Reports on Surveys with the R/V Dr Fridtjof Nansen

AGLEN, Asgeir, Jakob Gjøsæter, Bjørn Myrseth and Snorre Tilseth

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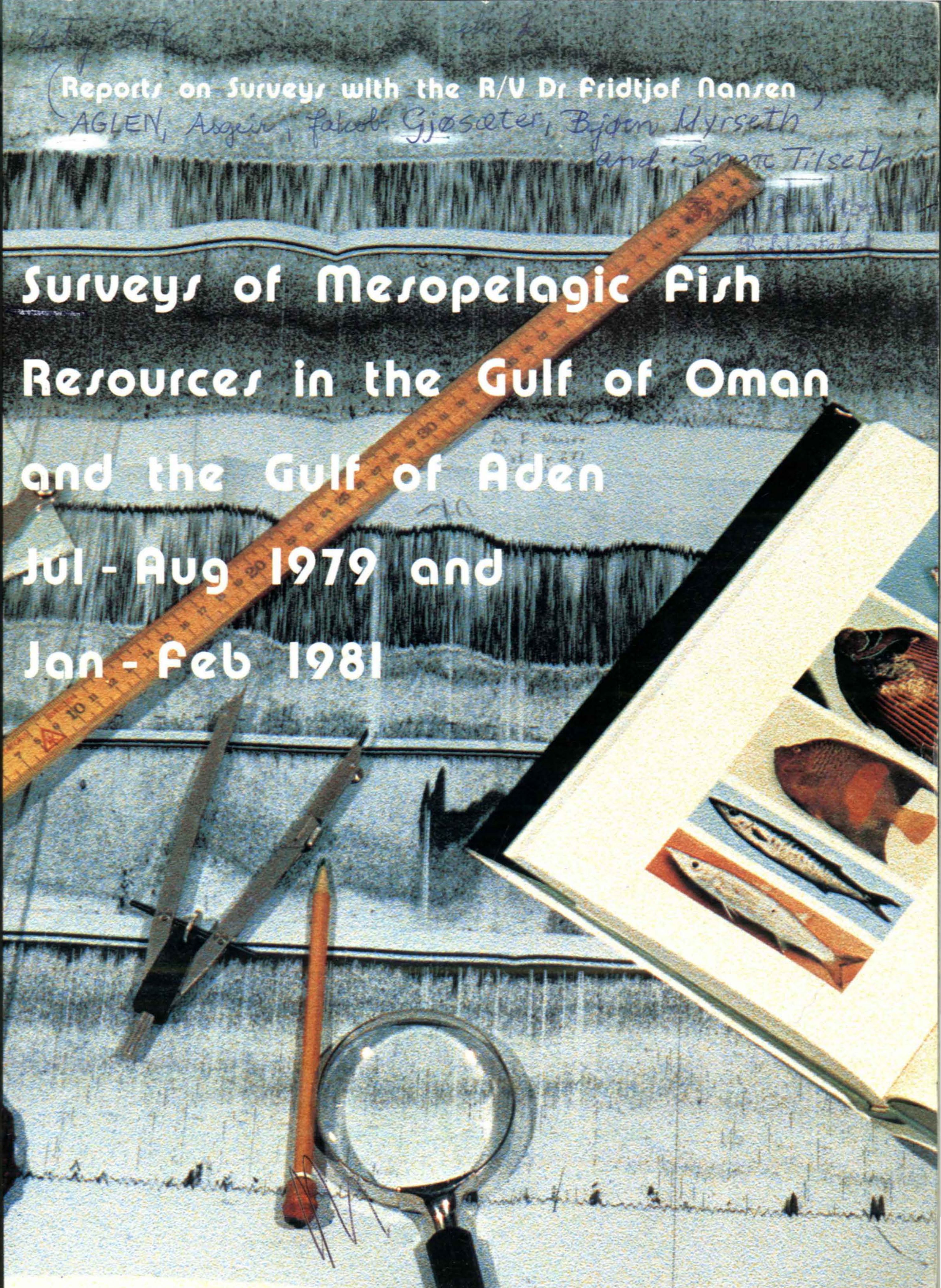

Institute of Marine Research, Bergen
University of Bergen, Department of Fisheries Biology

1982

«Dr. Fridtjof Nansen»

The fishery research vessel «Dr. Fridtjof Nansen» belongs to the Norwegian Agency for International Development (NORAD). It was designed and built for scientific and exploratory investigations of fishery resources of developing countries, under a joint plan with the Fisheries Department of FAO based on a funding of operation to be shared by FAO and Norway.

Reports on Surveys with the R/V "Dr. Fridtjof Nansen"

SURVEYS OF MESOPELAGIC FISH RESOURCES IN THE GULF OF OMAN AND THE GULF OF ADEN JUL-AUG 1979 AND JAN-FEB 1981

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INTRODUCTION

During the surveys of the pelagic fish resources of the Northwestern Arabian Sea carried out with R/V "Dr. Fridtjof Nansen" during 1975-1977, mesopelagic fish were observed in abundance over wide areas. Usually the densest concentrations were found in the Gulf of Oman, in the Gulf of Aden and off Pakistan, and some trawl stations in these areas gave very high catch rates. The data from these cruises and from other available sources have been analysed by Gjøsæter (1978, 1981a), and by Gjøsæter and Kawaguchi (1980). These studies conclude that the mesopelagic stocks in the Arabean Sea is the largest known so far. An analysis carried out by Wijkstrøm (1978) concluded that a commercial fishery for mesopelagic species might be possible in these areas.

Therefore, it was decided to undertake more research in these areas, and further cruises were conducted with the R/V "Dr. Fridtjof Nansen" in the Gulf of Oman and the Gulf of Aden in July-August 1979 and in January-February 1981.

The purpose of these cruises was to make new estimates of the abundance of the mesopelagic fishes, to collect data for further studies on the ecology and life history of the species conserned, and to do experimental fishing.

Preliminary results of these cruises were reported by Gjøsæter and Myrseth (1979) and by Aglen, Gjøsæter and Tilseth (1981). Some of the data collected were also analysed by Gjøsæter (1981b).

MATERIAL AND METHODS

In 1979 R/V "Dr. Fridtjof Nansen" worked in the Gulf of Oman from 4 July to 3 August and in the Gulf of Aden between 8 and 29 August. In 1981 she worked in the Gulf of Oman 24 January to 13 February and in the Gulf of Aden from 17 February to 26 February.

The vessel is a 150 foot stern trawler with a main engine of 1500 Hp. A description of the vessel is given by Anon. (1978). The participating scientific and technical staff is listed in Annex 1.

The acoustical equipment consisted of three scientific sounders (120, 50 and 38 kHz) and two echo integrators, each with two channels. The vessel is also equipped with a sonar (24 kHz) and a net sonde (50 kHz). In addition to the hull mounted transducers, there is one towed body with two transducers.

The 38 kHz sounder used for integration, is coupled to a ceramic transducer and a 2 KW external transmitter was applied. A 120 kHz echo sounder was used to get better resolution in the upper 100 m.

Details about the acoustical equipment and the settings used are given in Annex 2.

During daytime the echo recordings were divided into three groups:

Plankton	(Usually upper 100 m)
Upper mesopelagic (DI)	(Usually 100-200, usually absent in Gulf of Aden)
Deep mesopelagic (D II)	(Usually below 200 m)

During night usually two groups could be recognized:

Upper mixed layer (N I, plankton)	(Upper 100 m)
Deep mesopelagic (N II)	(Below 200 m)

To estimate the amount of mesopelagic fish in the upper mixed layer, the recordings of plankton during daytime in the same or in a near by area were subtracted.

The integrated echo was converted to estimates of fish biomass using the formula:

$$B = \int MCdA = \bar{M}CA$$

where B is biomass of the scattering organisms, M is integrated echo intensity (mm/n.miles). A is the corresponding area. The conversion factor depends on the size of the fish.

$$C = C'L$$

where L is fish length and C' is a constant depending on the performance of the acoustical equipment and the fish species in question. As no reliable estimate of C' for myctophids are available, a C' estimated for other small pelagic fishes was used:

$$C = 0.1\ L \text{ for } 1979 \text{ and}$$
$$C = 0.6\ L \text{ for } 1981$$

where L is fish length in cm. This corresponds to an average target strength of -10 log L -22 dB ref. 1 kg/m^2, and should therefore be comparable to the conversion factor used on R/V "Dr. Fridtjof Nansen" during the surveys in 1975-76, and on R/V "Lemuru" with compensation for the difference in the performance of the equipment.

Fishing experiments and sampling to identify the sound scatterers were carried out using a modified Krill trawl and a Harstad trawl. The effective trawl opening was estimated to cover about 250 m^2. Records of fishing operations are given in Annex 3. Eggs and larvae were sampled with an 80 cm Juday net (180 µm mesh size) in vertical hauls from 50-0 m. Broken hauls were also made from 300-200 m, 200-100 m and 100-0 m. Zooplankton were sampled by a 60 cm Bongo with one 180 µm and one 90 µm mesh sized nets. The Bongo samples were made in double oblique hauls from 0-50-0 meters.

Eggs of Benthosema pterotum were artificially fertilized in the laboratory on board the R/V "Dr. Fridtjof Nansen". The eggs were incubated at 18 and 25^{o}C.

Underwater photographs were taken using a camera system consisting of an aluminium casing which housed a motor-driven 35-

mm camera, strobe light and an electronic shutter release taking pictures every 40 sec. When used in the upper 70 m an echo transducer could be mounted on the camera casing and the camera could be operated from the surface when fish was observed on the echosounder.

Standard hydrographic stations were worked out along transects during the surveys (Fig. 1-4).

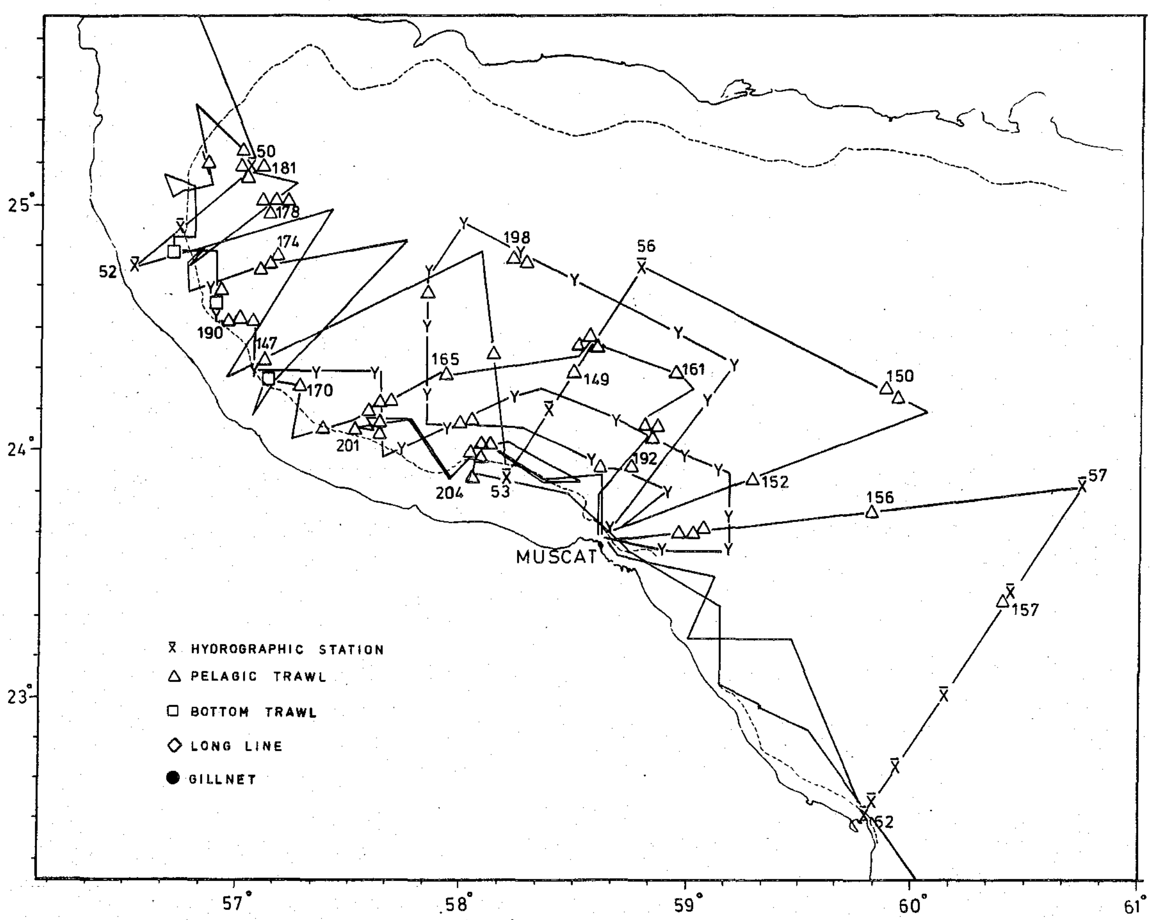

Fig. 1. Cruise tracks in the Gulf of Oman, 4 July - 3 August 1979.

In each station Nansen bottles were used in standard depths down to the bottom or to 500 m depth. Temperature and salinity were observed at all standard depths; 0-10-20-30-50-75-100-125-150-300-250-300-400-500 m. Oxygen was observed at the same depths except 0 m. The salinity and oxygen samples were analysed on board.

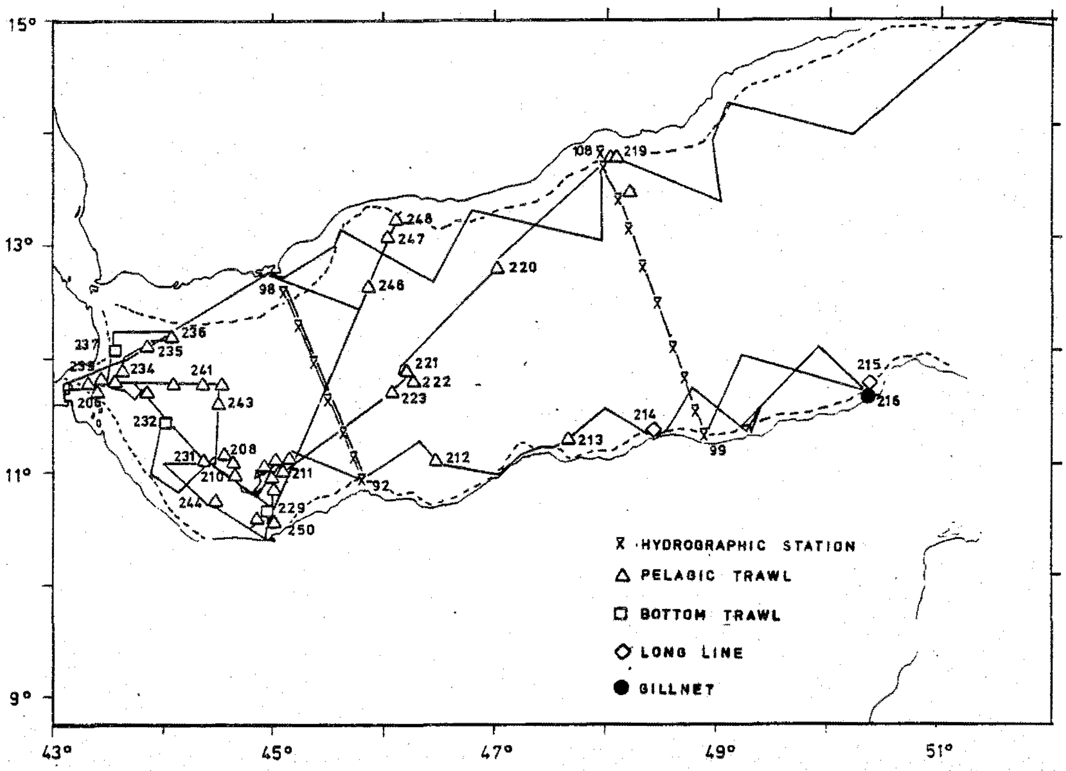

Fig. 2. Cruise tracks in the Gulf of Aden, 8 - 29 August 1979.

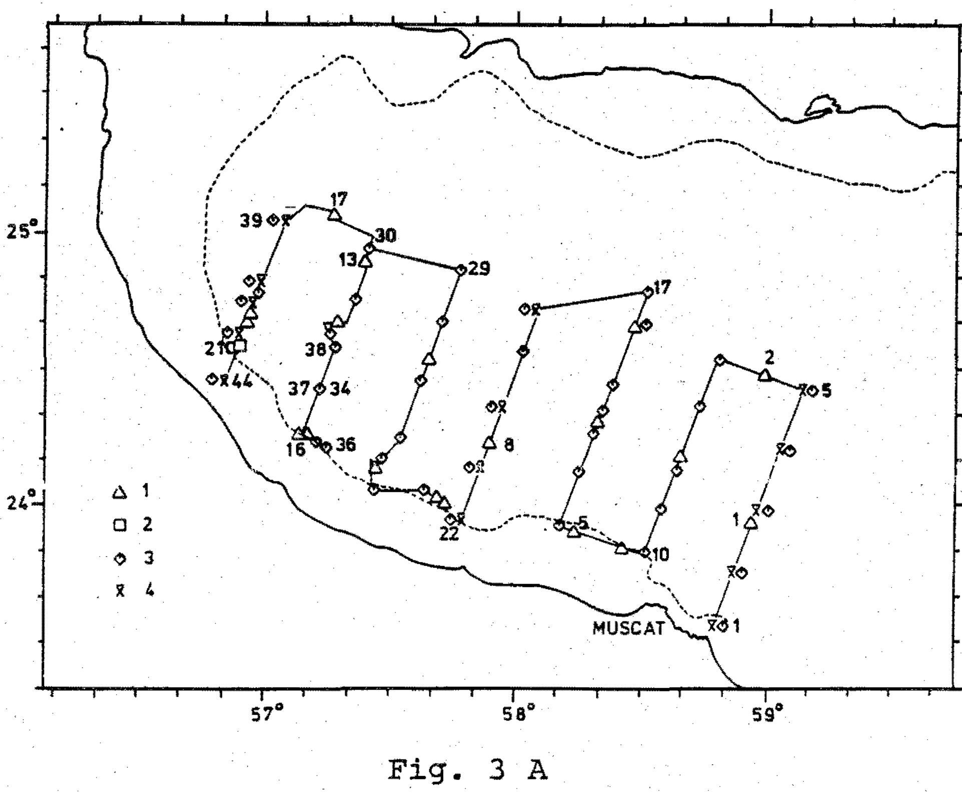

Fig. 3 A

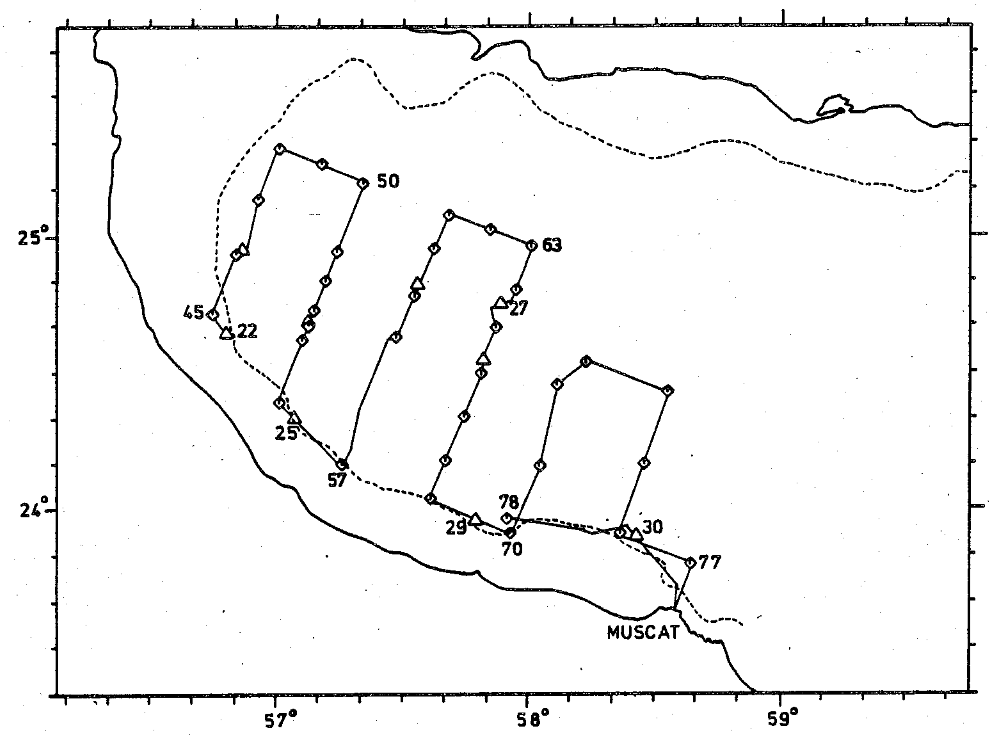

Fig. 3 B

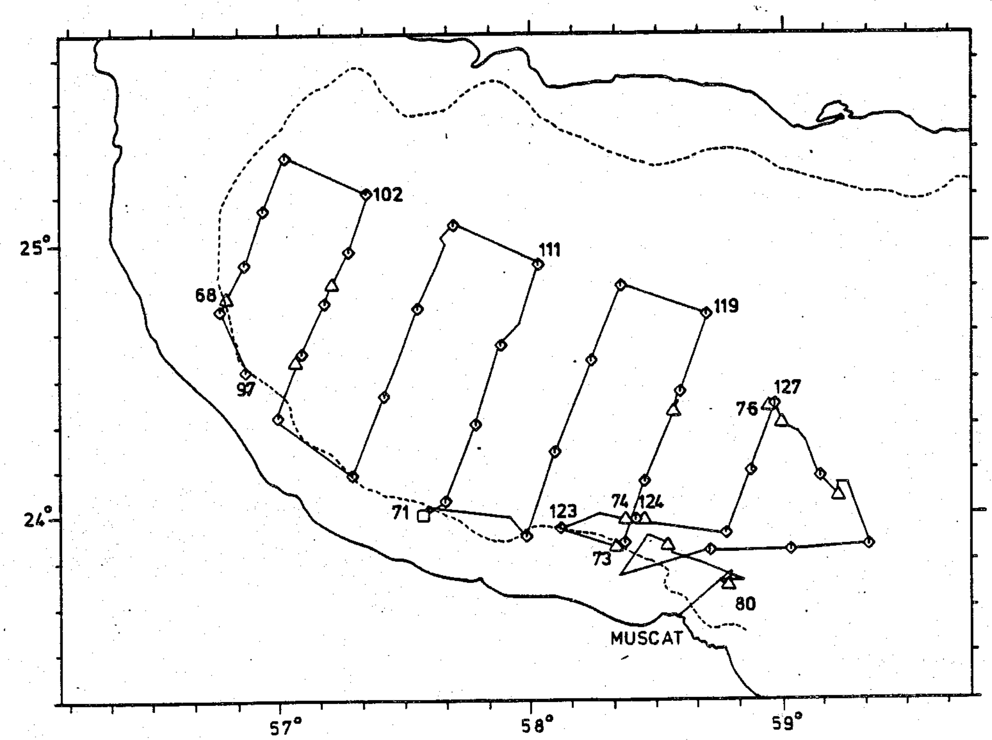

Fig. 3 C

Fig. 3. Cruise tracks in the Gulf of Oman, 1981.

