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An examination on the biological economics of inshore shore seine fishery: A case study from Dhanushkodi Island, Tamil Nadu

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Shore seining at Dhanushkodi, Tamil Nadu was an age old practice and its approach to fish, fisheries and fishers were detailed in the present study. The entire beach seining was carried out on the sea grass meadows which forms the breeding and feeding grounds of commercially important fishes and in turn showed the over dominance of juveniles in the catch. Gonadal examination itemised that, the majority of the fishes were in immature and maturing stage of ovarian development. The economic evaluation of juveniles of six important fish species reported a total economic loss of about INR 44.64 crores during 2015-16 by shore seining at Dhanushkodi. The gross revenue of fish landed per day varies from Rs 300 to Rs 15,000 and average reported being Rs. 5000/day in one unit. A total of 22 to 24 fishers involved in the activity and the profit has to be distributed accordingly.

[**Keywords:** Shore seining, Sea grass, Juveniles, Economic loss, CPUE]

Introduction

Shore seining is one of the commercially important traditional fishing method, practise immemmorial over the world for several thousand years [1]. Economic importance of growth over fishing were also highlighted[2]. Proper documentation of the traditional fishing gear and its operational activity especially the shore seines and its operational facts were meagrely reported from the marine fisheries sector. Some aspects of the structure, operational details and the fishery economics were articulated by various workers [2,3,4,5,,6,7,8.] . Tamil nadu, one of the leading marine fish producing states of India, has a coastline of 1076 km, 0.19 million sq.km EEZ and a continental shelf of about 41,412 sq.km holding the second position in the marine fish production of 0.709 million tonnes [9] . The marine fisheries potential of the state was estimated to be 0.719 million tonnes. Dhanushkodi (9° 10' 45.7392 N, 79° 25' 6.0348 E) located on the tip of Rameswaram Island separated to the mainland by Palk Strait which is about 24 kilometres from the Rameswaram town. Growth over fishing of commercially important fishes along the sea grass beds is a question for the sustainability of fishes, fishers and fisheries of the island. Continuous replacement of juveniles of finfishes and shellfishes on a large scale was indeed detrimental to the fishery and the subsequent recruitment will be affected[10]. Bulk of marine fish production comprised of juveniles and sub-adults [11]. The area selected for the present study is a rich bed of sea grass which forms the breeding and nursery ground of finfishes, shellfishes and molluscs. Despite the importance of sea grass beds and its contribution to the fisheries, there is scarce information on the social, biological and economic status of shore seine fisheries of Tamil Nadu. This is a preliminary attempt to analyse the biological economics of traditional shore seine fishery of Tamil Nadu especially at Dhanushkodi, a most sensitive ecosystem. Keeping the above scenario in mind, the objective of the present study is to assess the impact of shore seining on fishery resources and aquatic habitat and to identify the key issues relevant for the responsible use of shore seines and the sustainable livelihood of fishers.

Material and Methods

Seine is locally known as "*Kara vala* or *Marukku vala*" consist of a seine body at the centre and a codend to which the wings (both at the anterior and posterior) were attached. The seines were backed up by float lines and sinker lines, which helped the gear to keep the surface part to float and the lower part to been attached to the bottom and thereby preventing the escape of fishes respectively. Mesh size of the cod end and wings varies from 16mm to 18mm and 22 –

26 mm respectively. Hauling warps are attached to the both end of the wings which constitute around 1075 m along the both sides. Gear was fabricated with long wings and hauling rope to cover the maximum distance of fishing area. Fishers applied an indigenous technical knowledge of using tender coconut leaves which tied in a rope and attached to wings to get a herding effect. Overall length of the gear is about 1600m and they operated up to a depth of 3.5m. Fishing ground is around 2-2.5 km from the shore and the time of operation seems to be 4.00 am to 11.00 am in the morning. Traditional non-motorized boats were used to set the seine, while setting, one of the hauling warp was fastened to the shore by 2 -3 crews and towards the sea, the shore ward wing, seine body and seaward wing were set in a wide arc and make sure that the entire seine is in water which surrounds the fish shoal, then the second hauling rope was brought back to shore. Seines were set in the sea for 2 hours and after that, the hauling warps were hauled simultaneously to the beach manually by the crew members includes men, women and even children. Hauling rope and wings fabricated with coconut leaves herded the entire fish to the centre section of the seine. Gear targeted mainly finfishes, shell fishes, cephalopods and even some gastropods and bivalves.

