STATE OF THE STOCKS OF SHALLOW WATER PRAWNS AT SOFALA BANK

by

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1. INTRODUCTION

In 1977 a first preliminary assessment of the shallow water prawn stocks at Sofala Bank was made (Ulltang & al., 1980).

Using additional data from 1977-1982, the first assessment was updated in 1980 (Ulltang, 1980) and in 1983 (Ulltang & al., 1983).

The present report includes the detailed description of data and explanations of the methods used in the last assessment. Data from 1983, which were not available during the last assessment, are also included in the present report.

2. THE FISHERY

Reported or estimated total catches for the years 1974-1983 are given in Table 1 and Figure 1 A.

Table 1. Total catches (tonnes) of shallow water shrimp at Sofala Bank 1974-1983. Values in brackets indicate estimated catches.

Year	Mozambique	Foreign fleets	Total
1974	(6000-7000)	(4000-5000)	(10000-12000)
1975	(6000-7000)	(4000-5000)	(10000-12000)
1976	(6000-7000)	(5000)	(11000-12000)
1977	(5000)	4541	(9500)
1978	4732	4868	9600
1979	4182	4596	8778
1980	6925	1082	8007
1981	8581	796	9377
1982	6117	1791	7908
1983	6134	1967	8101

During the period 1980-1983 two important changes occurred in the fleets of the joint-venture enterprises. Firstly, the Efripel fleet almost doubled, and this increased the effective total fishing effort by about 33% compared to the 1979 level. Secondly, in 1980 a joint-venture company with Spain was founded, and most of the Spanish fleet working under licence was incorporated in the national fleet. As licenced vessels

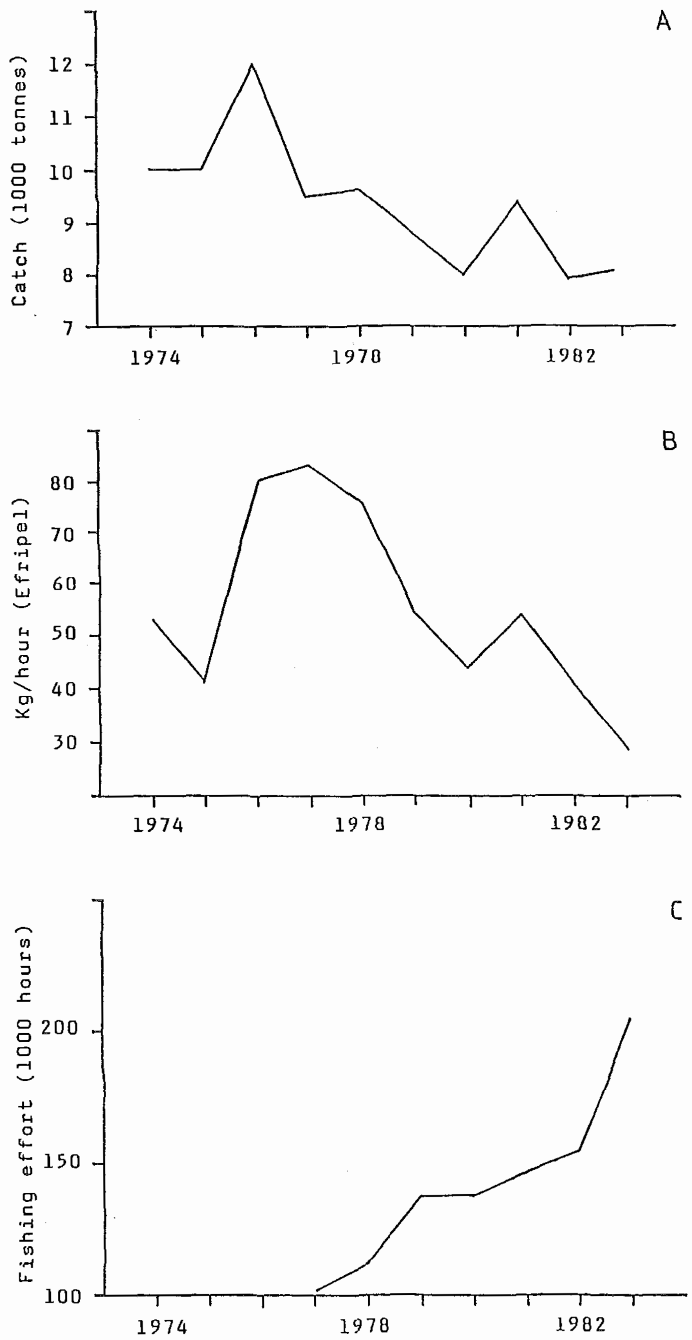

Fig. 1. A) Total catches for the period 1974-1983; B) Annual mean catch per hour for Efripel fleet (type Vega); C) Total fishing effort in Efripel trawling hours units during 1977-1983.

they had earlier not been allowed to work inside the 12 miles limit, while as a joint venture a high number of vessels were allowed to work very near the shore.

3. CATCH AND EFFORT DATA

As for the years 1974-1979, logbook data giving detailed information on catch and effort were available from the trawlers of the enterprise Efripel for the period 1980-1983.

Table 1.1 (Annex 1) includes data on total catch of the Efripel trawlers, the catch of the various species and hours of trawling for the period 1980-1983.

Number of trawl hauls taken in the various squares in 1980, 1981 1982 and 1983 are shown on Figures 1.1. to 1.4 (Annex 1). As in the previous years, the main fishing areas are Pebane and the area between Quelimane and the delta of the Zambezi River. However, comparing with the years 1974-1979, during the period 1980-1983 a more important part of the fishing effort was carried out all over the coast, between $16^{O}40'S$ and $19^{O}30'S$. Most probably this is related with the decrease in the catch rates observed during the last period of years.

Annual mean catch per hour for the whole period 1974-1983 for the Efripel trawlers (type Vega) is shown in Fig. 1 B and in the following table.

Year	74	75	76	77	78	79	80	81	82	83
Kg/h	63	52	90	93	86	64	58	64	51	39

Catch per hour of trawling was at a high level during the years 1976-1978 but has since declined and reached its lowest value in 1983. The fluctuation in total catch per hour is mainly caused by fluctuations in the catches of the species P. indicus (Fig. 2). As pointed out by Ulltang (1980) catch rates and total catches seem to be very dependent on variation in recruitment of this species.

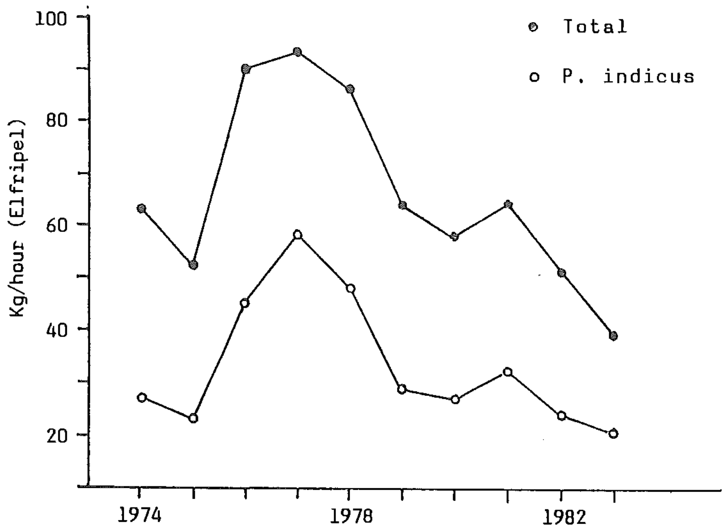

Fig. 2. Comparison between mean annual catch per hour of trawling of Total shrimp and P. indicus.

By dividing total catches by catch per hour of the Efripel trawlers, total fishing effort (in Efripel trawling hours units) can be estimated. The result is given below and in Fig. 1 C. The years 1974-1976 have not been included because of the large uncertainties in figures for total catches for these years.

Year	1977	1978	1979	1980	1981	1982	1983
Fishing effort (1000 hours trawling)	102	112	137	138	147	155	205

4. BIOMASS ESTIMATES

Mean annual biomasses for 1980-1983 were estimated by the "Swept area" method using catch per hour of the Efripel trawlers (type Vega).

Table 1.2 (Annex 1) includes data of total catch, catch of the various species and hours of trawling splitted by area and depth strata. The strata boundaries are shown in Fig. 1.5 (Annex 1).

Biomass was estimated for each strata (Annex 1, Table 1.3).

It is possible that biomass may be over-estimated by using the "Swept area" method, since it is known that the fishing fleet often is concentrated in rather small areas, and the catch rates in these areas may not be representative for the large stratum area. Stratified random trawl surveys by R/V "Dr. Fridtjof Nansen" conducted in October-November 1980 and September 1982 resulted in 44% and 14% lower estimates than those obtained by using Efripel catch rates from the same strata during the same periods. However, the trawl used by the research vessel may have a lower efficiency in catching shrimp than the commercial shrimp trawl, and in the "swept area" calculations 100% catching efficiency was assumed.

