SYMPOSIUM ON
CRUSTACEA

PART II

MARINE BIOLOGICAL ASSOCIATION OF INDIA

MARINE FISHERIES P.O., MANDAPAM CAMP

INDIA

PROCEEDINGS

OF THE

SYMPOSIUM ON CRUSTACEA

HELD AT

ERNAKULAM

FROM JANUARY 12 TO 15 1965

PART II

SYMPOSIUM SERIES 2

MARINE BIOLOGICAL ASSOCIATION OF INDIA

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SIZE DISTRIBUTION AND GROWTH OF *METAPENAEUS DOBSONI* (MIERS) AND THEIR EFFECT ON THE TRAWLER CATCHES OFF KERALA*

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ABSTRACT

Metapenaeus dobsoni (Miers) spawns almost throughout the year. The traditional method of tracing the progression of modes in monthly length frequency distribution to determine growth and age was not very successful. The application of a modified Von Bertalanffy equation furnished expected sizes at different ages. The total instantaneous mortality rate was found out from the approximate formulae of Holt-Beverton.

The size distribution of the catches landed by trawlers were obtained and the role played by the size distribution in influencing the catch and abundance has been discussed.

INTRODUCTION

Metapenaeus dobsoni is caught in enormous numbers both from the sea and also from the backwaters of Kerala and form a major part of the total prawn catch in the State. Traditionally, the fishery of *M. dobsoni* was based on the catches of inshore waters and backwaters. Recently, fishing has been extended to the offshore areas by the use of trawl nets and because of encouraging results, fishing in offshore area is likely to increase substantially within a few years. The trawler catches of *M. dobsoni* from the offshore waters off Cochin show wide fluctuations and it is believed that such fluctuations are due to fluctuating abundance of recruits coming into the fishery of the offshore area. The present paper examines in detail the age structure of the offshore catch of *M. dobsoni,* the age of the recruits to the offshore stock and also the possible causes of fluctuations in the abundance of recruits to the fishable stock. As the fishery of *M. dobsoni* is just being started in the offshore area, a detailed analysis on these lines will permit estimation of some of the essential vital statistics like the natural mortality rate which, at a later stage when fishing in the area will be fairly extensive, cannot be easily estimated.

MATERIALS AND METHODS

The basic data consists of the catch (in weight) and the effort in trawling hours for the 5 fishing seasons from 1958-59 to 1962-63. These are presented in Table I. The details of fishing operations of the trawlers, etc., have been given by George *et al.* (in press). The other data consists of length measurements of samples of *M. dobsoni* collected from the trawler catches every month.

It is well known that this prawn migrates to estuaries and backwaters in its early life and grows for sometime in such environments and then go back to the sea where further growth and attainment of sexual maturity take place. Because of this peculiar migratory habit, the size composition of the catch obtained from the backwaters and from the sea are likely to be different. Menon (1955) has stated that the vast majority of *M. dobsoni* do not grow beyond 60-65 mm. in

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TABLE I

Trawler catches of Metapenaeus dobsoni

Month	Effort (Tr. hr.)	Catch (kg.)	C/E		Effort (Tr. hr.)	Catch (kg.)	C/E
1957–58				1960–61			
August	31·08	...		September	30·16	..	
September	61·47	..		October	167·84	..	
October	67·08	..		November	207·18	99·99	
November	243·17	338·75		December	204·75	4,367·13	
December	301·92	29,620·48		January	243·25	4,537·83	
January	415·83	16,873·63		February	264·09	836·92	
February	287·70	1,986·20		March	432·67	3,219·71	
March	348·75	3,493·18		April	511·25	24,198·80	
April	309·75	12,562·46		May	451·25	2,813·03	
May	519·08	21,817·87		June	98·84	..	
June	147·92	12,608·13					
Total ...	2,733·75	99,300·70	36·32		2,611·28	40,073·41	15·35
1958–59				1961–62			
September	85·83	..		September	93·32	17·07	
October	108·50	..		October	303·42	140·34	
November	339·92	2,750·86		November	442·00	2,852·30	
December	535·63	1,490·93		December	675·00	51,242·92	
January	540·55	17,961·80		January	510·08	14,678·91	
February	511·82	17,053·58		February	506·25	19,736·65	
March	508·55	29,487·55		March	600·08	16,746·34	
April	454·83	39,418·43		April	605·50	30,362·46	
May	440·25	38,605·10		May	827·92	27,086·10	
				June	381·25	11,258·74	
Total ..	3,525·88	1,46,768·25	41·63		4,547·02	1,74,121·83	38·29
1959–60				1962–63			
September	57·00	..		September	91·92	..	
October	107·59	...		October	372·75	..	
November	301·17	385·10		November	679·17	5,793·78	
December	430·00	3,128·42		December	426·00	3,166·15	
January	491·25	5,999·40		January	534·75	8,573·71	
February	692·68	17,780·12		February	392·84	14,503·14	
March	608·75	2,202·56		March	447·50	6,962·54	
April	660·42	9,320·45		April	419·58	2,566·00	
May	387·33	12,737·88		May	399·25	7,673·12	
June	221·50	15,766·14		June	29·58	1,110·42	
Total ..	3,967·69	67,320·07	17·01		3,793·34	50,348·86	13·27

