Indian J. Fish., 58(2) : 15-21, 2011

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Fishery and population dynamics of silverbellies along the Kerala coast

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ABSTRACT

The fishery of silverbellies along the Kerala coast has been described bringing out various craft gear combinations and the seasonal variation in abundance of different species. The Beverton-Holt yield per recruit analysis was made in all the five species that contribute to the commercial fisheries and the F_{max} under the current t_c and t_{max} under the current F have been determined and the status of the stocks of each species brought out. In all the five species the F_{max} is shown to be less than the present F and the current age at first capture is less than the value that leads to increase the yields. Mixed fisheries assessment has been carried out in five species, which constitute about 90% by weight of silverbelly landings and the maximum equilibrium yield that could be taken was determined. The maximum equilibrium yield could be achieved at 25% of current fishing effort level and the current t_c. Similarly, maximum equilibrium yield of silverbellies could be obtained at 200% of the current codend mesh size keeping the current effort constant.

Keywords: Mixed fisheries assessment, Mortality rate, Population parameters, Silverbellies, Yield per recruitment

Introduction

The silverbelly landings in India have shown a steady increase from 44,140 tonnes in 1969 to 69,915 tonnes in 1994, thereafter falling to 53,498 tonnes in 1999, with maximum abundance in 1983 (91,733 tonnes). Tamil Nadu contributed to the bulk of the landings (67.5%), followed by Kerala (12.3%), Andhra Pradesh (8.8%) and Karnataka (4.9%) for the period 1993-1998. Apart from the two major fishing harbours at Cochin and Sakthikulangara, there are a number of centres, *viz.,* Munambam, Azhikal, Ponnani, Beypore, where mechanised boats land. Some important works on silverbellies include that of Nair (1953), Seshappa and Bhimachar (1955), Sam Bennet (1967), George *et al.* (1968), Antony Raja (1969), Banerji and Chakraborty (1970), Nair *et al.* (1970), James (1972), Silas *et al.* (1976), Mahadevan Pillai (1978), Luther (1979), Shanmughavelu and Pillai (1980) and Balan (1984).

By increasing the fishing effort, the yield can be increased to a certain level, but further increase in exploitation levels leads to reduction in the yield and if the effort is still further increased regardless of the reduction in total catch and catch rates, the stock under exploitation may collapse and the fishing industry faces the problem of rehabilitation. Such a situation would arise if proper scientific advice on the maximum possible effort and safe gear and mesh levels that could be deployed to exploit the resources of a stock/stocks in a given geographic area, was not made and not properly implemented. Hence, the exploited stocks need to be maintained carefully and scientific advice rendered to the government and industry on the range of measures required to ensure maximum economic and sustainable yield. The studies on population dynamics of Indian silverbellies are those of Venkatarman *et al*. (1981) on *Leiognathus jonesi,* Murty (1986a, 1990) on *L. bindus* and *Secutor insidiator*, Kartikeyan *et al*. (1989) on *L. jonesi*, and Murty *et al*. (1992) on four species along the Andhra Pradesh and Tamil Nadu coasts. The purpose of the present study was to understand the status of exploited stocks of silverbellies and to know the possible range of options for their rational exploitation.

Materials and methods

Data on landings and species composition of silverbellies were collected from two major trawl landing centres of Kerala, Cochin Fisheries Harbour and Neendakara Fisheries Harbour for a period of two years from January 1998 to December 1999. The quarterly species composition estimates for Kerala were obtained by raising the estimates of the landings centres to the respective districts, which were the raised to the estimated silverbelly catch of the state.

Estimation von Bertalanffy growth parameters (*VBGF*):

The length frequency data for the years 1998-1999 were used for the estimation of L_∞ and K using FiSAT.

Estimation of mortality rates

The rate of instantaneous total mortality (Z) was estimated by length converted catch curve of Pauly (1983) using the total annual length frequency distribution of catch from the two landing centres pooled. The natural mortality rate (M) was estimated using the equation of Pauly (1980). For this, the temperature value in the fishing grounds was taken as 27 °C following Suseelan and Rajan (1989). The value of rate of fishing mortality (F) was derived from Z and M.

