Indian Journal of Geo-Marine Sciences
Vol. 41(3), June 2012, pp. 265-271

Impact of non-selective gears on kingseer, *Scomberomoruscommerson* fishery in Karnataka

A.P. Dineshbabu[1], C. Muthiah, Geetha Sasikumar, Prathiba Rohit & Uma S. Bhat

Research Centre of Central Marine Fisheries Research Institute, Post Box No. 244, Mangalore 575 001, Karnataka, India.
[E-mail: dineshbabuap@yahoo.co.in]

Received 11 January 2011: revised 13 July 2011

Catch-length analysis of kingseer, *Scomberomorus commerson* from motorised (drift gillnets) and mechanized (purseseine and trawl) fishing operations in Karnataka from 2004 to 2009 was analyzed. Length composition varied in different gears with smaller fishes being predominant in trawl (59.6%) followed by purseseine (39.2%). In drift gillnet young ones formed only 1.2%. Thompson and Bell model predictionsof kingseer stock in the multifleet fishing scenario were attempted to examine the effects of the motorized and mechanized efforts on the maximum economic yield (MEY) by simulating different effort combinations. Theoretical economic yield obtainable from the drift gillnet fishery alone was obtained at 60% of the current F is (48.1%). This yield is much higher than those obtained from the present multi-gear fishery. When the drift gillnet and purseseine efforts are varied while avoiding the exploitation of juveniles in trawl, 28% increase in MEY is predicted at Rs. 1,087 million. Hence a reduction in the effort expended, by restricting trawl and purseseine operations and retaining the large meshed drift gillnets (65-170 mm) at MEY levels will result in maximum economic returns and for sustainability.

[Keyword: Seerfish, fishery, juveniles, growth overfishing].

Introduction

The narrow-barred Spanish mackerel (kingseer), *Scomberomorus commerson* and the Indo-Pacific king mackerel, *S. guttatus* are the most predominant species exploited in the Indian seas[1]. *S. commerson* is an important pelagic species occurring from the edge of the continental shelf to shallow coastal waters from depths of 10 to 70 m. Coastal waters of Karnataka are important fishing grounds for *S. commerson*, commercially important scomberoid of the region. It is an important source of income for the fishermen population and receives the highest unit return among finfish resources both in the domestic and export markets. In recent years, this resource has been heavily exploited[2], necessitating a detailed scrutiny of the fishing methods, impact on juveniles and proportion of the fish shared by different sectors *viz*., motorized and mechanised.

In Karnataka, seerfish fishery has been carried out traditionally by drift gillnets (65-170 mm mesh size). They target large sized fishes and the sustenance of this motorised fishery largely depends on the success of seerfish fishery[3]. Over the years operation of mechanised fishing fleet, such as trawlers and purseseiners, intensified the fishing operation, leading to exploitation of large quantity of juveniles[4]. Such activities have made an adverse impact on the motorised sector, which is thriving on selective harvesting of large sized seerfish. Though information on the seerfish fishery, stock assessment and management in India is available in many earlier publications[1,2,3,5,6] the possibility of "growth overfishing" and its detrimental consequences to fishable stock and revenue have received only little attention in a multi-species fishery[7,8]. Growth overfishing occurs when the fishes are harvested at an average size that is smaller than the size that would produce the maximum yield-per-recruit in a fishery. This indiscriminate exploitation of juveniles by non-selective gears has negative economic implications as it reduces the potential yield from a fishery.

The quantity and size composition of the fish depends on the type of gears. Indiscriminate harvest of immature fish is of particular concern especially when certain gears harvest smaller sized individuals of species that have been heavily exploited at fishing effort above the optimum levels. Therefore, impact of a multi-gear fishery on a stock is a combination of the

[1]For correspondence

size composition of the fish caught and the quantity of catch in each gear. In this study, the catch-length data of *S. commerson* in the major gears during 2004-2009 operated along the Karnataka coast is analyzed considering the impact of non-selective (trawl, purseseine) and selective gears (gillnet) on the economics of harvest in order to explore modifications in the fishing operations to achieve maximum economic returns at sustainable levels.

Materials and Methods

The weekly species wise catch and fishing effort data of gillnets, purseseines and trawls operating at Mangalore and Malpe Fishing Harbours of Karnataka were collected following the 'Stratified Multistage Random Sampling method[9]. Length (fork length) of *S. commerson* from each gear (drift gillnet-18,066, trawl-13,184, purseseine-647 numbers) was measured to the nearest millimeter. Length-frequency data thus collected were pooled and raised to the monthly catch from each gear. Length distribution data collected from each gear during 2004-09 were averaged to the annual average for each gear separately for virtual population analysis. Since kingseers are harvested by different gears (gillnets, purseseines trawl etc.) the effort expended by each category of units were standardized with gillnetter (fiberglass-canoe fitted with outboard engine) as standard unit following the method adopted by Silas and Pillai[10].

