POPULATION DYNAMICS OF SILVERBELLY *LEIOGNATHUS JON ESI* IN PALK BAY

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ABSTRACT

Based on catoh, effort and length-distribution data on *Leiognathus jonesi* collected at Mandapam over a period of sk seasons, age and growth, selection factor, coefficient of total mortality (Z) and coefficient of natural mortality (M) were derived[1]. For the estimated' natural mortality rclte (2.1) and for the mesh size (25 mm codend) now in operation, the optimum effort has been found to bs 50,000 standard night effort, (= 5,000 std. day effort), the yield per hundred recruits being 310 g. The isopleth diagram indicates that there was overfishing of silverbellies in 1973-74 and 1974-75 when the effort far exceeded the optimum level. The isopleth diagram also shows that the present mesh size yields the best catch and an increase in mesh size to 35 mm or decrease to 15 mm leads only to a decrease in yield. For a scientific rwanagetnemt of the fishery, it is suggested that the effort be maintained at 50,0000 night standard effort with the present mesh size at 25 mm so as to obtain sustained yield of this fish in the coming years.

INTRODUCTION

Considerable work has been done on the population dynamics of the major fisheries of the world and principles for the efficient management of the same have been evolved. Mention can be made of the work done by Beverton and Holt (1957), Gulland (1961), Beverton (1963), Cushing and Bridger (1966), Bayliff (1967), Schaefer (1967) and Ricker (1975). In the recent past, there have been some contributions on the population dynamics of commercially important fisheries occuring in the coastal waters of India, as for instance on oilsardirae, mackerel, 'ghol' and prawns (Subba Rao 1968, Anntgeri 1972, Banerji 1973, Banerji and Krishnan 1973, Sekharan 1974 and Ramamurthy et al 1975).

Among the coastal fisheries of India, silverbellies occupy an important place forming about 4% of the total marine fish catch, Nearly half of the total landings of silverbellies is obtained from Tamil Nadu, the bulk of which is obtained from the Palk Bay. Among them, *Leiognathus jonesi* formed the dominant species accounting for as much as 90%. This fish has been subjected to heavy exploitation off Mandapam in the Palk Bay after introduction of mechanised trawlers and it is important to examine the dynamics of the fishery to determine the effect of intensive fishing on the abundance of the stock.

Some aspects of silverbelly fisheries of the Palk Bay have been dealt with by Arora (1951), Krishnamurthy (1957), James and Adolf (1971), James (1973) and Venkataraman and Badrudeen (1974). As the total catch of *L. jonesi* obtained at Mandapam and other centres of Palk Bay did not show similar trends from year to year (Table 1) and as effort data were not available from other centres, catch and effort data for Mandapam alone were considered for this paper. Analysis of the catch and effort data of *L. jonesi* obtained off Mandapam for the past few years has shown a decline in the total catch and catch per boat trip from 1974-75 onwards. Hence it was felt essential to study the population dynamics of this fish so as to evolve suitable management policies in regard to this fishery. Based on the data collected (Venkataraman and Badrudeen MS) vital parameters like growth, mesh selection and natural and fishing mortalities were calculated.

ESTIMATION OF PARAMETERS

Age and growth

From 'the age studies made out (Venkataraman and Badrudeen MS *op. cit.),* it is seen that *L. jonesi* attains an average length of 72 mm at the end of one year and 108 mm at the end of two years. Further it reaches an average length of 116 mm when it is 28 months old. Von Bertalanffy growth curve was fitted and the growth parameters were found to be L_0 = 161.2 mm, K = 0.528 (yearly) and t_0 = 0.111 year. The length-weight relationship was worked out and found to be

$$\text{Log } W = 2.9276 \text{ Log } L - 6.6094$$

TABLE 1. *Total Calch of silverbellies from Mandapam and other centres of Pedk Bay during years* 1970-76.

	Mandapam catch in tonnes	Other centres catch in tonnes	Total Palk Bay catch in tonnes
1970	8267	15451	23718
1971	4054	8469	12523
1972	7833	9781	17614
1973	10047	10249	20296
1974	8799	13745	22544
1975	4786	10376	15162
1976	2055	27369	29484

From this length-weight relationship the weight of fish measuring in total length 161.2 mm (Lao) is found to be 114.8 g(Woo)

Recruitment and selection

The rate of mortality of fish may vary according to size and habit of the fish. Sometimes, small fishes may not be subject to fishing mortality as they may escape through the meshes of the net if the mesh size is big. Further they will not be subject to fishing mortality if they are not available in the fished area. Thus two factors come into play, one being the behaviour of the fish and the other being the properties of gear selection.

One of the parameters required for the preparation of simple Beverton-and-Holt4ype population model, is the age (t) or the length (1) at which the fish enters the exploited phases of the population. According to Beverton and Holt's definition (1957), the age of entry to the exploited phase (t) is determined by the size at which 50% of the individuals are retained by the fishing gear. For determining this, gear experiments have to be carried out by attaching a small-meshed cover over the codend of the trawl and funding out the size that has escaped the codend, Or else, it can be found from the size composition of the catches of nets of much smaller meshes fished at the same time and place. But in the case of *L. jonesi* neither of the two experiments could be carried out. Hence selection length for this fish at 50% level was determined based on length-frequency analysis of catch obtained in trawl and shore seine *(Karaivalai).*

In figure 1 (A-D) is shown weighted length-frequency composition of *L. jonesi* obtained in day fishing, night fishing and day-and-night fishing for the first four seasons. From (the graph it is seen that the modal values by day fishing, night fishing and day-and-night fishing together fell around 50 and 80 mm respectively. As the breadth of 80 mm fish falls *eat* 35 mm (Fig. 4) which is higher than the codend mesh size of 25 mm, the 50 mm mode was considered for the calculation of 50% of retention length. As the mesh selection operates only on the fishes whose size is lesser than the first mode viz. 50 mm, the percentage of size groups falling within this mode was calculated, the cumulative values of which have been plotted in Fig. 2 for different categories of fishing for the four seasons separately.

The estimates of 50% - rentention sizes for the four seasons in day fishing, night fishing and day-and-night fishing combined and their averages for four seasons are given in the Table 2. It is seen from the same table that in night fishing the average 50% - retention length is 43.06 mm and in day fishing 47.94 mm though the codend mesh size is same. The difference in 50% retention length in the day and night fishing is due to the migratory behaviour of the silverbelly. For the purpose of our .studies we have taken the average 50% retention length based on the pooled data of day and night catches for the four seasons. This comes to 47.81 mm which is corrected to 48 mm. The corresponding age for this value (48 mm) which represents l_c has been found to be 0.3722 year (t_c).

