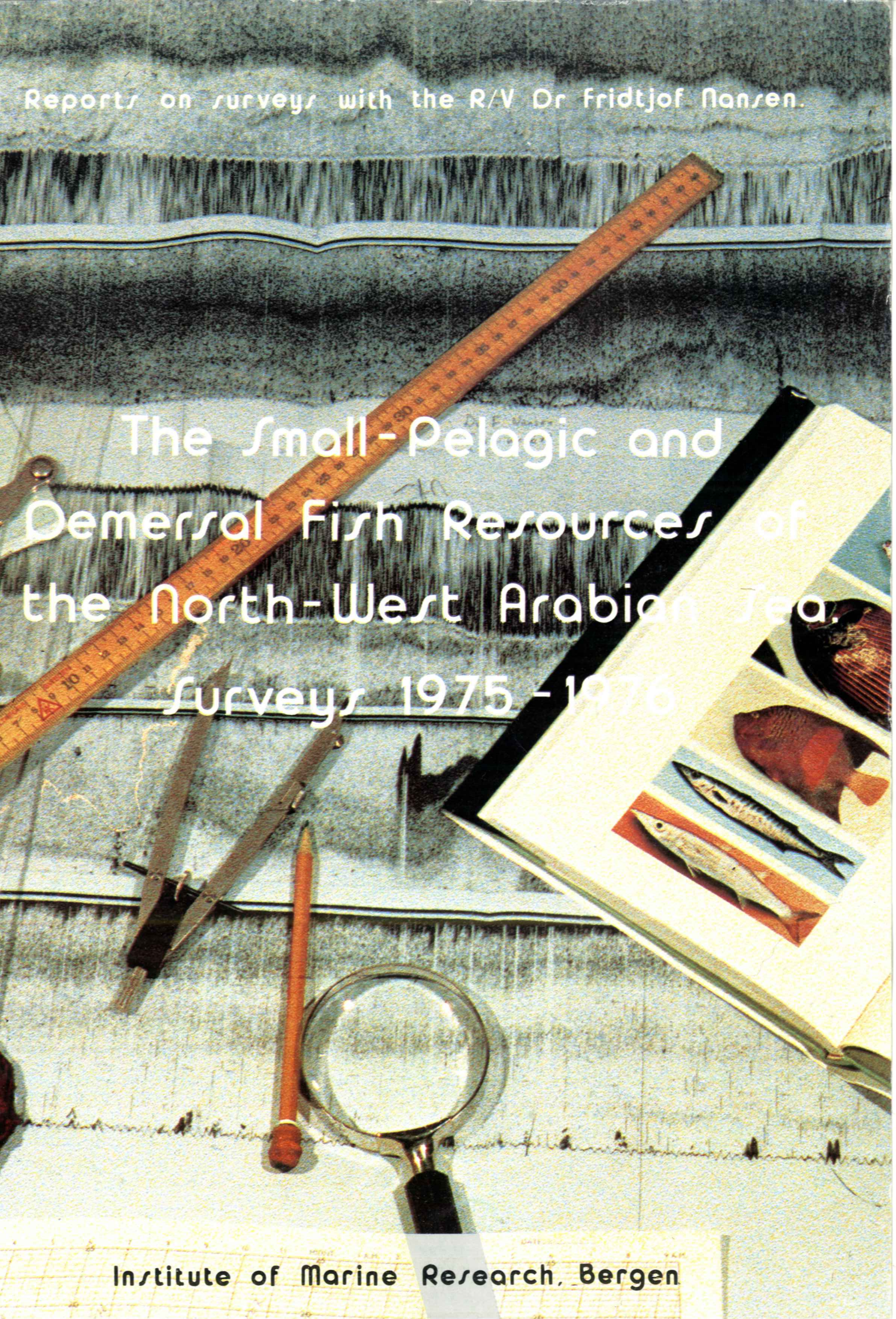
Reports on surveys with the R/V Dr Fridtjof Nansen.

The Small-Pelagic and Demersal Fish Resources of the North-West Arabian Sea.

Surveys 1975 - 1976



Institute of Marine Research, Bergen

«Dr. Fridtjof Nansen»

The fishery research vessel «Dr. Fridtjof Nansen» belongs to the Norwegian Agency for Development Cooperation (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 OF SURVEYS WITH THE R/V DR. FRIDTJOF NANSEN

THE SMALL-PELAGIC AND DEMERSAL FISH RESOURCES OF THE NORTH-WEST ARABIAN SEA.

Further analysis of the results of the R/V "Dr. Fridtjof Nansen" Survey, 1975-1976

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Preface

This document is a further analysis of the results of the Pelagic Fish Assessment Survey North Arabian Sea by the R/V "Dr. Fridtjof Nansen" in 1975-1976. Earlier reports have been issued for each of the five coverings of the region by the vessel. A preliminary final report was issued in August 1977.

Issued in Bergen, Mars 1981

INTRODUCTION

In accordance with the contract between the Food and Agriculture Organization of the United Nations (FAO) and the Institute of Marine Research, Bergen, the fishery resources of the western part of the north Arabian Sea were surveyed with the research vessel "Dr. Fridtjof Nansen" in the period 14 February 1975 to 24 November 1976.

Whilst the work is adequately described by the general term "resources survey", the objectives more specifically were:

a) to contribute to the knowledge of the composition of the "fishery" fauna of the region, directing attention primarily on species of present economic importance but taking due note of other species (for example, the mesopelagic) and of other faunistic elements (for example, zooplankton);

b) to add to knowledge of the distribution of the more important species of fish of the region and especially show the variations in distribution from season to season;

c) to measure the size of the stocks of each species, in the region generally and in distinct parts of the region;

d) to obtain some estimate of the magnitude of the catch that might be available from each stock, with some indication of appropriate fishing seasons, grounds and catch rates;

e) to ascertain, by fishing trials and from observations of the behaviour of each species (schooling habit, vertical migrations etc), the gears and methods that might be employed in the fisheries of each part of the region.

The survey operations were designed to achieve these objectives, as set out in the plan prepared by the Institute in August 1972 and submitted to FAO.

The survey was effected through 6 cruises in which work was carried out in every month of the year except July, and thus covered both monsoon periods. (See Figure 1).

The operational characteristics of the survey are summarized in Table 1 and are represented in Figures 2 to 6. It will be seen that the continental-shelf space was traversed several times, and oceanic space beyond the shelf were also visited. In the course of these traverses, acoustic observations were made uninterruptedly, surface observations were recorded, fishing was carried out frequently (570 stations) although insufficiently, as it proved (see below), and oceanographic observations were made even more frequently (939 stations). The result of this work was a very considerable quantity of data which, upon analysis, yield much evidence on the fishery resources of the region, of relevance to the several objectives set for the survey.

The region covered in this survey included the Pakistan coast but since a special survey was subsequently made of that coast, and the results from this survey were assimilated to that other, no reference is made in this report to the results from that coast. Some data obtained from observations on the North Kenya Banks, made during Cruises 1, 3, 4 and 6, have also been excluded. Data on mesopelagic fishes, plankton and large pelagic fishes have not been considered in the analyses for this report since they have been, or will be dealt with elsewhere, although some reference to main results from those other studies is made where appropriate.

A report was made of each cruise, shortly after its completion, and submitted to FAO (Cruises 1 and 2 were reported on together); a preliminary final report was prepared in August 1977, and submitted to FAO, it was subsequently discussed at the FAO/Norway Workshop "on the fishery resources of the north Arabian Sea" which took place in Karachi, Pakistan, in January 1978. From these and other discussions it became clear that the data obtained from this survey could yield somewhat more information and that perhaps more accurate estimates could be made of biomass. Preparation of the present report was therefore undertaken, to make use of a different treatment of the acoustic data (especially to calculate the variance of the recordings of each sector and to calculate confidence limits for estimates of biomass) and fuller use of the biological information.

