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Trawl Fishery of Juvenile Fishes along Mangalore-Malpe Coast of Karnataka and its Impact on Fish Stock

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Abstract

The article presents the quantitative and seasonal variation in percentage of juveniles in the commercial trawl fishery of Mangalore and Malpe in 2006 and discusses the possible impacts of juvenile fish fishery on fish stock in terms of quantity and value. Twenty finfishes and five shellfishes were identified in which considerable quantity of juveniles were caught, and the juvenile fishery is making notable impact on adult fishery. To understand the impact of the fishery of juveniles in a holistic manner, the species of juveniles caught by trawlers are categorized into three groups: I) both juveniles and adults are caught mainly by trawls II) juveniles of the species are caught in trawl, whereas their adults are targeted by gears other than trawl and III) juveniles of the species are caught by trawls regularly, but their adults are rarely caught or not figured in the fishery of the region. Detailed studies on the length-frequency distribution of important species were carried out to find juvenile percentage by weight, number, and months of abundance of juveniles. By statistical analysis (Thompson and Bell model), possible gain in weight and value of the resources, if the juveniles are not caught by trawls, was projected in category I and category II. In category I, the projection is made based on data available on *Nemipterus mesoprion* and the study shows that 7% increase in weight and 22% increase in value (286 lakh rupees) can be obtained if the juveniles of this species are not caught. In category II, *Scomberomorus commerson* is considered as an example for projection. Because the landings of the species by trawlers during 2006 was entirely formed of immature fishes, if the trawl avoids catching these juveniles, 20% increase in yield and 29% increase in value (406 lakh rupees) from the present level is projected by the study. The present article with these examples demonstrates the impact of juvenile fishery on the fish stock and fishery economy of the coast and concludes that since peak periods of specieswise juvenile exploitation is identified, by integrating these temporal data with the spatial data of juvenile fishery, management measures can be formulated and suggested so as to minimize the damages occurring to the commercial fishery due to juvenile exploitation.

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Introduction

Mangalore and Malpe fisheries harbours account for more than 53% of the total marine fish landing and 43% of trawl fisheries of Karnataka. The development of trawl fishery along this coast has been gradual since 1959. Over the years, fleet size of trawlers and trawling operation underwent qualitative and quantitative changes (Mohamed et al. 1998). This growth without doubt resulted in increased yields, employment and exports, it has also lead to excessive fishing pressure as a result of which juveniles of various fishes are exploited in large scale. A major quantity of the juvenile fishes are caught as 'bycatch' during some targeted fishery and are being discarded in the sea itself since it is of no edible value or it is economically not feasible to bring it to the shore. As the profitability from the trawl fishery declined due to stock-related and market-related reasons, there are indications that juveniles of some of the resources are becoming targeted fishery as an alternate source of income. World Wild life Fund pointed out that the problem related to the capture of immature fish reaches its acute level in the case of certain fisheries, with examples from Mediterranean waters, where the vessels completely focused on the capture of small fry and juveniles through using various gears in very shallow areas. Fishing carried out by trawling fleets relies on the capture of immature individuals, often falling far below the minimum legal size prescribed by EU rules (www.wwf.fi/www/uploads/doc/babyfishreport.doc). The present study is carried out to make an assessment of seasonal variations in the percentage of juveniles and to estimate the possible losses in terms of weight and value. Information on seasonal abundance of juvenile fishery of commercial species will help in deriving policies to reduce biological and financial loss due to juvenile fishery by formulating and introducing appropriate management measures.

To distinguish juveniles from adults in the fishery, few criteria are used in many parts of the world. Virginia Institute of Marine Sciences, USA, which is conducting regular juvenile surveys of fishes, especially of bluefish (*Pomatomus saltatrix*), term juveniles as young-of-year (YOY) i.e., fishes less than one year of age. (www.fisheries.vims.edu). It holds good for many temperate species, but in the case of tropical species, majority of which spawn within one year; hence, this criteria cannot be used. The definition, "juveniles are young fish, mostly similar in form to adult but not yet sexually mature" by Hubbs (1943) holds appropriate criteria for distinguishing juveniles of tropical fishes and it is used in the present study.