The mesh-selection length at 50% level was worked out for shore seine also *(Karaivalai)* having an average condend mesh size of 15 mm. Since the number of specimens obtained for length-frequency analysis in different seasons was

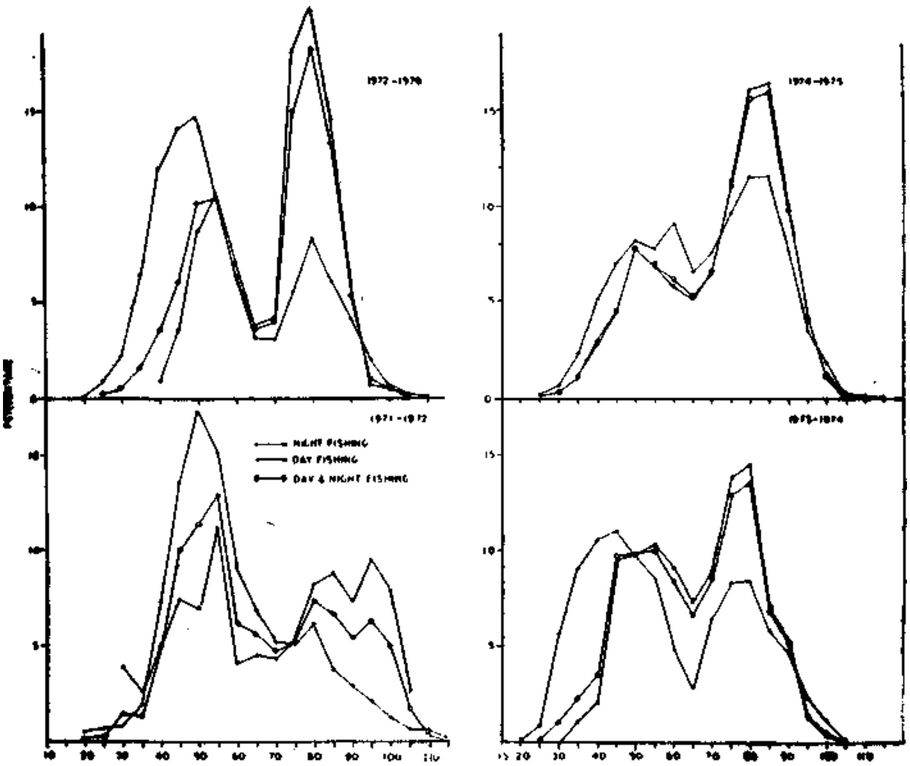


FIG. 1 Weighted length-frequency composition of *L. jonesi* in the day catch, night catch and day-and-night catch for four seasons, 1971-72 to 74-75.

not found to be sufficient for analysing length frequencies separately on a seasortwise basis, they were pooled together and analysed. Here four modes were otaserved falling respectively at 20 mm, 35 mm, 50 mm and 60 mm (Figure 3A). As the breadth of the fish having the mode at 20 mm falls at 5 mm. (Fig. 4), they should have normally escaped from the net whose mesh size is 15 mm. However, due to the clogging of the codend of the net by mud and slimy fishes, it has not been possible for the young fish having 20 mm mode to escape from the net. As no selection factor comes into play for this mode, the next mode falling at 35 mm was considered for the cakulation of 50% retention length which was found to be 29 mm (Fig. 3B).

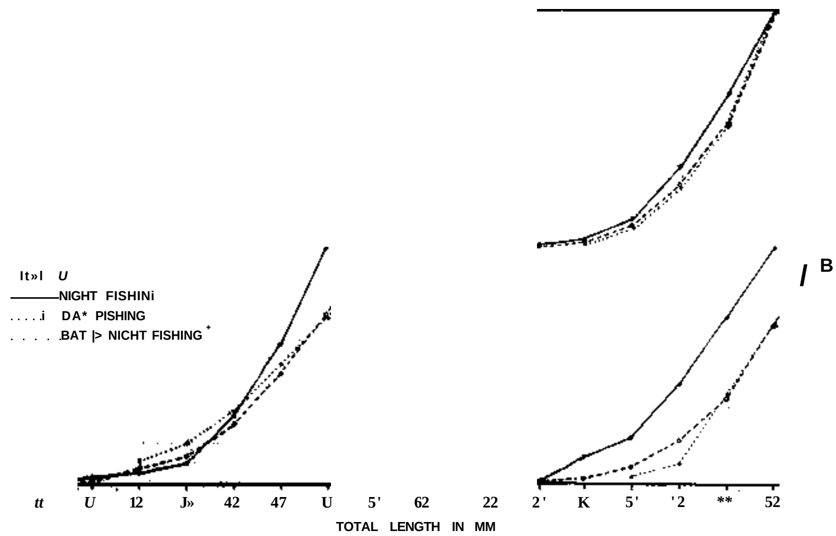


FIG. 2. The cumulaitive percentage of size groups falling within the first mode for day fishing, night fishing and day-and-night fishing for four seasons.

The selection factors for trawl and shore seine, as. determined by the expression:

$$\text{selection factor} = \frac{50\% \text{ retention length}}{\text{Mesh size}}$$

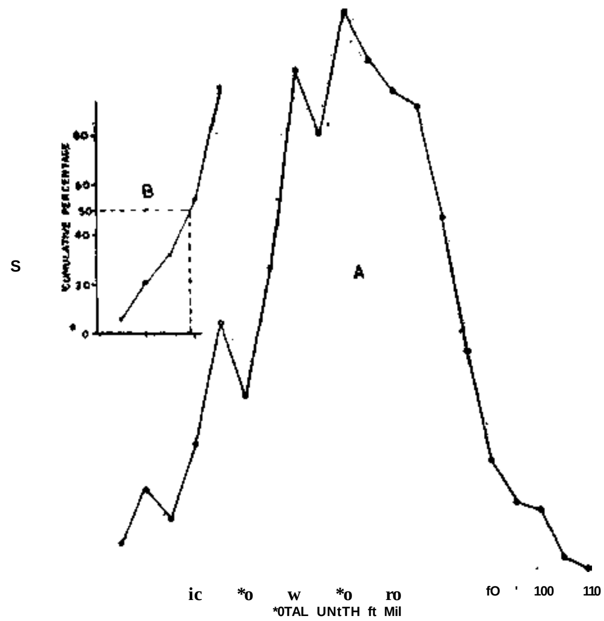
were found to be 1.92 mm for trawl and 1.93 mm for shore seine which were nearly same for the two nets.

Coefficient of total mortality

At first, the estimates of instataneous total mortality coefficient (2) of the combined catches of day-and-night fishing and of day fishing and night fishing 'separately for the Palk Bay were attempted. The number of fish falling in

TABLE 2. 50% *rentention length (in mm) in respect of night fishing, dav fishing and day-and-night fishing together and their averages for the four seasons from* 1971-72 t_Q 1974-75.