Length at first maturity was estimated following the logistic curve method[11]. Annual percentages of juveniles in the catch were estimated considering the fishes below length at first maturity. The biometric relationship for *S. commerson* worked out by Muthiah *et al*.[2] for west coast $W=0.0154214*L^{2.8138}$ were used in the analyses. Growth parameters K and L_∞ were estimated using ELEFAN I in FiSAT programme[12]. Natural mortality rate (M) was calculated using the empirical formula of Pauly[13] taking sea surface temperature of 30°C. Total mortality rate (Z) was estimated by the catch-curve method[14] and the fishing mortality rate (F) was derived by deducting M from Z. Exploitation ratio (E) was estimated from the relation E = F/Z. Length cohort analysis was carried out to assess the stock and mortality rates of cohorts[15]. Effects of changing the fishing effort by different gears on the biomass and yield were assessed using the Thompson and Bell yield[16] analysis using MS Excel spreadsheets.

Results

Catch trends

The total kingseer production in Karnataka showed decreasing trend with annual fluctuations. During 2004-2009, the annual catch decreased from 5,080 t in 2004 to 3,379 t in 2007, then increased to 5,427 t in 2008 but further reduced to 3,605 t in 2009 (Fig. 1).

Gear-wise trends

Kingseers are caught mainly by the drift gillnets accounting for 46.4% (26.4-64%) to the total landings by weight (Fig.1). During 2004-2009 the trawl accounted for 14.7% (5.3-33.1%), purseseine constituted 20% (3.5-41.2%) and while other gears (boatseines, shoreseines, bagnets etc.) netted 18.9% by weight. Trawl and purseseine accounted for three-fourth of the annual average proportions by numbers (Fig. 2). Contribution by drift gillnet, was only 26% in numbers though it is the traditional gear harvesting seerfish.

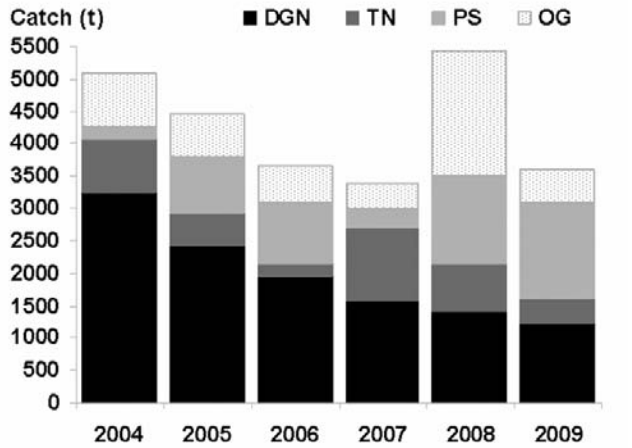

Fig. 1—Annual landings of *S. commerson* by gillnet (DGN), purseseine (PS), trawl (TN) and other gears (OG) in Karnataka during 2004-2009.

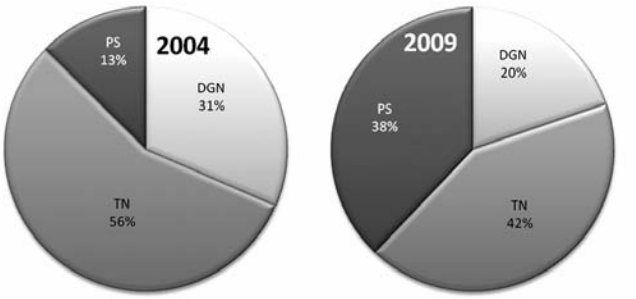

Fig. 2—Comparative annual proportions of *S. commerson* (by numbers) landing in 2004 and 2009 by gillnet (DGN), purseseine (PS) and trawl (TN) in Karnataka

The estimated annual average effort by drift gillnet, trawl and purseseine and catch-per-unit-effort along the Karnataka coast are given in Table 1. During 2004-09, an estimated average annual standard drift gillnet effort of 39,221 units landed 1,980 t of seerfishes at a CPUE of 50.5 kg.During this period, an estimated 628 t of seerfishes were landed by 1,38,852trawl units (boatdays) at a CPUE of 4.5 kg. Purseseine units (45,874 units) landed 855 t of kingseer annually at a catch rate of 18.6 kg/unit. CPUE showed an increasing trend in the purseseines and a decreasing trend in other gears during 2004-2009 periods.