The location of the present study is shown in Figure 1. Study was conducted from July 2015 to June 2016, a regular visit to the island was carried fortnightly and collected the catch composition of various units operated on that particular day of sampling. Length and weight data of six commercially important fishes from the shore seine fisheries were recorded along with the auctioned

Fig. 1 — Location of the present study

price. Those fishes below the size of length at first maturity (Lm) were considered as juveniles and Lm of the fishes were collected from the earlier published works. Proportion of juveniles and adults based on the length frequency data were also calculated. Catch from the units observed on the observation day was raised to the total number of units operated on that day and then raised to the month. Following the method of Alagaraja and Srinath[12] the annual estimates were arrived by considering the monthly estimated number of units and the actual fishing days. Economic evaluation of juveniles was estimated by considering the assumption that the weight gained by each species when it attained the length at first maturity. The biomass of adult corresponding to 1 kg of juveniles was calculated by the formula,

$$QA = ((100/w)\ W/100)\ (1\text{-}M)^{13}$$

where QA is the adult biomass corresponding to 1 kg of juvenile after a period of 't' years; w is the individual weight of juvenile in gram; W is the individual weight of adult fish after t years and M is the mortality rate. The individual weight of adult fish corresponding to the juvenile fish after t years was calculated from the established length-weight relationship of the same. This was followed by fitting the bio economic model [13, 14, 15]to calculate the economic loss due to juvenile fishing and the formula is given as:

$$EL = (\sum_{i=1}^{n} C_i\, Qi/(1+\delta)^t/_n) - (\sum_{i=1}^{n} c_i\, q_i/n)$$

where EL is the average economic loss for the quantity of juveniles landed for the six species, Ci and ci denotes the average whole sale price of adult and juvenile fishes of each species respectively, Qi is the estimated quantity of adults equivalent to the quantity of juvenile landed (qi), '□' is the standard discount rate, 'n' is the total number of species studied and't' represent the age of corresponding fish in years at minimum harvestable size. A field survey (Socio – economic) was carried out in the island along with the ichthyofaunal sampling to identify the key issues of fishers and fisheries.

Results

A total of 86 shore seine hauls were monitored between July 2015 and June 2016. About 50 commercial important fishes were identified. The juveniles in each haul dominated more than 75 percent of the catch. There was a tremendous decline in the catch as well as the effort during the last 10 to 20 years which executed that the effort and CPUE decreases

from 150 to 12 units and 1 – 2 t to 5 – 800 kg respectively and the maximum CPUE reported was 700 kg during the study. The monthly catch data of shore seines at Dhanushkodi are shown in Table 1.

Landings of major fishery resources, season wise fish diversity and major species landed were shown in Figure 2 & 3. Percentage contribution of juveniles in total fish landings by shore seines during different season was shown in Figure 4. The gonadal examination of the collected fish samples provided the month wise immature, maturing and mature percentage and it was shown in Table 2. The mean length, length at first maturity and price comparison of adult and juveniles of the commercially important fishes were shown in Table 3. Economic evaluation of six major fish species was shown in Table 4 and the gain in biomass and revenue due to juvenile fishing, when the juveniles were allowed to grow up to its Lm were shown in figure 5. A total of 13 sea grass species were identified by earlier workers [16, 17]but during the present study only 6 species were identified. Three fourth of the respondents were opined that the populations are dropping drastically, attributing to