	Night fishing	Day fishing	Day-and-night fishing
1971-72	45.50	47.00	47.75
1972-73	43.50	49.00	49.00
1973-74	38.50	49.00	48.00
1974-75	44.75	46.75	46.50
Average	43.06	47.94	47.81



FJG. 3. A. Pooled length-frequency composition of *L. jonesi* in shore-setae catches for the years 1971 to 1974; B. Cumulative percentage size groups within 35 mm mode.

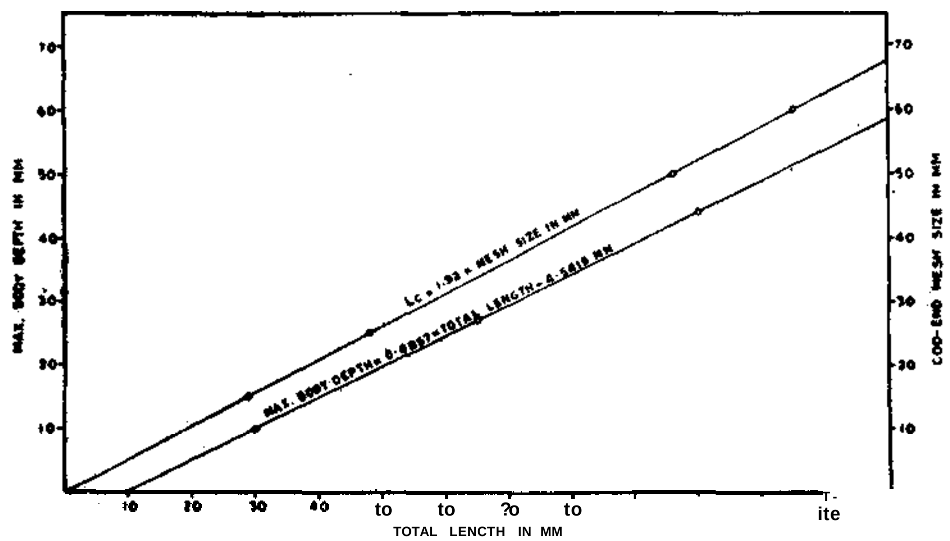


FIG. 4. The total length-maximum body depth relationship of *L. jonesi* and codend mesh-size length at capture or 50% retention length relationship.

different length groups in a particular sample day were raised to the catch of the fish obtained on that day and the pooled length frequencies of different sample days were again raised to the monthly catch, thus arriving at weighted frequencies (in numbers) for different months of the year. On the basis of age studies (Venkataraman and Badrudeeti MS) fish falling under and inclusive of 70 mm size group (70-74 mm) were designated as 0+ year-old fish and those falling above 70mm size group and up to 105mm size groups were designated as 1 +-year-old fish. Those falling above the size group of 105 mm were designated as 2+ year-old fish.

The catch per boat-trip in numbers of 0+, 1+ and 2+ year^ld fish from the Palk Bay for both day and night catches together for six seasons from May 1970-April 1971 to May 1975-April 1976 is given in Table 3. It is seen from the table that between 0+ and 1 + year-old fish of different year classes, only in 3 cases viz, 1970-71, 1973-74 and 1974-75 year classes were 1+ year-old fish

TABLE 3. *Catch per boat trip in numbers of* 0+, 1+ *and 2+ year-old* L. jonesi, *obtained by day and night fishing together from the Palk Bay during* 1970-71 *to* 1975-76 *seasons at Mandapam.*

	Total boat trips	Catch per boat trip in number 0+year	l+year	2+year
1970-71	4321	18975	75945	1500
1971-72	10149	34679	15275	143
1972-73	15422	32283	40644	13
1973-74	19345	48109	32905	20
1974-75	19703	25726	35449	6
1975-76	21281	13160	13816	29

TABLE 4. *Catch per boat trip in numbers of* 0+, 1+ *and* 2+ *year-old* L. jonesi *obtained by day fishing from the Palk Bay during* 1970-71 *to* 1975-76 *seasons at Mandapam.*

	Total boat trips	Catch per boat trip in numbers 0+ year	1+ year	2+ year
1970-71	5390	15212	60883	1202
1971-72	1830	88525	55968	———
1972-73	3767	94017	147739	———
1973-74	4222	184263	134535	68
1974-75	10838	40533	59157	———
1975-76	4093	54302	51794	51

lesser in strength and in other cases 1 + year-old fish were greater in number than the proceeding 0+ year-old ones. Though in all the year classes the strength of 2+ year-old fish is less than 1+ year-old fish, 2+ year-old one formed an insignificant portion of the commercial catches, as the oldest specimens of L. *jonesi* from the Palk Bay were only two years and four months old. However, baised on this, best Z estimates could not be made out as the strength of 2+ year-old fish was too poor.

Further a study of the strength of the 0+, 1+ and 2+ year-old fish calculated on the basis of day catch alone, which contributes to a major portion of this fishery (Table 4), showed that only in respect of 1973-74 year class could the instantaneous total mortality coefficient be worked out as in the rest of the year classes the strength of 0+ year-old fish was less than the succeeding 1 + year-old fish.

TABLE. 5. *Catch per boat trip in numbers of* 0+, 1+ *and 2+ year-old* L. jonesi *obtained by night fishing from the Palk Bay during* 1970-71 *to* 1975-76 *seasons at Martdapam. Annual instantaneous total mortality coefficients* (Z) *for* 0+/1 + *year classes and* 1+/2+ *year classes are also given.*

	Total boat trips	0+ year	Z	1+ year	Z	2+ year	Average Z
1970-71	1306	7710		10050		842	
			0.20		4.05		2.13
1971-72	8319	22834		6325		174	
			1.33		5.92		3.63
1972-73	11655	12330		6031		17	
			1.00		6.76		3.88
1973-74	15123	10098		4532		7	
			0.44		5.93		3.19
1974-75	8866	7623		6464		12	
			1.46		5.59		3.53
1975-76	17188	3363		4772		24	
Average Z			0.89		5.65		3.27

Catch per boat trip in numbers of 0+, 1+ and 2+ year-old fish obtained by night fishing alone from the Palk Bay during 1970-71 to 1975-76 seasons are given in Table 5. In this case, it is seen that the strength of the 0+ year-old fish was higher than 1 + year-old fish whose strength was in turn higher than 2+ year-old fish for all the year classes. Hence the instantaneous total mortality coefficients (z) of different year-classes were worked out by the following equation:

$$Z = \mathrm{Log}_e \_$$

where Nl is the catch per unit effort in numbers of an age group in a given year and N2 is the catch per unit effort in numbers of the suceeding age group of the same year-class in the subsequent year. The Z values between the 0+ and 1+ year-old and also between the 1+ and 2+ year-olds are presented in Table 5. The Z values between 0+ year and 1 + year old fish for different year classes showed wide fluctuations during the seasons under consideration. Because of the poor strength of 2+ year-old fish the Z values between 1+ year old fish and 2+ year-old fish were found to be high.