Seasonal trends

Average seasonal production during 2004-2009 period ranged from 12 t in July to 929 t in September (Fig. 3). Post-monsoon period from September to December was most productive for all gears with more than 50% of the annual kingseer catch landed during that time. Gillnetters and trawlers contributed to the kingseer fishery almost throughout the year, whereas, contribution by purseseiners was substantial only during August-October period.

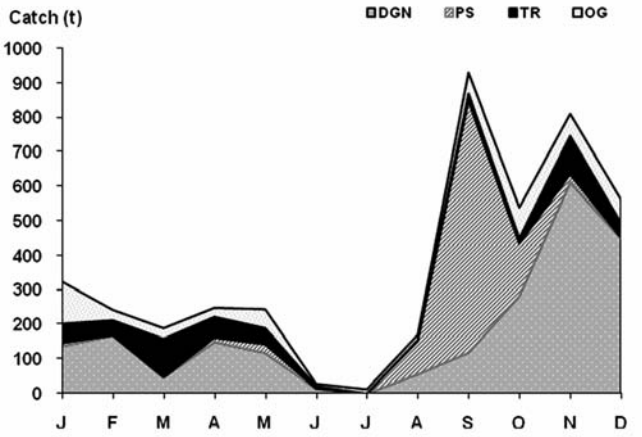

Fig. 3—Seasonal trends in *S. commerson* landing by gillnet (GN), purseseine (PS), trawl (TN) and other gears (OG) in Karnataka during 2004-2009.

Size distribution

Length frequency of *S. commerson*was multimodal in all gears during 2004-2009 (Fig. 4). In the large meshed drift gillnet, the length ranged from 22 to 148 cm. Average annual mean size in drift gillnets was 69 cm, with annual mean sizes ranging from 67 to 70 cm. Smaller sizes were exploited in bulk quantities by the trawl, where the size ranged from 6 to 100 cm, with average annual mean size of 39 cm. Further, the annual mean sizes instead showed a downward trend from 45 cm (2007) to 33 cm (2009). Purseseiners exploited medium sized kingseers in the size range of 20-98 cm with average annual mean size of 49 cm (36-58 cm).

Juvenile exploitation

Length at first maturity was estimated as 70 cm for *S. commerson*. On an annual basis, out of 3.12 million numbers (average) of fish caught in the region [drift gillnet (25.6%), trawl (38.8%) and purseseine (35.7%)], the recruits (<70 cm) and spawners

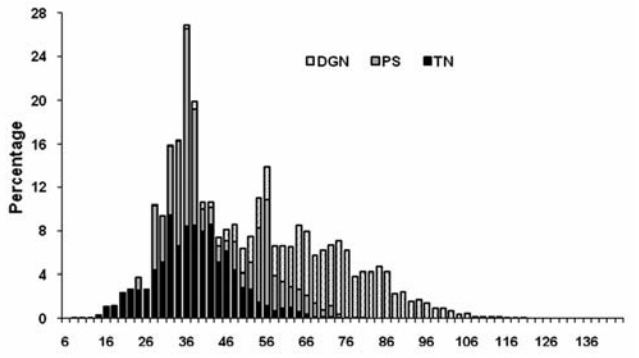

Fig. 4—Length frequency distribution of *S. commerson* landing by drift gillnet (DGN), purseseine (PS) and trawl (TN) in Karnataka during 2004-2009.

Table 1—Fishing effort and Catch per unit effort (kg) of *S.commerson* in Karnataka by drift gillnet (DGN), trawl (TN) and Purseseine (PS).

Gear	Effort	2004	2005	2006	2007	2008	2009	Average
DGN	Units	41123	31718	25295	47433	56262	33495	39221
	CPUE	78.9	76.4	77.1	33.5	25.5	37.0	50.5
TN	Units	124453	119949	158817	161228	138616	130049	138852
	CPUE	6.7	4.4	1.2	6.9	5.1	3.0	4.5
PS	Units	51322	38615	46868	54492	41368	42578	45874
	CPUE	3.5	22.1	20.3	5.3	33.1	34.9	18.6
Total*	Units	53957	49816	40181	89380	137730	84008	68581

*Standard effort

(>70 cm) constituted 86.9% and 13.1% respectively. The fishery was sustained mainly by size-groups between 23-83 cm (96%). Exploitation of recruits was higher intrawl (44.3%) followed by purseseine (40.2%) when compared to drift gillnet (15.4%). Whereas, the fishes larger than the size at first maturity formed only 1.7% in trawl and 5.3% in purseseine as against 93% in the drift gillnet (Fig. 5).

