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Biology, stock size and catch of Small Pelagic Fish along the coast of Mozambique

Henrik Gislason
Maria Imelda Sousa

Contents

Abstract

A compilation of all the available information on the main small pelagic fish resources of mozambican waters is presented. Resource data on distribution areas, reproduction, age, growth and stock size are described. Actual catch and catch per unit of effort of the commercially exploited stocks are also given.

Results of the preliminary assessment of the stocks of scad and mackerel and the problems envolving the assessment of Kelee shad stock at Maputo Bay are discussed.

1. Introduction

The term small pelagic species was introduced by Saetre and Silva (1979) who included sardine, herring, anchovy, scad, mackerel, jack, barracuda, driftfish and ponyfish in the group.

The small pelagic species are found at depthsless than 200 m all along the coast of Mozambique. Fig. 1 shows the main areas of high abundance of the

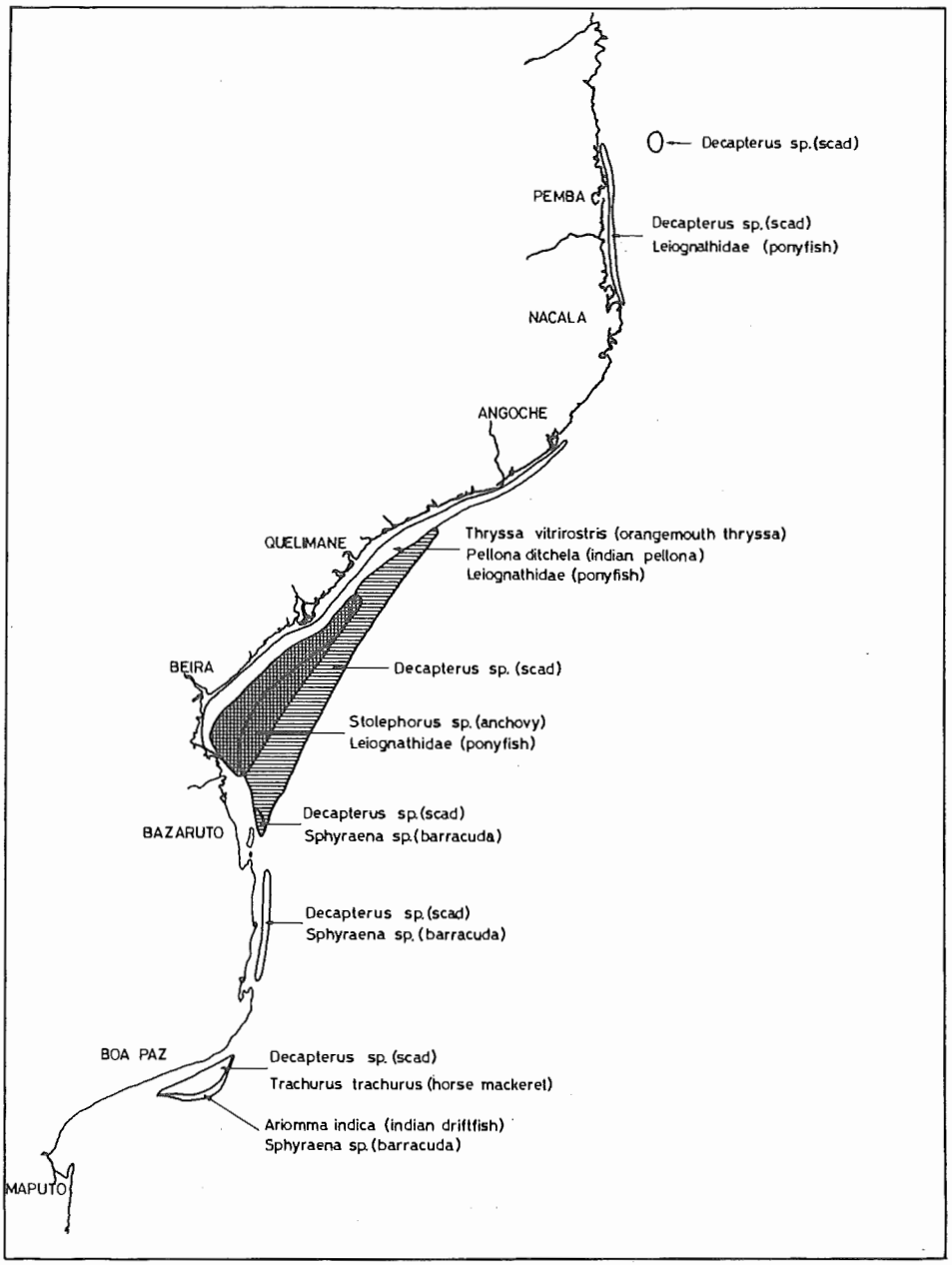

Fig. 1 - Distribution of the most abundant stocks of small pelagic fish.

most important species. Many of them show a pronounced daily vertical migration. During daytime they can be found in schools close to the bottom, at night they disperse in the watercolumn. This picture is most clear for scad, mackerel, jack, barracuda, driftfish and ponyfish, and less so for the sardines and herring. Anchovy is an exception as it is almost never caught by bottomtrawl.

Scad and mackerel are the main species caught in a bottom trawl fishery at Sofala Bank and Boa Paz at a depth of 40 to 90 m. Many of the others occur in the bycatch of the shrimptrawlers operating in more shallow waters or are caught in the artisanal and semiindustrial fishery along the coast.

Since 1976 more than 20 different scientific surveys have been made in mozambican waters. The results have been described in various reports. In addition samples have been taken from the commercial landings. The aim of this paper is to present a review of this information and to give some recommendations on the future lines of research.

2.1. Anchovy

Only one species, Stolephorus buccaneeri Strasburg 1960, which now should called Stolephorus punctifer (Fowler 1938), was reported by Saetre and Silva (1979). Later investigations have shown that at least 4 species are present of which S. punctifer and S. heterolobus are far the most common (Mascarenhas et al., in press). Among the less important are S. indicus and one more species which has not yet been identified with certainty.

Stolephorus sp. can be found at depths from 20 to 60 m at Sofala Bank, at Bazaruto and in Delagoa Bay (Saetre and Silva, 1979). During daytime they form schools in midwater, at night they disperse in the watercolumn. Saetre and Silva (1979) suggested that a yearly migration between the northern and southern part of Sofala Bank might take place in association with spawning. This migration has not been confirmed by later surveys.

Anchovy is mainly caught by pelagic trawl. The fish measure in general from 2 to 7 cm although individuals up to 16 cm have been caught occasionally. Brinca et al. (1983) found that the average length of the fish caught was

lower during daytime than during the night and that the average length furthermore increased from the north to the south of Sofala Bank.

The parameters of the length weight relationships of the four species are given in Table 1. No information on growth is available. Saetre and Silva (1979) assumed that the growth of S. punctifer was the same as that of a similar species on the south west coast of India where anchovy reaches a length of 8 to 9 cm at an age of app. 6 months.

Table 1 - Length-weight relationship of anchovies ($w = a L^b$) W: weight in g, L: length in cm. From Mascarenhas et al (in prep.)

Species	n	a	b	r
S. punctifer	276	0.0061	4.143	.95
S. heterolobus	228	0.0032	3.376	.95
S. indicus	79	0.003	3.379	.86
S. sp.	293	0.0052	3.17	.98

Saetre and Silva (1979) found spawning to take place in the southern part of Sofala Bank at depths between 30 and 60 m in April and August. Brinca et al. (1983) found spawning fish in September in the same area. The smallest individuals in spawning belonged to the length group from 6.5 to 7.0 cm.

Stolephorus sp. is in general not available to bottom trawl and is thus not caught by the industrial fishery. At the moment the catch is assumed to be zero. Saetre and Silva (1979) estimated the stock size at Sofala Bank to an average of 140 000 tonnes in 1977-78. Brinca et al. (1981) found between 13 and 32 000 tonnes in 1980 while Brinca et al. (1983) found 70 000 tonnes of anchovy in 1982. The biomass of anchovy seems thus to show great fluctuations from year to year.

2.2 - Sardines and herrings

Several species belong to this group of which Indian pellona (Pellona ditchela), orangemouth thryssa (Thryssa vitrirostris), and kelee shad (Hilsa kelee) are the most important. They all occur at low depths. Indian pellona and orangemouth thryssa are usually caught together.

The sardines, Sardinella fimbriata, S. gibbosa, S. albella, S. sirm, S. longiceps and Dussumieria acuta are less frequent and are mainly found at low depths outside Beira and between Angoche and Pebane. Round herring, Etrumeus teres, have been observed outside Beira, at Bazaruto, at Boa Paz and further south, but not in any great quantities.

Indian pellona

Indian pellona has been caught at Sofala Bank from Beira to Angoche, at Boa Paz and in Maputo Bay. It is seldomly caught at depths below 4 m and is most abundant above 20 m. During the survey of "Pantikapey" in June 1981 higher catch rates were obtained at night than during daytime, but further samples are needed to confirm this observation.

The fish caught during the surveys measured from 4 to 21.5 cm with the majority in the sizerange from 13 to 17 cm. The average length is in general lower in catches from pelagic trawl than in catches from bottom trawl. In the bottom trawl catches there is a tendency towards a decrease in average length with depth. The length compositions of bottom trawl catches from various surveys at Sofala Bank are shown in Fig. 2. The smallest individuals were caught from April to June and in September-October. In Maputo Bay samples from the catch of the shrimptrawlers show recruitment to take place from March to September.

Brinca et al. (1983) found the following length-weight relationship:

$$\log W = 2.99 \log L - 2.14 \qquad r = 0.99$$

where W is weight in grammes and L length in cm.

Only very little information is available on the food of Indian pellona. The few stomachs examined during the surveys of "Muleve" in April 1981 and

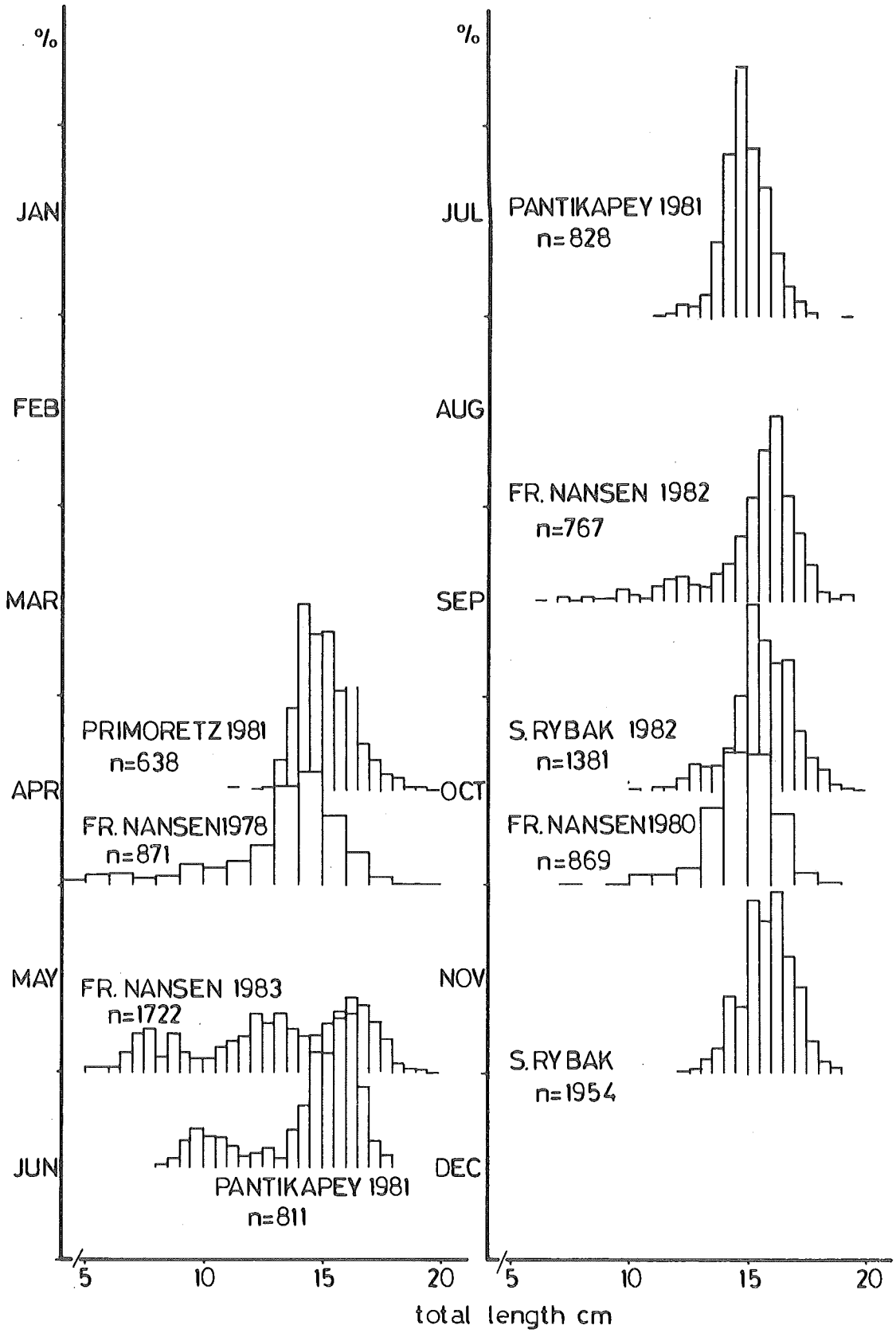

Fig. 2 - Indian pellona. Percentage length composition of bottom trawl catch at Sofala Bank in various surveys.

"S. Rybak" in October and December 1982 contained small shrimps and euphausids.

The available data on maturity stages at Sofala Bank is shown in Table 2. Spawning individuals (stage V) have been caught in all surveys, but the highest percentages were found in September and December 1982 where more

Table 2 - Maturity stages (percentage) of Pellona ditchela caught during various surveys at Sofala Bank.

SURVEY	FEMALES							MALES						
	I	II	III	IV	V	VI	n	I	II	III	IV	V	VI	n
Primoretz (April/81)	63.6		27.3		9.1		33	41.9		53.2		4.8	-	52
Fr. Nansen (Jun/83)	-	28.8	19.1	22.6	31.8	7.7	507	-	16.0	12.2	9.1	56.2	6.5	493
Fr. Nansen (Sep/82)	-	22.1	10.7	5.4	58.4	3.4	149	0.6	14.5	18.6	4.1	61.0	1.2	172
Fr. Nansen (Oct/80)	-	7.1	31.4	37.9	15.0	8.6	140	-	7.4	52.8	37.0	1.9	0.9	108
S. Rybak (Oct/82)	-	-	32.7	51.0	16.3	-	98	-	1.1	88.1	10.7	-	-	177
S. Rybak (Nov/Dec/82)	-	8.8	3.9	12.7	56.2	18.5	308	-	1.6	0.7	7.4	75.3	15.1	445

than 50% of the individuals caught were in spawning. Spawning was found to take place all along the coast from Machese to Angoche at depths between 7 and 27 m (Fig. 3). There is a tendency for the large individuals to start spawning before the smallest. The length at first maturity was estimated by Brinca et al. (1983) to be between 13 and 14 cm for females. Males become mature at a slightly smaller size.