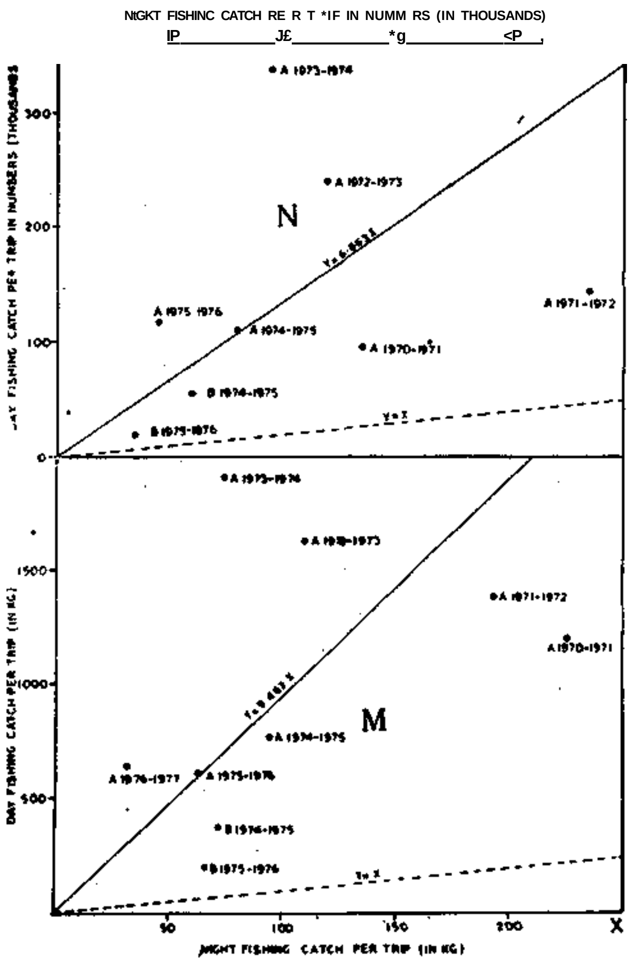
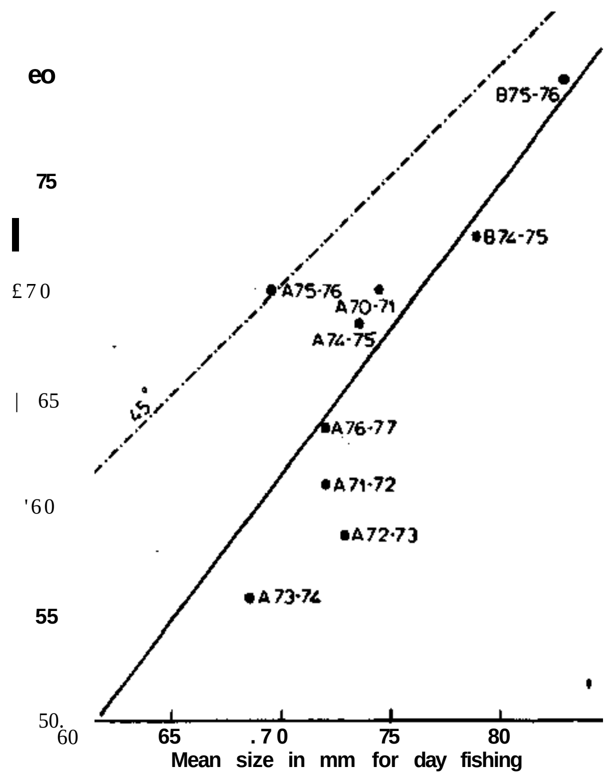


FIG. 5. The regression of catch per boat-trip during day on catch per boat-trip during night (M), and catch in number per boat-trip during day on number per boat-trip dining night (N), plotted in respect of each half-year period. As and Bs in the figure refer irespectiively to May-October and November-April periods of respective fishing seasons.

The differences in the strength of 0+ year old and 1+ year-old fish between day and night catches can be understood from Fig. 6 wherein the mean size of night fishing is plotted against the mean size of day fishing for the corresponding half-year periods and it is evident that the mean size is lower in night catch than in day catch. The difference is higher in lower mean sizes because the smallest size groups (10-50 mm) are not caught in day fishing in proportion to night fishing. Further Fig. 5 M, where the regression lines between the catch per trip by night and day fishing are given, shows that the catch per boat obtained in day fishing is nearly 10 times that of night fishing. However the variation in numbers between the catches of day and night fishing is only 7 times which is due to the more number of smaller-sized specimens being caught at night (Fig. 5N). This variation in the catch per boat-trip in respect of size and numbers can be attributed to diurnal migration observed in silverbellles (Venkataraman and Badrudeen 1974).



FI<3. 6. The regression of the mean sizes in day catches on night catches plotted in respect of each half-year period'.

Thus the analysis of the catch and size-group data of day and night catches show as if two types of gears have been operated on the same stock. Under these circumstances, it became necessary to standardise the effort in terms of both day catch and night catch and arrive at the total instantaneous mortality coefficients (Z) of day and night catches together. For a better representation of different age groups, it was felt desirable to analyse the age groups in terms of half-yearly classes as the mesh selection size was found to be 48 mm which it attains when it is about six months old.

In Table 6 are shown the total catch of *L. jonesi*, the effort put in (in terms of boat-trips) and the weighted numbers in the catch for each half-year class during the seasons 1970-71 to 1975-76 for day and night fishing separately.

TABLE 6. *The total catch of* L. jonesi, *the effort put in (in terms of boat trips) and the weighted numbers (in thousands) in the catch for half year class for day and night fishing separately in each half year period from May-October* 1970 *to November-April* 1976.