The estimates derived from the Efripel data were therefore used as the best available estimates of mean annual biomass, correcting for the part of the biomass outside the strata covered by the Efripel trawlers. The correction was made using data from trawl surveys carried out in Sofala Bank in 1980, 1982 and 1983 (Table 1.4, Annex 1).

The following table shows the results obtained.

Table 2. Mean annual biomass (tonnes) based on Efripel catch per hour corrected for biomass outside the fishing area.

Year	Mean annual biomass of the fishing areas B, C and D	Time of the survey	Correcting factor	Corrected biomass
1980	3449	Oct-Nov	0.66	5226
1981	3637	-	0.67*	5428
1982	2803	Sep	0.68	4122
1983	2312	May-Jun	0.67	3451

* No survey was made in 1981. Correcting factor computed as the mean of 1980 and 1982 factors.

It should, however, be stressed that there are two factors which could lead to substancial errors in the estimates. A lower efficiency in catching shrimp present in the area covered by the trawl than the 100% assumed, would result in underestimating the abundance. Non-random fishing searching for the best concentrations would have the opposite effect. Both factors are probably present.

5. ESTIMATION OF MORTALITY

Total mortality (Z), fishing mortality (F) and natural mortality (M) for P. indicus were estimated using two different approaches:

1) The use of catch per effort data (Ulltang, 1980)
2) Cohort analysis (Jones and Zalinge, 1981)

5.1. The use of C.p.u.e. data

Total mortality (Z) was estimated from the variation with time of number caught per hour of trawling.

The method is based on the assumption that changes in number caught per hour reflect changes in abundance and not changes in availability.

For a period of no recruitment, the mean monthly mortality during the period may be estimated as the slope of the regression line of ln (catch/hour) against time.

Fig. 3 indicates that almost no recruitment occurred during the following periods: 1980 - June to September, 1981 - June to October, 1982 - June to August and 1983 - June to August.

The regression lines of ln (catch/hour) against month during these periods (Fig. 4), starting with the last month of recruitment, gave estimates of Z as shown in Table 3.

Table 3. Mean monthly total mortality of P. indicus.

Year	Z (monthly)
1980	0.37
1981	0.29
1982	0.37
1983	0.37

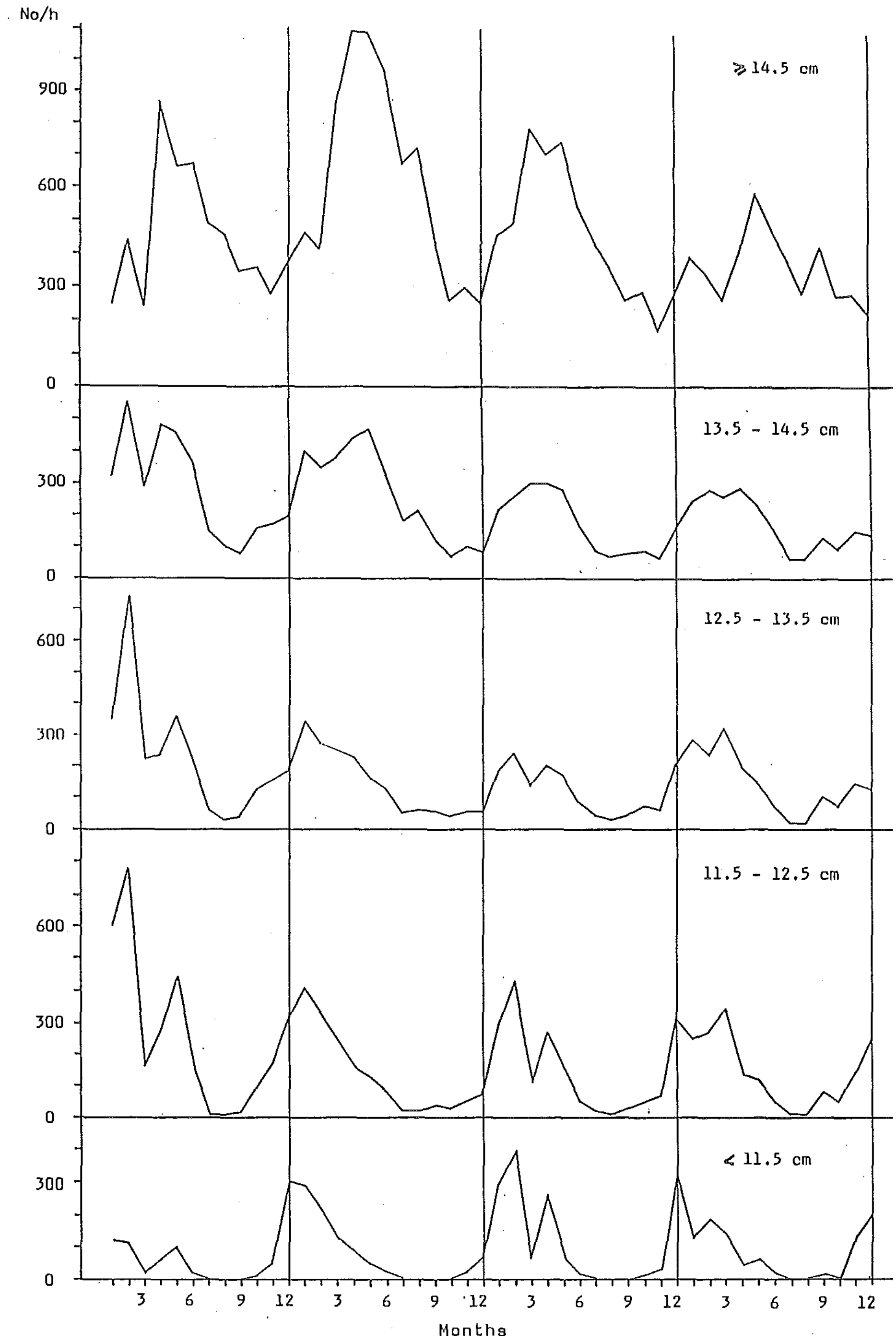

Fig. 3. P. indicus. Number caught of the various length groups per hour trawling plotted against month for the period 1980-1983.

Table 4 gives the mean monthly fishing mortality for the years 1980-1983, estimated by dividing annual catch by mean annual biomass.

Table 4. Mean monthly fishing mortalities computed from total annual catches and mean annual biomasses.

Year	Total annual catch (tonnes)	Mean annual biomass (tonnes)	$F_{monthly}$
1980	8 007	5 226	0.13
1981	9 377	5 428	0.14
1982	7 908	4 122	0.16
1983	8 101	3 451	0.20

Natural mortality (M) was then calculated by subtracting fishing mortality from total mortality.

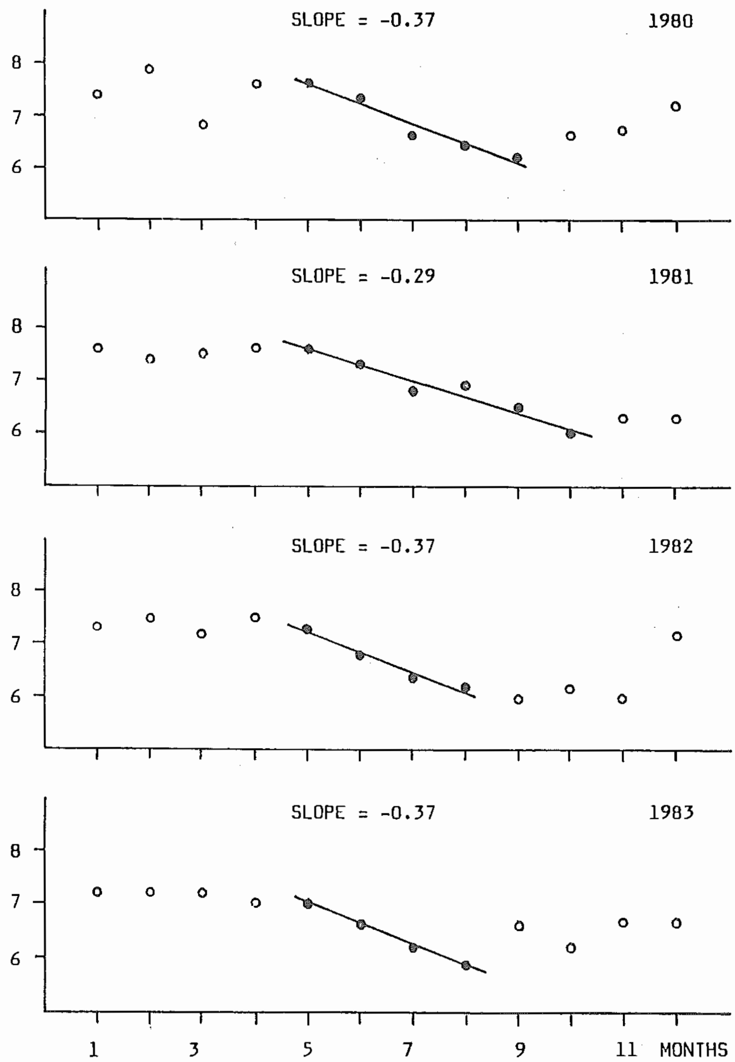

Fig. 4. P. indicus. Regression of the logarithm of total number caught per hour of trawling plotted against month.

