Assessment of economic impact of juvenile fishing of sciaenids along Mumbai Coast, India

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Present study is about the economic loss to fishery sector of sciaenids fishery resource due to juvenile fishing. Sciaenids fishery include two species of bigger sciaenids O. biauratus (Cantor) and P. diacanthus (Lacepede ) and four species of lesser sciaenids J. macrorhynus (Mohan), J. vogleri (Bleeker), J. sina (Cuvier) and O. cuvieri (Trewavas). Study was done for Mumbai coast using bio-economic model, based on data from three important landing centers (New Ferry Wharf, Sassoon Docks and Versova) of Mumbai. Total estimated economic loss was at about INR.128 crores for 2010-2011 being highest from New Ferry Wharf (Rs. 68 crores) and lowest from Sassoon Docks (Rs.25 crores). The major economic deficit is in the month of November. Study provides an insight about the loss due to juvenile fishing in a shrimp oriented fishery where juveniles of other fishes form a major portion of the by-catch. This would reduce future yield to the fishery besides economic loss.

[Keywords: By-catch; Economic loss; Juvenile; Sciaenids]

Introduction
India, with a coastline of 8129 km and an extensive EEZ of 2.02 millions Km², has an estimated marine fishery potential of 3.9 million tonnes per annum. The marine fishery of the country has been providing an important source of occupation and livelihood for the Indian coastal communities. Over a span of last 50 years, marine fish catches increased considerably from 0.6 to 3.16 million tonnes, contributing 4.6% to the agricultural Gross Domestic Production (GDP) of the country. In India the Sciaenids catch along North West coast is very high. Sciaenid also known as croakers, drummers and jew fish is an important demersal fishes occurring from the edge of the continental shelf to shallow coastal waters from the depth of 50-70 m, occupying second major important demersal fish contributing 5.4% of the total marine fish production of India during 2010-2011. The landing of Sciaenids in Maharashtra is 8.45% to the total marine fish catch of the state with an estimated value of 2215 crores. There is a challenge on sustainability of fishing resources due to increased juvenile fishing. Growth overfishing occurs when the fishery targets fishes of a size below the optimal harvestable size. When the fishes are removed before the cohort has had the opportunity to achieve its maximum biomass level, the fishery will lose much of the potential yield that could be achieved by catching them in the near future. The juveniles are the future adult stock which play vital role for availability and maintenance of every future fish stock. Large-scale removal and destruction of young and juveniles of fishes and crustaceans are especially detrimental to the fishery because when juvenile mortality is increased the future catches and subsequent recruitment will be affected. Juveniles contribute more to the Sciaenids fishery forming 1.8% of the group catch in 2000. Sciaenids selected for the present study include the commercially important six species, namely, bigger Sciaenids such as Protonibea diacanthus (Lacepede) and Otolithoides biauritus (Cantor) and lesser Sciaenids such as Otolithes cuvieri (Trewavas), Johnieops vogleri (Bleeker), Johnius macrorhynus (Mohan) and Johnieops sina (Cuvier).

Bulks of the marine landing in India consist of juvenile fish. Despite Sciaenids being an important demersal fishery there is scare information on the economic impact of Sciaenids by-catch in the form of juveniles and discards from Indian waters. There in perhaps more amount of time for the collection of elaborate data would give better understanding of the
problem of by-catch, discards and the loss sustain thereon. This is a preliminary attempt to analyze the generation of juveniles landed and the economic loss sustained as a result of catching juveniles indiscriminately.

**Materials and Methods**

**Collection of data**

The study was conducted from October 2010 to April 2011. Regular visit was made to pre-selected important landing centers in Maharashtra such as New Ferry Wharf, Sassoon Docks and Versova landing centers once in a week. During the observation day, the total catch of all the fish in general and Sciaenids in particular was noted. Length data for both adult and juvenile, the quantity of juveniles landed along with the corresponding price was recorded.

Those fish below the size of length at maturity (Lm) were classified as juveniles and those above as adults. The Lm and the mortality rates of the individual fish species were collected from different research articles for estimating the biomass of fish corresponding to the quantity of juveniles landed, assuming they were left in the water to grow up to their size of length at first maturity. The mortality rate fitted in this model is actually the proportion of total and natural mortality. The length-weight relationship was also collected from published data for estimation of total weights of six species using SAS®.

**Fitting of the model**

Species wise length frequency data collected from selected landing centers were classified as juveniles and adult based on length at first maturity (Table 1). The juveniles were arranged species wise in ascending order based on the total length measurement taken at the landing centers.

Employing the earlier published data on length-weight relationships, calculation of species wise total juvenile weights was carried out. With this process, the total weight of each species recorded for study periods from all the three landing centers were computed. The corresponding price of adult and juveniles was fed in the data table and this resulted in getting separate price for the adult and juvenile population of each species. This was again done month wise for each landing centre.

