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A SHORT NOTE ON THE AVAILABLE INFORMATION ABOUT DEMERSAL FISH ON THE SHALLOW PART OF SOFALA BANK

by

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Introduction

It has recently been proposed to change some of the old shrimp-trawlers working on Sofala Bank into fishtrawlers. The survey of "Monsenor" gave a first indication of the performance of such a trawler. However, more data on the biomass of fish and the influence of the fishery is needed before the effect of introducing new vessels can be evaluated.

This note describes the present information on the biomass and catch of demersal species which constitutes a large part of the by catch of the shrimptrawlers and thus seem to be more vulnerable than the pelagic stocks to an increase in effort. In addition preliminary data on growth and mortality of two demersal species, J. belengerii and O. ruber, which are frequently found in the bycatch, is presented.

The fishery

The stock of demersal fish on the shallow part of Sofala Bank is exploited by the artesanal fishery, the semiindustrial small-scale fishery and by the industrial trawlers fishing for shallow water shrimps. Information on total catch, species composition and effort is only available from the shrimpfishery.

The bycatch of fish in the shrimpfishery on Sofala Bank

Data on species composition and magnitude of bycatch was collected onboard shrimptrawlers belonging to the company PESCAMAR in 1983 and the beginning of 1984 (C. Silva, pers. comm.). Table 1 shows the results for the most abundant families and species of demersal fish. In total the demersal species constitutes 69% on the bycatch. Except in August and September, where many samples were collected from hauls made at more than 35 m of depth, the most important family was Sciaenidae.

The total catch of shallow water shrimp in 1983 was estimated to be 8012

tonnes of which EFRIPEL caught 2075 tonnes and the other compagnies plus the licensed and private vessels 5937 tonnes (L. Brinca, pers. comm.). On the assumption that the percentage of fish in the total catch is 50% for EFRIPEL and 79% for the others, the total yearly bycatch of fish can be estimated to 26500 tonnes of which 69% or 18300 tonnes is demersal species. The total catch of O. ruber and J. belengerii can likewise be estimated to 2900 and 1600 tonnes, respectively.

Biomass of demersal species

Tables 2a to c show the catchrates and estimated abundance of fish obtained during various research surveys on Sofala Bank. The abundance has been calculated by dividing the catch per hour by the area swept assuming the efficiency of the trawl to be 1.0. The area swept was estimated as the distance between the wings of the trawl multiplied by the distance towed.

The estimates are of course subject to a large uncertainty. On one hand the herding effect of the bridles was neglected, on the other hand the efficiency of the trawl was assumed to be one.

A summary of the estimates are given in table 3. It is surprising to note that, even though the gears used had very different vertical openings, the abundance comes out more or less the same. The table also contains the size of the different subareas used, with the exclusion of areas unsuitable for trawling (L. Brinca, pers. comm.). By calculating the average catchrate in each subarea as a weighted average of the survey results and by multiplying these averages by the size of the subareas a minimum estimate of the stock of demersal fish of 19000 tonnes was obtained, table 4.

Due to the uncertainties mentioned above this figure should not be taken at its face value. A more realistic estimate is that the biomass of demersals on the shallow parts of Sofala Bank is in the order of 20000 to 60000 tonnes.

A minimum estimate of the biomasses of O. ruber and J. belengerii was obtained by the same method. The results are 2000 and 2200 tonnes, respectively, table 5.