Materials and methods

Monthly estimates of catch of commercially important fishes landed at Mangalore and Malpe Fisheries Harbours were carried out based on weekly observations. Percentage of juveniles in each sample was estimated from the length-frequency distribution. The data thus obtained were used for calculating the percentage of juveniles in the fishery by number and by weight. Monthly percentage of juvenile in the landing was also found using length-frequency distribution. Criteria given by Hubbs (1943) is considered for distinguishing juveniles from adults. Minimum size at maturity (MSM) was found from the maturity studies of individual species. The minimum size at which advanced matured ovary was found was considered as MSM. Length cohort studies were carried out on important species to find out yield and fishing mortality in different size groups. Projection of catch in single gear and multigear scenario was carried out by Thompson and Bell projection model (Thompson & Bell 1934) with the help of input data from length-cohort studies.

Results and discussion

At Mangalore and Malpe, 108 species of finfishes, 4 species of cephalopods, and 12 species of shrimps were landed by trawlers in 2006. Important groups in which considerable quantity of juveniles were landed were groupers, thread fin breams, whitefishes, soles, ribbonfishes, scianids, carangids, pomfrets, seerfishes and Indian mackerel. *Nemipterus mesoprion* (*N. mesoprion*) was the most important species in which high percentage of juveniles were found. The list of 20 commercially important finfish species and five important shellfishes (for which total landing of the species is <100 t in weight and juvenile component is <1% in composition) is given in the Table 1. During 2006, juvenile formed 22% by weight (2,914 t) and in *Nemipterus japonicus* (*N. japonicus*), juvenile formed 12% (696 t). In sole, *Cynoglossus macrostomus,* the juvenile percentage was 26% (1,119 t) and in whitefish, *Lactarius lactarius*, annual percentage of juveniles was 18% (97 t). In ribbonfish, *Trichurus lepturus*, 341 t of juveniles landed at Mangalore and Malpe in 2006. In carangid, *Decapterus ruselli*, juvenile percentage was 5% (118 t).

In management perspective, the juveniles caught by trawlers were categorized into three groups. (1) Juveniles of the species, adults of which is mainly caught by trawls. (2) Juveniles of the species, adults of which are mainly caught by gears other than trawls. (3) Juveniles of the species, whose adults are rarely seen or not seen in the fishery of the region. The categorization was carried out to specifically identify the impact of the juvenile fishery by trawl on the adult fishery by of same gear or any other gears so as to assess biological loss for the fishery as a holistic manner.

Among the important species, thread fin breams, whitefishes, soles, ribbonfishes, scianids, carangids and pomfrets are included under category I. In category II, seerfishes, Indian mackerel and oilsardines are included. Category III includes groupers, *Epinephelus* species especially *E. diacanthus* in which "protogyny" was reported (McIlwain et al. 2006).

Table 1. Trawl landing of commercially important resources with their juvenile contribution, at Mangalore and Malpe fisheries harbours in 2006.

Species			Juvenile landing			
Sl.no	Finfishes	Total landing (t)	Weight (t)	% in weight	% in number	Peak months & (%)
1	*Epinephelus diacanthus*	3646	3573	98	99	Oct (34%), Jan (23%)*
2	*Nemipterus mesoprion*	13386	2945	22	42	Dec (96%), Nov (86%)
3	*Cynoglossus macrostomus*	4599	1196	26	35	Feb (63%), Jan (60%)
4	*Nemipterus japonicus*	5780	694	12	35	Mar (58%), Feb (53%)
5	*Saurida tumbil*	3775	302	8		
6	*Trichurus lepturus*	25471	255	1	5	Jan (12%), Feb (12%)
7	*Scomberomorus commerson*	183	183	100	100	Mar (26%), Feb(18%)*
8	*Saurida undosquamis*	2118	169	8		
9	*Decapterus russelli*	2559	118	5	15	
10	*Decapterus macrosoma*	546	104	19		
11	*Lactarius lactarius*	553	99	18	36	
12	*Rastrelliger kanagurta*	2415	87	4		
13	*Epinephelus modestus*	397	48	12		
14	*Sardinella longiceps*	555	33	6		
15	*Leiognathus bindus*	572	29	5		
16	*Secutor insidator*	331	26	8		
17	*Parastromateus niger*	317	16	5		
18	*Otolithus rubber*	158	16	10		
19	*Priacanthus hamrur*	1361	14	1		
20	*Epinephelus epistictus*	113	14	12		
	Shell Fishes					
1	*Loligo duacelli*	6698	201	3	20	Apr (58%), Feb (16%)
2	*Sepia pharaonis*	6165	123	2	13	Mar (33%), Feb (32%)
3	*Metapenaeus dobsoni*	798	64	8	15	Dec (49%), Jan (10%)
4	*M.monoceros*	3025	61	2	7	May (22%), Mar (12%)
5	*S.choprai*	1014	20	2	6	Feb (16%), May (5%)