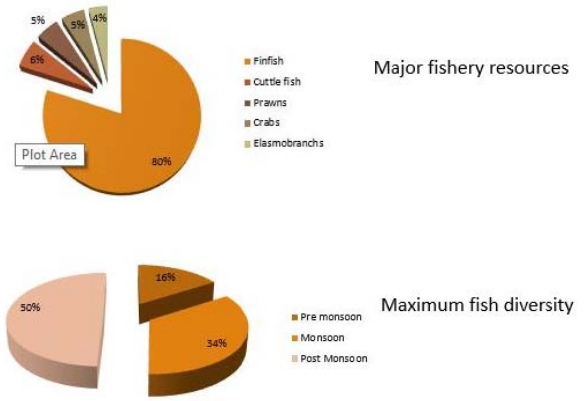

Fig. 2 — Landing of major fishery resources and season wise fish diversity

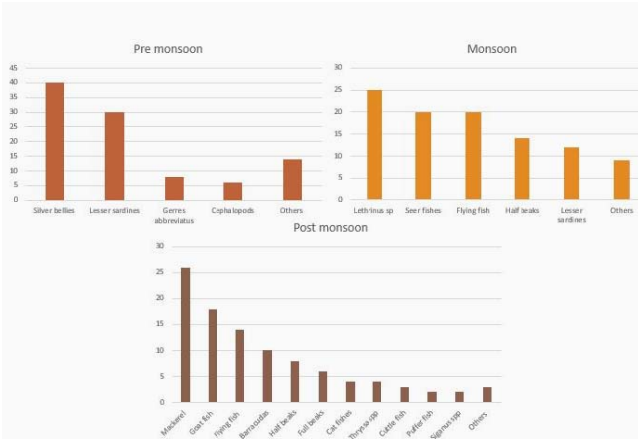

Fig. 3 — Season wise landing of major fish species from shore seines at Dhanushkodi (%)

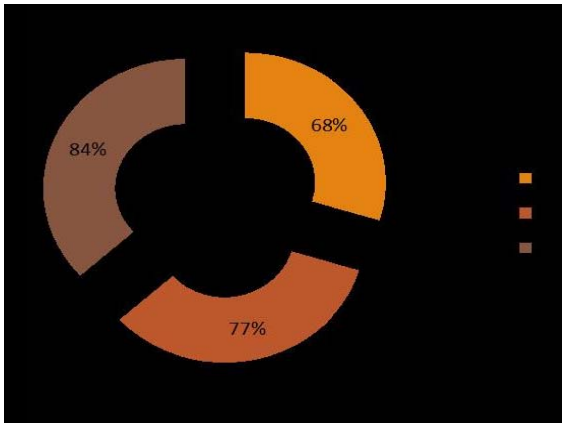

Fig. 4 — Season wise percentage contribution of juveniles in total fish landing of Shore seines at Dhanushkodi

Table 1 — Monthly catch data of shore seines at Dhanushkodi (July 2015 – June 2016)

Month	Number of units operated	Total catch landed (tonnes)	Average CPUE (kg)
July 2015	294	129	435
August	345	134.5	390
September	360	126	350
October	348	178	515
November	354	184	520
December	346	171	495
January 2016	358	225	630
February	339	196.5	580
March	344	190	552
April	328	152	462
May	342	148	432
June	324	140	430

Table 2 — Gonadal examination of juveniles of six commercially important fishes

Month	Immature (%)	Maturing (%)	Mature (%)
July 2015	49	32	19
Aug	48	33	19
Sept	56	28	16
Oct	52	30	18
Nov	42	32	26
Dec	59	30	11
Jan2016	56	32	12
Feb	51	33	16
Mar	61	28	11
Apr	56	25	19
May	54	22	27
Jun	52	18	30

Table 3 — Mean length, Length at first maturity (Lm) and landing centre price of adults and juvenile fishes

Species	Mean length (mm)	Lm (mm)	Landing centre price (Rs/kg)	
			Adult fish	Juvenile
Lethrinus nebulosus	190	394	200	50
Scomberomorus commerson	310	790	400	60
Rastrelliger kanagurta	142	217	100	40
Upeneus tragula	72	145	100	30
Sphyraena obtusata	115	295	120	40
Sepioteuthis lessoniana	64	139	150	40