length in the backwaters and from the length data obtained from samples of trawler catches it is found that the majority exceed 60–65 mm. Hence to get an integrated picture of growth, in addition to the length data of *M. dobsoni* from trawler catches, length data of *M. dobsoni* landed at Alleppey and Narakkal by the indigenous boats have also been included. Instead of presenting the original data relating to the different sources, Table II gives the modal size of the catch for each month separately for the two sexes.

TABLE II

The modal values (mm.) of size distribution of M. dobsoni

Month	Modal size in mm. for Males	Females
	I. Trawler catches	
1957		
March	83	88, 103
April	88	95
May	93	98
June	93	98
..	..	..
December	83, 103	98, 115
1958		
January	83, 103	98, 118
February	73, 83, 103	98, 103
March	78, 88, 103	98
April	83 103	..
May	88	93
June	93	103
November	68, 103	93
December	...	88
1959		
January	78, 98	93
February	83	98
March	83	93
April	83	93
May	73, 88	83, 93, 103
September	88	..
November	103	93
December	68, 103	
1960		
January	73	53, 88
February	78	88, 98
	II. At Alleppey	
1957		
March	60	60
April	73	73
May	73	78
June	88	78, 103
July	93	103
August	98	108
September	98	75 113
October	68, 83, 98	83, 113
November	73	..
December	—	..
1958		
January	68, 83, 103	73, 98, 113
February	68, 88	53, 78, 98
March	53, 73	53, 73
April	73	73
May	73, 88	73, 93
June	78, 88	73, 103
July	93	83, 103
August	98	85, 108
September	98	83, 113
October	63, 98	68, 113
November	63	68, 88
December	68	73, 83

TABLE II (*Contd.*)

Month	Modal size in mm. for Males	Females
1959		
January	68	73, 93
February	58	63
March	73	73
April	73	73
May	73	78
June	88	98
July	83	63, 83, 103
August	93	..
September	93	108
October	103	113
November	63	68
December	68	78
1960		
January	58	58, 73
February	48, 68	48
March	63	58
April	68	63
May	73	73
June	88	78 98
July	68, 88	103
August	63, 93	63, 108
September	98	88, 113
October	..	..
November	..	..
December	53	58
1961		
January	63	63
February	63	63
March	58	58
April	68	58, 68, 78
May	73	68
June	83	68, 83
July	88	103
August	88	103
III. Narakkal		
1957		
March	58	53
April	53, 63	53, 63
May	63, 73	78, 98
July	93	108
August	98	108
September	98	113
1958		
April	58, 73	53, 68, 78
August	..	..
September	98	93, 113
1959		
February	53	53
April	68	73
May	73	73, 83, 93
June	83	68
July	63, 93	63, 88, 108
August	68, 98	78, 113
September	98	113
October	-	113
1960		
February	68	58, 68

Size Composition of the Catch

The fluctuations in the abundance of the different year-classes, particularly the newly recruited class in the fishery, may cause substantial fluctuations in the catches of the fish. Thus if the abundance of the recruited class is high in any year, it will not only influence the catch of that year but may also affect the catch of subsequent years, if the fishery is based on more than one year-class. Thus to explain the fluctuation in catch, it is necessary to know the abundance of the various age groups in the population every year. Since it is almost impossible to estimate the absolute-abundance, generally some indices of abundance are found out. The best index of abundance of an age group in the population in a fishing season is given by the catch (in numbers) per unit of effort.

To obtain data on the abundance of different age groups every year, the following procedure was followed. The raw data available for a month was the total catch (by weight) and the total effort (in trawling hours) and also the length measurements of a sample of *M. dobsoni* for the month together with the weight of the sample.

The length measurements from the monthly sample were arranged in a frequency distribution table. If n_i is the frequency of *M. dobsoni* in the i-th size class in the sample, the estimated number of *M. dobsoni* of the i-th size class in the catch for the month was obtained by multiplying n_i by the raising factor W/w where W is the weight of the catch during the month and w is the weight of the monthly samples. Table III presents the monthwise size distribution of the catch for each fishing season from 1958–59 to 1962–64. Table IV presents the catch (number) per trawling hour for the various size groups for all the fishing seasons from 1957–58 to 1962–63.