1. CONDUCT OF THE SURVEY

1.1 Narrative

In general, the survey was carried out according to plan and without untoward event, save for an unexpected call into Muscat, on 27-30 May 1976, as a result of which the coverage of Masira Bay was relatively poor on that cruise, and for a damaged purse seine net. The SW Monsoon persisted along the Somali coast at the end of August and beginning of September, 1975 (Cruise 3), with winds reaching force 8-9 beaufort, and to a certain degree prevented fishing operations. During Cruise 5, in June 1976, the onset of the SW Monsoon, with windforce 5-6 beaufort, again to some extent prevented fishing and reliable echo integration, off Pakistan and Iran.

In early March 1975 (Cruise 1) the vessel was adrift south of Socotra while the entire crew was engaged in repairing the purse seine which had been damaged in a set some days earlier. During Cruise 2 the vessel spent 8 days, in May, at Dubai for repair of the satellite navigation system.

In Cruise 3, the plankton samples in the Gulf of Oman and off the Pakistan coast were taken with a 20 cm Bongo net, because the 60 cm diameter Bongo net had been lost off the Oman coast.

Upon completion of Cruise 2, and in the course of a voyage to Mombasa, the vessel called in at Cochin for intercalibration of its acoustic equipment with the equipment of R/V "Rastrelliger". This work provided basic date for setting a value for the conversion constant, C. During Cruise 3, on 14-15 November, 1975, the acoustic equipment of the research vessel was intercalibrated with the equipment of the Japanese research vessel "Shoyo-Moru".

After Cruise 3 the density of the survey grid was varied in accordance with the results of previous cruises, so as to give best coverage of those areas in which important resources had been located.

1.2 Plan, Equipment and Methods

Plan

The work was executed generally in accordance with the plan submitted to FAO In 1972 in which the survey was conceived as a systematic programme of cruises in which the region would be traversed twice in each year. Essentially the work was to be an acoustic survey supplemented by fishing operations for the identification of acoustically observed organisms and for the collection of material for biological analysis, and by oceanographic work (hydrographic stations and plankton collections) by which to make an ecological characterization of each part of the surveyed region.

In the work-plan it was assumed that "the off-shore extent of the survey will be limited to abt. 300 nautical miles" but in the event most of the work was carried out in a coastal zone of which the average width was about 12.5 nm. Moreover, the easterly limit to the survey was set at the Pakistan/India border, thus excluding the coast of India. With this reduction of the total area to be surveyed it was possible to carry out the work with one vessel, rather than with two as contemplated in the work-plan.

Vessel and gear

The R/V "Dr. Fridtjof Nansen" is 150 feet long, a combined stern trawler and purse seiner. A main engine of 1500 horsepower gives a maximum speed of 13 knots. There is accommodation for 28 men. All winches are hydraulic. The vessel carries two pelagic trawls, one bottom trawl and one purse seine, some gillnets, bottom lines and hand lines. Fig. 7 shows the main deck arrangement. All gears were ready for use on short notice. The details of the fishing gears are given in Fig. 8 and Fig. 9.

A satellite navigator is included in the navigation equipment, allowing very precise determination of position.

Acoustics

The acoustic equipment consists of 3 scientific sounders (120, 50 and 38 kHz), 2 echo integrators, 1 searchlight sonar (18 kHz) and 1 netsonde (50 kHz).

The two echo integrators were coupled to the 50 kHz scientific sounder, integrating the depth slices 8-50, 50-100, 100-150 or 100-250, 150-350 or 250-450 m. The settings of the sounder were as follow: Basic range: 0-100 or 0-250 m - Transmitter 10 kW - Pulselength and bandwidth 0.6 msec, 1 kHz - Receiver TVG and gain 20 logR-20 dB - Recorder gain 6 or 7. The gain on the echo integrators was mainly set to 30 dB, and the threshold setting was 1. Echo integrator values were read for each nautical mile sailed and average values for each 5 nautical mile were calculated and logged. All logged echo integrator values were referred to 30 dB gain on the integrators and the above-mentioned settings on the sounder. The 120 kHz and 40 kHz echo sounders were used for a "closer look" at interesting recordings. The sonar was operated continuously, mainly on range 0-2000 m.

Continuous watch was kept on the acoustic instruments, and fishing operations for identification purposes were carried out whenever the echo sounder recording changed its characteristics. The acoustic data were scrutinized once each day. Echoes and integrator contributions from false bottom, wakes etc. were deleted, and the integrator readings were grouped in four categories: small pelagic fish, mesopelagic fish, demersal fish, 0-group fish and plankton.

The sonar counting technique described by Smith (1971) was used in localities where small near-surface schools were found. The sonar was then used on basic range 0-500 m. The transducer was kept constantly trained at 70° to the starboard or port side, and the schools appearing on the recording paper between 100 and 500 m were counted.

Since the 10 kW transmitter for the 38 kHz echo sounder failed for a part of cruise 2, the investigations in the Gulf of Oman and parts of the coast of Pakistan during that cruise were carried out with the 1 kW transmitter and the receiver setting 20 logR - 0 dB. Later the two transmitters were intercalibrated and the following relation was found:

$$11.7 \cdot M_1 = M_2$$

where M_1 is the integrator output using the normal setting and M_2 is the integrator output at 1 kW transmitter and 20 logR 0 dB receiver.

The vessel's acoustic equipment was calibrated with that of other vessels so that with correctly measured factors the echo-integrator output of the one could be converted to comparable values of the other. During the intercalibration run of R/V "Rastrelliger" and R/V "Dr. Fridtjof Nansen" the two vessels sailed 24 nautical miles, one closely following the other but avoiding the wake. The log counter/reset facilities on the two vessels were synchronized before start. Recordings of single fish and scattering layers were fairly good during the run.

The result of a least mean square analysis of the observed integrator outputs was:

Ras (120 kHz) = F.N. (120 kHz) 7.9 - 13

Ras (120 kHz) = F.N. (38 kHz) 1.1 - 11

The correlation coefficients were both 0.95.

Fish biology

The following guidelines were followed in the biological work:

A. GENERAL:

- Large fish (each specimen): Length - Weight - Sex - Maturity stage - Gonad weight - Volume of total stomach contents - Sample material for age determinations - Observations and collections of ecto- and endo-parasites.

- Small fish: Weight of entire sample - Length of each individual - Weight of each length category - Number in each length category - Five (or more) fish in each length category were examined as above - Mean weight was computed.

B. LENGTH MEASUREMENTS:

- Bony fish: Fork length (LF_1) measured from the tip of the snout (mouth closed) to the posterior tip of the central (shortest) caudal fin ray. Small species were measured to the 0.5 cm below the measurement and large species to 1 cm below the measurement. For Trichiurus total length (LT_1) was measured to the 1 cm below.

  Sharks: Total length (LT_2) measured from the tip of the snout to the posterior tip of the upper caudal lobe.

- Lobsters: Carapace length (CL_1) measured from the tip of the rostrum to the posterior edge of the cephalothorax.

- Crabs: Carapace width (W_1) measured across the widest point of the carapace, including spines.

C. BIOLOGICAL CONDITION:

The ponderal index or condition factor (K) was calculated from: $K = \frac{W}{L^3} 100$

where W is the mean weight for each length group. The criteria for the observation of maturity stages were as follows:

Maturity state	Stage No.
Immature	I
Mature unripe	II
Mature ripening	III
Mature nearly ripe	IV
Mature ripe (Non spawning)	V
Mature ripe running (spawning)	VI
Mature spent	VII

Stomachs were denoted full (8), about half-full (4) and empty or nearly so (2) by visual estimates.

Fatness was determined by visual observation of alimentary fat deposits as follows:

1 : lean	- no trace of fat on digestive tract.
2 : fattening	- fat strands few, less than about 2 mm thickness on digestive tract.
3 : fat	- fat strands of more than 2 mm thickness on digestive tract but not obscuring viscera.
4 : very fat	- fat deposits entirely obscuring viscera in body cavity.

