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MESOPELAGIC FISH OFF MOZAMBIQUE

By

JAKOB GJØSÆTER and INGER-MARIE BECK
Department of Fisheries Biology, University of Bergen, Norway

ABSTRACT

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The mesopelagic fauna off Mozambique was studied on five cruises of R.V. "Dr. Fridtjof Nansen" during 1977 and 1978. It primarily consisted of Myctophids. At most stations, *Benthosema fibulatum* or *Diaphus* spp. were dominant.

The abundance was estimated using a 38 kHz echo sounder and electronic integrators. In a zone from the shore to about 200 nautical miles (n. miles) about 5 to 9 million tonnes of mesopelagic fish were estimated to be present. No seasonal variation in abundance was observed. Catch rates were generally low.

INTRODUCTION

The mesopelagic fish seem to be an important potential resource for future fisheries. Large stocks of myctophids have been observed in the Arabian Sea and off southwest Africa. Species distributions have been studied off south Africa (GRINDLEY and PENRITH 1965, HULLEY 1972, a and b) and off Kenya and Somalia (KOTTHAUS 1972, GJØSÆTER 1981). Collections from oceanic waters from about 20°N to 45°S were studied by NAFPAKTITIS and NAFPAKTITIS (1969) and NAFPAKTITIS (1978). There seems to be little information on mesopelagic fish from Mozambique and adjacent waters although some collections of *Diaphus* from this area were treated by NAFPAKTITIS (1978).

From August 1977 to June 1978 the Norwegian research vessel "Dr. Fridtjof Nansen" surveyed fisheries resources off Mozambique (SÆTRE and SILVA 1979). During these surveys, data on mesopelagic fish were collected.

The purpose of the present paper is to describe the distribution of collected species and to give a preliminary estimate of abundance based on acoustical methods. Some aspects of the biology of the species involved are also discussed.

MATERIALS AND METHODS

R.V. "Dr. Fridtjof Nansen" worked off Mozambique from August 1977 to June 1978. The whole coast was covered four times. Details on cruise tracks and the work carried out are described in the cruise reports (ANON. 1977, 1978 a, b and c).

R.V. "Dr. Fridtjof Nansen" is a 150-foot combined stern trawler and purse seiner. The main engine of 1500 Hp gives a maximum speed of 13 knots. The boat carries two pelagic trawls and one bottom trawl. A satellite navigator allows a very precise determination of position.

ACOUSTICS

The acoustic equipment consists of three scientific sounders (120, 50 and 38 kHz), two echo integrators, each of two channels, one sonar (18 kHz) and one net-sonde (50 kHz). The two echo integrators were coupled to the 38 kHz sounder.

Echo integrator values were read at each n.mile and averaged over five n.miles. Continuous watch was kept on the acoustical instruments, and fishing was conducted whenever the echo recordings changed characteristics. The acoustical data were scrutinized once a day. Integrator contributions due to false bottoms, wakes etc. were deleted, and the readings were split into four categories: small pelagic fish, demersal fish, plankton and fish larvae and mesopelagic fish.

Following FORBES and NAKKEN (1972) the output of an echo integrator is proportional to the fish density:

$$P_A = C_W \cdot M \qquad (1)$$

where P_A is the fish density expressed in weight per unit area, M is the integrator reading and C_W a conversion coefficient depending on the fish species and size, as well as on the characteristics of the sounder and integrator used. It can be shown that C_W is proportional to the length of the fish (NAKKEN 1975, NAKKEN and OLSEN 1977).

A value of C_W of 10.5 tonnes/mm and n.mile^2 was established for a mixture of mainly pelagic species with an average length of about 17 cm on a previous cruise of R.V. "Dr. Fridtjof Nansen". The density coefficients, C_W, used in the present study will then be:

$$C_W = 10.5 \ \frac{l}{17} \qquad (2)$$

where l is the mean length in cm of the observed species. More details on the acoustical methods applied, and a discussion of the reliability of acoustic estimates of biomass of mesopelagic fish are given by GJØSÆTER (1981).