A: 24 - 28 January B: 28 January - 1 February

C: 9 - 13 February

1. Pelagic trawl, 2. Bottom trawl, 3. Plankton station,
4. Hydrographical station.

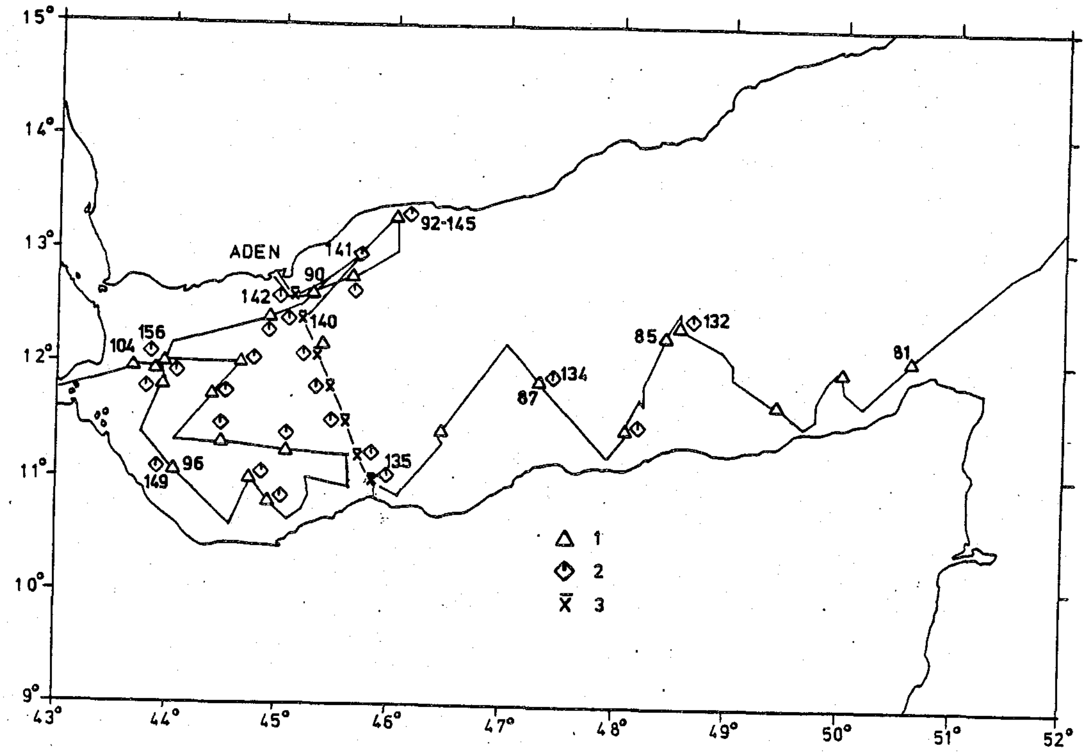

Fig. 4. Cruise track in the Gulf of Aden, 17 - 26 February 1981. 1. Pelagic trawl, 2. Plankton station, 3. Hydrographical station.

BEHAVIOUR AND SPECIES COMPOSITION

GULF OF OMAN

Mesopelagic fish were found off the continental shelf where the water was deeper than about 200 m. During day time two sound scattering layers were usually observed in addition to a weak plankton layer in the surface. The upper layer (D I) was usually found at about 150 m depth and had a vertical extention of 20-40 m (Table 1, Fig. 5). It consisted of small schools and dense concentrations. Below this layer and usually centered about 250 m depth a second scattering layer (D II) appeared. This usually had a vertical extention of 70-100 m. Although it sometimes gave very high echo recordings, it had a more "smoky" appearance on the echograms than D I. About one hour before sunset the upper layer started to migrate slowly upwards. About half an hour before sunset it usually reached about 100 m. At

Table 1. Vertical distribution of mesopelagic fish layers in 1979. Ranges are given in parenthesis.

Area	Time	Day				Night		
		D I		D II		N I	N II	
		Depth	Vertical extention	Depth	Vertical extention	Vertical extention	Depth	Vertical extention
Gulf of Oman	July-79	181 (150-215)	43 (30-60)	265 (225-295)	86 (50-105)	72 (60-90)	219 (185-245)	65 (35-100)
Gulf of Aden	Aug.-79	-	-	363 (275-400)	161 (100-220)	66 (50-90)	354 (260-400)	156 (100-250)

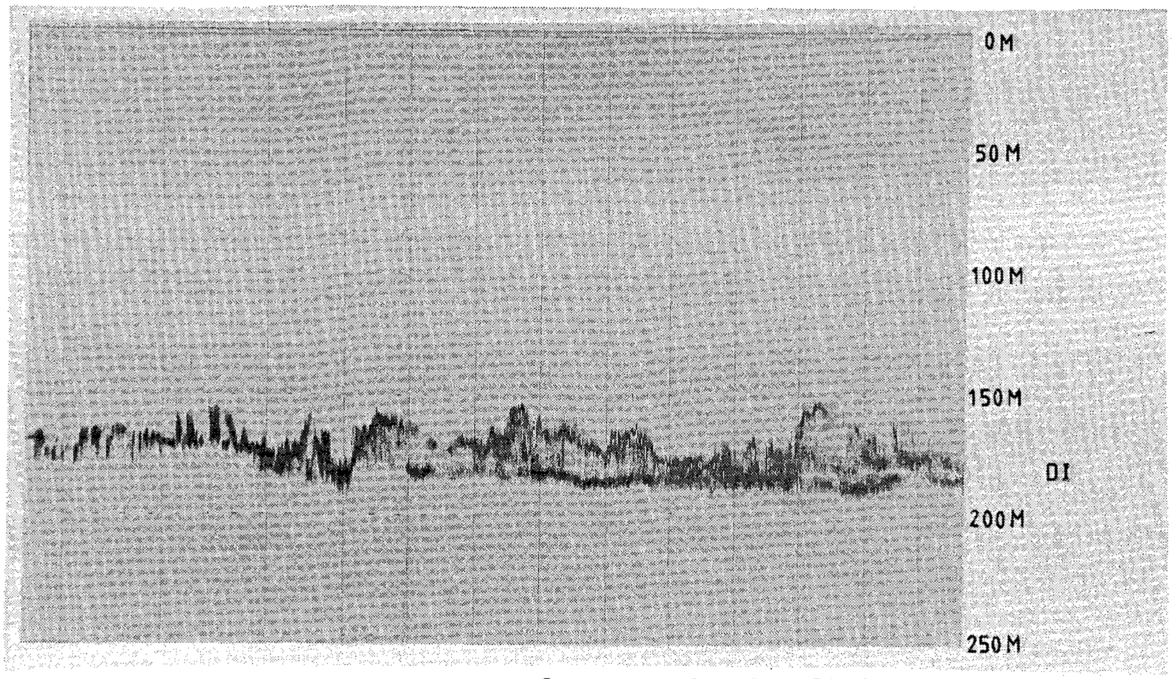

Fig. 5. Shallow day layer of mesopelagic fish (D I) in the Gulf of Oman.

this time both this layer and parts of the lower layer moved rapidly towards the surface where they mixed with the plankton layer. Parts of the deep day layer stayed in deeper waters also during night time (Fig. 6). Sometimes fish seem to migrate from the D I to the D II layer during daytime (Fig. 7).

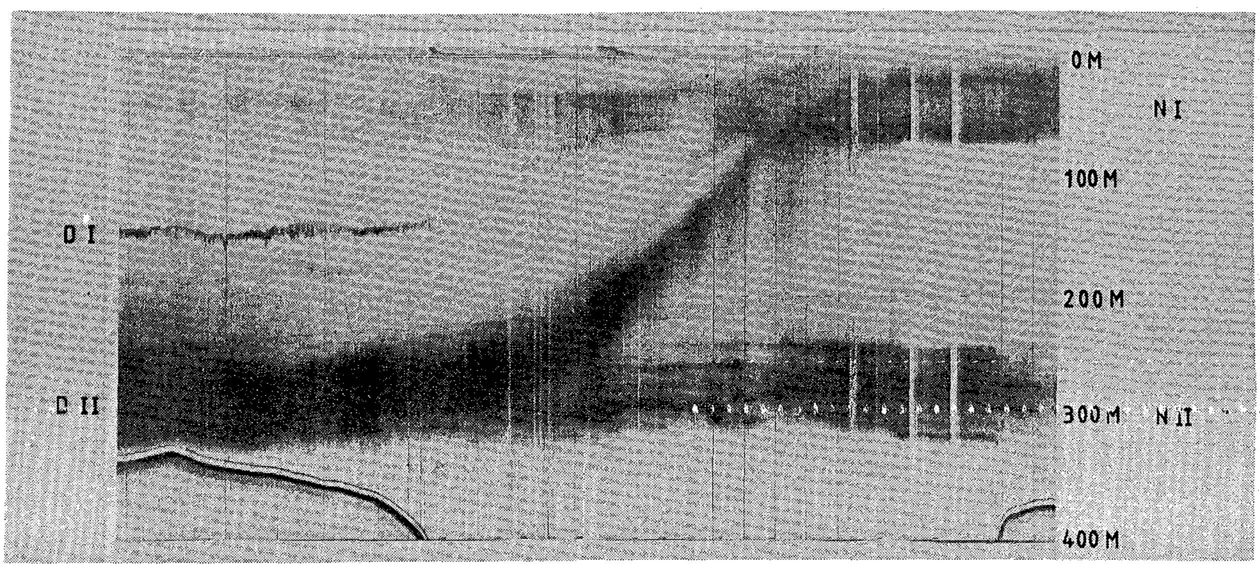

Fig. 6. Vertical migration of scattering layers in the Gulf of Oman. The distance between the vertical lines is one nautical mile.

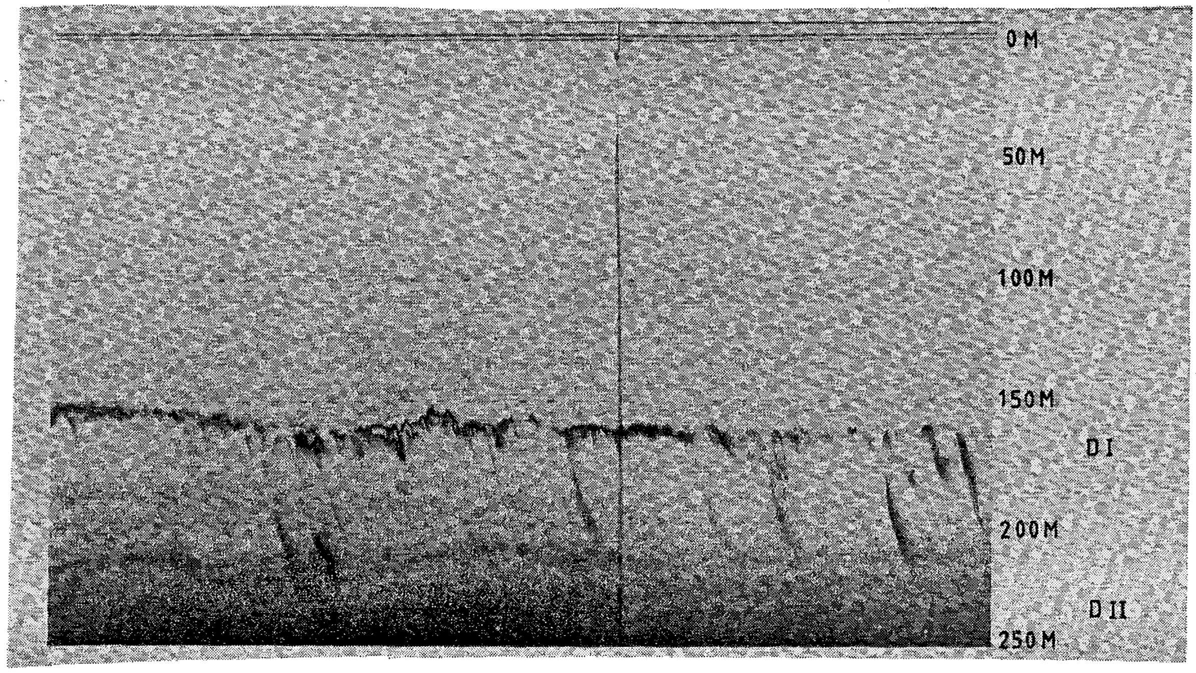

Fig. 7. Echogram showing fish migrating from a D I to a D II layer. The ship was laying still during the recording.

The shallow day layer (D I) consisted almost exclusively of Benthosema pterotum (Table 2). The salps observed in the trawl catches from this layer in 1981 may be contamination from the surface layer where they were very numerous. In the deep day layer (D II) B. pterotum was also the dominant form, although salps also made up a large proportion of the catches. In tows from the lower part of the D II layer shrimps were sometimes numerous, and in contrast to the salps, these were probably partly responsible for the echoes received from these layers.

During night time B. pterotum was second to salps in abundance in 1981, but among those animals which are supposed to give sound scattering, B. pterotum was dominant (Table 2). A towed transducer sounding upwards showed that parts of the night layer (N I) extended upwards beyond 10 m depth which is the upper limit for the echo integration. This experiment was carried out at new moon, and probably most of the fish will stay deeper during the other parts of the moon cycle.

Table 2. Composition (percentage of weight) of trawl catches in the sound scattering layers in the Gulf of Oman. Figures in the brackets give the percentage of the catch exclusive of salps, + present but less than 0.1% of weight.

	1979				1981			
	Day		Night		Day		Night	
	D I	D II	N I	N II	D I	D II	N I	N II
Myctophidae	99.2	73.2	94.6	44.5	96.0(100)	44.9(60.1)	46.8(90.4)	55.2(86.0)
Champsodon	0.1	1.1	0.7	1.4		2.9	0.6	1.4
Harpadontidae		6.0	+	33.1		0.8	+	0.2
Cubiseps		0.4	0.6			1.1	1.7	0.1
Lestidium	+	0.7	0.6	+	+	1.1	0.3	1.7
Trichiurus	0.3	3.7	+	0.4	+	0.2	0.1	+
Vinciguerria						0.1	+	+
Epinnula					+	0.7	0.3	
Synagrops						0.2	+	0.1
Other fishes	0.1	0.2	0.4	1.9	+	0.5	+	1.0
Shrimps/Krill		8.5	+	8.5	+	21.0(28.1)	0.1	2.5
Squid	0.3	1.8	0.9	1.3		1.0	1.9	0.6
Salps/Jellyfish		4.0	2.0	7.6	3.9	25.2	48.3	36.5
No. of hauls	16	11	17	3	30	14	23	8

In catches from the deep night layer (N II) B. pterotum made up 55% of the weight, or 86% if the salps were excluded in 1981 and about 45% in 1979. Harpadon contributed 33% in 1979, but only 0.2% in 1981.

Tows taken between the depths of the scattering layers or at the surface during day time in 1981 gave large numbers of salps, but no fishes. Tows with Juday net showed that small krill and other plankton organisms, too small to be caught in the trawl, could be numerous. It seems, however, safe to conclude that fish, and mainly B. pterotum were responsible for most of the sound scattering. This view is supported by the pictures taken in these layers during the cruise in 1981, showing mainly fish and salps (Fig. 8-9).

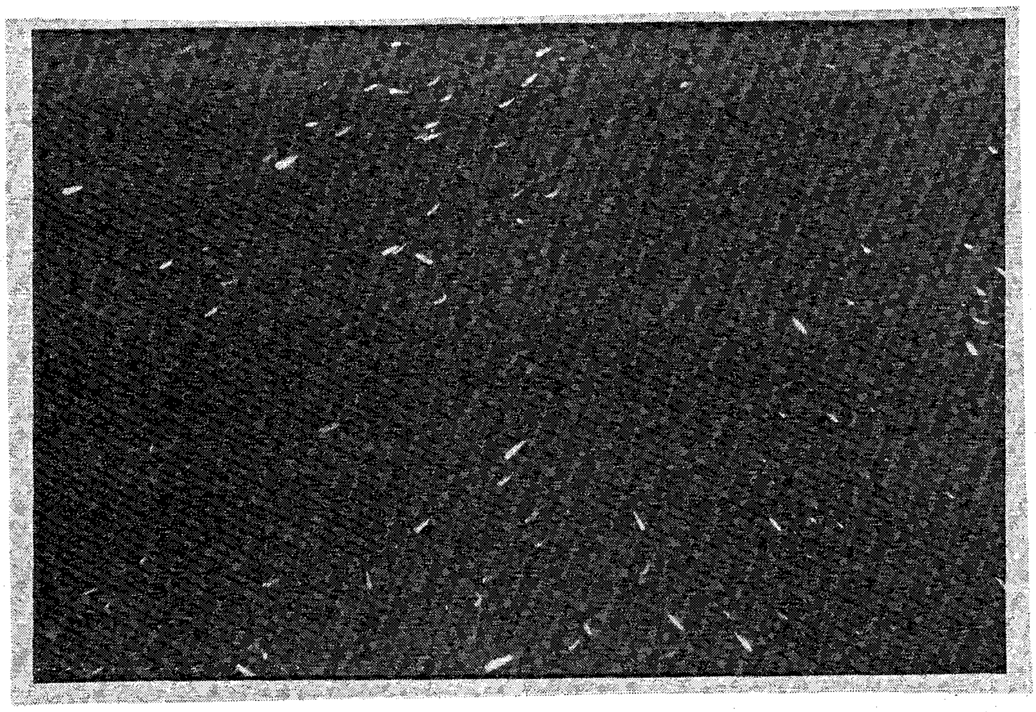

Fig. 8. Photo showing myctophids in a D I layer.

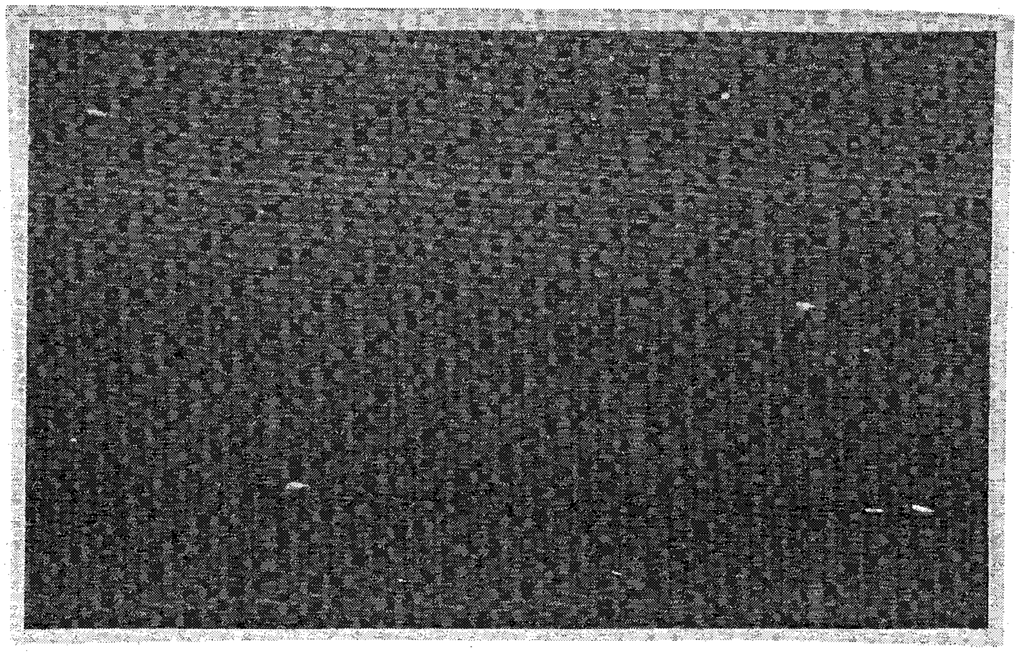

Fig. 9. Photo showing myctophids in a D II layer.