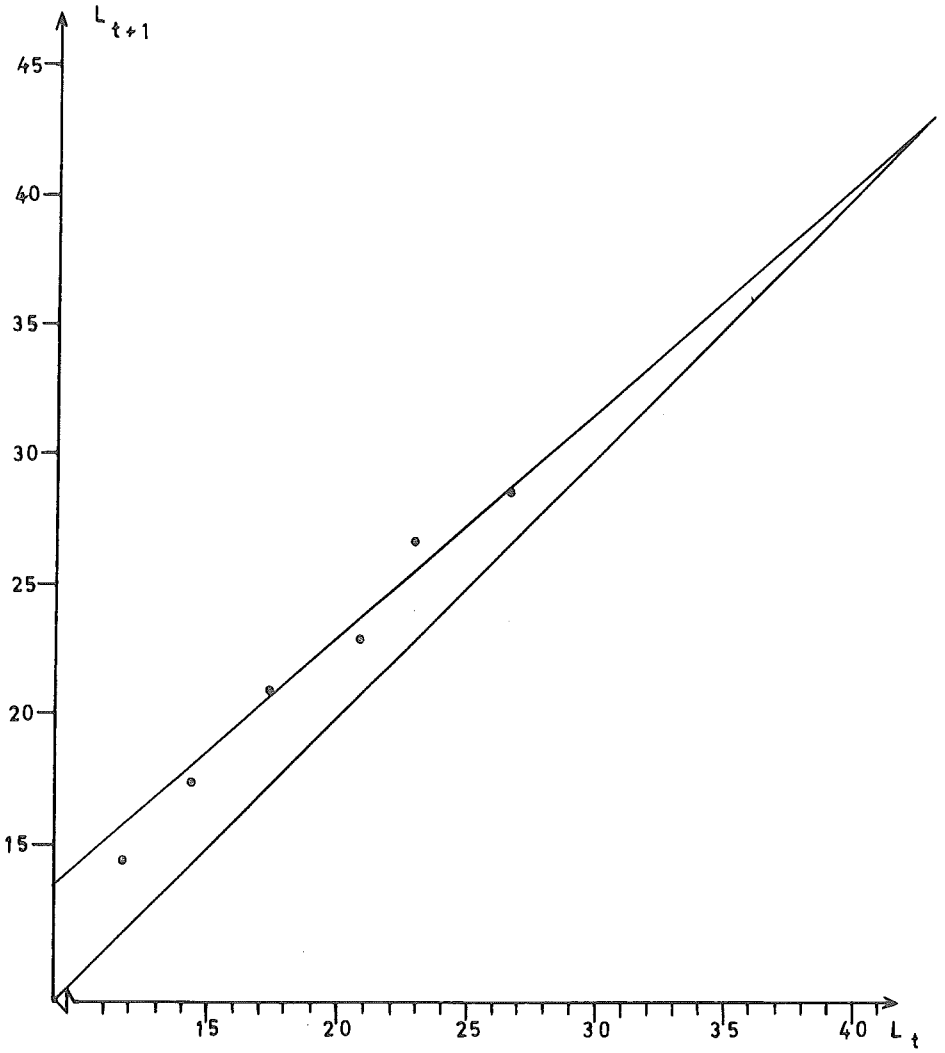

Fig. 1 - Otolithes ruber. Ford-Walford plot of length at age in Maputo Bay. Data from I. Timochin & B. Sousa (pers. comm.)

L_{∞} = 42.9 cm, K= 0.1434 year $^{-1}$

Table 6 presents a summary of the catch and biomass figures. It is evident that the present fishery is likely to exert a significant influence on the demersal stocks.

Growth and mortality of O. ruber and J. belengerii

In order to study the effects of the shrimpfishery on O. ruber and J. belengerii a first attempt was made to estimate their total mortality from the average length compositions obtained during the surveys of "Fr.Nansen", table 7 and 8. Preliminary estimates of growth parameters were obtained by use of a Ford-Walford plot, figs. 1 and 2, of the results of the scalereadings made by I. Timochin and B. Sousa in Maputo Bay, tabel 9. The total mortality was then estimated by inserting L_∞ and K into the formula of Beverton & Holt (1956):

$$Z = K \frac{L_\infty - \bar{L}'}{\bar{L}' - L'}$$

where L' is the length at which the fish is fully recruited to the fishery and $\bar{L}'$ the average of all fish larger than L'. Table 10a and b show the resulting estimates of Z. In addtition the relative increase in total mortality and the relative increase in the effort of the shrimptrawlers since 1977-78 are shown. It is easily seen that the total mortality shows the same trend as effort for both species.

In order to exclude the effect of using growth parameters estimated for Maputo Bay, another calculation was performed where L_∞ was set equal to the maximum length observed during the surveys. Without knowledge of K it is ofcourse only possible to estimate Z/K. But assuming K to be constant, the proportional increase in total mortality can still be estimated, table 11a and b. Again the same trend of increasing mortality with effort is seen.