FISHING GEAR

The pelagic trawl had an opening of 16 × 16 fathoms, usually corresponding to a height of 17 m when fishing. It was operated with superkrubs doors and 120 m bridles and always used together with a net sonde.

The bottom trawl covered a track of about 60 m between the doors when fishing with 40 m bridles. The footrope was equipped with 0.5 m bobbins, and the effective vertical opening of the net was 6.5 – 7.0 m.

A cover net with small meshes was used on both trawls.

BIOLOGICAL SAMPLES

From all catches mesopelagic fish were sorted out and the volume measured or estimated. From some catches, samples were also preserved for species identification and for biological studies. The stations where such samples were collected, are shown in Fig. 1.

RESULTS AND DISCUSSION

SPECIES COMPOSITION AND DISTRIBUTION

The composition of the species in all catches was studied during a cruise in April – June 1978, and in some during January – March 1978. A list of species caught on these cruises is given in Table 1. Preliminary identification carried out at sea during the other cruises suggests that the dominant species were the same.

Benthosema fibulatum was caught both in bottom and pelagic trawl in the whole area, and was dominant at most stations south of 20°S. The species is very abundant in the northwestern Indian Ocean (GJØSÆTER 1981), and KOTTHAUS (1972) caught specimens as far south as about 5°S in the Indian Ocean. GRINDLEY and PENRITH (1965) reported the occurrence of *B. fibulatum* off the Natal coast, but further examination has shown that the specimen reported is *B. suborbitale* (HULLEY pers.com.) However, another specimen from their material (42°11'S, 19°26'E) showed in fact to be *B. fibulatum* (HULLEY pers.com.). Based on these records and the present observations, *B. fibulatum* seems to be present in coastal waters along the whole east Africa.

At the station (25°14'S, 34°33.5'E) *B. pterotum* was the only species caught. The catch was about 7 kg. Previously, *B. pterotum* was known in the Arabian Sea south to about 3°N off east Africa (GJØSÆTER 1981). The present record seems to be the first from the southern Indian Ocean.

These specimens could not be distinguished from *B. pterotum* from the northern Arabian Sea in their distribution of photophores, but they had

