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Fishery and biological traits of obtuse barracuda *Sphyaena obtusata* (Cuvier, 1829) off south-west coast of India

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Abstract

Aim: The present study was conducted to investigate the fishery, diet composition and reproductive aspects of obtuse barracuda landed in Karnataka, south-west coast of India.

Methodology: Feeding and reproductive traits of 1229 samples (638 males and 591 females) of *S. obtusata* was studied for a period of five years. The index of relative importance (IRI) was determined for each diet component in the stomach. Reproductive aspects such as maturity stages, gonadosomatic index and fecundity were investigated.

Results: The most predominant prey item in terms of frequency of occurrence (93.1%), number (91.4%), weight (93.2%), IRI (3615.5) and also % IRI (98.5%) was fishes. Crustaceans and cephalopods were noticed less frequently and were represented by shrimps and *Loligo* sp. The estimated length at first maturity for male and female fishes was 20.5 and 21.3 cm, respectively. Higher GSI values were observed during post monsoon (October-November) followed by summer pre monsoon (April-May) season in both males and females, indicating two peak spawning periods.

Interpretation: The comprehensive study on major biological characteristics of *Sphyaena obtusata* could be useful for developing appropriate management strategies for conservation and judicious exploitation of this commercially important resource.

Key words: Barracuda, Fecundity, Gonadosomatic index, *Sphyaena obtusata*



Fishery, Food and Feeding

- Trends in landings
- Length distribution
- Feeding intensity
- Index of relative importance

Forms > 1/3rd of barracudas landings
 92.3% of the fish landed from trawlnets
 Length range 11.6 – 35.0 cm
 Feeds voraciously on fish
 Fish component in the diets has % IRI of 98.5
 Crustaceans and cephalopods in minor quantity

Reproductive biology

- Sex ratio
- Length at 1st maturity
- Gonadosomatic index
- Fecundity

Overall sex ratio is 1:0.93 (M:F)
 Length at 1st maturity of males 20.5
 Length at 1st maturity of females 21.3 cm
 Maximum GSI during post & pre-monsoon months
 Spawns throughout, peaks in Oct-Nov & Apr-May
 Average fecundity is 2,01,240 (± S. E. 27,721) eggs

The study provides an in depth understanding of various aspects of fishery and biological aspects of obtuse barracuda, *Sphyaena obtusata* with respect to its length distribution, exploitation pattern, diet composition, maturity, gonadal development, fecundity and spawning season.

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Introduction

Fishes belonging to family Sphyraenidae consists of voracious predators, are economically important and widely distributed in all equatorial, tropical and warm temperate seas (Allam *et al.*, 2004; Akadje *et al.*, 2013). These fishes are mostly pelagic, live solitary or in schools and are capable of adaptation to diverse ecological condition (Whitehead *et al.*, 1986). Family Sphyraenidae commonly known as barracudas include only one genus, *Sphyraena* and with 27 valid species globally (Froese and Pauly, 2019). Of these, only 9 species have been confirmed in India (Eschmeyer and Fong, 2017). The obtuse barracuda is a small and commercially important species of barracuda reported along the Indian coast, and is usually found in bays, estuaries (Senou, 2001), rocky areas and sea grass beds (May and Maxwell, 1986). These fishes are exploited by various fishing gears and mainly caught in trawlnets, gillnets and outboard ringseines (Senou, 2001; Najmudeen *et al.*, 2015).

Diet composition of fish is essential to understand the basic functioning of fish assemblages and is generally used for trophic modeling as it is an important component in ecological based management (Mohanraj and Prabhu, 2012). Information on reproductive biology is an essential component in the study of the population dynamics and biology of fish species (Murua and Saborido-Rey, 2003). Numerous studies have been conducted on the fishery, length weight relationship and population dynamics of obtuse barracuda from different parts of the world (Sivashanthini *et al.*, 2009; Kasim, 2000; Najmudeen *et al.*, 2015). However, there is no detailed information available on feeding and reproductive biology of obtuse barracuda. Therefore, the present study was conducted to investigate the diet composition and reproductive biology of obtuse barracuda which facilitate in formulating regulatory management measures for judicious exploitation of this important fish species to maintain the fishery at sustainable levels.

Materials and Methods

Landings of *S. obtusata* by various commercial fishing vessels along Karnataka coast were gathered from the National Marine Fisheries Data Centre (NMFDC) of ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI), Kochi during the period from 2013 to 2017. Fish samples were collected on a weekly basis from Mangalore and Malpe fishing harbours of Karnataka during January 2013 to December 2017 for biological investigations. The samples were collected all round the year, except during June and July since operation of mechanized fishing vessels is prohibited. Fork length and weight of 638 male and 591 female fishes were measured to the nearest 0.1 cm and 0.1 g with a measuring tape and digital weighing balance respectively.