Plankton

Plankton samples were taken at the hydrographic stations from oblique tows with a 60 cm diameter Bongo net of 300 mesh size. The net was lowered to 50 m depth and then hauled at a vessel speed of 1.5-2 knots. Displacement volumes of the samples were measured on board.

Hydrography

The vessel is equipped with 20 Nansen water bottles for hydrographic work. Termperature readings and seawater samples for salinity determinations were collected at hydrographic stations at standard depths: 10 - 20 - 30 - 50 - 75 - 100 - 125 - 150 - 200 - 250 - 300 - 400 - 500 m. Salinities were determined on board using an inductive salinometer. Samples for oxygen titration were taken at 10 - 30 - 50 - 100 - 150 - 200 - 250 - 300 meters and oxygen content was determined by the Winkler method. On each hydrographic station and on most of the fishing stations continuous temperature/depth curves were obtained with the bathythermograph. A thermograph recorded the temperature continuously at 4 m depth.

1.3 Execution of the Work

The region surveyed, and its divisions, are geographically described in Table 2. The total coastline is approximately 3,530 nm. The total distance travelled in the course of the survey was approximately 33,500 nm of which approximately half was devoted to the intensive survey work over the continental shelf and some immediately adjacent oceanic waters. The remainder of the mileage was devoted to special, wider-ranging oceanic traverses, especially across the Gulfs of Aden and Oman, to fishing operations and to service travel.

The total shelf area is approximately 44,000 nm^2. Since in some sectors, during some cruises, the acoustically-observed stocks occupied waters both over and beyond the continental shelf, the surveyed space in 7 cases in Table 3 is shown as having been of area more than 100% of the area of the shelf; substracting the "extra" areas from the total surveyed area (Col. 9 of Table 3) leaves a total of 32,384 nm^2 which constitutes 73.6% of the area of the shelf.

In order to avoid ambiguities in reporting the analysis of survey results it is necessary to name and define a number of different kinds of "areas", but in the first place we must point out that we endeavour (and hope to have succeeded) to avoid using the word "area" other than in the specific sense of "superficial extent", as in "the area of the continental shelf of Sector 1 is 9,340 nm^2".

By "sector" we refer to a defined part of the ocean space over which the vessel moved in the course of this survey; we have defined 7 such sectors in Table 2. Each sector comprises continental shelf space and oceanic space, the division between which is marked by the 100 fm contour. The total area surveyed is thus the number of square nautical miles of ocean space over which the vessel moved whilst survey work was being done; it includes a considerable amount of oceanic space of which it is difficult to measure the area. The area of the continental shelf can be measured by virtue of the bounding lines (coast, 100-fathom and the inter-sectorial lines drawn for the survey), and insofar as the vessel traversed the whole or part of this space, the survey area can easily be measured, and the density of survey can be given; in the case of oceanic survey however, determination of the distance on each side of the vessel's track to which its observations can be held to be representative presents some difficulty. thus "total area surveyed" must be a somewhat uncertain figure.

This report, however, relates mainly to work over the continental shelf the space of which has been marked, variously into 3 types: "patches", occupied space and unoccupied space; the first of these terms refers to the individual pieces of shelf space in which positive recordings were made and which are marked off by estimator boundary lines as in Figures 10-21; the sum of the areas of these patches within a sector, as observed in the course of a cruise, is the occupied space of the sector; the difference between the area of the continental shelf of a sector and the observed occupied space is unoccupied space in which only zero recordings have been made.

In the acoustic work, 3.9 recordings* were made per 100 nm^2, on the average over all cruises; this signifies 19.5 nm of acoustic track per 10-mile square, which in turn signifies that each unit area was traversed twice on each cruise. The intensity of survey, as measured by this index, varied from

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* The word "recording" is hereafter used, throughout the text, to signify the 5-mile-average integrator recording.

cruise to cruise, being greatest on the first two cruises (4.1) and least on Cruise 5 (2.5). The intensity varied also between sectors during each cruise, the variation being greatest on Cruises 1 & 2 (the greatest intensity being nearly 4 times the least) and smallest on Cruise 3 (with ratio less than 2). More detailed information on survey intensity is to be found in Table 3.

Fishing was carried out on 570 occasions of which 451 occurred in the region with which this report is concerned, the remaining 119 having been carried out chiefly in Pakistani waters. The biological treatment of the samples taken from these catches provided information on not less than 305 species of fishes, crustacea and jelly-fish.

Oceanographic stations were occupied on 939 occasions and 225 plankton samples were taken.

From this summary, and the relevant tables, it will be seen that the survey work was carried out duly according to plan. A basis for an evaluation of the work of this survey can be found in data from acoustic survey work in the Barents Sea in which the number of recordings per 100 nm^2 was 8.7 in 1977 and 8 in 1978. Considering that the Barents Sea work was directed upon a well defined region and stocks of which much is known, in contrast with the exploratory nature of the work in the Arabian Sea, and considering the greater size of the vessel with which the Barents Sea work was carried out as well as operational differences in the work of the two area, the survey intensity of 3.9 recordings per 100 nm^2 obtained with R/V "Dr. Fridtjof Nansen" must be regarded as quite satisfactory.

1.4 Treatment of Data

The data with regard to fishes taken in the catches were treated, in the first instance, by the usual biological methods, of presentation in histograms and calculation of mean length (and its standard deviation) and mean weight. Species-composition tables, by cruise and by area, were also prepared.

For the estimation of the conversion constant, C, mean length of the acoustically observed fishes had to be calculated; this was done by the following procedure. A record having been made of the number of individuals of each species in each catch, and of their total weight, the mean weight of the captured individuals of each species could be calculated. A correponding mean length was then calculated from the formula:

$$\bar{l} = \left(\frac{W}{0.2147}\right)^{\frac{1}{2.991}}$$

This formula is derived from the familiar weight/length relation $W = aL^b$ with values of the constants for Caranx carangus given by Franqueville and Freon (1976). This species was chosen, from among 28 species for which Franqueville and Freon give W/L formulae, as an "average fish". Thus, values of $\bar{l}$ and N (number of captured individuals) were available for each species in each catch. A length frequency table, of 20 size-classes, was then prepared for each sector by assigning the number of individuals of each species of each catch to the size-class corresponding to the $\bar{l}$ of those individuals. A sector mean length of all species was then calculated from this table.

In the preliminary final report the recordings were averaged for each 1° square and biomass was estimated from these mean values. This treatment, however, made inadequate and perhaps inaccurate use of the information obtained during the survey: it abandoned the measure of variation in the data, and blurred the indications of distributional patterns. An alternative treatment was therefore applied.

The recordings, separately of demersal and pelagic fishes, were written onto maps on which the survey track had been traced. The two values at each observation point were added and "contour" lines were drawn, by eye, around groups of values of more or less the same magnitude. These groups constituted patches whose area could be measured by planimeter and for which mean and variance could be calculated. The patches were then classified in strata, with mean values from 0 to 9.9 (I), from 10 to 29.9 (II) and greater than 30 (III). For each sector a mean and variance was calculated for each stratum, for demersal and pelagic separately and for the sum of the two; overall sector means and variances were then obtained by weighting the stratum values by the area of the "patches" of each stratum. Confidence limits were then calculated and these became the values from which an estimate of biomass, demersal and pelagic, was to be made. Each value was then multiplied by the area of the sector to which it related to give a sector total integrator value, and the final step was to multiply each such value by an appropriate value of the conversion constant, C.

A value of the constant C (weight of the biomass of 1 square nautical mile that gives an integrator value of 1 mm; see, for example Forbes and Nakken, 19) had been obtained from the inter-calibration work with the R/V "Rastrelliger". This value was 10 t/nm^2 for a fish of length 17 cm. Since experimental work (see, for example, Nakken and Olsen) had shown that for a particular species the value of C is directly proportional to length, it was assumed that as a first approximation the value of C for a sector could be calculated from the formula:

$$C = 10 \times \frac{\bar{l}}{17}$$

in which $\bar{l}$ is the mean length of the fishes present in the area in which the integrator recording had been obtained. A mean value for length of all fishes of interest in each of the sectors was obtained as described above.