GULF OF ADEN

During day time a surface plankton layer and one deep scattering layer were found in most of the area. The DSL corresponding to the D II in the Gulf of Oman was usually found at depth of about 350-400 m in 1979 and 300-350 m in 1981. It had a vertical extension varying between 100 and 200 m (Table 1). In the western part of the Gulf, scattered schools corresponding the the D I layer of the Gulf of Oman were observed in 1981, but not in 1979.

At dusk, parts of the mesopelagic layers migrated towards the surface and mixed with the plankton.

The surface layer (N I) extended from the surface down to about 100 m, with the higest concentrations between about 30 and 70 m. Parts of the fish remained in deep water (N II) (Table 1).

The shallow day layer (D I) observed in 1981 consisted almost exclusively of Benthosema pterotum (Table 3). In the deepest

Table 3. Composition (percentage of weight) of trawl catches in the sound scattering layers in the Gulf of Aden. +, present, but less than 0.1% of weight.

	1979				1981			
	Day		Night		Day		Night	
	D I	D II	N I	N II	D I	D II	N I	N II
Myctophidae		34.6	56.1	33.2	91.5	64.5	45.2	20.4
Gonostomatidae		3.0		1.6		1.2	0.4	10.2
Sternoptychidae		6.3		2.8	0.5	2.1	+	10.2
Cubiceps		0.8	10.8				2.3	
Lestidium		0.6	4.1	0.3		1.2	2.7	
Chauliodus		21.2		5.5		9.1	+	
Trichiuridae							0.4	6.8
Other fish		6.0	10.2	4.6		2.1	0.7	2.3
Shrimps/krill		4.5	4.2	11.3	2.8	5.8	8.7	2.0
Squids		1.5	2.2	0.4	2.1	1.8	4.7	1.4
Salps/Jellyfish		19.7	12.4	40.2	3.1	9.1	16.7	40.8
Swimming crabs						3.0	17.9	+
No. of hauls		15	11	3	4	8	10	1

Table 4. Preliminary list of Myctophidae caught in the Gulf of Aden, February 1981.

	August 1979	February 1981
Electrona rissoi	x	x
Hygophum proximum	x	x
Benthosema pterotum	x	x
B. fibulatum	x	x
Myctophum spinosum	x	x
M. nitidulum	x	x
Symbolophorus evermanni		x
Diaphus garmani	x	x
D. regani	x	x
D. coeruleus	x	x
D. sp. nov.	x	x
D. diademophilus	x	x
D. lucidus	x	x
D. megalops	x	x
D. parri	?	x
D. lobatus	x	x
D. problematicus	x	
Lampadena sp.		x
Lampadena luminosa	x	
Lampanyctus spp.		x
L. macropterus	x	
L. indet.	x	
L. tenuiformis	x	
L. nobilis	x	
Lepidophanes sp.		x
L. longipes	x	
Ceratoscopelus warmingi	x	x
Bolinichtys blacki	x	
Diogenichtys panurgus	x	

layer (D II) Myctophidae were dominant followed by Chauliodus sp. In the shallow night layer (N I) Myctophidae were still the dominant fish. In 1979 Cubiceps sp and other fishes were also important while swimming crabs and salps made up a large part of the total catch in 1981.

The deep night layer (N II) was sampled only a few times. Both years jellyfish made up a large part of the catches. Among the fish, Myctophidae were dominant. In 1979 Gonostomatidae and Sternoptychidae made up 10% each.

A preliminary list of the Myctophidae identified so far is given in Table 4. A complete list must await a more thorough analysis of some samples.

Quantitatively Benthosema pterotum was the dominant species in the western part of the Gulf (W of 47°E) while various Diaphus species dominated in the eastern part. In 1979 Lampanyctus spp. were also rather important.

REACTION TO LIGHT

The reaction of mesopelagic fishes to light was studied twice in the Gulf Of Oman. A 1000 W high pressure sodium lamp was used as a light source.

The first experiment was carried out at new moon. The light was mounted at the side of the vessel and the echo sounder was used to monitor the reaction of the fish. Underwater photography was used to identify the organisms aggregating. The light made the scattering layer sink and concentrate at a depth of about 50 m (Fig. 10). Photographs show that myctophids were the dominant organisms in this layer (Fig. 11).

In the second experiment the light was mounted on a small boat. This experiment was carried out about 10 days after new moon. This time the fish concentrated in a cone around the light (Fig. 12), but the concentrations were not as dense as those observed during the first experiment.

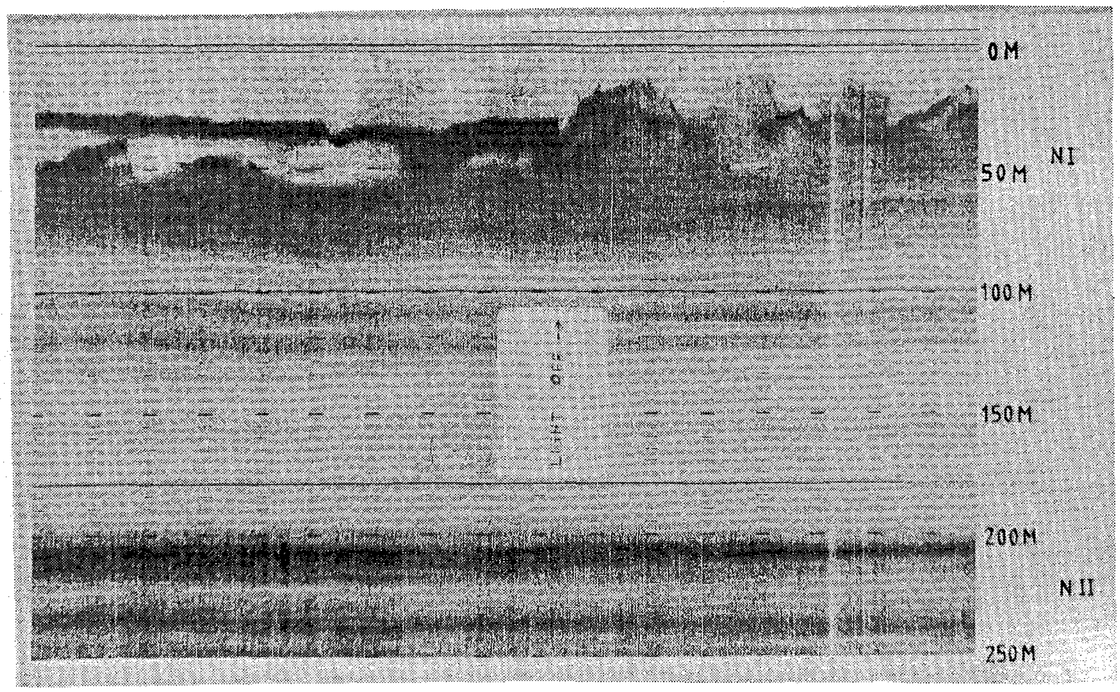

Fig. 10. Echogram from a light station, showing the dispersion of fish when the light is turned off. The ship was laying still during the recording.

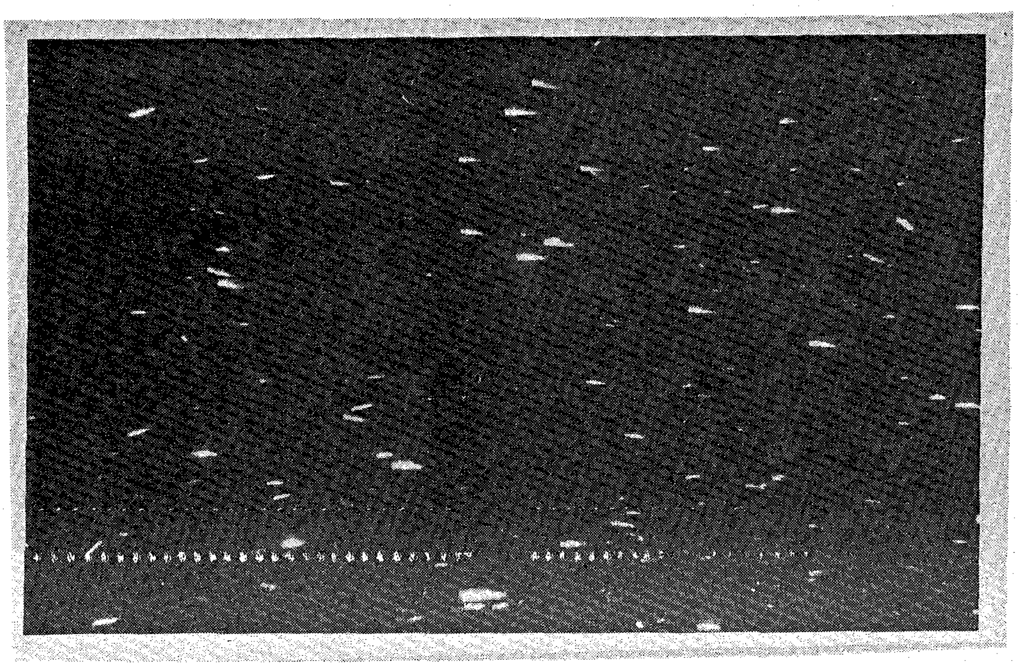

Fig. 11. Photo taken in 50 m depth at the light station shown in Fig. 10.

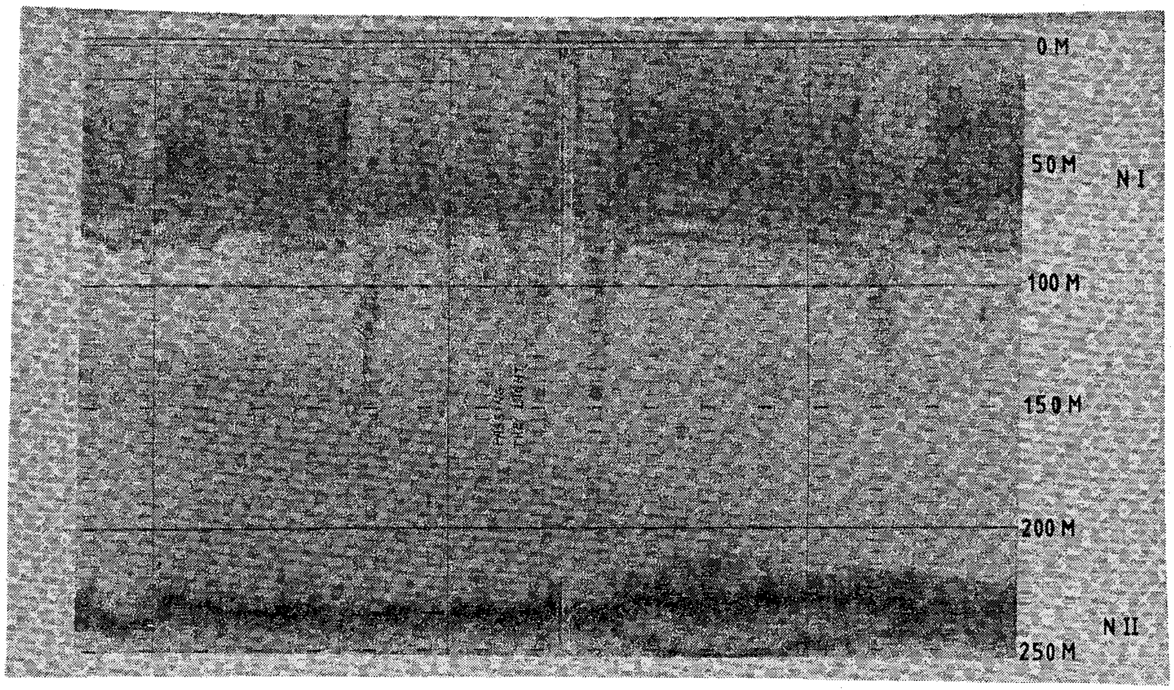

Fig. 12. Echogram from a light station showing slightly increased concentration at some distance from the light source.

During both experiments most of the myctophids present were adult B. pterotum with length between 35 and 43 mm. Most of them had mature gonads.

ACOUSTICAL ABUNDANCE ESTIMATION

GULF OF OMAN

During 1979 the southern part of the Gulf of Oman was covered during the period 4 July - 3 August. The northern part was not surveyed (Fig. 1).

The echo abundance was converted to biomass using the equations

$$B = C' L\bar{M} A$$

where B is biomass, C' convertion factor, L average fish length, $\bar{M}$ average integrator reading and A is the corresponding area (see page 3). A mean fish length of L=35 mm was used for the transformation (see Fig. 16).

In the part of the Gulf covered, a biomass of about 6 million tonnes was found. If the densities recorded are representative for the whole Gulf, the total biomass of mesopelagic fish was about 8 million tonnes.

The density of fish per m^2 surface area was calculated for one degree squares. It ranged from 20 to 165 g/m^2 with a mean of 87 g/m^2.

In 1981 the abundance of mesopelagic fish in the Gulf of Oman was studied during three surveys (Fig. 3):

I	24 - 28 January
II	28 - 31 January
III	9 - 14 February

The period 1 - 9 February was used for a detailed survey with fishing experiments in the area south of $24^{o}50'$N and west of $57^{o}40'$E.

In 1981 the mean length of the fish was 39 mm (see Fig. 17) and the variation between areas and between the different layers were too small to warrant the use of different lengths, in the conversion factor.

During night time parts of the fish seemed to be found in the upper 10 m and were therefore lost. During day time parts of the organisms responsible for the echo obtained from the lower layer were not fish. No compensation is made for these biases in the following estimates. It is also supposed that those parts of the Gulf covered (about 2/3) are representative for the whole area. Based on these assumptions the following abundance of mesopelagic fish was estimated:

Survey	I	8 mill. tonnes
	II	11 " "
	III	13 " "

The variances are rather high (Table 5) and the differences between the estimates may not be significant. The mean of the three estimates,

11 million tonnes

therefore seems to be the best estimate of the biomass of mesopelagic fish in the Gulf of Oman in January - February 1981.

Table 5. Echo abundance (mm integ. deflection) from the three main surveys in the Gulf of Oman.

Survey	DAY					NIGHT				
	No. five miles	D I mean	D I SD	D II mean	D II SD	No. five miles	N I mean	N I SD	N II mean	N II SD
I										
W58°E	25	50	52	183	240	32	117	47	88	173
E58°E	14	57	186	30	63	29	79	59	1.4	2.2
II										
W58°E	27	23	26	360	407	38	175	79	82	127
E58°E						19	94	45	31	57
III										
W58°E	41	63	74	286	181	28	175	79	73	88
E58°E	34	55	89	152	250	36	122	64	10	18

DETAILED SURVEYS IN 1981

An area in the Gulf of Oman south of 24°50'N and west of 57°40'E was covered six times during the period 1-9 February. The coverage differed, so the six surveys are not directly comparable. Several trends are, however, evident (Table 6). The upper day layer usually had the lowest echo abundance and high variance. The lower day layer always showed the highest echo abundance and usually high variance. The two night layers had similar abundance. The upper layer had low variance, the lower higher. In general these trends can also be seen in the data from the main surveys.

Table 6. Echo abundance from the detail surveys 1-9 February 1981.

Date	DAY					NIGHT				
	No. five miles	D I		D II		No. five miles	N I		N II	
		mean	SD	mean	SD		mean	SD	mean	SD
1-2	13	138	104	924	691	7	147	57	103	254
2-3	12	146	133	533	210	8	187	59	156	116
3-4	6	86	61	523	348	9	268	116	252	169
4-5	9	70	36	1039	678	10	302	53	303	115
5-6	13	32	43	348	315	19	232	74	226	137
6-9	9	120	118	569	327	17	221	80	161	141
Mean	62	100	100	654	518	70	230	86	204	158

Totally the day recordings were higher than the night recordings. No significant increase or decrease in abundance could be traced during this period.

Converted to biomass of mesopelagic fish in the area (2120 n.miles^2) the following results are obtained:

Detail survey	1	3.7 million tonnes
	2	2.7 " "
	3	2.3 " "
	4	4.2 " "
	5	2.1 " "
	6	2.4 " "
Mean		2.9 million tonnes
Standard deviation		0.8 million tonnes

GULF OF ADEN

The Gulf of Aden was surveyed during the period 8-29 August 1979 (Fig. 2). The integrated echo abundance was converted to biomass as described above (page 18).

In the western part of the Gulf of Aden, B. pterotum with mean length about 4 cm was an important component of the scattering layers, and this length is used for the calculation. In the eastern part of the Gulf there was much variation in species and size composition, and fishes with no swim bladder (eg. Chauliodus) had an important position in the fauna. It is therefore difficult to estimate an equivalent mean size. Four centimeters was used, however, although it probably gives an underestimate of the true biomass.

The total biomass of mesopelagic fish was estimated to 2.6×10^6 tonnes in the Gulf of Aden west of 47^oE and 1.6×10^6 tonnes between 47^o and 51^oE. According to the acoustical surveys the total biomass was therefore about 4 million tonnes.

The density of fish per m^2 surface area was calculated for one degree squares. It varied from 50 g/m^2 and 7 g/m^2 within the Gulf of Aden. The mean density was 17 g/m^2.

Five one degree squares in the inner part of the Gulf of Aden were covered three times during the survey with the following results:

Period	Fish density
8 - 19 August	23 g/m^2
20 - 25 "	41 "
26 - 29 "	42 "

As a total of 14 one degree squares were covered more than once and the estimated biomass increased in 13 of these, the increase seems to be significant. The performance of the equipment was followed carefully throughout the survey, and no change was recorded. During the last part of the cruise a different setting of the equipment was used (see Annex 2). On very scattered recordings in deep water this can account for a 30% increase in estimated abundance due to a lower threshold effect. For dense recordings, however, there is little difference between the settings. This change can therefore only partly explain the increase in estimated abundance.

A few squares in the central and eastern part of the Gulf were also covered more than once. These too, indicated a rise in biomass, although less pronounced. Therefore, migration cannot account for the increase. Individual growth can explain at least part of the increase. Recruitment of juveniles, which according to plankton samples were abundant during the first part of the cruise, may also be part of the explanation.

In 1981 the abundance was estimated during one survey conducted 17 to 26 February (Fig. 4).

The integrated echo abundance (Table 7) was converted to biomass using the same conversion factors as in the Gulf of Oman. The mean length of the targets was supposed to be 33 mm.

Table 7. Mean echo abundance (mm integ.deflection) from the scattering layers in the Gulf of Aden 1981.

	West of 47°E			East of 47°E		
	No. of five miles	mean	SD	No. of five miles	mean	SD
Day D I	30	1.3	3.1	94	11.3	15.6
D II	30	91	32	94	136	132
Night N I (excl. plankton)	48	50	44	90	110	65
N II	48	44	20	90	45	34

The following estimates were obtained:

Area west of 47°E	9 million tonnes
Area east of 47°E	8 million tonnes
Total Gulf of Aden	16 million tonnes

These estimates include all sound scatterers excluding the plankton in the N I layer. No compensation is made for the fact that a considerable part of the fishes caught in the deep layers have no swim bladder, and therefore lower target strength.

CATCH RATES

In the Gulf of Oman 52 trawl stations were taken in the mesopelagic fish layers in 1979 and 74 in 1981. (See Annex 3 for details.) In 1979 the mean catch rate was 200 kg/h, 6% of the stations gave catch rates higher than 500 kg/h, and 2% higher than 1000 kg/h (Table 9).

In 1981 the mean catch rate was about 1000 kg/h and 44% and 36% of the stations gave catch rates higher than 500 kg/h and 1000 kg/h respectively. Seven percent gave more than 6000 kg/h (Table 9).

Most of the high catch rates were obtained in the shallow day layer (D I), but also nearly 20% of the hauls in the surface layer (N I) during night gave catch rates higher than 1000 kg/h.

In the Gulf of Aden 28 and 23 trawl stations were taken in the mesopelagic fish layers in 1979 and 1981 respectively. The mean catch rates were very low (40 and 60 kg/h) and no hauls gave catch rates higher than 500 kg/h (Table 9).

Table 9. Distribution of catch rates during the cruises in 1979 and 1981.

Year Area	Type of layer	Catch rate in kg/h <50	50 – 499	500 – 999	1000 – 1999	2000 – 3999	4000 – 5999	6000 – 7999	≥8000
<u>1979</u>									
Gulf of Oman	D I		15	1	1				
	D II	5	6						
	N I	2	19	1					
	N II	1	2						
Gulf of Aden	D I	1							
	D II	15	1						
	N I	6	3						
	N II	1	1						
<u>1981</u>									
Gulf of Oman	D I		4	2	8	8	3	4	1
	D II	2	12						
	N I	1	16	3	1	2			
	N II		7	1					
Gulf of Aden	D I	2	2						
	D II	6	3						
	N I	4	6						
	N II								

CATCH RATES IN RELATION TO DENSITY ESTIMATES OBTAINED BY ECHO-INTEGRATION

During trawling echo integration was run in a depth interval corresponding to the vertical opening of the trawl. From these values the average fish density (g/m^3) at the trawl opening was estimated. These estimates are plotted against the obtained catch pr m^3 filtered sea water in Fig. 13. Table 10 shows the average "trawl efficiency" (the ratio between catch/m^3 and density) for each layer. The average "trawl efficiency" seems to be considerably higher for the D I layer than for any of the other layers. This difference is significant, while the difference between D II, N I and N II are not significant.