The results obtained by the c.p.u.e. method for the years 1977-1983 are summarized below. The values for 1977-1979 are taken from Ulltang (1980).

Table 5. Estimates of monthly Z, F and M for P. indicus during 1980-1983.

Year	Z (P. indicus)	F	M (P. indicus)
1977	0.27 (Apr-Aug)	0.09	0.18
1978	0.39 (Jun-Sep)	0.10	0.29
1979	0.51 (Apr-Jul)	0.12	0.39
1980	0.37 (May-Sep)	0.13	0.24
1981	0.29 (May-Oct)	0.14	0.15
1982	0.37 (May-Aug)	0.16	0.21
1983	0.37 (May-Aug)	0.20	0.17

The results suggest that M is lower than assumed in earlier reports. The mean M as estimated above for the years 1977-1983 is 0.23, while a value of 0.3 was assumed earlier. As a result of the increasing fishing effort, monthly F has increased from a level of about 0.1 in 1977-78 to about 0.2 in 1983.

A check on the results above was made by carrying out a cohort analysis.

5.2. Length cohort analysis

The method of Jones and van Zalinge (1981) was applied to an annual frequency distribution of length, assuming that recruitment occurs annually, each year-class making its first appearance in the fishery about September-October and becoming reduced to negligible numbers one year after. Therefore length data from September '81 to August '82 is believed to relate to the catches of a cohort through the course of its entire life.

The method was applied using growth parameters from Madagascar, and an input value of F/Z=0.5 based on the results in the previous section. Tables 1.6 and 1.7 (Annex 1) give the worksheets for applying the method.

Some few individuals have been caught with length greater than the value used for L_∞. These numbers were not used in the calculations. The resulting errors in the estimates will be negligible and will only affect the largest size groups.

Estimates of F and Z were obtained for females of carapace length ranging from 29-39 mm. For the smallest individuals the mortality estimates tend to be quite small since these are incompletely recruited to the fishing gear. Estimates obtained for sizes bigger than 39 mm were not considered because the estimates obtained for larger individuals are more dependent on the input value of F/Z and therefore less reliable than the ones obtained for smaller individuals.

Resulting mean monthly F during the period September 1981-August 1982 was estimated as 0.16, assuming M=0.18, or 0.13, assuming M=0.23. M=0.18 is the mean for 1981-82 as estimated in Table 5.

Assuming M=0.18 the estimated F-value by the cohort analysis is very similar to those resulting from the c.p.u.e. method for 1981-1982.

Yield per recruit curves for P. indicus were estimated for the two alternative values of M (0.18 and 0.23). The curves are shown in Fig. 5.

6. CONCLUSIONS

Ulltang (1980) recommended that fishing effort should not increase to more than 33% over the 1979 level, this corresponding to an increase in fishing mortality to 0.16. A further increase should not be allowed before data on effects on the stocks of fishing at that level become available.

The present analysis indicates that fishing mortality reached the level of 0.16 in 1982 and increased further to 0.2 in 1983. With the new estimates of natural mortality, this level of F

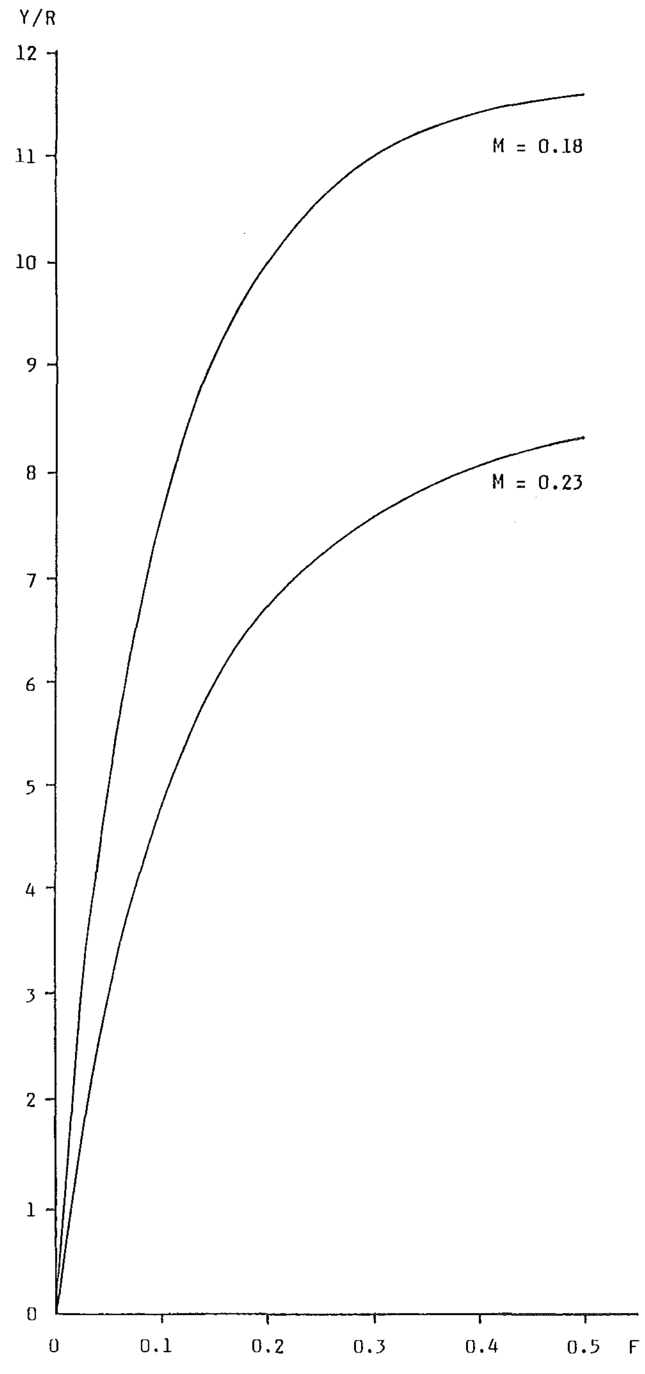

Fig. 5. P. indicus. Yield per recruit (Y/R) plotted against fishing mortality (F) for natural mortality (M)=0.18 and 0.23.

corresponds to a level of fishing effort near the optimum level from yield per recruit considerations. $F_{0.1}$ has now been estimated to about 0.2 (M=0.18) or 0.3 (M=0.23).

The main factor causing the annual fluctuations in catch per unit of effort seems to be fluctuations in recruitment of P. indicus. It has not yet been possible to demonstrate any relationship between spawning stock and resulting recruitment for this species. A longer time series would be needed for demonstrating a relationship if it existed. But even assuming that there are no strong relationship between spawning stock and resulting recruitment, the gains in yield which could be expected from a further increase in fishing mortality would be very moderate, especially when compared to the corresponding decrease in catch per hour trawling. For example, assuming M=0.18, an increase in fishing mortality from 0.16 to 0.20 increases yield by about 7%, while mean annual biomass and thereby catch per hour trawling decreases by 14%. If recruitment is decreasing with decreasing spawning stock size, the gain in yield is lower than 7% or even negative, while biomass and catch per hour trawling decrease by more than 14%.

Taking into account both the uncertainties which exist in the yield per recruit studies (i.e. uncertainties in the value of growth parameters and natural mortality) and the low recruitment of P. indicus the last five years, it is adviced not to allow a further increase in fishing mortality. Instead, one should try to keep F at a level not higher than that estimated for 1982.

There are in principle two different ways of controlling fishing mortality. It can either be controlled by directly limiting fishing effort (for example by limiting the number of vessels participating in the fishery) or by setting catch quotas.

Concerning the first approach, one problem is how to control the effective fishing effort by for example taking fully into account the effectiveness of the vessels when a new one is substituting an old one.

The main difficulty with the second approach is that the catch corresponding to a certain F-level is dependent on recruitment.

This could to some extent be overcome if catch quotas for a year were not finally decided before some indications of recruitment were available.

In Fig. 6 is shown the relationship between catch per hour during January-March and the whole year for the EFRIPEL trawlers, indicating that the abundance during the first three months is a good indicator of the abundance for the year as a whole.

