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APPLICATION OF 'YIELD PER RECRUIT' AND 'SURPLUS YIELD' MODELS TO THE GREY MULLET FISHERY OF NEGOMBO LAGOON, SRI LANKA

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Introduction:

The maximum sustainable yield (MSY) has been widely used to determine the biological status of exploitation of fishery rasources. The yield per recruit model of Beverton and Holt (1957) has been widely used in the determination of variation of yield per recruit of a fish stock with fishing effort while surplus yield model of Schaefer (1954) is used to estimate the MSY and the maximum sustainable fishing effort of a fishery. In the management of small scale fisheries, in addition to the biological status of the fish stock, socio-economic conditions are also been considered and the concept of maximum social yield (MScY) has been suggested recently to determine the optimum rate of exploitation (Panayotou, 1982). However, estimation of MScY needs the determination of MSY.

In Negombo lagoon (7°10'N and 79°50'E), grey mullets are the most important group of fish contributing for about 38% of the total fin fish catch (Wijeyaratne, 1984). Nine species of grey mullets have been recorded to exist in this lagoon (Costa and Fernando, 1981). They are *Liza dussumieri* (*L. subviridis*), *L. macrolepis*, *L. strongylocephalus* (*Valamugil cunnesius*), *L. tade*, *L. vaigiensis*, *L. parsia*, *L. oligolepis*, *Mugil cephalus and Valamugil buchanani*.

In this analysis, Beverton and Holt's (1957) "yield per recruit" model and Schaefer's (1954) "surplus yield" model were used to determine the maximum sustainable yield of grey mullets and the optimum fishing effort needed to obtain that amount of yield in Negombo lagoon.

Materials and Methods:

The grey mullet catch of Negombo lagoon was sampled weekly at fish landing sites at Katunayake, Pitipana and Negombo from January, 1980 to December, 1982. The species of grey mullets were identified and the numbers present in each 2 cm length group were recorded. The total weight of each grey mullet species as well as that of all fish species landed were measured. The types of gear used and the amount of time spent in fishing were also recorded. Using these catch data, instantaneous mortality coefficients and catchability coefficients for each gear were calculated by the methods described by Pauly (1980) and Gulland (1969). The yield per recruit (Y/R) of six species of grey mullets, namely *Liza dussumieri*, *L. macrolepis*, *L. tade*, *Mugil cephalus*, *Valamugil buchanani and V. cunnesius* at different levels of instantaneous fishing mortalities was calculated by Beverton and Holt's (1957) yield model. The fishing efforts of each gear which are needed to obtain maximum Y/R of each grey mullet species were then determined. Maximum sustainable yields of grey mullets for different types of gear were calculated also by the 'surplus yield' model of Schaefer (1954) using the procedure described by Pauly (1980).

Results and Discussion:

Seven species of grey mullets were identified in the commercial catches of the lagoon during this study. These are *Liza dussumieri*, *L. macrolepis*, *L. tade*, *L. vaigiensis*, *Mugil cephalus*, *Valamugil buchanani*

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oand *V. cunnesius*. In adaitin to these, Costa and Fernando (1981) have identified two more species, *L. parsia* and *L. oligolepis*. All these species except *L. vaigiensis*, *V. buchanani* and *V. cunnesius* have been observed from the brush parks of the lagoon by De Silva and Silva (1979). Most of these species have been observed in the estuaries of India. In Hoogly, Thakur (1970) has observed five species of grey mullets namely, *Mugil cephalus*, *M. corsula*, *M. cunnesius* (*V. cunnesius*), *M. parsia* and *L. tade* while in Mahanadi, in addition to the above species *L. macrolepis* (*M. troscheli*) has also been found. In brackishwater environments of West Bengal, Pakrasi *et al.* (1966) have observed four species of grey mullets of which *L. tade* and *M. parsia* were the most important.