Indian pellona is caught as a by-catch in the shrimpfisheries at Sofala Bank and in Maputo Bay. The by catch in the industrial shrimpfishery at Sofala Bank was estimated to 1 600 tonnes in 1982 (C. Silva, pers. comm.). In addition Indian pellona is caught by the semi-industrial trawlers operating from Beira and by artisanal boats along the coast. Due to the lack of data from these fisheries no estimate of the total catch can be given.

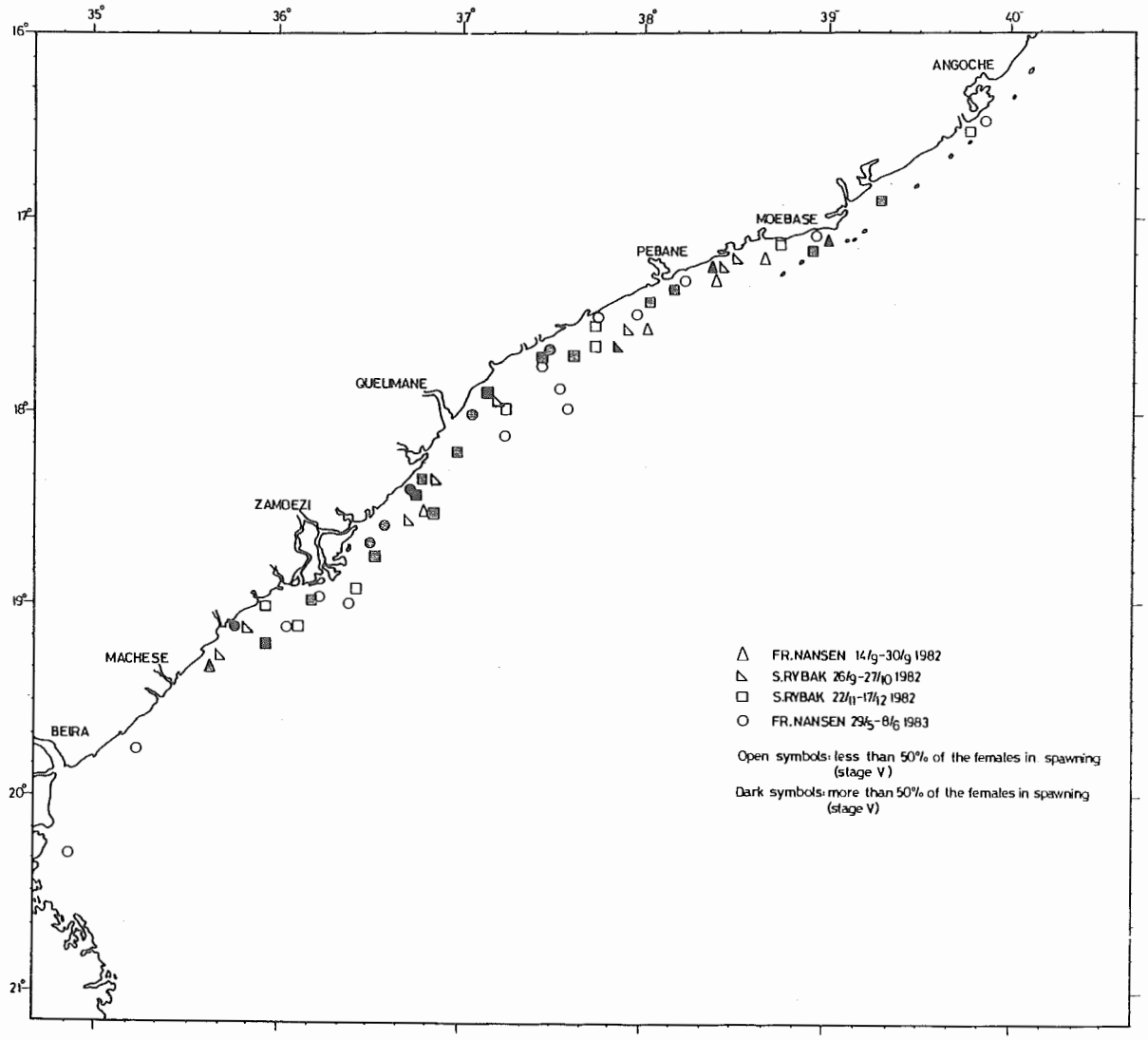

Fig. 3 - Indian pellona. Occurrence of spawning females at Sofala Bank during various surveys.

Brinca et al. (1981) estimated the stock of Indian pellona at Sofala Bank to be between 39 and 64 thousand tonnes. Brinca et al. (1983) estimated the total stock of Indian pellona and orangemouth thryssa combined to be 23 thousand tonnes at Sofala Bank.

Orangemouth thryssa

Orangemouth thryssa is usually caught in the same hauls as Indian pellona and shares the same distribution area. As for Indian pellona the highest catch rates were obtained at night during the survey of "Pantikapey".

Fish from 4 to 22.5 cm have been caught during the surveys, but the majority measured from 12 to 17 cm. The average length of fish caught by pelagic trawl is lower than that of fish caught by bottom trawl. The length composition of the bottom trawl catches can be seen in Fig. 4. At Sofala Bank the smallest individuals are in general caught between the mouth of the Zambezi river and Pebane. As for pellona recruitment seems to take place from April to June and in September-October. In Maputo Bay the smallest individuals can be found from March to September.

Brinca et al. (1983) found that the length-weight relationship could be described by:

$$\log W = 3.17 \log L - 2.40 \qquad r = 0.99$$

The few stomachs examined during the surveys of "Muleve" and "S. Rybak" contained fish, small shrimps (Palaemon styliferus)and euphausids.

Saetre and Silva (1979) concluded that the main spawning season was from March to May. The data from later surveys presented in Table 3 show that

Table 3 - Maturity stages (percentage) of Thryssa vitrirostris caught during various surveys at Sofala Bank

SURVEY	FEMALES							MALES						
	I	II	III	IV	V	VI	n	I	II	III	IV	V	VI	n
Primoretz (April/81)	97.2		2.8	-	-	-	36	76.9		23.1	-	-	-	39
Fr. Nansen (June/83)	-	62.0	19.4	4.1	13.6	.9	413	-	52.3	25.1	2.1	20.5	-	370
Fr. Nansen (Sep/82)	-	31.7	42.3	11.5	14.4	-	104	32.8	.8	25.8	10.9	27.3	2.3	128
Fr. Nansen (Oct/80)	0.7	17.9	27.6	48.3	0.7	4.8	145	-	48.3	40.2	11.5	-	-	87
S. Rybak (Oct/82)	-	22.3	50.3	24.6	-	-	179	-	24.4	66.7	8.3	.6	-	168
S. Ribak (Nov/Dec/82)	-	29.5	2.2	.6	28.6	39.1	325	-	5.2	-	.6	58.7	35.5	344

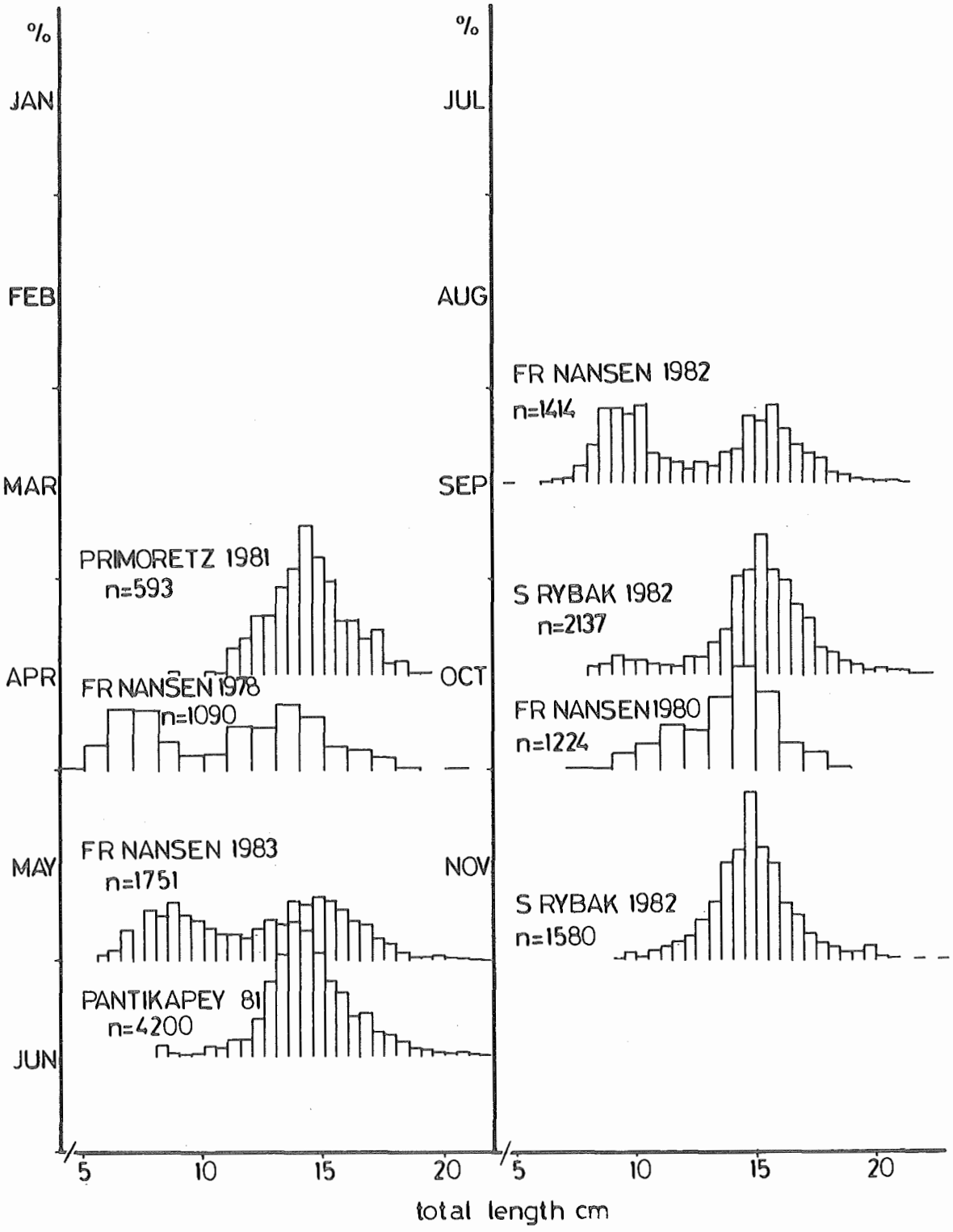

Fig. 4 - Orangemouth thryssa. Percentage length composition of bottom trawl catch at Sofala Bank in various surveys

the main spawning takes place in December, but spawning fish have also been found in June and September. At Sofala Bank the main concentrations of fish in spawning have been found between the mouth of the Zambezi river and Angoche, Fig. 5. In Maputo Bay spawning takes place in the second half of the year.

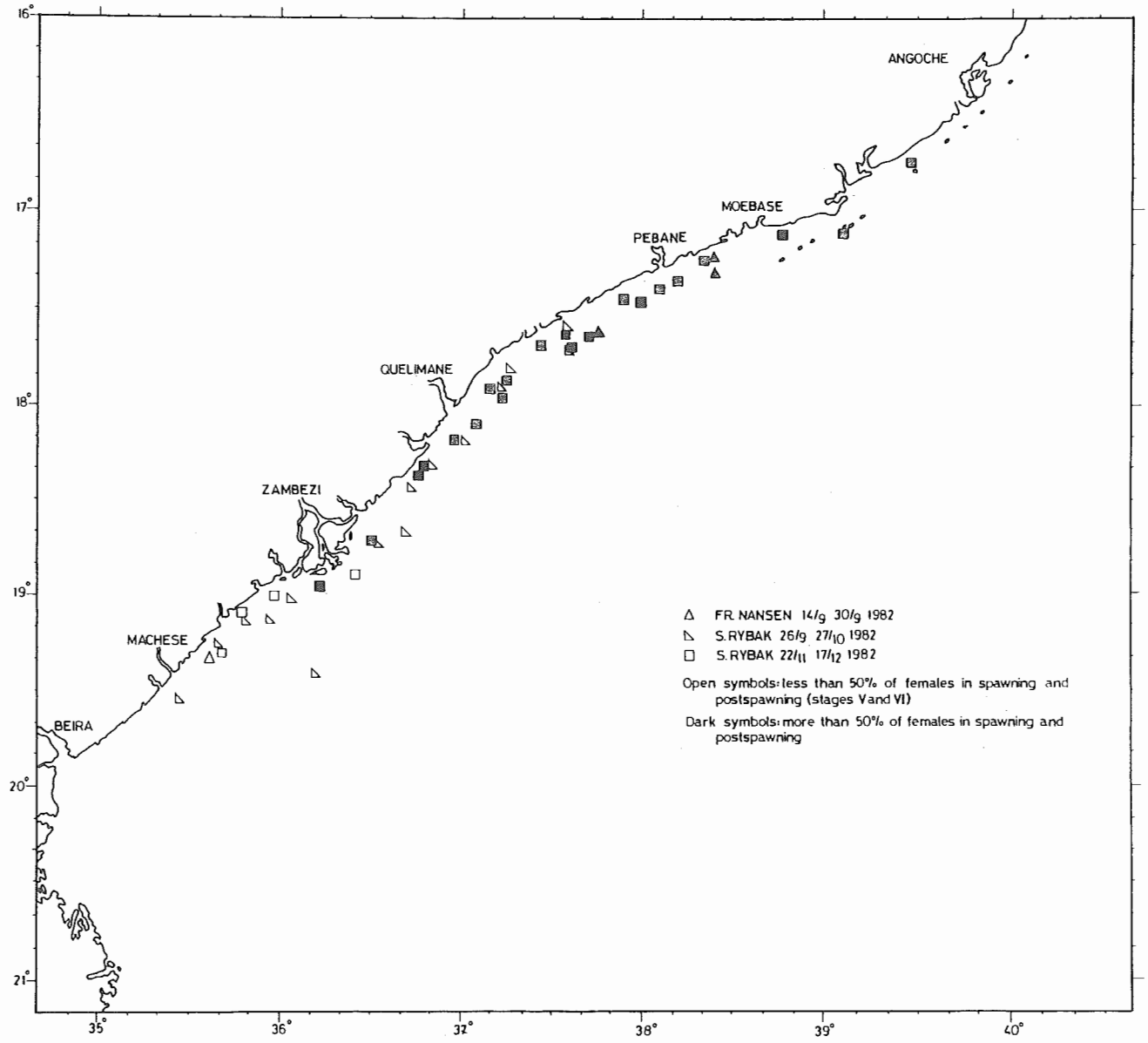

Fig. 5 - Orangemouth thryssa. Occurrence of spawning females at Sofala Bank during various surveys.

The yearly by-catch in the industrial shrimpfishery at Sofala Bank is in the order of 1200 tonnes (C. Silva, pers. comm.). One more species of thryssa, T. setirostris, occurs in the catch, but in much lower quantities (300 tonnes per year). No estimates of the catch in the semi-industrial and artisanal sectors exist.

