1.75x +83.31 | $y=0.22x^2$ +2.68x +111.87 | $y=0.13x^2$ +1.60x +8.77 | $Y=0.05x^2$ +0.64x + 28.84 | $y=0.01x^2$ + 0.22x + 22.5 | $Y=0.06x^2$ +1.56 x+ 31.0 |
| b) Mackerel | $y=0.05x^2$ -1.10x +248.9 | $y=0.06x^2$ -0.52x + 136.06 | $y=0.11x^2$ +2.12x + 236.3 | $y=-0.07\ x^2$ +0.87 x +187.13 | $y=-\ 0.02x^2$ +0.04x + 9.97 | $y=-0.13\ x^2$ +1.40x + 51.08 | $y=0.04x^2$ -0.41x + 40.80 | $y=0.06\ x^2$ -0.87 x + 61.66 |

r=0.39, chlorophyll. b, r= 0.18, chlorophyll. c, r=0.14, n.nitrate, r=0.62 and n-ammonia, r=0.14 in 2011. In Oil sardine, in 2011, Ennore region, total length varies with temperature, r=0.49, salinity, r=0.57, dissolved oxygen, r=0.52, total soluble solids, r=0.40 and n-nitrate, r=0.07. In 2011, at Chennai fisheries harbor region, total length varies with temperature, r=0.48, r=0.65, dissolved oxygen, r=0.35, total dissolved solids, r= 0.46, chlorophyll. a, r=0.48, chlorophyll.c, r=0.15, n-nitrate, r=0.254 and net primary productivity / gross primary productivity, r=0.34. In 2010, Chennai fisheries harbor region total length varies with temperature, r=0.16, salinity, r=0.05, dissolved oxygen, r=0.15, pH, r=0.29, chlorophyll.a, r=0.12, chlorophyll. b, r=0.13, chlorophyll.c, r=0.40, net primary productivity, r=0.49, n-ammonia, r=0.55 and net primary productivity/gross primary productivity, r= 0.02. In 2010, Ennore region, total length varies with chlorophyll.b, r=0.15, gross primary productivity, r=0.33, net primary productivity, r=0.36 and n. ammonia, r=0.10 in 2010. In 2009, Chennai fisheries harbor region, total length varies with temperature, r=0.07, salinity, r=0.21, pH, r= 0.11, total soluble solids, r=0.23, chlorophyll.a, r=0.23, chlorophyll.b, r=0.44, chlorophyll c, r=0.32, n-nitrate, r=0.32, n-ammonia, r= 0.01 and net primary productivity/ gross primary productivity, r=0.01. In 2009, Ennore region total length varies with temperature, r= 0.27, salinity, r=0.35, pH, r=0.25, dissolved oxygen, r=0.01, chlorophyll b, r=0.12, chlorophyll c, r=0.20, net primary productivity, r=0.05, n-phos, r=0.02, n-nitrate, r=0.07 and net primary productivity/gross primary productivity, r=0.20. In 2008, Mackerel in Chennai fisheries harbor region, total length varies with salinity, r=0.69, pH, r=0.03, chlorophyll a, r=0.33, gross primary productivity, r=0.36, net primary productivity, r= 0.29 and n-nitrate, r=0.38. In Mackerel in Ennore region, total length varies with dissolved oxygen, r= 0.06, total soluble solids, r=0.72, chlorophyll a r=0.27, chlorophyll b, r=0.59, chloro - phyll c, r=0.35, n-phosphate, r=0.32, n-nitrate, r=0.20, n-ammonia r=0.59 and net primary productivity / gross primary productivity, r=0.44.

**Seasonal effect of morphometric parameters with male female relationship in Mackerel and Oilsardine fishes**

Morphometric parameters of Mackerel and Oil sardine of minimum 25 fishes were taken from kasimedu landing centre of Chennai coast and correlated with male and female fishes of the same species and its relationship were tabulated. The significance of its value in different months were found out both at 5% and 1% level of significance. The distribution pattern of both fishes for 12 months for consecutive 5 years, 2007, 2008, 2009, 2010 and 2011 along Chennai coast were found out. The different morphometric characters and males and females were correlated using Pearson Correlation technique using Sigma XL version 6.1 software. In Oil sardine, caudal peduncle length is more in female, r=0.49 in than that of males, r=0.56. Total length is more in males, r=0.63 than in females, r=0.59. Length of lower jaw is more in females r=0.76 in males, r=0.59. Length of head in males, r=0.71 is more than in females, r=0.46. Pelvic fin length is more in females than, r=0.75 than in males, r=0.66. Length of anal fin is more in males, r=0.61 than in females, r=0.59. In 2009, anal fin length is more in females, r=0.20 than in males, r=0.02. Correlation is more in total length, r=0.09 in males than in female, r=0.05. Correlation is less in females in the length of caudal peduncle, r=0.01 and in males, r=0.13. Males and females are correlated and the correlation is r=0.77 in the year 2009. Males and females correlation in the year 2010 is r=0.79. In the year 2011, males and females are correlated at r=0.85. Feb'08 and Dec'08 r=0.99, Mar'09 and Nov'09 at r=0.99,Feb'10 and Aug'10 at r=0.99, Mar'11 and Aug'11 at r=0.99. In Oil sardine, Jan'08 and Oct'08 are correlated at r=0.99, Mar'09 and Oct'09 at r=0.99, Sep'09 and Nov'09 at r=0.86, Feb'10 and Nov'10 at r=0.87, Sep'10 and Dec'10 at r=0.99, July'11 and Dec'11 at r=0.99 and Jan'11 and Oct'11 at r=0.87. In Oil sardine, among the 4 years tested, Sep'11, the total length is 202.08 mm and the least total length is 135.67 mm in Aug'11. In the year 2010, the total length is 174.86 mm, June'10 and the least total length is Sep'10, 162.50 mm. In the year 2009, the total length is 175.51 mm, Apr'09 and the least length is 134.17 mm, May'09. In the year, 2008, the total length is 178.87 mm, May'08 and the least length is Nov'08 is 133.32 mm. The seasonal effect, among the seasons in the year 2008, post monsoon, summer, pre-monsoon and winter, among the months, summer the length is more and in winter season least length is observed. In the year 2009, the total length is more in Apr'09, 175.51 mm and the least length is also observed in summer month, 134.17 mm. In the year 2010, summer month the total length is more, 174.86 mm, the least length is 162.50 mm in pre monsoon season. In the year 2011, pre monsoon season, the most total length is 202.08