- 100% juveniles in all the months and percentage is monthly percentage of catch.

Category I

Finfishes: In category I, *N. mesoprion* was the most important species in which highest percentage of juveniles were found. During the year, juvenile formed 42% by number and 22% by weight (2,914 t). For the present study, the MSM 12.8 cm derived from maturity studies of the species was considered as criteria for distinguishing juveniles. Length-frequency distribution revealed that highest number of juveniles was found in December (96%) followed by November (86%). From January to April, juvenile represented in high proportions with percentage ranging from 50% to 69%.

In the case of *N. japonicus*, juvenile formed 35% by number and 12% by weight (696 t). MSM was found to be 13.8 cm. Highest percentage of juveniles were found during March (58%). In February, December and January, the percentages of juvenile in the fishery were high, 53%, 47% and 42%, respectively. Zacharia and Nataraja (2003) reported that *N. mesoprion* have an extended spawning season off Mangalore with major peak during October-December and a secondary peak during March-April. The bi-peak in juvenile abundance may be corresponding to these two peaks in spawning.

In sole, *Cynoglossus macrostomus*, the juvenile percentage was 35% by number and 26% by weight (1,119 t). MSM was found to be 11.5 cm, highest percentage of juveniles was found in February (63%). In January, April and September, the percentages of juvenile in the fishery were high and the percentages were 60%, 58%, and 49%, respectively.

In whitefish, *Lactarius lactarius*, annual percentage of juveniles was 35% by number and 18% by weight (97 t). The incidence of juveniles in the fishery was high in June, August and September, the percentages were 64%, 61% and 56%, respectively.

In ribbonfish, *Trichurus lepturus*, 341 t of juveniles landed at Mangalore and Malpe in 2006. Even though it only formed just above 1% by weight, it formed about 5% by number. In January, February and March, the percentages of juveniles were more than 12%.

In carangid, *Decapterus ruselli*, juvenile percentage was 15% by number and 5% by weight (118 t). Highest incidence of juveniles was noticed in January (48%) followed by October (38%) and November (19%).

Shellfishes: In shrimp, *Metapenaeus dobsoni*, juvenile percentage was 15% by number and 8% by weight (64 t). Highest incidence of juvenile percentage was observed in December (49%) followed by January (10%) and March (9%). In

M. monoceros, annual juvenile percentage was 7% by number and 2% by weight (61 t). Highest catch was observed in May 22%. In *Solenocera choprai*, annual percentage of juveniles was 6% by number and 2% by weight (20 t). The highest percentage of juveniles was observed in February (16%).

In cuttle fish, *Sepia pharaonis*, annual percentage of juveniles were 13% by number and 2% by weight (123 t). Highest juvenile landing was observed in March (33%) followed by February (32%) and May (26%). In squid, *Loligo duvaceli*, annual juvenile percentage was 20% by number and 3% by weight (201 t). Highest percentage of juveniles was observed in April (58%) and another peak was observed in October (30%).

Category II.