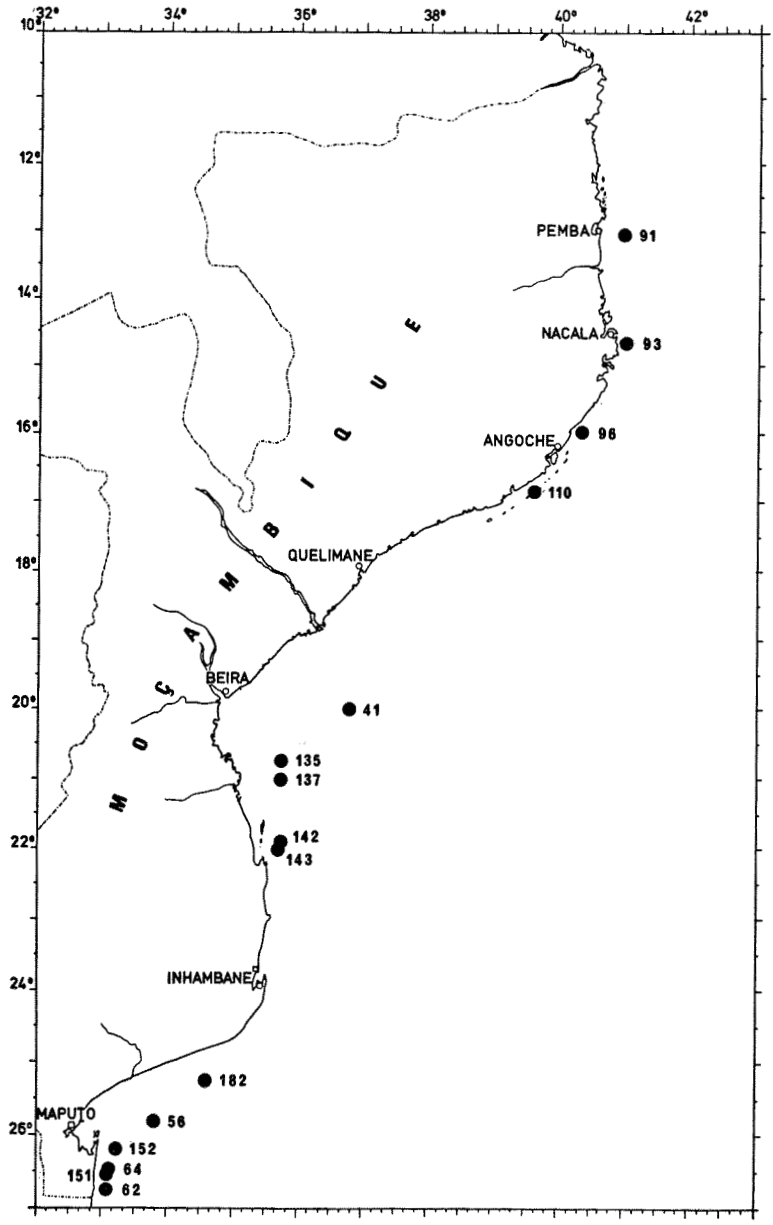

Fig. 1. Fishing stations where mesopelagic fish were caught off Mozambique.

Table 1. Species identified during cruises 3 and 4 of R.V. "Dr. Fridtjof Nansen". 1 and 2 indicate first and second species in abundance, + indicates presence in sample.

AREA	NORTHERN AREA			SOFALA BANK				BAZARUTO		DELAGOA		INHACA			
St. no.	91	93	96	41	100	135	137	142	143	56	182	64	62	152	151
Bentosema fibulatum		+	+			1	2	1		2			1	1	+
B. pterotum											1				
Hygophum hygomi				+											
Myctophum spinosum	+														
M. obtusirostrum			+												
M. asperum				+											
M. aurolaternatum				+											
Symbolophorus evermanni	1		+												
Diaphus garmani			1			2	+	+		+					
D. nielseni		1	+		2		+								
D. watasei				1					2	1		1		2	1
D. suborbitale			+												
D. thiollierei		+			+					+					
D. perspicillatus		2	2	2	1	+	+								
Lampanychtus sp.	2		+												
Maurolicus muelleri							1	+	1						2
Polymetme corythaeola														+	

Table 2. Number of gill rakers on the first gill arch of *Benthosema pterotum* from the Indian Ocean.

Number of gill rakers	Frequency of occurrence		
	Position		
	21°37′N 59°37′E	24°37′N 57°11′E	25°14′S 34°33,5′E
6+1+14			1
15			1
7+1+13			1
14			5
15			12
16			7
17			1
8+1+16	2		2
17	6	7	
18	1	9	
19		1	
9+1+15	1		
16			
17	2		
18		2	
19		1	
Mean nr.	26.00	26.90	23.10

a lower number of gill rakers on the first gill arch (Table 2). Although the difference in this single character does not justify description of a new species, it warrants further studies on the taxonomy of *B. pterotum* stocks along the east coast of Africa.

Hygophum hygomi was caught at only one station, at about 20°S latitude. This species apparently has a bisubtropical distribution (Bekker 1965). Nafpaktitis and Nafpaktitis (1969) caught this species between about 20°S and 35°S in the Indian Ocean.

Myctophum spinosum and *M. aurolaternatum* were caught at one station each, between 13° and 15°S. Nafpaktitis and Nafpaktitis (1969) caught both species southwards to 10°S in the Indian Ocean.

M. asperum and *M. aurolaternatum* were caught at one station at about 20°S latitude. Nafpaktitis and Nafpaktitis (1969) caught *M. asperum* between 10°N and 10°S and *M. aurolaternatum* between 5°N and 10°N in the Indian Ocean.