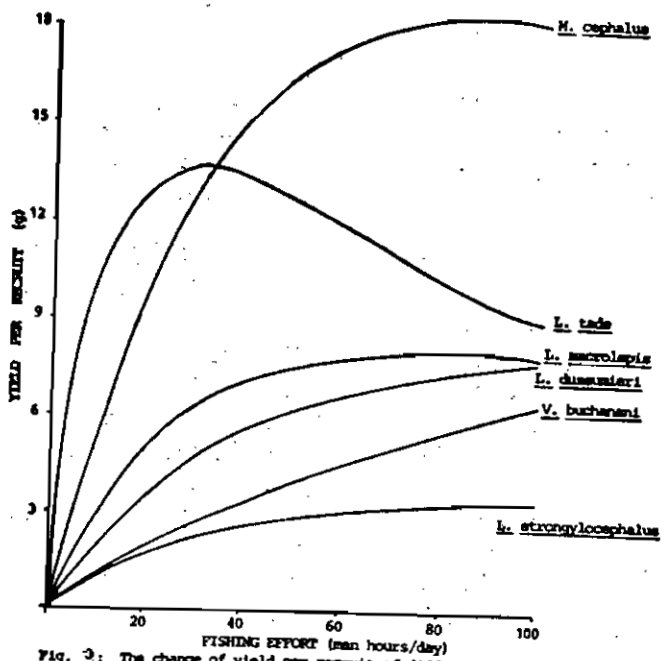

Fig. 3: The change of yield per recruit of different species of grey mullets with the fishing intensity of brush parks.

TABLE 1

Catch and effort statistics of grey mullet fishery in Negombo lagoon

Type of gear	Total weight of grey mullets landed (kg/year)	Grey mullet catch as a % of total grey mullet catch of all gears	Grey mullet catch as a % of total fish catch of all gears	Fishing effort		Grey mullet catch per unit effort kg/manhour
				manhours per year	manhours per day	
Brush parks	11206	48.80	52.01	23565	75.5	0.4829
Encircling nets	4060	16.76	21.84	58575	187.7	0.0717
Gill nets	1604	6.88	24.85	12359	39.6	0.1275
Cast nets	4117	17.78	43.49	27889	89.4	0.1505
Modified set nets	2106	9.44	70.08	6370	20.4	0.3373
Other gears	77	0.35	3.36			

Catch and effort statistics for grey mullets in Negombo lagoon are summarized in Table 1. Total catch of grey mullets of the entire lagoon was about 23,000 kg/year (5.67 kg/ha/year) while the total catch of all fin fish species was about 63,000 kg/year (14.74 kg/ha/year). About half of the catch of grey mullets came from the brush parks. The contributions from cast nets and encircling nets were about 18% and 17% respectively while those of modified set nets and gill nets were less than 10%. However, of the total fin fish catch of modified set nets, more than 70% were the grey mullets. Similarly, about 50% of the total catch of brush parks comprised of grey mullets. In encircling nets and gill nets, the percentage occurrence of grey mullets was less than 25% of the total fin fish catch (Table 1). When the catch of grey mullets per unit effort is considered brush parks were the most efficient type of gear for grey mullet with a catch per unit effort of 0.48 kg/man hour. The value for encircling nets was the lowest with 0.07 kg/man hour.

TABLE 2

Total Catch and Relative Importance of Grey Mullets in Negombo Lagoon.

Species	Total catch (kg)	Relative importance (%)
Liza dussumieri	8470	37.25
L. macrolepis	2125	9.10
L. tade	5981	25.19
L. vaigiensis	136	0.58
Mugil cephalus	1398	6.12
Valamugil buchanani	1920	8.56
V. cunnesius	3107	13.07
Other grey mullets	32	0.13

The total catch and the relative importance of different species of grey mullets in Negombo lagoon are given in Table 2. The catch of *L. dussumieri* was the highest immediately followed by *L. tade*. These two species together contributed to more than 60% of the total grey mullet catch of the lagoon. *V. cunnesius* was the next most important grey mullet species in the commercial catch contributing to 13% of the total grey mullet catch. The catch of *M. cephalus* was very low being only 6% of the total mullet weight landed. This species composition may reflects the abundance and recruitment rates of different grey mullet species present in the lagoon. In Hoogly estuary, India, *M. parsia* and *L. tade* were found to be the most abundant while in Mahanadi estuary, *V. cunnesius* *M. cephalus* and *M. parsia* predominated (Thakur, 1970). Grey mullets, which contributed for about 38% of the total fish catch, formed the most important group of fishes in the commercial landings of Negombo lagoon. This figure is above that recorded for Mahanadi estuary where 30% of the total fish catch is constituted by grey mullets (Thakur, 1970).

TABLE 3

Catchability coefficients and optimum fishing efforts of different types of gear used in Negombo lagoon.