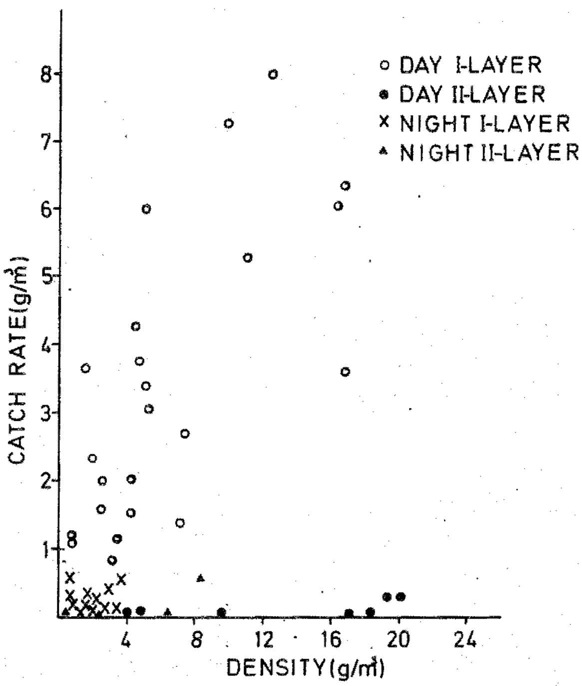

Fig. 13 A

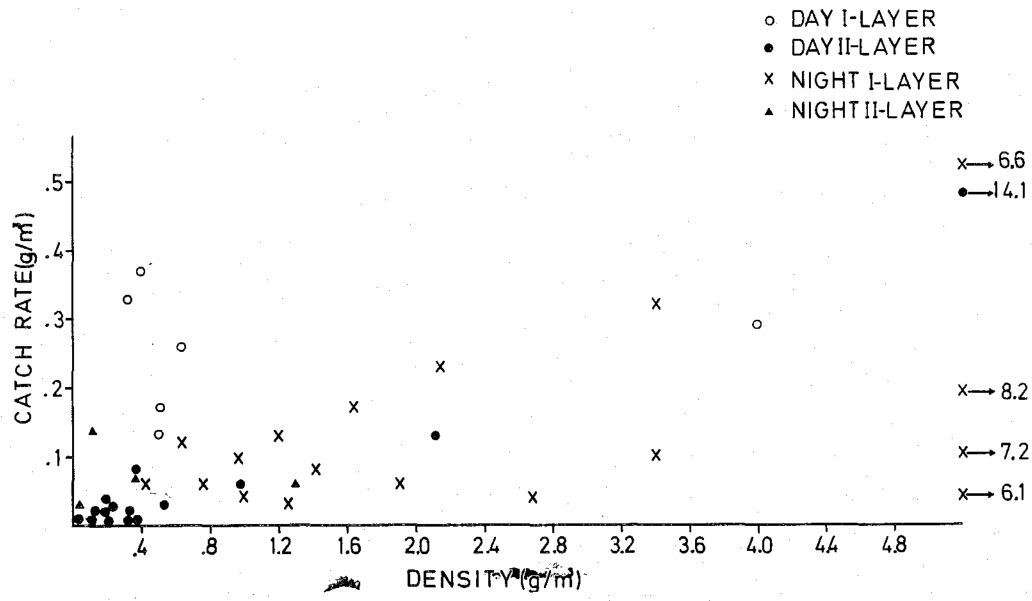

Fig. 13 B

Fig. 13. Catch rate (grams per m^3 filtered seawater) in relation to fish density (g/m^3) estimated acoustically in various layers.
A: Gulf of Aden and Gulf of Oman July-August 1979.
B: Gulf of Oman January-February 1981.

Table 10. Average "trawl efficiency" [ratio between catch (gram) pr m^3 and density (g/m^3)] for various layers during the two cruises.

Kind of layer	D I		D II		N I		N II	
Year	1979	1981	1979	1981	1979	1981	1979	1981
Average trawl efficiency	0.51	0.77	0.11	0.05	0.07	0.17	0.61	0.07
Standard deviation	0.38	0.51	0.08	0.10	0.05	0.20	0.61	0.06
No. of stations	6	23	16	11	18	17	4	7

The low "trawl efficiency" in the N I, N II and D II-layers may give reasons to suspect that the fish in these layers were mixed up with plankton giving high contribution to the integrator values. The N I-layer was in fact mixed up with some plankton which remained as a separate layer in the upper 100 m during day time. However, the echo-contribution from this plankton layer usually represented just one to ten percent of the total integrator values during day time in the Gulf of Oman and up to 50% in the Gulf of Aden. Juday net hauls did not give much plankton in any of the layers.

In 1981 some underwater photos were taken in connection with trawl hauls and light experiments. Fish was recognized on most of the pictures in all layers, while plankton organisms were rather scarce. Salps and jellyfish were the only recognizable plankton on the pictures (Some faint traces could be shrimps). Table 11 shows the average number of fishes and salps per picture. About 30 pictures were taken at each station.

Table 11. Average number of fish and salps per picture taken in the scattering layers in the Gulf of Oman, January 1981.

Kind of layer	Nearest Trawl st. no.	Average number per picture		Remarks
		fish	salps + jellyfish	
D I	47	13	0.02	
D I	51	2	0.1	Camera not in the middle of the layer
D II	52	7	0.4	
D II	57	9	0.1	
N I	48	66	0.3	Fish gathered in the light
N I	48	3	1.0	Camera below the most dense layer
N I	59	5	0	

A cage calibration of salps indicated that the average target strength is in the order of -50 dB per kg salps, which means that some hundred kilos of salps are needed to give the same echo as one kg of fish.

The conclusions is that the echo contribution from plankton was small compared to the contribution from fish in all layers. Therefore the plankton is not responsible for the observed differences in "trawl efficiency". There has to be a real difference in catchability.

The D I layer was composed of schools in a presumably lighted zone, while the other layers in darkness, had a rather homogeneous density. This difference in light conditions may cause a difference in the fish reaction towards the trawl. Probably the fish in the D I layer are able to see the trawl. The fish has not enough mobility to avoid the trawl opening, but they may be able to avoid coming in contact with the walls of the foremost part of the trawl. This means that they may be herded towards the centre of the trawl, thus being more easily caught. The fish in the other layers are probably not able to see the trawl and may therefore have a less directional reaction, so that much of the fish may be filtered through the meshes in the foremost part of the trawl. The average "trawl efficiency" for the D II, N I and N II layers together is 0.13, which seems to be reasonable for small, passive fishes, when the shape and mesh size of the trawl are taken into consideration (Fig. 13).

COMPARISONS WITH PREVIOUS CRUISES

In the Gulf of Oman the five acoustical surveys carried out by R/V "Dr. Fridtjof Nansen" during 1975-76 gave abundance estimates ranging between 8 and 20 million tonnes (mean 13 million tonnes). The survey in August 1979 gave 8 million tonnes and then in January 1981 11 million tonnes, provided that abundance off the coast of Iran, which was not covered, was similar to that on the Oman side (Fig. 14).

In the Gulf of Aden the previous cruises gave estimates ranging between 6 and 40 million tonnes (mean 20 million tonnes), while the cruises in 1979 and 1981 lead to an estimate of 4 million and 16 million tonnes respectively (Fig. 15). Although the total biomass usually has been larger in the Gulf of Aden than

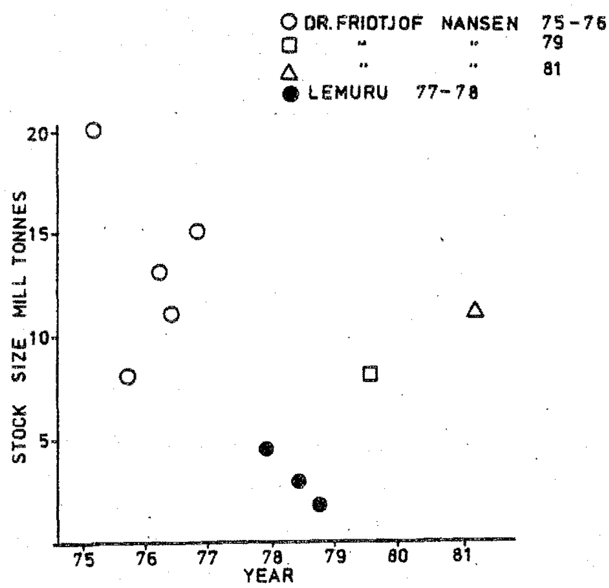

Fig. 14. Estimated abundance of mesopelagic fish in the Gulf of Oman 1975 - 1981.

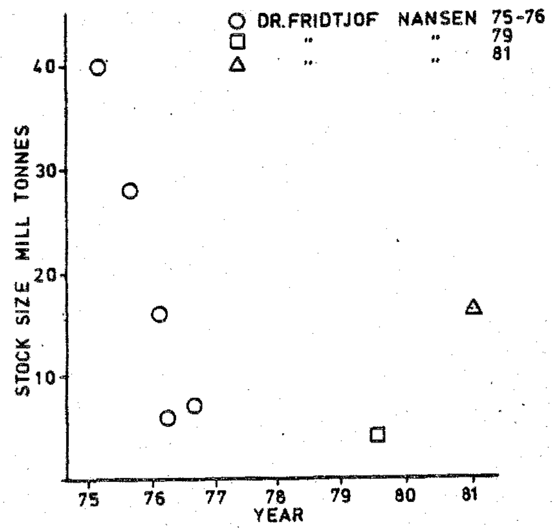

Fig. 15. Estimated abundance of mesopelagic fish in the Gulf of Aden 1975 - 1981.

in the Gulf of Oman, the biomass per unit surface area has usually been highest in the Gulf of Oman.

It is more difficult to compare the trawl catches because during the cruises conducted in 1975-76 trawling was mainly conducted to identify the sound scatters, and not to obtain high catch rates. Trial fishing was, however, one of the objectives of the surveys in 1979 and 1981.

In spite of this difference in approach we had lower mean catch rates from the mesopelagic fish layer in the Gulf of Aden in these years than from most of the previous cruises (Table 12). In the Gulf of Oman the catch rates were low in 1979 but higher in 1981.

Table 12. Mean catch rates in kg/hour of trawling from the mesopelagic fish layers on cruises with R/V "Dr. Fridtjof Nansen".

Cruise	Gulf of Oman			Gulf of Aden		
	Catch kg/h	Myctophidae %	No of hauls	Catch kg/h	Myctophidae %	No of hauls
1-2				120	94	7
3	280	89	4	4900	96	2
4	2470	99	10	230	90	6
5	1060	88	9	315	95	1
6	50	89	7	45	50	5
1979	200	93	52	40	40	28
1981	1010	94	74	54	60	23

In the Gulf of Aden there was also a difference in catch composition. With one exception (cruise 6) the family Myctophidae represented between 94 and 96% of the mean catches given in Table 2. In 1979 the corresponding proportion was about 40% and in 1981 60%. The percentage from 1979 is the lowest recorded. It seems therefore that the abundance of this family has decreased even more than the decrease in total echo abundance suggests. In the Gulf of Oman no such change was observed.

During the "Regional fishery survey and development Project" the echo abundance of mesopelagic fish in the Gulf of Oman was estimated by R/V "Lemuru", and the following results were obtained:

November	1977	4.6 million tonnes
May	1978	2.9 million tonnes
September	1978	1.7 million tonnes

These results are very much lower than those obtained by R/V "Dr. Fridtjof Nansen" both in 1975-76 and in 1979 and 1981.

In parts of the area R/V "Lemuru" observed denser concentrations than those found with the R/V "Dr. Fridtjof Nansen", but also large areas with no recordings of mesopelagic fish was reported from the "Lemuru" survey.

This difference is probably caused by the much lower performance, and the higher threshold used on the acoustical equipment on R/V "Lemuru" compared with that on R/V "Dr. Fridtjof Nansen" (FAO, 1981).

BIOLOGICAL OBSERVATIONS

Samples were taken to study size distribution, age, gonad maturation and feeding. These studies are in progress, and will not be treated here. Some size distributions are, however, given in Fig. 16-18.

TRAWL EXPERIMENTS

In 1979 the Krill trawl was used with different weights on the lower wings. Two hauls with 80 kg weights on the wings gave trawl openings of 10 and 13.5 m. When the weights were increased to 190 kg, the vertical opening varied between 12 and 18.5 m. Higher speed gave smaller vertical opening.

To compare the efficiency of the Krill trawl and the Harstad trawl, 10 parallel trawl hauls were carried out (Table 13). The effective opening of the trawls are estimated to be 250 m^2 and

400 m^2 for the Krill and Harstad trawl respectively, and the catches were corrected according to their openings.

If we look at catch per nautical mile, the Krill trawl caught in average 143 kg and the Harstad trawl 82 kg. This difference was analysed using a Wilcoxon paired-sample test, and found to be significant.

The Harstad trawl was towed with higher speed as it was difficult to keep the speed constant during the trials. Average

Tabell 13. Comparison of Krill trawl and Harstad trawl 1979. (Original data, not corrected for trawl opening).

Tr.st. no.	Type of trawl	Depth	Layer	Speed knots	Trawl opening m	Catch pr. n. mile	Catch pr. hour
159	Krill	42	N I	2.3	14	47	105
160	Harstad	41	N I	2.7	15	33	80
162	Krill	176	D I	2.0	14	118	248
163	Harstad	183	D I	2.1	14	180	405
166	Harstad	38	N I	3.3	15	28	90
167	Krill	40	N I	2.2	14	44	105
172	Krill	35	N I	1.5	13.5	31	47
174	Harstad	35	N I	2.2	13	55	120
175	Krill	280	D II	2.0	15.5	26	49
176	Harstad	291	D II	2.3	13	13	30
179	Krill	48	N I	2.0	17	145	270
180	Harstad	36	N I	2.3	15	44	110
181	Harstad	33	N I	2.5	15	206	495
182	Krill	33	N I	2.2	14	236	495
190	Krill	204	D I	2.0	16	77	150
191	Harstad	187	D I	2.0	17	131	255
192	Krill	315	D II	2.2	17	38	90
193	Harstad	277	D II	2.8	17	15	41
194	Krill	20	N I	2.2	12	135	270
195	Harstad	20	N I	3.3	12	118	400
199	Harstad	30	N I	2.9	14	21	60
200	Krill	30	N I	3.0	14	27	80

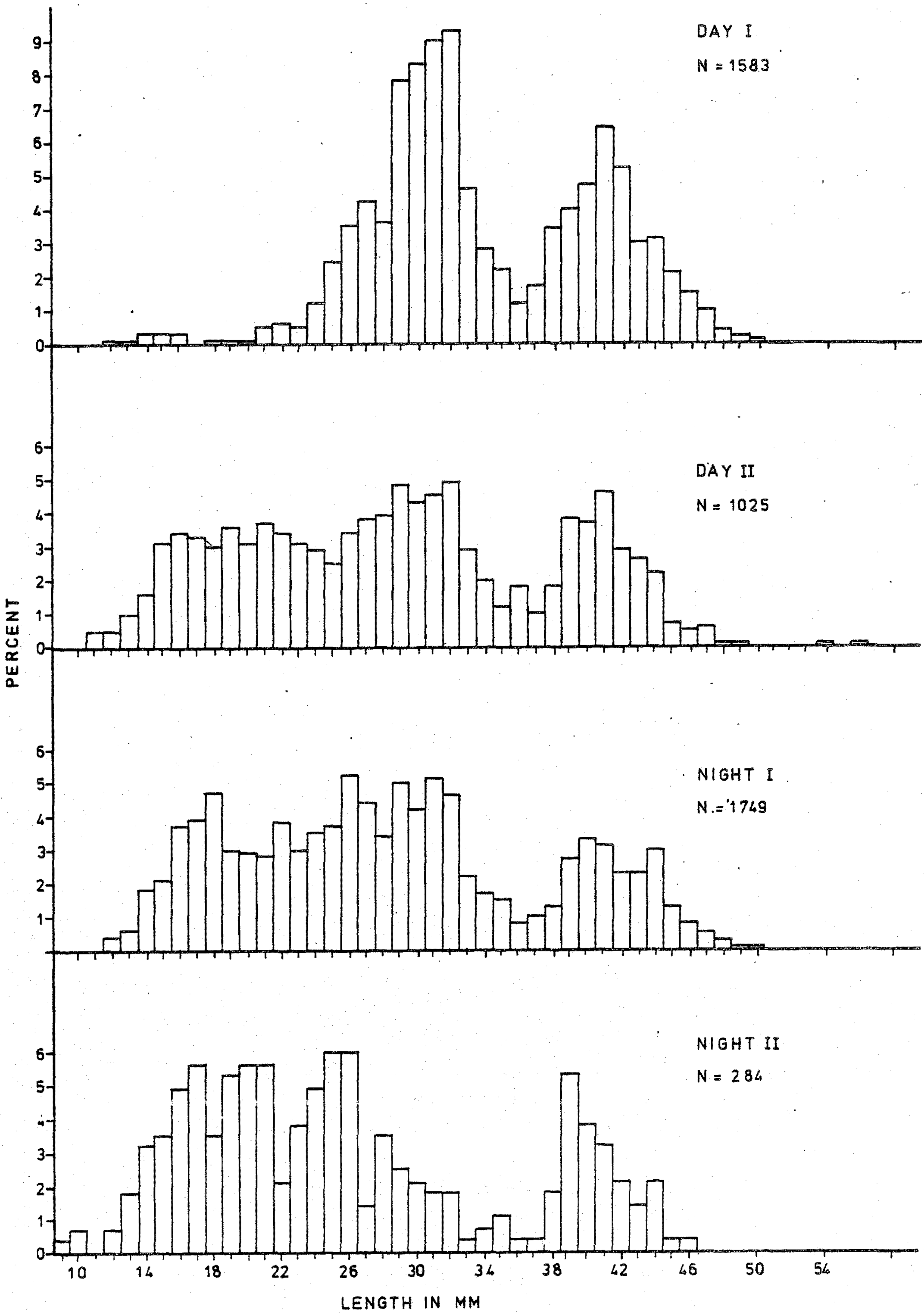

Fig. 16. Size distribution of B. pterotum in the Gulf of Oman, July 1979.

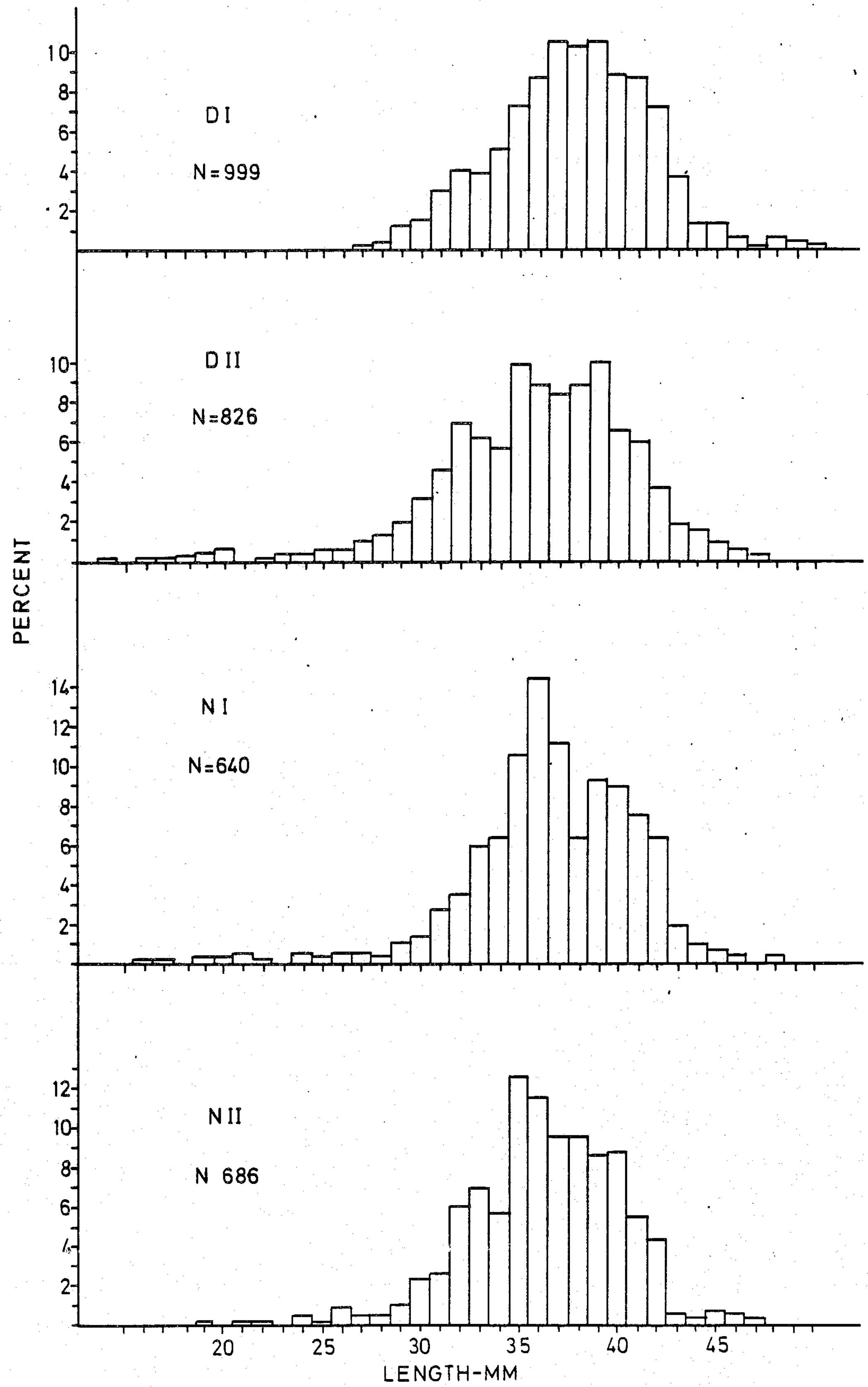

Fig. 17. Size distribution of B. pterotum in the Gulf of Oman, January - February 1981.