Brinca et al. (1981) estimated the biomass of Thryssa sp. at Sofala Bank to be between 13 and 32 thousand tonnes. Brinca et al. (1983) estimated the total biomass of pellona and thryssa in the same area to be 23 thousand tonnes.

Kelee shad

The kelee shad, Hilsa kelee, is abundant in coastal and estuarine waters at depths above 20 m. It forms the base of important gillnet fisheries at Maputo and Beira.

It is difficult to delimit the geographical distribution of kelee shad from the data collected during the surveys as few hauls were made in very shallow water.Fig. 6 shows the catch rates obtained at Sofala Bank during the surveys of "Pantikapey" and "S. Rybak". The highest catch rates were observed outside Machese and between Pebane and Moebase. The few fish caught during the other surveys at Sofala Bank were taken in the same areas. No information is available on the local distribution in Maputo Bay and at Beira. However, large seasonal changes in the catch rates are found which may suggest that migrations are of importance. The juveniles probably have a more nearshore distribution than the adults. In Maputo Bay they are caught by beach seines on 1 to 2 m of depth.

Only a few length samples are available from the surveys. In Maputo Bay the length composition of the gillnet catch has been sampled since 1977. The fish caught measure from 12 to 23.5 cm, the largest numbers are found in the length group from 16 to 20 cm. The length compositions obtained are heavily influenced by the selection pattern of the nets, and the length composition of the kelee shad caught by the shrimp trawlers,Fig. 7 probably gives a better picture of the length composition of the stock. Note however that total length was used before 1982 while fork length has been used since. The relationship between fork length, L_F, and total length

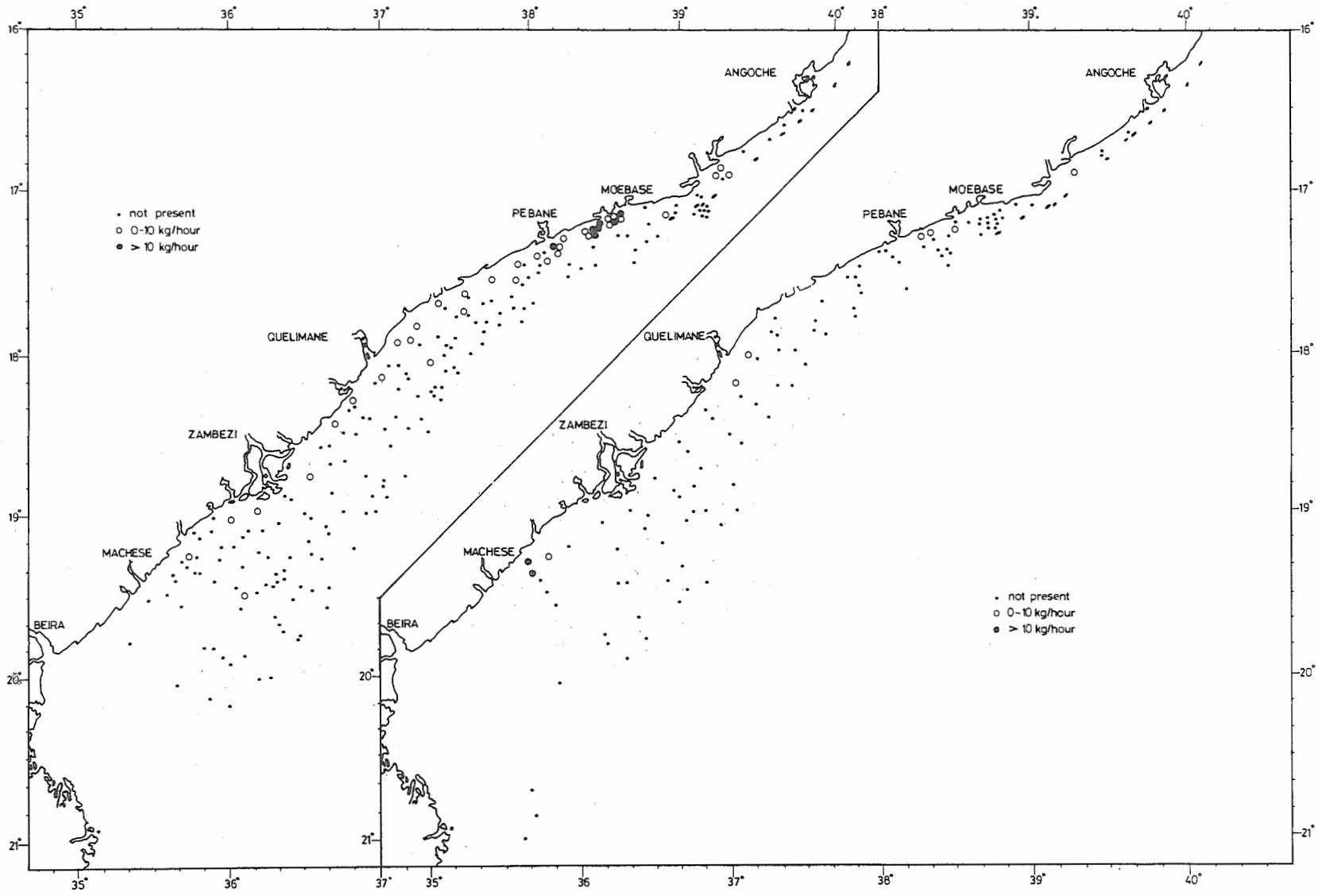

Fig. 6 - Kelee shad. Catch rates obtained at Sofala Bank during the surveys of "Pantikapey" June-July 1981 (right) and "S. Rybak" October-December 1982 (left).

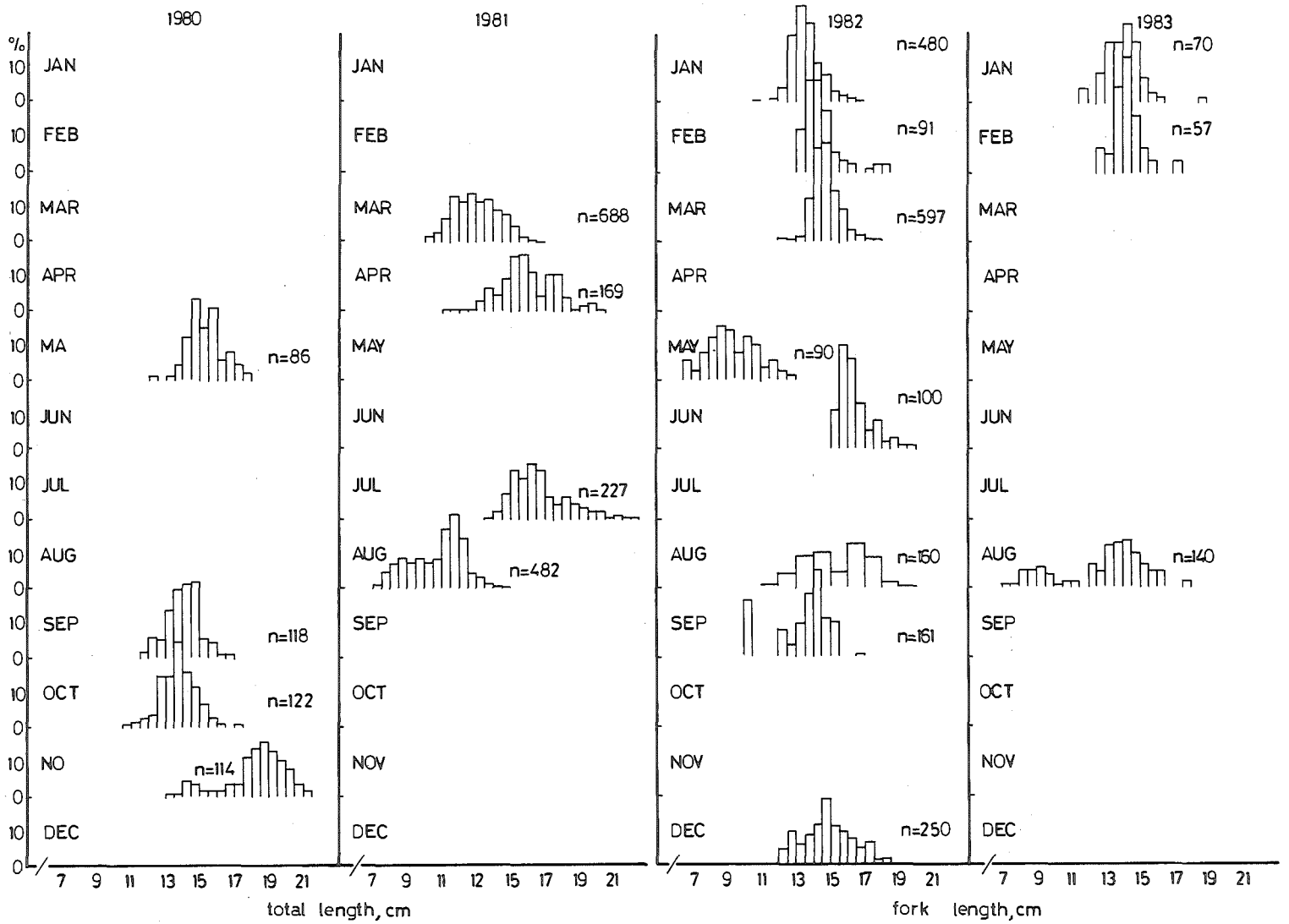

Fig. 7 - Kelee shad. Percentage length composition of bycatch of shrimp trawlers in Maputo Bay. Length groups based on total length in 1980 and 1981, on fork length in 1982 and 1983.

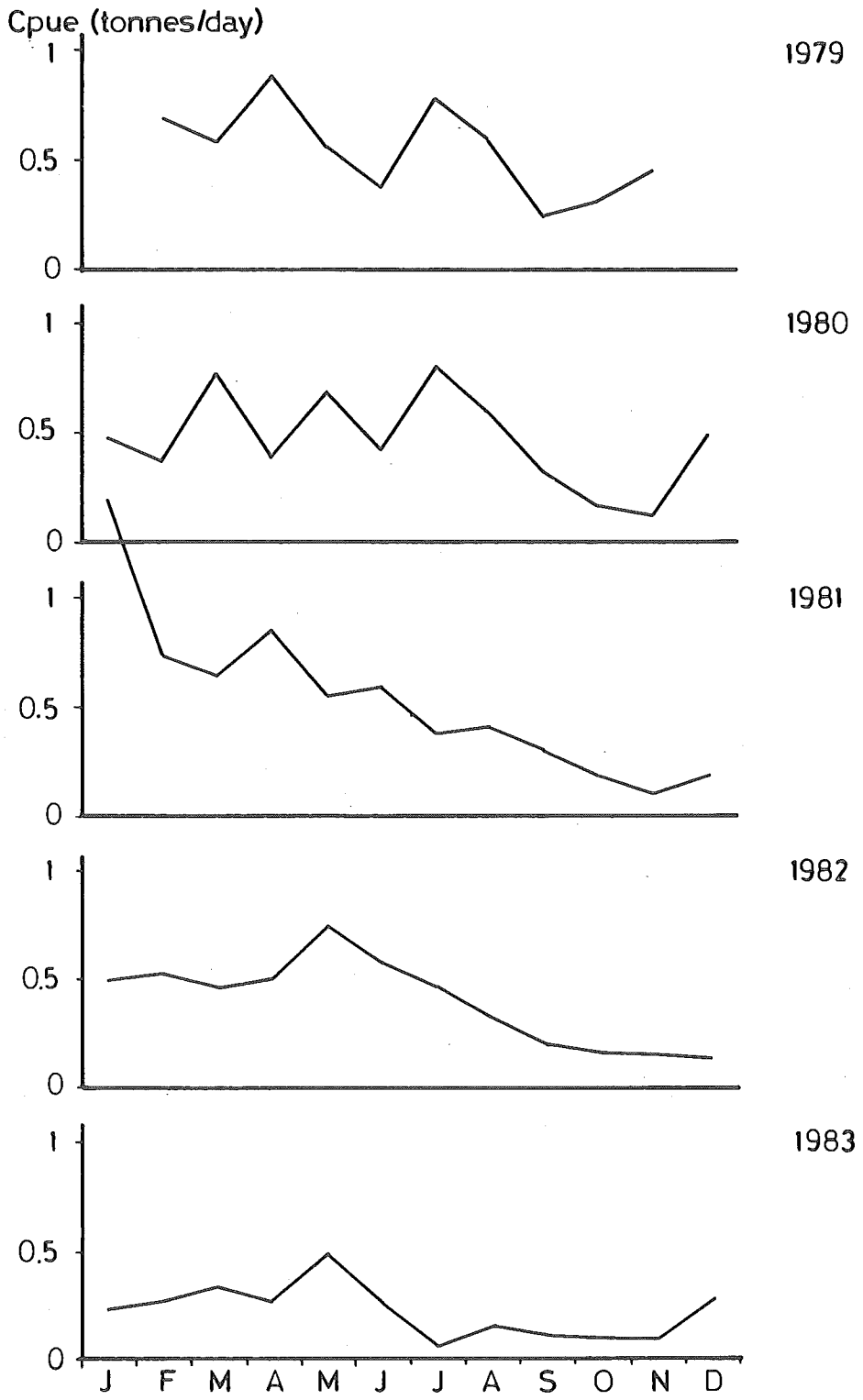

Fig. 8 - Kelee shad. Catch per unit of effort (tonnes/day/boat) of SULPESCA gillnetters in Maputo Bay, 1979-1983.

L, both in cm was estimated by Gjøsaeter and Sousa (1983 a) to:

$$L = 0.231 + 1.223\ L_F$$

The same authors described the length-weight relationship by:

$$\log W = 3.27 \log L - 2.36 \qquad r = 0.99$$

where W is weight in g and L total length in cm.

Gjøsaeter and Sousa (1983a) used the ELEFAN I program (Pauly and David, 1981) to fit a von Bertalanffy growth curve to the length distributions of the shrimp trawl catch. The best fit was obtained by:

$$L_t = 23.0\ (1 - e^{-1.2\ (t-t_o)})$$

where L_t is total length in cm at time t. Furthermore they used the primary growth rings of the otoliths to determine the age of the fish. This gave the following equation:

$$L_t = 21.5\ (1 - e^{-1.1\ (t - 0.44)})$$

However, some doubt exists concerning the interpretation of the primary rings in the socalled intermediate zone of the otolith, where broader but more diffuse rings are superimposed on the primary rings. Assuming the diffuse rings to be laid down daily will give an estimate of t_o more close to zero and may also change the estimates of the other parameters in the last equation slightly.

At Sofala Bank individuals in spawning were observed during the surveys of "Fr. Nansen" in September 1982 and June 1983 and "S. Rybak" in November--December 1982. In Maputo Bay the main spawning takes place from October to January with a peak in December (Gjøsaeter and Sousa, 1983a). There is also evidence of a second spawning in June-July. The same authors estimated the size at first maturity to be between 14 and 15 cm (Fork length) corresponding to an age of app. 1½ year.