The central and largest body of data is the set of echo-integrator recordings. As described above, these were scruitinzed once each day; the scrutiny was a team consultation during which, after deletion of non-biotic contributions, the recordings were grouped and partitioned into the four categories of biota; the data with which this report is concerned are the values assigned to the categories small pelagic and demersal. The grouping and partitioning was effected by reference to evidence available in the characteristics of the echo traces, and to other evidence from fishing and from surface observations; it was subject to arbitrary criteria as to the category to which each species or kind of fish or other biota was to be assigned and to the ability of the observer to associate particular kinds of traces with particular species or kinds. Of course, the critical confirmatory evidence was to have come from fishing, but if, at any time and for whatever reason, this were inadequate the identification and hence the grouping and partitioning would be faulty. This indeed was the case with the work in the Gulf of Oman during the final cruise; the recordings on that occasion were identified as caused by small pelagic fish, but subsequent examination of the traces and recordings indicated that the bulk of the acoustically observed biomass was of mesopelagic fishes, they do not however provide evidence from which to decide upon the fraction of the recordings that should have been assigned to small pelagic fishes which, undoubtedly, must have been present in some quantity; for this reason all the readings in the Gulf of Oman of Cruise 5 have been abandoned. For a different reason, namely change of criterion, another block of data, from the southern part of Sector 1 (off the Somali Coast), obtained during Cruise 4, has been abandoned. In that case some large concentrations of Synagrops, correctly identified, were assigned to the small pelagic category since at that time that genus was held to be small pelagic; subsequent evidence led to Synagrops being counted as mesopelagic but by that time it was too late to make a revised assignment to small pelagic.

2. BACKGROUND INFORMATION WITH REGARD TO THE REGION

The workplan for the project, prepared by the Institute, was based upon a review of information available with regard to the region, a summary of which was included in the workplan. For the purposes of the survey the important features of the surveyed region are:

1. its sharing the Indo-Pacific fauna, of which the large number of species, adapted to tropical and sub-tropical habitats, is a distinctive characteristic;

2. the two-monsoon climatic regime and the diverse physical, chemical and biotic consequences of this regime;

3. the several up-welling situations; and

4. the high levels of primary production.

Obviously these are only separately specified manifestations of the structure and behaviour of what is a vastly complex system; nevertheless, interconnected though they must be, they separately had strong significance in the planning of the survey operations, as in progressive revision of those plans, and have to be kept in mind in analysing the results.

The higher levels of the biota were, of course, the immediate target of the work and from feature 1 the survey planners had to prepare for a considerable task of identification in working on catches to be taken; moreover it had to be expected that interpretation of echo-traces would be made difficult by the diversity of species. It was clear, however, that many if not the majority of the species would be of little importance and that special attention should be directed upon a relatively short list of species which were already of economic importance in the Indian Ocean; the species thought to be most abundant were the following:

Sardines:	
Indian oil sardine:	Sardinella longiceps
Other sardines:	Sardinella sindensis
	Sardinella fimbriata
	Sardinella dayi
Rainbow sardine:	Dussumieria acuta
Mackerels:	
Indian mackerel:	Rastrelliger kanagurta
Mackerel:	Scomber japonicus
Horse Mackerels, jacks and scads:	
Scad:	Decapterus ruselli
Jack:	Caranx spp.
Anchovies:	Stolephorus spp.
Other species:	
Frigate mackerel:	Auxis thazard
Horse mackerel:	Caranx spp.
Tunas:	
Yellowfin tuna:	Thunnus albacares
Skipjack:	Katsuwonus pelamis
Little tunny:	Euthynnus affinis

Of the sardines the most abundant and most widely distributed species is the Indian oil sardine. In India the oil sardine is caught in substantial quantities only between Ratnagiri and Cape Comorin, but its distribution is probably continuous from Somalia along the coast of the Arabian peninsula and Pakistan. Sardinella sindensis which is caught irregularly and in small quantities along the southwest coast of India, near Cape Comorin, was known to be abundant in the Gulf of Oman. Results of recent survey work off the northern part of the Arabian peninsula and the west coast of India, as well as egg and larvae investigations, had indicated that anchovies might constitute important inshore resources in the area. Various Stolephorus species had been found on the Arabian coast and in India.

The Indian Mackerel (Rastrelliger kanagurta) was known to be widely distributed in the Arabian Sea along the coast from Africa to India, although the only substantial fishery at that time was on the southwest coast of India (mostly by beach-seining). Mackerel schools had been seen (not frequently) at the surface off Arabia (Aden-Mukalla). On one occasion the fish had been recorded as a scattering layer at a depth of 20-80 fathoms just above the bottom for 10-15 nautical miles. The largest schools had been estimated to be of 10-20 tons. Horse mackerels had been caught in both the western and eastern parts of the ocean.

A substantial body of information on the biology of the important species listed above, and on others, was available from local research, published especially in the Indian Journal of Fisheries (see Weber, 19), and is being drawn upon in the current analysis.

The climatic regime with its strongly contrasted monsoon periods (feature 2) is a major determinant of the periodicity and intensity of biotic processes in this region, and the incidence of strong winds, especially near the middle of the SW Monsoon, had to be allowed for in deciding upon the timing of the cruises. Of immediate relevance to the survey was the probability that the distribution of species of interest would be found to be related in various ways to this regime and that, insofar as the timing of each monsoon and the intensity of its winds might vary so it might be found that the distribution of some species varied, even markedly. These considerations had a bearing on search tactics and, as is discussed later in this report, have a bearing on an interpretation of the acoustic evidence on the distribution and abundance of the stocks.

Of longer range importance is the role of the climatic regime, and of variations in that regime, especially through its generation of upwelling, in the primary and secondary production processes, (features 3 and 4) and through them in determining the abundance of the species of interest, both at their average levels and at other levels they take in particular seasons and from year to year. The survey programme could not include an analysis of the relationship in which the stocks stand to their habitat or, more particularly, of the role of the climatic regime, but in the interpretation of results some assumptions must be made as to the relations that prevail in that relationship.

In particular, it was to be supposed that major concentrations of some stocks would be found to be associated in some way with the upwelling sites, and that any differences of abundance of stocks which might be found between sectors of the surveyed region would be connected with differences of primary production. Cushing (1971) and Alverson (1971, a) discussed the distribution of productivity of the Indian Ocean in relation to resource survey priorities. Observations of primary production from the Indian Ocean Expedition had shown very high production in the western part of the Arabian Sea during the SW Monsoon period extending far (500 miles) seaward. Pronounced upwelling along the coasts of Somalia and Arabia during the SW Monsoon (May through September) nourishes high primary production in this sector and during the NE Monsoon a narrow coastal zone of fairly high production is maintained along the coast of Kenya, Somalia and in the Gulf of Aden. Unfortunately, no observations of basic production in the north-eastern part of the Arabian Sea had been reported, but estimates of plankton biomass, from measurement of displacement volume, had shown high values off the Malabar coast and confirmed that production was high fairly far offshore in the western Arabian Sea. That tertiary production in general followed the same pattern had been demonstrated by the distribution of fish eggs and larvae (Nellen 1973); again, high concentrations of these stages seemed to extend far seaward in the western part of the ocean, but no information on species distribution was available. It was not unlikely that the distribution of pelagic coastal species would be found to be continuous from the Gulf of Oman along the Pakistan coast to the productive zone off the Malabar coast, and these sectors were also expected to harbour considerable resources of pelagic fish.

Finally, several particular oceanographic features were noted which could affect the acoustic observations and fishing operations and whose effects had perhaps to be taken into account in interpreting the results. The entire area is tropical with strong heating from radiation, and high evaporation, resulting in high temperature and high salinity in the surface layer. There is a bimodal temperature cycle nearly within the whole area, with maxima in April-May and in October. The summer decrease is explained as a result of wind intensity.