Symbolophorus evermanni was the dominant species at one station at about 13°S and was present at one station near 16°S. Previously Nafpaktitis and Nafpaktitis (1969) recorded this species south to about 15°S in offshore waters.

Diaphus garmani was caught between 16°S and 26°S. It was the most abundant species in a night haul with pelagic trawl at 50 m depth at 16°S. It ranked second in a bottom trawl haul at 50 m depth at about 21°S. The records fall within the known range for this species as described by NAFPAKTITIS (1978).

D. nielseni was caught from 15°S to 21°S. At 15°S it was the dominant species. This species was only caught with the pelagic trawl. *D. nielseni* is previously known from this area (NAFPAKTITIS 1978).

D. watasei was caught between 22°S and 27°S where it ranked first or second in three bottom trawl hauls at depths between 265 and 460 m. It was never caught with the pelagic trawl. NAFPAKTITIS (1978) recorded this species between 5°S and 28°S.

D. perspicillatus was caught at five stations between 14°S and 21°S. At one station (14°S) it was the dominant species, and at two station the second dominant. It was caught with both thep elagic trawl and the bottom trawl. NAFPAKTITIS (1978) recorded *D. perspicillatus* from the same area.

D. suborbitale was caught at one and *D. thiollierei* at two stations between 14°S and 17°S. Neither of them were abundant. *D. suborbitale* has previously only been recorded between 7°N and 8°S in the Indian Ocean (NAFPAKTITIS 1978, GJØSÆTER 1981), and therefore the present catch localities (17°S) probably are a southern extension of the distribution of this species. *D. thiollierei* has previously been recorded from this area.

Maurolicus muelleri was caught at four stations between 21°S and 27°S. At two of these stations it was the dominant species and at one it ranked second. It was caught both with pelagic and bottom trawls. *M. muelleri* has a world-wide distribution. It has been captured off south Africa (GREY 1964), but apparently not off Mozambique.

Polymetme corythaeola was caught in a bottom trawl at one station (26°S). This species is previously known from the Indian Ocean off Natal (about 29°S–30°S) and in the northern Indian Ocean south to about 5°S off Zanzibar. The present record suggests that it may be distributed continuously along the east African coast.

BEHAVIOUR

Mesopelagic fish were observed in most of the area studied. In offshore waters a deep-scattering layer (DSL) was usually observed. Sometimes this layer was found below 500 m which was the lower limit for the echo integration carried out to estimate fish abundance. At sunset the DSL, or part of it, migrated towards the surface and during night it was situated in the upper 100 m (Fig. 2). Usually the DSL consisted of dispersed fish, and schools were seldom observed. Generally, the fish density was highest close to the continental slope.