Kelee shad is caught in gillnet fisheries at Maputo, Beira, Moma and probably

several other places along the coast south of Angoche. In addition it occurs as a bycatch in the shrimpfisheries.

The gillnet fishery at Beira has been described by Garcia and Blanco (1983). The fleet consists of approximately 90 small boats. The total yearly catch is in the order of 1000 tonnes. The best catches are obtained in the wet season from October to April. Apart from this kelee shad is also caught as a bycatch by the small shrimptrawlers operating near Beira.

The gillnet fishery in Maputo Bay has been described by Monteiro (1974), Sousa (1982) and Gjøsaeter and Sousa (1983).The total reported catch is in the order of 1000 tonnes. Approximately 30 boats are operating from Maputo harbour, but in addition app. 180 artisanal boats operate from various small landing sites along the bay. The best fishing season is May to August. Kelee shad is also caught by beach seines and as a bycatch in the local shrimpfishery.

No assessments of the stocks of kelee shad has yet been made due to the lack of data on total catch, mortality and stock size. However, catch per unit of effort data is available for the gillnetters of SULPESCA operating from Maputo harbour, Fig. 8. Unfortunately this data is to a large extent influenced by events within the company. In January 1981 new boats equipped with radio were put into operation. This resulted in a large increase in the catch per fishing day as the fishermen now were able to inform each other about the location of schools within the day. However, the radios quickly became damaged and the catch rates dropped to very low values by the end of 1981. In 1982 the catch rate continued to be at a low level and in 1983 a further reduction was seen. This reduction might be due to a decrease in the size of the stock of kelee shad and it was hence recommended that no increase in effort should take place before the catch rates improved.

2.3. Ponyfish

Five species of ponyfish have been recorded in Mozambican waters of which the common ponyfish, Leiognathus equulus, and the pugnose ponyfish, Secutor insidiator, are the most abundant.The three others are Gazza minuta, Leiognathus elongatus and Secutor ruconius. Gazza minuta is fairly widespread, but appears only in low quantities. The two lastmentioned

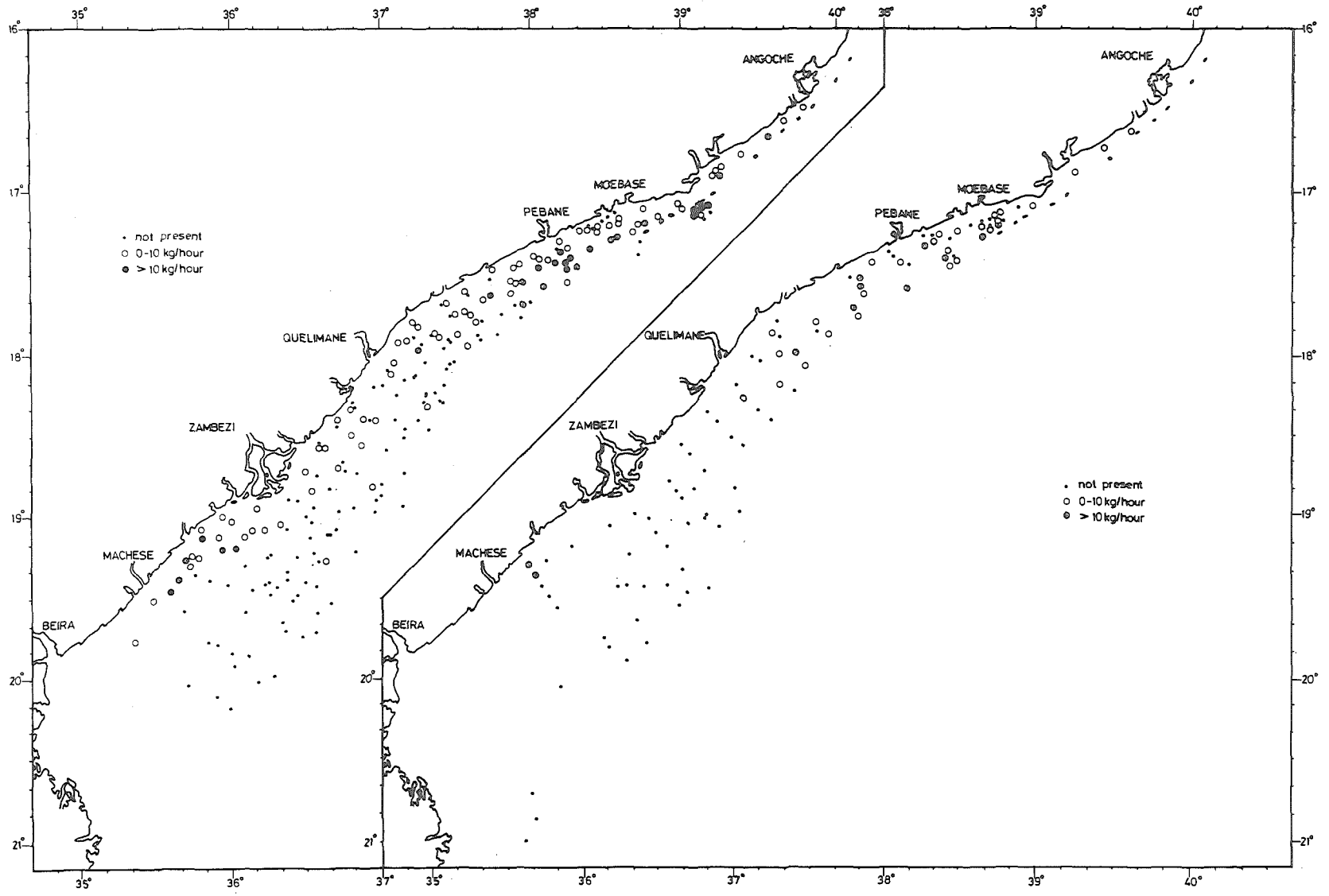

Fig. 9 - Common ponyfish. Catch rates obtained at Sofala Bank during the surveys of "Pantikapey" June-July 1981 (right) and "S. Rybak" October-December 1982 (left).

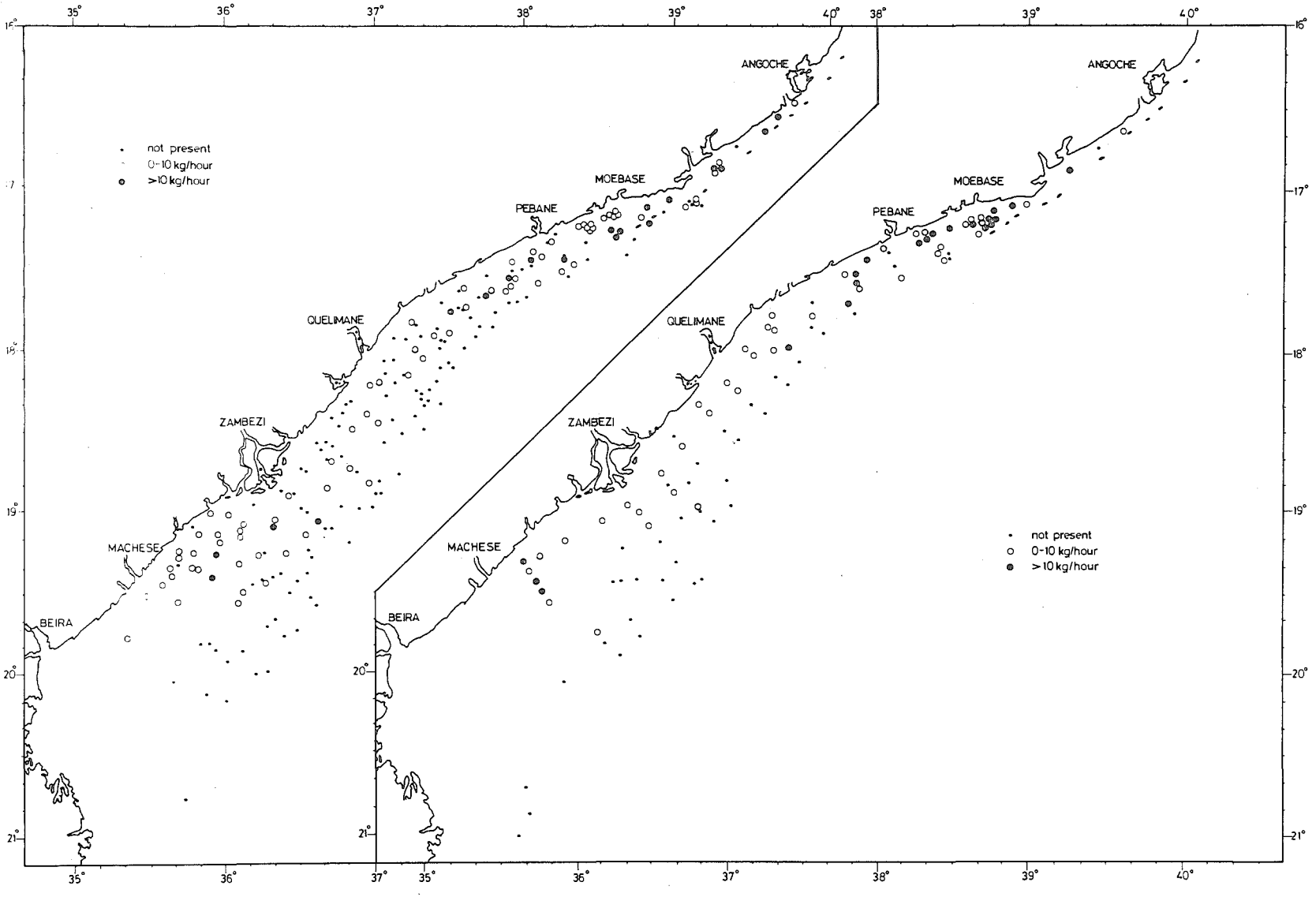

Fig. 10 - Pugnose ponyfish. Catch rates obtained at Sofala Bank during the surveys of "Pantikapey" June-July 1981 (right) and "S. Rybak" October-December 1982 (left).

species are rare.

The common and the pugnose ponyfish are found at Sofala Bank, at Boa Paz and in Maputo Bay. During the survey of "Fr. Nansen" in January-March 1978 concentrations of ponyfish were furthermore recorded north of Sofala Bank between Pemba and Nacala, but the species was not identified. At Sofala Bank two major distribution areas are found, Figs.9 and 10. One in the northern part, outside Pebane, and one in the southern part, at Machese. The southern area probably extends at least down to Beira, as ponyfish are common in the landings of the local fishermen. The main concentrations of ponyfish are found at depths above 40 m, but occasionally they have been caught down to 120 m. During daytime ponyfish are found in mixed schools at the bottom or in midwater (Saetre and Silva, 1979, Brinca et al., 1983).

Figs. 11 and 12 present the length distributions of the common and pugnose ponyfish at Sofala Bank. The majority of the common ponyfish caught measure from 10 to 15 cm. The smallest individuals have in general been caught near the mouth of the Zambezi river. In Maputo Bay the smallest individuals are found in the bycatch of the shrimptrawlers in the period from September to April. The pugnose ponyfish is a bit smaller than the common ponyfish, the majority measure from 8 to 12 cm. In Maputo Bay the smallest individuals are caught in January-February and in June-July.

Table 4 presents the data from Sofala Bank on the maturity of the common ponyfish. The highest percentage of fish in spawning were found in September and November-December.

Table 4. Maturity stages (percentage) of Leiognathus equulus caught during various surveys at Sofala Bank.

SURVEYS	FEMALES							MALES						
	I	II	III	IV	V	VI	n	I	II	III	IV	V	VI	n
FR. NANSEN (June/83)	-	73.6	14.6	4.6	7.3	-	110	-	72.0	22.0	-	6.1	-	82
FR. NANSEN (Sep/82)	-	-	-	47.6	52.4	-	21	-	-	3.4	44.8	48.3	3.4	29
S. RYBAK (Oct/82)	-	8.1	21.0	48.4	22.6	-	62	-	11.8	51.0	35.3	2.0	-	51
S. RYBAK (Nov/Dec/82)	-	21.3	0.6	40.0	35.1	3.5	174	-	9.5	3.9	35.3	47.0	4.3	232

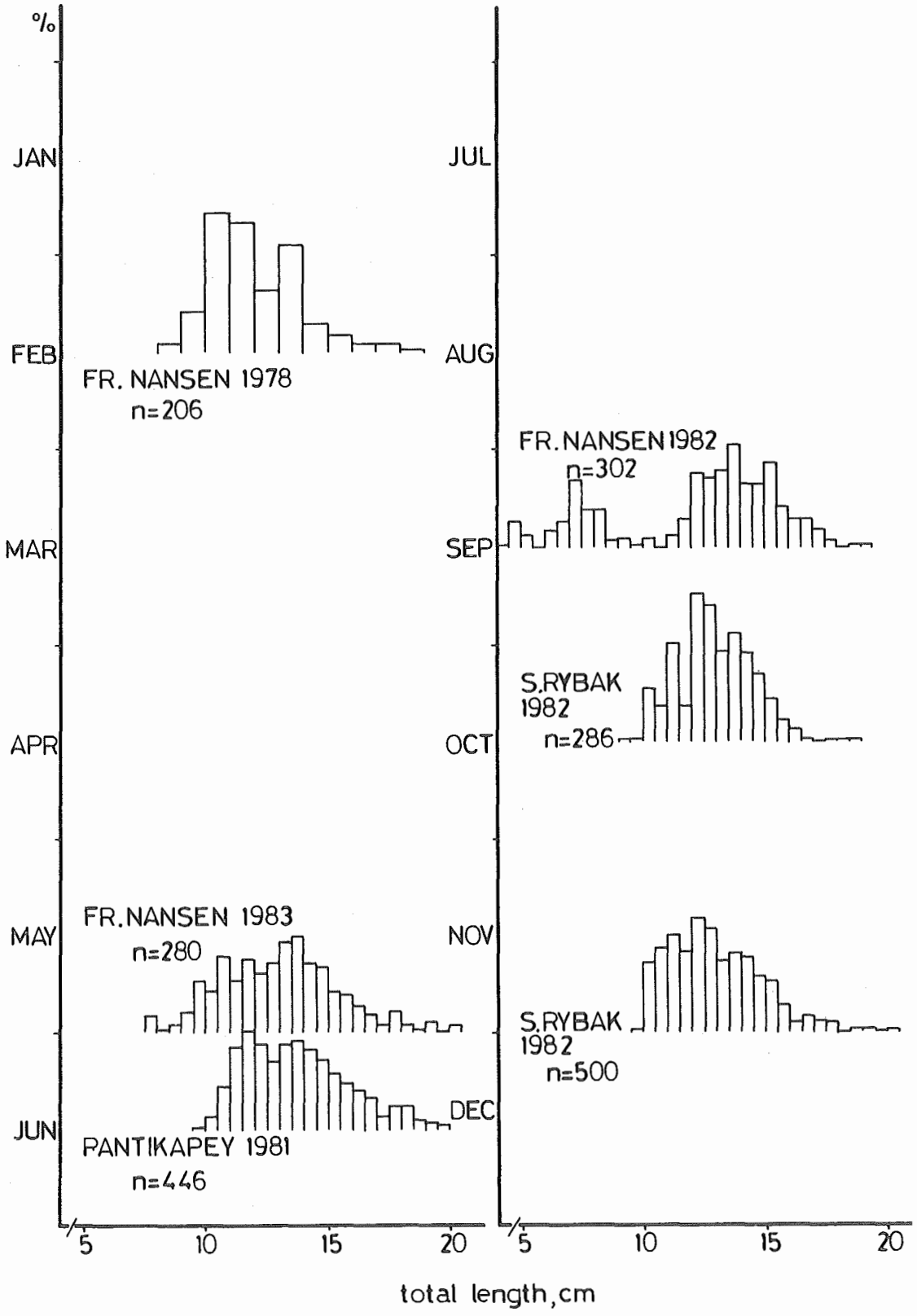

Fig. 11 - Common ponyfish. Percentage length composition of bottom trawl catch at Sofala Bank during various surveys.