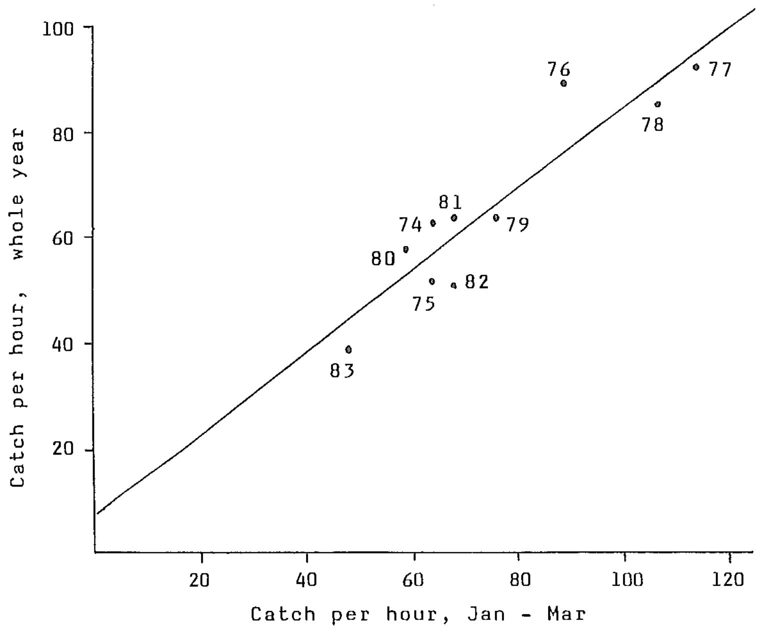

Fig. 6. EFRIPEL trawlers. Mean catch per hour (kg) during the whole year plotted against mean catch per hour during January-March.

An index of recruitment was calculated for each year during the period 1977-1983 by dividing total yield by the yield per recruit for P. indicus corresponding to the fishing mortality estimated for the year in question. These indices were plotted against mean catch per hour trawling for the EFRIPEL trawlers during January-March each year. The results are shown in Fig. 7 (M=0.18) and Fig. 8 (M=0.23). There is a strong correlation, again indicating that the abundance of shrimp during the first

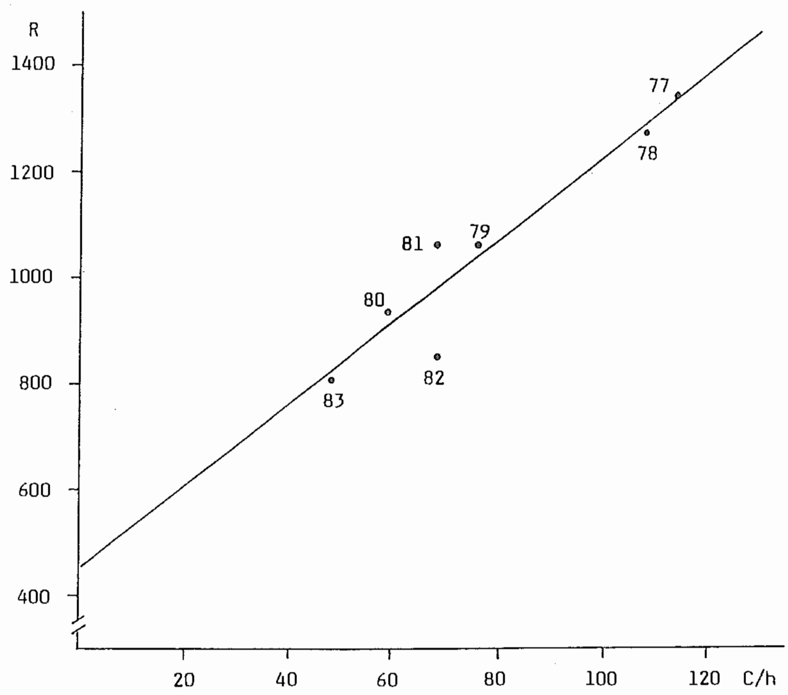

Fig. 7. Index of recruitment (R) plotted against mean catch per hour (c/h) during January-March. M=0.18.

three month of the year is a good indicator of the total recruitment that year.

The estimated regression lines in Figs. 7-8 can be used to estimate total annual catch corresponding to a certain F-level when mean catch per hour during January-March is known. For each mean catch per hour a corresponding index of recruitment can be calculated. By multiplying this index with yield per recruit of P. indicus for the F-level decided, the total catch can be predicted. In Table 6 are shown as an example resulting catches for some selected F-values for five different levels of mean catch per hour during January-March (covering the range which has been observed 1977-1983).

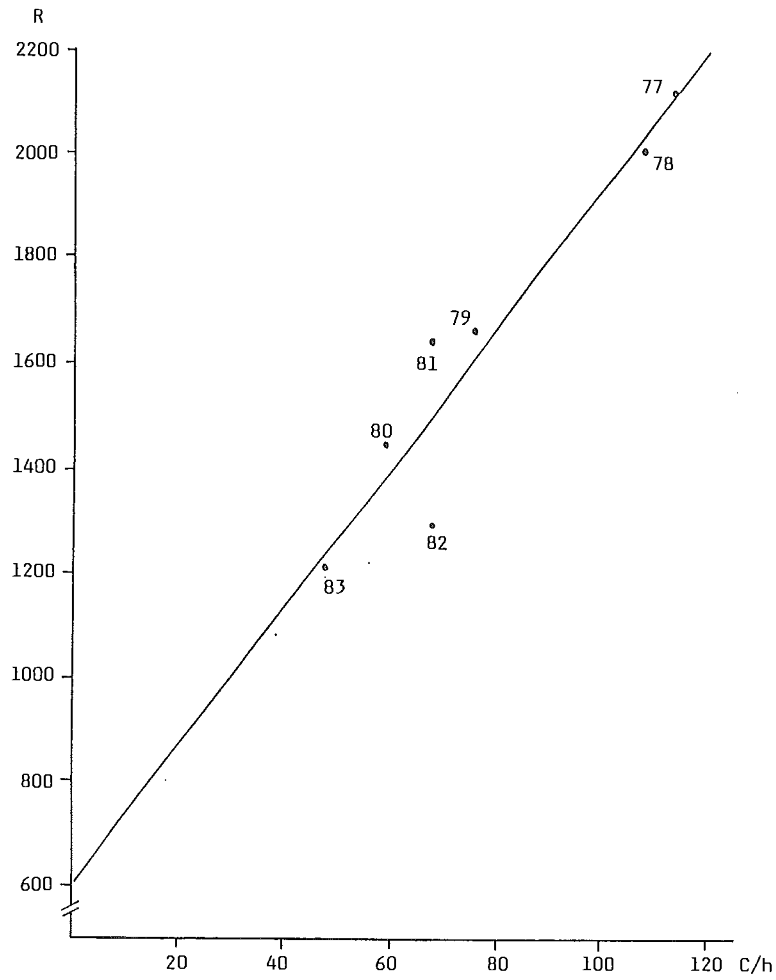

Fig. 8. Index of recruitment (R) plotted against mean catch per hour (c/h) during January-March. M=0.23.

Because of the large fluctuations in recruitment, it is advisable not to set the final catch quota before some indications of recruitment are available, and the procedure suggested above for calculating total catches would make it possible to take the final decision in April after for example having set a preliminary quota (at a rather low level) earlier.

It is not possible to estimate natural mortality with any high precision, but the two values used should indicate the likely range. It is advisable for the moment to base management considerations on M=0.18. This value is appreciably lower than

Table 6. Predicted annual catches (tonnes) corresponding to various values of mean catch per hour (kg) of the EFRIPEL trawlers (type VEGA) during January-March and selected values of monthly fishing mortality (F).

M=0.18

Mean catch per hour	F 0.12	F 0.14	F 0.16	F 0.20
40	6275	6713	7072	7616
60	7541	8067	8499	9151
80	8809	9424	9928	10690
100	10077	10781	11358	12230
120	11346	12138	12787	13769

M=0.23

Mean catch per hour	F 0.12	F 0.14	F 0.16	F 0.20
40	5999	6495	6916	7586
60	7399	8010	8530	9356
80	8797	9525	10143	11125
100	10197	11039	11755	12894
120	11594	12553	13368	14662

the value assumed earlier, and has the effect of decreasing estimated gains in yield by increasing fishing effort. Therefore, the estimated limits which the yield will vary between at F=0.16 is somewhat lower than those given by Ulltang (1980).

As pointed out in earlier reports, the fact that yield per recruit curves were not available for other species than P. indicus introduces an extra uncertainty into the assessment. However, because of the large contribution to the catches from this species, it was found justifiable to apply the conclusions based on Y/R for this species to the whole population of shallow water prawns at Sofala Bank.

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A N N E X 1

Table 1.1 Catch and effort data for the EFRIPEL trawlers (type VEGA), 1980-1983.

