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An Evaluation of Economic Impact on Juvenile Landings of Cephalopods in Mumbai Waters, Northwest Coast of India

RAMKUMAR SUGUMAR[1]*, SUJIT SUNDARAM[1], ASHOK K JAISWAR[2], RANJITH LAKSHMANAN[3], SUSHANT K CHAKRABORTY[2] and VINOD KAVUNGAL[4]

[1]CMFRI Research Centre, Mumbai, India.
[2]Central Institute of Fisheries Education, Mumbai, India.
[3]CMFRI Research Centre, Tuticorin, India.
[4]CMFRI Research Centre, Calicut, India.

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ABSTRACT

Economic assessment of juvenile landings of 5 dominant cephalopods at New Ferry Wharf (NFW) landing centre, Mumbai was carried out during January to December, 2013. Dominant cephalopod fishery recorded include one species of squid, *Uroteuthis (P) duvaucelii*, three species of cuttlefishes, *Sepia elliptica, Sepia pharaonis*, *Sepiella inermis* and a species of octopus, *Cistopus indicus* together contributing 98% of total cephalopod landings. Estimated total annual economic gain calculated using bioeconomic model was Rs. 33.22 crores with estimated biomass gain of 4995 t per annum, if juveniles are allowed to grow up to length at first maturity $(L_m)/L_{mean}$. Among five species, *C. indicus* contribute maximum with 64.07 % of average juvenile catch followed by *U. (P) duvaucelii* (26 %), *S. elliptica* (23.63 %), *S. inermis* (23.27 %), and *S. pharaonis* (12.85 %). On these resources, while in *S. inermis*, both Lm equals L_{mean} indicates breakeven point for the species. The study revealed that peak spawning season of these species coincides with peak juvenile landings which may result in reduction of overall size range thus will lead to loss of fishery in economic as well as ecosystem regime. The study indicates the improvement of harvest biomass by 2.95 times which would result in generating additional revenue to the fishers by a margin of 3.71 times; if juveniles are allowed to grow up to Lm/ L_{mean} whichever is greater. Based on finding of present study management measures such as temporary fishing holidays at juveniles fishing grounds, feeding grounds and spawner abundance grounds which in turn allow these high valued species to contribute to the fishery with high economic gain and sustainable utilization of the resources may be adopted.

Key words: Cephalopods, Bycatch, Juvenile fishing, Economic loss

INTRODUCTION

Cephalopod fishery comprises mainly of squid, cuttlefish and octopus and forms high valued seafood commodity next to shrimp being exploited principally by trawl gear[16, 29]. Maharashtra occupies second position in cephalopod fishery of the country[4]. The species commercially exploited are Indian squid *U.(P.) duvaucelii*, Ovalbone cuttlefish *Sepia elliptica*, Pharaoh Cuttlefish *Sepia pharaonis*, Spineless cuttlefish *Sepiella inermis* and Old women octopus *Cistopus indicus* and which forms 98% of the total cephalopod landings of the state[29]. Cephalopod resources contribute 10% of seafood export earnings of the country experiencing high fishing pressure[15]. Furthur damage to this resources is done by the non-selectivity behaviour of the trawl gear, as a result juvenile landings of these commercially important species are noticed round the year[16, 18, 22, and 3]. Wider continental shelf with even topography down to 50-60 m depth of northwest coast provides more trawling area; especially off Mumbai where more than 270 km from the coast is having depth below 100 m[2]. Trawl cod end mesh size of 10 to 25 mm are being practised in the country despite the regulation of 35 mm size[20]. Adding to the above, multiday trawl fishing, which benefits the investors in terms of low production cost, also encourages juvenile landings of high valued species[21]. With ever increasing market value for juvenile cephalopod landings, the entire juvenile caught by multiday trawl fleet are brought to landing centre and utilised for export as processed food and being sold in domestic market. New Ferry Wharf (NFW) landing centre alone accounts for 33% of trawl landings of Maharashtra state[4]. NFW, Sassoon Docks and Versova landing centres, account for nearly 60% of Maharashtra landings[1]. In view of the increasing economic importance and decreasing cephalopod resources the present study was an attempt to quantify juvenile landings of five dominant cephalopod species, landed as by catch at NFW, Mumbai and the resulting economic loss to the fishers. The findings of the study would form the data base for formulating suitable strategy and policy for the sustainable management of these valuable resources.