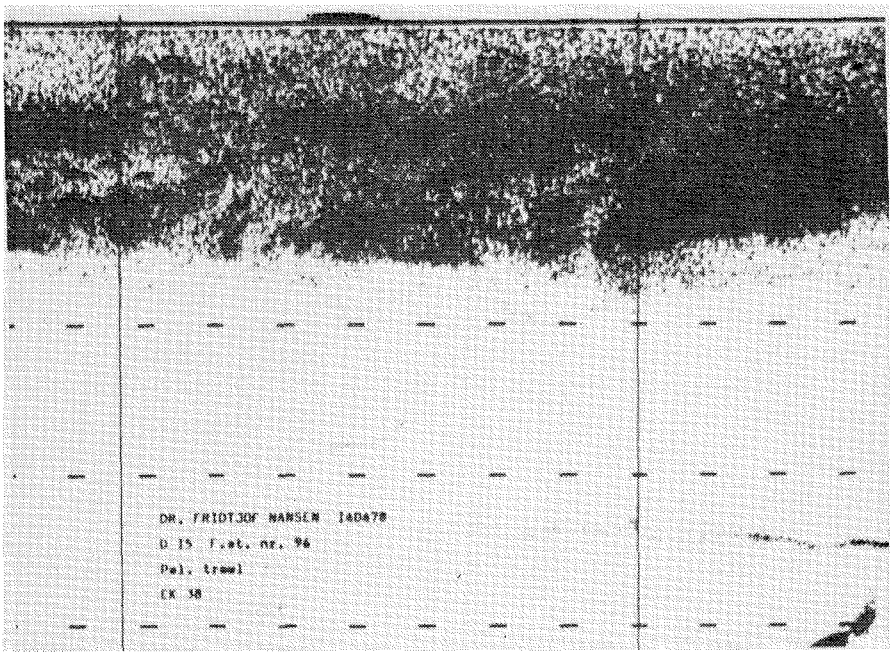

Fig. 2. Mixture of plankton and mesopelagic fish during night time. Distance between horizontal lines 50 m.

Along most of the coast, a scattering layer was found above the bottom at depths between 300 and 350 m. Mesopelagic species were also observed close to the bottom in more shallow waters (Fig. 3). *Diaphus watasei* was found in this bottom layer both day and night. During daytime *Benthosema fibulatum* and *Maurolicus muelleri* were also caught in this layer.

BIOLOGICAL OBSERVATIONS

Observations on the biology of mesopelagic fish species were made on the January-March 1978 and April-June 1978 cruises. Fig. 4 gives the length distributions of the sampled species.

Benthosema fibulatum, which was the most abundant species, ranged in length between about 30 and 90 mm. There was no difference in size distribution between samples from March and from May 1978.

Primary growth rings in the otoliths, which are supposed to be formed daily (PANNELLA 1974), were studied in a few fish, and the results seem to confirm the conclusion that *B. fibulatum* reaches its maximum size in about one year (GJØSÆTER 1981).

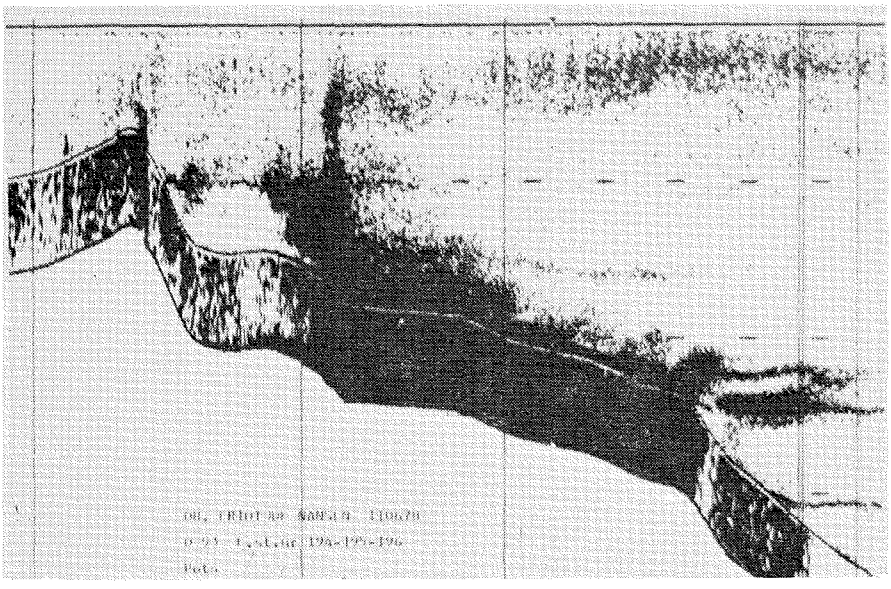

Fig. 3. Recordings of mesopelagic fish along the continental slope. Distance between horizontal lines 50 m.

Gonads and stomach contents were studied in a sample from March 1978. Most of the gonads were mature or ripening. Copepods and euphausids were the most important food items.

The catch of *B. pterotum* consisted of adult fish only. A few gonads were studied, and they were all maturing or ripe. Therefore, there seems to be little doubt that the species spawn in this area. The biology of these two species is further discussed by GJØSÆTER (1981).