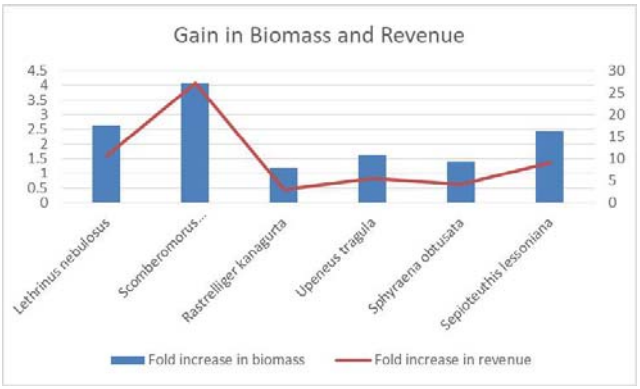

Fig. 5 — Gain in biomass and revenue when the juveniles were allowed to harvestable size

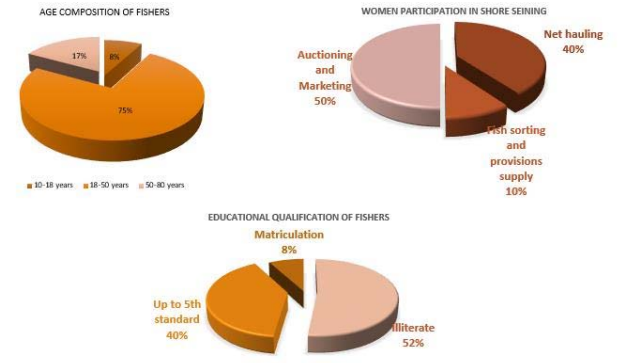

Fig. 6 — Socio-personal characteristics of fishers at Dhanushkodi Island

intensive fishing activity and heavy turbulence.

Sea grass species identified were *Halodule uninervis, Halophila sp, Syringodium isoetifolium, Cymodocea rotundata, Cymodocea serrulata* and *Enhalus sp*. Socio – economic survey carried out at the island along with the ichthyofaunal sampling identified the key issues of fishers and fisheries. The significant findings of the socio-economic survey was shown in figure 6.

Discussion

The present study revealed the non-selective multispecies fishery of shore seines, which landed mainly finfish (80%), Cuttle fish (6%), Prawns (5%), Crabs (5%) and Elasmobranchs (4%). Maximum fish diversity was observed during the post monsoon season (50%), followed by monsoon (34%) and pre monsoon (16%). Saleela *et al*.,[8]also observed the maximum diversity and landing during post monsoon season by shore seine at Poovar. During the post monsoon and monsoon, fishery mainly comprised of juveniles of high value fishes which includes Seer fish *(Scomberomoru scommerson), Lethrinus nebulosus, Rastrelliger kanagurta, Ablennes hians, Strongylura strongylura, Upeneus tragula, Sphyraena obtusata, Exocoetus sp, Sepiotheuthis lessoniana, Penaeus semisulcatus, Portunus pelagicus* etc. but during the pre-monsoon the fishery comprised of only Silver bellies, lesser sardines and some other low value fishes. Awesome fishery during the monsoon and post monsoon articulated the presence of commercially important finfishes and shellfishes in the sea grass beds for breeding and feeding.

Percentage contribution of juveniles in the total catch varies during season and the maximum landing during post monsoon (84%) followed by monsoon (77%) and pre monsoon (68%). The contribution of juveniles to total landing was almost same throughout the year really questioned the sustainability of fishery of the Island. Six important fish species landed by shore seine were selected for studying the gonadal maturity and economic evaluation of juveniles. Gonadal studies revealed that, the average percentage contribution of immature samples were 53.5% followed by maturing, 28.2% and the least by the mature individuals, 18.46% in almost all the months. Operation of shore seine was mostly concentrated on the seagrass beds, which resulted in large quantities of juvenile catch. Economic evaluation of juveniles of six important species revealed the tremendous economic loss due to the juvenile fishing. From the table 4, it is apparent that, the estimated juvenile landings of *Lethrinus nebulosus* one of the major breams landed at Palk Bay formed about 59 tonnes during the year and the landing centre price was Rs. 50 per kg. If the juveniles could have allowed to grow up to its length at first maturity (Lm), the estimated adult landings will be of 156.35 tonnes and the gross revenue estimated will be 3.12 crores. This is 2.65 times more than the juvenile landings and