Estimation of yield per recruit

This was done by using the Beverton and Holt (1957) yield equation. The smallest length in the catch of each species over the two year period was taken as length at recruitment. The value of W_{∞} derived using the value of L_{∞} and the estimated length-weight relationship. The values of length – weight relationship has not been calculated for *Leiognathus brevirostris* and *Gazza minuta*. Hence, the values given by Hameed Batcha and Badrudeen (1992), and Jayabalan and Krishna Bhat (1997) were taken.

Estimation of recruitment pattern

The recruitment pattern was estimated using the FiSAT package.

Estimation of yield and mixed fishery assessments

Yield per recruit and biomass per recruit at different levels of F was estimated using LFSA package. For studying the effects of change in the effort and codend mesh size, Beverotn Holt (1957) yield per recruitment analysis was done using different values of F and t_c. The L_c values were converted to t_c values using inverse VBGF equation.

Results and discussion

Estimated landings of silverbellies in Kerala

Kerala ranked second in the country being next to Tamil Nadu in silverbelly landings. The silverbelly landings of Kerala constituted, on an average, 1.5% of the total marine fish landings of the state during the 30 year period from 1969 to 1999. The total silverbelly catch of Kerala declined from 14,019 tonnes in 1969 to 6,154 tonnes in 1999 with peak abundance in 1973 (18,392 tonnes) contributing 38.2% to the total silverbelly landings of India. Among the nine coastal districts of state, Quilon stood first in the silverbelly landings, accounting for 46.5% of the silverbelly catch of the state during 1998-1999, followed by Calicut by contributing 20.9% and Alleppey with 8.9%.

The mechanised sector, consisting mainly of the trawls, contributed to 51.6% of the silverbelly landings of the state while the motorised sector consisting of outboard trawl net, boatseine, ring-seine and disco net, contributed to 33.9% of the landings. The contribution of the artisanal sector with non-mechanised bottom set gillnets and drift gillnets, shore seines and boat seines was 14.5%. Though the trawl nets dominated the catches, the proportion of the catch taken by the different gears in different districts indicated variations. Among the different gears, trawls contributed to 53.4% of the silverbelly catch during 1998-1999.

While the pre-dominance of trawls in the silverbelly fishery of Kerala was the most notable feature of the gearwise analysis of landings, it was conspicuous by its complete absence in Trivandrum district. Except Trivandrum, trawls dominated in contributing silverbelly landings in all the other districts except Calicut, where outboard ring-seines contributed to the majority of the landings (48.1%). In Quilon, Alleppey, Calicut, Cannannore and Kasargode, the outboard ring seines contributed to a sizeable part, being second only to the trawls, while in Ernakulam and Trichur districts, trawls were the major gear contributing to over 85% of the silverbelly landings. All other gears were only of minor importance with regard to the silverbelly fishery, barring the contribution of non mechanised drift gillnets (13.7%) in Malappuram and outboard trawl nets (9.7%) in Alleppey.

The peak seasons of silverbelly landings were the first two quarters of the year, which contributed to over 70% of the landings of the whole year. The lean period was during the third quarter which coincides with the monsoon trawling ban and the two months immediately following the ban.

Species composition

Thirteen species of silverbellies were landed in the commercial catches, while the other three (*L. fasciatus, L. smithhursti and L. elongatus)* were only of stray occurrence. The silverbelly landings of Kerala were dominated by *L. splendens*, contributing to 47.3% of the landings, followed by *S. insidiator* (24.5%) and *L. brevirostris* (8.7%). The estimated species composition of the silverbellies landed by trawls in Kerala for the period 1998-1999 is shown in Fig. 1. It can be seen that, only