Year Month	Catch (kg) P. indicus	M. monoceros	P. japonicus	P. monodon	P. latisulcatus	Total catch	Hours of trawling	Catch/hour
1980								
Jan	29 716	26 986	598	4 276		61 576	1 022.43	60.23
Feb	97 028	26 446	148	23 222		146 844	2 029.74	72.34
Mar	50 462	62 840	6 682	6 744	96	126 824	2 586.95	49.02
Apr	124 814	56 046	2 946	5 240	66	189 112	2 611.14	72.43
May	112 416	89 516	2 382	4 778	356	209 448	2 539.60	82.47
Jun	98 140	75 746	3 110	2 450	20	179 466	2 608.23	68.82
Jul	67 404	94 818	8 730	10 346	120	181 418	2 888.73	62.80
Aug	87 686	88 900	11 038	4 646	104	192 374	4 189.62	45.90
Sep	57 136	84 716	5 400	4 800	8	152 060	3 549.28	42.85
Oct	66 290	97 974	2 868	11 618		178 750	3 395.76	52.61
Nov	65 460	107 764	1 646	14 630	100	189 600	3 627.52	52.27
Dec	95 198	88 614	446	18 008		202 266	3 582.20	56.46
Total	951 750	900 366	45 994	110 758	870	2 009 738	34 631.20	58.03
1981								
Jan	142 626	78 838	152	37 146	724	259 486	3 914.18	66.30
Feb	104 006	77 270	2 184	11 158		194 618	3 355.99	57.97
Mar	137 088	102 438	2 824	7 900	12	250 262	3 100.16	80.72
Apr	175 416	121 386	3 264	11 288	8	311 362	3 403.86	91.47
May	172 708	114 322	9 490	6 644		303 164	3 398.48	89.20
Jun	129 324	84 754	5 286	10 418		229 782	2 984.03	77.01
Jul	110 450	124 524	9 564	5 174		249 712	3 800.98	65.70
Aug	95 146	91 426	5 852	6 516		198 940	3 130.22	63.55
Sep	65 416	78 360	1 802	4 594		150 172	3 278.63	45.80
Oct	42 412	88 980	4 836	4 400	104	140 732	3 600.21	39.08
Nov	34 510	59 188	466	15 562		109 726	2 426.25	45.23
Dec	42 512	72 560	888	14 056		130 016	3 302.29	39.35
Total	1 251 614	1 094 046	46 608	134 856	848	2 527 972	39 695.28	63.68
1982								
Jan	96 454	90 606	1 170	7 908	4	196 142	3 354.95	58.48
Feb	97 164	78 712	4 728	5 702	-	186 306	2 851.59	65.33
Mar	112 968	131 216	7 368	5 782	404	257 738	3 188.71	80.82
Apr	149 856	141 812	6 596	4 064	326	302 654	3 913.26	77.35
May	139 972	85 234	2 662	3 408	80	231 356	3 869.60	59.80
Jun	93 498	91 996	3 728	18 604	274	208 100	3 851.99	54.03
Jul	73 308	98 662	7 042	10 694	214	189 920	3 975.86	47.75
Aug	67 580	91 262	7 998	10 646	274	177 760	4 539.46	39.14
Sep	50 522	66 128	10 366	7 618	850	135 484	4 413.01	30.69
Oct	50 462	37 722	894	5 978	48	95 104	3 709.61	25.65
Nov	28 616	80 800	800	2 588	-	112 804	2 995.33	37.66
Dec	72 844	67 926	816	6 994	40	148 620	3 254.07	45.68
Total	1 033 244	1 062 076	54 168	89 986	2 514	2 241 988	43 917.44	51.05

Table 1.1 (contd)

Year Month	Catch (kg) P. indicus	M. monoceros	P. japonicus	P. monodon	P. latisulcatus	Total catch	Hours of trawling	Catch/ hour
1983								
Jan	68 470	51 440	3 322	18 614	20	141 866	2 609.58	54.35
Feb	90 400	64 302	4 598	7 422	246	166 968	3 584.72	46.58
Mar	113 604	68 068	2 254	24 014	352	208 292	4 661.65	44.69
Apr	113 718	78 096	7 474	6 972	254	206 514	4 768.90	43.30
May	128 102	78 432	1 608	15 678	124	223 944	4 549.06	49.23
Jun	64 762	44 080	1 574	16 086	726	127 228	3 137.35	40.55
Jul	17 420	16 684	2 440	2 710	212	39 466	1 099.63	35.91
Aug	39 270	37 458	10 366	4 796	926	92 816	3 337.82	27.82
Sep	56 336	22 582	1 756	7 100	146	87 920	2 768.66	31.75
Oct	46 264	32 302	13 096	7 948	1 432	101 042	3 581.69	28.20
Nov	78 088	50 742	302	20 510	26	149 668	4 379.64	34.18
Dec	73 524	59 756	1 456	8 230	44	143 010	4 331.16	33.03
Total	889 958	603 942	50 246	140 080	4 508	1 688 734	42 809.86	39.45

Table 1.2 Catch and effort data of the EFRIPEL trawlers (type VEGA) for strata B, C, D and E, 1980-1983.

Area	Depth (m)	Catch (kg) P. indicus	M. monoceros	P. japonicus	P. monodon	P. latisulcatus	Total catch	Hours of trawling
1980								
B	5-15	38 290	8 894	66	4 404		51 654	607.58
	15-25	12 558	5 112	248	1 358		19 276	260.21
C	5-15	113 526	24 856	504	49 108		187 994	2 947.14
	15-25	122 452	100 936	4 216	16 224	62	243 890	4 665.42
	25-35	111 454	159 294	18 408	12 936	262	302 354	5 599.19
	35-45	49 590	100 356	9 592	8 636	290	168 464	2 972.40
	45-55	8 102	26 762	980	3 134		38 978	568.60
D	5-15	6 480	3 506	248	1 218		11 452	232.98
	15-25	274 424	262 478	6 334	8 480	20	551 736	9 789.14
	25-35	101 328	125 148	4 060	2 848	232	233 616	4 004.35
	35-45	8 004	20 300	328	322		28 954	413.73
E	15-25	94 810	56 128	1 174	1 612		153 724	2 312.78
	25-35	10 010	4 822	16	72		14 920	210.50
1981								
B	5-15	32 008	16 212	194	2 830		51 244	758.05
	15-25	18 784	19 082	114	1 988		39 968	536.81
C	5-15	226 290	103 556	1 176	56 604	590	388 216	5 968.31
	15-25	309 150	259 682	11 955	23 096	10	603 893	8 883.21
	25-35	176 046	229 520	16 520	16 146		438 232	6 263.39
	35-45	26 342	41 980	5 850	3 028	8	77 208	1 222.58
	45-55	228	574	8	42		852	14.57
D	5-15	77 756	46 076	354	16 562	124	140 872	2 283.51
	15-25	248 566	232 046	3 830	11 512	104	496 058	8 887.48
	25-35	83 092	117 562	6 050	2 364	12	209 080	3 548.20
	35-45	1 172	2 712	140	82		4 106	66.43
E	15-25	32 270	19 196	230	298		51 994	822.39
	25-35	2 376	2 800	42	8		5 226	84.07
1982								
A	5-15	82	8		4		94	4.00
B	5-15	32 882	6 500	268	7 756		47 406	1 068.53
	15-25	7 730	3 538	280	1 840		13 388	363.87
	25-35	106	114		52		272	8.82
	35-45		116		6		122	2.83
C	5-15	88 230	25 952	716	23 118	98	138 114	3 071.62
	15-25	132 992	121 546	4 474	18 850	164	278 026	6 820.37
	25-35	161 158	247 620	19 766	13 284	798	442 626	8 144.15
	35-45	88 302	218 526	18 452	9 282	1 078	325 640	5 247.44
	45-55	5 316	31 036	208	1 464		38 024	495.27
D	5-15	36 502	8 710	1 372	3 134	80	49 798	995.44
	15-25	312 936	237 780	4 312	8 008	78	563 114	11 332.12
	25-35	137 496	110 554	3 653	1 690	174	253 567	4 850.73
	35-45	2 490	7 818	136	376		10 820	205.60
E	5-15	102	46				140	2.75
	15-25	22 738	30 070	244	682		53 734	949.23
	25-35	4 182	12 162	292	140		16 776	354.67

Table 1.2 (contd)

Area	Depth (m)	Catch (kg) P. indicus	M. monoceros	P. japonicus	P. monodon	P. latisulcatus	Total catch	Hours of trawling
1983								
B	5-15	59 380	26 142	64	10 584	46	96 216	1 885.91
	15-25	8 632	4 180	32	1 474	24	14 342	396.05
C	5-15	163 372	35 416	1 390	73 782	134	274 094	6 581.83
	15-25	194 024	136 504	6 934	21 398	564	359 424	10 031.25
	25-35	111 896	123 828	28 066	10 258	1 108	275 156	7 122.35
	35-45	12 092	33 788	8 174	2 366	1 912	58 332	1 509.15
	45-55	84	474	114	22	26	720	29.49
D	5-15	34 566	17 814	286	6 420	54	59 140	1 507.62
	15-25	239 272	148 920	2 760	10 660	286	401 898	10 185.48
	25-35	52 724	68 622	2 344	2 786	354	126 830	2 980.43
	35-45	362	1 526		58		1 946	45.05
E	5-15	182	274		50		506	15.41
	15-25	13 038	6 346	82	222		19 688	505.35
	25-35	334	108				442	11.99
F	15-25							2.50

Table 1.3 Biomass estimates based on EFRIPEL catch per hour of trawling. (Strata B, C and D). Swept area during one hour of trawling = 3 x 1.852 x 0.017 x 2 km^2.