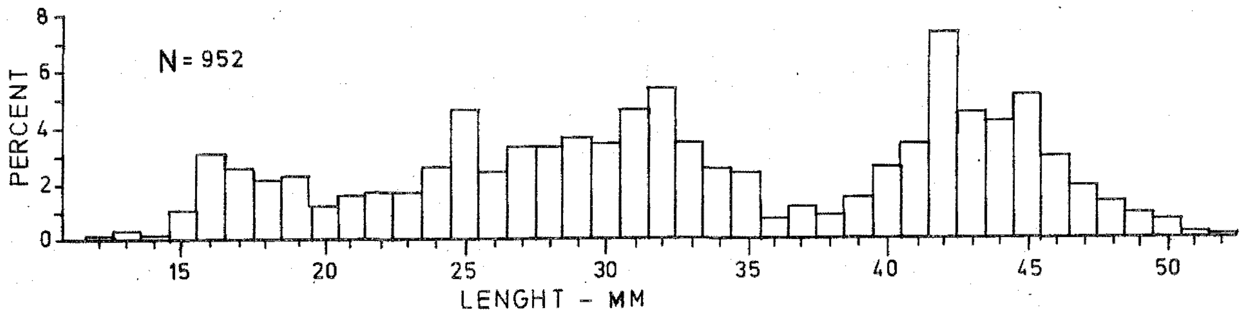

Fig. 18. Size distribution of B. pterotum in the Gulf of Aden. February 1981.

catch per hour trawled for the Krill trawl and the Harstad trawl was 293 and 203 kg respectively. This difference was also analysed and found to be significant.

Possibly a larger part of the smallest fish are filtered through the meshes in the Harstad trawl than in the Krill trawl. Then fish caught in the Harstad trawl should be expected to be larger than those caught in the Krill trawl. Fig. 19 shows the length distribution for the fish caught in the Krill trawl and Harstad trawl in the 10 parallel trawl hauls. The figure does not give any reason to believe that there is any significant difference in size.

In the same way we have split these length distributions in fish, caught at day and at night with the two trawls, but none of the distributions indicate a difference in size of fish from the two trawls.

Experiments with fine meshed net bags attached to the outside of the panels of the Krill trawl was carried out to catch fishes filtered out through the meshes in the trawl. Three net bags were attached in positions shown on Fig. 20. The results of these experiments are given in Table 14. The catches in the net bags showed great variations and no correlation to the catches in the cod end of the trawl. It is difficult to draw any conclusions about the filtering effect of the trawl from these experiments.

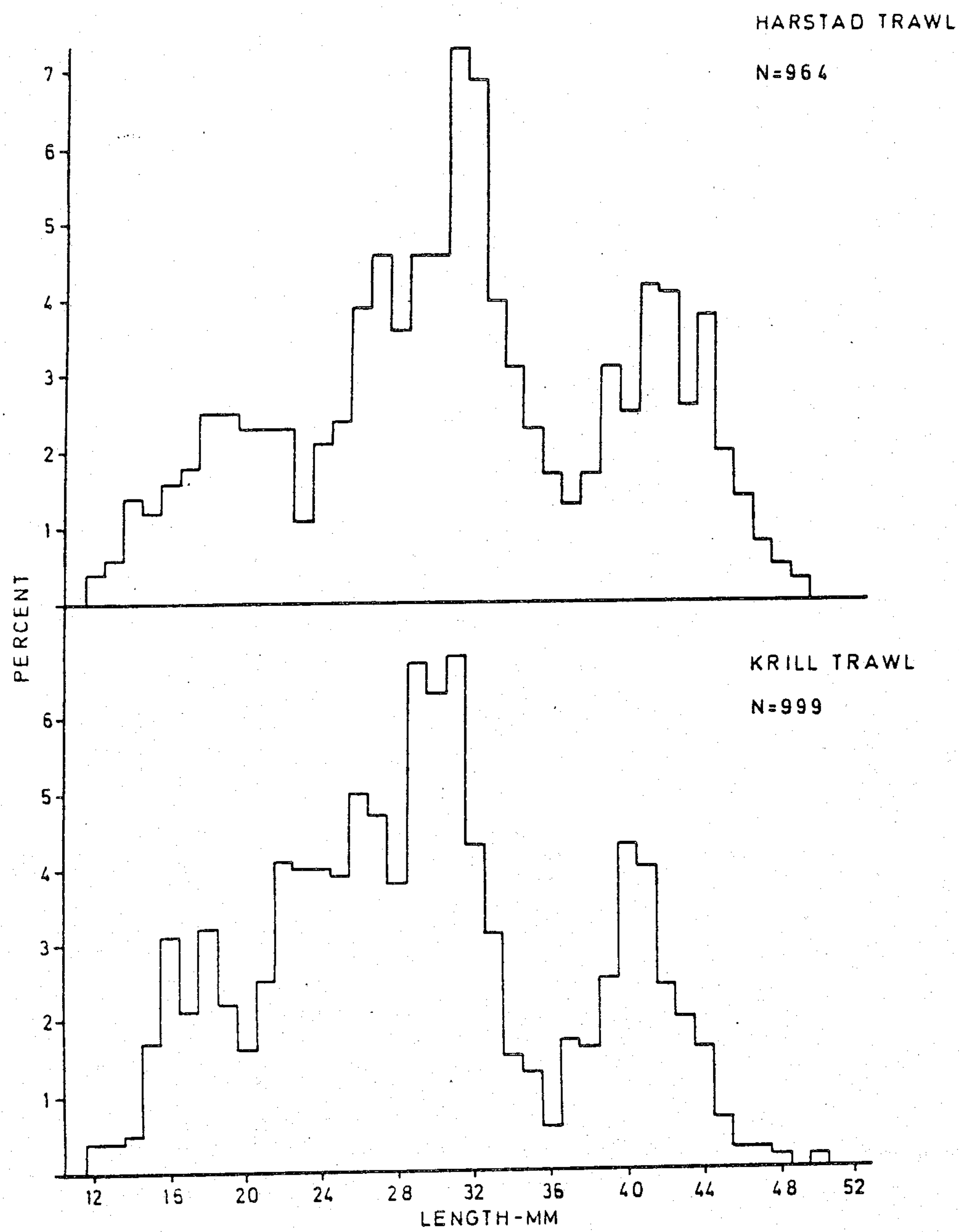

Fig. 19. Length distribution of B. pterotum from the Krill trawl and the Harstad trawl, 1979.

Table 14. Catches in bags on the Krill trawl 1979.

Tr.st. no.	Total catch	Number of fish in each bag			Number of fish per kg catch		
		Forward	Central	Backward	Forward	Central	Backward
159	70	8	2	0	0.11	0.03	0
161	120	14	4	0	0.12	0.03	0
162	165	0	5	0	0	0.03	0
164	250	0	3	3	0	0.01	0.01
165	40	0	2	1	0	0.05	0.03
167	70	10	1	17	0.14	0.01	0.24
168	230	18	0	11	0.08	0	0.05
169	195	50	1	51	0.26	0.01	0.26
170	90	19	4	2	0.21	0.04	0.02
172	27.5	0	0	0	0	0	0
175	33	2	25	1	0.06	0.76	0.03
178	90	4	3	3	0.04	0.03	0.03
179	180	115	1	7	0.64	0.01	0.04
182	330	54	4	36	0.16	0.01	0.11
183	900	1	3	3	0.001	0.003	0.003
187	20	1	0	0	0.05	0	0
190	100	4	1	0	0.04	0.01	0
194	135	2	0	0	0.02	0	0
195	200	7	77	2500	0.04	0.39	12.50
196	45	0	55	0	0	1.22	0
201	40	0	0	0	0	0	0
203	40	0	0	0	0	0	0
206	60	6	0	4	0.10	0	0.67
224	10	13	0	0	1.30	0	0
225	17	0	0	5	0	0	0.29
226	20	0	0	0	0	0	0
233	15	4	0	0	0.27	0	0
234	20	0	0	0	0	0	0
235	25	5	0	0	0.20	0	0
236	15	0	0	0	0	0	0
240	14	4	2	0	0.28	0.14	0
242	25	19	0	2	0.76	0	0.08

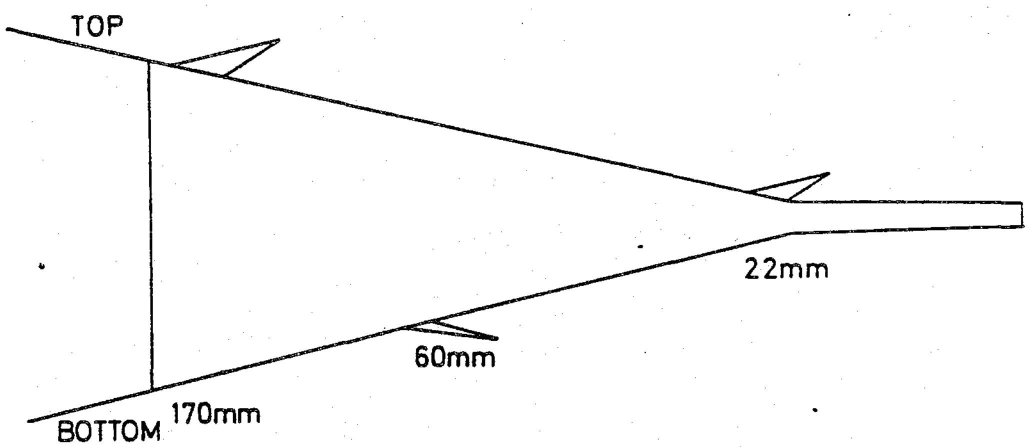

Fig. 20. Net bags used on the trawls. The figures indicate the mesh size in the trawl.

DISTRIBUTION OF EGGS AND LARVAE OF BENTHOSEMA PTEROTUM IN THE GULF OF OMAN

One of the objectives of this cruise to the Gulf of Oman was to find and identify eggs of Benthosema pterotum and to study the spawning biology of this species. These important biological aspects have not been described previously.

The distribution of myctophid larvae in the Gulf of Oman in January/February 1981 is presented in Figs. 21 A and B. Larvae of Benthosema pterotum predominated in these samples and completely outnumbered larvae of all other fish species.

B. pterotum larvae were found in 69, of 77 Juday net hauls (50-0 m) during the first survey (24 January - 1 February). The highest number of larvae found in one haul were 564. Three different areas with more than 200 larvae/m^2 were found (Fig. 21 A). One in the western part of the Gulf, close to the shelf region and northwards, one in the middle of the Gulf extending towards the Iran side of the Gulf and one area in the outer part of the Gulf of Oman in the slope region just east of 58^{O}E.

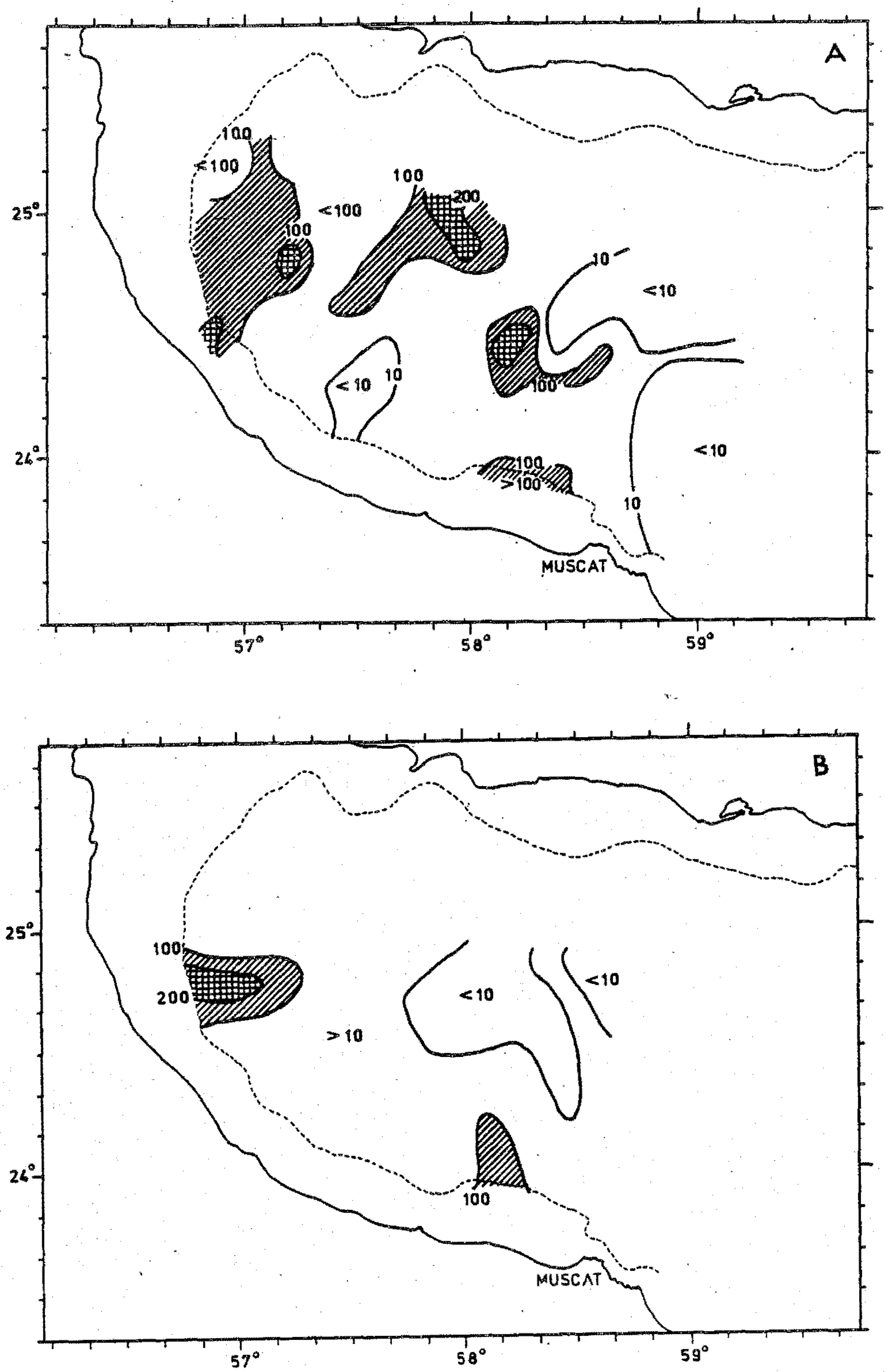

Fig. 21. Distribution of larvae of B. pterotum in the Gulf of Oman. Number of larval per m^2 surface area.
A: 24 January - 1 February. B: 9 - 13 February.

During the last survey (9-13 February) a reduced amount of B. pterotum larvae were found (47 of 51 Juday net hauls) compared to the first survey. Only one area with more than 200 larvae/m^2 were found (Fig. 21 B). The relative reduction of larval quantity was estimated by integration of the two distribution maps. During the second survey the quantity of larva was reduced by 63% compared to the quantity found during the first cruise.

This shows that the total concentration of larvae varies and changes quickly during a short period of time. This is most probably due to heavy predation on larvae, but could also be because the B. pterotum population in the area may spawn in cohorts.

The average number observed was 43 larvae/m^2 (109 samples). This density was equivalent to Fursa's (1973) observations in the Gulf in January-April in 1969. Nellen (1973), however, found the average of 335 larvae/m^2 in March-April 1965. Nellen (1973) also points out that B. pterotum larvae were the only myctophid species in the samples. In no other area such high concentrations of one single species of Myctophidae larvae have been observed. According to Fursa (1969, 1973) and Nellen (1973) the spawning period of B. pterotum in the Gulf of Oman clearly varies with the season, however most larvae seems to be found during the winter monsoon in January to April.

The eggs and newly hatched larvae of B. pterotum are not previously described. We were, however, successful in fertilizing and incubating B. pterotum eggs on board the R/V "Dr. Fridtjof Nansen", and thereby able to identify eggs and the early larval stages. Ripe fish were found in trawl samples from 200-300 meters depth. Eggs were dissected from the ovary and fertilized in sea water (20°C 36.6°/oo). Ripe eggs from the ovary had an opaque chorion, segmented yolk with one oil droplet. The eggs were slightly eliptical with a diameter of 0.7 - 0.8 mm (long axis). Transferred to sea water and fertilized, the eggs absorbed water and the diameter of the chorion increased to 1.0 - 1.1 mm. The chorion became transparent and almost spherical, the shape of the yolk mass was unchanged. The chorion of fertilized eggs was very fragile . (Details will be published elsewhere.) The incubation time was 16 hours and 10 hours at 20.5°C and 25.0°C respectively. The larvae were transparent without pigmentation at hatching, and the yolk sac was fully resorbed within three days at 25°C.

Broken hauls were taken from 100-50 and 50-0 meter on every second station during the last cruise. The results are presented in Table 15 as the distribution of B. pterotum eggs and larvae in double broken hauls through 24 hours.

Table 15. The distribution of B. pterotum eggs and larvae in broken hauls from 100-50 and 50-0 meters depth through 24 hours. (2-11 February, Gulf of Oman, see Fig. 21 B).

Hours	06h - 12h		12h - 18h		18h - 24h		24h - 06h	
Depth	100-50	50-0	100-50	50-0	100-50	50-0	100-50	50-0
% Eggs	100	0	0	0	0	0	81	19
% Larvae	30	70	1	99	20	80	27	83
No. of hauls	4	4	6	6	5	5	7	7

Most larvae were found in the upper 50 meters during 24 hours. Eggs were only found at midnight and in the early morning hours, and most eggs were found in the deepest hauls (100-50 m). The eggs found at midnight were all in the early clevage stages, and must have been spawned only a few hours prior to sampling. Eggs were only found in two hauls between 06 hours to 12 hours and these eggs were close to hatching. In one set of triple broken hauls, 300-200, 200-100 and 100-0 meters taken at 23 hour (5 February), eggs were only found in the two deepest hauls, 5 and 61 eggs respectively.

These observations indicate that B. pterotum spawns in the mesopelagic layer at night, and that the eggs slowly ascends towards the surface and hatch before they reach the upper 50 meters of the water column. With a few exceptions yolk sac larvae were found in hauls from 50-0 meters. This means that the most vulnerable larval stages are spent in deeper waters.

The main spawning area was found in the western part of the Gulf of Oman. In this area the highest concentration of both fish and larvae of B. pterotum were found. Judging from the distribution of larvae presented in Fig. 21 A it seems, however, that spawning occurs all over the Gulf.

From the data on the spawning period (Fursa 1969, 1973 and Nellen 1973) and our data on the spawning biology and distributions of eggs and larvae of B. pterotum in time and space, a very high effort, distributed over most of the year, will be necessary to give reliable estimates of stock size of B. pterotum from egg and larval surveys.