Feeding and reproductive traits were studied based on the analysis made on 1229 fishes. After careful dissection,

stomachs and gonads taken out from the individual fishes were preserved for more detailed analyses. Based on the visual observations, fullness of stomach was classified as: empty, trace, one-fourth full, half full, three-fourth full and full. Total weight of the content in the stomachs was recorded and prey items were broadly categorized into fishes, crustaceans and cephalopods and weight of each prey item was recorded separately. Ranking was given to the various food items found in the stomach using points method. The prey items present in the stomach were identified up to the generic/species level, following the keys and identifying descriptions given by Froese and Pauly (2017) and the number of identified food items counted. Partially digested fish remains were grouped as unidentified fish remains. The index of relative importance (IRI) was determined for each diet component in the stomach (Pinkas *et al.*, 1971) on the basis of three indices: (i) wet weight percentage of each food item (%W) to the total weight of all the food items in the gut; (ii) percentage of the number (%N) of each food item to the total number of all identified food items; and frequency of occurrence (%F) of each food item in the total number of guts examined. IRI was calculated as:

$$IRI = (\%N + \%W) \times \%F.$$

Gonad weight was measured to the nearest 0.01 g, maturity stages of the fishes were determined based on the macroscopic appearance of the testes or ovary and the space occupied by them in the body cavity following the method of Ferreri *et al.* (2009) with suitable modifications. Homogeneity in distribution of male and female and any significant deviation from the expected sex ratio of 1:1 was tested by Chi-square test (Snedecor and Cochran, 1967; Arshad *et al.*, 2016). Length at first maturity (L_m) is defined as the fork length at which 50% of the fishes reached sexual maturity was estimated following the method of King, 2007 from the logistic equation:

$$P = 1 / (1 + \exp [-r \times (FL - L_m)])$$

where, P is the proportion of mature individuals in a length class, FL is fork length, r (intercept) and L_m (slope) are two parameters of logistic model. These two parameters were estimated using the Non-Linear Regression routine from the ratio of reproductive to non-reproductive fish groups.

Samples of ripe ovaries (maturity stage V and VI) were preserved in 4% buffered formalin solution for estimating fecundity and ova diameter. Gonado-somatic index (GSI) was calculated considering the gonad weight and total weight of fish by the equation:

$$GSI = [\text{Gonad weight} / (\text{Body weight} - \text{Gonad weight})] \times 100$$

Absolute fecundity was estimated by taking 3-5 subsamples from anterior, posterior and mid part of the ovary lobe as size of the egg differs from different parts. Each sub sample was weighed to the nearest 0.001g and then dispensed with a fine

brush and oocytes were counted and ova diameter measured with a grid (Murua et al., 2003). Fecundity was calculated by the formula:

$$F = [\text{gonad weight} \times (\text{subsample egg count} / \text{gonad sub sample weight})]$$

Results and Discussion

Five yearly trend (2013-2017) of *Sphyræna obtusata* landed in Karnataka revealed maximum and minimum landings of 2339 and 1044 t during 2015 and 2014 (Fig. 1). *S. obtusata* (Mean value 1775 tonnes from 2013-2017) is the major species and represented more than 1/3rd of the total barracuda landings (Mean value 4687 t from 2013-2017) of the state. The contribution of *S. obtusata* to the total barracuda landings varied from 33% (2016) to 44% (2013) during the study period (Fig. 1). The fork length of *S. obtusata* ranged from 11.6 cm to 35.0 cm having an estimated annual average length of 22.2 cm. Fishes having fork length ranging between 20 and 26 cm dominated (84.4%) the catch. Similar length range was reported from earlier studies (Jaiswar et al., 2004; Sivashantini et al., 2009; Najmudeen et al., 2015).

Among 1229 fishes analyzed, only 464 (37.8%) had food component in varied quantity, while stomachs of 765 (62.2%) fishes were empty. Sixty nine fishes (5.6%) had full food content in their stomach, 39 fishes (3.2%) with three-fourth full, 94 fishes (7.6%) with half full, 117 fishes (9.5%) with one-fourth full and 145 fishes (11.8%) had trace quantity of food content in their stomach. Barracudas are generally described as specialized piscivorous (Kalogirou et al., 2012). Higher number of empty stomach is common in fishes which feed on other fishes (Juanes and Conover, 1994). In addition, the occurrence of high proportion of empty stomach could be attributed to the expulsion of food items during their struggle while they are trapped (Rajesh, et al., 2019) in trawl nets.