Species	Catchability coefficients					Optimum fishing efforts (manhours/day)				
	Brush parks	Encircling nets	Gill nets	Cast nets	Modified set nets	Brush parks	Encircling nets	Gill nets	Cast nets	Modified set nets
Liza dussumieri	0.0037	0.0042	0.0120	0.0026	0.0256	127	112	39	181	18
L. macrolepis	0.0045	0.0031	0.0060	0.0008	0.0198	78	113	58	438	18
L. tade	0.0111	0.0026	0.0075	0.0064	0.0269	30	127	44	52	13
Mugil cephalus	0.0032	0.0017	0.0034	0.0002	0.0107	91	171	85	14500	27
Valamugil buchanani	0.0011	0.0034	0.0091	0.0007	0.0204	391	126	47	614	21
V. cunnesius	0.0083	0.0050	0.0168	0.0189	0.0260	125	208	62	55	40

The catchability coefficient of a particular species was found to vary greatly with the type of gear. The lowest catchability coefficients for all gear other than brush parks were observed for *M. cephalus* while the lowest for that gear was obtained for *V. buchanani* (Table 3). [illegible] catchability coefficients for bru[illegible] and modified set nets were observ[illegible] *tade* while those for other types were obtained for *V. cunnesius*.

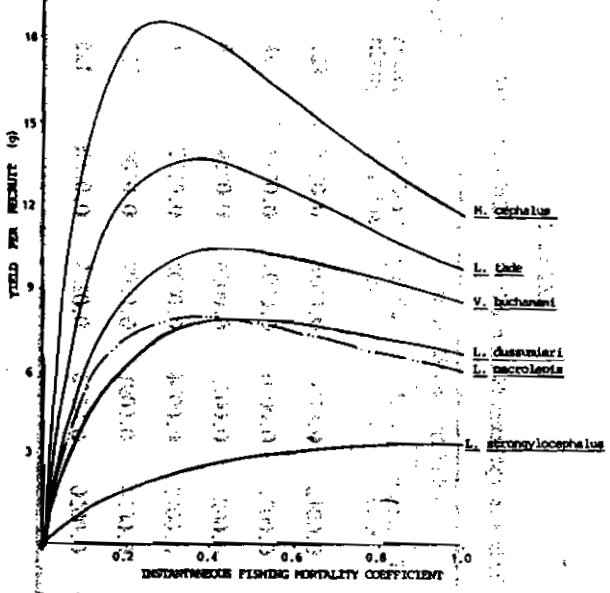

Fig 4: The change of yield per recruit of the different species of grey mullets with instantaneous fishing mortality coefficient.

TABLE 4

Instantaneous fishing mortality coefficients and the parameters used in Beverton and Holt's yield equation.

F — Instantaneous fishing mortality coefficient
Optimum F — Calculated optimum value of instantaneous fishing mortality coefficient.
M — Instantaneous natural mortality coefficient.
t_o — Age when the length would theoretically be zero (years)
t_r — Age at recruitment (years)
t_c — Age at first capture (years)
k — Coefficient of growth
w_∞ — Asymptotic weight (g)

Species	F	Opitimum F	M	t_o	t_r	t_c	k	w_∞
Liza dussumieri	0.4595	0.47	0.7024	—0.1126	0.1170	0.7287	0.1526	1753
L. macrolepis	0.1230	0.35	0.5628	—0.5975	—0.3080	0.4534	0.0969	3139
L. tade	0.5488	0.33	0.5109	—0.1949	—0.0335	0.5832	0.1734	1276
Mugil cephalus	0.1845	0.29	0.5082	—0.3623	—0.1232	0.4993	0.0943	6698
Valamugil buchanani	0.3191	0.43	0.6541	—0.3238	—0.1043	0.4803	0.1582	1891
V. cunnesius	0.9408	1.04	1.0408	—0.2651	—0.0601	0.5245	0.3365	264

The change of Y/R with instantaneous fishing mortalities (F) are shown in Fig. 1. The parameters used in these calculations are given in Table 4. Y/R increases with F until it reaches a maximum value and then decreases. The optimum level of F, at which maximum Y/R is obtained are also given in Table 4. The minimum and maximum values of these were observed for *M. cephalus* and *V. cunnesius* respectively. It is also seen that the optimum level of F for *L. dussumieri*, *L. macrolepis*, *V. cunnesius*, *M. cephalus* and *V. buchanani* are higher than the existing level (Table 4). This indicates that by increasing the fishing ... Y/R of these species could be in... Fig. 1 shows that Y/R at a particular ... of F varies with the species. The hig... and the lowest values for Y/R at a give... value of F were observed for *M. cephalu...* and *V. cunnesius* respectively. The chang... of Y/R with fishing efforts of differen... types of gear is shown in Figs. 2—6. Th... optimum fishing efforts of different type... of gear for each grey mullet species at whic... the highest Y/R is obtained are given i... Table 3.