If, now, a size-age relation can be obtained, the age distribution of the catch for each fishing season can be easily obtained.

Age and Growth

Mean sizes of a fish at different ages are generally obtained by tracing the monthly progression of modes found in monthly length-frequency distribution of the fish. It is well known that this method will give successful results only if the fish has a restricted short spawning period. When a fish spawns over a prolonged period, different broods continually enter into the stock and samples from such stock will not clearly show the distinct existence of all these broods. In fact it is virtually impossible to follow the modal progression of a distinct brood over any length of time. A new brood can probably be traced over a few months after it enters the fishery. But sometimes when a brood is relatively strong, it can be traced through more months.

Menon (1955) was the first to study the problem of age determination of *M. dobsoni* by the method of length-frequency distribution. Even though he is aware that the species spawns throughout the year with probably a high intensity of spawning from May to December, he tried to follow the method of tracing the monthly progression of modes over the successive months and came to erroneous conclusion regarding the size of the prawn at the end of the 1st and 2nd year of the life of the prawn. In this, he seems to have been largely influenced by the results of the rearing experiments carried out by him. In the rearing experiment, a single post-larval form of *M. dobsoni* lived for eleven months and attained a size of 67 mm. It is difficult to say how he overlooked the biological fact that the growth in artificial condition may be different from that in the natural condition. A logical scrutiny of the length-frequency data indicates the need for the revision of the conclusion arrived at by him. In the length-frequency data of *M. dosoni* collected from West Hill station in 1949–50 and as presented in his paper, he starts with the mode at 43 mm. in July 1949. According to him, it progresses to 53 mm. in August 1949, is absent in September 1949, progresses to 63 mm. in October. The author does not say anything about this group in November but he continues to say that the mode remains at 63 mm. in December 1949 and in the

TABLE III

Size distribution of trawler landing of Metapenaeus dobsoni
(Number in thousands)

Class interval (mm.)	November	December	January	February	March	April	May	June	Total	N/E
1957–58										
51–55			2·6	1·8					4·4	1·6
56–60			10·6	1·8					12·4	4·5
61–65			50·3	3·6	1·6		8·0		63·5	23·2
66–70			100·5	10·3	8·1	9·7	16·0		144·6	52·9
71–75		65·3	140·2	37·4	29·2	124·3	152·3	7·4	556·1	203·4
76–80	52·1	224·9	222·2	33·8	60·0	213·8	304·6	18·5	1,129·9	413·3
81–85	..	466·4	582·0	65·2	60·0	441·2	789·6	111·2	2,515·6	920·2
86–90	52·1	289·2	399·4	70·1	89·2	406·2	990·0	292·8	2,589·0	947·1
91–95	52·1	354·5	220·0	29·6	64·8	301·2	869·8	370·6	2,262·5	827·7
96–100	78·2	1,035·5	410·0	29·0	105·4	281·8	553·1	222·4	2,715·4	993·3
101–105	78·2	802·3	497·3	50·1	95·6	147·7	276·6	341·0	2,288·8	837·2
106–110	..	363·8	190·5	14·5	47·0	77·7	112·2	151·9	957·6	350·3
111–115	52·1	214·6	97·9	8·5	6·5	19·4	32·1	37·1	468·2	171·3
116–120	..	214·6	145·5	6·0	4·9	13·6	12·0	11·1	407·7	149·1
121–125	..	93·3	15·8	3·0	..	..	..	..	112·1	41·0
126–130	..	..	...	–	..	1·9	..	..	1·9	0·7
					E = 2,733·75				16,229·8	5,936·8
1958–59										
51–55			16·4		97·5	8·9			122·8	34·8
56–60	8·8		21·8		113·8	..	21·3		165·7	47·0
61–65	11·0		54·6		108·3	26·7	31·9		232·5	65·0
66–70	17·6		98·3		211·3	17·8	159·6		504·6	143·1
71–75	28·7	59·2	344·1	183·8	417·1	205·0	457·5		1,695·2	480·8
76–80	35·3	30·7	759·2	334·2	704·2	517·0	446·8		2,827·4	801·8
81–85	45·5	24·1	540·7	490·1	1,126·8	2,085·6	1,159·6		5,472·4	1,552·0
86–90	61·7	54·8	469·7	384·3	904·7	1,452·8	1,159·6		4,487·6	1,272·7
91–95	61·7	50·4	584·4	490·1	682·6	1,016·1	1,095·8		3,981·1	1,129·0
96–100	59·5	30·7	486·1	484·6	563·4	820·0	542·6		2,986·9	847·1
101–105	55·1	6·6	207·5	105·8	189·6	543·7	648·9		1,757·2	498·3
106–110	19·8	..	27·3	50·1	48·8	89·1	170·2		405·3	114·9
111–115	..	2·2	..	5·6	4·9	53·5	..		66·2	18·8
116–120	11·0	..	5·5	11·1	..	..	..		27·6	7·8
121–125	15·4	4·4	16·4	11·1	4·9	..	..		52·2	14·8
126–130	..	2·2	...	..	..	..	..		2·2	0·6
					E = 3,525·88				24,786·9	703·0
1959–60										
46–50			26·5						26·5	6·7
51–55			33·1						33·1	8·3
56–60			23·1	8·7					31·8	8·5
61–65		0·7	56·2	92·9	2·8	7·7			160·3	40·5
66–70		9·7	105·8	206·2	10·0	59·1	42·1		432·9	109·1
71–75	1·3	53·1	211·6	320·1	37·2	115·6	98·3		845·2	213·5
76–80	0·4	51·7	167·0	412·3	50·5	170·8	168·5		1,021·2	258·0
81–85	4·7	50·3	145·5	432·6	55·5	183·6	224·7	121·7	1,218·6	300·8
86–90	5·5	65·5	94·2	319·4	48·3	149·0	367·9	347·6	1,397·4	353·1
91–95	9·8	73·1	77·7	142·3	35·0	127·1	272·4	434·5	1,171·9	296·1
96–100	5·9	62·8	74·4	235·2	25·0	118·1	235·9	278·1	1,035·4	261·6
101–105	3·8	42·8	18·2	130·6	12·8	39·8	112·3	260·7	621·0	156·9
106–110	2·5	9·7	8·3	34·8	3·3	3·9	30·9	156·4	249·8	63·1
111–115	3·4	5·5	5·0	14·5	0·6	1·3	..	17·4	47·7	12·1
116–120	3·0	9·7	1·7	2·9	..	..	..	..	17·3	4·5
121–125	0·4	0·7	..	2·9	..	..	..	..	4·0	1·0
126–130	..	..	..	..	..	..	..	..	..	..
					E = 3,967·69				8,314·1	1,993·8