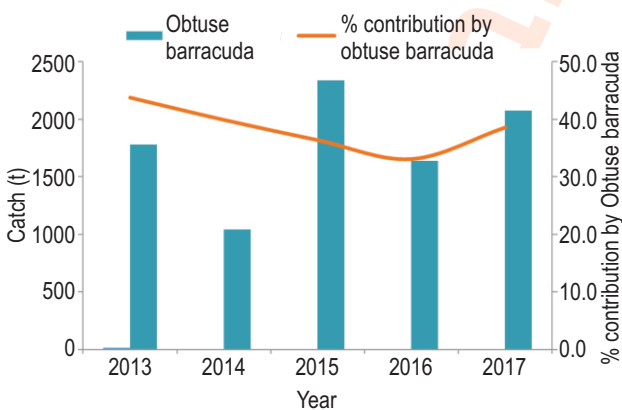


Fig. 1 : Landings (t) of obtuse barracuda and its contribution (%) to total barracudas catch during 2013-17 in Karnataka.

The prey of *obtuse barracuda* belonged to three major taxonomic group viz., fishes, cephalopods and crustaceans (Table 1). Among these, the most predominant prey items in terms of frequency of occurrence (93.1%), number (91.4%), weight (93.2%), and IRI (98.5%) was fishes. The teleost group comprised of 8 genera/species and remains of partially digested fishes. Partially digested unidentified fish remains formed the largest prey item among teleosts in terms of frequency (27.3%), number (34.2%) weight (30.6%) and IRI (48.3%). These partially digested fish items could not be identified even up to family level. The identifiable teleost prey item observed in the present investigation were mostly pelagic and mesopelagic species such as *Encrasicholina devisi*, *Bregmoceros* sp., *Megalaspis cordyla*, *Sardinella longiceps*, and *Leiognathus* sp., except *Saurida* sp., a benthic teleost. Among these, the highest prey selectivity was shown towards *E. devisi*, *Bregmoceros* sp. and *Megalaspis cordyla* as it is evident in terms of their frequency, number, weight and IRI (Table 1). Barracudas are highly predatory in nature and feed voraciously on other pelagic and supra-benthic fishes due to their swift swimming efficiency (Kalogirou et al., 2012). Crustaceans and cephalopods represented by shrimps (unidentified) and *Loligo* sp., were noticed less frequently in minor quantity in the diet of *S. obtusata* (Table 1). The results of previous studies are in agreement with the present observation and reported the minor role of crustaceans and cephalopods as supplementary diet components of barracudas (Golani et al., 2006; Kalogirou et al., 2012).

Males constituted 51.9% (n=638) and females 48.1% (n=591) with an overall sex ratio (males: females) of 1:0.93. In general, males dominated in almost all the months in the fishery except during April, September, November and December where more number of females was encountered. The females were dominant during few months due to migration undertaken by females for the purpose of spawning (Rajesh et al., 2016). Even though, the variations in sex ratio were observed in almost all the months, statistically significant difference were noticed only in January and October where males dominated the fishery. Detailed investigations on the reproductive biology of *S. obtusata* are not available and, hence, the result of the present study is comparable with the available literature on other species of barracudas (Allam et al., 2004). The significant dominance of females during summer season for *S. chrysotaenia* and significant predominance of males during all the season, except summer for *S. flavicauda* and the significant female dominance in autumn for *S. sphyræna* has been reported from Egyptian Mediterranean waters of Alexandria (Allam et al., 2004).

The present study is the first report on length at first maturity for both male and female fishes separately for *S. obtusata*. The estimated length at first maturity (length at which 50% of fish matured) for male and female fishes was 20.5 and 21.3 cm, respectively. All individuals of males and females were mature

Table 1 : Index of relative importance (IRI) of food items in the diet of *S. obtusata*

Food components	% Frequency	% Number	% Weight	Index of relative importance (IRI)	% IRI
Unidentified partially digested fish	27.3	34.2	30.6	1771.8	48.3
<i>Encrasicholina devisi</i>	25.2	27.9	22.6	1271.1	34.6
<i>Bregmaceros</i> sp.	16.3	13.2	5.5	303.7	8.3
<i>Megalaspis cordyla</i>	8.5	5.4	10.2	131.7	3.6
<i>Decapterus</i> sp.	6.1	4.2	8.5	77.1	2.1
<i>Sardinella longiceps</i>	4.1	2.3	5.5	32.1	0.9
<i>Saurida</i> sp.	2.4	1.6	4.3	14.0	0.4
<i>Rastrelliger kanagarua</i>	1.7	1.4	3.6	8.7	0.2

Table 2 : Gonadosomatic index of *S. obtusata*

Months	Female	Male
Jan	3.27 ± 0.72	0.31 ± 0.34
Feb	6.57 ± 0.60	0.53 ± 0.28
Mar	10.4 ± 1.70	0.59 ± 0.08
Apr	19.02 ± 2.71	2.02 ± 0.09
May	17.72 ± 0.73	1.28 ± 0.06
Aug	5.27 ± 1.89	0.95 ± 0.11
Sep	6.34 ± 1.95	1.23 ± 0.26
Oct	11.53 ± 1.77	1.74 ± 0.15
Nov	21.38 ± 1.10	2.66 ± 0.09
Dec	6.98 ± 0.76	0.85 ± 0.22