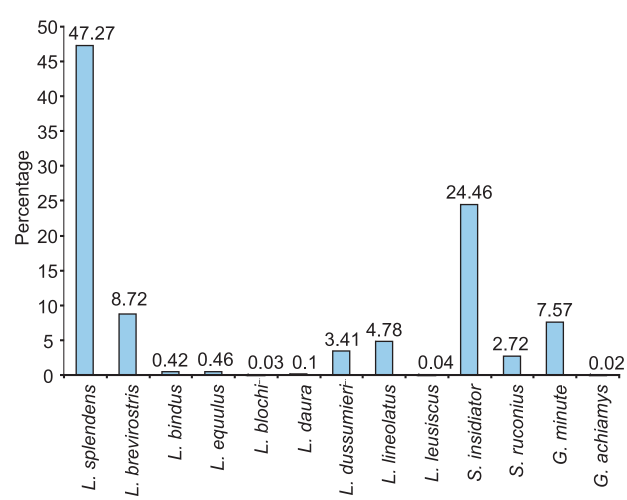

Fig. 1. Estimated species composition (percentage) of silverbellies of Kerala during 1998-1999.

seven species figured prominently in the fishery contributing to over 98% of the catches. The third quarter is not represented well since it corresponds to the period of the trawling ban.

Catch per unit effort

The trawl landings of silverbellies in Kerala during 1998 had registered an average catch per unit effort of 5.24 kg, with a maximum of 6.55 kg during the first quarter of the year and a minimum of 0.52 kg in the third quarter. The maximum catch per unit effort of 10.89 kg was recorded in Alleppey, followed by Quilon (10.89 kg), and Calicut (6.02 kg). The minimum of 1.07 kg was recorded in Malappuram, while Ernakulam recorded a catch per unit effort of 1.65 kg.

During 1999, the annual trawl landings recorded an average monthly catch per unit effort of 5. 55 kg, with a maximum of 6.8 kg in the first quarter and a minimum of 2.61 kg in the third quarter. The maximum catch per unit effort of 12.37 kg was recorded in Quilon, followed by Calicut (4.45 kg) and Ernakulam (4.35 kg). The minimum catch per unit effort of 0.51 kg was again recorded in Malappuram.

Nearly 90% of the silverbelly landings of the state are contributed by the four species *viz., L. splendens, L. brevirostris, S. insidiator* and *Gazza minuta*. The rest is contributed by *L. bindus, L. equulus, L. blochi, L. daura, L. dussumieri, L. lineolatus,* and *S. ruconius. L. fasciatus*, *L. smithhursti, L. leuciscus , L. elongatus* and *G. achlamys.*

The variations observed in species composition along different regions of the country have also been observed along Kerala coast. There was virtually no information on the peak periods of abundance of the different species of silverbellies along the Kerala coast. The present study has contributed towards this knowledge and reported 5 species (*Leiognathus smithhursti, L. leuciscus, L. elongatus, L. blochi* and *G. achlamys*) for the first time off Kerala.

Population dynamics

The estimated values of population parameters of all the five species of siliverbellies are given in Table 1. The yield per recruit as a function of fishing mortality rate (under the current t_c) shows that the present fishing mortality rate is much beyond the level at which maximum yield per recruit is obtained in *L. splendens*, *S. insidiator, S. ruconius and G. minuta*, however, in the case of *L. brevirostris*, these were close to each other. Thus, in all the species studied here, the fishing pressure was higher than the level at which greater yield per recruit could be obtained. The estimated values of population parameters of all the five species in the present study fall well within the ranges obtained from the other similar studies (Table 2).

The yield per recruit as a function of age at first capture (under the current F) shows that the present age at first capture in all the five species is far less than the level at which maximum Y_w/R could be obtained.

The yield estimated as a function of fishing mortality rate expressed at percentage of the present shows that maximum yield could be obtained at around 20% of the present fishing mortality rate in *L. splendens,* at the current level in *L. brevirostris*, at around 20% level in *S. insidiator*, about 60% level in *S. ruconius*, about 30% level in *G. minuta* (Fig. 2-6). In all the five species together, the maximum equilibrium yield of around 8000 t could be harvested at around 20% level of the present fishing mortality (Fig. 7). In the case of yield as a function of age at first capture, there is scope for a substantial increase in the t_c with reference to the species (Fig. 9). The estimated recruitment pattern suggests that it is continuous, with one peak in *L. splendens*, without any major peak in *L. brevirostris,* with two peaks in *S. insidiator,* with one peak in *S. ruconius* and with two peaks (one being insignificant) in *G. minuta* .