However, it is important to remember that these estimates are preliminary only. First of all they are based on very little data, secondly the length compositions are influenced by the time of year at which the samples were taken, and thirdly the formula of Beverton & Holt (1956) assumes the stock to be in a steady-state. If O. ruber spend 6 years in attaining a size

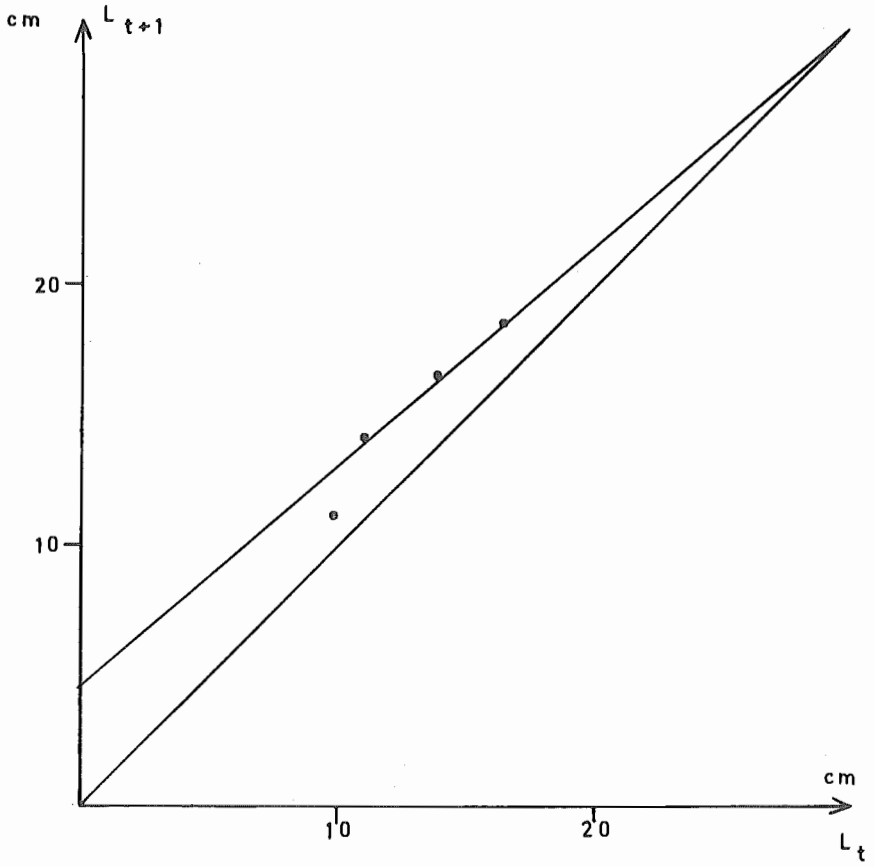

Fig. 2 - Johnius belengerii. Ford-Walford plot of length at age in Maputo Bay. Data from I. Timochin & B. Sousa (pers. comm.)
L_{∞} = 29.8 cm, K= 0.1673 $year^{-1}$

of 28.6 cm as estimated for Maputo Bay, it seems ridiculous to compare an estimate of Z from 1977-78 with an estimate from 1980, as it takes much longer time for a new steady state to develop.

A guess on the yearly catch of a fishtrawler of the size of "Monsenor".

A first estimate of the yearly catch of a fishtrawler of the size of "Monsenor" can be made from the average catchrate obtained during the experimental fishing.

Excluding hauls where the trawl was damaged the average catchrate was app. 200 kg per hour. Assuming the future fishtrawler to have the same catchrate, to operate 180 days a year and 12 hours per day, the total yearly catch per boat will be in the order of 430 tonnes.

Unfortunately, the species composition of the catch was not quantified onboard "Monsenor". From the results obtained by the various surveys of "Fr. Nansen" it seems reasonable to assume that max. 50% the catch, or 215 tonnes per year, will consist of demersal species.

At present nothing is known about the number of boats which will start fishing and the areas where they will operate. It is thus not possible to predict the total catch.

Summary and conclusion

The total biomass of demersal species on the shallow part of Sofala Bank was estimated to be in the order of 20 to 60 thousand tonnes. The total catch cannot be estimated with certainty as the catch in the semiindustrial and artesanal fishery is unknown. Approximately 18 thousand tonnes of demersal fish was caught as a bycatch in the fishery for shallow water shrimps on Sofala Bank in 1983.