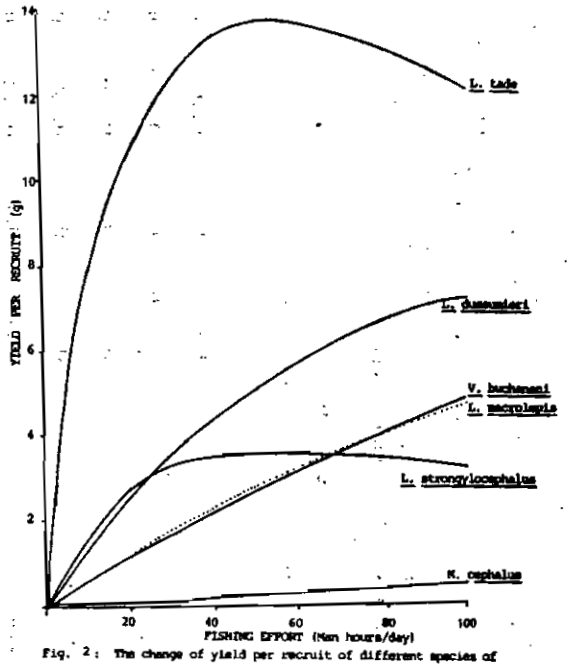

Fig. 2: The change of yield per recruit of different species of grey mullets with the fishing intensity of cast nets.

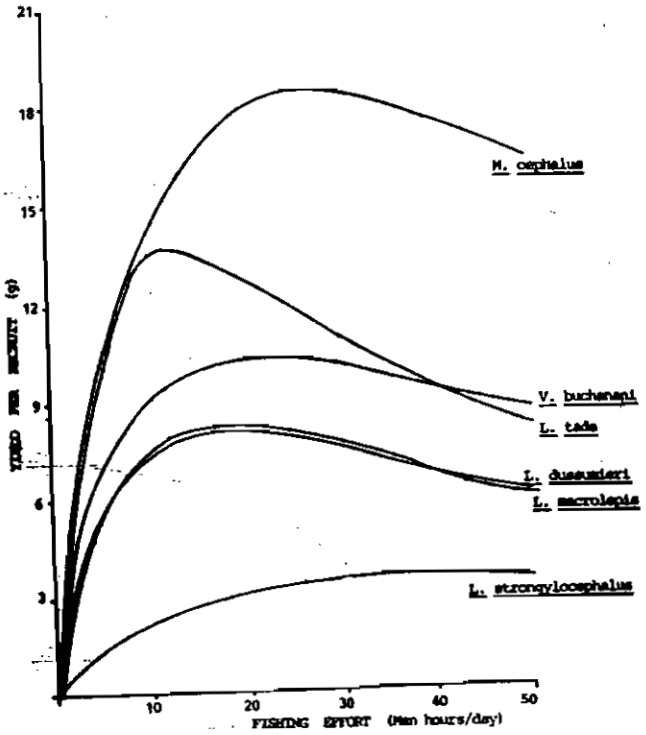

Fig. 4 : The change of yield per recruit of different species of grey mullets with the fishing intensity of modified set nets.

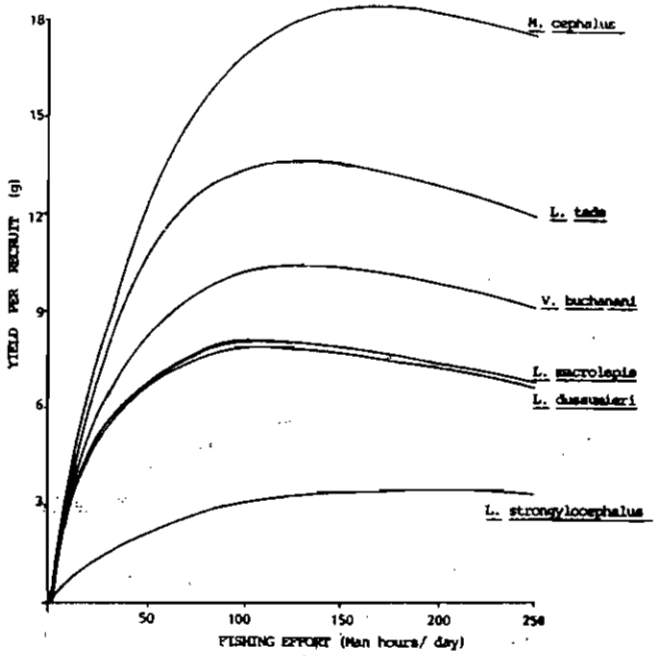

Fig. 5: The change of yield per recruit of different species of grey mullets with the fishing intensity of encircling nets.