		Weight of the catch in tonnes	Boat trip efforts	0-44 mm 0-0.5 year	45^74 mm 0.5-1 year	75-94 mm M.5 year	95-109 mm 1.5-2 year	110 mm and aobve 2 year and above
May 70-Oot 70	D	4900	4094	52299	19623	222353	92672	5380
	N	74	329	1196	2393	2393	2393	598
Nov 70-Apr 71	D							
	N	1-53	977	2039	4441	4027	4312	502
M&y 71-Oct 711	D	2550	1830	37439	124561	95992	6430	
	N	93«	4866	25663	158556	35667	8681	1394
Nov 71- Apr 72	D							
	N	100	3453	1411	4323	7535	726	55
May 72-Oot 72	D	6180	3767	7801	346361	545239	11293	
	N	797	7262	53»9	124994	38306	5244	117
Nov 72-Apr 73	D							
	N	319	4393	2358	10966	24395	2341	85
May 73-Oct 73	D	8119	4222	40064	737892	546224	21783	286
	N	646	8699	53351	77328	28612	5312	75
Nov 73-Apr 74	D							
	N	425	6424	4657	17381	31983	2625	32
May 74-Oct 74	D	6728	8646	41560	365107	505950	47218	
	N	421	4491	5249	38261	24158	3903	66
Nov 74-Apr 75	D	843	2192	2686	29945	76285	11687	
	N	316	4375	4626	19447	26360	2885	44
May 75-Oct 75	D	2234	3589	41501	178913	1«®822	14911	66
	N	514	8106	9052	31607	30133	5401	53
Nov 75-Apr 76	D	114	504	683	1160	6249	2009	142
	N	602	9082	6227	10916	33916	12573	351

D = Day fishing; N = Night fishing

It is seen from the table that the catches of *L. jonesi* are more in the day than in night. In Table 7 are shown the numbers of fish per standard effort based on day's catch for different age groups and in the Table 8, the same are shown based on night's catch. In Table 9 are shown Z values in respect of half-yearly classes 1/1.5 and 1.5/2 of *L. jonesi* based on night standard effort and day standard effort respectively. Their average Z values for different seasons and for the entire period are also shown. The Z value for 0.5/1 half-yearly class were not calculated as in many seasons the 0.5 half-yearly class was poorly represented in the fishery as compared to its representation in the succeeding half-year.

TABLE 7. *Number of fish per standard effort based on day's catch for half year groups in each half year period.*

	Weight of the catch in tonnes	Standard effort	CPUE in kg	0HX5 year	0.5-1 year	1-1.5 yeair	1.5-2 year	2 year and above
May 70-Oet 70	4974	4156	1197	12872	47792	54077	22874	1438
Nov 70-Apr 71	153	127	1202	16056	34969	31711	33951	3953
May 71-Oot 71	3488	2503	1394	25211	113H11	52601	29158	557
Nov 71-Apr 72	100	72	1385	19601	6O042	104698	10091	768
May 72-Oct 72	6976	4253	1640	.145015	110820	137208	3888	27
Nov 72-Apr 73	319	194	1643	12157	56528	125749	12068	437
May 73-Oot. 73	8765	4558	1923	20495	178855	126116	5945	101
Nov 73-Apr 74	425	221	1921	21071	78647	144722	11878	145
May 74-Oot 74	714'8	9187	778	5095	43906	57702	5564	7
Nov 74-Apr 75	1159	3016	384	2425	16377	34033	4831	15
May 75-Oct 75	2748	4414	623	96070	47694	49605	4602	27
Nov 75-Apr. 76	716	3422	209	2019	3529	11737	4261	114

The average Z values derived by night standard effort ranged from 1.48 to 4.53 and the corresponding values on day standard effort from 1.11 to 5.35. The average Z values for the entire period for both the half-year closses by night standard effort came to 3.19 and the same for day standard effort 3.15.

The estimates of Z for *L. jonesi* were also calculated within the same season (Table 10) for 1/1.5 and 1.5/2 half-yearly classes respectively, as also their average values. The range in the average half-yearly instantaneous total mortality rates for different seasons was from 1.65 to 4.42. The average Z for the entire period for both the half-year classes came to 3.07.

The range in the annual average values of Z for the six seasons calculated oh the basis of day and night standard efforts and for within the same season for 1/1.5 year-classes is from 1.67 to 5.54, the average Z value for the entire time period being 4.06. (Table 11) (Z values for 1.5/2 half-year classes were not taken into consideration because of the poor strength of 2+ year-old fish).

TABLE 8. *Number of fish per standard effort based on nights' catch for half year groups in each half year period.*

	Weight of the catch in tonnes	Standard effort	CPUE in kg	0-0.5 year	0.5-1 year	1-1.5 year	1.5-2 year	2 year and above
May 70-Oct 70	4974	22010	226	243,1	9024	10211	4319	272
Nov 70-Apr 71	153	977	157	2087	4546	4122	4413	•514
May 710ct 71	3488	18077	193	3491	15662	7283	4037	77
Nov 71-Aipr 72	100	3453	29	409	1252	2183	210	16
May 72-Oet 72	6976	63441	110	972	7430	9198	261	2
Nov 72-Apr 73	319	4393	73	537	2496	5553	534	19
May 73-Oot 73	8765	118413	74	789	6884	4854	229	4
Nov 73-Apr 74	425	6424	65	725	2706	4979	409	5
Miay 74-Oct 74	7148	76060	94	615	5303	6970	672	1
Nov 74-Apr 75	1H59	16080	72	455	3072	6383	906	3
Mlay 75-Oct 75	2748	43018	64	9858	4894	5090'	472	3
Nov 75-Apr 76	716	10798	66	640	1118	3720	1328	46

Coefficient of natural mortality

Estimates of natural mortality rate from fishing intensity and total mortality: In Table 12 are shown the standard night effort, the standard day effort for the six seasons from 1970-71 to 1975-76 and the annual Z values for the respective seasons calculated on the basis of 1/1.5 half-year classes. Running averages of standard effort are also given in the same table to test whether they correlate better with the estimated Z values. Here the standard effort put in the season i and in the season prior to i were averaged because in the ith season the recruits

TABLE 9. *Instantaneous total mortality rates* (Z) *of* L. jonesi *for* 1/1.5 *and* 1.5/2 *half year classes for both night and day standard efforts. The average Z values for the half year periods as a whole are also shown.*

	Night fishing as standard effort			Day fishing as standard effort		
	1/1.5	l'.5/2	Average	1/1.5	1.5/2	Average
May 70-Oct 70						
Nov 70-Apr 71	0.84	2.13	1.48	0.47	1.76	1.11
May 71-Oct 71	0.02	4.05	2.03	0.08	4.11	2.10
Nov 71-Apr 72	3.53	5.53	4.53	1.65	3.64	2.64
May 72-Oct 72	2.12	4.65	3.39	0.99	5.92	3.46
Nov 72-Apr 73	2.85	2.62	2.73	2.43	2.19	2.31
May 73-Oot 73	3.1*	4.89	4.04	3.05	4.78	3.92
Nov 73-Apr 74	2.47	3.S2	3.15	2.36	3.71	3.04
May 74-Oct 74	2.00	6.01	4.01	3.26	7.43	5.35
Nov 74-Apr 75	2.04	5.41	3.73	2.48	5.91	4.20
May 75-Oct 75	2.60	5.71	4J16	2.00	5.19	3.59
Nov 75-Apr 76	1.34	2.33	1.84	2.46	3.46	2.96
Average	2.09	4,29	3.19	1.93	4.37	3.15