The total number of fishing hours in the shrimpfleet has increased almost 70% from 1977-78 to 1983. This increase seems to have been accompagnied by a decrease in the average length of at least some of the demersal species presumeably caused by an increase in their mortality.

Table 1 - Composition of bycatch of Pescasar shrimptrawlers (from C. Silva)

Month	% fish in catch	Total fish kg h^{-1}	Demersals kg h^{-1}	Sciaen. kg h^{-1}	O. ruber kg h^{-1}	J. beleng. kg h^{-1}	Ariidae kg h^{-1}	Mullidae kg h^{-1}	Nemipt. kg h^{-1}	Pomad. kg h^{-1}	Synod. kg h^{-1}
February 83	79	123	62	31.9	12.8	10.0	15.7	3.0	1.7	9.4	.9
March	78	100	78	26.8	13.9	7.4	13.9	7.8	.0	7.3	6.3
April	82	133	83	24.7	12.4	6.4	11.8	6.1	2.2	14.5	3.8
May	79	106	76	31.1	15.8	7.9	9.1	2.6	.3	11.6	3.3
June	76	99	85	36.8	20.2	9.6	7.4	6.7	2.6	3.0	7.9
July	87	150	106	21.7	12.8	4.0	6.0	9.4	13.1	13.2	12.7
August	88	151	129	3.9	2.7	.6	1.5	21.6	33.0	4.6	33.9
September	74	101	82	14.2	9.2	2.1	.4	3.7	24.7	1.7	21.1
October	-	-	-	-	-	-	-	-	-	-	-
November	83	213	125	55.8	18.7	17.9	7.3	7.9	.0	17.2	.0
December	89	203	105	42.5	13.4	17.0	10.9	1.7	.0	12.9	.0
January 84	73	130	108	44.6	30.7	8.8	29.0	3.5	.0	.7	.0
February	62	73	54	19.9	11.0	2.6	18.1	1.0	.0	.4	.0
AV.	79	132	91	29.5	14.5	7.9	10.9	6.3	6.5	8.0	7.5
AV. %		100	69	22.3	11.0	6.0	8.3	4.8	4.9	6.1	5.7

Table 2a. Catchrates and abundance estimates from the survey of "Fr. Nansen" Sept. 1982. Swept area = 0.1067 km^2/h (~3.2 kn x 18 m)

AREA	Hours Fishing	Depth (m)	Total kg/h	Pelagic kg/h	Demersals kg/h	Demersals* tonnes/km^2	Sciaenidae kg/h	Sciaenidae* kg/km^2
North of 17°30'	7.5	25	208.3	129.7	65.0	.61	10.9	102.2
17°30'- 19°00'	4	25	150.2	51.2	76.4	.72	58.1	544.6
17°30'- 19°00'	4	25-45	519.6	382.5	119.3	1.12	1.5	14.1
17°30'- 19°00'	2	45	135.0	39.2	86.8	.81	-	
South of 19°00'	7	25	253.8	202.2	36.6	.34	13.9	130.3
South of 19°00'	2	25-45	250.5	212.0	28.3	.27	-	
South of 19°00'	3.5	45	44.9	21.4	21.5	.20	-	

* q= 1.0

Table 2b. Catchrates and abundance estimates from the survey of "Pantikapey" June-Aug. 1981. Swept area = 0.1111 km^2/h (~4 kn x 15 m)

AREA	Hours fishing	Depth (m)	Total kg/h	Pelagic kg/h	Demersals kg/h	Demersals* tonnes/km^2	Otolithes kg/h	Otolithes* kg/km^2	Johnius kg/h	Johnius* kg/km^2
Angoche + Moebase	6	30			87.1	.78	1.2	10.8	.8	7.2
Quelimane II	9	30			83.8	.75	18.6	167.4	30.4	273.6
Quelimane II	5	30			94.4	.85	6.9	62.1	4.1	36.9
Quelimane I	12	30			55.8	.50	7.0	63.0	7.4	66.6
Quelimane I	7	30			72.3	.65	.9	8.1		
Machese	5	30			41.2	.37	4.7	42.3	9.5	85.5
Machese	3	30			55.9	.50				