MATERIALS AND METHODS

Experimental trawling off NFW was carried out by shrimp trawlers, which belong to Gujarat fishermen. . The trawlers operated ranged between 12.5-15 m plank-built boats in overall length (OAL) fitted with 95-160 bhp engines and fish holding capacity of 5-6 tonnes. The trawl nets used were 40-60 m in length with 18-25 mm cod end mesh size. The size of the otter boards used for the net is 76×165 cm while the weight of each otter board ranges from 55-80 Kg. These trawlers undertook voyage trips lasting for 10-15 days of fishing. It takes 1-2 days steaming time to reach the fishing grounds and the actual trawling hours are 120-140 h/trip. The fishing area extends from south of Saurashtra coast to Ratnagiri covering an area (17^0-21^0 N and 71^0-73^0 E) of approximately 25, 000 sq.km. The depth of operation ranged between 60-80 m.

Weekly observations were made at NFW during January to December 2013 to collect the data on the landings of juveniles, adults, and their total catch and price of all five species. Size-wise juvenile's landings were also recorded. Catch data between 1st June to 15th August was not available due to southwest monsoon and trawl ban imposed by the Maharashtra government. The Dorsal Mantle Length (DML) was the standard length measured using digital calliper. The total number of boats landed and the total catch landings of five species were obtained from the database at Mumbai Research Centre of Central Marine Fisheries Research Institute.

The catch recorded from the observed number of boats on the day of observation was raised to total number of boats landed on that day, and then raised to the month and monthly estimates were used to arrive at annual estimates by taking into consideration the number of fishing days and monthly estimated number of boats by following the method of Sekharan[23] to determine the quantity of adults and juveniles of each species landed during the study period. Based on Length at first maturity collected from published papers for each species, proportion of juveniles and adults from observed length frequency data was determined for all the five species.

Species wise total juvenile and adult weight corresponding to length data was calculated based on length-weight relationship method[14]. Class intervals of 5 mm DML were used as size frequency datasets for *S. inermis* and 10 mm DML for remaining four species. Adult biomass corresponding to 1 kg of juveniles was obtained from Bio economic model and economic loss due to juvenile fishing were estimated following the method of Najmudeen *et al*[18]. The mortality rate was calculated as the proportion of total and natural mortality[9]. The economic loss due to juvenile landings of each species was estimated by assuming that the weight gained if they were allowed to grow up to average mean length or length at first maturity, whichever is later. The concept is that in that length most animals in the population would have an opportunity to become mature and spawn and contribute to the future generation sustainably. The annual average landing centre price of adult and juvenile of each species were used to estimate the economic loss.

RESULTS AND DISCUSSION

The length at first maturity (L_m), average annual mean length (L_{mean}) and average annual landing price structure of adult and juveniles and length range during study period of all the five species are shown in Table 1. The percentage distribution of size ranges of juveniles of different species landed are shown in Figure 1.

The estimated annual juvenile landings of *U. (P.). duvaucelii* forms 26 % of total catch with peak landing during January followed by February and November (Table 2). Kuber[12, 13] and Kizhakudan[11] reported the peaking spawning season for *U. (P.). duvaucelii* along northwest coast is from December to May, which results in more landings of juveniles similar to the findings of present study. Sundaram[29] also observed peak landing abundance during March to April. In *U. (P.). duvaucelii*, L_{mean} was 134.38 mm and L_m was 90 mm, if juveniles are not caught and allowed to grow up to $L_{mean,}$ an additional revenue of Rs. 18.48 crores (Table 2) would have been realized and biomass added was found to be 937 tonnes per annum. The percentage-wise juvenile size group landed is shown in Figure 1. Mohamed[15] estimated juvenile landing of *U. (P.). duvaucelii* along west coast from 1997 to 2001 with 12.8% and from 2002 to 2005 with 5.3% to total catch. The increase in juvenile landing year by year may be due to technological advancements, sectoral conflicts between fishers [18]. Mohamed[15] used Minimum legal size (80 mm) as cut-off point between juvenile and adult size, whereas in the present study L_m 90 mm was used as cut-off point as followed by several authors[18, 9, and 6]. Mohamed[15] estimated juvenile loss of *U. (P.). duvaucelii* as 188.2 crores for whole India from 1997 to 2005 by using L_{mean} as cut-off point similar to the present study. Mohamed[16] reported minimum size range landed was 35-40 mm along west coast,

Table 1: Length at first maturity, L_{mean} and average annual landing prices of 5 selected species of cephalopods