The surface currents change with the monsoon. During the NE Monsoon there is a drift, mainly westward, but modified by the direction of coast lines, particularly towards southwest along the Somali coast. The current system is more regular and also stronger during the SW Monsoon period, at that time forming an eastbound drift also modified by the direction of coast lines, as a northeastward rather strong and stable current along the Somali and Arabian coasts and a southeastern flow along the Indian coast. Within the central region there is an eastward flow.

The westward flow during the NW Monsoon is rather weak. It is strongest along the western coasts particularly south of $6^{o}N$ where it exceeds 100 cm/s. During the SW Monsoon the currents are stronger. The northeast bound current outside the Somali coast is reported to be between 2 and 5 knots with maximum in July. In the Gulf of Aden there is a weak flow into the Gulf during the NE Monsoon and a flow out during the SW Monsoon. Along the Indian coast there is a weak and variable mostly northward current during the NE Monsoon and a stronger southward flow during the SW Monsoon.

The vertical temperature profile show a strong decrease down to about 200 m thereunder a much slower decrease with depth. Wyrtki (1971) has given some vertical curves which show temperature declines of up to 15-18^{o}C from the surface down to 200 metres.

Of great importance is also the oxygen minimum at intermediate depths with values mostly between 0 and 1 ml/L. As a consequence of this it was expected that fish would be located generally in upper layers.

3. SURVEY RESULTS

3.1 Composition of the Catches

The basic rule for deciding when and where to fish, laid down in the adopted work-plan, was that fishing should take place whenever the character of the echo-trace changed. Thus, theoretically, all traces, except those from the beginning of the cruise until the first catch, should be catch-identified, and it should be reasonable to assume that all integrator readings recorded after one catch and until the next catch were a measure of the biomass of stocks of the composition revealed by the first catch. The basic rule implies, however, that each significant change in stock composition will be clearly manifest in the echo-trace and readily detectable by a trained observer; but if, as is most probable, stocks of different species can cause echo-traces indistinguishable from one another, the basic rule is inadequate. Adding to this the humanly inevitable failure of observers at times, from fatigue or for other reasons, to detect or to react to changes in echo-traces, then it must be accepted that catches taken in obedience to this rule cannot provide comprehensive and accurate evidence of the composition of the observed stocks. Again, the rule may be sufficient if the criterion of significance is that the change in character should be only such as to require a change of conversion factor and if the objective of the acoustic work is solely to measure biomass, irrespective of composition of the stocks. But if the composition of the stocks is of importance, as indeed it was in this survey the rule is still more inadequate. On the other hand, it is to be borne in mind that the catches were not the sole source of evidence of stock composition: other information is available from the records of surface observations, such as of schooling behaviour. This other information has, of course, been taken into account in the analysis of acoustic records.

The survey objectives with regard to stock composition extended beyond species identification to include, as the work-plan required (see Section 1.2), observations of length, weight, sex, sexual condition and stomach contents, and samples of catches were taken for this purpose. However, in this respect too the results are inadequate: the number of fully analysed catch samples is relatively small and it is for this reason that mean length of individuals of

observed stocks (for determination of the value of the conversion constant) had to be made in the manner described in Section 1.4.
Table 4a shows, for each sector, the number of species which appeared in the catches of only 1 cruise, those that appeared on 2 cruises and so on. Similarly, Table 5a shows for each cruise the number of species which appeared in all 5 sectors, those that appeared in 4 sectors and so on. It will be observed that in the two tables the distributions are notably similar; in Table 4a, the means for two sectors fall outside (one below and one above) the 95% confidence limits of a weighted mean for the whole table. The data of these tables are combined in Table 6 where, the concentration in the upper left-hand sector of the table is considerable; few species (3%) occurred in all 7 sectors in all five cruises, and most species occurred in 1 or 2 cruises (67%) in 1 or 2 sectors (53%). Table 4a is to be interpreted as giving some indication of seasonal variability of the accessibility and vulnerability of the species of which the biota is composed; Table 5a, on the other hand, gives an indication of ubiquity compounded with the indication of variability of accessibility and vulnerability. In addition, the results in these tables to some degree reflect simply the chanciness of the particular fishing operations by which the samples were obtained.

A result somewhat the same as that of Table 5a is presented by tabulations of
(a) appearances of families in the catches (Table 7a);
(b) citation, in the text of the cruise reports, of species observed (Table 7b), and was obtained by Druzhinin (1973), as the following figures show:

Number of cruises in which each species appeared	This Survey (Table 5a, col. 8) %	Druzhinin (Table 4) %
1	49.1	46.6
2	24.1	24.2
3	13.2	16.2
4	6.6	10.6
5	3.6	3.1
6	1.8	2.5
7	1.6	0.6
8		0.3

A puzzling feature of Table 4a is the number of zeros in line 5, since it is contrary to expectation that a series of fishing operations in these sectors, especially, in Sectors 3 and 4, should fail to capture specimens of the dominant Clupeoids. This feature might appear from, among a number of processes, a failure to make correct identification and there is some evidence of this. For example, the presence of Sardinella longiceps was sometimes noted only by the general term "oil sardines" and since this is a generic and not a species title it could be that for the purpose of Table 4a some actual presences of this species were not credited to it. Table 4c, showing presence of important families was prepared as an attempt to circumvent this deficiency. It will be seen that the Poisson-like distribution of Table 4a does not appear in Table 4c and that the values (frequencies) are more uniform; the mean frequency is 6.7 and the values have a distribution very close to normal; the mean number of appearances per family is 2.6, close to the central value of the table. This result, however, goes only some of the way to resolve the problem of the zeros in Table 4a: two sectors, 2 and 3, have no families which have been caught at all times, and although dealing with families ensures that all appearances of all species belonging to a particular family are credited to that family, it does not mean that every species of a family was always present in each appearance of its family.

But in Table 7a there is evidence of another aspect of this matter. Not only are the appearances low -- in pelagic fishing each family appeared on the average in only 3% of the hauls whilst in demersal fishing each family appeared in 12% of the hauls -- but of the 55 families, 39 appeared in both pelagic and bottom trawls while only 2 families appeared in only pelagic hauls and 14 families appeared only in bottom trawls. It is yet to be ascertained whether what holds for these 39 families, that is, that they can be caught both in surface and bottom waters, holds as well for the species of which they are composed, or that in each family some species are pelagic and some demersal. Nevertheless, the evidence here throws some doubt on the validity of the distinction between pelagic and demersal types. The considerations here depend largely on the definition of pelagic and demersal fish and on the way the trawls are operated. Often, particularly in shallow waters, the pelagic trawl was hauled on or very close to (1/2m) the bottom.

Druzhinin (1973) in a report on similar work relating to a large part of the region to which the present report relates, listed some 322 species taken in fishing operations. For the present survey a list of 456 species and 128 families was drawn up and coded. The family codes (as distinct from species codes) are many times entered in the catch records with report of quantity taken. In some cases such records related to species for which codes existed but final species identification was not made; in other cases a record of family code related to specimens that could be assigned to the family but which were not of the recognised and coded species. Thus the total number of species was not less than 456 and might have been as many as 584 (456 + 128) or even more. Table 8 presents a summary of data on the number of species found in each shot, of surface pelagic net, of bottom trawl and other gears, and by all gears. The geometric mean number of species in a shot, for all gears, is 7.4 which means, supposing that species were caught entirely at random and that once a species was taken in the course of a cruise it would not be taken again during that cruise, that for 584 species a minimum of 79 shots would be required to obtain specimens of all species; but, since on the average, each species made about 2 appearances in the course of a cruise, a minimum of 158 shots would be necessary under these unrealistic conditions. If then we modify our specification of conditions, and we make them more realistic by, on the one hand, reducing the chance that a gear will take specimens from all species present in a locality at the time of a shot, and, on the other hand, reducing the fit of the distribution, abundance and behaviour of each species to the distribution in time and space of the fishing operations, the required number of shots is considerably greater. The original, unrealistic conditions imply a value of 1 for the gear catching-power ('catchability' of authors) whereas a value of 0.5 would probably be more realistic*. Those conditions also imply that every species is present within each sector in one or other of the fished localities at the times of fishing, represented by individuals of a size and abundance that would make it likely that a gear with catching-power of 0.5 would take some specimens of it. This condition, however, is highly improbable: some species are of such limited distribution and their numbers so small that they are

* We hold that catchability holds as much between species as it does between size-groups of a species, especially since each species is characterized by a mean size.

taken only extremely rarely, even by intensive fishing of a locality; the pattern of distribution of some species is so changeable that their presence in some locality might never synchronise with fishing operations there; species of short life-span may be represented at times by only post-larvae and small juveniles. Theoretically, each species could be rated, as to its availability/accessibility/vulnerability (AAV index) to a specified net, on a scale from 0 to 1; a species which is always present, abundant and catchable, would be rated 1, others, such as those just cited, would be rated less. The average rating might perhaps be 0.5 and if that were the case the number of shots required, taking also into account the fishing-power factor of 0.5, would be 632 per cruise $(15.8 \times \frac{1}{0.5} \times \frac{1}{0.5})$; in contrast, the average number of shots per cruise (counting the first two cruises as one) was 90.