* q= 1.0

Table 2c. Catchrates and abundance estimates from the survey of "Fr. Nansen" June 1983. Swept area= 0.0933 km^2/hour (~2.8 kn x 18 m)

AREA	Hours Fishing	Depth (m)	Total kg/h	Pelagic kg/h	Demersals kg/h	Demersals* tonnes/km^2	Otolithes kg/h	Otolithes* kg/km^2	Johnius kg/h	Johnius* tonnes/km^2.
Angoche + Moebase	3	50	295.2	108.8	170.3	1.83	1.8	19.3	-	
Quelimane II	5.25	35	150.4	94.4	45.4	.49	9.4	100.8	4.1	43.9
Quelimane I	7	35	321.3	219.7	74.5	.80	9.5	101.8	15.1	161.8
Machese	4.5	35	268.5	181.4	71.8	.77	5.9	63.2	7.1	76.1
Beira	3.5	35	858.8	677.9	150.9	1.62	20.8	222.9	20.8	222.9

* q= 1.0

Table 2d. Catchrates and abundance estimates from the survey of "Meleia" August 1981. Swept area= 0.0549 km^2/hour

AREA	Hours Fishing	Depth (m)	Total kg/h	Pelagic kg/h	Demersals kg/h	Demersals* tonnes/km^2	Otolithes kg/h	Otolithes* kg/km^2	Johnius kg/h	Johnius* tonnes/km^2
Angoche	6.2	10-25	110.2	13.0	91.2	1.66	19.2	349.7	1.9	34.6
Moebase	6.1	10-40	133.1	42.7	87.9	1.60	5.4	98.4	5.6	102.0
Quelimane II	6.1	10-50	92.4	15.3	73.6	1.34	8.1	147.5	11.4	107.7

* q= 1.0

Table 2e. Catchrates and abundance estimates from the survey of "Fr. Nansen", Oct.-Nov. 1980. Swept area= 0.0972 km^2/hour (7.3.0 km x 17.5 m)

Area	Hours Fishing	Depth (m)	Total kg/h	Pelagic kg/h	Demersals kg/h	Demersals* tonnes/km^2	Sciaenidae kg/h	Sciaenidae* kg/km^2
Ilha do Fogo - Angoche	13.5	25	185.7	78.5	90.3	.93	8.0	82.3
Zambezi - Ilha do Fogo	10.5	25	236.0	109.7	84.8	.87	46.1	474.1
Zambezi - Ilha do Fogo	5.5	25-49	316.5	161.1	128.7	1.32	-	-
Zambezi - Ilha do Fogo	3	50	257.2	200.4	54.7	.56	-	-
Save - Zambezi	8.5	25	516.5	312.4	177.7	1.83	88.5	910.2
Save - Zambezi	4.5	25-49	162.4	48.3	99.9	1.03	.3	3.1
Save - Zambezi	4	50	126.2	43.4	79.3	.82	-	-

* q= 1.0

Table 3 - Abundance of demersal species (tonnes/km^2) on Sofala Bank

Area	Depth (m)	km^2	Fr. Nansen 80	Pantikapey 81	Meleia 81	Fr. Nansen 82	Fr. Nansen 83
Angoche	25	859	.93	.78	1.66	.61	1.83
Moebase	45	1626			1.60		
Quelimane II	35	3958	1.04 [1]	.75	1.34	.87 [2]	.49
Quelimane *I	35	4377		.50			.80
Machese	35	7047	1.83	.37		.31 [3]	.77
Beira	35	1842					1.62

1) $t/_{km^2} = \frac{(1057 + 1386 + 1325 + 1495) \cdot .87 + (1995 + 1077) \cdot 1.32}{1057 + 1386 + 1325 + 1495 + 1995 + 1077} = 1.04$

2) $t/_{km^2} = \frac{(1057 + 1386 + 1325 + 1495) \cdot .72 + (1995 + 1077) \cdot 1.12}{1057 + 1386 + 1325 + 1495 + 1995 + 1077} = .87$

3) $t/_{km^2} = \frac{(1207 + 2571 + 1842) \cdot .34 + 3269 \cdot .27}{1207 + 2571 + 1842 + 3269} = 0.31$

Table 4 - Abundance (tonnes/km^2) and total biomass (tonnes) of demersal species on Sofala Bank. Numbers of hours trawling in brackets