TABLE 10. *Instantaneous total mortality rates for the half year groups within the same period.*

	1/1.5 year	1.5/2 year	Average of 1/1.5 and 1.5/2 year
May 70-Oct 70	0.86	2.77	1.81
Nov. 70-Apr 71	1.15	2.15	1.65
May 71-Oct 71	0.59	3.96	2.27
Nov 71-Apr 72	2.34	2.50	2.42
May 72-Oct 72	3.56	4.87	4.21
Nov 72-Apr 73	2.34	3.33	2.84
May 73-Oct 73	3.05	4.04	3.55
Nov 73-Apr 74	2.50	4.40	3.45
May 74-Oot 74	2.34	6.51	4.42
Nov 74-Apr 75	1.95	5.71	3.83
May 75-Oct 75	2.38	5.06	3.71
Nov 75-Apr 76	1.03	3.36	2.20
Average	2.09	4.06	3.07

of the previous season also contribute to the fishery. Linear regression values between the standard efforts and the average Z values are given in Table 13. The same between running average efforts and the average Z values for the respctive seasons were calculated and the regression values are shown in Table 13.

In the same table, the annual instantaneous natural mortality coefficients (M) are also given. The M values for differennt standard efforts ranged from 2.28 to 3.75. It is seen the standard night efforts showed better correlation with their Z values as compared with that of standard day efforts. This is due to more or less uniform and regular night fishing operations as compared with irregular and restricted day fishing operations. As between the natural mortality rates derived by standard night effort and by standard night effort based on running average viz. 2.28 & 2.50, the former showed a better fit.

Estimates of natural mortality rate from virgin or little exploited stock: In theory> Z estimated from samples collected at the onset of fishing or shortly thereafter should be a reflection of M if the full range of exploitable ages in the virgin population was available on grounds first exposed to fishing and if recruitment to the stock in the year prior to fishing has not been affected by natural trends (e.g. Ricker 1975, Beverton and Holt 1956, Ketchen and Forrester 1966). Prior to 1960, there was very little of machanised fishing in the Palk Bay area and the annual landings in the early 50s at Thangachimadam, an important fishing centre for silverbellies in Rameswaram Island were only 500 tonnes (Arora

TABLE 11. *Average instantaneous total mortality rates* (Z) *using* 1/1.5 *year groups based on night fishing as standard effort, day fishing as standard effort and within the same half year groups.*

	iZ Night fishing as Std. effort	iZ Day fishing as Std effort	4Z Within the same half year group	Average	Annual Z
May 70-Oct 70	—	—	0.86	0.86	1.67
Nov 70-Apr 71	0.84	0.47	1.15	0.81	
May 71-Oct 71	0.02	0.08	0.59	0.23	3.74
Nov 71-Apr 72	3.53	1.65	2.34	3.51	
May 72-Oct 72	2.12	0.99	3.56	2.23	4.77
Nov 72-Apr 73	2.85	2.43	2.34	2.54	
May 73-Oet 73	3.18	3.05	3.05	3.10	5.54
Nov 73-Apr 74	2.47	2.36	2.50	**2.44**	
May 74-Oot 74	2.00	3.26	2.34	2.53	4.69
Nov 74-Apr 75	2.04	2.48	1.95	2.16	
May 75-Oct 75	2.60	2.00	2.38	**2.33**	3.94
Nov 75-Apr 76	1.34	2.45	1.03	1.61	
Average	2.09	1.93	2.09	**2.03**	4.06

TABLE 12. *Standard night effort, standard day effort and 2 year average of the above standard efforts for six seasons and the corresponding total annual instantaneous mortality rates* (Z) *for* 1/1.5 *year groups.*

	1970-71	71-72	**72-73**	73-74	**74-75**	75-76
Standard night efforts (in thousands)	23	**22**	68	**125**	92	54
Standard day efforts (in hundreds)	43	26	**44**	**48**	**122**	78
Standard night efforts 2 year aewareges (in thousands)	23	**23**	45	97	109	**73**
Standard day efforts 2 year averages (in hundreds)	43	35	35	46	85	100
Average Z (annual)	1.67	**3.74**	**4.77**	5.54	4.69	3.94

1951). Further the total landings in Rameswaram Island (mostly from the Palk Bay) obtained by indigenous nets in 1952-53 and 1953-54 amounted to only 629 and 740 tonnes respectively (Krishnamurthy 1957).

From Arora's (1951) length-frequency data on *L. jonesi* (which he identified as *L. splendens*)* caught during 1949-50 from Thangachimadam by boat seine *(Madavalai)* having a codend mesh size of 13 mm the growth parameters, mean size and 50% selection length were calculated (Venkataraman et al MS) and found to be K = 1.6248 (annual basis) L = 109.7 mm, 1 = 66.4 mm and lc = 35 mm. By using the formula $\frac{\quad}{T - i_c}$, the annual Z value was found to be 2.24.

Based on the above growth parameters, the length-frequency data of this fish for the period 1949-50 were converted to half-year age-group percentages and found to be as follows:

0 - 0.5 year	= 33.47%
0.5 - 1.0 year	= 14.34%
1.0 - 1.5 year	= 22.00%
1.5 - 2.0 year	= 9.07%
2.0 and above	= 0.92%

The annual Z values for the 0/0.5 year groups, 1/1.5 year groups, and for 1.5/2 year groups were determined and the values are 1.32, 1.78 and 4.58 •respectively. The average annual Z value comes to 2.56. This Z value and the value derived by the formula given in the foregoing paragraph, viz, 2.24 came very near to the M estimate obtained by fishing intensity and total mortality viz. 2.28 which was taken for yield studies.

Yield per recruit

The isopleth diagram (Fig. 7) for *L. jonesi* has been drawn using the vital parameters already derived, as given in Beverton and Holt yield-function table, for 'the M value of 2.1. This value (for which M/K is 4, in the yield function table) is nearest to the M value of 2.28 which has been taken into consideration in the present studies. The yield isopleths for M value of 2.6 (M/K = 5) and 1.6 (M/K = 3) are given in figures 8 and 9, respectively. The equivalent scale of standard night fishing effort (in thousands) and standard day

Airora (1951) and Krishnaimiurthy (1957) have observed that *Leiognathus splendens* formed a dominant fishery in the Palk Bay. However, James (1971) did not come across this species in the commercial catches from the Palk Bay but instead observed a new species, *L. jonesi* Which closely resembles *L. splendens.* In the course of present investigations also, the authors found that *L. jonesi* was the dominant form in the silverbelly catches and *L. splendens* was observed only in stray numbers. Hence, it is reasonable to dedaice that what has been regarded as *L. splendens* by the earlier authors actually refers to *L. jonesi.*