Ranking after *Benthosema fibulatum*, *Diaphus perspicillatus* was the most abundant species in the area. The length of this species ranged between about 20 and 60 mm. NAFPAKTITIS (1978) found mature eggs in females ranging between 48 and 54 mm in the Indian Ocean. For Hawaiian waters, CLARK (1973) suggests that the species reaches maturity after one year (note: *D. elucens* is a synonym).

D. nielseni was also fairly common in the catches. This species ranged in length between 30 and 50 mm with a mode between 35 and 40 mm. NAFPAKTITIS (1978) found three females, measuring 32–36 mm, which had ripe gonads.

Diaphus watasei was often abundant in bottom trawl catches. This large species ranged in length between 80 and 170 mm. Fish caught during March 1978 had a slightly lower modal length than those caught during May 1978. The gonads were studied in one sample from March 1978. Only females were caught and they were, with few exceptions, ripe. The

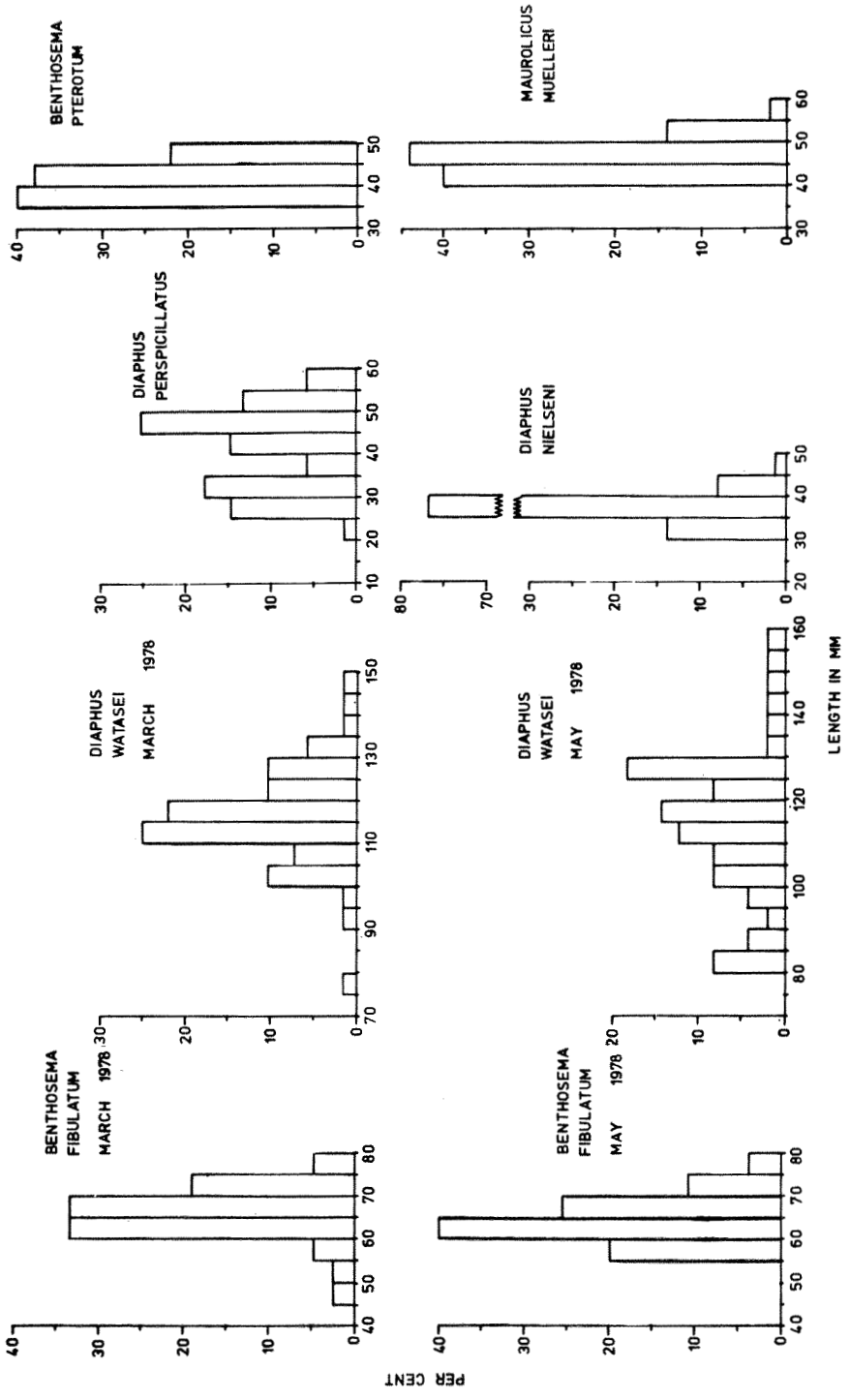

Fig. 4. Length distribution of some mesopelagic fishes caught off Mozambique.

smallest ripe female observed, was 110 mm. NAFPAKTITIS (1978) found ripe females measuring between 124 and 157 mm in the same area. Stomachs contained euphausids, prawns, small squids and copepods. Myctophids were also observed in one stomach, but the species could not be identified due to advanced digestion. *D. watasei* is usually caught close to the bottom. Juveniles are, however, supposed to live pelagically.

Maurolicus muelleri was fairly common in parts of the area studied. Only adult specimens, ranging in size between 40 and 60 mm, were caught.

ABUNDANCE

The abundance of mesopelagic fish has been calculated from acoustical data and the length composition of the catches (Table 3). As length data are only available from two cruises, and no significant difference could be observed between those data, the same lengths, 40 mm for the area north of 18°S and 50 mm for the area south of 18°S, were used for all surveys.