S. No.	Species	L_m (DML in mm)	L_{mean} (DML in mm)	Average annual landing price Juveniles in Rs/kg.	Adults in Rs/kg.
1	*U. (P.). duvaucelii*	90	134.38	67	133
2	*Sepia elliptica*	80	61.63	40	78
3	*Sepia pharaonis*	153	239.55	80	234
4	*Sepiella inermis*	40	42.49	27	55
5	*Cistopus indicus*	80	52.9	30	57

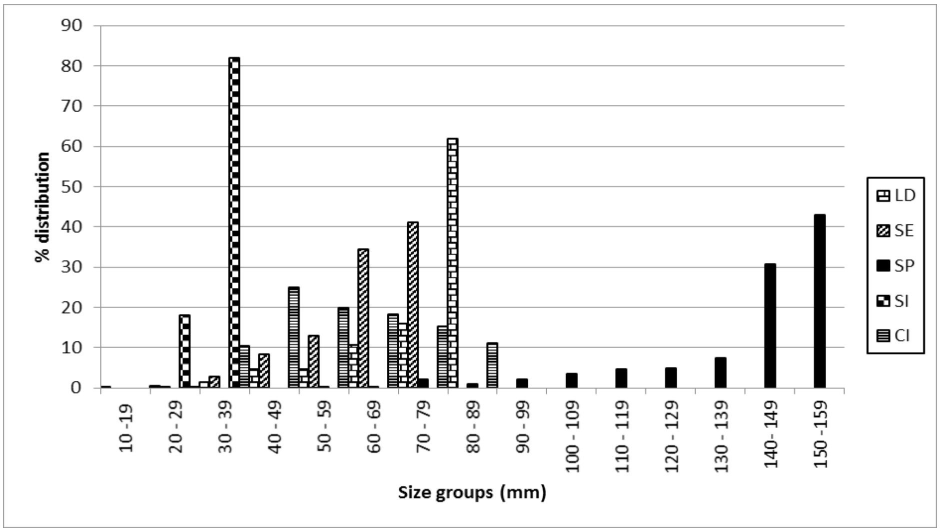

Fig. 1: Percentage distribution of juveniles in various size groups of cephalopods LD- *U. (P.). duvaucelii,* SE- *Sepia elliptica*, SP- *Sepia pharaonis*, SI- *Sepiella inermis*, CI- *Cistopus indicus*

whereas present study reports minimum landed size range was 10 - 20 mm.

The estimated juvenile landings of *S. elliptica* was found to be 23.63% of total catch with peak landing in March followed by January and February i.e., during postmonsoon period (Table 2). In *S. elliptica,* L_{mean} was less than $L_{m,}$ it means species was experiencing juvenile overfishing during the study period. L_m was used as cut-off factor in estimating economic loss of juveniles, by stating that if juveniles are allowed to grow up to L_m instead of $L_{mean,}$ an additional biomass of 616 tonnes per annum may be realized and estimated loss was found to be Rs 2.34 crores (Table 2). According to Kasim[10] spawning season of *S. elliptica* was from October to March along the northwest coast of India. In the present study, the maximum number of juveniles was observed in the catch during March - May, it means once juveniles recruited to the fishery are fully exploited. Hence having fishing restrictions during March-May would help in curtailing the economic loss due to exploitation of juveniles and would also ensure conservation of the species.

In *S. pharaonis*, estimated juvenile landing was 12.85% of total catch with peak landings in April and May i.e., during premonsoon period (Table 2). In *S. pharaonis*, the average annual mean length was 239.55 mm and L_m was 153 mm. If juveniles are not caught and allowed to grow up to $L_{mean,}$ additional revenue of Rs. 9.8 crores (Table 2) would have been realized and biomass added was found to be 638 tonnes per annum. Sundaram[30] reported peak spawning period was from February to May and second spawning from October to December which results in more landings of juvenile. Nair[17] reported that length at first maturity was high on west coast from 157 – 160 mm, the same results was observed by Silas[25]. Mohamed[15] estimated economic loss due to juvenile landings of *S. pharaonis* along Indian coast as Rs. 252.16 crores if it is allowed to grow up to $L_{mean.}$ Due to high price in export as well as in domestic markets, the entire catch of *S. pharaonis* is landed (Mohamed[16]), which encourages juvenile utilisation without discards. Mohamed[15] estimated juvenile landings of *S. pharaonis* on west and east coast with 6.9% and 22.4% respectively to total catch from 1998 – 2004 with minimum size-range observed on west coast with 35 – 65 mm, whereas