Calculation of adult quantity in weight corresponding to 1 kg of juveniles was worked out by the formula:

$$QA = ((100/\omega) W/100) (1-M)$$

where $Q_A$ is the quantity of adult corresponding to 1 kilogram of juvenile after a period of $t$ years as given for six species; $\omega$ is the individual weight of the sciaenid juvenile in gram; $W$ denotes the weight of the individual adult fish after a period of $t$ years and $M$ is the mortality rate.

Virtual biomass corresponding to the juvenile biomass has been calculated using the formula given by. From this we have computed the total adult biomass corresponding to the juvenile biomass. This has been followed by fitting of the bio-economic model to calculate the economic loss due to the catch of juveniles. The formula to calculate the economic loss due to juvenile fishing is given as:

$$EL = \left(\sum_{i=1}^{n} C_i \cdot Q_i / (1 + \delta)^t / n\right) - \left(\sum_{i=1}^{n} c_i \cdot q_i / n\right)$$

where $EL$ represents the average economic loss for the quantity of juveniles landed for the five species. $C_i$ and $c_i$ denotes the annual average wholesale price of the adult fish and juvenile fish respectively for each species and $Q_i$ is the estimated virtual quantity of the adult corresponding to the quantity of juvenile landed $(q_i)$. Where $n$ represents the total number of species studied, $\delta$ is the standard discount rate and $t$ represent the age in years of the fish at minimum harvestable size. Total catch was divided by the sample weight and raising factor was obtained. Actual measured fish was multiplied by this raising factor to arrive at the total number of juvenile and adults on a particular day. In the same way the data for other observation days were also raised and the same procedure was followed to raise it for the month. This method was applied following.

The discounting is carried out in the estimation of the annual economic loss because the benefit of getting the adult biomass corresponding to the price
Table 2—The economic deficit of juvenile Sciaenids

<table>
<thead>
<tr>
<th>Species</th>
<th>Economic deficit (%)</th>
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<tbody>
<tr>
<td>O. biauritus</td>
<td>52.93</td>
</tr>
<tr>
<td>P. diacanthus</td>
<td>23.70</td>
</tr>
<tr>
<td>J. vogleri</td>
<td>9.79</td>
</tr>
<tr>
<td>O. cuvieri</td>
<td>7.56</td>
</tr>
<tr>
<td>J. macrorhynus</td>
<td>5.63</td>
</tr>
<tr>
<td>J. sina</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Figure 1—Comparison of species-wise economic loss due to juvenile fishing.

appreciation will be achieved only after a period of 10 years, when the fishes reaches minimum harvestable size or length at first maturity.

Results

Species wise economic loss
The annual average wholesale price of adult and juvenile Sciaenids at study areas varies significantly. The estimate shows that the bigger Sciaenids contributed 76.64% while lesser Sciaenids cause 23.36% to the economic loss. Percentage loss contributed by six species is in Table 2. Among the six selected species O. biauratus recorded the highest loss which was worked out to Rs. 67,90,90,133. Of the lesser sciaenids J. vogleri scored highest loss and J. macrorhynus the least (Figure 1).

Month wise total economic loss
The gross economic inflicted due to the capture of juveniles of Sciaeneds is estimated for month-wise. The economic loss was found to be maximum in the month of November with the economic deficit of Rs. 23,90,51,559 with highest percentage of loss by catching juveniles of O. biauritus and P. diacanthus. Similarly, February month show second higher economic deficit with major portion contributed from bigger Sciaenids (Rs.16,95,10,146). Loss was less in October month with deficit of Rs.11, 72, 75,320. The economic deficit depicts that there is a great quantity of bigger Sciaenids landing throughout the year along Mumbai coast. It is evident that between two species of bigger sciaenid such as Koth and Ghola landed, the Koth juveniles are always dominant throughout the year. Economic loss has been calculated for the different species and month (Table 3).

Discussion
Detailed analysis for both bigger and lesser Sciaenids with the total of six species shows there was a deficit of about Rs. 128 crores. Analysis reveals that maximum loss was sustained in November and in the month of December and January there was least annual loss due to juvenile fishing. In subsequent month there was increase in loss. Irregularities in the trend and sudden declined in December may be due to migratory movement of Sciaenids along offshore in response to temperature change. Different species of Sciaenids spawn at different time, however peak season of spawning of Sciaenids in Mumbai coast is in July-August. It also reported that major bulks of landing comprise juveniles off Mumbai coast during November-December. Though landing of lesser Sciaenids are more the loss sustained by them is less compare to bigger Sciaenids. Analysis of species wise total economic also shows that catching of juveniles of Koth and Ghola gave higher loss because their adults would have fetch high price for their swim bladder and meat. Though the flesh of Koth and Ghola and their swim bladder are exported in spite of being juveniles, lesser sciaenid juveniles which are too small are discarded in the landing centers or in the sea itself.