TABLE III (*Contd.*)

Class Interval (mm.)	November	December	January	February	March	April	May	Total	N/E
1960–61									
46–50		4·6	2·1					6·7	2·6
51–55		4·0	2·1					6·1	2·3
56–60	0·1	5·2	7·5	0·7	1·2			14·7	5·6
61–65	0·6	4·6	9·7					14·9	5·7
66–70	1·2	12·6	8·6	1·3			2·3	26·0	9·9
71–75	0·8	51·1	64·6	2·6		67·8		186·9	71·6
76–80	1·0	67·8	186·4	11·2	2·5	209·0	27·5	505·4	193·6
81–85	0·8	31·0	197·2	33·0	11·2	440·7	128·2	842·1	322·5
86–90	1·2	35·0	94·8	23·8	41·2	536·7	155·6	888·3	340·2
91–95	0·6	65·5	128·2	25·1	91·2	570·6	103·0	984·2	376·9
96–100	1·1	72·4	101·3	23·8	128·6	717·5	52·6	1,097·3	420·3
101–105	1·7	71·8	65·7	10·6	149·9	728·8	32·0	1,060·5	406·2
106–110	1·2	37·3	18·3	4·6	32·5	367·2	36·6	497·7	190·6
111–115	0·4	24·7	9·7	4·0	3·7	73·4	4·6	120·5	46·1
116–120	1·8	71·8	14·0	3·3	13·7	67·8	2·3	174·7	66·9
121–125	1·3	44·2	6·5	..	5·0	62·1	..	119·1	45·6
126–130	0·2	1·1	..	..	..	..	..	1·3	0·5
				E = 2,611·28				6,546·4	2,564·1