Population characteristics

The L_∞ and K estimated ELEFAN I for *S.commerson* were 162 cm and 0.78 year^{-1}. The total mortality rate (Z) obtained from the length-converted catch curve analysis for the pooled length frequency data was 5.35. Natural mortality rate (M) was estimated as 1.61 and the fishing mortality rate (F) derived from Z-M was 3.94. The exploitation ratio (E) was found to be 0.70 from the region.

Cohort analysis and Yield predictions

The results of the length cohort analysis for the pooled length frequency data (Table 2) indicated that from length group 36 cm the exploitation ratio increased steadily. Results of length-converted Thompson and Bell multi-fleet (drift gillnet, trawl and purseseine) analysis for *S. commerson* from Karnataka coast is given in Fig. 6. MSY for *S. commerson* was estimated as 4,422 t and the corresponding biomass was 2,945 t. The results indicated that the species is exposed to higher fishing pressure, and the effort has to be reduced by 60% from the present level of exploitation. Maximum economic yield (MEY) was estimated at Rs. 852 million for a fishing effort 70% lower than the current levels. The yield of *S.commerson* would be maximum in drift gillnet at 0.3 F.

The Thompson and Bell prediction for multi-gear combinations on the MEYof *S. commerson* fishing operation is depicted in Fig. 7. It is observed that when the drift gillnet and purseseine efforts are varied while avoiding the exploitation in trawl, 28% increase in MEY is predicted at Rs. 1,087 million. When only drift gillnets are operated at 60% of the present effort level, 48.1% enhancement in the economic return is

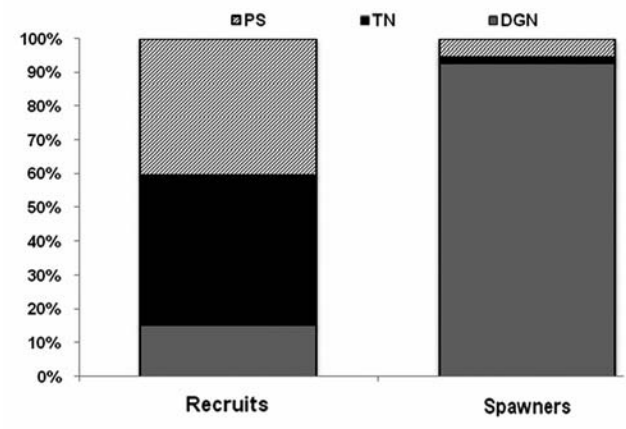

Fig. 5—Average annual proportions of recruits (<70 cm) and spawners (>70 cm)of *S. commerson* landing by drift gillnet (DGN), purseseine (PS) and trawl (TN) in Karnataka during 2004-2009.

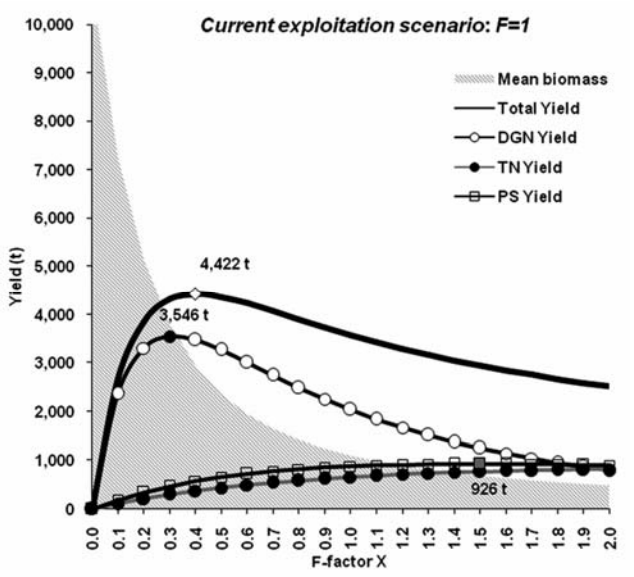

Fig. 6—The yield curve of *S. commerson*, separated into drift gillnet (DGN), purseseine (PS) and trawl (TN) components.