In category II, where adults are caught mainly by gears other than trawl, most important species is seerfish, *Scomberomorus commerson*, for which major gear for the commercial fishery is drift gillnet. In trawls, almost all the fishes caught were immature. In trawls, seerfish landing was183 t, which formed 16% of the seerfish landing in Mangalore-Malpe fisheries harbours. Although in all the months 100% of the catch was formed of juveniles, catch was highest in March (26%) followed by February, September, December and January with 18%, 13%, 10% and 9%, respectively. Muthiah & Pillai (2003) stated that out of 11.61 t million *S. commerson* landed by trawlers, only less than 1% get a chance to reproduce once before they were caught. In Indian mackerel and oil sardine, influence of juvenile fishery in trawl was found to be negligible when compared with total landing from the coast.

Category III

In category III, adults are rarely seen in the fishery but fishery for the juveniles is commercialized. In *Epinephelus diacanthus*, almost all the fishes caught were immature females (<F3stage), which by definition (Hubbs 1943) can be considered as juveniles. In this species, the assumption of impact of juvenile fishery is complicated because the species shows “protogyny” and no male was observed during the study. Big fishes were rarely caught, which were not available for maturity studies. Detailed study on the life history of the species has to be carried out to understand the impact of the capture of immature females in the population of this important resource.

Impact studies

Statistically, it is possible to project the difference in weight and value of the resources if the juveniles are not caught by trawls. In the first scenario in category 1, the juvenile fishery is damaging the adult catch in trawl itself, and in the second category, the losses are occurring in gears other than trawls, which are the major gear for those fishery. In the third category, the impact is to be studied in wide geological platform where no data is available on the adult fishery from the area of fishing of juveniles.

As an example in the first category, *N. mesoprion* catch was analyzed and results are given in tables. Here, Thompson and Bell predictive model is used from the results obtained through length cohort studies of the species for the year (Table 2). Yield in 2006 is found to be 13,347 t with a value of 1,258 lakh rupees. If the fishing mortality upto a size of MSM is reduced to zero (no juvenile fishing), the resulting yield is 14,293 t with an increase in weight of 7% and an increase in value of 23% (286 lakh rupees). The increased percentage for value reflects the increased value realized for bigger sized fishes.

Table 2: Thomson and Bell projection of catch and value of *Nempterus mesoprion* if juveniles are not exploited by trawlers.

Table 2.1.Yield and Value with present fishing mortality

Size class (cm)	Fishing Mortality	Average weight (g)	average price (Rs/kg)	Numbers	Total Mortality	Yield (t)	value 000' Rs.
4	0.00	1.3	2	870867	1.61	0	0
5	0.00	2.4	2	806678	1.61	0	0
6	0.02	3.9	2	744956	1.63	3	5
7	0.05	6.0	4	685179	1.66	11	43
8	0.11	8.8	4	626926	1.72	32	130
9	0.22	12.2	4	569502	1.83	85	341
10	0.43	16.4	4	511770	2.05	209	835
11	0.69	21.4	4	451677	2.30	400	1598
12	1.16	27.3	4	389608	2.77	762	3049
13	1.72	34.2	4	323031	3.33	1206	4825
14	2.08	42.1	10	254674	3.69	1473	14726
15	2.70	51.1	10	192584	4.31	1805	18051
16	2.60	61.2	10	136093	4.21	1562	15624
17	2.31	72.5	10	94727	3.93	1228	12280
18	2.67	85.1	10	65984	4.28	1213	12125
19	3.50	99.0	10	43115	5.11	1242	12421
20	2.60	114.3	10	24775	4.21	683	6833
21	2.58	131.0	16	15084	4.19	510	8167
22	3.92	149.2	16	8751	5.53	516	8254
23	2.86	169.0	16	3871	4.47	218	3483
24	2.22	190.4	16	1857	3.84	105	1679
25	1.87	213.4	16	906	3.48	55	883
26	0.30	238.2	16	424	1.92	6	100
27	1.61	264.7	16	259	3.22	23	361
						13347	**125813**

Table 2.2. Yield and Value with juvenile fishing mortality zero.