Class Interval (mm.)	September	October	November	December	January	February	March	April	May	June	Total	N/E
1961–62												
56–60	0·4	..	1·3	..	1·9	..	..	..	..	4·9	8·5	1·9
61–65	0·9	2·6	2·7	..	..	3·4	5·0	..	34·1	..	48·7	10·7
66–70	2·6	1·3	1·3	11·0	1·9	23·6	5·0	..	46·9	7·3	100·9	22·2
71–75	0·9	..	17·4	22·0	48·0	138·1	96·5	17·1	110·9	36·6	487·5	107·2
76–80	0·4	5·2	10·7	73·2	65·2	437·8	220·0	160·0	208·9	39·0	1,220·4	268·4
81–85	0·4	2·6	24·1	124·5	90·2	410·8	342·6	754·1	417·8	268·1	2,435·2	335·6
86–90	..	1·3	18·8	205·0	201·5	572·5	465·7	1,022·6	993·4	672·6	4,153·4	913·4
91–95	..	1·3	38·9	230·7	1,190·0	649·9	592·1	1,022·6	750·4	458·1	3,934·0	865·2
96–100	..	..	88·5	783·6	351·1	474·8	514·0	1,233·9	1,112·8	280·2	4,838·9	1,064·2
101–105	..	2·6	85·9	1,402·4	383·8	505·1	484·0	611·2	805·8	224·2	4,505·0	990·7
106–110	..	2·6	26·8	823·8	176·5	131·3	131·4	182·8	174·8	58·5	1,708·5	375·7
111–115	..	..	26·8	1,362·1	284·0	151·5	161·3	171·4	89·5	9·7	2,256·3	496·2
116–120	..	2·6	36·2	845·8	107·4	53·9	44·9	74·2	60·0	2·4	1,227·4	269·9
121–125	..	1·3	5·4	201·4	3·8	6·7	3·3	5·7	..	..	227·6	50·1
126–130	..	..	11·0	..	..	..	..	..	..	..	11·0	2·4
				E = 4,547·02							27,163·3	5,773·8

TABLE III (*Contd.*)

Class Interval (mm.)	November	December	January	February	March	April	May	June	Total	N/E
1962–63										
41–45	..	..	..	..	10·7	..	..	..	10·7	2·8
46–50	12·2	..	..	..	10·7	0·5	..	..	23·4	6·2
51–55	12·2	2·7	..	..	19·5	0·5	..	..	34·9	9·2
56–60	9·1	1·3	4·7	4·4	23·1	4·9	..	..	47·5	12·5
61–65	24·3	1·3	9·3	13·2	40·8	15·7	..	..	104·6	27·6
66–70	9·1	6·8	84·0	97·1	83·4	39·5	65·3	..	385·2	101·6
71–75	24·3	47·4	136·9	198·6	175·7	73·7	189·1	0·9	846·6	223·2
76–80	9·1	47·4	192·9	278·0	246·8	53·1	294·5	2·3	1,124·1	396·3
81–85	24·3	28·4	180·5	317·7	344·4	62·8	408·3	18·7	1,385·1	365·2
86–90	9·1	23·0	172·7	368·4	285·8	72·0	312·9	56·5	1,300·4	342·8
91–95	30·4	51·4	224·1	434·6	292·9	99·1	244·3	51·0	1,427·8	376·4
96–100	158·1	98·8	306·5	450·1	129·6	73·7	147·3	37·4	1,401·5	369·5
101–105	188·5	125·9	157·1	275·8	60·4	33·6	97·1	24·6	963·0	253·9
106–110	121·6	25·7	66·9	99·3	23·1	10·8	25·1	4·1	376·6	99·3
111–115	121·6	31·1	56·0	112·5	19·5	4·3	3·3	0·5	348·8	91·9
116–120	63·8	35·2	29·6	46·3	3·6	2·7	1·7	0·5	183·4	48·4
121–125	6·1	1·4	6·2	..	..	..	..	0·5	14·2	3·7
126–130	..	..	..	..	..	..	..	..	..	..
			E = 3,793·34						9977·8	2,730·5

TABLE IV

Numbers caught per hour of trawling in sizes (mm.)

Year/Size (m.m.)	46–	51–	56–	61–	66–	71–	76–	81–	86–	91–	96–	101–	106–	111–	116–	121–	126–
1957–58		1·6	4·5	23·2	52·9	203·4	413·3	920·2	947·1	827·7	993·3	837·2	350·3	171·3	149·1	41·0	0·7
1958–59		34·8	47·0	65·9	143·1	480·8	801·8	1,552·0	1,272·7	1,129·0	847·1	498·3	114·9	18·8	7·8	14·8	0
1959–60	6·7	8·3	8·5	40·5	109·1	213·5	258·0	300·8	353·1	296·1	261·6	156·9	63·1	12·1	4·5	1·0	
1960–61	2·6	2·3	5·6	5·7	9·9	71·6	193·6	322·5	340·2	376·9	420·3	406·2	190·6	46·1	66·9	45·6	0·5
1961–62			1·9	10·7	22·2	107·2	268·4	535·6	913·4	863·2	1,064·2	990·7	375·7	496·2	269·9	50·1	2·4
1962–63	6·2	9·2	12·5	27·6	101·6	223·2	296·3	365·2	342·8	376·4	369·5	253·9	99·3	91·9	48·4	3·7	