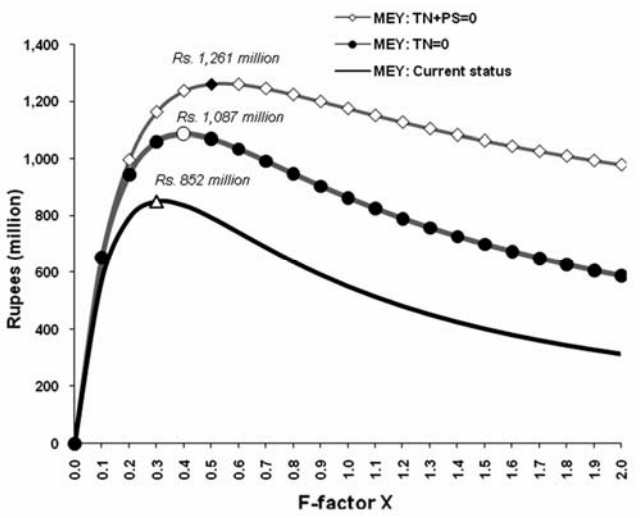

Fig. 7—Projection scenario of MEY when (a) trawl (TN) effort is 0, (b) purseseine and trawl efforts are restricted, compared with the current status in exploitation of *S.commerson*.

Table 2—Jones' length-cohort analysis with catch (C) its proportions in drift gillnet (DGN), trawl (TN) and purseseine (PS) for *S. commerson* off Karnataka coast.

L	C	DGN	TN	PS	Av. Numbers in population	Fishing Mortality (F)	Total Mortality(Z)	Exploitation rate (F/Z)	Standing stock (N)	Standing stock (B)	Yield (t)
7	12	0.00	1.00	0.00	6630	0.00	1.61	0.00	108.224	399	0.0
9	606	0.00	1.00	0.00	6455	0.01	1.62	0.00	106.730	797	0.0
11	1005	0.00	1.00	0.00	6283	0.01	1.62	0.01	105.228	1382	0.0
13	1010	0.00	1.00	0.00	6112	0.01	1.62	0.01	103.725	2180	0.0
15	4031	0.00	1.00	0.00	5944	0.04	1.65	0.02	102.196	3213	0.1
17	12963	0.00	1.00	0.00	5775	0.13	1.74	0.07	100.565	4497	0.6
19	14232	0.00	1.00	0.00	5600	0.14	1.76	0.08	98.845	6044	0.9
21	28572	0.00	1.00	0.00	5426	0.29	1.91	0.15	96.986	7859	2.3
23	32370	0.00	0.99	0.01	5241	0.34	1.95	0.17	94.965	9940	3.4
25	44433	0.00	0.70	0.30	5056	0.48	2.09	0.23	92.799	12282	5.9
27	31739	0.00	0.98	0.02	4862	0.35	1.96	0.18	90.643	14897	5.2
29	120159	0.00	0.44	0.55	4684	1.37	2.98	0.46	87.762	17636	24.1
31	109550	0.01	0.56	0.43	4422	1.30	2.91	0.45	84.143	20399	26.6
33	187986	0.01	0.61	0.38	4177	2.35	3.97	0.59	79.856	23084	54.3
35	193507	0.03	0.42	0.56	3860	2.59	4.20	0.62	74.746	25497	66.0
37	309026	0.02	0.33	0.65	3546	4.52	6.13	0.74	68.411	27285	123.3
39	225689	0.02	0.45	0.53	3127	3.65	5.27	0.69	61.769	28570	104.4
41	124800	0.05	0.77	0.18	2802	2.19	3.80	0.58	57.056	30378	66.4
43	129285	0.06	0.80	0.14	2585	2.42	4.04	0.60	53.359	32484	78.7
45	91618	0.14	0.68	0.18	2370	1.83	3.44	0.53	50.028	34612	63.4
47	102634	0.17	0.72	0.10	2197	2.18	3.80	0.58	46.988	36740	80.2
49	101185	0.19	0.52	0.29	2019	2.31	3.92	0.59	43.846	38548	89.0
51	70855	0.31	0.48	0.21	1847	1.73	3.34	0.52	41.071	40410	69.7
53	83270	0.29	0.39	0.32	1710	2.16	3.78	0.57	38.501	42212	91.3
55	115052	0.19	0.16	0.66	1565	3.25	4.86	0.67	35.413	43092	140.0
57	148100	0.17	0.09	0.73	1392	4.69	6.31	0.74	31.552	42453	199.3
59	73596	0.39	0.11	0.50	1193	2.61	4.22	0.62	28.215	41832	109.1
61	84592	0.55	0.14	0.31	1074	3.30	4.91	0.67	25.662	41788	137.7
63	79954	0.58	0.15	0.27	948	3.47	5.08	0.68	23.034	41072	142.6
65	64182	0.53	0.12	0.35	831	3.10	4.72	0.66	20.674	40254	125.0
67	67457	0.64	0.07	0.29	734	3.65	5.26	0.69	18.481	39186	143.0
69	59933	0.73	0.02	0.24	637	3.67	5.28	0.69	16.349	37657	138.0
71	62138	0.87	0.03	0.10	550	4.35	5.96	0.73	14.292	35676	155.1
73	62510	0.78	0.03	0.19	465	5.12	6.73	0.76	12.203	32936	168.7
75	33792	0.88	0.03	0.09	383	3.21	4.82	0.67	10.529	30664	98.4
77	34152	0.97	0.03	0.00	332	3.68	5.30	0.70	9.270	29074	107.1
79	34781	0.97	0.01	0.02	283	4.35	5.96	0.73	7.999	26963	117.2
81	38237	0.99	0.01	0.00	235	5.74	7.35	0.78	6.666	24107	138.3
83	33704	1.00	0.00	0.00	186	6.30	7.91	0.80	5.353	20736	130.6
85	18031	1.00	0.00	0.00	144	4.12	5.74	0.72	4.373	18114	74.7
87	19414	1.00	0.00	0.00	119	5.35	6.96	0.77	3.629	16048	85.8
89	12276	1.00	0.00	0.00	94	4.11	5.72	0.72	2.986	14078	57.9
91	13802	1.00	0.00	0.00	77	5.65	7.27	0.78	2.441	12251	69.3
93	11172	1.00	0.00	0.00	59	5.82	7.44	0.78	1.918	10233	59.6
95	7266	1.00	0.00	0.00	45	4.79	6.40	0.75	1.518	8596	41.2
97	7509	1.00	0.00	0.00	35	6.33	7.94	0.80	1.187	7129	45.1
99	5407	1.00	0.00	0.00	25	6.05	7.66	0.79	0.894	5688	34.4
101	3184	0.97	0.03	0.00	19	4.61	6.23	0.74	0.690	4643	21.4
103	3917	1.00	0.00	0.00	14	7.58	9.19	0.82	0.517	3673	27.9
105	1323	1.00	0.00	0.00	10	3.43	5.05	0.68	0.385	2891	9.9
107	1188	1.00	0.00	0.00	8	3.78	5.39	0.70	0.314	2489	9.4