The present study has considered the data of five species of silverbellies from Kerala coast with the objective of assessing the resource situation of silverbellies vis-à-vis their exploitation in the region. In *L. splendens,* the present F is much beyond the F_{max}, close to F_{max} in *L. brevirostris*, less than F_{max} in *S. insidiator* and beyond the F_{max} in *S. ruconius* and *G. minuta* (Fig. 7). The yield as a function of fishing mortality rate expressed as percentage of the present value (under the current t_c) shows that maximum

Table 1. Estimated values of growth parameters, mortality rates, length and age at entry and first capture of different species of silverbellies as used in the present study (f values are also shown)

Species	L_{max} (mm)	L_∞ mm	K (per year)	Z	M	F	t_c	ϕ	M/K
Leiognathus splendens	140	154	0.52	6.55	1.38	5.42	0.06	4.09	2.65
L. brevirostris	135	140	0.86	7.59	1.97	5.26	0.65	4.23	2.29
Secutor incidiator	120	130	0.8	7.16	1.91	5.25	0.27	4.03	2.38
S. ruconius	98	92	1.19	6.14	2.73	3.43	0.21	4.01	2.29
Gazza minuta	180	160	1.7	8.91	2.96	5.95	0.03	4.64	1.74

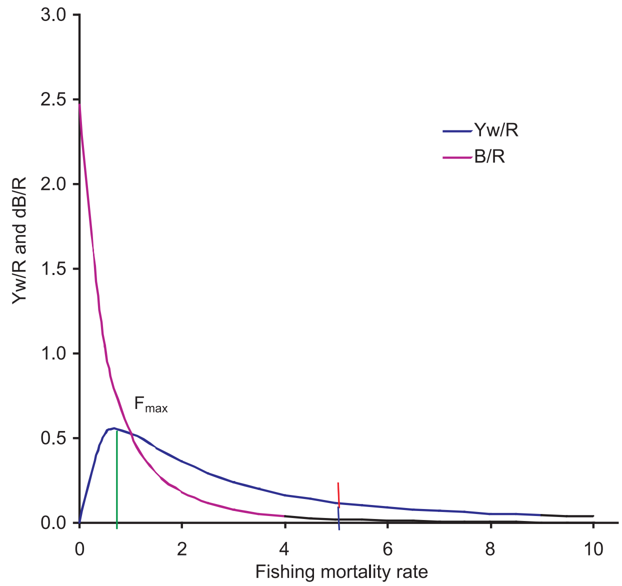

Fig. 2. Yield per recruit (g) and biomass per recruit (g) as a function of fishing mortality rate in *Leiognathus splendens* (Current F and Yw/R are shown by small vertical lines)

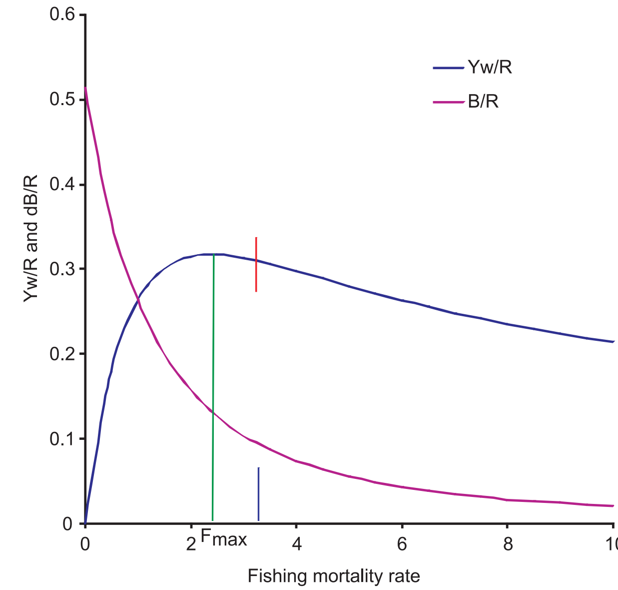

Fig. 4. Yield per recruit (g) and biomass per recruit (g) as a function of fishing mortality rate in *Secutor ruconius* (current F and Yw/R are shown by small vertical lines)