following two months has moved upto 68 mm. and so on. This interpretation of the progression of modes seems to be fallacious. If the mode 43 mm. in July 1949 can progress to 63 mm. in October 1949, a growth of 20 mm. in three months, it is difficult to believe that it did not grow at all during the next two months, but again had a growth of 15 mm. in the next four months. In fact the author ignored the small mode at 68 mm. in November, to which the growth represented by mode at 63 mm. in October 1949 grew. This group could not be traced in the length-frequency distribution curves of subsequent months. The mode at 63 mm. in December 1949 is obviously the group with the mode at 48 mm. in November 1949 which passes through the modal value of 68 mm., 68 mm., 73 mm., 78 mm., 78 mm. and 83 mm. respectively in subsequent months. The author has ignored the entry of several new broods between November to May.

In the following, the same data has been re-analysed keeping in mind the prolonged spawning habit of the species. The length-frequency data from the trawler catches and also those from the catches at Alleppey and Narakkal have also been taken into consideration. Table V presents the results of the findings. The first column gives the source of the data and the month of the first appearance of a group. The modal value at the first appearance is then given and then the values of the modes in subsequent months as far as the same group could be traced. The relative placement of the first mode is made according to its size and its subsequent growth and the month of its first appearance has nothing to do with its placement. The average value for each column is given at the bottom. From these values, it is seen that the group represented by 28·00 mm. moves to 41·3 mm. next month, showing a growth of 13·3 mm. Thus the group at 28·00 mm. must be the prawn which had completed about 2 months. Following the average values, it is seen that the prawn attains a size of about 97·5 mm. at the end of the 12 months' life.

It may be argued that there is some amount of arbitrariness in making the placement of the first mode and this may influence the average values. It is true that the relative placement of the first modal value is somewhat arbitrary but consideration of the value of the mode and its subsequent growth leaves very little freedom for the placement of the same. To confirm the findings obtained by this method, another method of analysis was adopted which is given below.

It is assumed that *M. dobsoni* obeys the growth law represented by the Bertalanffy's equation:

$$l_t = l_\infty \{1 - e^{-k(t-t_0)}\}$$

where l_t is the length of the fish at any age t ; l_∞ is the asymptotic length; K the growth coefficient and t_0 = an adjustment in the time axis.

Assuming that the size of the prawn was zero at $t = 0$, and $t_0 = 0$, the above equation can be rewritten as:

$$l_{t+1} = a + bl_t$$

a linear form, where $b = -\log_e \mathrm{K}$ and $l_\infty = a/(l - b)$. The least squares estimates of a, b could be obtained from the data, if we arrange the data in such a way that if any modal value is represented by l_t during a month, it is represented by l_{t+1} next month. Following this procedure, the values of l_t and l_{t+1} have been written down in Table VI. Only those modes have been taken into consideration which could be distinctly identified and traced for at least a few months.

The least square estimates of a, b are obtained as $a = 15{\cdot}38$ and $b = 0{\cdot}87$. From these the estimated values of K and l_∞ are obtained as:

$$\mathrm{K} = 0{\cdot}14 \text{ and } l_\infty = 118{\cdot}31.$$

Taking these estimates, the Bertalanffy's equation can be written as:

$$l_t = 118{\cdot}31\,(l - e^{-0.14t}).$$

TABLE V

Recognizable modes and their progression through months

Source and the month of first appearance	Values of modes (in mm.) in successive months																		
Menon																			
January 1950	28	38	48																
November 1949	28	43	48																
December 1949	28	..	48	58															
July 1949		43	53	..	63	68													
November 1949			48	63	68	68	73	78	78	83									
Alleppey																			
February 1960 (f)			48	58	63	73	78	..	..	88									
February 1960 (m)			48	63	68	73													
March 1957 (m)					60	73	73	88	93	98	98	98							
March 1957 (f)					60	73	78	78											
June 1957 (m)										88	93	98	98						
January 1958 (m)						68	68	73	73	78									
May 1958 (m)										88	88	93	98	98	98				
May 1958 (f)											93	103	103	108	113	113			
June 1957 (f)												103	103	108	113	113	..	113	
July 1959 (m)									83	93	93	103							
July 1957 (f)																			
Menon													103	103	108	113	113	..	113
July 1949																			
Narakkal															108	108	108	113	113
March 1957				58	63	73													
July 1957				53	68	73	83												
February 1959 (m)							73	83	88	88									
Alleppey																			
May 1961 (m)									83	88	93	93							
Trawler																			
March 1957 (m)										88	95	98	98						
March 1957 (f)							73	78	83	88	93								
February 1958 (m)								78	83	83	83	88							
December 1958 (f)										88	93	..	98						
Average ..	28·0	41·3	48·7	58·8	64·1	71·3	74·8	79·4	83·0	87·6	92·3	97·5	99·9	104·0	108·0	111·7	111·3	113·0	113·0
Estimated age (in months)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