Contd.

Table 2—Jones' length-cohort analysis with catch (C) its proportions in drift gillnet (DGN), trawl (TN) and purseseine (PS) for *S. commerson* off Karnataka coast.—Contd.

L	C	DGN	TN	PS	Av. Numbers in population	Fishing Mortality (F)	Total Mortality(Z)	Exploitation rate (F/Z)	Standing stock (N)	Standing stock (B)	Yield (t)
109	995	1.00	0.00	0.00	6	3.95	5.57	0.71	0.252	2098	8.3
111	901	1.00	0.00	0.00	5	4.60	6.22	0.74	0.196	1717	7.9
113	724	1.00	0.00	0.00	3	4.93	6.54	0.75	0.147	1355	6.7
115	447	1.00	0.00	0.00	2	4.06	5.67	0.72	0.110	1067	4.3
117	248	1.00	0.00	0.00	2	2.87	4.48	0.64	0.086	877	2.5
119	79	1.00	0.00	0.00	1	1.08	2.69	0.40	0.073	779	0.8
121	82	1.00	0.00	0.00	1	1.26	2.87	0.44	0.065	723	0.9
123	111	1.00	0.00	0.00	1	2.01	3.62	0.55	0.055	647	1.3
125	35	1.00	0.00	0.00	1	0.73	2.34	0.31	0.047	582	0.4
127	141	1.00	0.00	0.00	1	3.66	5.28	0.69	0.039	494	1.8
129	12	1.00	0.00	0.00	0	0.39	2.00	0.19	0.031	412	0.2
131	17	1.00	0.00	0.00	0	0.62	2.23	0.28	0.028	387	0.2
133	38	1.00	0.00	0.00	0	1.60	3.21	0.50	0.023	342	0.5
135	17	1.00	0.00	0.00	0	0.89	2.50	0.35	0.019	295	0.3
137	16	1.00	0.00	0.00	0	0.98	2.60	0.38	0.016	258	0.3
139	37	1.00	0.00	0.00	0	3.04	4.65	0.65	0.012	200	0.6
141	35	1.00	0.00	0.00	0	4.96	6.57	0.75	0.007	121	0.6
143+	25*	1.00	0.00	0.00	0	3.76	5.37	0.70	0.002	32	0.4
											3580

projected at Rs. 1,261 million from the region. In other words, the current loss due to the harvest of smaller size groups in value terms is Rs. 410 million.