Some studies have been made to quantify the amount of juveniles landed on the coast of India. One such elaborate study by Radhakrishnan et al. reported that an average of 50% of the observed catch consist of juveniles. Indian fishery has been defined as unmanaged and entire catch of bottom trawl as by-catch. This being only by the trawlers, the other destructive gears like purse seine, ring seine etc. also catch large quantities of juveniles. Recently, few authors has studied the economic impacts of catching the juveniles in the
Table 3—Economic deficit by fishing of juvenile Sciaenids

<table>
<thead>
<tr>
<th>Species</th>
<th>Landing centers (Rs/annum)</th>
<th>Economic loss in month</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>New Ferry Wharf</td>
<td>Versova</td>
</tr>
<tr>
<td>Otolithoides biauritus</td>
<td>37,38,84,164</td>
<td>20,37,16,446</td>
</tr>
<tr>
<td>Protonibea diacanthus</td>
<td>13,68,45,539</td>
<td>7,60,24,229</td>
</tr>
<tr>
<td>Johnieops vogleri</td>
<td>6,88,15,350</td>
<td>3,75,35,950</td>
</tr>
<tr>
<td>Otolithes cuvieri</td>
<td>6,30,72,823</td>
<td>96,85,541</td>
</tr>
<tr>
<td>Johnius macrorhynus</td>
<td>2,96,24,034</td>
<td>1,80,73,736</td>
</tr>
<tr>
<td>Johnieops sina</td>
<td>1,26,96,014</td>
<td>12,97,973</td>
</tr>
</tbody>
</table>

fisheries sector of India\textsuperscript{4,21,23}. Trawl fisheries is detrimental to the juvenile of fish\textsuperscript{23}. Najmudeen and Santhiadas\textsuperscript{4} had analyzed the economic impact of juvenile fishing in multi-gear multi-species fishery of Kerala. Analysis covers wide range of gear like trawl, purse seine, ring seine and mini-trawlers and the economic loss sustain due to juvenile landing. Trawl is the major component and the gross economic loss due to juvenile fishing has been estimated by them was around 15,686 million US$ per annum by an estimated 29,241 trawlers on the Indian coast\textsuperscript{4}. This only accounts for the juveniles that are landed, as discards remained unaccounted.

Though it is better to remove a part of the catch from the aquatic ecosystem in order to allow the other fish to grow better and also get a proper food supply for the remaining stock and this how the concept of surplus production evolved. However, if the juveniles are wantonly destroyed, then the problem of recruitment to the future stock would arise. For the conservation of marine wealth and regeneration and rejuvenation of the juvenile fishes, the government has implemented a uniform ban on trawlers and mechanized boats along the Indian coastal areas. India also has regulation fixing the cod-end mesh size of trawls at 35 mm. However this is not practiced and the mesh size of trawls in India range from 10 to 25 mm.

While investigating the key factors that has led to increase in the juvenile component Najmudeen and Santhiadas\textsuperscript{4} stated that technological advancements coupled with inter and intra-sectoral conflicts have directed fishers to think about short term benefits rather than future benefits. According to them in Central Kerala the entire share of the by-catch or undersized fishers landed by mechanized vessels belong to the fishermen crews which they sell at the landing centre itself for low prices. Though such an incentive is not offered to the fishers in Maharashtra, the juvenile of Sciaenids are no doubt utilized in some way or the other either as fish meal for the lesser Sciaenids and consumed fresh or exported as fillet for the bigger Sciaenids. FAO encourages landing of by-catch as long as they are utilized\textsuperscript{24}. Such promotion or prevailing practice definitely reduces the discards being thrown into the sea and also utilization of by-catch but it undermine the important of avoiding juveniles catching in fisheries management as the future yield would be reduced. Because major portions of by-catch usually includes juvenile of commercially important species\textsuperscript{25}. Good fisheries management generally requires that fishing gears retain large fish while allowing small juveniles to escape\textsuperscript{26}.

The bio-economic model that has been used here takes recruitment as constant. This also happens to be one of the rigorous assumptions of the dynamic pool model\textsuperscript{17}. This model also does not take into account of the discards that is thrown in the sea itself and takes only the one that is landed at the fish landing centers. Present study highlight the negative impact of juveniles exploitation results considerable economic loss, in term of what could have been obtained if allowed to grow till adult.

**Conclusion**

The economic loss incurred from juvenile fishing are addressed in the study with reference to six species of Sciaenids from three major landing centers in Mumbai. The economic loss incurred from juvenile landing of *O.biauritus* is highest and least by *J.sinu*. Juvenile fishing and its subsequent loss is more in the month of November and resulted in greater loss in terms of value and ecosystem. Unless strict regulation in trawlers operation is implemented and cod end mesh size is increased at least marginally to 35 mm from the present 10-25 mm, the unrestricted landing of juveniles would continue. This may lead to economic and biological damage to the available resources.
Acknowledgements

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References