TABLE VI

Values of a mode (x) in a month and the corresponding mode (y) next month (in mm.)

x	y	x	y
28	38	93	103
38	48	103	103
28	43	103	108
43	48	108	113
48	58	113	113
43	53	103	103
63	68	108	108
48	63	108	113
63	68	113	113
68	68	83	93
68	73	93	93
73	78	98	103
78	78	103	103
78	83	103	108
48	58	108	113
58	63	113	113
63	73	93	98
73	78	98	98
108	108	58	63
108	108	63	73
108	113	53	68
113	113	68	73
48	63	73	83
63	68	73	83
68	73	83	88
60	73	88	88
73	73	83	88
73	88	88	93
88	93	93	93
93	98	88	95
98	98	95	98
98	98	98	98
60	73	73	78
73	78	78	83
78	78	83	88
88	93	88	93
93	98	78	83
98	98	83	83
68	68	83	83
68	73	83	88
73	73	88	93
73	78	93	98
88	88		
88	93		
93	98		
98	98		
98	98		

$b = 0{\cdot}87$ $K = -\log_e b = {\cdot}14$

$a = 15{\cdot}38$ $l_\infty = \frac{a}{1-b} = 118{\cdot}31$

TABLE VII

Estimated size of M. dobsoni *at various ages*

Age (in months)	Estimated size in mm.	Average size in mm. from table V	Age (in months)	Estimated size in mm.	Average size in mm. from table V
1	15·5	..	13	99·1	97·5
2	28·9	28·0	14	101·6	99·9
3	40.6	41·3	15	103·9	104·0
4	50·8	48·7	16	105·8	108·0
5	59·5	58·8	17	107·4	111·7
6	67·2	64·1	18	108·8	111·3
7	73·9	71·3	19	110·0	113·3
8	79·7	74·8	20	111·1	113·0
9	84·7	79·4	21	112·0	..
10	89·1	83·0	22	113·0	..
11	93·0	87·6	23	113·5	..
12	96·3	92·3	24	114·2	..
..	...	..	36	117·6	..

Putting different values of t, in the equation, the estimated sizes of the prawns at different ages are obtained as in Table VII. Alongside the estimated values obtained from the Bertalanffy's equation, the average values at successive months of growth as obtained from Table V are given. Even though there could be some arbitrariness in the first placement of the mode in the first method the agreement between the results of the two approaches were pretty close. On the evidence of these, it can be said that *M. dobsoni* attains a length of about 95 mm. at the completion of age 1 and it attains a length of 114 mm. at the end of age 2 and it becomes nearly 118 mm. at the end of age 3.

AGE DISTRIBUTION OF THE CATCH

Accepting the above age-size relation, the number of *M. dobsoni* of different ages caught per trawling hour in the different years are shown in Table VIII.

From the size composition and therefore the age composition of the catch it is clear that the catch consists primarily of the 0-year class above 65 mm. size and the 1-year class. Hence the fluctuations in catch will be mainly due to the fluctuations in the abundance of the 0-year class. Since the fishery depends both on the 0-year as well as on the 1-year class, good abundance of 0-year class in successive years will yield good catch and poor abundance of 0-year class in successive years will result in poor catch. The age structure of the catch in different years generally conform to this.

TABLE VIII

Abundance of different age groups in catch

Year	Number caught per trawling hour 0-year (n_0) (upto 95 mm.)	1-year (n_1) (96 to 115 mm.)	2-year (n_2) (116 mm. and above)	Mortality rate $\log_e n_1/n_2$
1957–58	3393	2351	191	4·62
1958–59	5528	1479	23	5·68
1959–60	1594	494	5	1·47
1960–61	1332	1063	113	1·20
1961–62	2722	2927	322	3·72
1962–63	1763	815	52	..
			Average	3·56

Now the variation in the fluctuation of the 0-year class may be due to either (1) variation in availability or (2) due to variation in the number of spawners in the previous year.

The effects of variations in availability can generally be distinguished from the effects of changes brought about by changes in spawning stock remaining after a fishery. If availability was high, a large catch would be followed by a small spawning but if the catch was high due to appearance of strong year class, a large catch would be followed by a large or average spawning. Similarly a small catch would be followed by a large spawning if availability was low but by a small or average spawning if the catch was small as a result of the presence of week year classes.