We argue that such a result was to be expected, with respect both to appearances during successive cruises with each sector, and to appearances in the different sectors during each cruise, considering the number of species, the size of the area, and the number of fishing operations. But this is a result which relates, we believe, only to catching and not to acoustic observing. It tells us something about identification of the observed stocks but not about biomass density. Insofar as the partitioning of echo-trace between pelagic and demersal stocks depends on identification it cannot, in the light of this evidence, be held to be very reliable. Then, in view of the evidence of Table 7a the distinction is perhaps not biologically real and in that case the biomass density value for the two types together (that is, total trace less mesopelagic, plankton etc.) is probably the most reliable measure. The values for the types separately will then be an indication of the proportion of time spent by these stocks in each of the two strata rather than a separation of stocks according to supposed preferences for these strata, which might be characteristic of each species.

3.2 The Acoustic Measurement of Biomass

The raw data from the acoustic work are the recordings, summarised in Tables 10a to g, and as a first step, we must examine the statistical characteristics of these data. It will be seen in these tables that the variances without exception are greater than the mean and generally are many times greater.

Thus it is clear that the observations were of contagiously distributed populations, a feature which was already obvious in the patchiness shown in Figures 10 to 21. Moreover, a strong correlation holds between mean and variance, as exemplified by Figure 22; the data from which this figure was drawn are the means and variances for cruise and resource type (demersal and pelagic) of Sector 1 in Table 9a. Similar results, with even higher correlations, were obtained for other Sectors, and for patches and strata but with lower correlations. Roughly the result is:

Value of Mean	Value of Variance
$\bar{x} < 10$	about 7 $\bar{x}$
$10 \leq \bar{x} < 30$	15 $\bar{x}$
$\bar{x} > 30$	60 $\bar{x}$

The effect of this characteristic is that some statistical methods "including the t-test and analysis of variance, cannot be applied without the risk of considerable errors" (Elliott, 1977). The appropriate course of action, in this situation, would be to transform all the data, replacing x by log (x + 1) (Elliott l.c.); unfortunately the complete set of original data was not readily accessible at the time of preparation of this report and therefore the analysis has been made at the simple level of arithmetic means and variances, leaving until some later opportunity such deeper analyses and more subtle comparisons as might be made with transformed data.

The mean sector/cruise recordings are assembled in Tables 11a and b for ease of comparison. The distribution of these values is, in both cases, highly skewed positively and highly leptokurtic but after transformation (replacing x by log (x + 1) each distribution is close to normal. The values for demersal stocks are relatively uniform in two blocks, Sectors 1 and 2 and Sectors 3 to 7; also there is some grouping between cruises: Cruise 4, which was executed entirely during the NE Monsoon, has lowest mean, Cruises 1/2 and 5, whose execution extended from the end of the NE Monsoon through the transitional month April into the beginning of the SW Monsoon have the same mean, while the means of Cruises 3 and 6 (with converse location in time, from end of SW Monsoon through October into the beginning of the NE Monsoon) are almost the same and are higher than the other two. Analysis of variance of these transformed means results in F-test value at 5% for comparison of the cruises mean square with residual mean square and at between 5% and 1% for comparison between sectors and residuals. The coefficient of variation (of transformed values) for pelagic (40.5%) is only little more than that for demersal (38.7%), and although analysis of variance shows comparisons in Table 11b are non-significant, they are not without interest. As in Table 11a, there is a grouping of the sectors, Sectors 2 and 5 being highest, Sectors 1 and 2 being next (and these two pairs are nearly equal), and Sectors 3, 6 and 7 are substantially lower than the others. The Cruise 4 overall mean is in this case the highest and those of Cruise 1/2 and 5 are lowest (but not equal) whereas those of Cruises 3 and 5 are equal. This suggests that comparisons between cruises might not be correct and that these values should instead be grouped by seasons (see Figure); when this is done still greater differences appear for pelagic: the overall mean for values obtained in the NE Monsoon is 11.6, for the SW Monsoon is 6.4, April 3.9 and October 7.9. For demersal stocks the effect of this regrouping is the opposite, the coefficient of variation of the seasonal values is half that of the cruise values. Thus, it may be taken that, despite having some species in common, the demersal and pelagic biota show marked differences of acoustic density both spatially (between-sector differences) and temporarily (of difference of seasonal response); but there are indications, even in this analysis, of sector/season interactions for which we have not yet made any allowance.

It is to be kept in mind that the data in Table 10 are simply mean values of recordings each of which has the same weight as every other; they therefore are merely indices of acoustic density. The sets of these values, relating to separate patches, grouped in strata, must be weighted each according to the total area of the patches of the stratum to which it refers. This analysis has shown, however, an approach to the analysis of the weighted and converted data which we take to constitute measurements of biomass.

The biomass estimates are made from the stratum-area weighted mean recordings for each sector during each cruise; the successive calculation steps are set out in Table 11, and it will be seen that the confidence limits of each mean have been calculated.

The sector/cruise biomass estimates are set out in Table 12 a and b. Interpretation of these values, with overall range from 3,000 to 1,087,000 tonnes and considerable differences between cruises and between sectors, is somewhat difficult, because, in the first place, of differences of area of the sectors, and, in the second place, of the problems of seasonality discussed above. To reduce the area effects the figures have been converted in Table 13 a and b, to biomass per square mile of continental shelf; these values have an overall mean of 36.1 t/nm^2 for pelagic and of 17.4 t/nm^2 for demersal the sum of which gives about 17t/km^2 which is similar to estimates made for other regions of the northern Indian Ocean (Raja, 1980). In the table of pelagic values, the low figures for Sectors 6 and 7 may have resulted from the absence of data from the last cruise, otherwise the Gulf of Oman appears to be less productive of pelagic stocks than are the other sectors.

But, while this conversion of the biomass estimates adds some confidence to inter-sectorial comparisons, some doubts remain as to what in fact is being compared and what the estimates are of: are the individual cruise values truly representative of the amount of biomass of some period? and, if so, of what period in each case? among the individual values, is the greatest a measure of the maximum reached by the stocks? and are the mean values a true measure of the average to be expected in each sector, or do they measure that to which authors refer with the expression "standing stock?"

In the first approach to this analysis we assumed that the biomass of each stock must fluctuate each year and we further assumed, with regard to the acoustically observable stocks, that the fluctuation must be from a minimum at some time shortly after spawning, when the mature individuals had lost weight from spawning and replenishment of their numbers by recruitment had not yet overtaken the loss by natural mortality, to a maximum produced by recruitment and the rapid growth of the recruits. We also expected, though with less confidence, that the maxima (and, therefore, also the minima) would occur in the same season for such a proportion of the stocks that a similar annual cycle would appear in the total biomass. Although the recordings indicate, as discussed earlier in this section, that the pelagic stocks are at their maximum during the NE Monsoon and at their minima in the transition month April, Figures 23 a to g give meagre support to our assumptions, and chiefly in the case of Sector 2 in which both demersal and pelagic stocks show something like an annual cycle.*

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* The individual curves in these figures are discussed in greater detail below.