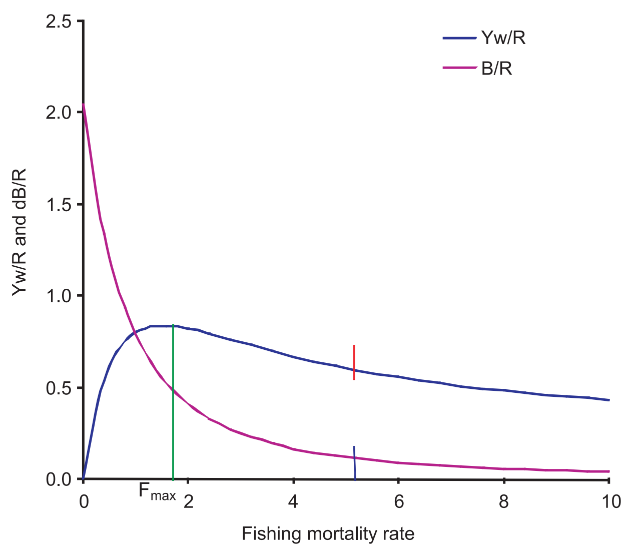

Fig. 3. Yield per recruit (g) and biomass per recruit (g) as a function of fishing mortality rate in *Secutor insidiator* (current F and Yw/R are shown by small vertical lines)

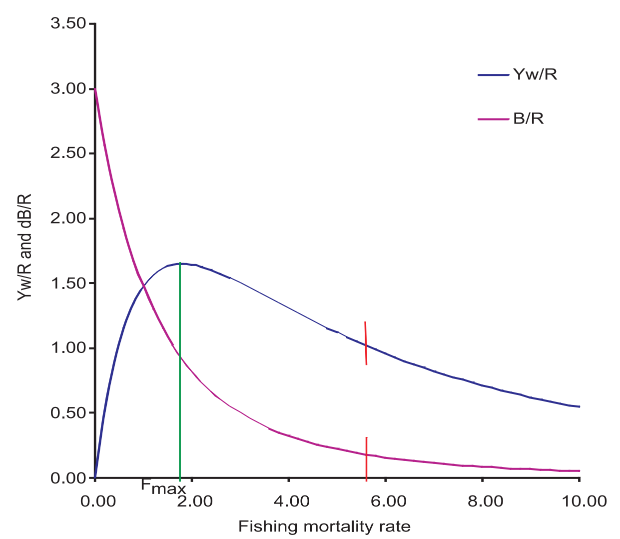

Fig. 5. Yield per recruit (g) and biomass per recruit (g) as a function of fishing mortality rate in *Gazza minuta* (current F and Yw/R are shown by small vertical lines)

yield is possible in the case of *L. splendens* at around 25% of the present F (effort), at the current F in the case of *L. brevirostris,* about 25% of the current F in *S. insidiator*, about 65% of the current F in *S. ruconius* and at about 30% of the current F in *G. minuta* (Fig. 10). In all the five species, maximum yield of around 8000 t which is nearly 300% of the present is possible at around 23% of the present fishing effort. It may be noted that the current yield of all the five species is of the order of 2600 t (Fig. 7). The situation can be better seen in where the yield as percent of present is plotted against the fishing mortality rate, which is also expressed as percent of present rate. By reducing the effort to around 25% of the present, the yields would increase to about 300% of the present (Fig. 8).

The yield per recruit as a function of age at first capture (under the current F) in the five species suggests that the current values of t_c are less than those which would ensure higher yields in all the five species. It is also clear (Fig. 9) that the yield of these species increases under the current

Table 2. Estimated values of growth parameters, mortality rates, length and ages at entry and first capture of different species of silverbellies from the Indo-Pacific region.