In the fishery under consideration, the problem is very much simple. Since the fishery in the offshore area is new and is just starting and the fishery in the inshore and backwaters depend entirely on juveniles below 65 mm. in size, the spawners in the stock are practically unaffected by fishing. Hence any variation in the abundance of recruits, *i.e.*, in the abundance of 0-year class in the offshore stock of *M. dobsoni* must be due to variation in availability.

ESTIMATES OF MORTALITY RATE

If n_t is the number of *M. dobsoni* of age t and n_{t+1} is the number of age $t + 1$, then $\log_e (n_t/n_{t+1})$ gives an estimate of the total instantaneous mortality rate i between age t and $(t + 1)$. In the present case, since the recruitment does not fully take place until the prawn is above 70 mm. the index of abundance of 0-year class is not fully representative. Hence, the instantaneous mortality rate could be calculated by this method only between year classes 1 and 2. This is shown in the last column of Table VIII. The estimated rate varies considerably from year to year and fluctuating availability must account for such variation. The average annual total instantaneous mortality rate based on 6 seasons' data was estimated at 3·56 by this procedure.

Where age cannot be determined accurately, Beverton and Holt has proposed the following approximate formula:

$$i = \frac{K(l_\infty - \bar{l})}{(\bar{l} - l')}$$

where

K = growth coefficient in Bertalanffy's growth equation.

l_∞ = the asymptotic length in Bertalanffy's growth equation.

l' = the size at which full recruitment takes place.

$\bar{l}$ = the average size of the prawn in the catch above the size of recruitment.

K and l_∞ have already been estimated.

The value of K found in Table VI is in units of month. If the year is taken as unit the value of K becomes 1·68. For each season, the value of l' was taken as the first mode of the length distribution of catch and thereafter $\bar{l}$ was calculated. The basic data are from Table III. The estimates of i for the various years are as follows:

	Estimates of i from approximate formulae
1957–58	.. 3·33
1958–59	... 5·57
1959–60	... 5·47
1960–61	.. 3·96
1961–62	.. 2·61
1962–63	.. 3·31
Average	.. 4·04

This estimate is not very different from the estimate obtained by the first method.

Since the fishing by trawling in the offshore stock has just commenced and the offshore stock is practically independent of the fishery in inshore and backwaters, the component of mortality due to fishing in the offshore stock must be negligible. In other words, the natural mortality is very high.

The direct consequence of high natural mortality rate of *M. dobsoni* (with short life span) is, as we have seen before, that the annual fishing success would depend heavily on the numerical strength of the incoming year class and would therefore be relatively unstable. This will be exhibited by great fluctuation in the average catch per unit effort among different years. Since the natural mortality rate is very high, the commercial fishing for *M. dobsoni* can be expanded greatly without in any way damaging the offshore stock of the species.

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DISCUSSION

DR. B. RASMUSSEN: Are there different year groups represented in the catches ?

MR. S. K. BANERJI: In the offshore catches the late 0-year class and the first year class are mostly represented. In the backwater catches only prawns upto about 70–75 mm. are represented.

DR. B. R.: When do they mature ?

MR. M. J. GEORGE: In our studies we have found that the post-larvae of these prawns which come into the backwaters at very small sizes grow upto about 70–75 mm. in this environment and then migrate back to the sea. No mature females have been caught in the backwater although sometimes mature males are met with. Maturation takes place in the marine environment.

DR. J. H. WICKSTEAD: In Singapore, some of the prawns come to the brackish waters for breeding. I wonder whether that is the case here.

MR. M. J. G.: In the case of some of the palaemonids in these waters they are found to breed in the brackish water environment and the post-larvae ascend the river.

DR. S. Z. QASIM: Von Bertalanffy's equation has 3 parameters, namely l_∞, k and t_0. I would like to know if, while modifying this equation, you included any other parameters.

MR. S. K. B.: No other parameter was included.

DR. S. Z. Q.: The value 3·56 that you have given for the mortality rate refers to F + M or only one of the two ?

MR. S. K. B.: It is an estimate for F + M. But since the fishing has only just started in this area F is negligible and, therefore, the estimate may be taken to represent the natural mortality coefficient M only.

DR. S. Z. Q.: Beverton and Holt's model generally refers to total mortality from which the natural mortality is calculated. But how did you directly estimate M ?

MR. S. K. B.: The former answer explains this.

DR. S. Z. Q.: Unless the year-classes are clearly defined it seems rather difficult to fit in Von Bertalanffy equation, with the length-frequency data.

MR. S. K. B.: Differentiating the Von Bertalanffy equation we can get it in a form from which k and l_∞ could be obtained. Some work has been done on these lines by the Inter-American Tropical Tuna Commission.