Strata	Depth	Area (km^2)	1980 kg/h	1980 Biomass	1980 (tonnes)	1981 kg/h	1981 Biomass	1981 (tonnes)	1982 kg/h	1982 Biomass	1982 (tonnes)	1983 kg/h	1983 Biomass	1983 (tonnes)
B	5-15	223	85.02	100	482	67.60	80	464	44.37	52	242	51.02	60	247
	15-25	974	74.08	382		74.45	384		36.79	190		36.21	187	
C	5-15	1 063	63.79	359		65.05	366		44.96	253		41.64	234	
	15-25	1 235	52.27	342	1 050	67.98	444	1 236	40.76	266	883	35.83	234	713
	25-35	707	54.00	202		69.97	262		54.35	203		38.63	145	
	35-45	490	56.68	147		63.15	164		62.06	161		38.65	100	
D	5-15	1 070	49.15	278		61.69	349		50.03	283		39.23	222	
	15-25	1 537	56.36	459	1 917	55.82	454	1 937	49.69	404	1 678	39.46	321	1 352
	25-35	2 336	58.34	721		58.93	729		52.27	646		42.55	526	
	35-45	1 238	69.98	459		61.81	405		52.63	345		43.20	283	
Total		10 873		3 449			3 637			2 803			2 312	

Table 1.4 Biomass estimates from trawl surveys at Sofala Bank.

Strata	Biomass (tonnes) 1980	1981	1982	1983
1	46	2	17	
2		104	33	34
3		729	197	243
4		583	142	1 169
Sub total	2 046	1 416	372	1 446
5		0 (a)	117	514
6		228	-	200
Sub total	933	651 (a)	-	714
Total	3 025	2 069 (a)	-	2 160

(a) The total biomass estimate was corrected comparing the results of "Dr Fridtjof Nansen" survey with the results obtained in another vessel - "S. Rybak" - surveying the same area at the same time. This was made because Stratum 5 seemed to need a further stratification.

Table 1.5 P. indicus. Number caught per hour of trawling by length group, 1980-1983.

Month	<11.5	11.5-12.5	12.5-13.5	13.5-14.5	14.5-15.5	≥15.5	Total
	Total length (cm)						
1980							
Jan	123	600	350	318	170	78	1 639
Feb	116	778	732	549	357	86	2 618
Mar	21	165	216	290	178	66	936
Apr	65	277	227	489	453	412	1 923
May	99	441	355	463	327	328	2 013
Jun	22	161	225	356	277	390	1 431
Jul	1	17	57	149	144	343	711
Aug	2	12	33	99	136	325	607
Sep	2	16	36	82	115	233	484
Oct	13	106	119	157	184	178	757
Nov	51	170	147	166	145	133	812
Dec	301	324	179	189	175	207	1 375
1981							
Jan	287	408	345	395	278	188	1 901
Feb	217	333	271	352	260	156	1 589
Mar	127	248	253	379	391	459	1 857
Apr	88	157	229	443	513	581	2 011
May	51	128	160	470	487	605	1 901
Jun	19	79	125	317	382	580	1 502
Jul	4	24	52	176	210	463	929
Aug		19	54	213	249	469	1 004
Sep	4	35	54	120	166	294	673
Oct	6	28	39	75	97	161	406
Nov	23	53	54	106	130	167	533
Dec	69	74	51	89	99	150	532
1982							
Jan	290	289	178	221	224	232	1 434
Feb	390	429	236	261	256	235	1 807
Mar	64	110	128	301	387	389	1 379
Apr	262	283	196	305	365	338	1 749
May	77	161	174	281	332	403	1 428
Jun	14	50	80	172	229	314	859
Jul	5	19	40	92	160	283	599
Aug	8	11	27	67	117	240	470
Sep	8	27	41	74	110	145	405
Oct	9	52	72	94	140	147	514
Nov	28	68	59	70	71	100	396
Dec	331	316	206	160	157	122	1 292
1983							
Jan	124	251	284	251	243	147	1 300
Feb	181	268	229	227	210	134	1 299
Mar	138	348	316	262	181	83	1 328
Apr	42	136	194	279	240	166	1 057
May	57	123	136	241	283	301	1 141
Jun	14	47	71	160	225	247	764
Jul	2	11	19	65	107	278	482
Aug	2	14	21	66	95	182	380
Sep	9	81	95	130	177	246	738
Oct	3	45	72	86	126	145	477
Nov	122	139	137	147	130	151	826
Dec	195	248	125	136	100	112	916

Table 1.6 Cohort analysis for females; Cohort September'81 - August'82; $L_\infty = 48.2$, $K = 0.21$, $M = 0.18$

Carapace length (L)	$\frac{48.2-L1}{48.2-L2} = A$	$X = A^{0.429}$	No.caught $\times 10^6$	Cohort no. $\times 10^6$	F/Z	$F_{monthly}$	$Z_{monthly}$
51			0.03 a)				
49			0.15 a)				
47			0.29	0.58	(0.5)		
45	2.667	1.523 (1.231) b)	0.61	1.63	0.58	0.25	0.43
43	1.625	1.231	1.34	4.12	0.54	0.21	0.39
41	1.385	1.150	2.03	7.78	0.55	0.22	0.40
39	1.278	1.111	2.27	12.12	0.52	0.20	0.38
37	1.217	1.088	2.10	16.63	0.47	0.16	0.34
35	1.179	1.073	2.38	21.70	0.47	0.16	0.34
33	1.152	1.062	2.56	27.19	0.47	0.16	0.34
31	1.132	1.054	2.89	33.25	0.48	0.17	0.35
29	1.116	1.048	2.09	38.71	0.38	0.11	0.29
27	1.104	1.043	1.55	43.73	0.31	0.08	0.26
25	1.094	1.039	1.17	48.42	0.25	0.06	0.24
23	1.086	1.036	0.61	52.60	0.15	0.03	0.21
21	1.079	1.033	0.34	56.48	0.09	0.02	0.20
19	1.074	1.031	0.04	60.08	0.01	0.002	0.18

a) Values not used ($L>L_\infty$)

b) Value used in preference to 1.523

Table 1.7 Cohort analysis for females; Cohort September'81 - August'82; $L_\infty = 48.2$, $K = 0.21$, $M = 0.23$

Carapace length (L)	$\frac{48.2-L1}{48.2-L2} = A$	$X = A^{0.548}$	No.caught $\times 10^6$	Cohort no. $\times 10^6$	F/Z	$F_{monthly}$	$Z_{monthly}$
51			0.03 a)				
49			0.15 a)				
47			0.29	0.58	(0.5)		
45	2.667	1.711 (1.305) b)	0.61	1.78	0.51	0.24	0.47
43	1.625	1.305	1.34	4.78	0.45	0.19	0.42
41	1.385	1.195	2.03	9.25	0.45	0.19	0.42
39	1.278	1.144	2.27	14.70	0.42	0.17	0.40
37	1.217	1.114	2.10	20.58	0.36	0.13	0.36
35	1.179	1.094	2.38	27.23	0.36	0.13	0.36
33	1.152	1.081	2.56	34.59	0.35	0.12	0.35
31	1.132	1.070	2.89	42.69	0.36	0.13	0.36
29	1.116	1.062	2.09	50.37	0.27	0.09	0.32
27	1.104	1.056	1.55	57.81	0.21	0.06	0.29
25	1.094	1.050	1.17	64.96	0.16	0.04	0.27
23	1.086	1.046	0.61	71.71	0.09	0.02	0.25
21	1.079	1.043	0.34	78.36	0.05	0.01	0.24
19	1.074	1.040	0.04	84.80	0.006	0.001	0.23

a) Values not used ($L>L_\infty$)