10.76 times more than the gross revenue of it. *Scomberomorus commerson,* another high valued export quality fish with an annual juvenile landing of 61 tonnes and the approximate gross revenue obtained for juveniles estimated to be 0.366 crores. If the fish was allowed to its Lm, the estimated adult biomass will be of 248.27 tonnes and the price accounted to be 9.93 crores, and there will be 4.07 fold increase in biomass and 27.13 increase in revenue. *Rastrelliger kanagurta,* the national fish of India facing a huge fall in catch throughout Tamil Nadu[9]formed about 43 tonnes of juvenile catch from the seine articulating to 0.17 crores. The estimated adult biomass and gross revenue will be 52.03 tonnes and 0.52 crores respectively with 1.21 fold increase of biomass and 3.05 fold increase of gross revenue. *Upeneus tragula*, one of the major goat fishes of Palk Bay which holds high demand in domestic market, formed about 66 tonnes of juvenile landing accounted to be 0.19 crores. There will be 1.62 fold increase in biomass and 5.58 fold increase in gross revenue, if the fish could have been allowed to grow to its Lm. *Sphyraena obtusata,* domestically demanded obtuse barracuda formed about 76 tonnes of juvenile landing turned to be 0.304 crores. There will be an estimated 106.92 tonnes of adult biomass and 1.26 crores of adult fish gross revenue with 1.39 fold increase in biomass and 4.35 fold increase in revenue, if the fish was allowed to its Lm. *Sepioteuthis lessoniana*, commonly known as Palk bay squid formed about 49 tonnes of juvenile landing with an approximate gross revenue of 0.196 crores. There will be 2.44 fold increase in biomass and 9.13 fold increase in gross revenue if the fish was allowed to grow up to its Lm. The fold increase in revenue and biomass was maximum in case of *Scomberomorus commerson* followed by *Lethrinus nebulosus, Sepioteuthis lessoniana, Upeneus tragula* and *Sphyraena obtusata*. This was only a preliminary assessment of juvenile fishery by shore seines around Dhanushkodi Island, by considering only a few number of dominant fishes. Large scale landing of other valuable resources will be needed to understand the real picture of juvenile fishery along the island. Even though the profit obtained from the low value fishes were low, the increasing demand in the production of fish meal and fertilizer, it is being caught[18] .Radhakrishnan *et al.,*[19]reported that, 50 per cent of the observed catch consist of juveniles in Indian waters. The concept of surplus production model evolved for fish stock assessment with a basis that, to get proper food supply and growth, it is better to remove a part of the stock from the aquatic system. But if the juveniles are removed continuously, it will thoroughly affect the proper recruitment and replenishment. Matsuoka, 2008[20] reported that, major portions of the by-catch comprised of juveniles of commercially important fishes. Even though FAO[21]has encouraged the fisheries by-catch as they are properly utilized, but Armstrong *et al.,* 1990[22]clearly defined the good fisheries management by fulfilling the criteria that, fishing gears should retain only the large sized fishes while allowing the juveniles to escape. The study of assessment of juvenile fishery by shore seines along Tamil Nadu coast was very meagre and couldn't found a single reference from the same. Literature review from India recognized some studies related to the estimation of economic loss due to juvenile fishery by trawlers. Najmudeen and Sathiadas (2008)[13] estimated an economic loss of 15,686 million US dollar per annum due to the juvenile fishing from Indian trawlers. Dineshbabu *et al.,* 2014, [23]estimated the loss due to low value bycatch along Manglore coast was found to be Rs. 280 million. Mohammed et al., 2009,[24] quantitatively and qualitatively assessed the exploitation of juvenile cephalopods from Arabian Sea and Bay of Bengal and estimated an economic deficit of Rs. 425 crores articulating the juvenile landings of *Uroteuthis duvaucelli, Sepia pharaonis* and *Octopus membranaceous.* Gaihiamngam *et al*., (2013)[14] assessed the economic impact of juvenile fishing of six dominant sciaenids at New Ferry Wharf and estimated about 68 crores. Sugumar *et al.,* (2015)[15] evaluated the economic impact of juvenile landings of five dominant species of cephalopods from Mumbai waters and estimated the loss of Rs, 33.22 crores and recently Sugumar *et al.,* (2016) [25] assessed the economic impact of growth overfishing of commercially important four marine ariids and estimated total annual economic gain of Rs. 13.15 crores with an estimated biomass gain of 1222 tonnes per annum.