In Sector 2 the pelagic stocks are shown as having a single maximum in the entire 2-year period and while two maxima appear for demersal stocks some doubts must be entertained about the reality of one or the other of them. The pelagic stocks of Sector 5 are shown, like those of Sector 2, with a single maximum. The rest of the curves are non-descript, to say the best of them.

However, the evidence, although it gives only weak support to our assumptions, does not point to a rejection of those assumptions and even less does it suggest alternative assumptions. We return to these questions after the following examination of evidence with regard to each of the seven sectors, in turn.

Sector 1 Somali east coast 2°N 46°E to 11°N 51°E*

Pelagic Fishes:

Round herring (Etrumeus teres) was found in relatively small quantities in the southern part of this sector during most of the cruises. During April 1976 (Cruise 5) this species was observed in small schools and scattering layers at depths between 50 and 100 m and at depths of 120-160 m just off Mogadiscio. The recordings of round herring, sardinella (Sardinella sp.) and spotted herring (Herklotsichthys sp.) were not so dense as to promise commercial catches with the gears used by "Dr. Fridtjof Nansen".

The most important pelagic fish species observed in the northern part of the sector was the mackerel (Scomber sp.), which was observed along the edge of the continental shelf between 5° and 8° N during spring both in 1975 and in 1976. During the day the fish formed small schools at the bottom at 300-350 m depth while during the night they appeared as a pelagic scattering layer in 150-200 m depth.

In November 1976 (Cruise 6) several schools were recorded near the bottom at a depth of 150 m in the area of Mogadiscio. These schools were classified as mackerel but the true identity could not be estalished because trawling conditions were unsuitable. If these recordings originated from mackerel, the observation may serve as an indication of a seasonal shift of concentration

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* These indications are only approximate.

since it was made 180-300 nautical miles south of the area where the fish was observed during the spring cruises.

Scattered recordings of anchovy (Engraulis sp and Stolephorus sp.) and scad (Decapterus sp.) were observed in nearshore waters during all cruises.

Relatively high abundances of small pelagic fish were observed in the northern-most part of this sector during all cruises except for Cruise No. 4. The recordings originated from Indian oil sardinella (Sardinella longiceps), round herring and scad (Decapterus macrosoma and Decapterus maruadsi). The fish was observed in near-surface schools and in scattering layers at 10-30 m depth over the shelf area between Ras Asir and Ras Hafun. The observations indicate both higher biomass and higher availability of the fish for fishing operations in autumn than in spring. During the spring surveys the schools were observed to be small while schools of more than 100 tonnes were found in autumn 1975.

Near-surface schools were only partly recorded by the echosounder, and therefore their biomass was estimated from sonar counts of the schools; during the spring surveys their biomass amounted to only a small fraction of the total pelagic biomass, but in autumn 1976 (Cruise 6) it was found that schools of this kind within the area constituted about 1/6th of the total.

The observations on the state of the gonads of the small pelagic fish caught in this north-eastern locality are especially interesting, and are of particular relevance to a consideration of the AAV Index in connection with a possible annual cycle of fluctuation in biomass. Indian oil sardinella and layang scad were observed to be mainly ripening and nearly ripe, during all periods of observation, with higher percentages of nearly ripe during the autumn surveys. A significant portion of the Indian oil sardinella stock was spawning in November 1976. The round herring was ripening during the spring surveys while the fish observed in October 1975 were recently spent, the fish of small size observed in November 1976 were all immature. These observations indicate that the area is a spawning locality for all three species. The observations show that the Indian oil Sardinella and probably also the layang scad spawn in late autumn while the round herring spawns earlier in the autumn. The observations of ripening stages in early spring indicate also a spawning period for all three species in late spring. This evidence is referred to again in the section below relating to Sector 3.

The maximum biomass density in January, shown in Figure 23a1, is perhaps consistent, within our assumptions, with the evidence of autumn (?September) spawning, and so then also might be the low value in August, but the minimum in February of 1975 can scarcely be accepted as a true measure of the sector pelagic biomass during the NE Monsoon; but, by the same token the value for October 1976 does not correspond well to the October 1975 value. Thus, if we accept the central three values (August, January and April) we must hesitate about accepting the first and last values, or if we accept the latter we must doubt the former. Short of attributing this situation to technical errors in operation and reading of equipment and/or in the analytical procedures, we are bound to make further assumptions to the effect:

(a) that the stocks tend to form in localised concentrations

(b) that the concentrations shift about within a sector, and perhaps at times move out of it; and

(c) that in the course of a cruise the observations might happen to be consistently of unoccupied space.

(d) that year to year variations in stock sizes occur.

These assumptions then distinguish the maximum-biomass values from the minimum-biomass values, at least methodologically. The former may be overestimates by virtue of under-estimation of the biomass in the apparently unoccupied space, but at least we have a fair approximation to the biomass value of at space -- we can't go far wrong in counting it zero, since any error in that respect would only mean that our overall estimate was the less wrong; for the minimum, however, we have no indication of the value that should be assigned to those localities that harbour missing stocks.

Demersal Fishes:

A large amount of demersal stock was observed in the northern part of this sector in autumn 1975 (Cruise 3) but was not identified. The recordings were made at depths between 100 and 300m in the locality in which mackerel had been observed in spring (Cruise 1/2), but since bad weather conditions created a lot of noise on the echosounder no conclusions could be drawn as to the origin of the recordings and since such density was not observed in that locality during later cruises we can do no more than note the observation.

Mention must be made here, with relevance as well to results relating to demersal stocks of all other sectors, to the fact that the echosounder had a dead zone in the bottom 1-2 m of water depending on depth and bottom configuration, failing to measure biomass lying in the bottom 3m of water. All estimates of demersal biomass density are therefore subject to the possibility that significant quantities of biomass lay, unmeasured in that bottom stratum. Since there is good reason to suppose (a) that whenever demersal stocks are observed in a locality some proportion of them lies in the bottom stratum, (b) that in some times of the day and in some seasons the concentration in the bottom stratum is very high, and (c) that in some localities in which the echosounder gives no indication of the presence of demersal stocks there might nevertheless be some stocks in the bottom stratum, it may also be supposed that all values of demersal biomass density obtained during the survey are lower than the true values, except where other causes (see p. 38) have resulted in an overestimate of what has been observed. In balance, however, we believe that the demersal stock, in general, has been underestimated.

The two maxima of the curve, in Figure 23a2, for demersal stocks of this sector at first sight seem to conform to the assumption of an annual cycle but they differ importantly in timing; therefore, except in the event that a 3-month shift had taken place of one or the other, one of these cannot be a measure of the maximum reached in its year. Graphically, as suggested by the dashed line on the left of the figure, it seems plausible to suggest that a maximum had been reached in April 1975 when, however, the vessel was elsewhere.

Total Biomass:

From the evidence available we conclude that the pelagic biomass of this region can reach a maximum of 116 $\mp$ 14 t/nm^2 and the demersal biomass a maximum of 65 $\mp$ 23 t/nm^2 which means in total, with continental shelf area of 9,340 nm, from about 953,000 to 1,214,000 tonnes of pelagic biomass and from 392,000 to 822,000 tonnes of demersal biomass. Since the maxima of the two types do not coincide, the maximum for the sum, which occurred during the NE Monsoon, was somewhat less, ranging from 1,258,000 to 1,527,000 tonnes.

Sector 2 Somali North Coast: 11° 41' N 43° 28' E to 12° 02' N 50° 02' E

Pelagic Fishes:

Small pelagic fish were very scattered in this area during all surveys and catch rates were also quite low. An important observation was the finding of small scad, 6-11 cm in length, in offshore waters in September 1975 (Cruise 3).