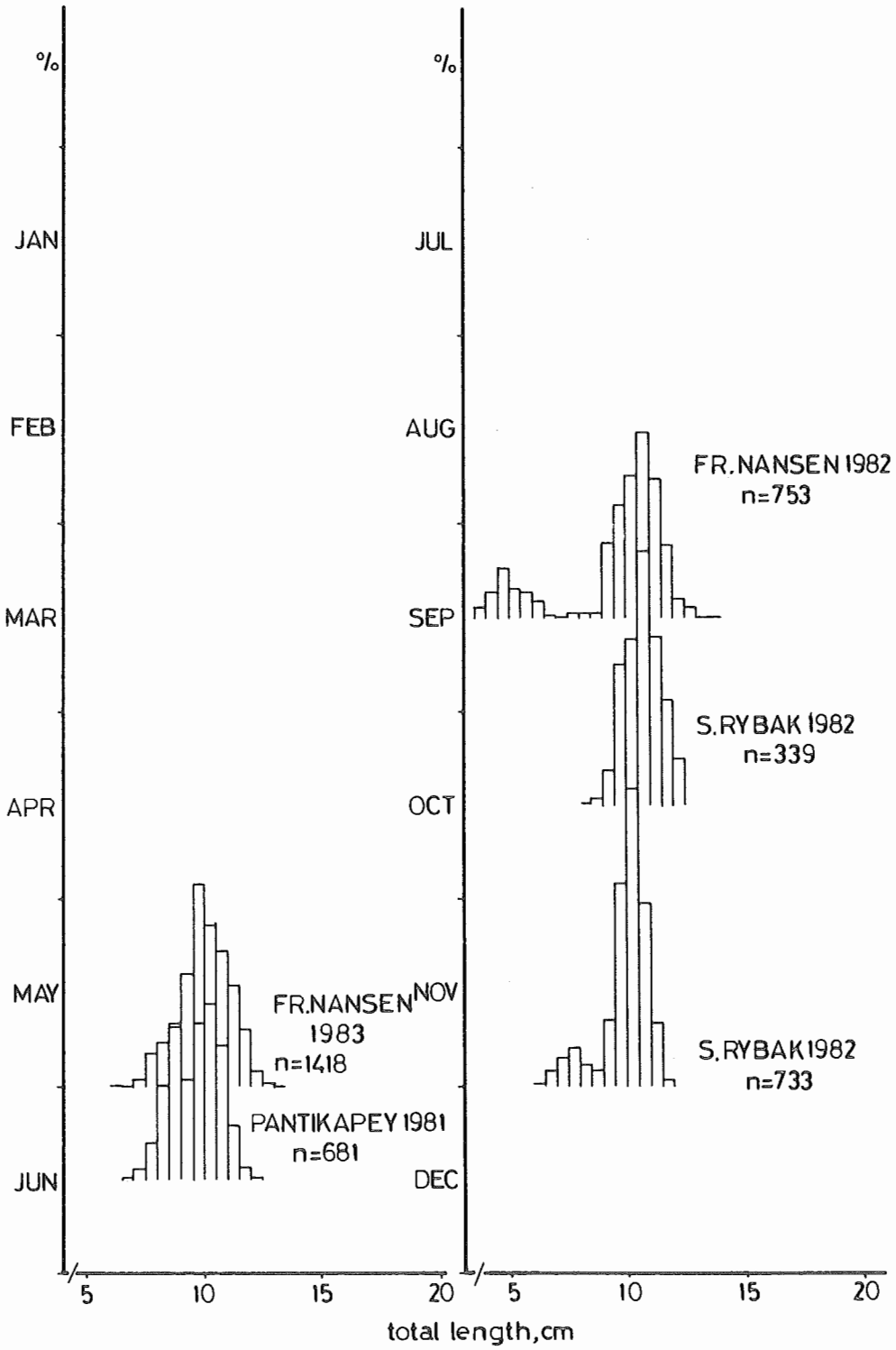

Fig. 12 - Pugnose ponyfish. Percentage length composition of bottom trawl catch at Sofala Bank during various surveys.

Both species are caught as a bycatch in the shrimpfisheries. The present catch in the industrial shrimpfishery on Sofala Bank is probably in the order of 500 tonnes per year. No data is available from the small-scale and semi-industrial fisheries.

During the survey of "Fr. Nansen" in April-June 1978 the biomass of ponyfish was estimated to 25000 tonnes on Sofala Bank and 4000 tonnes in the Bazaruto area.

2.4. Scad and Mackerel

The most abundant species in this group is Russell's scad (Decapterus russellii)which is caught in a bottom trawl fishery at Sofala Bank and Boa Paz together with layang scad (D. macrosoma), bigeye scad (Selar crumenophthalmus) indian mackerel (Rastrelliger kanagurta) and horsemackerel (Trachurus trachurus). They all show a pronounced daily vertical migration. During daytime they stay close to the bottom, at night they disperse in the watercolumn.

The identification of the species, especially those of the genus Decapterus, has presented great problems. At least four species of Decapterus have been recorded from the western Indian Ocean (FAO, in prep.): D. lajang Bleeker 1885, D. macarellus Cuvier 1833, D. macrosoma Bleeker 1851 and D. russellii (Ruppell 1830). The latest surveys have shown that D. russellii and D. macrosoma are far the most abundant. It thus seems probable that the D. kiliche reported by Birkett (1979) and Anon. (1981) and the D. maruadsi reported by Saetre and Silva (1979) and Brinca et al. (1981, 1983) are identical to D. russellii, while the D. muroadsi reported by Boudnitchenko (1977) is identical to D. macrosoma. For T. trachurus it has not yet been examined whether the subspecies caught is the same as the T. trachurus capensis occurring off South Africa. The T. delagoa recorded by Birkett (1979) is probably identical to the T. trachurus recorded from later investigations.

Borges et al. (in press) have recently presented a preliminary assessment of the fishery for scad and mackerel and a review of the biology of the species. Most of the material presented here has been taken from their report.

Scad

The scads have been found from Boa Paz to Cabo Delgado at depths up to 200 m, but are most abundant between 20 and 90 m. Fig. 13 and 14 present the results obtained at Sofala Bank for D. russellii and D. macrosoma during the surveys of "Pantikapey" and "S. Rybak". D. russellii seems to occur at more shallow water than D. macrosoma.

Fig. 15 shows the length composition of Russell's scad caught by bottom trawl during various surveys at Sofala Bank. The average length of fish caught by pelagic trawl is in general lower. The smallest individuals have been caught by pelagic trawl in the socalled "untrawlable" area outside Beira, which seem to function as a nursery area, but concentrations of 0-group fish (Decapterus sp.) have also been observed from Nacala to Cabo Delgado (Anon., 1978) and at Boa Paz (Brinca et al., 1981). During the "Fr. Nansen" 1977-78 and the "Aelita" 1976-77 surveys Decapterus sp. of a length of up to 37 cm were caught at depths between 115 and 200 m between Bazaruto and Boa Paz and between Pemba and Nacala. Unfortunately the species was not identified.

The length composition of the commercial catch has been sampled since 1979. The sizerange is in general narrower than found during surveys. The largest D. russellii are caught at Boa Paz, where the average length is 18.1 cm compared to 16.4 cm at Sofala Bank. For D. macrosoma and Selar crumenophthalmus only length compositions from Sofala Bank are available.

Table 5 shows the parameters of the length-weight relationship of the three species.

Table 5 - Scad. Parameters of the length-weight relationships ($W = a\ L^b$). W= weight in g, L= length in cm.

Species	a	b	r	author
D. russellii	0.0068	3.121	0.93	Gjøsaeter and Sousa (1983)
D. macrosoma	0.0038	3.258	0.94	Sousa and Gislason (in prep)
S. crumenophthalmus	0.0022	3.506	0.98	Borges et al. (in press)

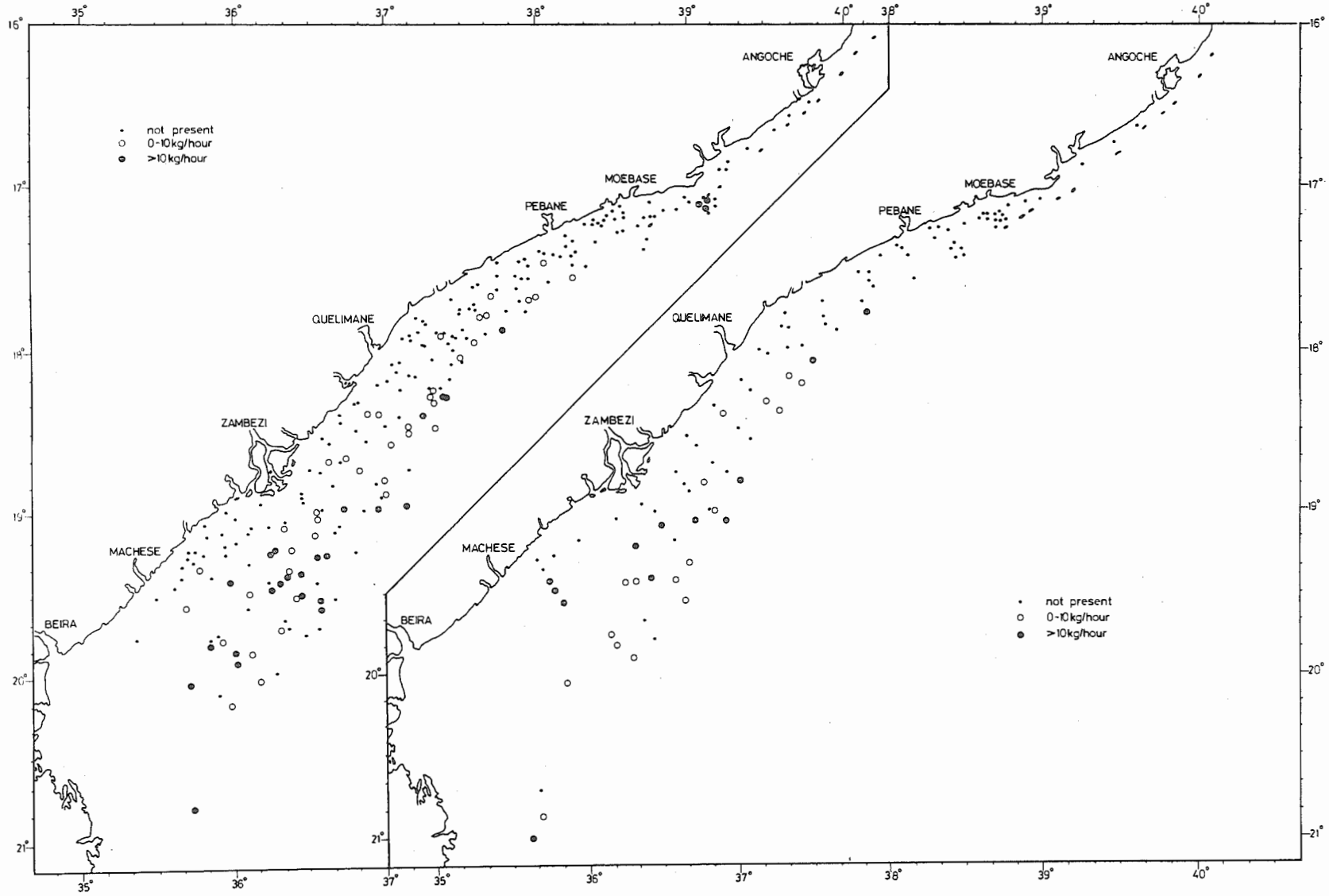

Fig. 13 - Russell's scad. Catch rates obtained at Sofala Bank during the surveys of "Pantikapey" June-July 1981 (right) and "S. Rybak" October-December 1982 (left).

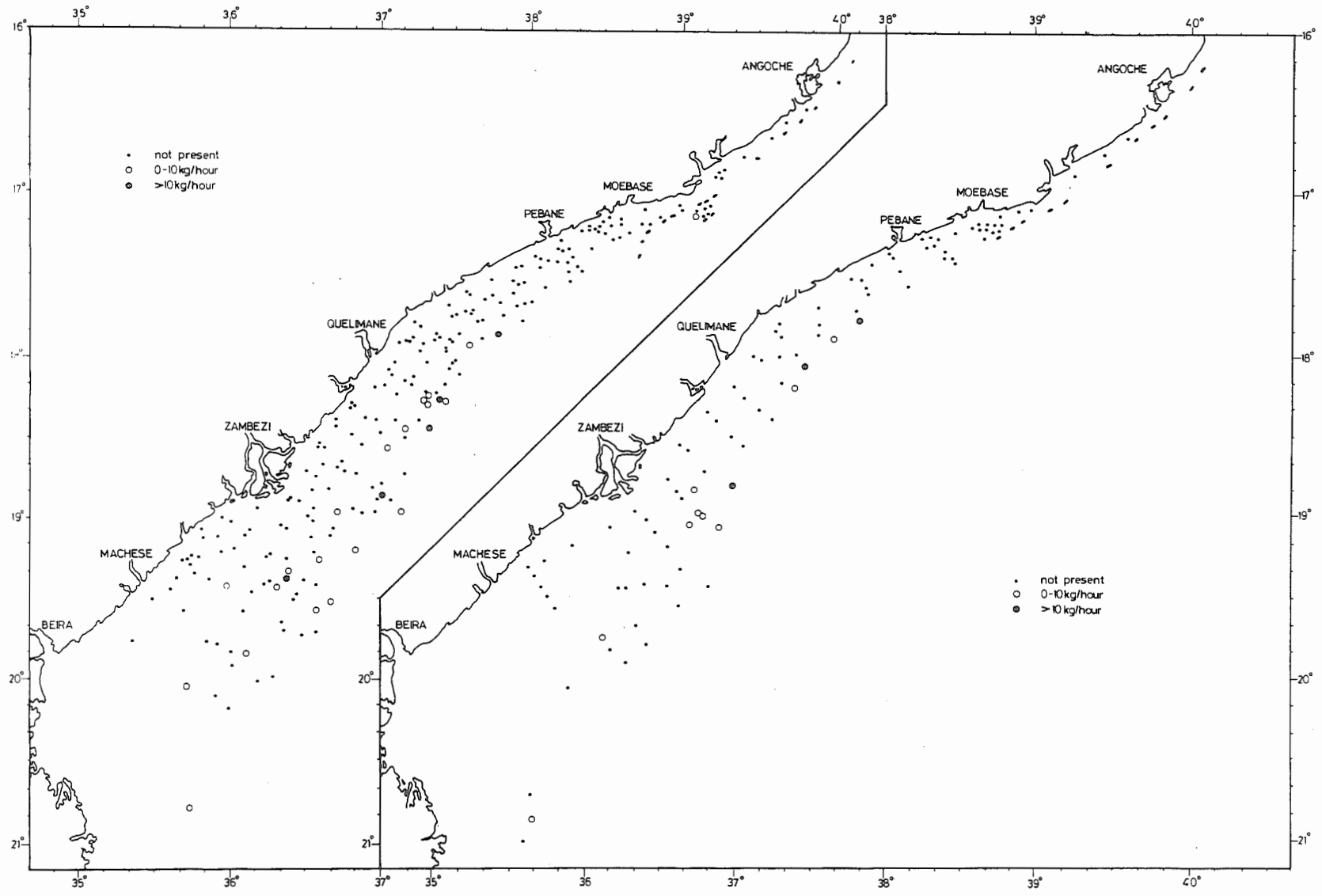

Fig. 14 - Layang scad. Catch rates obtained at Sofala Bank during the surveys of "Pantikapey" June-July 1981 (right) and "S. Rybak" October-December 1982 (left).