HYDROGRAPHICAL OBSERVATIONS

GULF OF OMAN

The hydrographical conditions in the Gulf of Oman during the two survey periods, summer 1979 (July-August) and winter 1981 (January-February) appear from Fig. 22-23. In the summer the surface water was characterized by high temperature stratifica-

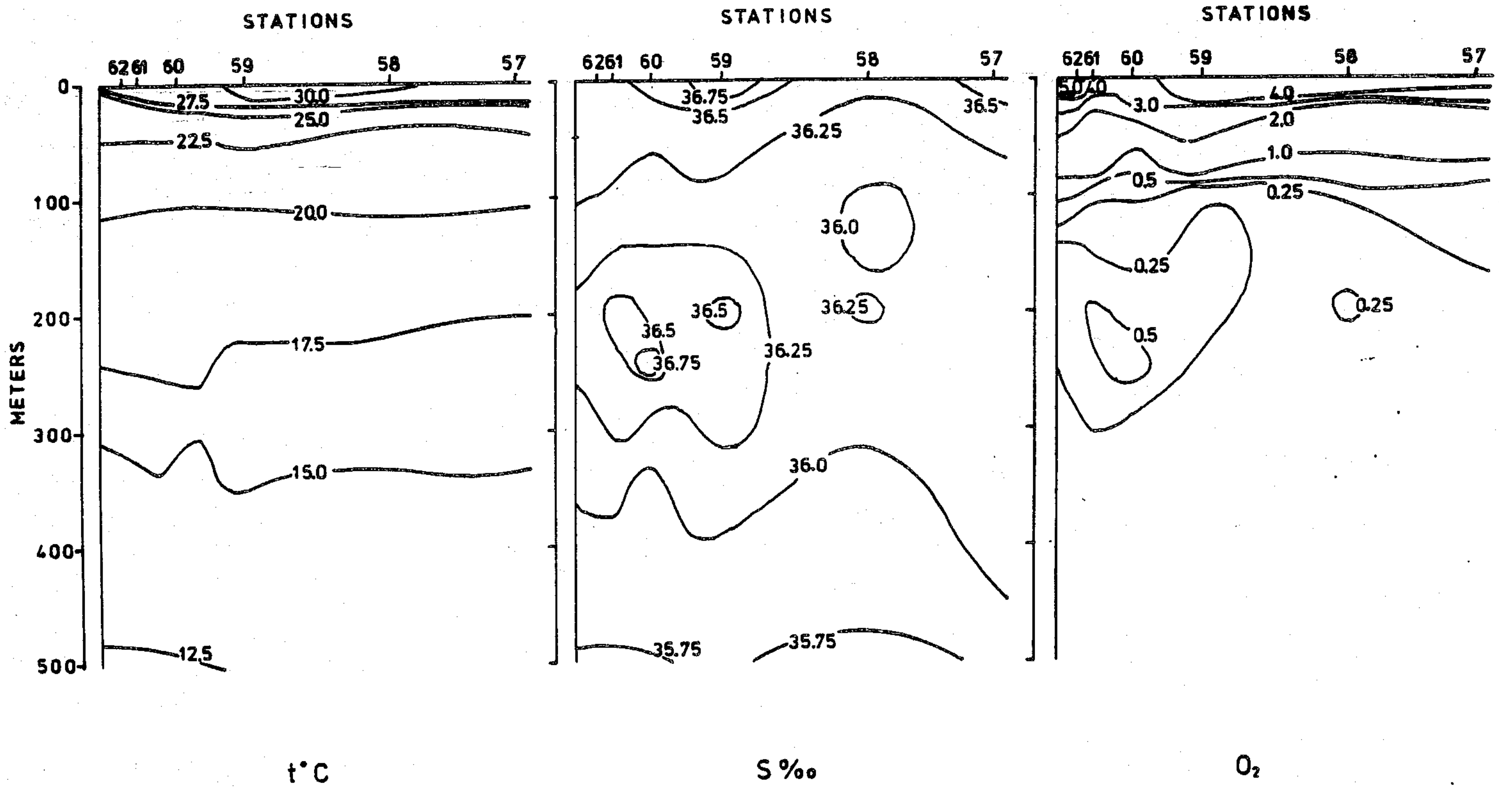

Fig. 22 A

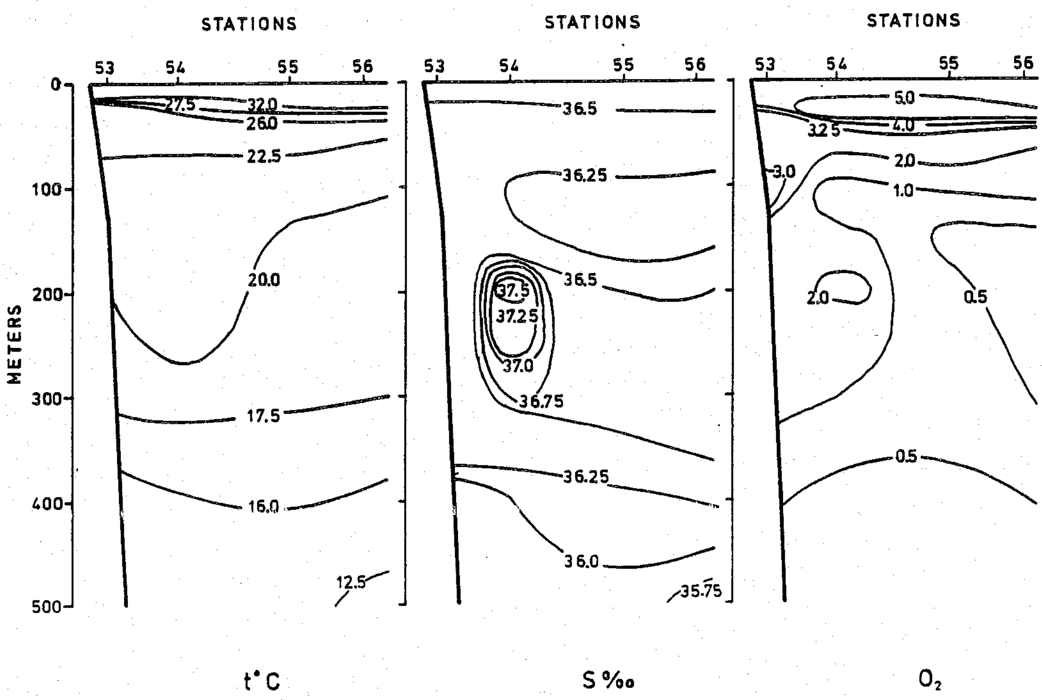

Fig. 22 B

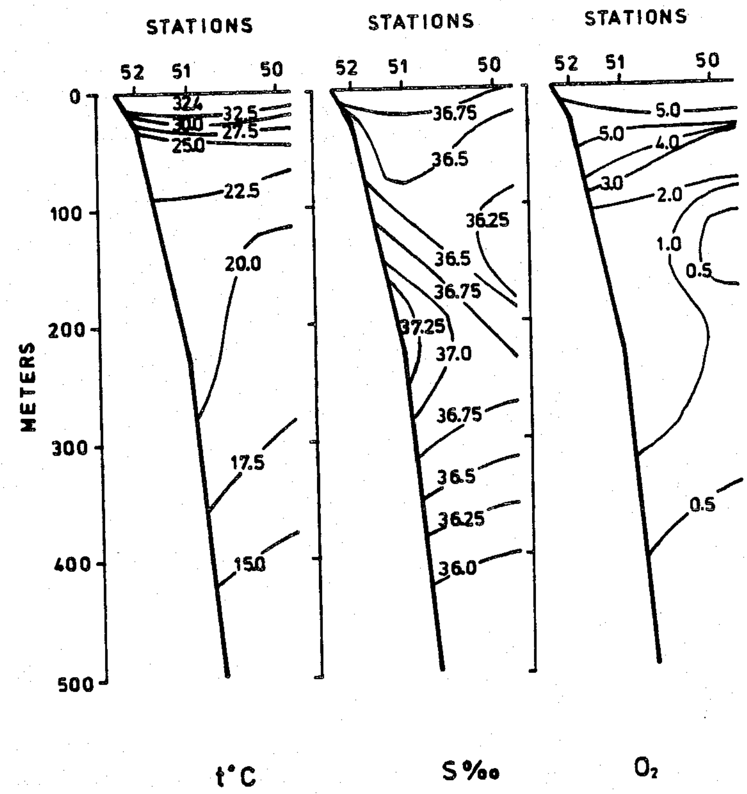

Fig. 22 C

Fig. 22. Hydrographical sections in the Gulf of Oman. August 1979. A: Section I B: Section II C: Section III

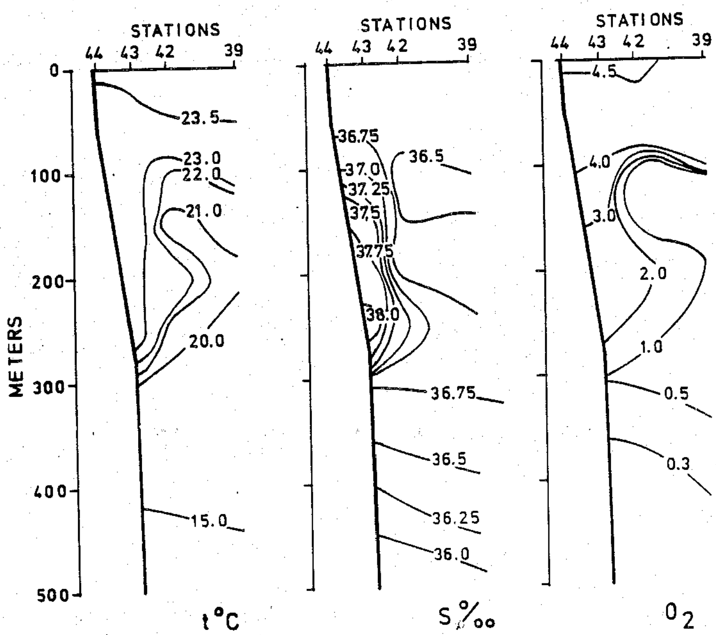

Fig. 23 A

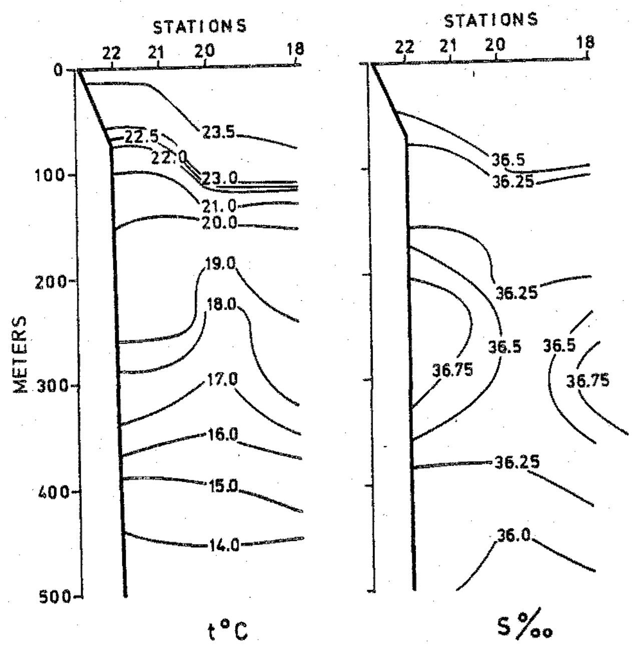

Fig. 23 B

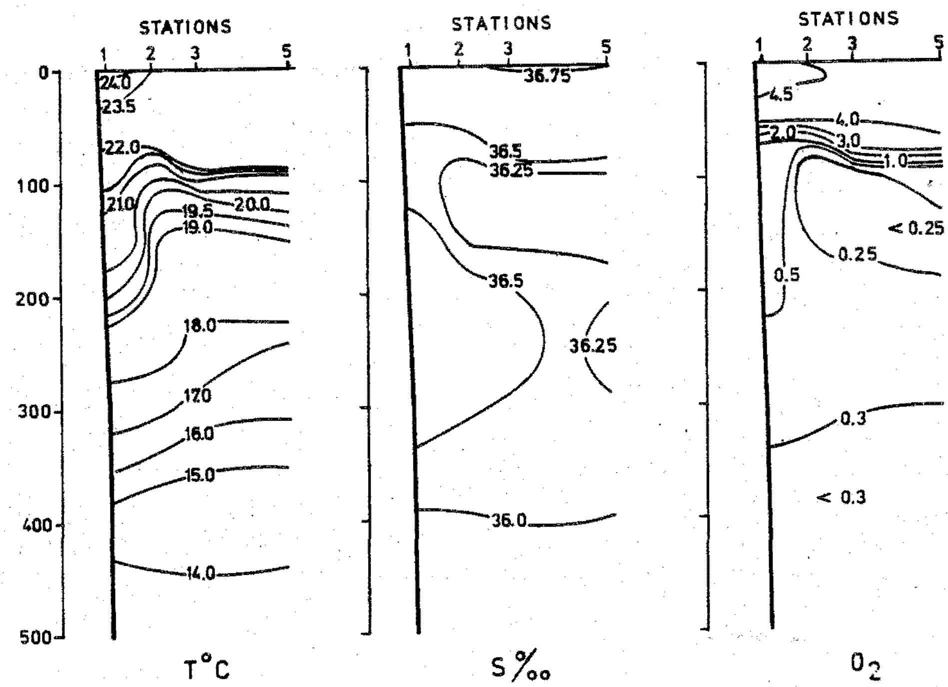

Fig. 23 C

Fig. 23. Hydrographical sections in the Gulf of Oman, January-February 1981. A: Section I B: Section II C: Section III

tion with a thermocline at about 25 m. The stratification of the watermasses is clearly controlled by the temperature with very little stratification of the salinity distribution in the surface watermasses. In winter 1981 the surface water was mixed down to 100 m on all three sections in the central part of the Gulf. The watermasses in the southern part of the Gulf along the continental slope of the Sultanat of Oman are influenced by watermasses that most probably originates from the Persian Gulf. This was observed in both surveys. In summer 1979 a core of water with high salinity was observed at section III (Fig. 22 C) at a depth between 150-250 m and at section II at about 175-300 m close to the continental slope. In winter 1981 the core of this watermass was observed at about the same depths and positions (Fig. 23).

The distribution of the oxygen content of the watermasses in the Gulf of Oman followed that of the temperature. The highest gradients were observed in the thermocline in both survey periods (Fig. 22-23). In summer 1979 water with oxygen concentrations lower than 0.5 ml/l was observed below 100 m on section I, and at about 400 m on section II and III. In winter 1981 oxygen minimum watermasses were found at 100-250 m on section I and cores of watermasses with low O_2 content at 150-200 m and 200-350 m on section II and on section III below 350 m.

GULF OF ADEN

The hydrographic featûres of the Gulf of Aden during the two survey periods are presented in Figs. 24-25. The surface watermasses were characteristic for the two seasons. During summer 1979 we observed the thermocline in the upper 50 m, varying in depth due to the current systems in the Gulf (Fig. 24). In winter 1981 the upper 100 m was characterized by unstable mixed watermasses, except for the central part of the Gulf where we observed a core of surface water with higher temperature and salinity. The thermocline was observed at about 100 m (Fig. 25).

The deep watermasses in the southern part of the Gulf was most probably influenced by currents from the Red Sea. A core of watermasses with high salinity (>36,5^{o}/oo) was observed at 250 m decending to more than 500 m on section I in summer 1979 (Fig. 24). In winter 1981 a core of watermass was observed in the same section (I) at about 400 m (Fig. 25). Oxygen minimum layers were found in summer 1979 at about 100-150 m on section I and II. In 1981 oxygen minimum layers were found in the Gulf of Aden at about 200 m.

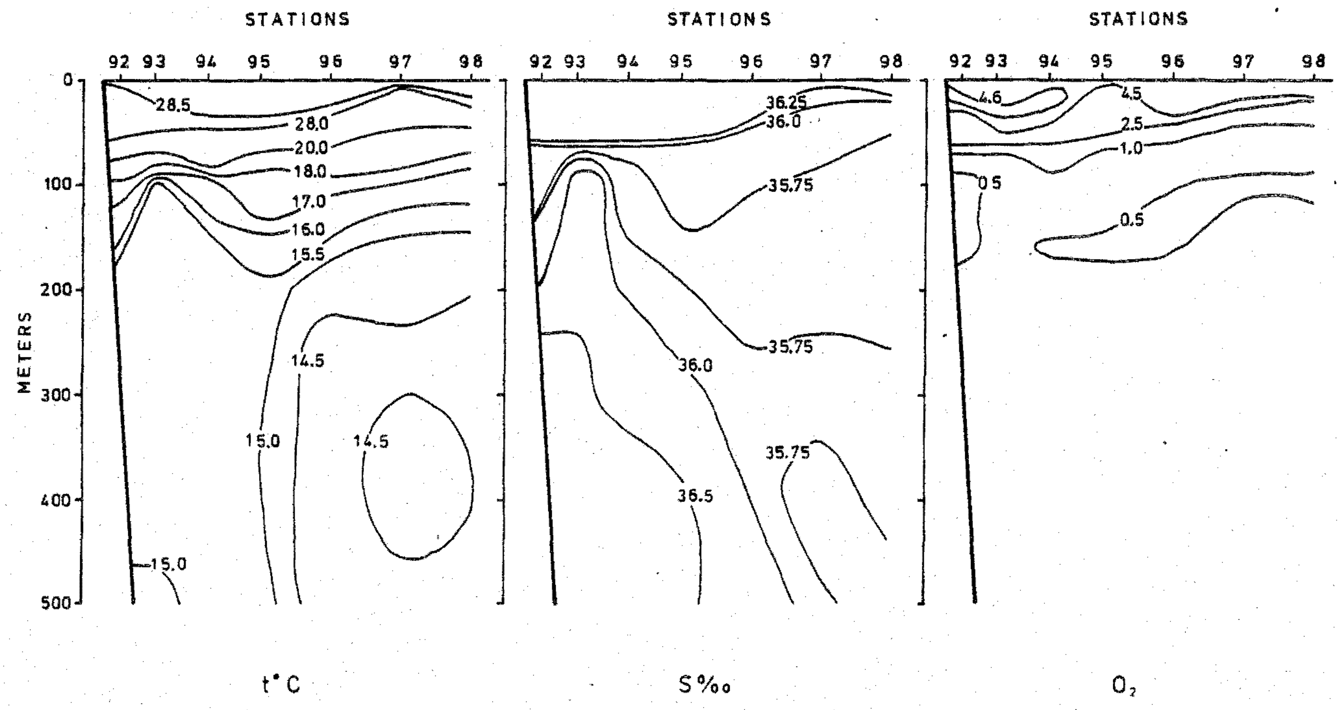

Fig. 24 A

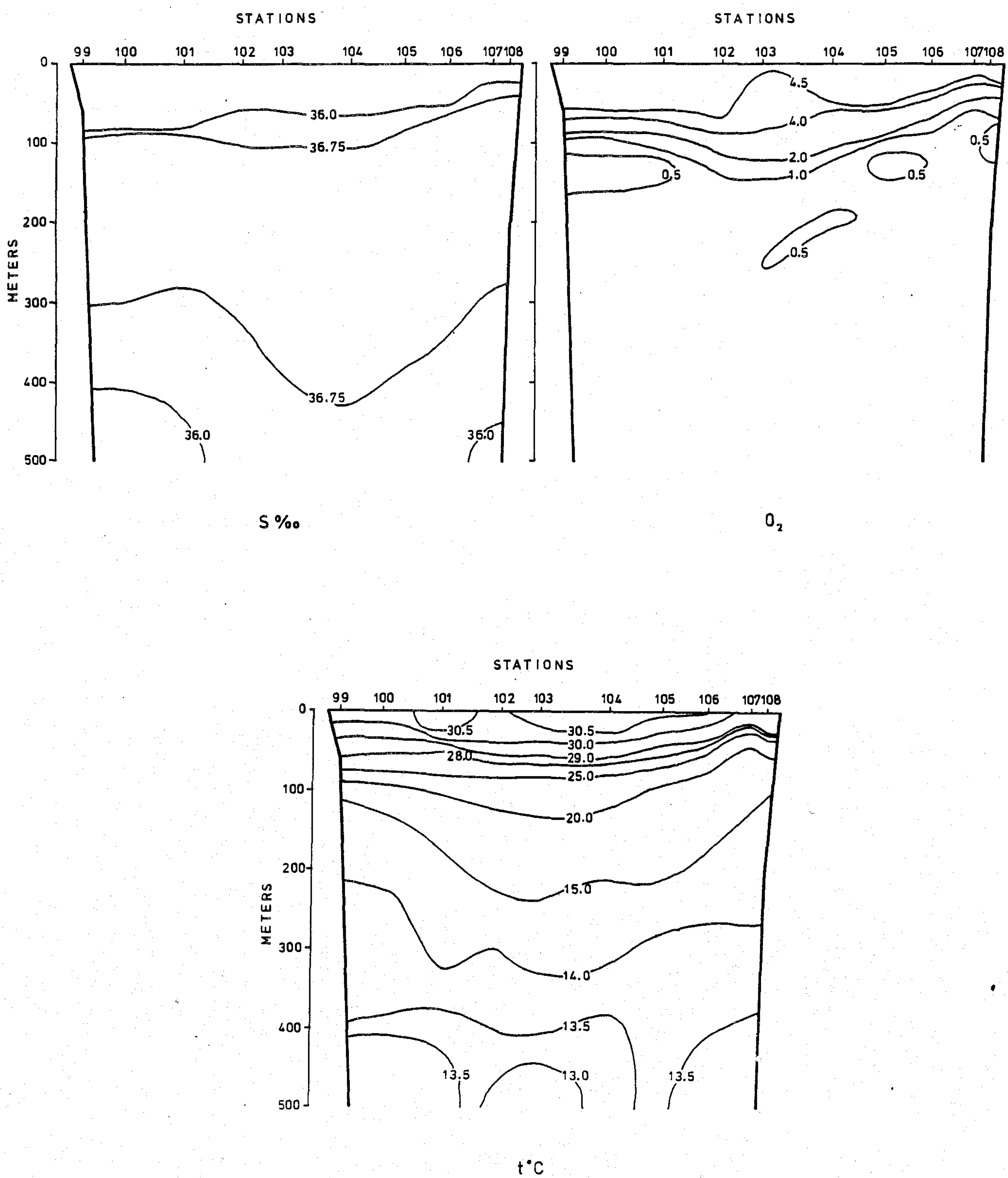

Fig. 24 B

Fig. 24. Hydrographical sections in the Gulf of Aden. August 1979. A: Section I B: Section II

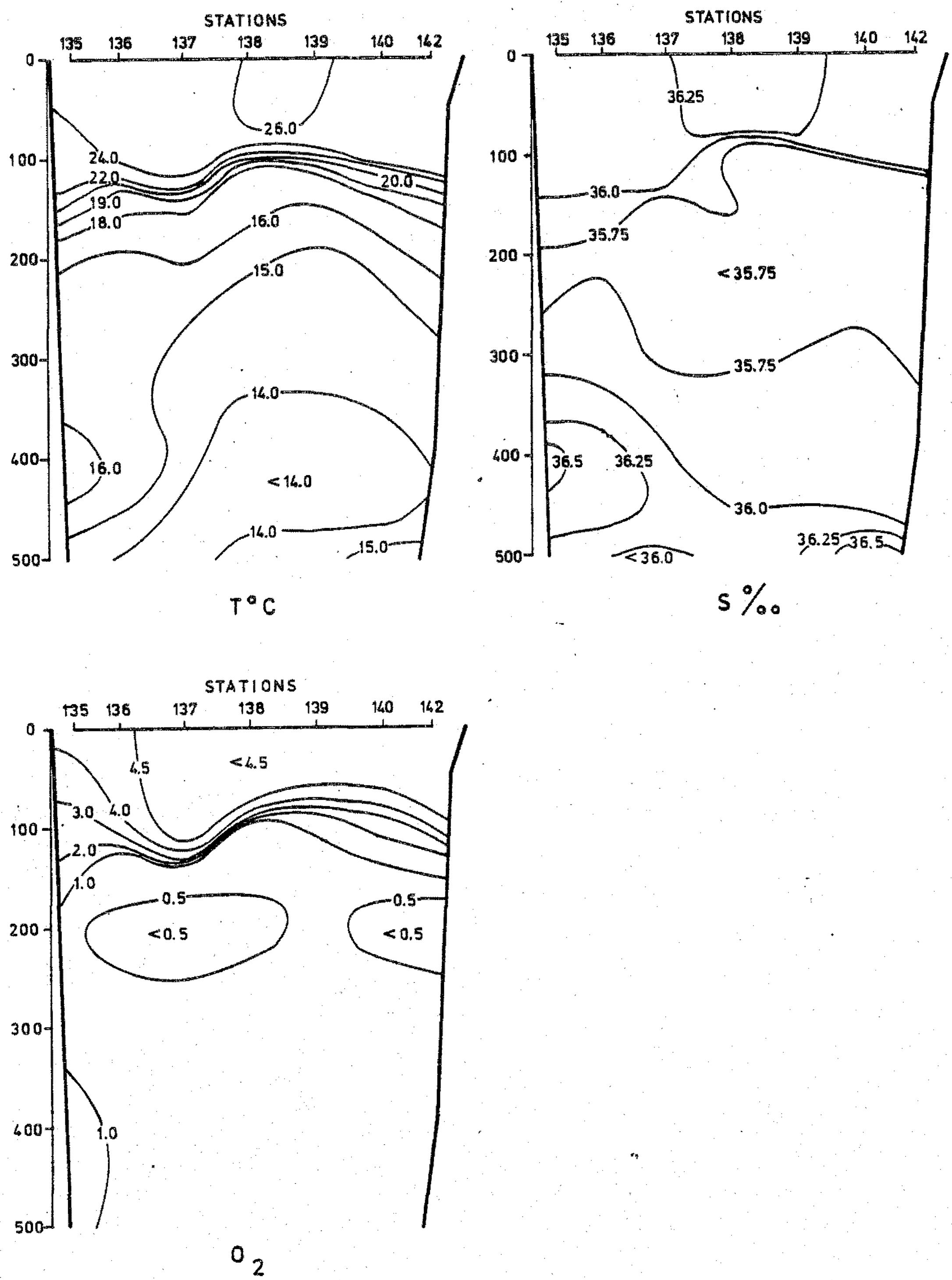

Fig. 25. Hydrographical section in the Gulf of Aden. February 1981.