TABLE 13. *Values of instantaneous natural mortality coefficients* (M) *and catchability coefficient* (qp *for different combination of efforts and instantaneous total mortality rates* (Z) *and their correlation coefficient* (r) *values.*

Independent variables (X)	Dependent variable (Y)	q, b value	M a value	r value
Standard night effort	Average Z for 1/1.5 year groups only	0.0277	2.28	0.84
Standard day effort	—do—	0.0098	3.47	0.26
Standard night effort of 2 year averages	—do—	0.0252	2.50	0.70
Standard day effort of 2 year averages	—do—	0.0054	3.75	0.11

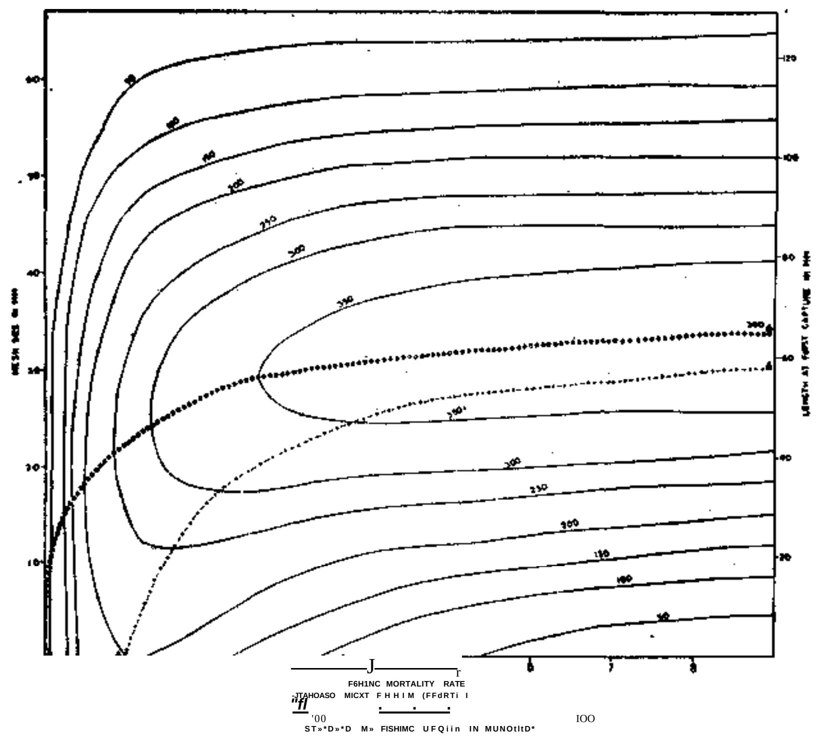


FIG. 7 Yield isopleth diagram of length at first capture (LC) on fishing mortality (F) for the natural mortality (M) of 2.1. The contours oar isopJeths represent the magnitude of yield (Yw/R) in g per 100 recruits of *L. jonesi.* The fine AA represents the condition for the largest mesh size in least fishing mortality. The line BB (eumetric fishing curve) represents the condition for the smallest mesh size and highest fishing mortality.

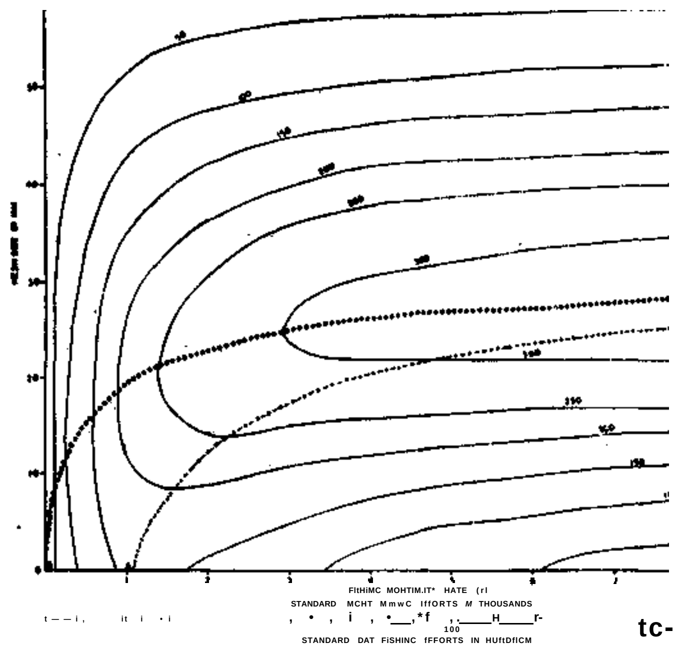


FIG. 8. Yield isopleth diagram for the M value of 2.6.

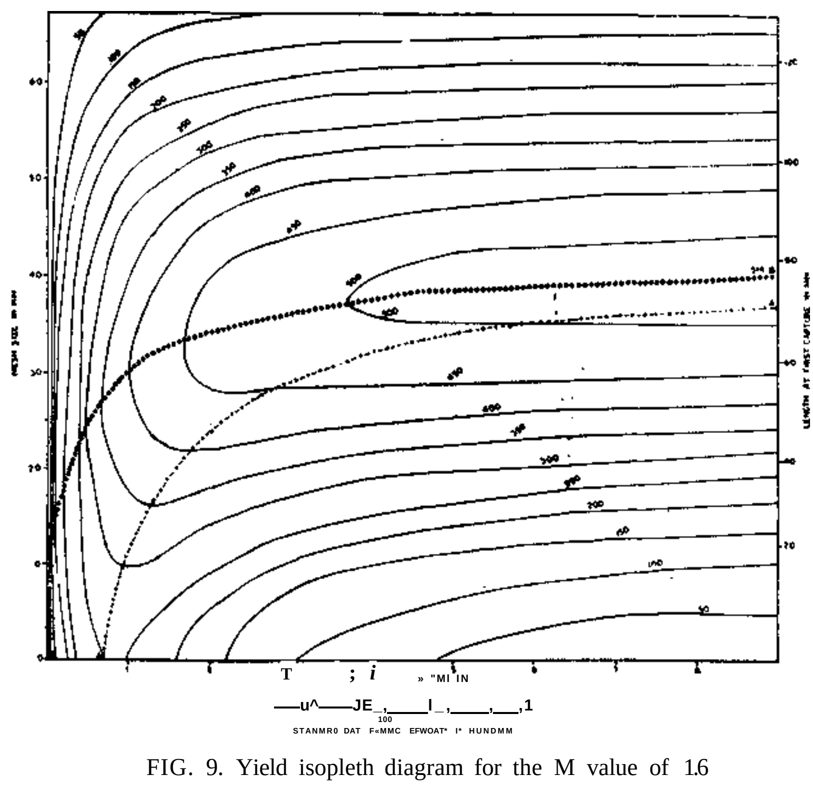


FIG. 9. Yield isopleth diagram for the M value of 1.6

fishing effort (in hundreds) for the instentaneous fishing mortality rate (Fj were calculated on the basis of 'the catchability coefficient q for the respective isopleth diagrams (Fig. 7-9).