The estimate obtained from the first cruise is probably an underestimate as the source level of the acoustic equipment at that time was lower than on the later cruises. Although this is partly compensated for in the calculations, the detection threshold was different in such a way that small concentrations of weak targets, such as mesopelagic fish, were not included in the integrated echo abundance.

The other estimates, 5.5–8.5 million tonnes for the whole area, are fairly uniform.

Based on the material available, it is not possible to demonstrate any consistant differences in abundance between seasons or between areas. In general, however, it seems that the area from the 200 m depth contour

Table 3. Abundance estimates (in million tonnes) of mesopelagic fish in zones of 0—30 n.miles and 30—200 n.miles off the 200 m depth contour off Mozambique.

Cruise no.	South of 18°S		North of 18°S		Total
	0—30 n.miles	30—200 n.miles	0—30 n.miles	30—200 n.miles	
1	1.2	1.0	0.02	0.3	2.5
2	0.4	2.9	0.8	1.7	5.8
3	0.9	5.9	0.2	1.5	8.5
4	1.1	1.2	0.5	2.7	5.5
Mean	0.9	4.5	0.4	1.6	5.6

to 30 n.miles seaward of this line has a higher density of mesopelagic fish than the more offshore areas.

Averaging over the three last cruises, which are supposed to give the most reliable estimates, the following densities were observed:

	0–30 n.miles	30–200 n.miles
N of 18°S	9.1 g/m²	6.4 g/m²
S of 18°S	11.0 g/m²	4.5 g/m²

These mean densities are much lower than those generally observed in the northern Arabian Sea (GJØSÆTER 1981), but they are still high enough to be of commercial interest. An approximate estimate of maximum potential yield of an unexploited stock can be derived from the equation:

$$Y \max = 0.5\ MB_0$$

where M is the instantaneous mortality rate and B_0 the size of the virgin stock (GULLAND 1970). The mortality of the mesopelagic fish in the area is not known, but the mean instantaneous mortality rate for the most important species is probably at least 2. Therefore, according to the equation above, the maximum potential yield may be similar to the stock size. This is, however, a first approximation only, and any fishery must be closely followed to discover signs of recruitment failure or other adverse effects on the stock at an early stage.

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