Values are mean ± SE.

when they attained 23.8 and 24.3 cm length, respectively. The results of this study suggested that male fishes mature earlier as compared to female fishes. Early maturation of males compared to females in barracudas was reported earlier for *Sphyræna chrysotaenia*, *S. flavicauda* and *S. sphyræna* from Egyptian Mediterranean waters (Allam et al., 2004) and for *S. putnamae* from south-eastern Arabian Sea (Rajesh et al., 2020). Further, the longer time taken by the female fishes to mature could be related to the diversion of more energy for reproduction compensating the somatic growth (Miller and Kendall, 2009; Rajesh et al., 2019).

Similar early maturation of male compared to female fishes has been reported for other species of barracudas from Egyptian Mediterranean waters of Alexandria (Allam et al., 2004). They reported the length at first maturity for males and females of *S. chrysotaenia*, *S. flavicauda* and *S. sphyræna* at 17.3 and 19.3, 25.5 and 28.0 and 26.7 and 27.6 cm respectively.

The mean values of gonado-somatic index (GSI) of females varied from 3.27 to 21.38 (Table 2) with the highest values observed in November (21.38), April (19.02), October (11.53) and March (10.4) signifying high reproductive activities during these months. Similar pattern of GSI was recorded in case of males with higher values in November (2.66), April (2.02), October (1.74) and May (1.28). The pattern of GSI of both females and males suggests bimodal spawning activity during October-November and April-May. Further, incidence of matured and spawning ovaries all the months in varied frequencies implied that the spawning activity takes place throughout the year. The results of the present study is in agreement with the earlier investigations carried out by Premalatha and Manojkumar (1990). They observed a prolonged spawning season from October to March with the peak period during November and December. The spawning period of other smaller barracuda species such as *S. chrysotaenia*, *S. flavicauda* and *S. sphyræna* was reported as May-July, June-July and May-June, respectively, from the Egyptian Mediterranean waters of Alexandria (Allam et al., 2004).

Table 3 : Fecundity and ova diameter in *S. obtusata*

Length of fish (cm)	Weight (g)	Fecundity (no.)	Ova diameter (mm)
25.5	94.7	82,722	0.04-0.73
25.8	98.5	88,128	0.05-0.68
26.0	103.1	1,30,752	0.04-0.70
26.2	100.9	1,54,991	0.08-0.78
26.6	106.5	1,96,447	0.11-0.80
26.9	107.3	2,08,001	0.09-0.83
28.3	112.5	2,26,653	0.12-0.72
28.7	121.3	2,64,653	0.14-0.76
30.1	148.5	2,80,630	0.11-0.78
30.7	155.6	3,79,421	0.11-0.83

The fecundity estimates from an individual female fish varied from 82,722 to 3,79,421 eggs (Table 3) with an average of 2,01,240. Fecundity correlated positively with fork length, body weight and gonad weight of obtuse barracuda indicating that the larger females produce more number of eggs compared to smaller ones. The absolute fecundity of 74,399 to 2,41,853, 84,197 to 2,60,549 and 46,778 to 1,03,453 eggs were estimated for *S. chrysotaenia*, *S. flavicauda* and *S. sphyraena* in the Egyptian Mediterranean waters of Alexandria (Allam et al., 2004). The fecundity of obtuse barracuda increased with length and weight in the present study is in agreement with the earlier studies conducted for other *Sphyraena* species (Wadie et al., 1988; Allam et al., 2004).

The ova diameter ranged from 0.04 to 0.83 mm. Three groups such as immature, maturing and ripe eggs were noticed in the ovary of *S. obtusata*. Immature eggs were small, non-yolked and whitish translucent, maturing eggs were partially opaque with lot of yolk and ripe eggs were completely transparent. The presence of ova in different developmental stages represents that this species is a multiple spawner releasing ripe eggs in various fractions in batches during spawning period (Allam et al., 2004).

The result of this study provides some important aspects of fishery, food and feeding habits and reproductive biology of *S. obtusata* along the south-west coast of India. This comprehensive information on major biological characteristics could be useful for developing appropriate management strategies for conservation and judicious exploitation of this commercially important fish species to maintain the fishery at sustainable levels.

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Add-on Information

Authors' contribution: **K. M. Rajesh:** Collection of Data, Experimental design, writing and editing of the paper; **P. Rohit:** Experimental design, writing and editing of the paper; **E. M. Abdussamad:** Writing and editing of the paper.

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