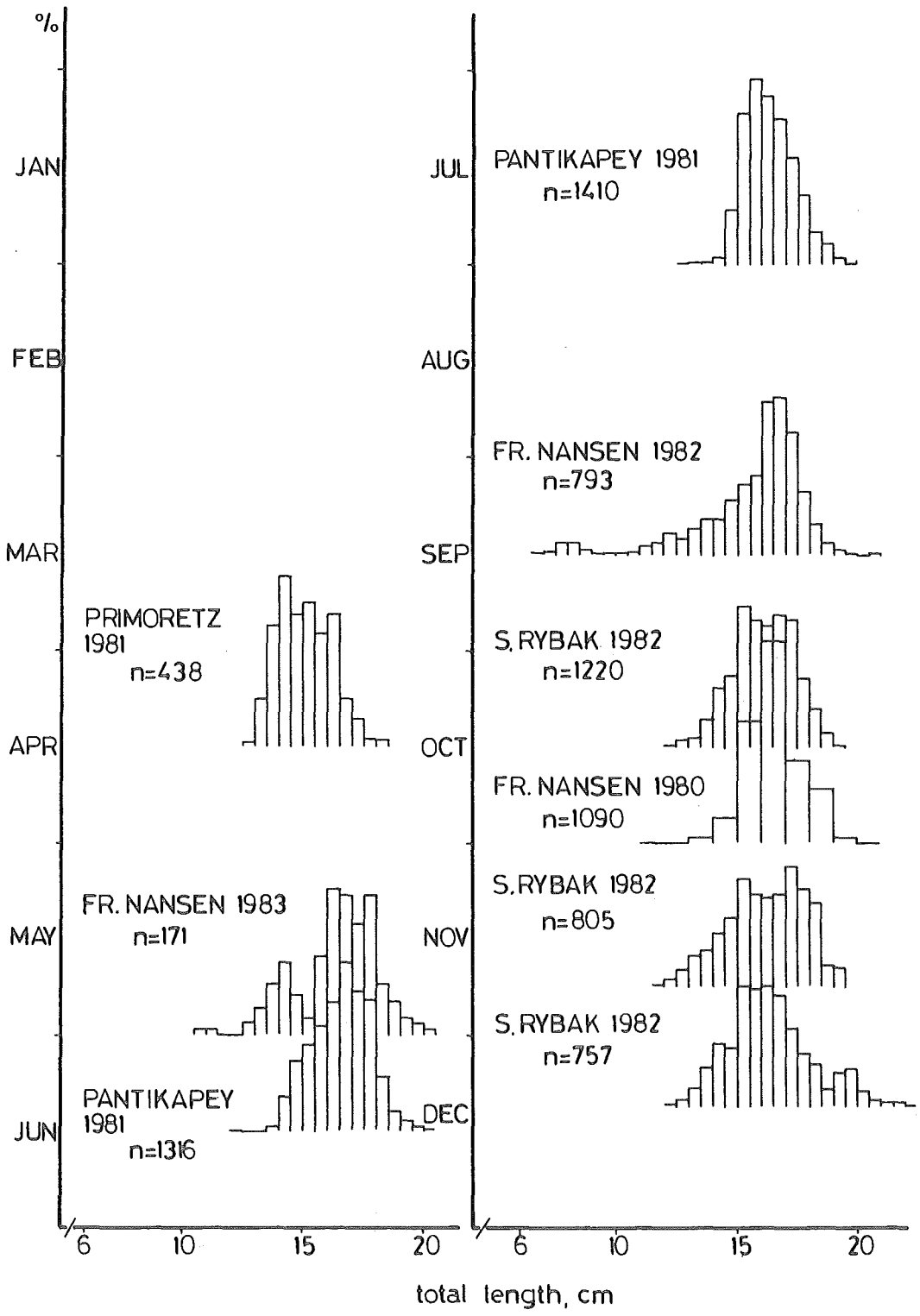

Fig. 15 - Russell's scad. Percentage length composition of bottom trawl catch at Sofala Bank during various surveys.

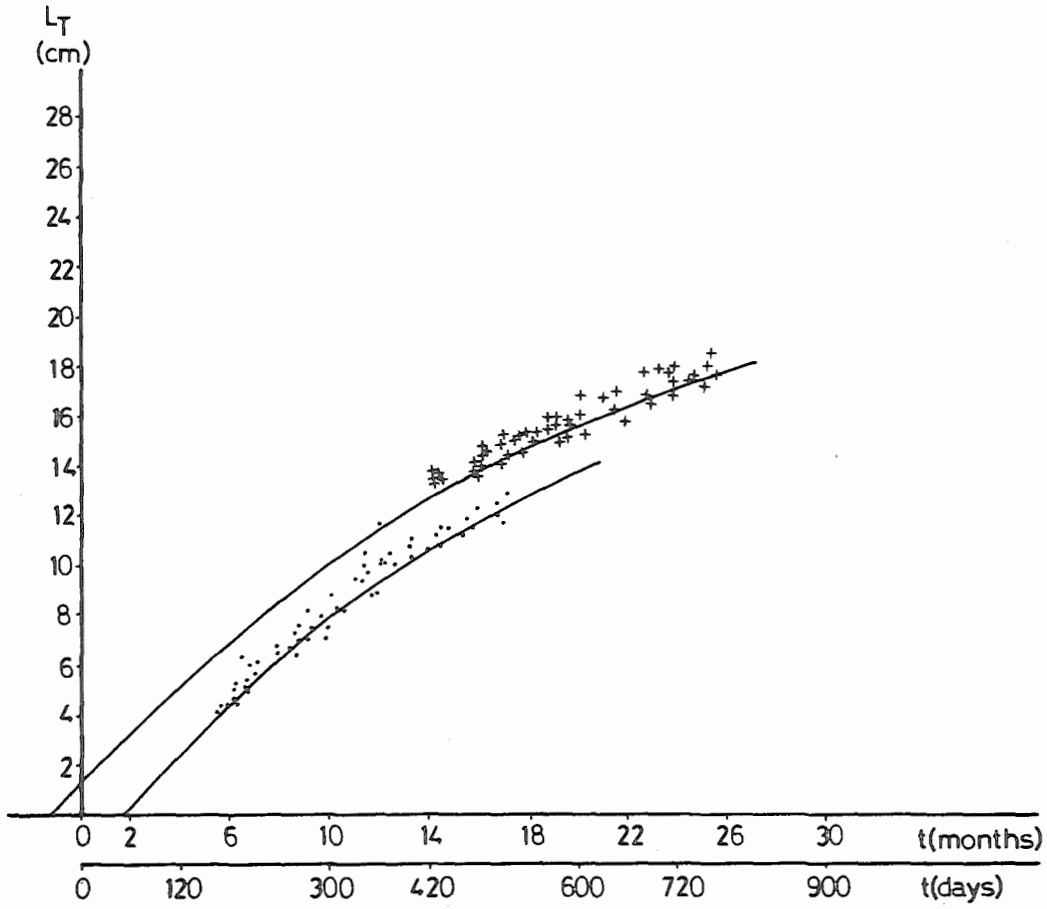

Fig. 16. Russell's scad. Growth curves based on two sets of otolith readings.

Only the food of D. russellii has been examined. A few stomachs investigated during the survey of "S. Rybak" in 1982 contained fish and euphausids.

The daily growth rings of the otoliths were used to estimate the age and growth parameters of D. russellii and D. macrosoma. For D. russellii the growth parameters were furthermore estimated by fitting growth curves to the length distributions of the commercial catch by means of the ELEFAN I program (Pauly and David, 1981), Table 6. The parameters estimated by the two methods are more or less in accordance. However the two sets of otolith readings for D. russellii give very different estimates of t_o

Table 6 - Scad. Parameters of the von Bertalanffy growth equation

Species	Method	Sizerange cm	L cm	K $year^{-1}$	to year	Author
D. russellii	daily growth rings	13.4 - 18.6	24.8	0.56	-0.10	Gjosaeter and Sousa (1983)
	" " "	4.2 - 13.0	22.0	0.64	0.14	Brinca et al (1983)
	ELEFAN I	10.5 - 22.5	24.8	0.43		Gjosaeter and Sousa (1983)
	"	"	24.4	0.42		" "
	"	"	26.0	0.46		" "
D. macrosoma	daily growth rings	14.0 - 20.5	27.4	0.43	0.54	Sousa and Gislason (in prep)

Fig. 16. This could be due to differences in the technique used for preparing the otoliths which may have resulted in a different number of visible rings. The maximum value of L_∞ estimated by these data is 27.4 cm and the growth curves may need a revision when the large Decapterus sp. recorded by "Fr. Nansen" and "Aelita" have been identified.

D. russellii and D. macrosoma have both a long spawning period with two peaks one in August-September another in December-January. The main spawning period of S. crumenophthalmus falls from October to February. Spawning individuals of D. russellii have been found both at Sofala Bank and at Boa Paz. At Sofala Bank they mainly occurred in the area south of Quelimane at depths between 19 and 54 m (Brinca et al., 1983). No spawning activity was observed at greater depths and the spawning

migration to deep waters suggested by Saetre and Silva (1979) has not been confirmed. The size of first maturity is 13 to 14 cm for females and 12 to 13 cm for males (Brinca et al., 1983).

Borges et al. (in press) estimated the total annual mortality by the method of Jones and Zalinge (1981) from the average length composition of the catch, Table 7. Especially for D. macrosoma the estimate is very high. This

Table 7 - Scad. Estimates of total mortality. From Borges et al. (in press)

Species	Method	Area	Sizerange cm	Z Year $^{-1}$
D. russellii	Jones and Zalinge (1981)	Sofala	16.0 - 21.5	3.2
	Borges et al (in press)	"	16.0 - 21.5	3.4
	Jones and Zalinge (1981)	Boa Paz	18.0 - 21.0	1.8
D. macrosoma	" "	Sofala	20.0 - 23.0	6.9

may be due to a decreasing catchability with size or to a migration of large fish away from the fishing area.

Indian mackerel

The Indian mackerel, Rastrelliger kanagurta, has been recorded from Boa Paz to Angoche at depths up to 100 m. Fig. 17 present the results of "Pantikapey" and "S. Rybak" in terms of catch rates.

Indian mackerel seems to be abundant at slightly lower depths than the scads as it is frequently caught as a bycatch by the industrial shrimptrawlers operating at depths above 40 m. The juveniles have mainly been caught by pelagic trawl in the southern part of Sofala Bank.

The length composition observed during various surveys on Sofala Bank is given in Fig. 18. The fish measure from 10 to 26.5 cm. Borges et al. (in press) described the length composition of the commercial catch. As for

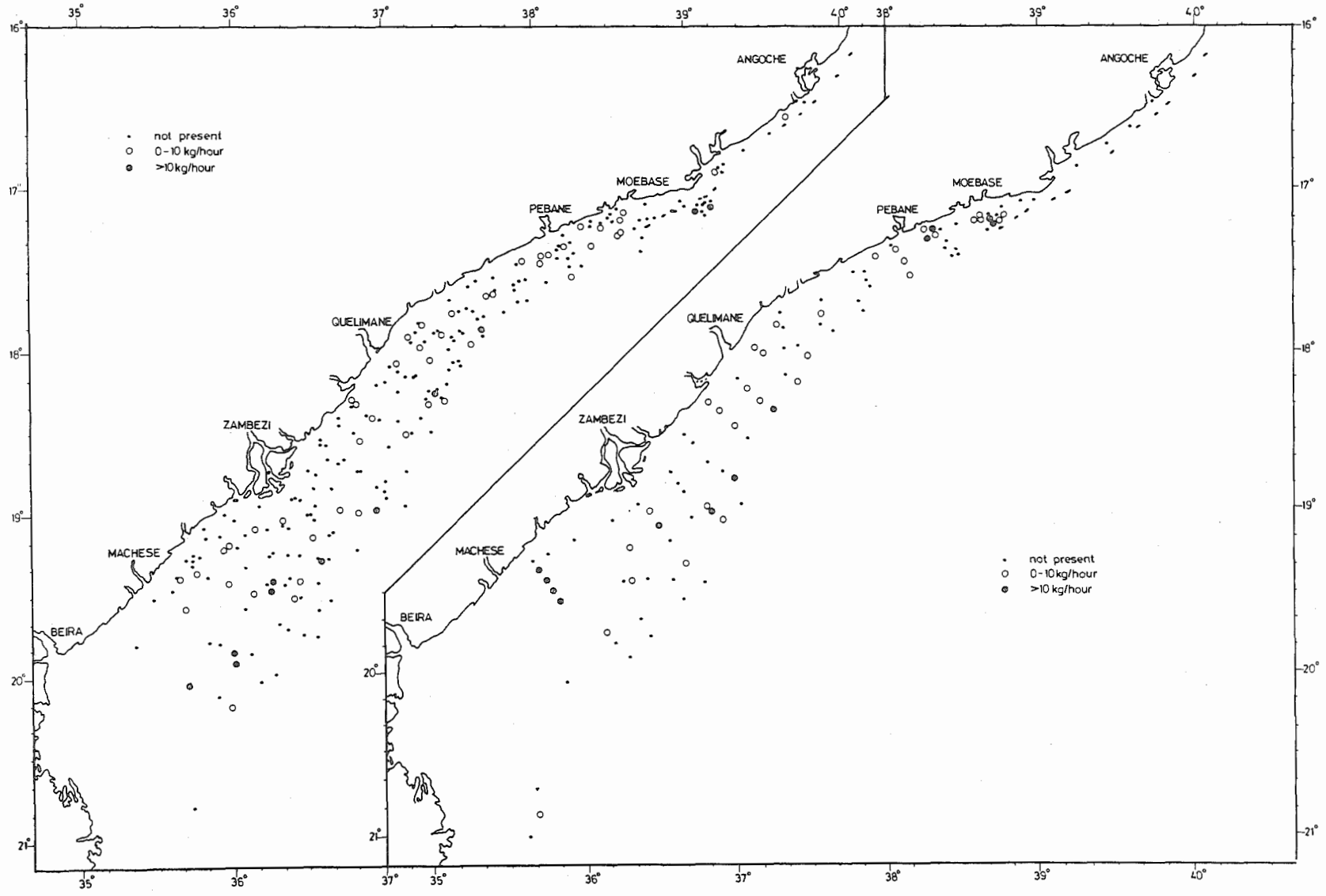

Fig. 17 - Indian mackerel. Catch rates obtained at Sofala Bank during the surveys of "Pantikapey" June-July 1981 (right) and "S. Rybak" October-December 1982 (left).