b) Value used in preference to 1.711

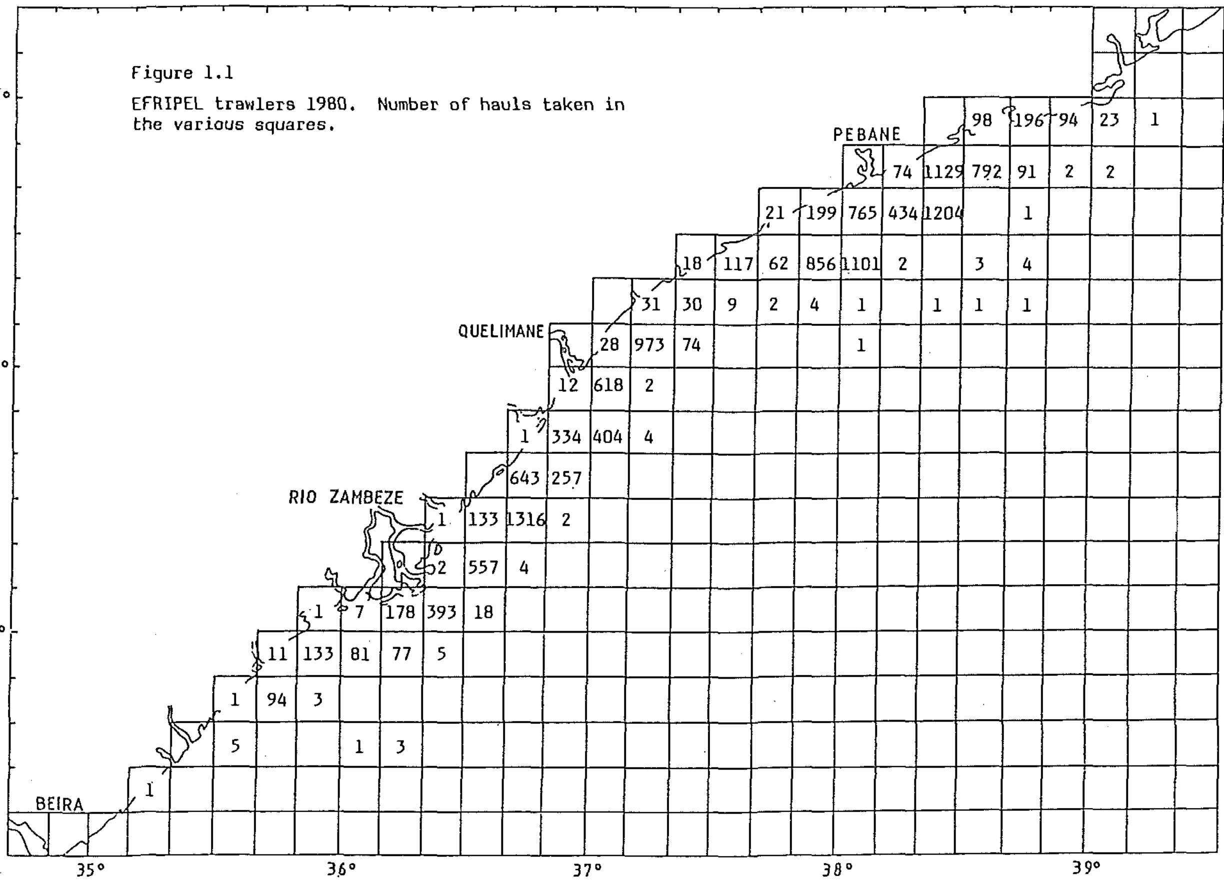
Figure 1.1
EFRIPEL trawlers 1980. Number of hauls taken in the various squares.
PEBANE
QUELIMANE
RIO ZAMBEZE
BEIRA
17°
18°
19°
35°
36°
37°
38°
39°

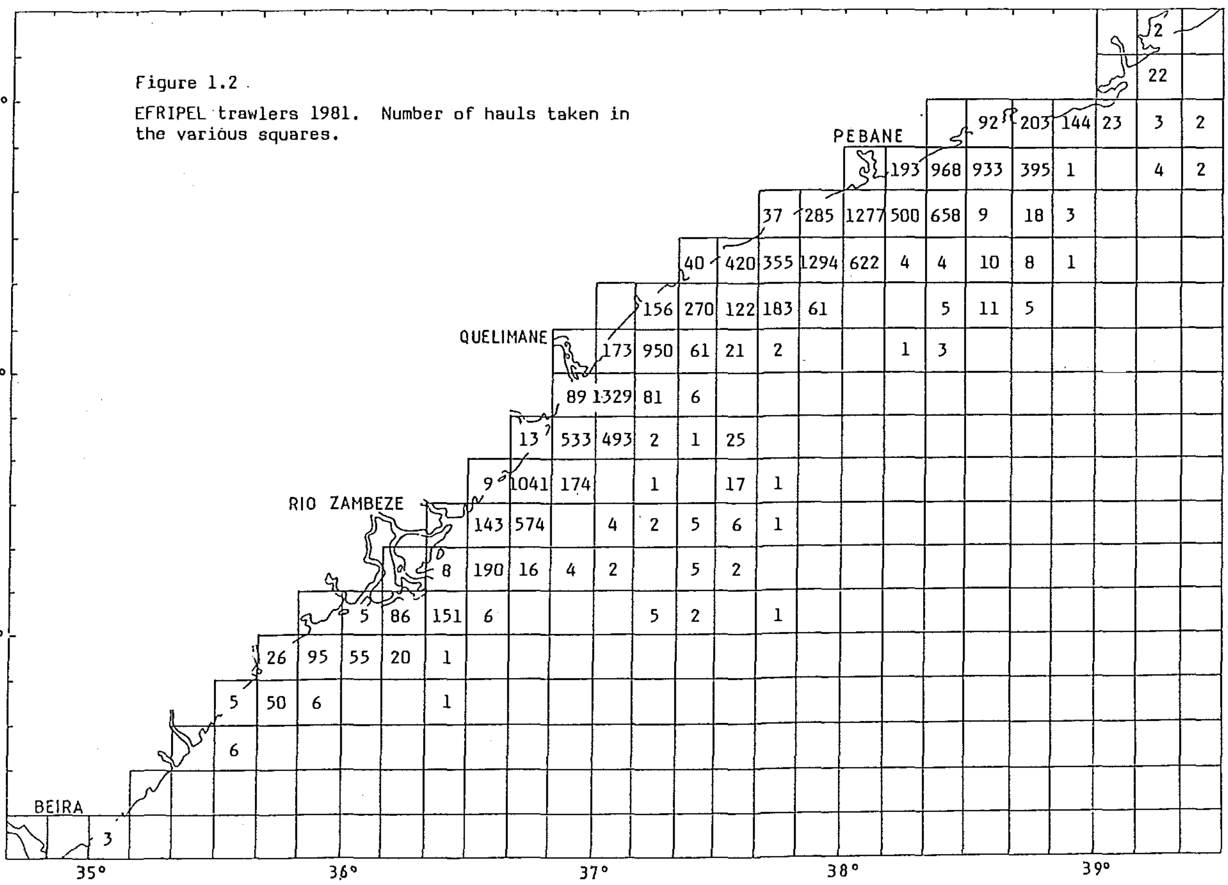
Figure 1.2
EFRIPEL trawlers 1981. Number of hauls taken in the various squares.
PEBANE
QUELIMANE
RIO ZAMBEZE
BEIRA
17°
18°
19°
35°
36°
37°
38°
39°

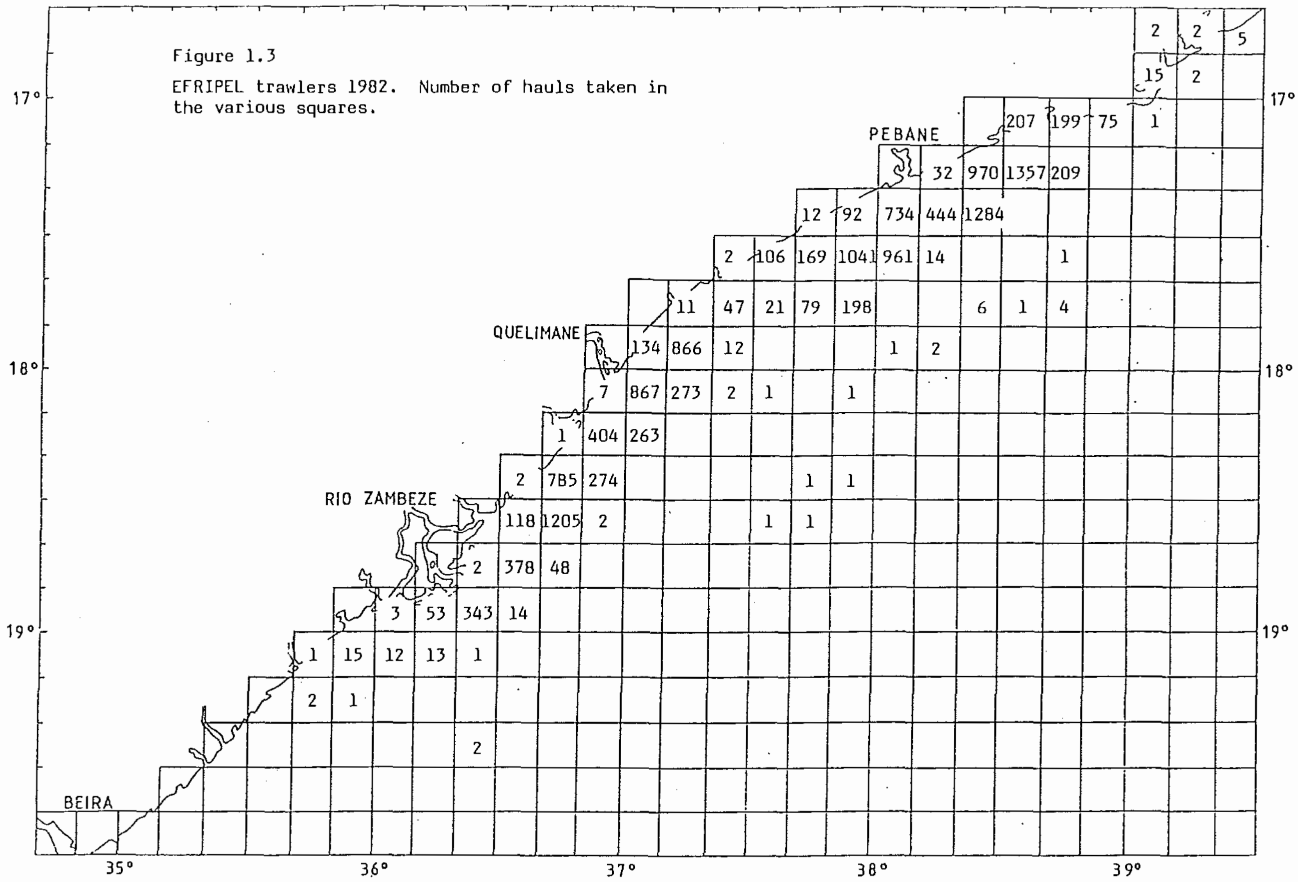

Figure 1.3

EFRIPEL trawlers 1982. Number of hauls taken in the various squares.