TECHNOLOGICAL WORK WITH BENTHOSEMA PTEROTUM

Storage experiments

In fresh condition B. pterotum has firm flesh and a strong and very typical smell which is difficult to describe.

(i) No cooling, no draining.

A quantity of 10 kg fish caught 3/8 in the Gulf of Oman (trawl station 202, N 24°03' E 58°07') with an initial temperature of 25°C and a pH 6.6 was held in a container at ambient temperature. Changes during storage are recorded in Table 16. Samples were prepared during the experiment for later analysis in Tromsø: 40 grams minced fish was mixed with 40 ml of 10% TCA (Trichloracetic acid) and subsequently frozen; also 1 kg was taken from the batch and frozen as well.

Table 16. Storage experiment with B. pterotum.

Day	time	temp. (°C)	pH	Appearance and smell
3/8	12.30	24.8	6.6	fresh
	14.30	31.0	6.6	fresh
	16.45	31.4	6.7	not fresh
	18.45	31.6	6.7	not fresh
	21.00	33.8	6.6	slightly spoiled
4/8	03.00	30.2	6.5	spoiled

(ii) Cooling with freshwater ice, no draining.

A quality of 20 liters of fish caught 2/8 in the Gulf of Oman at trawl station 199 (N 24°03' E 58°07') was mixed with 10 liters crushed freshwater ice and stored in the chill room of the ship which is normally kept at -10°C. Changes are seen in Table 17. Samples were taken during the experiment for further analysis in Tromsø.

Table 17. Storage experiment with B. pterotum.

Day	time	temp. (°C)	pH	Appearance and smell
2/8	23.00	25.0	6.6	fresh, bright, typical smell
	24.00	8.4	7.3	fresh; paler
3/8	24/00	-1.0	7.4	fresh; pale
4/8		0	7.2	
5/8		1	7.0	
7/8		8	7.3	fresh; pale
8/8		5	7.8	
9/8		6	7.0	not fresh; paler; softening; sweet smell
10/8		3	7.4	" " "
11/8				" " "
12/8				slightly spoiled
13/8				spoiled

Silage

Silage was prepared from 5 liters minced fish and 85 ml of a mixture of propionic and formic acid (1:1) both of 85% concentration. After mixing the pH was 4.5. The fish had been caught 3/8 at trawl station 202 (N 24°03' E 58°07') in the Gulf of Oman. The initial temperature was 24.8°C. Daily samples were taken for analysis in Tromsø.

Autolysis

A quantity of 10 liters fish caught 3/8 in the Gulf of Oman at trawl station 202 was stored at 45°C in the engine room of the ship. After 6 hours the fish was spoiled. It appears that the initial temperature of 25°C is too low and warming up too slow to obtain any positive preserving effects of the high ambient temperature.

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ANNEX 1. Scientific and technical staff.

Cruise 1. 4 July - 30 August 1979.

A. Aglen	(from 1 August)
A.M.A. Al-Harthy	(10-20 July)
M.A. Ghaddaff	(from 11 August)
H. Gjøsæter	
J. Gjøsæter	(from 11 August)
H. Jensen	(till 31 July)
I.M. Hassan	(from 11 August)
J. Klett	
B. Myrseth	(till 31 July)
Y.A. Nuur	(from 12 August)
H. Pettersen	
T. Strømme	
F.J. Teutscher	(parts of August)
H. Ullebust.	

Cruise 2. 24 January - 26 February 1981.

A. Aglen	
A. Al-Amry	(31 January - 13 February)
M. Bouhlel	(22 - 26 February)
J. Gjøsæter	(from 31 January)
K. Hansen	
J.P. Maude	
I. Svellingen	
S. Tilseth	(till 13 February)

ANNEX 2. Details of the acoustic equipment and settings used.

During both cruises a 38 kHz scientific sounder was connected to two echo integrators. The settings used were as follows:

TVG and receiver gain	20logR-20dB
Recorder gain	8
Pulse length	0.6 msec
Bandwidth	3 kHz (1 kHz in 1979)
Transducer	$8^{\circ} \times 8^{\circ}$, ceramic
10 log ψ	-21 dB
Integrator gain	20 dB
Integrator recorder mode	x 10
Integrator threshold	1 (~0.01Vp)

At these settings calibration were performed in January 1981 both with a -29 dB steel sphere (130 mm in diameter) and a -35 dB cuprous sphere (50 mm diameter). The calibrations gave a sum of source level and voltage respons of 138 dB, at 20 m depth. The integrated echo intensity from the steel sphere showed 1.4 dB drop when applying 1 kHz bandwidth instead of 3 kHz. Repeated hydrophone calibrations from August 1979 to August 1980 have shown a stable SL of 233±1 dB//1μPa ref. 1 m.

The receiver gain and time varied gain (TVG) have, however, been changed (in April 1980) as Figure 26 shows.

According to Fisher and Simmons (1977) and Foote (1981) the hydrographic conditions in the area gives a sound absorption of about 7 dB/km at 38 kHz. Based on this an ideal TVG is shown in Figure 26. This shows that the TVG applied in 1979 was too high while the one applied in 1981 was too low. In 1981 corrections were made according to the depth of the recordings, but no corrections were made in 1979. This is believed to be the main reason why the integrator values obtained during night tended to be higher than during day in 1979. (In 1981 the opposite tendency was found among the uncorrected values).

For the depth intervals where most of the myctophid fish recordings occurred the difference between August 1979 and January 1981 is about 7 dB.

The factors applied for converting echo-intensities to fish densities were

C_{79} = 0.1∘L tonnes/n.mile^2 per mm per n.mile
C_{81} = 0.6∘L " " " " "

for 1979 and 1981 respectively.

(L = standard length, cm).

These are based on an average target strength of -10logL -22 dB per kg fish. This is compareable to the value of -28.4 dB/kg for 5.2 cm fish applied by FAO (1981), when the backscattering cross section per kg fish is assumed to decrease linearily with fish length. During other cruises with "Dr. Fridtjof Nansen" in 1979 a conversion factor of 0.2∘L tonnes/n.mile^2 was applied. This value was, however, assumed to represent a cod type fish which is more heavy bodied (NAKKEN & AUNG 1980).

Threshold settings

In the Gulf of Aden the fish tended to be very scattered vertically. This distribution resulted in weak echoes over a great depth interval. This situation requires high signal/noise ratio. Figure 27 shows the smallest recordable target strength for single fishes as function of depth, when the lowest threshold not including noise is applied. At the standard setting (20 logR-20 dB) the threshold setting was limited by electronical noise (0.005 Volt) which corresponds to a TS_{min}=-48 dB at 500 m depth. While applying the 20 logR - 0 dB setting, all acoustical signals at calibrated output were raised by 20 dB while the electronical noise remained constant. The threshold setting was thus limited by the acoustic noise corresponding to a TS_{min}=-59 dB at 500 m depth. This latter setting was applied during the last week of the cruise in the Gulf of Aden in 1979. It was found to give 20-30% higher integrator values for the most scattered recordings at about 350 m depth. However, it was not applied during the survey in 1981 because signals from more dense recordings in the upper layer easily run into saturation in the receiver when the 20 logR -0 dB setting is used. This is shown by the low TS_{max} in Figure 27. At the most applied settings (20 logR -20 dB and ca 0.01 Volt threshold) proper integration is made of targets of less than -30 dB target strength at 10 m depth or more than -42 dB at 500 m when referred to single fishes. This TS_{min}=-42 dB corresponds to a minimum volume back scattering strength of -72 dB/m^3 or a "threshold density" of about 0.1 grams/m^3 when referred to multiple scatterers.

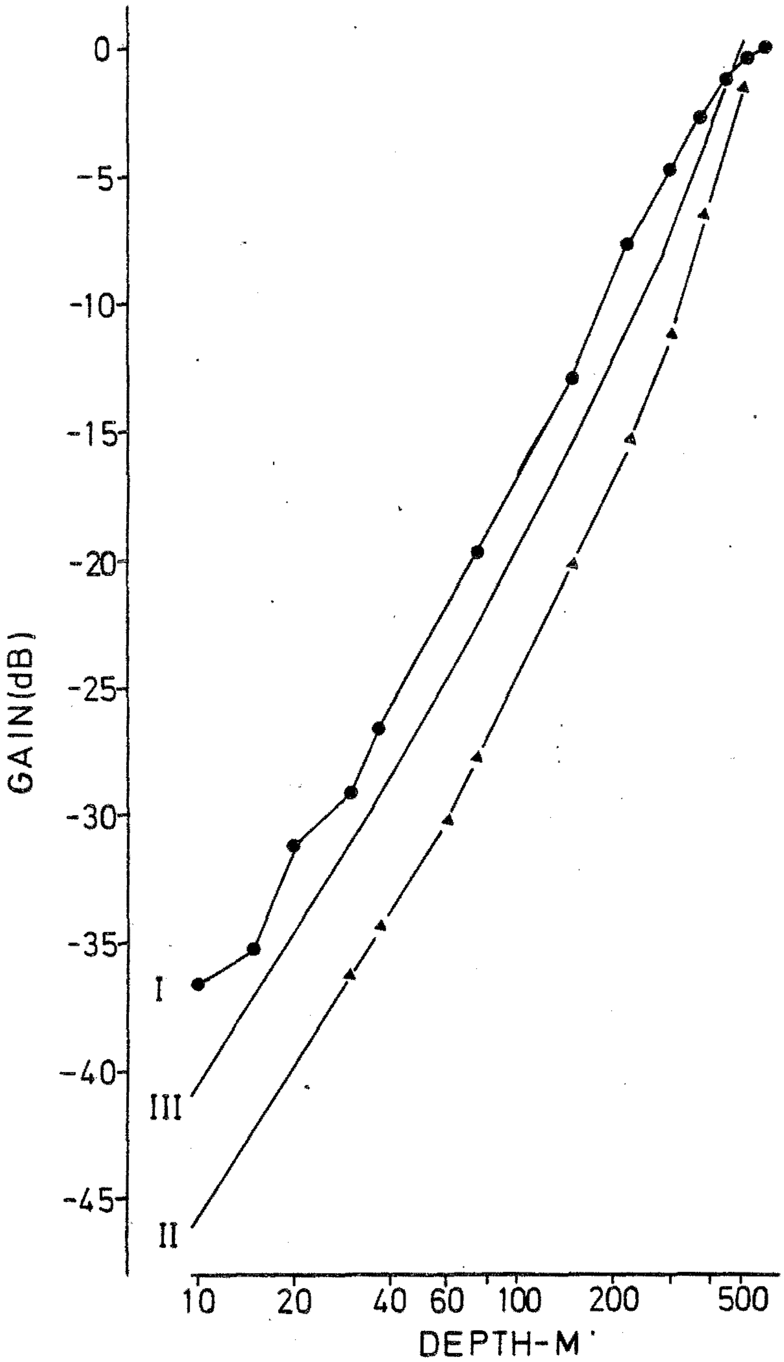

Figure 26 Time varied gain functions:
I - Function applied in 1979
II- Function applied in 1981
III- Ideal function according to hydrographic conditions.

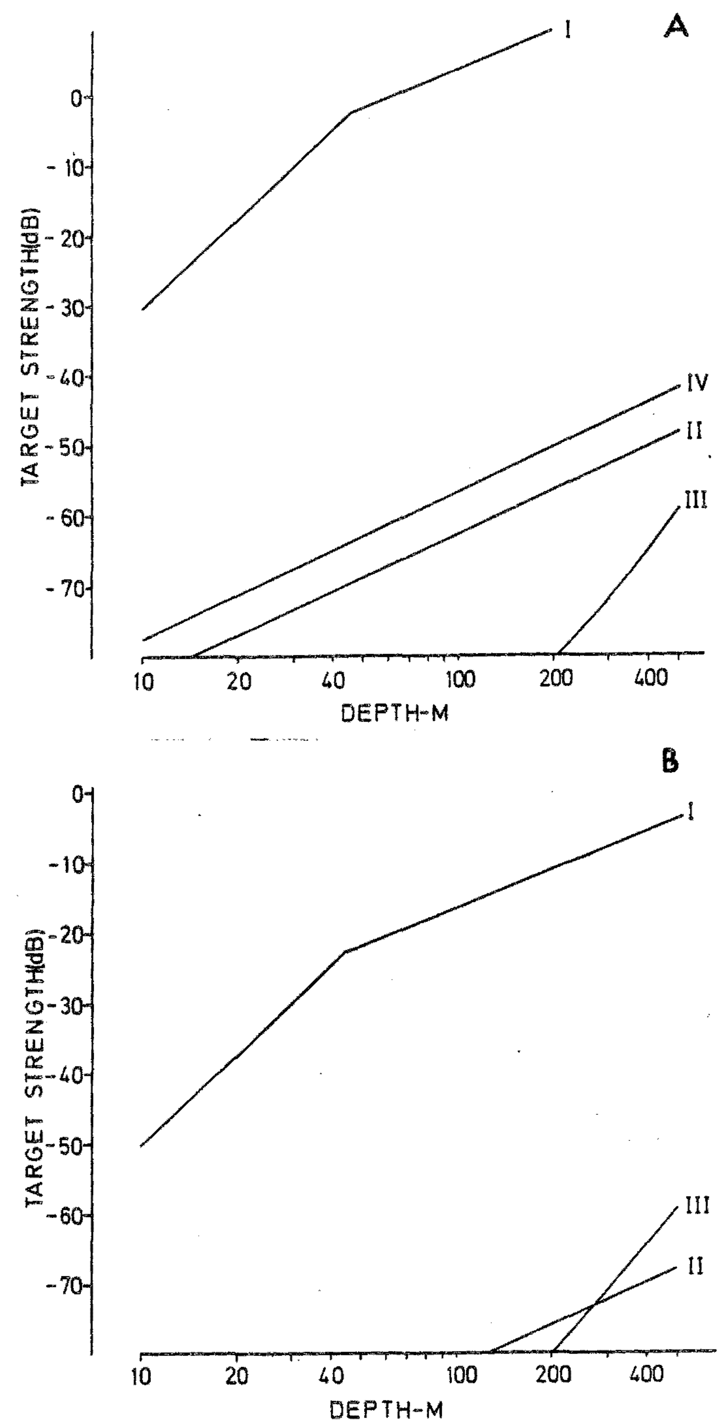

Figure 27 Maximum and minimum target strength (for single fishes) required for proper echo integration.

I: Maximum target strength (limited by receiver saturation)

II: Minimum target strength to avoid masking by electrical noise (0.005 Vp at calibrated output)

III: Minimum target strength to avoid masking by "normal" acoustic noise.

IV: Minimum TS when using 0.01 Vp threshold.

A: 20 logR - 20 dB mode

B: 20 logR - 0 dB mode

ANNEX 3

Records of fishing operations.

Table 1. Trawl stations in the Gulf of Oman 1979.

Table 2. Trawl stations in the Gulf of Aden 1979.

Table 3. Trawl stations in the Gulf of Oman 1981.

Table 4. Trawl stations in the Gulf of Aden 1981.

Table 1. Trawl stations in the Gulf of Oman July - August 1979. Bottom depth is marked + when more than 500 m.

Trawltype: K: Krilltrawl H: Harstadtrawl

Date	Time start	St. no.	Time trawled	Bottom depth	Trawl depth	Scattering layer type	Trawl type	Position N	Position E	Total catch kg.	Catch pr. hr. Mycto-phidae	Catch pr. hr. Other fish	Catch pr. hr. Others	Notes
5.7	2255	147	0.3	300	30	N I	K	24°22'	57°07'	30	97	3		
6.7	0918	148	0.5		285	D II	K	24°23'	58°08'	40	45	17	18	Mostly shrimps
6.7	1743	149	0.67	+	278	D II	K	24°18'	59°51'	13	11	4	4	
7.7	0757	150	0.67	+	165	D I	K	24°15'	59°51'	330	492			
7.7	0955	151	0.67		285	D II	K	24°14'	59°51'	40	36	21	3	
7.7	1755	152	0.67	+	130	D I	K	23°54'	59°17'	270	403			
10.7	2133	154	0.5		232	N II	K	24°40'	59°01'	31	20	30	13	Mostly shrimps 7.0 kg/h
10.7	2259	155	0.5		46	N I	K	23°41'	58°59'	19	29	7	3	
11.7	0511	156	0.73	+	102	D I	K	23°46'	59°49'	120	156	-8		
11.7	1735	157	0.71	+	152	D I	K	23°22'	60°23'	65	91			
12.7	2137	158	0.67	+	245	N II	K	24°04'	58°49'	25	6	21	11	Salps 5.7, shrimps 5.3 (kg/h)
12.7	2319	159	0.67	+	42	N I	K	24°07'	58°48'	70	89	4	12	Mostly Salps 11.1 kg/h
13.7	0123	160	0.57	+	41	N I	H	24°08'	58°50'	50	80	4	4	
13.7	0507	161	0.55	+	105	D I	K	24°18'	58°56'	120	218			
13.7	0913	162	0.67	+	176	D I	K	24°24'	58°36'	165	246			
13.7	1110	163	0.67	+	183	D I	H	24°24'	58°35'	270	403			
13.7	1336	164	0.67	+	193	D I	K	24°31'	58°25'	250	373			
13.7	?	165	?		255	D II	K	24°29'	57°56'	40				
13.7	2335	166	0.67	+	38	N I	H	24°12'	57°38'	60	83	7		
14.7	0111	167	0.67	+	40	N I	K	24°13'	57°41'	70	95	10		

Date	Time start	St. no.	Time trawled	Bottom depth	Trawl depth	Scattering layer type	Trawl type	Position N	Position E	Total catch kg.	Catch pr. hr. Mycto-phidae	Other fish	Others	Notes
14.7	0251	168	1.5	+	40	N I	K	24°12'	57°35'	210	135	3	3	
14.7	0608	169	0.5	300	226	D II	K	24°06'	57°21'	195	30			
14.7	1000	170	0.67	350	285	D II	K	24°14'	57°14'	92	66	4	67	Shrimps 40, Squids 4, Salps 20 (kg/h)
14.7	1256	171	0.65	327	327		B	24°18'	57°07'	249		373	10	
15.7	2207	172	0.58	+	35	N I	K	24°46'	57°07'	28	43	3	2	
15.7	2320	173	0.33	+	25	N I	K	24°45'	57°07'	40	104	3	12	Salps 11 kg/h
16.7	0057	174	0.5	+	35	N I	H	24°45'	57°07'	60	112		8	
16.7	0931	175	0.68	+	281	D II	K	25°01'	57°09'	33	9	7	33	Shrimps 21 kg/h
16.7	1115	176	0.67	+	291	D II	H	25°01'	57°09'	20	5	3	22	" 11 kg/h
16.7	1303	177	0.67	+	227	D I	H	25°05'	57°11'	90	135			
16.7	1442	178	0.67	+	227	D I	K	24°59'	57°09'	90	134	1		
16.7	2212	179	0.67	+	48	N I	K	25°08'	57°01'	180	258		11	
16.7	2349	180	1	+	36	N I	H	25°09'	57°01'	110	108	2		
17.7	0135	181	0.67	+	33	N I	H	25°09'	57°06'	330	493			
17.7	0303	182	0.67	+	33	N I	K	25°12'	57°03'	330	469	7	17	Salps 10, Squids 7
17.7	0905	183	0.7	+	185	D I	K	25°11'	56°50'	900	1285			
18.7	1022	184	0.67	185	170		B	24°48'	56°54'	382	12	501	25	
18.7	1450	185	0.5	273	258		B	24°35'	56°54'	960	20	1891	9	
18.7	1717	186	0.5	273	225	D II	H	24°36'	56°54'	150	289	10	1	
18.7	2112	187	0.53		212	N II	K	24°32'	57°02'	20	33	3	2	
18.7	2237	188	0.72		46	N I	H	24°33'	56°59'	150	202	4	2	
19.7	1130	190	0.67	+	204	D I	K	24°07'	57°38'	100	148	2		