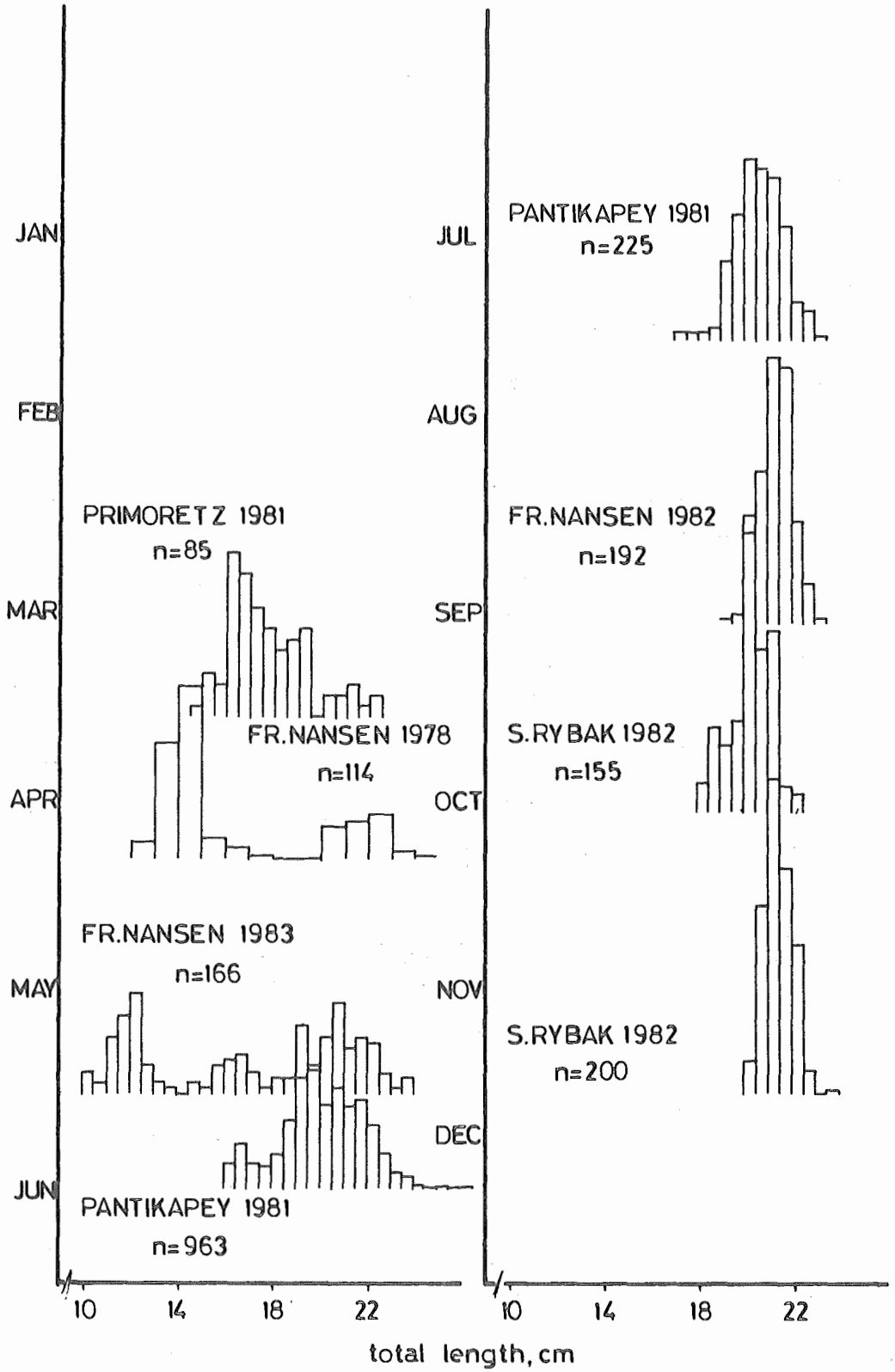

Fig. 18 - Indian mackerel. Percentage length composition of bottom trawl catch at Sofala Bank during various surveys.

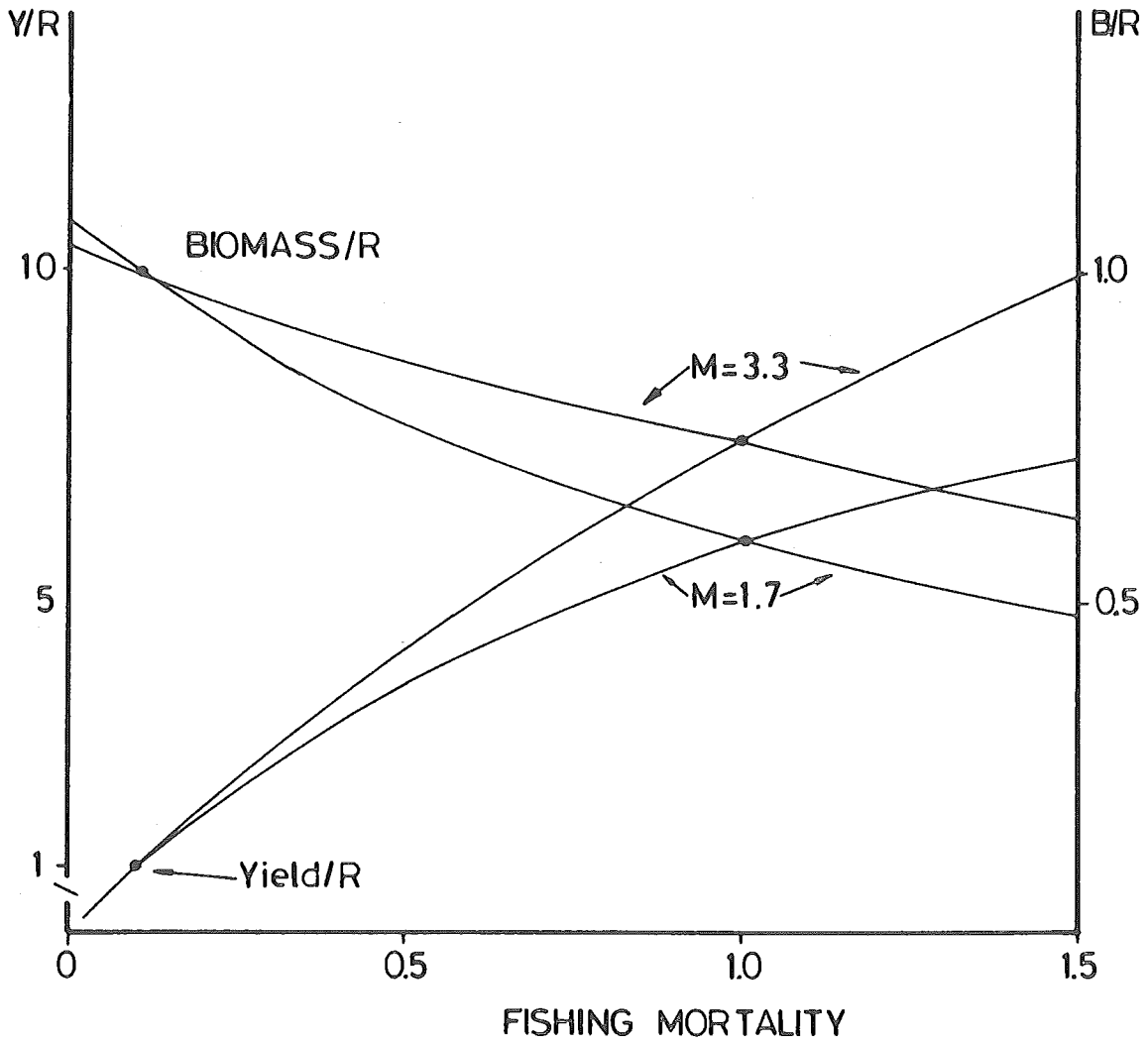

Fig. 19 - Russel's scad. Yield per recruit (Y/R) and biomass per recruit (B/R) at different levels of fishing mortality. Arbitrary units. Y/R and B/R at present level of fishing mortality (~0.1) set equal to 1.0

D. russellii the average length in the catch is higher at Boa Paz than at Sofala Bank. The length-weight relationship was described by the following equation:

$$\log W = 3.30 \log L - 2.39$$

Sousa and Gislason (in prep.) used dailygrowth rings of otoliths to determine the growth parameters and obtained:

$$L_t = 27.8 \left(1 - e^{-0.75 (t - 0.13)}\right)$$

Growth curves were also fitted to the length compositions of the commercial catch by use of the ELEFAN II program (Pauly et al., 1981). Although this method gave L_∞ from 28.5 to 30.5 cm which are larger than the value estimated by age readings, the growth curves are more or less identical in the size range from 13 to 20 cm.

The spawning season lasts from July to April. At Sofala Bank the maximum spawning activity is found in the period from November to February, at Boa Paz it occurs one or two months later. No special areas seem to be preferred for spawning.

Borges et al. (in press) estimated the total annual mortality to app. 9. The explanation for such a high value of mortality may either be migration away from the fishing area or a decreased catchability of the large fish.

Horsemackerel

The horsemackerel, T. trachurus, has only been recorded from Boa Paz where it occurs at depths from 30 to 150 m. The best catch rates have been obtained during summer at a depth of app. 50 m.

Only very few samples are available from the surveys. Fish caught in the commercial fishery measure from 11 to 27 cm. Borges et al. (in press) described the length-weight relationship by:

$$\log W = 2.83 \log L - 1.78 \qquad r = .98$$

The main spawning season at Boa Paz is between August and November (Saetre and Silva, 1979, Borges et al., in press).

The fishery

The fishery for scad and mackerel started in 1977. Two types of vessels, RTM (GRT ~2900, HP ~ 1300) and SRTM (GRT ~ 1920, HP ~ 1000) have participated in the fishery. At the moment 5 SRTM vessels are fishing. The total catch and catch per unit of effort at Sofala Bank and Boa Paz are presented in Table 8. It is uncertain whether the catch per unit of effort

Table 8 - Catch and catch per unit of effort (tonnes per hour SRTM trawling) at Sofala Bank and Boa Paz. Modified from Borges et al. (in press)

		Sofala Bank		Boa Paz	
Year	Total catch (tonnes)	Catch (tonnes)	Cpue (tonnes/hour)	Catch (tonnes)	Cpue (toones/hour)
1977	2801	851	.46	1950	.65
1978	16909	13478	.54	3431	.43
1979	8926	8897	.39	29	.22
1980	5249	3907	.84	1342	1.02
1981	6866	4973	.79	1893	.77
1982	5899	2673	.81	3226	.66
1983*	5705	4911	.93	794	.58

* only January to September (incl.)

figures before 1980 reflect the changes in stock size as the RTM and SRTM vessels show opposite trends. At present the catch rate is about 900 kg per hour at Sofala Bank and 600 kg at Boa Paz. These catch rates are more or less constant during the year and no seasonality is apparent in the fishery.

The species composition of the catch has been sampled since April 1981,

Table 9. Scad and mackerel make up app. 61 and 70 percent of the total catch at Sofala Bank and Boa Paz, respectively. The catch of scad and

Table 9 - Average percentage species composition of catch of bottomtrawlers at Sofala Bank and Boa Paz, 1981-83 (September incl.). From Borges et al. (in press).

	Sofala Bank	Boa Paz
D. russellii	34	35
D. macrosoma	9	4
S. crumenophthalmus	4	17
R. kanagurta	14	9
T. trachurus		5
Others	39	30

mackerel in 1982 can thus be estimated to app. 3900 tonnes.

Indian mackerel is also caught as a bycatch in the industrial shrimpfishery on Sofala Bank. In 1982 this bycatch was probably in the order of 200 tonnes.

Assessments

Saetre and Silva (1979) estimated the total stock of scad and mackerel to app. 100 thousand tonnes in 1977-78 of which 40 thousand were found on Sofala Bank. In 1980 and 1982 the stock of scad and mackerel at Sofala Bank was estimated to be 13-32 and 94 thousand tonnes, respectively Brinca et al., 1981 and 1983).Borges et al. (in press) estimated the fishing mortality in the same area to be in the range from 0.02 to 0.3 by dividing the annual catch with the estimates of stock size. In addition they used the "area swept" by the commercial fleet to estimate the proportion of the stock caught after correcting for the difference in efficiency between commercial vessels and random surveys. In this way

the fishing mortality was estimated to app. 0.1 in 1981 and 0.05 in 1982. They furthermore calculated the yield and biomass per recruit of D. russellii for two values of natural mortality (M= 3.3 and 1.7), Fig. 19. Assuming the present fishing mortality to be app. 0.1 they concluded that an increase in effort to the double would not reduce the biomass per recruit by more than 3 to 7 percent and thus not endanger the stock. This conclusion is of course based on only one species. However, for Indian mackerel and layang scad the mortality created by the fishery is also small compared to the effects of natural mortality and migration, and probably these species have biomass per recruit curves similar to the one estimated for D. russellii.

Malabar cavalla

The malabar cavalla, Carangoides malabaricus, is abundant at depths from 10 to 100 m. It can be caught by both bottom and pelagic trawl.

The fish caught during surveys measured between 2 and 49 cm. Fig. 20 shows the length compositions of the catches made by bottom trawl on Sofala Bank. Juveniles of a length between 2 and 6 cm were caught in pelagic hauls in the "untrawlable" area outside Beira by "Fr. Nansen" in October-November 1980.

Boudnitchenko et al. (1977) and Boudnitchenko (1979) examined a few stomachs and found they contained small fish, crustaceans and cephalopods.

The percentage of individuals in maturity stage V, Table 10, and the occurrence of juveniles referred to above suggest that spawning takes place in October-December. It is possible that a second spawning may take place in the dry season.