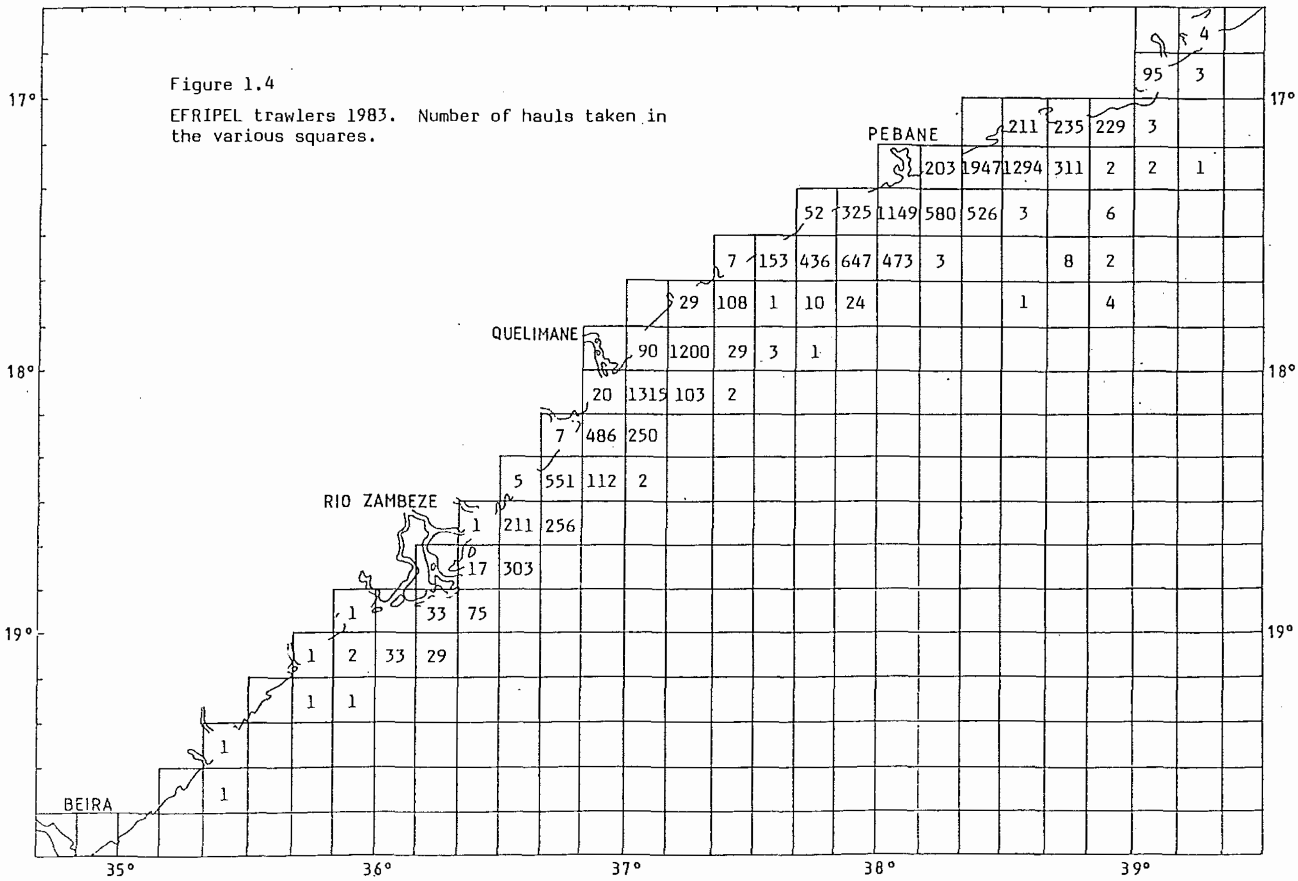

Figure 1.4

EFRIPEL trawlers 1983. Number of hauls taken in the various squares.

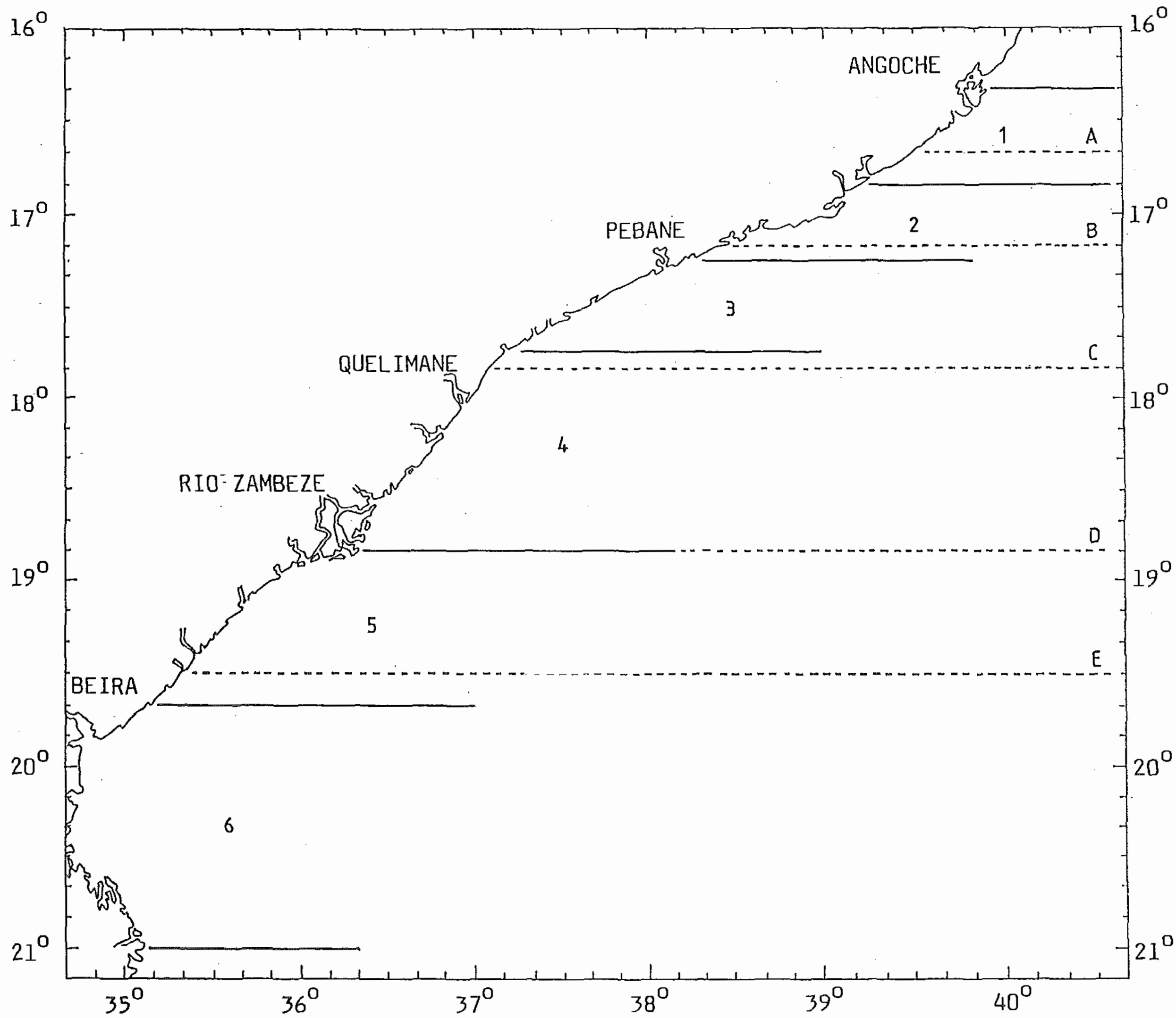

Figure 1.5 Strata boundaries of the commercial fishing (dotted line) and of the fishing surveys (full line).