AREA	Depth	km^2	Fr. Nansen 80	Pantikapey 81	Meleia 81	Fr. Nansen 82	Fr. Nansen 83	Weighted av.	Biomass
Angoche	25	2485	.93 (13.5)	.78 (6)	1.62 (12.3)	.61 (7.5)	1.83 (3)	1.12	2783
Moebase	45								
Quelimane II	35	8335	1.04 (16.0)	.62 (21)	1.34 (6.1)	.87 (8)	.65 (12.25)	.83	6918
Quelimane I	35								
Machese	35	8889	1.83 (13)	.37 (5)		.31 (9)	.95 (8)	1.03	9156
Beira	35								
									18857

Table 5 - Abundance (kg/km^2) and biomass (tonnes) of O. ruber and J. belengerii on Sofala Bank

SPECIES			Otolithes ruber				Johnius belengerii			
Area	Depth (m)	Area (km^2)	Pantikapey 81	Meleia 81	Fr. Nansen 83	Av.	Pantikapey 81	Meleia 81	Fr. Nansen 83	Av.
Angoche	25	859	10.8	349.7	19.3	112.7	7.2	34.6	-	47.5
Mqebase	45	1626		98.4				102.0		
Quelimane II	35	3958	167.4	147.5	100.8	144.3	273.6	207.7	43.9	194.6
Quelimane I	35	4377	63.0		101.8	77.3	66.6		161.8	101.7
Machese	35	7047	42.3		63.2	52.2	85.5		76.1	81.0
Beira	35	1842			222.9	222.9			222.9	222.9
BIOMASS (TONNES)				1968				2315		

Table 6 - Biomass and bycatch of demersal fish on the shallow part of Sofala Bank

Tonnes x 10^{-3}	Total Demersals	Otolithes ruber	Johnius belengerii
Biomass	20-60	2-6	2-6
Catch	18.3	2.9	1.6

Table 7 - Percentage length composition of Otolithes ruber during various surveys

cm	Fr. Nansen 1977-78	Fr. Nansen 1980	Fr. Nansen 1982	Fr. Nansen 1983
6	1.1		0.3	0.3
7	3.4		1.1	1.4
8	2.4		1.7	1.1
9	0.2	0.3	4.5	1.5
10	1.1	1.6	4.0	2.5
11	0.5	1.6	4.3	3.6
12	0.2	2.8	7.1	3.7
13	1.8	3.2	7.7	3.4
14	2.2	3.8	8.8	4.9
15	4.3	2.8	7.1	5.9
16	2.7	3.5	6.3	6.1
17	2.9	1.3	5.4	7.4
18	2.4	4.7	7.1	8.5
19	2.5	8.5	5.4	6.7
20	4.0	9.8	2.8	7.8
21	2.9	7.9	3.1	6.4
22	5.1	8.9	4.3	5.6
23	5.2	9.5	4.8	3.6
24	4.9	6.0	3.4	4.9
25	6.7	6.0	4.0	3.7
26	7.1	4.7	2.0	3.3
27	6.0	2.5	1.1	1.8
28	6.7	0.6	1.4	2.5
29	6.3	2.2	0.3	1.1
30	2.9	2.5	0.9	0.8
31	4.0	0.9	0.3	0.5
32	4.2	0.6	0.9	0.5
33	2.2	1.9		0.1
34	1.3	0.9		0.3
35	0.5			0.1
36	0.7			
37	0.4	0.3		
38	0.4			0.1
39	0.2			
40		0.3		
41	0.5			
42				
43				
44		0.3		
45				
n	553	316	352	734
$\bar{l}$	23.58	21.68	17.34	19.15

Table 8 - Percentage length composition of Johnius belengerii during various surveys.

cm	Fr. Nansen 1977-78	Fr. Nansen 1980	Fr. Nansen 1982	Fr. Nansen 1983
1				
2				
3				
4				0.8
5			0.6	3.3
6	1.1	0.6	2.4	6.2
7	2.7	3.0	4.9	7.4
8	3.6	4.5	11.3	9.4
9	2.2	7.3	13.4	8.0
10	3.6	10.8	12.9	8.2
11	8.5	20.3	14.2	9.9
12	7.2	16.4	16.1	12.3
13	16.8	12.7	11.5	12.6
14	17.2	9.7	6.2	12.1
15	15.7	7.8	4.3	5.5
16	10.7	2.2	1.4	2.4
17	4.3	2.8	.2	1.5
18	4.3	1.3	.5	.3
19	1.6	.6		.1
20	0.7		.2	.1
21				
22				
23				
24				
25				
n	447	464	628	1559
$\bar{l}$	13.97	12.39	11.29	11.32
n	447	464	628	1559
$\bar{l}$	13.97	12.39	11.29	11.32