The socio economic survey conducted along with the ichthyofaunal sampling exposed the poor living standards of the fishing community involved in shore seining. It was surprised to see the age composition of crew members which ranges from 10 to 85 years. Average age of the crew members around to be 36 years. There was strong participation of children, and old people in setting and hauling of nets. Active

participation of women in shore seine operation includes; hauling of nets, sorting of fishes, collection of in-kind remuneration on behalf of husbands, auctioning, processing and marketing of fishes were also remarkable. Usually middle aged and old aged women were the participants of seining. More than 50 per cent of the crews were illiterate and the average educational qualification was merely at primary level. Majority of the crew and household members neither attended school nor completed their primary level of education. Maximum educational qualification reported during the study was up to matriculation (less than 5%). There was a strong kinship ties between the shore seine owners and the crew members, the entire family was involved in fishing activity and the legacy is being continued. There was full time involvement (100%) in shore seining by the fishers and net mending was the additional fisheries activity they were involved that to during the lean season. There was no non fisheries occupation for men as well as women in the fishing community and shore seining formed the only household income. So there was 100per cent dependency on shore seining for their family income. All the fisher families involved in seining were under the national poverty line and vulnerable to absolute poverty. Majority of the houses were made in traditional ways and a lot of houses were not equipped with electricity even. Catch depletion, competition from other users, natural calamities and diseases were some of the vital determinants contributing to the vulnerability of shore seining at Dhanushkodi.

The bulk catch of high valued juvenile fishes from the sea grass beds of Palk Bay throughout the year resulting in the catch depletion and thereby affecting the sustainability of the fish and fisheries of the island. Their poor living standards, low literacy rate, unforeseen natural calamities always enforced the fishers to exploit the catch either juveniles or sub adults. Tamil Nadu Marine Fisheries Regulation Act is the only management regulation existing for the shore seine fisheries at Dhanushkodi Island, but its effectiveness was very meagre. Traditional boats used were not registered and not following the mesh size regulations even. The study recommends the following measures to maintain the sustainability of fisheries at the island which includes, seasonal closure of fishing grounds, seasonal ban, gear modifications, mesh size regulations, co-ordination of community awareness programmes, community participation in monitoring fishery management measures and a thorough assessment of shore seine fishery for a longer duration from various area of operation to develop a reliable data base on fishery. Recommendations indicated above can be achieved easily by Ecosystem based fisheries management and occupational diversification to other income generating sources. The restoration of sensitive ecosystem like the sea grass beds by utilizing the ecological knowledge of traditional fishermen is necessary to manage the feeding and breeding grounds of commercially important finfishes, shellfishes and molluscan resources.

Conclusion

The traditional inshore shore seine fishery at Dhanushkodi, Tamil Nadu is an age old fishing activity presently facing an immense depletion in catch and effort when compared to the historic maximum. Identified about 50 commercial important fishes from the catch and >75% of the catch were dominated by the juveniles. There was a dreadful decline in the catch as well as the effort during the last 10 to 20 years. During the study the maximum CPUE reported was 700 kg and the entire beach seining was carried out on the seagrass meadows which forms the breeding and feeding grounds of fin fishes and shell fishes. Gonadal examination itemized that, the majority of the fishes were in immature and maturing stage of ovarian development. The economic evaluation of six major fishery resources revealed that there will be multi-fold increase in biomass and revenue, if the fish was grown up to its maturity. Economic status of the fishers was substantially low, no fisher involved in the activity were above the poverty line and there was no non-fisheries occupation for men and women other than shore seining. Source of house hold income other than fishing was completely nil so that there was full-time involvement of fishers.

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