For the mesh size of 25 mm (codend), the eumetric fishing curve falls at the effort of 50,000 standard night effort (5,000 standard day effort) with an yield of 310 g per hundred recruits (Fig. 7). The isopleth diagram shows that any increase in effort beyond the one observed above (50,000 standard night effort) results only either in marginal increase in the catch or the increase is not commensurate with the additional effort put in. As for instance, if the effort is raised to 1,00,000 standard night effort (= 10,000 standard day effort.) which is double of the optimum effort, the yield increases only by 40 g viz. 350 grams which works out to only 13% increase.

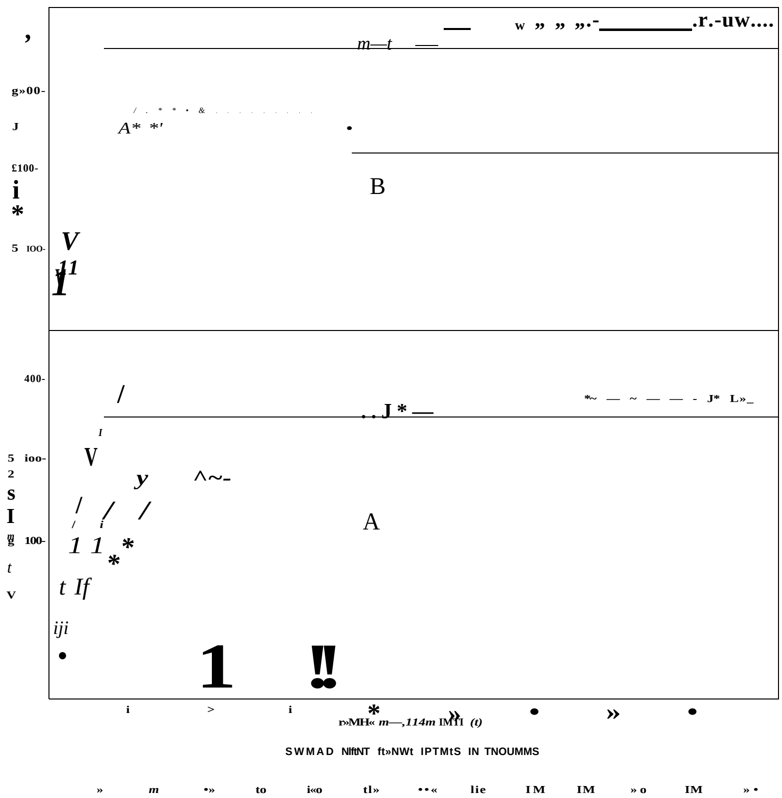


FIG. 10. Yield/100 recruits for mesh size of 25 mm codeod for different M values and efforts (A), and yield/100 recruits for the mesh sizes of 35 mm, 15 mm and 25 mm at the value of 2.1 (B).

If M is 2.6, then the enumetric curve for the present mesh size falls at 1,20,000 standard night effort with an yield of 300 grams (Fig. 8) per 100 recruits. If M is at 1.6 the eumetric curve falls at 15,000 standard might effort, with an yield of 320 g per 100 recruits.

In figure 10 is shown yield per hundred recruits for the present mesh size of 25 mm codend for different M values and efforts. As already noted in figure 7, the optimum yield per hundred recruits of 310 grams falls at 50,000 standard night effort for the M value of 2.1. For this effort the yield per hundred recruits are 250 g and 420 g, respectively if M values are 2.6 and 1.6. Figure 10 also shows the yield per hundred recruits decreases to 275 g When the mesh size is increased to 35 mm or decreased to 15 mm, at the M value of 2.1.

DISCUSSION

The estimate of natural mortality (M) in regard to the important marine fishes of India poses a great problem for the fishery biologists, on account of various factors like determination of age, short life span and standardisation of effort. In die case of oilsardine the estimate of M ranged from 0.67 to 1.45 (Banerji 1973, Annigeri 1971, Sekharan 1974). For mackerel, the same ranged from 0.65 to 0.9 (Banerji 1973, Sekharan 1974). The Z value of ghol was estimated as 0.87 which was considered as equivalent to M as the fishery was in a virgin state. The estimate of M (2.28) derived for *L. jonesi* is higher when compared with the values obtained for oilsardine, mackerel and ghol. This can be attributed to the observation made that the life span of oilsardine, mackerel and ghol is longer than that of *L. jonesi* whose life span is less than three years only.

In 1970-71 and 1971-72 seasons the standard night effort put in was 23,000 (= 2,300 standard day effort) and 22,000 (= 2,200 standard day effort), respectively, for the silverbelly fishery, the total catch for the respective seasons being 5,127 and 3,588 t. The yield per hundred recruits in both the seasons was 200 g. In the above mentioned two seasons, it is seen that the effort put in and the yield per hundred recruits were below the optimum viz. 50,000 standard night effort and 310 g, respectively, as deduced from the isopleth diagram (Fig. 7). In 1972-73, the effort put in was a little above optimum (68,000 standard night effort) the catch being 7,285 tonnes. The yield for hundred recruits viz. 320 grams was also nearly at optimum level.

In 1973-74 the effort put in, 1,25,000 standard night effort, was nearly double that of 1972-73 and in 1974-75 also there was a steep rise in the effort (92,000) as compared with that of 1972-73 season. In 1973-74 and 1974-75 seasons, eventhough the effort increased enormously the catch did not show corresponding increase, the respective total catches being 9,190 and 8,308 t. The yield per hundred recruits, viz, 350 g was also not in commensurate with increased effort (Fig. 7). This is because the effort put in these two seasons was nearly double that of optimum effort (50,000 standard night effort) resulting in diminishing returns. In 1975-76 season, the effort (54,000 standard night effort) nearly corresponded to the optimum effort but the total catch realised, viz, 3,464 t was much below the optimum catch. For a scientific management of the fishery and for getting optimum yield, it is necessary that the effort should not exceed the optimum (50,000 standard night effort). The isopleth diagram indicates that there was overfishing in respect of *L. jonesi* in 1973-74 and 1974-75. Owing to the poor return of silverbelly there was a reduction in effort in 1975-76 which was nearly at optimum level. However, we cannot be certain that this will continue to be maintained in the coming years and hence it is necessary that measures be taken to keep the effort to the optimum level in the coming years so as to obtain sustained yield year after year. Studies on mesh size in relation to yield has shown that there is no need to increase the mesh size or decrease the same as the yield per hundred recruits decreases in both instances.

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