mm and the least length is observed in pre monsoon season, 135.67 mm. In the year 2008, summer ≥ pre monsoon ≥ post monsoon ≥ winter season. In the year 2009, summer month ≥ pre monsoon ≥ winter season ≥ post monsoon season. In the year 2010, summer ≥ pre monsoon ≥ winter and ≥ post monsoon season. In the year 2011, pre monsoon ≥ post monsoon ≥ summer ≥ winter season. In Oil sardine, caudal peduncle, p9-p10 among the 4 years tested in 2008, the most length is in pre-monsoon season, 15.59 mm and the least length is in winter season, 10.21 mm. In the year 2009, winter season, the most length is 12.49 mm, least length in post monsoon length is 10.23 mm. In the year 2010, winter season length is more and the least length is summer season, 11.82 mm. In the year 2011, pre monsoon length is most 12.87 mm and the least length is also in pre monsoon season, 8.85 mm. In 2008, pre monsoon length ≥ winter ≥ post monsoon ≥ summer. In 2009, winter season ≥ pre monsoon ≥ post monsoon ≥summer season. In 2010, winter ≥ pre monsoon ≥ summer ≥ post monsoon season. In 2011, pre monsoon ≥ post monsoon ≥ summer ≥ winter season.

In Mackerel, 2008, the most total length is observed in Oct'08 and the least in Dec'08. In the year 2009 the most was observed in Oct'09, 280.73 mm and the least was observed in Feb'09, 221.28 mm. In the year 2010, the most total length was observed in Feb'10, 254.33 mm, July'10 is 238.17 mm is the least. In the year 2011, the most length is observed in June'11 month, 252.41 mm and the least length is in Aug'11,205.17mm. In caudal peduncle length in Mackerel in the year 2008, Feb'08 was the most, 8.23 mm and the least was observed in Dec'08, 6.48 mm. in the year, 2009, the most length was observed in Apr '09, 10.10 mm, Feb'09 the least length is 7.16 mm. In the year 2010, Aug'10 the most length is 8.97, July'10 is the least in 7.60 mm, in the year 2011, Apr'11 is 8.45 mm is the most length, Aug'11 is 6.61 mm. Length of head in Feb'08 is most. 48.16 mm, the least length is 36.83 mm in Jan'08 month. In 2009, Apr'09 month, 56.77 mm the most length in Jan'09, 40.60 mm least length is observed. In 2010, Jan'10 is the most 53.30 mm, July'10 is the least, 50.42 mm. in 2011, mar'11 is the month in 53.99 mm, Apr'11 is the least, 47.30 mm. In seasonal effect, post monsoon ≥ winter ≥ summer ≥ pre monsoon season in the year 2008. In the year 2009, in winter ≥ summer ≥ pre monsoon ≥ post monsoon season. In the year 2010, summer ≥ post monsoon ≥ winter ≥ pre monsoon. In the year 2011, post monsoon ≥ winter ≥ pre-monsoon ≥ summer season. In the year 2008 in Caudal peduncle winter ≥ post monsoon ≥ summer ≥ pre-monsoon season. In the year 2009 in caudal peduncle length summer ≥ winter ≥ pre monsoon ≥ post monsoon season. In the year 2010, in caudal peduncle length, summer ≥ post monsoon ≥ pre-monsoon ≥ winter season. In the year 2011 in caudal peduncle length post monsoon ≥ winter ≥ pre monsoon and ≥ summer season. In the year 2008, in the length of head winter ≥ post monsoon ≥ summer and ≥ pre monsoon season. In the year 2009, summer ≥ post monsoon ≥ winter and ≥ pre monsoon season. In the year 2011, post monsoon ≥ winter ≥ pre monsoon and ≥ summer season.

## CONCLUSION

Among the 4 years tested in post monsoon season in the year 2011, head length is more in 39.83mm and total length is 182.95 mm, head length is more, 42.67 mm and total length is 183.47 mm in the year summer, 2011, pre-monsoon in the year 2009, 41.06 mm and total length is 173.05 mm, in monsoon head length is 41.56 mm and total length is 169.58mm in Mackerel. Among the 4 years tested, head length is more in 2010, in post monsoon season, 54.86 mm and total length is 257.84 mm, head length is more in summer season, 53.12 mm in 2009, total length is more in 249.91 mm, head length is more in pre monsoon season, 51.07 mm in 2009 and total length is 247.31 mm, head length is more in monsoon season, 52.84 mm in 2009 and total length is 256.09 mm in Oil sardine. Interaction between Mackerel, 2007 and 2008 is significant, Mackerel, 2007 and 2011, Mackerel, 2008 and 2009 ($p<0.05$), Mackerel, 2008 and 2011, $p<0.05$, Mackerel, 2009 and 2010, 0.035, ($p<0.05$), Mackerel, 2010 and 2011, 0.02($p< 0.05$). Interaction between Oil sardine, 2007 and 2011, $p< 0.05$, the other years are non significant.

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