Species	Area/Locality	Source	L_∞ mm	K (per year)	t_o (year)	Lr	t r	Lc	tc	Z	M	F	ϕ
L. bindus	Calicut, India	Pauly and David 1981	122	1.3	-	-	-	-	-	-	-	-	2.29
	Java	Dwiponggo *et al.*, 1986	125	1.38	0	-	-	50.3	-	8.84	2.83	-	2.33
	Samar sea	Silvestre 1986	121	0.98	0	-	-	-	-	4.28	2.21	2.07	2.16
	Visakhapatnam	Murty *et al.,* 1992	151	0.95			0.087		0.275	4.14	2.05	2.09	2.34
	Kakinada	Murty *et al.,* 1992	154	0.77			0.152		0.412	5.26	1.78	3.48	2.26
	Madras	Murty *et al.,* 1992	153	0.9			0.172		1.022	5.22	1.98	3.24	2.32
	Visakhapatnam	Murty *et al.,* 1992	163	0.95			0.08		0.257	4.72	2.01	2.61	2.4
	Kakinada	Murty *et al.,* 1992	165	0.7			0.155		0.412	5.43	1.64	3.79	2.28
	Madras	Murty *et al.,* 1992	167	0.96			0.147		0.814	7.44	2.01	5.43	2.43
	Kakinada, India	Murty *et al.,* 1992	158.4	0.58	-0	17	0.18	57	0.75	5.2	1.5	3.7	2.16
L. jonesi	Mandapam, India	Venkataraman *et al.*,1981	161.2	0.528	0.11	-	-	48	0.56	3.2	2.28	0.92	2.14
	Mandapam, India	Karthikeyan *et al.,* 1989	146.62	0.917	0	15	-	-	-	5.26	1.25	4.01	2.29
	Rameswaram	Murty *et al.,* 1992	155	0.7			0.33		1.076	5.36	1.67	3.69	2.23
	Rameswaram	Murty *et al.,* 1992	160	0.6			0.372		0.961	4.95	1.5	3.45	2.19
L. splendens	Porto Novo, India	Jayabalan 1988a	170	0.3259	-1.4	-	-	-	-	-	-	-	1.97
	Samar sea	Silvestre 1986	131	0.9	0	-	-	-	-	3.13	2.02	1.11	2.19
	Java	Dwiponggo *et al.*, 1986	145	1.25	0	-	-	96.5	-	4.64	2.55	2.09	2.42
	Java	Dwiponggo *et al.*, 1986	169	1.1	0	-	-	62.3	-	4	2.25	1.75	2.5
	Java	Dwiponggo *et al.*, 1986	167	0.9	0	-	-	62.3	-	3.27	1.98	1.25	2.4
L. equulus	Samar sea	Silvestre 1986	240	0.56	0	-	-	-	-	2.2	1.26	0.94	2.51
	Java	Dwiponggo *et al.*, 1986	215	1.5	0	-	-	134	-	5.68	2.5	3.1	2.84
L. elongatus	Malaysia	Chan and Liew 1986	135	0.8	0	-	-	-	-	3.1	1.8	1.3	2.16
L. leuciscus	Samar sea	Silvestre 1986	137	0.93	0	-	-	-	-	3.86	2.12	1.74	2.24
	Java	Dwiponggo *et al.*, 1986	135	1.83	0	-	-	47.6	-	6.15	3.31	2.84	2.52
L. brevirostris	Java	Dwiponggo *et al.*, 1986	120	0.95	0	-	-	71	-	2.79	2.2	0.59	2.14
L. dussumieri	Pamban	Murty 1992	162	1.2			0.25		0.63	6.7	2.35	4.35	2.5
	Pamban	Murty 1992	175	0.8			0.343		0.851	5.46	1.76	3.7	2.39
S. insidiator	Kakinada, India	Murty 1991	123	1.2	-0	27	0.2	80	0.86	6.1	2.6	3.5	2.26
	Visakhapatnam	Murty 1992	120	1.2			0.258		1.052	4.88	2.55	2.33	2.24
	Kakinada	Murty 1992	125	1.06			0.279		1.1	4.69	2.33	2.36	2.22
	Madras	Murty 1992	125.5	1.22			0.334		1.011	5.67	2.55	3.12	2.28
	Visakhapatnam	Murty 1992	130	0.85			0.332		1.31	5.28	1.99	3.29	2.16
	Kakinada	Murty 1992	130	0.85			0.332		1.291	4.36	1.99	2.37	2.16
	Madras	Murty 1992	138	1.3			0.279		0.81	8.72	2.59	6.13	2.39
S. ruconius	Java	Dwiponggo *et al.*,1986	90	2.2	0	-	-	36	-	8.91	4.22	4.69	2.25
	Java	Dwiponggo *et al.*,1986	83	1.45	0	-	-	49	-	8.86	3.29	5.57	2
G. minuta	Porto Novo, India		160	0.8649	-0.2	-	-	-	-	-	-	-	2.34