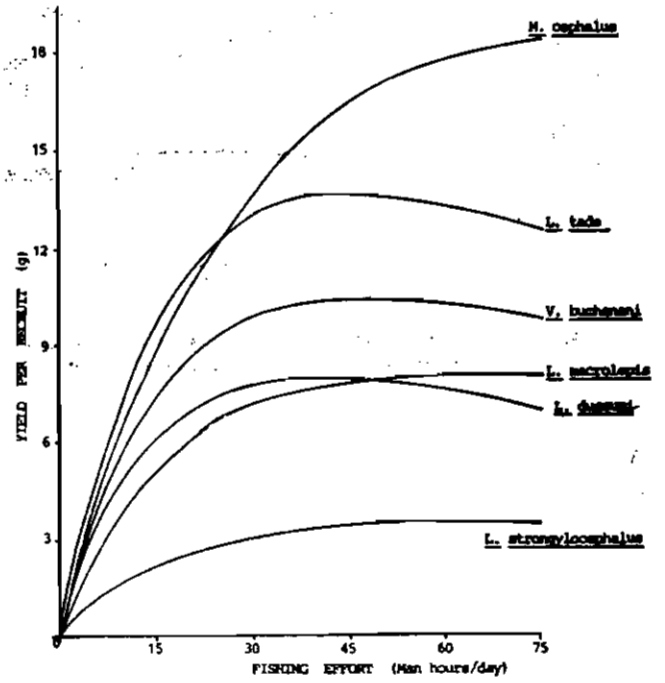

Fig. 6: The change of yield per recruit of different species of grey mullets with the fishing intensity of gill nets.

Since catchability coefficients of cast ets for *L. macrolepis*, *L. dussumieri*, *M. phalus* and *V. buchanani* are very low Table 3), bringing a change in the use of his gear may not significantly affect their atch. However, a decrease in the use of ast nets may increase the catch of *L. tade* nd *V. cunnesius* because maximum Y/R f these species whose catchability coeffi- ients are higher with this gear, is obtained t lesser fishing effort values than the existing vel (Fig. 2). Similarly, increasing the use f brush parks will increase the catch of all rey mullet species other than *L. tade*. ince catchability coefficient of *V. buchanani* or this gear is very low (Table 3), change in the use of brush parks may not how a significant change in the total atch of this species. To obtain maximum /R of *L. dussumieri*, *L. macrolepis* and *L. ade* from modified set nets, the use of this ear has to be decreased. Since the catcha- ility coefficients of these three species, vhich contribute for 68.5% of the total rey mullet catch, are high with this gear, his decrease of the use may significantly ffect the total grey mullet catch. Similarly, lecrease in the use of encircling nets will lso increase the Y/R of all grey mullet pecies other than *V. cunnesius* wh ch com- rises only 13% of the total grey mullet atch. The increase in the use of gill nets will increase the Y/R of all grey mullet pecies other than *L. dussumieri*. Therefore he analysis using Beverton and Holt's model hows that a decrease in the use of cast nets, ncircling nets and modified set nets and an increase in the use of brush parks and gill ets will increase the yield of grey mullets n Negombo lagoon.

TABLE 5

Maximum sustainable yields and optimum fishing efforts of different types of gear for the grey mullets calculated by Schaefer's 'surplus yield' model.

Type of gear	MSY (kg/year)	Optimum effort (Man-hours/day)
Brush parks	12593	109.7
Encircling nets	5096	133.1
Gill nets	1679	42.8
Cast nets	4383	64.2
Modified set nets	2797	15.8

The maximum sustainable yields and maximum sustainable fishing efforts of different types of gear calculated by Schaefer's 'surplus yield' model are given in Table 5. The MSY of grey mullets in Negombo lagoon was calculated to be 27148 kg/year which is about 15% higher than the present catch. This analysis also indicates that the use of brush parks and gill nets has to be increased while that of modified set nets, cast nets and encircling nets has to be decreased in order to obtain the MSY of grey mullets.

When the fishing effort is changed, in multispecies fisheries, the species composition of the catch may also change (Panayotou, 1982). However, since the prices of individual grey mullet species do not greatly vary from each other, the unit market value of the total grey mullet catch may not vary considerably due to the changes of species composition which may result by the changes of fishing efforts of different types of gear.

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