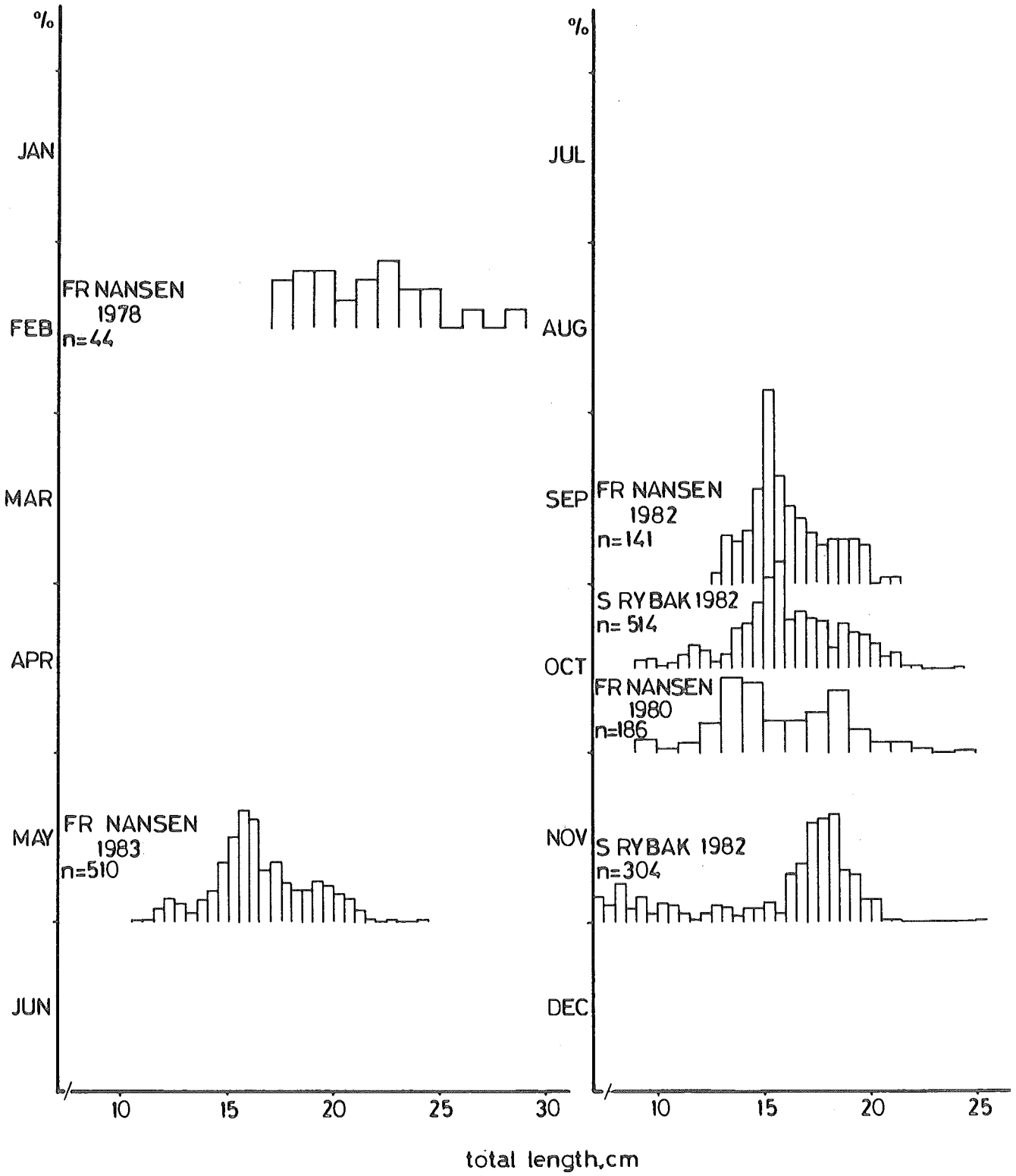

Fig. 20 - Malabar cavalla. Percentage length composition of bottom trawl catch at Sofala Bank during various surveys.

Table 10 - Maturity stages (percentage) of Carangoides malabaricus caught during various surveys at Sofala Bank.

	FEMALES							MALES						
	I	II	III	IV	V	VI	n	I	II	III	IV	V	VI	n
Muleve Jul-Aug/79	-	25.0	50.0	25.0	-	-	12	-	20.0	66.7	13.3	-	-	15
S. Rybak Oct/82	-	-	37.0	43.5	19.6	-	46	-	-	96.7	3.3	-	-	30
S. Rybak Nov/Dec/82	-	3.3	-	27.9	60.7	8.2	61	-	-	-	8.4	73.2	18.3	71

The malabar cavalla is caught in the fishery for scad and mackerel and in the industrial shrimpfishery at Sofala Bank. The yearly catch in these fisheries is in the order of 700 tonnes. No estimates of biomass are available.

2.5. Indian driftfish

Indian driftfish, Ariomma indica, has been reported from Boa Paz to Angoche from 10 to 350 m of depth. At Sofala Bank the majority of the catches were taken above 50 m of depth, at Boa Paz the largest concentrations were found around 100 m.

Saetre and Silva (1979) suggested a migration from Boa Paz to Sofala Bank in September-October and back again in February-March. This migration has not been confirmed by later surveys. On the contrary a one hour haul of 3.6 tonnes was made at Boa Paz during the survey of "S. Rybak" in October--November 1982, the time of year when Saetre and Silva (1979) assumed driftfish to be migrating northwards.

Only a few length samples have been collected during the surveys. In general the fish ranged from 16 to 23 cm.

Two spawning seasons were found by Saetre and Silva (1979), one in January the other in July-August. The few samples of maturity stages taken during later surveys indicate the same seasonal pattern.

The yearly bycatch of Indian driftfish in the fishery for scad and mackerel is in the order of 100 tonnes.

Saetre and Silva (1979) estimated the total biomass in April-June 1978 to app. 19 thousand tonnes.

2.6. Barracuda

At least four species: Sphyraena obtusata, S. japonica, S. jello and S. forsteri have been identified during the surveys. However, the morphological differences between the species are small and the keys given by Smith (1965) and FAO (1974), which both have been used for identification, are conflicting. It is thus probable that the same species has been reported under different names from survey to survey.

Barracuda occurs along the whole coast. From April to June the major concentrations are found at Bazaruto and at Boa Paz (Saetre and Silva, 1979). Most of the fish caught has measured from 20 to 30 cm, but occasionallyy individuals up to 147 cm long have been encountered.

The yearly catch of barracuda in the fishery for scad and mackerel is in the order of 100 tonnes. Saetre and Silva (1979) estimated the total biomass to 17 and 2 thousand tonnes in September 1977 and April-June 1978, respectively.

3. Summary and recommendations

Table 11 presents a summary of the acoustic biomass estimates of the most abundant stocks of small pelagic species. The average total biomass along the coast of Mozambique is in the order of 340 thousand tonnes of which 230 thousand tonnes are found at Sofala Bank. Anchovy is the most abundant species with an estimated average biomass of 110 thousand tonnes of which 100 thousand are found on Sofala Bank. The main part of the biomass of sardines, Thryssa sp. and Pellona ditchela, is also found on Sofala Bank, while the scad and mackerel seem to be more dispersed along the coast. The biomass of anchovy seems however to be subject to large seasonal and interannual variations. Excluding anchovy the biomass of other small pelagics on Sofala Bank has been estimated to have been on a more or less stable level between 120 and 140 thousand tonnes during the surveys in 1977-78, 1980 and 1982, although the biomass of sardines decreased and that of scad and mackerel increased during the last survey of "Fr. Nansen".

The catch rates obtained during two of the latest bottom trawl surveys at Sofala Bank are presented in Table 12 for some of the more abundant species. Only day hauls have been included. The hauls were made with the same bottom trawl as used in the industrial fishery for scad and mackerel and the catch rates obtained reflect more or less the picture of the acoustic surveys in terms of the relative importance of the various species.

It is difficult to assess the total catch of small pelagics because of the lack of information from the small-scale fishery. Presumeably the catch in this fishery which includes the artisanal and semi-industrial sectors is in the order of at least 20 thousand tonnes (Anon. 1982). This figure was compiled from the records of the provincial authorities for 1981 and is likely to be an underestimate as an unknown part is sold outside the official channels. No data on the species composition of the catch is available, but as the fishery takes place in shallow water where sardines, shad and ponyfish is abundant, it seems reasonable to assume that at least half consists of small pelagics. Table 13 shows the estimated total catch of small pelagics in various sectors. The estimates from the industrial sector refers to 1982.

Table 11 - Acoustic estimates of main stocks of small pelagics from the surveys of "Fr. Nansen" (thousand tonnes).

Species	Time	North of Sofala Bank	Sofala Bank	Bazaruto	Delagoa Boa Paz	Inhaca	Total
Scad	Sept 77	32	41	32	11 b)	-	
	Oct-Nov 77		30	1	9 b)		
	Apr-Jun 78		25	26	5 b)	0	
	Oct-Nov 80		13 - 32				
	Sept 82		94 a)				
	Average	32	43	20	8 b)	-	103
Anchovy	Sept 77	0	290	20	0	0	
	Oct-Nov 77		30	0	0		
	Apr-Jun 78		95	0	5	0	
	Oct-Nov 80		13 - 32				
	Sept 82		70				
	Average	0	102	7	2	0	111
Thryssa and pellona	Sept 77	0	82	0	0	0	
	Oct-Nov 77		100	0	0		
	Apr-Jun 78		90	0	16	0	
	Oct-Nov 80		52 - 96				
	Sept 82		23				
	Average	0	74	0	5	0	79
Others	Sept 77	5	0	8	8	0	
	Out-Nov 77		0	0	0		
	Apr-Jun 78		25	12	43	5	
	Oct-Nov 80		13 - 32				
	Sept 82		14				
	Average	5	12	7	17	3	44
Total Average		37	231	34	32	3	337

a) including R. kanagurta

b) including T. trachurus

Table 12 - Average catch per hour of some small pelagic species during the bottom trawl surveys of "Pantikapey" and "S. Rybak" on Sofala Bank. Only day hauls included. Number of hours in brackets.

Species	Depths	"Pantikapey" June - July 1981				"S. Rybak" Oct.- Dec. 1982			
		South of Zambezi river		North of Zambezi river		South of Zambezi river		North of Zambezi river	
Indian pellona	< 20	214.0	(5.5)	3.3	(46.0)	56.9	(24.8)	20.2	(67.0)
	20-45	1.2	(17.8)	1.9	(17.0)	0.0	(21.4)	4.4	(49.8)
Orangemouth thryssa	< 20	42.4	(5.5)	7.0	(46.0)	24.7	(24.8)	13.8	(67.0)
	20-45	2.9	(17.8)	9.2	(17.0)	.1	(21.4)	1.9	(49.8)
Ponyfish	< 20	15.8	(5.5)	24.6	(46.0)	7.6	(24.8)	17.3	(67.0)
	20-45	3.7	(17.8)	56.9	(17.0)	4.6	(21.4)	23.9	(49.8)
Russells scad	< 45	18.6	(23.3)	8.9	(63.0)	40.8	(46.2)	.6	(116.8)
	45-100	11.1	(12.4)	9.3	(4.1)	196.2	(11.8)	100.7	(26.4)
Layang scad	< 45	2.1	(23.3)	.5	(63.0)	2.4	(46.2)	.0	(116.8)
	45-100	.2	(12.4)	7.0	(4.1)	1.4	(11.8)	18.1	(26.4)
Indian mackerel	< 45	37.9	(23.3)	2.5	(63.0)	5.6	(46.2)	.8	(116.8)
	45-100	1.6	(12.4)	5.7	(4.1)	32.1	(11.8)	15.7	(26.4)
Malabar cavalla	< 45	1.9	(23.3)	2.5	(63.0)	2.9	(46.2)	2.8	(116.8)
	45-100	11.1	(12.4)	1.5	(4.1)	4.5	(11.8)	41.4	(26.4)
Barracuda	< 45	4.7	(23.3)	4.9	(63.0)	1.4	(46.2)	2.1	(116.8)
	45-100	2.8	(12.4)	3.3	(4.1)	9.5	(11.8)	83.9	(26.4)

Table 13 - Estimated annual catch of small pelagic species (tonnes x 10^{-3}). Estimates from the industrial sector refers to 1982.

Fishery	Industrial		Small scale		
Species	Scad and mackerel	Bycatch of shrimptrawlers	Maputo	Beira	Other landing sites
Indian pellona		1.6			
Thryssa sp.		1.5			
Kelee shad		.3	1.0	1.0	
Ponyfish		.5			
Driftfish	.1	.3			
Barracuda	.1	.1			
Malabar cavalla	.2	.5			
Russell's scad	2.0				
Layang scad	.4				
Bigeye scad	.4				
Indian mackerel	.5	.2			
Horsemackerel	.5				
Not identified			?	?	10.0*
T O T A L	4.2	4.8	1.0	1.0	10.0*

* Estimated as half of the total reported catch of the provincial authorities in 1981.

The maximum potencial yield, Y max was calculated by Saetre and Silva (1979) by use of the formula suggested by Gulland (1970); $Y_{max} = 0.5.M.B_o$, where B_o is virgin biomass. They arrived at a yearly total of 470 thousand tonnes of which 310 thousand were anchovy and 125 thousand scad and sardine. Assuming as Saetre and Silva (1979) that M is equal to 2.0 for anchovy and to 1.0 for scad, mackerel and sardine, new estimates of the maximum potential yield were calculated from the revised biomass figures of Table 11. For anchovy this gives a potential yield of 110 thousand tonnes, a much lower figure than calculated by Saetre and Silva (1979), for scad the estimate is approximately 50 thousand tonnes and for sardines

approximately 40 thousand tonnes. It is important to remember that these figures are preliminary and have to be revised when the fishery develops. However in general they indicate that the fishery can be expanded in the future.

Two fisheries for small pelagics have in the past been given special attention by the Institute: the gillnet fishery for kelee shad in Maputo Bay and the fishery for scad and mackerel at Sofala Bank and Boa Paz. It has not yet been possible to make an assessment of the fishery in Maputo Bay due to the lack of estimates of mortality, biomass and total catch. The sampling system are at the moment being extended to cover the artisanal boats and more length samples will be taken from the bycatch of the shrimptrawlers in the future. Hopefully these length samples can be used to give a first estimate of the total mortality. The possibility of using the small portable echosounder of the institute to obtain at least an index of biomass is also being investigated. If short term predictions have to be made in the future it will futhermore be necessary to investigate the possibilities of obtaining indices of recruitment by yearly standard trawlings with a small bottom trawl close to the shore where the juvenile kelee shad can be caught.

The main problem in the assessment of the stocks of scad and mackerel is the very high and unrealistic estimates of mortality. At the moment a survey is being carried out with the dual objective of discovering the distribution areas of the large fish and obtaining an unbiased index of the size of the stock. The results of this survey will hopefully provide more information about the total length composition of the stock and may thus improve the estimates of mortality.

It is very important that the echointegration surveys of "Fr. Nansen" continue in the future. If possible these surveys should take place in the first half of the year at a time when the juveniles scad and mackerel are concentrated in the "untrawlable" area in the southern part of Sofala Bank. This will provide an opportunity for collecting information about the recruitment to the scad and mackerel stocks and its variation from year to year. In addition it will provide useful information on the possible influence of a future fishery for anchovies in this area on the recruitment to the fishery for scad and mackerel.

The considerations for the future must of course be seen in conjunction with the plans of the fishing sector. At this moment when more attention is being paid to the development of the small-scale fishery it may be appropriate for the Institute to consider how it could contribute to the planning of this sector. It is likely that questions such as, how many boats and fishermen is the optimum for this part of the coast?, will be raised in short time. One of the future tasks of the institute could be to answer this question by making comparable studies of the catch and biomass of fish in various areas. The decision to start such a work can however not be taken by the Institute alone. It has to be discussed with the fishing sector.

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