Date	Time start	St. no.	Time trawled	Bottom depth	Trawl depth	Scattering layer type	Trawl type	Position N	Position E	Total catch kg.	Catch pr. hr. Mycto-phidae	Catch pr. hr. Other fish	Catch pr. hr. Others	Notes
19.7	1340	191	0.67	388	187	D I	H	24°08'	57°37'	170	255			
29.7	1413	192	0.5	+	315	D II	K	23°55'	58°44'	45	4	41	45	
29.7	1809	193	0.37		277	D II	H	23°59'	58°44'	15	12	26	3	
29.7	2343	194	0.5	+	20	N I	K	24°07'	58°01'	135	249	10	11	
30.7	0108	195	0.5	+	20	N I	H	24°07'	58°02'	200	387	13		
30.7	0715	196	0.75	+	100	D I	H	24°37'	57°53'	45	60			
30.7	1406	197	0.5	+	160	D I	H	24°47'	58°16'	135	270			
30.7	1557	198	0.67	+	175	D I	K	24°49'	58°13'	45	68			
2.8	2105	199	1	+	30	N I	H	24°03'	58°07'	60	58	2		
2.8	2255	200	0.5	+	30	N I	K	24°03'	58°07'	40	64	2	14	
3.8	0350	201	1	+	25	N I	K	24°06'	57°30'	40	15	9	17	
3.8	1125	202	1	+	180	D I	K	24°03'	58°07'	750	750			
3.8	2150	203	0.5	+	21	N I	K	24°00'	58°04'	40	76	3	1	
4.8	0405	204	0.62	300	18	N I	K	23°55'	58°02'	144	213	7	14	

Table 2. Trawl stations in the Gulf of Aden August 1979. Bottom depth is marked + when more than 500 m.
Trawl type: K: Krilltrawl H: Harstadtrawl

Date	Time start	St. no.	Time trawled	Bottom depth	Trawl depth	Scattering layer type	Trawl type	Position N	Position E	Total catch kg.	Catch pr. hr. Mycto-phidae	Catch pr. hr. Other fish	Catch pr. hr. Others	Notes
13.8	2205	206	0.5	340	32	N I	K	11°46'	43°23'	60	73	42	5	
13.8	2359	207	0.5	330	27	N I	H	11°49'	43°23'	130	201	52	7	
14.8	1308	208	1	+	318	D II	K	11°08'	44°32'	10	2	4	5	
14.8	1604	209	0.5	+	184	D I	K	11°13'	44°35'	20			36	
14.8	1713	210	0.5	+	0		K	11°16'	44°35'	15			30	
14.8	2245	211	0.5	+	30	N I	H	11°08'	45°08'	15				
16.8	1307	212	1.43	+	307	D II	K	11°05'	46°40'	15	1	5	5	
16.8	2214	213	0.5	?	52		H	11°19'	47°41'	1	+	1		
20.8	1248	217	1	+	360	D II	L	13°28'	48°11'	6	1	3	2	
20.8	2225	219	0.5	+	0		K	13°46'	48°04'	5	0	7	3	
21.8	0850	220	0.58	0	368	D II	K	12°53'	47°00	10	4	11	2	
21.8	1802	221	0.63		200	D II	H	11°55'	46°08'	7	2		9	
21.8	2300	223	1.2	+	25	N I	K	11°42'	46°03'	5	2	2		
22.8	1350	224	1	+	300	D II	K	10°58'	44°49'	10	2	6	2	
22.8	1645	225	1	+	233	D II	K	11°00'	44°57'	17	4	13		
22.8	2250	226	0.55	+	30	N I	K	11°26'	45°26'	20	12	15	9	
23.8	0316	227	0.75	+	206	N II	K	11°07'	43°04'	20	2	2	22	
23.8	1358	228	1.3	+	186	D II	K	10°40'	45°00'	20			15	
23.8	1812	229	0.5	40	32		B	10°28'	44°59'	100		158	42	
24.8	0810	231	0.75	+	37	N I	K	11°04'	44°27'	34	9	12	23	
24.8	0925	232	1	+	509		B	11°28'	43°59'	400		367	33	
24.8	1509	233	0.75	426	345	D II	K	11°44'	43°48'	15	3	6	11	
24.8	2155	234	0.55	+	0	N I	K	11°53'	43°35'	20	9	18	10	
25.8	0117	235	1	+	60	N I	K	12°07'	43°53'	25	6	5	14	
25.8	0746	236	0.5	465	300	D II	K	12°15'	44°07'	15	6	15	9	
25.8	1325	237	0.5	152	144		B	12°04'	43°31'	130		260		
25.8	1715	238	0.5	+	309	D II	K	11°47'	43°29'	45	72	10	8	
26.8	0700	240	1	+	310	D II	K	11°47'	44°02'	14	1	11	2	
26.8	1012	241	0.75	+	130		H	11°47'	44°20'	3			4	
26.8	1301	242	1	+	315	D II		11°47'	44°30'	25	4	10	11	
26.8	1521	243	1	+	357	D II	K	11°41'	44°29'	17	2	10	6	
27.8	0228	244	0.67	+	340	N II	K	10°46'	44°24'	60	6	18	66	
27.8	2319	245	0.5	+	30	N I	K	10°36'	44°58'	25	21	7	21	
28.8	1308	246	1	+	345	D II	K	12°38'	45°53	20	4	7	10	
28.8	1726	247	0.5	+	164	D II	K	13°06'	46°00'	20			40	
28.8	2025	248	0.5	+	28	N I	K	13°15'	46°04'	17	18	10	6	

Table 3. Trawl stations in the Gulf of Oman, January-February 1981. Bottom depth is marked + when more than 500 m.

Date	Time start	St. no.	Time trawled	Bottom depth	Trawl depth	Scattering layer type	Position N	Position E	Total catch kg.	Catch pr. hr. Myctophidae	Catch pr. hr. Other fish	Catch pr. hr. Salps	Notes
Gulf of Oman													
24.1.	20.42	1	0.5	500	0	N I	23°57'	58°58'	100	+	+	200	
25.1.	04.00	2	0.3	+	50	N I	24°27'	58°59'	17	27	3	4	
25.1.	08.00	3	0.5	+	280	D II	24°10'	58°40'	20	3	3	20	Shrimps
25.1.	16.00	5	0.3	167	135	D I	23°53'	58°13'	595	1550		240	
25.1.	20.15	6	0.5	+	40	N I	24°17'	58°19'	128	85	5	160	
26.1.	00.26	7	0.3	+	50	N I	24°38'	58°28'	190	140	30	400	
26.1.	09.45	8	0.5	+	300	D II	24°12'	58°02'	146	175	60	50	
26.1.	15.55	9	0.5	334	160	D I	24°02'	57°41'	76	95		60	
26.1.	17.23	10	0.3	400	280	D II	24°02'	57°41'	85	40	10	5	Shrimps 200 kg/h
26.1.	21.35	11	0.5	320	220	N II	24°10'	57°24'	64	30	20	80	
27.1.	02.15	12	0.5	+	50	N I	24°32'	57°38'	190	110	20	250	
27.1.	08.32	13	0.5	+	320	D II	24°54'	57°24'	8	6		4	Shrimps 6 kg/h
27.1.	11.30	14	0.8	+	100	D I	24°40'	57°19'	130	40		120	
27.1.	16.35	15	1	326	50	D I	24°13'	57°12'	1073	725		300	
27.1.	19.15	16	0.5	326	60	N I	24°16'	57°10'	306	250		350	
28.1.	03.05	17	0.5	+	50	N I	25°06'	57°19'	114	65	15	140	
28.1.	08.36	18	1	480	160	DI	24°48'	57°00'	2800	2800			
28.1.	11.18	19	0.5	440	300	D II	24°45'	56°58'	119	200		35	
28.1.	21.30	22	0.5	216	25	N I	24°42'	56°46'	142	225	15	50	
29.1.	01.09	23	0.5	470	220	N II	24°55'	56°50'	52	25	25	50	
29.1.	11.15	24	0.5	+	290	D II	24°42'	57°09'	50	5	40	10	Shrimps 40 kg/h
29.1.	16.01	25	1	283	110	D I	24°18'	57°07'	3600	3600			

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30.1.	00.46	26	0.5	+	30	N I	24°48'	57°34'	123	120	10	110	
30.1.	08.18	27	0.5	+	140	D I	24°46'	57°58'	555	1110			
30.1.	11.05	28	0.5	+	330	D II	24°33'	57°51'	114	40	15	40	Shrimps 130 kg/h
30.1.	16.25	29	0.5	334	260	D II	23°59'	57°48'	93	85	10	85	
01.2.	15.49	30	1.3	161	130	D I	23°54'	58°15'	440	160		190	
01.2.	22.10	31	0.5	325	260	N II	23°55'	57°55'	100	40	15	145	
02.2.	02.32	32	0.5	+	40	N I	24°12'	57°31'	114	90	20	115	
02.2.	09.00	33	0.5	+	110	D I	24°26'	57°15'	1340	2680			
02.2.	11.20	34	0.5	+	140	D I	24°26'	57°14'	646	1270		20	
02.2.	15.42	35	0.5	327	130	D I	24°16'	57°08'	3300	6600			
02.2.	17.15	36	0.5	328	95	D I	24°17'	57°08'	1950	4040			
02.2.	19.35	37	0.5	-	3	N I	24°24'	57°06'	400	640		160	
03.2.	04.14	38	0.5	270	200	N II			41	42	12	20	
03.2.	06.35	39	0.5	295	100	D I	24°33'	56°57'	600	1050		150	
03.2.	09.05	40	0.5	317	140	D I	24°20'	57°07'	3530	7060			
03.2.	14.36	41	1	323	140	D I	24°16'	57°08'	2208	2210			
03.2.	16.40	42	0.38	334	210	D II	24°15'	57°11'	114	360		30	
03.2.	18.10	43	0.3	331	80	D I	24°17'	57°11'	2900	8700			
03.2.	22.50	44	0.5	+	80	N I	24°16'	57°29'	228	315		135	
04.2.	03.10	45	0.5	326	250	N II	24°16'	57°09'	57	40	20	40	
04.2.	05.55	46	1	306	70	D I	24°28'	57°02'	680	680			
04.2.	12.04	47	0.5	322	150	D I	24°22'	57°03'	440	880			
04.2.	18.45	48	0.5	+	40	N I	24°30'	56°59'	720	500		950	
05.2.	01.38	49	0.5	326	50	N I	24°17'	57°08'	120	140		60	
05.2.	04.12	50	0.5	316	200	N II	24°29'	57°05'	140	170		105	
05.2.	09.30	51	1.3	278	50	D I	24°29'	56°57'	2000	1600			
05.2.	15.36	52	0.5	343	250	D II	24°18'	57°13'	220	325		85	
05.2.	16.57	53	0.6	333	130	D I	24°17'	57°12	2500	4050			

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05.2.	20.05	54	0.5	271	215	N II	24°22'	57°01'	320	510		130	
06.2.	05.58	55	1	+	30	N I	24°44'	57°09'	2600	2080		520	
06.2.	09.15	56	0.5	+	240	D II	24°48'	57°12'	180	20		240	
06.2.	11.00	57	0.5	+	300	D II	24°46'	57°13'	100	30	30	60	Shrimps 80 kg/h
06.2.	17.10	58	1	250	150	D I	24°09'	57°18'	4090	4090			
06.2.	22.35	59	2	355	50	N I	24°08'	57°28'	1330	430	20	210	
07.2.	02.15	60	2	323	50	N I	24°19'	57°09'	720	240	5	110	
07.2.	05.50	61	1	305	30	D I	24°23'	57°04'	3600	3600			
08.2.	09.40	62	0.5	278	10	x	24°23'	56°59'					Salps only
08.2.	11.00	63	0.5	280	150	D I	24°27'	57°00'	1360	2720			
08.2.	14.00	64	0.5	+	300	D II	24°28'	57°15'	160	105	20	60	Shrimps 135 kg/h
08.2.	15.51	65	0.5	+	250	D II	24°28'	57°15'	45	25	10	50	
08.2.	17.23	66	1	+	85	D I	24°31'	57°13'	2500	2500			
08.2.	23.50	67	1	+	60	N I	24°31'	57°09'	480	105	25	350	
09.2.	06.35	68	0.5	245		D I	24°47'	56°47'	700	700		700	
09.2.	16.21	69	0.5	+	160	D I	24°53'	57°13'	640	1325			
09.2.	19.40	70	0.5	355	35	N I	24°34'	57°04'	520	700		340	
11.2.	09.35	72	0.5	+	140	D I	24°26'	58°35'	100	180		20	
11.2.	16.11	73	0.8	290	170	D I	23°54'	58°21'	5100	5225		1275	
11.2.	20.45	74	0.5	+	50	N I	23°59'	58°23'	140	11	185	75	
11.2.	22.07	75	0.5	+	0	N I	23°59'	58°28'	2000	+		2000	
12.2.	04.10	76	1	+	40	N I	24°24'	58°57'	300	65	15	200	
12.2.	06.05	77	0.7	+	70	D I	24°08'	59°04'	1080	1265	5	170	
12.2.	09.30	78	1	+	165	D I	24°03'	59°13'	6100	6040	5	25	
12.2.	20.35	79	0.5	+	260	N II	23°55'	58°30'	90	3	42	70	Shrimps 16 kg/h
13.2.	01.39	80	0.5	+	80	N I	23°46'	58°48	40	15	30	10	Shrimps/ Squids 25 kg/h

Table 4. Trawl stations in the Gulf of Aden, February 1981.
Bottom depth is marked + when more than 500 m.

Date	Time start	St. no.	Time trawled	Bottom depth	Trawl depth	Scattering layer type	Position N	Position E	Total catch kg.	Catch pr. hr. Myctophidae	Catch pr. hr. Other fish	Catch pr. hr. Others	Notes
Gulf of Aden													
17.2.	20.15	81	0.5	+	0	N I	12°05'	50°38'	10	4	1	15	Mostly swimming crabs
18.2.	02.03	82	0.5	+	50	N I	11°58'	49°59'	40	6	1	73	Salps 58 kg/h
18.2.	08.40	83	0.5	+	350	D II	11°40'	49°26'	19	11	23	4	Chauliodus 20 kg/h
18.2.	16.13	84	0.5	+	300	D II	12°23'	48°43'	14	5	7	14	
18.2.	19.40	85	0.5	+	75	N I	12°18'	48°28'	30	13	17	30	Sw.crab 18 kg/h
19.2.	02.30	86	0.5	+	50	N I	11°27'	48°03'	15	2	13	15	Cubiceps 9 kg/h
19.2.	11.10	87	0.5	+	340	D II	11°53'	47°18'	20	17	9	14	Salps 11 kg/h
19.2.	20.05	88	0.5	+	360	D II	11°26'	46°28'	30	12	11	27	Jellyfish 24 kg/h
20.2.	16.44	89	0.6	+	200	D I	12°09'	45°18'	45	63	2	15	Salps 12 kg/h
22.2.	17.03	90	1	+	160	D I	12°40'	45°15'	280	265		15	
22.2.	21.50	91	0.5	+	55	N I	12°47'	45°34'	30	37	1	22	Euphausids 11 kg/h
23.2.	03.50	92	0.5	+	50	N I	13°17'	45°57'	5	2		8	Sw.crab 7 kg/h
23.2.	13.00	93	0.5	+	320	D II	12°25'	44°53'	5	2	3	4	
23.2.	20.30	94	0.5	+	40	N I	12°01'	43°55'	40	72		8	
24.2.	00.41	95	0.5	476	40	N I	11°47'	43°50'	50	72	14	14	
24.2.	06.55	96	0.9	+	50-175	-	11°02'	44°03'	5	3	1	1	
24.2.	14.11	97	1	+	200	D I	10°37'	44°44'	20	20		0	
24.2.	17.48	98	0.5	+	-	D II	10°46'	44°56'	20	16	5	14	Shrimps/ krill 10 kg/h
25.2.	07.35	99	0.5	+	325	D II	11°15'	45°05'	6	4	3	4	

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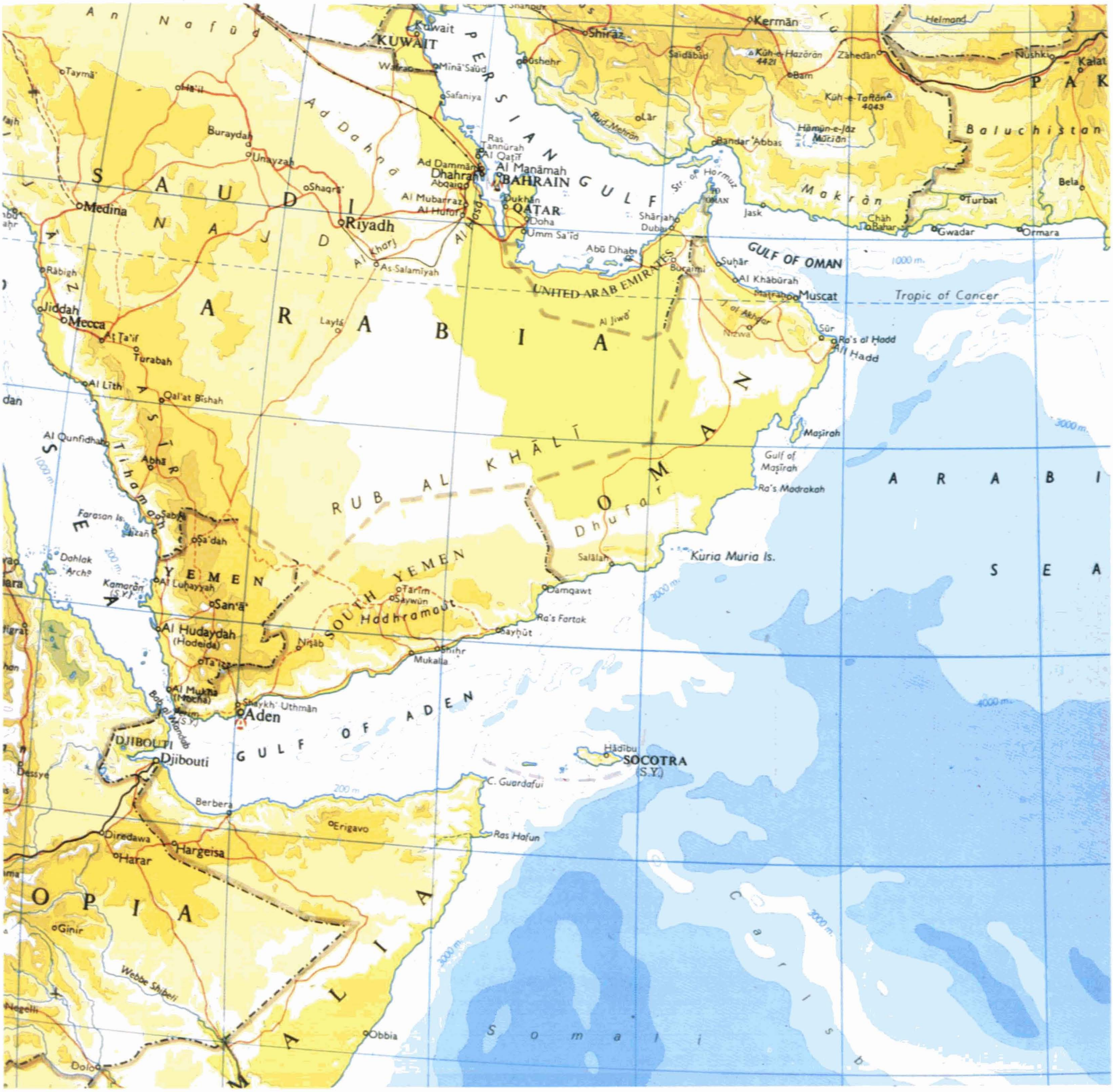
25.2.	12.42	100	0.5	+	250	D II	11°18'	44°28'	45	85	1	4	
25.2.	22.05	101	0.5	+	50	N I	11°43'	44°23'	30	20	2	38	Shrimp/ krill 32 kg/h
26.2.	03.50	102	0.5	+	50	N I	11°57'	44°35'	10	5	4	11	Sw.crabs 9 kg/h
26.2.	09.45	103	0.5	+	225	D I	12°00'	43°45'	4	6		2	
26.2.	12.10	104	0.5	+	375	D II	11°58'	43°42'	40	73	2	5	



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