Discussion

Aim of the commercial fisheries management is to optimize the benefits while ensuring sustainability. When multi-gears target shoaling species of different ages, it is possible to draw some generalization about the appropriate season, depth of operation and size composition of that species based on the harvest. When older fishes are targeted in selective gears such as gillnet the yield from the fishery is increased by selectivity. For instance, in Karnataka, among the three major gears targeting kingseers, the mean weight of the fish caught by trawl and purseseine are 0.5 kg and 0.8 kg respectively, whereas in drift gillnets it is 2.5 kg. Greater yield and commercial value is obtained for kingseer landed in drift gillnet due to its bigger size (3 to 5 times) while the gear is harvesting only 26% of the total harvest by numbers. This shows that *S.commerson* is optimally harvested by large meshed drift gillnets. This observation of exploitation of different size groups in different gears is significant especially when non-selective gears such as trawl nets and purseseines catch 74% of total juvenile and young seerfish catch by numbers without giving a chance to spawn at least once. With the intensification of multiday trawl fishing, the contribution of trawl to seerfish in Karnataka increased from 4% in 1990 to more than 14% during 2004-09. Though motorization of fishing crafts significantly contributed to the increase in seerfish landings in mid-eighties, it helped in better exploitation of large sized fishes from farther and deeper waters. On the other hand, intensification of mechanized fishing by continuous improvement in fishing capacity, size, endurance, engine power, introduction of high opening mid-water trawl net and changes in fishing strategies have undoubtedly contributed to the increased proportions from mechanized sector in recent years but also resulted in increased exploitation of juveniles leading to unsustainable fishing levels.

During 2004-09, the mean length of exploited *S. commerson* by drift gillnet was 69 cm whereas, it was 39 cm and 44 cm in trawl and purseseine respectively. The minimum size at maturity of seerfish is estimated at 70 cm FL so, nearly all fish caught by trawl and purseseine were juveniles. Though similar fishing mortality of immature fish were reported by earlier workers from various locations[3,5,17,18,19,20] such large scale exploitation of juveniles by non-selective gears like trawl, and purseseine should be avoided to prevent growth overfishing.

Present exploitation rate of 0.7 indicates the species is under high fishing pressure. Thompson and Bell analysis done here also supports this view as maximum

yield can be obtained at a reduced fishing effort, (F of 0.3) for the region. However considering the proportions of juveniles exploited by trawl and purseseines, the operations of these gears should be restricted while targeting kingseers inorder to catch larger size groups. When drift gillnets are only operated, the model predicted that the present gillnet fishing effort is in excess of 40% of the MEY. This necessitates reduction in the effort expended on targeting seerfish by restricting trawl and purseseine operations and retaining the large meshed drift gillnets (65-170 mm) at MEY levels for maximizing economic returns and for sustainability. Gillnet fisheries provides the opportunity for facilitating the exploitation of a section of the fish stocks by regulating the mesh size. Such rationing can be manipulated to balance welfare of the fish stock and sectoral profits[21]. Results of the study suggest substantial reduction in the fishing effort of the non-selective gears targeting juveniles as well as reduction in the current drift gillnet effort levels to that of 2006 levels, if the resource management objectives are to be achieved.

Acknowledgement

Authors are grateful to Dr. G. Syda Rao, Director, Central Marine Fisheries Research Institute, Kochi for facilities and to the technical staff, Mangalore Research Centre of CMFRI for assistance rendered in sampling.

References

1 Muthiah C and N G K Pillai, Status of seerfish fishery in the Indian seas. *Stock assessment of seerfishes along the west coast of India*. *In*: V.S.Somvanshi, S.Varghese and A.K.Bhargava (Eds.), Proc. Tuna Meet-2003, (2005), pp.73-85.

2 Muthiah C, N G K Pillai, U Ganga and M Srinath, *Stock assessment of seerfishes along the west coast of India*. *In*: V.S.Somvanshi, S.Varghese and A.K.Bhargava (Eds.). Proc. Tuna Meet-2003 (2005) pp 97-111.

3 Muthiah C, H M Kasim and Uma S Bhat, Exploited seerfish fishery resources of India – a review *In*: V.N. Pillai and N.G.Menon (Eds.), *Marine Fisheries Research and Management.* Central Marine Fisheries Research Institute, Cochin, (2000) pp 426-467.