Table 9 - Average length (cm) at age of O. ruber and J. belengerii in Maputo Bay. Based on scalereadings. Data from I. Timochin & B. Sousa (pers. comm.)

Species \ Agegroup	0	I	II	III	IV	V	VI
Otolithes ruber	11.7	14.3	17.4	20.9	22.9	26.7	28.6
Johnius belengerii	9.9	11.1	14.0	16.4	18.5		

Table 10 - Estimates of total mortality, Z, relative mortality and relative effort of shrimptrawlers using 1977-78 as 1.0. Growth data from Maputo Bay.

10a. Otolithes ruber, L'= 15 cm, K= 0.1434 year^{-1}, L_∞ = 42.9 cm

SURVEY	$\bar{L}'$ (cm)	Z	Rel. Z	Rel. effort of shrimptrawlers
Fr. Nansen 1977-78	25.62	.233	1.0	1.00
Fr. Nansen 1980	23.11	.350	1.50	1.29
Fr. Nansen 1982	20.83	.543	2.33	1.41
Fr. Nansen 1983	21.24	.498	2.14	1.68

10b. Johnius belengerii, L'= 13 cm, K= 0.1673 year^{-1}, L_∞ = 29.8 cm

SURVEY	$\bar{L}'$ (cm)	Z	Rel. Z	Rel. effort of shrimptrawlers
Fr. Nansen 1977-78	15.38	1.01	1.00	1.00
Fr. Nansen 1980	14.93	1.29	1.28	1.29
Fr. Nansen 1982	14.43	1.80	1.78	1.41
Fr. Nansen 1983	14.63	1.56	1.54	1.68

Table 11 - Estimates of Z/K, relative mortality and relative effort of shrimptrawlers using 1977-78 as 1.0. L_∞ equal to maximum length in catch

11a. Otolithes ruber L'= 15 cm, $L_\infty = L_{Max} = 44.5$ cm

SURVEY	$\bar{L}'$	Z/K	Rel.Z	Rel.effort of shrimptrawlers
Fr. Nansen 77-78	25.62	1.778	1.00	1.00
Fr. Nansen 80	23.11	2.638	1.48	1.29
Fr. Nansen 82	20.83	4.060	2.28	1.41
Fr. Nansen 83	21.24	3.728	2.10	1.68

11b. Johnius belengerii L'= 13 cm, $L_\infty = L_{Max} = 20.5$ cm

SURVEY	$\bar{L}'$	Z/K	Rel.Z	Rel. effort of shrimptrawlers
Fr. Nansen 77-78	15.38	2.151	1.00	1.00
Fr. Nansen 80	14.93	2.886	1.34	1.29
Fr. Nansen 82	14.43	4.245	1.97	1.41
Fr. Nansen 83	14.63	3.601	1.67	1.68

Table 12 - Changes in some important variables in the Gulf of Thailand Trawl Fishery 1960-73

Area of Gulf ~ 300 000 km^2. Adapted from Pauly (1979): Theory and Management of Tropical Multispecies Stocks. ICLARM Studies and Reviews no. 1

YEAR	Effort hours trawling x 10^{-6}	Total catch tonnes x 10^{-3}	Catchrate kg/h	% of non-commercial species
1960	~ 0	~ 0	303	9.0
1961	.37	110	296	9.4
1962	.60	166	176	9.0
1963	.82	211	257	11.6
1964	1.78	402	226	10.9
1965	2.17	375	177	11.3
1966	3.42	448	131	14.6
1967	3.97	457	115	10.8
1968	4.18	456	109	12.3
1969	4.35	457	105	14.3
1970	4.75	456	96	15.0
1971	6.17	450	73	18.6
1972	6.78	454	67	20.4
1973	8.51	426	50	22.4