effort itself, if the t_c (*i.e.* codend mesh size) is increased to 200% of the present and a total of 170% of the present yield could be obtained (Fig. 10).

The above analyses clearly lead to the major conclusion that the effort needs to be reduced by about 80% (since F is proportional to fishing effort) and the codend mesh size of trawl nets (since the age at first capture is proportional to codend mesh size) can be increased substantially.

Since the five species studied here contribute to nearly 90% of silverbelly landings in the state, the present results can safely be taken as reflecting the situation in all the silverbelly species in the region. It should be noted that the analytical model of Beverton and Holt (1957) used here assumes the population to be in equilibrium state with the natural mortality rate being constant, growth to be constant, recruitment to be constant and the fishing mortality rate for all ages beyond t_c to be constant. Hence maximum equilibrium yield of about 8000 t of silverbelly can be obtained at around 30% of the currently expended effort with the present codend mesh size. If the codend mesh size is increased further, with the reduced fishing effort, the equilibrium yield could still be higher. The present results,

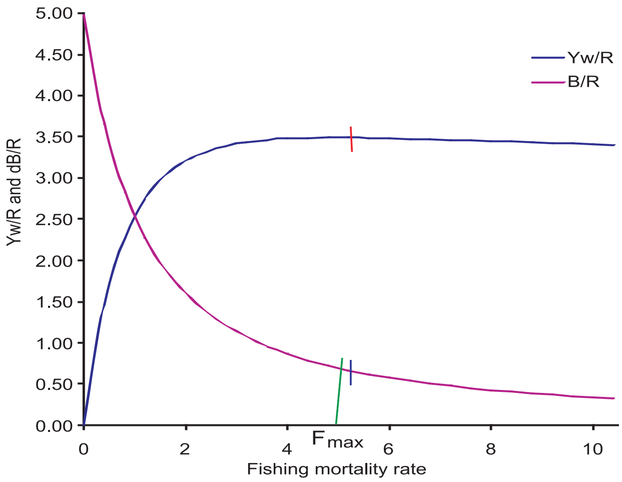

Fig. 6. Yield per recruit (g) and biomass per recruit (g) as a function of fishing mortality rate in *Leiognathus brevirostris* (current F & Yw/R are shown by small vertical lines)

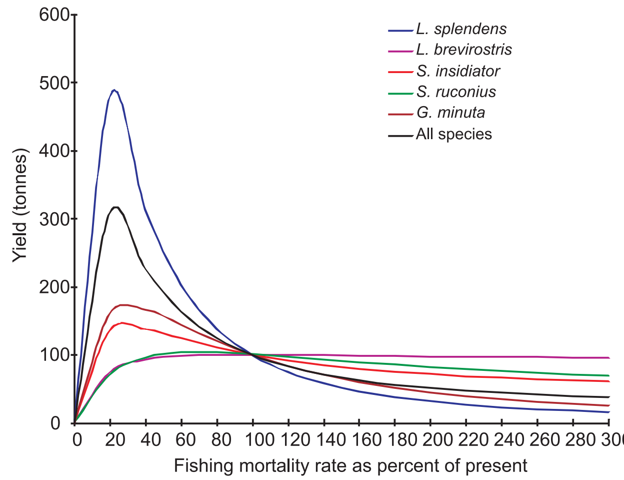

Fig. 8. Estimated yield as percentage of present (in different species and all species together) as function of fishing mortality