Size class (cm)	Fishing Mortality	Average weight (g)	average price (Rs/kg)	Numbers	Total Mortality	Yield (t)	value 000' Rs.
4	0	1.3	2	870867	1.61	0	0
5	0	2.4	2	806679	1.61	0	0
6	0	3.9	2	745025	1.61	0	0
7	0	6.0	4	685897	1.61	0	0
8	0	8.8	4	629290	1.61	0	0
9	0	12.2	4	575195	1.61	0	0
10	0	16.4	4	523606	1.61	0	0
11	0	21.4	4	474516	1.61	0	0
12	0	27.3	4	427915	1.61	0	0
13	0	34.2	4	383796	1.61	0	0
14	2.08	42.1	10	342151	3.69	1978	19784
15	2.70	51.1	10	258733	4.31	2425	24251
16	2.60	61.2	10	182839	4.21	2099	20990
17	2.31	72.5	10	127264	3.93	1650	16498
18	2.67	85.1	10	88648	4.28	1629	16290
19	3.50	99.0	10	57924	5.11	1669	16687
20	2.60	114.3	10	33285	4.21	918	9180
21	2.58	131.0	16	20265	4.19	686	10972
22	3.92	149.2	16	11757	5.53	693	11090
23	2.86	169.0	16	5201	4.47	292	4680
24	2.22	190.4	16	2495	3.84	141	2256
25	1.87	213.4	16	1217	3.48	74	1186
26	0.30	238.2	16	569	1.92	8	134
27	1.61	264.7	16	347	3.22	30	485
						14293	**154483**

In the second category, where adults are caught by gears other than trawls, *S. commerson* can be considered as a classic example. Here, length cohort analysis was conducted for pooled length-frequency data from trawl and gillnet. From the results of the analysis, size, group-wise mortality, population number are calculated and these values were used in Thomson and bell predictive model for projecting multigear scenario using length frequency data from trawl and gillnet separately (Table 3).

Table 3. Present Scenario and Thompson and Bell projection of catch and value of seerfish, if juveniles are not exploited by trawlers.

Scenarios	Present Yield	Projected Yield
Seerfish catch by gillnet (t)	1098	1541
Seerfish catch by trawl net (t)	189	
Total catch (t)	1287	
Increase in gillnet catch if there is no juvenile catch by trawlers (t)		253.6
Increase (%)		19.71
Value realized for seerfish catch in gillnet (Rs. lakh)	1279	
Value realized for seerfish catch in trawl net (Rs. lakh)	111	1796
Total	1390	
Increase in value of gillnet catch if there is no juvenile catch by trawlers (t)		406
Increase (%)		29.21

Pooled yield from gillnet and trawl during 2006 is 1,287 t with value of 1,390 lakh rupees and if the trawl is not catching the juveniles of seerfishes (if fishing mortality for seerfishes in trawl is zero), the projected yield in gillnet is 1541 t with an increase in weight of 20% and an increase in value of 29% (406 lakh rupees). Here also increased percentage for value than that of weight reflects the increased value realized for bigger sized seerfishes. Similar exercises of yield prediction by Thomson and Bell multifleet analysis were carried out by Muthiah et al. (2003) and projected that the total catch of *S. commerson* will slide down with increase in trawl effort from the present.

Conclusion

It is often argued that in tropical multispecies trawl fisheries, it is impossible to make policies for avoiding juvenile catches. However, by incorporating the knowledge about temporal and spatial juvenile abundance data, it is possible to formulate policies to reduce juvenile fishery. From the landing data, it is possible for us to identify the peak months of juvenile exploitation. The additional information required is about the spatial distribution of juvenile. Once these two sets of data are available, the scientists can understand the spatio-temporal distribution of juveniles of each species and fishermen can be advised to avoid specific geographical area in specific seasons to reduce the juvenile fishery. Since the trawlers are equipped with geographical positioning systems and most of our offshore fishing operations are targeted fishery according to market demand, these policies can be implemented under responsible fisheries guidelines, so as to minimize the damages occurring to the commercial fishery due to juvenile exploitation.

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