Table 2: Economic evaluation of juveniles of 5 selected species of cephalopods

S.No.	Species	Estimated juvenile landing (tonnes)	Price realized for juveniles (<LFM) (Rs in crores)	Estimated biomass (tonnes)	Fold increase in biomass per year	Estimated price realised (economic loss) (Rs. in crores)	Fold increase in total revenue per year	Month of Maximum juveniles landing	Month of Minimum juveniles landing
1	*U. (P). duvaucelii*	912	6.11	2800	3.07	18.48	3.02	January	December
2	*Sepia elliptica*	254	1.02	617	2.43	2.34	2.29	March	November
3	*Sepia pharaonis*	142	1.14	639	9.83	9.83	8.62	April	August
4	*Sepiella inermis*	199	0.54	357	1	1.00	1.85	November	February
5	*Cistopus indicus*	189	0.57	582	1.57	1.57	2.75	December	February

LFM = Length at First Maturity

in the present study minimum size- range observed was 50 – 60 mm.

Annual estimated juvenile landings of *S. inermis* was found to be 23.27% of total catch with peak in November, September and May. In *S. inermis,* L_m and L_{mean} was found to be same at 42.49 mm, the economic gain realised at this length was Rs. 1 crore and realised estimated biomass was 357 tonnes per annum (Table 2). Sundaram and Khan[28] reported four spawning seasons (October, January, April and August) similar observation was made in the present study with three peak juvenile landing season. Neethiselvan[19] 2002 reported the continuous occurrence of immature and mature individuals throughout the year proving that there is high chance of occurrence of juveniles in landings. Sundaram and Chavan[31] reported maximum number of indeterminants in May – June which coincide with juvenile landings of our study.

In *Cistopus indicus*, annual estimated juvenile landings was found to be 64.07% of total catch with maximum landing in December (Table 2). L_m at 80 mm was more than $L_{mean.}$ 52.9 mm was taken as cut-off factor for estimating economic loss and it was found to be 1.6 crores and realised biomass was 583 tonnes per annum. Sundaram and Deshmukh[32] recorded that all females of *C. indicus* mature above 130 mm with speak spawning season from March to May. In the present study, most of the juveniles are landed before peak spawning season that indicate growth overfishing which may leads to collapse of this fishery in future.

Very few researchers had estimated the economic loss of bycatch from trawl net in India, of which Najmudeen and Sathiadas[18] estimated the economic loss due to juvenile fishing from trawlers of India and loss was found around 15,686 million US dollars per annum. Salim[21] estimated economic deficit of juvenile landings in trawl net of Ernakulum district, Kerala with loss of Rs.1350 per trip per trawl. All these works estimates accounts only for the loss from landed catch, however discards still remains unaccounted. Dineshbabu[6] estimated economic loss due to landing of low value finfish as bycatch in trawl net along Mangalore coast, Karnataka during 2011 and the loss was found to be Rs. 280 million and further stated that landing and utilization of low value bycatch (LVB) over the period in Indian coast increased from 14% in 2008 to 25% in 2011, this increasing trend was due to increase in price and demand for LVB for the production of fish meal and fertilizer. The present study shows that harvest biomass can be improved by 2.95 times and would result in 3.71times additional revenue to fishers if juveniles are allowed to grow up to L_m or L_{mean} whichever is greater. Similar study conducted by Mohamed[15] on two species of cephalopods-*. U. (P.). duvaucelii* and *S. pharaonis* along entire Indian coast, estimated that the harvest biomass can be improved by 25 and 34 times respectively if juveniles are allowed to grow up to L_{mean}.

Due to increase in gap between demand and supply, increase in domestic prices of juveniles, increasing fishing fleet size, increasing fishing hours, demand for value added products in domestic and in export markets, decreasing catch per unit effort, complexity in implementing legal enforcement in multispecies multi-gear fishery, leads to reduce discards of juvenile/low-value bycatch on one side and encourages landings of juveniles of high valued species on another side which in long term will question the sustainability of these resources[24, 27, 8, 26, 5, 7]. The study reveals that peak spawning season of these species coincides with peak juvenile landings which may result in reduction of overall size range thus will lead to loss of fishery in terms of economics as well as ecosystem regime. Due to increase in juvenile landings of cephalopods, loss in terms of economic and biological benefits to the stakeholders can be mitigated with implementing temporary fishing holidays in juveniles fishing grounds, feeding grounds and spawner abundance grounds.

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