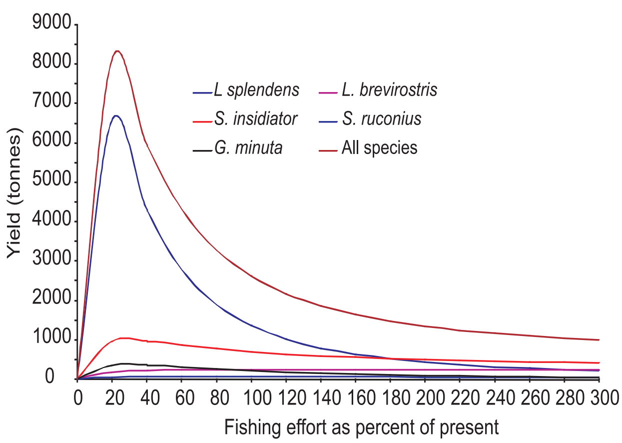

Fig. 7. Estimated yield of different species at different levels of fishing effort in Kerala

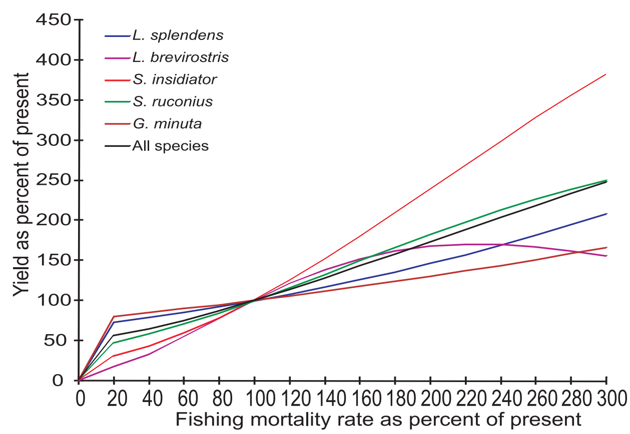

Fig. 9. Estimated yield of different species as function of age at first capture expressed as percent of present

however, cannot be taken as suggestive of overexploitation of silverbelly resources, because of the equilibrium assumption: at the current effort and codend mesh size levels, the equilibrium yield is around 2600 t of the five species. Immediate reduction of fishing effort on the basis of the present results would lead to a drastic decline in the landings immediately, but if such reduced effort is maintained at the same level constantly, the yield would continue to grow over a period of time and then attain equilibrium level. In the long-term predictions, it is necessary to realize that the yields are equilibrium ones and any regulation should be done keeping in view the long-term changes and transition from one equilibrium to another.

Acknowledgements

The authors are grateful to Dr. G. Syda Rao, Director, CMFRI for encouragement and support. They also wish to

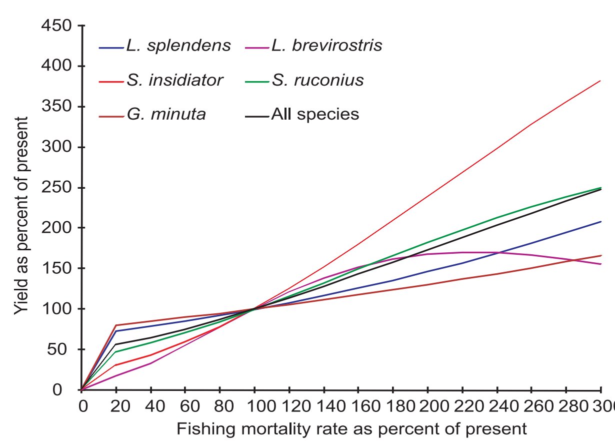

Fig. 10. Estimated yield a percent of present (in different species and all species together) as function of fishing mortality rate also expressed as percent of present

express sincere thanks to Dr. Sathish Sahayak and Shri. N. Rudramurty for their help and support.

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Date of Receipt : 11.11.2010
Date of Acceptance : 02.06.2011