4 Dineshbabu A P and Radhakrishnan E V, Trawl fishery of juvenile fishes along Mangalore Malpe coast of Karnataka and its impact on fish stock. *Asian Fish. Sci.* 22 (2) (2009) 491-500.

5 Muthiah C, H M Kasim, N G K Pillai, T M Yohannan, B Manojkumar, K S Koya, U S Bhat, T SBalasubramanian, M N K Elayathu, C Manimaran, H K Dhokia and M V Somaraju, Status of exploitation of seerfishes in the Indian seas. *In*: N.G.K.Pillai, N.G.Menon, P.P.Pillai and U.Ganga, (Eds.) *Management of Scombroid Fisheries*. Central Marine Fisheries Research Institute, Kochi, (2002) pp.177-186.

6 Muthiah C, N G K Pillai, H M Kasim and U S Bhat, Seerfishes, In: Mohan Joseph, M. and Jayaprakash, A.A. (Eds.) 2003. *Status of Exploited Marine Fishery Resources of India.* Central Marine Fisheries Research Institute, Kochi - 682 014, India. (2003) pp. 45-50.

7 Najmudeen T M and R Sathiadas. Economic impact of juvenile fishing in a tropical multi-gear multi-species fishery. *Fish. Res.***92** (2008) 322-332.

8 Mohamed K S, M Joseph, P S Alloycious, G Sasikumar, P Laxmilatha, P K Asokan, V Kripa, V Venkatesan, S Thomas, S Sundaram and G S Rao. Quantitative and qualitative assessment of exploitation of juvenile cephalopods from the Arabian Sea and Bay of Bengal and determination of minimum legal sizes. *J. Mar. Biol. Ass. India* **51** (1) (2009) 98-106.

9 Srinath M, Kuriakose S and Mini K G. Methodologies for estimating marine fish landings in India. *CMFRI, Spl. Publ.* 86 (2005) pp. 1-57.

10 Silas E G and P P Pillai. Methodology and brief review of the oceanological features of the Indian waters. *Bull.Cent.Mar.Fish.Res.Inst*., **36** (2) (1985) 6-7.

11 King M, Fisheries biology, assessment, and management. Fishing News Books/Blackwell Scientific Books. Oxford, England. (1995) pp 352.

12 Gayanilo F C Jr., P Sparre and D Pauly. FAO-ICLARM stock assessmenttools (FiSAT) user's manual. *FAO Comp.Info.Ser. (Fisheries)* 8 (1995) pp 126.

13 Pauly D. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. Cons. CIEM*., **39** (3) (1980) 175-92.

14 Pauly D. Length converted catch curves. A powerful tool for fisheries research in the tropics. (part II). *ICLARM Fishbyte*, **2** (1) (1984)17-19.

15 Jones R. Assessing the effects of changes in exploitation pattern using length composition data (with notes on VPA and cohort analysis). *FAO Fish. Tech. Pap*. **256** (1984) pp 118.

16 Thompson W F and F H Bell. Biological statistics of the Pacific halibut fishery 2. Effect of change in intensity upon total yield and yield per unit of gear. *Rep. Int. Fish. (Pacific Halibut) Comm*., **8** (1934) pp 48.

17 Kasim H Mohamad and K M S Ameer Hamsa. On the fishery and population dynamics of seerfish *Scomberomorus commerson* (Lacepede) off Tuticorin (Gulf of Mannar). *Bull. Cent. Mar. Fish. Res. Inst.,***44** (1) (1989) 45-53.

18 Yohannan T M, A A Jayaprakash, M Srinath, R Thiagarajan, P Livingston, H Mohamad Kasim and G Luther. Stock assessment of *Scomberomorus commerson* along the Indian coast. *Indian J. Fish*., **39** (3, 4) (1992) 111-118.

19 Pillai P P, N G K Pillai, T V Sathyanandan and M N K Elayathu. Fishery biology and stock assessment of *Scomberomorus commerson* (Lacepede) from the southwest coast of India. FAO /IPTP Expert Consultation on the Indian Ocean Tunas. Coll. Vol. Working Doc. TWS/93/2.2 (1994).

20 Devaraj M, H Mohamad Kasim, C Muthiah and N G K Pillai. 1999. Assessment of the exploited seerfish stocks in the Indian waters. *J. Mar. Biol.Ass.India*. **41** (1&2) (1999) 62-83.

21 Mirinda L E, Agostinho A A and Gomes L C. Appraisal of the selective properties of gill nets and implications for yield and value of the fisheries at the Itaipu Reservoir, Brazil-Paraguay. *Fish. Res*., 45 (2000) 105-116.