Of the two maxima in the estimates of biomass of this sector, the second corresponds in its timing to the maximum for Sector 1 but is at a somewhat lower level of production. The first is placed in the NE Monsoon season but later in that season than the second and with very wide confidence limits, although its central value is close to that of the second. It is tempting to think that the observations in this sector obtained a rough sketch of an annual cycle of abundance of the pelagic stocks but the extremely low values recorded for the last two cruises rather mar the picture.

Demersal Fishes:

As observed above, the curve for demersal fishes of this sector (Figure 22b) conforms to a concept of annual cycle of abundance and its regularity suggests that some confidence could be placed not only in the maximum but in an estimate of the average biomass of a twelve-month cycle.

Total Biomass:

Taking the second of the pelagic maxima as the more reliable estimate the data indicate that in this sector the pelagic stocks can reach a level of 75 20 t/nm^2, from about 128,000 to 225,000 tonnes and the demersal stocks a level of 42 13 t/nm^2, from 67,000 to 128,000 tonnes. The maximum of the sum also appeared during the NE Monsoon period (of 1976) and ranged from 194,000 to 307,000 tonnes.

Sector 3 Socotra:

Pelagic Fishes:

The failure to traverse this sector during the 4th and 5th cruises leaves the evidence with regard to it very scant indeed. However, this sector and the shelf off Ras Asir were the site, during the SW Monsoon cruise (No. 3) of 1975, of an observation of much interest. When the sector was traversed in late-August/early-September only insignificant quantities of pelagic fish were observed. The locality was revisited a month later and very good concentrations were observed, with biomass, in only 4 patches, of from about 230,000 to 320,000 tonnes. Since the pelagic biomass of Sectors 1 and 3 is estimated, from the first traverse, to have been between 340,000 and 480,000 tonnes, the estimate from the second visit has much significance, even if its correct interpretation is inaccessible. It cannot replace the estimate of the first traverse since it pertains to both Sector 3 and Sector 1, and to only a very small proportion of the latter, and it may have resulted from a redistribution of stocks which had been observed and measured on the first traverse; on the other hand the concentrations of this second visit might have come from:

(a) localities of these two sectors which, during the first traverse, had been judged "unoccupied",
(b) other sectors,
(c) deeper waters.

Each of these four possibilities has its own, distinct implications for the analytical procedures and for the interpretation of results, but, perhaps of most direct relevance to the analysis that can be made at this stage is the clear evidence from this case that major changes of abundance can take place relatively quickly and hence the conclusion that must be drawn from this evidence that average abundance over, say, twelve months can be reliably estimated only when the patterns of distribution are well described and the cycles of abundance are well defined.

The interest of this second visit was further enhanced by biological observations on fish caught at the time, which showed that the Indian oil sardinella and the layang scad were almost ripe and that the round herring had recently spawned; this leads to the idea that biogeographically this zone, from about 11° N on the east Somali coast to about 50° 30' E on its north coast and including the Socotra sector is a spawning locality for these, and perhaps other pelagic species.

The biomass density observed during the second visit was in excess of 200 t/nm^2, but this cannot be taken to be representative of the entire sector. The maximum for the sector, during the SW Monsoon (Cruise 6) was about 38 t/nm^2, lower than the maxima of all other sectors except 6 and 7.

Demersal Fishes:

The evidence with regard to these stocks in this sector is even more scant than that for pelagic stocks, but is similar in showing a minimum in the SW Monsoon and a low maximum, less than that of all other sectors except 5.

Total Biomass:

The pelagic stocks can reach a maximum of 38 $\mp$11 t/nm^2, giving total pelagic biomass between 112,000 and 224,000 tonnes and the demersal stocks 20 $\mp$7 t/nm^2, between 55,000 and 115,000 tonnes total demersal biomass; the sum lies between 190,000 and 315,000 tonnes.

Sector 4 Yemen Coast 12° 30' N 43° 30' E to 16° 30' N 52° 30' E

Pelagic Fishes:

The main species in the western part of this sector were sardinella and scads, except for during the autumn cruise in 1976 (No. 3) when trevally was found to be the dominant species. The small pelagic fish were rarely observed in dense concentrations, most often they formed scattering layers or small schools at varying depths in waters shallower than 70 m. In the most shallow waters ponyfish at times made up a significant part of the biomass, and at the same time was the dominant species in trawl catches.

Surface schools were spotted near Aden both in early spring 1976 and in autumn of the same year. The schools were relatively small and scattered, and a purse seine set for a typical school in February 1976 (Cruise 4) resulted in 1.5 tonnes of white sardinella. Indian oil sardinella constituted only a minor portion of the catches in the area.

In the eastern part of the sector, however, the species constituting the major portion of these quantities was Indian oil sardinella, although other sardinella species as well as scads and horse-mackerel (Trachurus sp.) were present in significant quantities. In the most shallow waters again different species of ponyfish made up large portions of the catches.

The fish were observed in the eastern part both as small surface schools and as schools and scattering layers in midwater. During some cruises a relatively large portion of the small pelagic fish biomass was observed as surface schools. The fish were then only partly recorded on the echo-sounder and hence it is likely that the abundance has been underestimated. The cruise with the largest underestimation was in autumn 1976 when two areas of surface schools were found to contain respectively 50,000 and 20,000 tonnes of fish. The most dense concentrations were found in near-shore shallow waters, 10-30 m, but as a rule within limited localities. Detailed sonar mapping of such local concentrations showed that 1,000-10,000 tonnes of fish, mainly Indian oil sardinella, formed these dense patches. As the extension of the patches was quite small, 1-5 nautical miles, it is possible that some of them lay outside the survey grid.

The observations here have a general relevance to the estimate of pelagic stocks, especially of the small pelagic fishes. If an important proportion of these stocks spent much time in very shallow waters, inaccessible to the research vessel, and it seems likely that juvenile stages habitually did so, then the pelagic stocks biomass will have been underestimated.

The curve of biomass density estimates (Figure 22d) gives no support to an assumption of annual cycle; indeed the left hand segment of the curve, from end of March to mid-February, looks as though it might be the latter part of a two-year cycle, and the right-hand segment as though it were the first quarter of such a cycle; whether or not this is the case is an issue which available evidence cannot resolve.

Demersal Fishes:

Ponyfish, and to some extent catfish and seabream, were frequently caught in shallow waters 10-30 m, while threadfin bream was caught somewhat deeper. In the deep water hauls, deeper than 150 m, Palinurichthys sp. and lizardfish were caught, at times in good quantities. The discrimination between small pelagic fish and demersal fish was difficult at times since ponyfish, horsemackerel and catfish were recorded and caught both at the bottom and in midwater. While, recordings thought to originate from horsemackerel were always classified as small pelagic fish and those originating from catfish as demersal fish, some mixing of the two categories took place at times in the case of ponyfish.

The observations above with regard to the curve for estimates of pelagic biomass hold more or less equally for the curve for estimates of demersal biomass.

Total biomass:

The pelagic stocks manifested maximum density of 57 ∓8 t/nm^2, giving total biomass between 376,000 and 495,000 tonnes, in the NE Monsoon and the demersal stocks of 26 ∓4 t/nm^2 (from 164,000 to 238,000 tonnes) at the beginning of that season. The maximum of the sum of the two types was shown in the first cruise (from 528,000 to 645,000 tonnes) but was only slightly more than the maximum shown in the last cruise (from 515,000 to 613,000 tonnes), both maxima in the NE Monsoon.

Sector 5 South Oman Coast: 16° 30' N 52° 30' E to 22° 30' N 59° 40' E

Pelagic Fishes:

The recordings of small pelagic fish in the sector were dominated by Indian oil sardinella and round herring while other species of sardinella, rainbow sardine, anchovy and horsemackerel (Trachurus sp.) also were present in significant quantities.

The most dense concentrations were found in the Gulf of Masira, south-west of Masira Island. During autumn 1975 (Cruise 3) good concentrations of Indian oil sardinella were found to move rapidly towards the south-west of this sector. The fish were recorded as large schools during the day and scattering layers during the night in 10-30 m depth. Immature fish made up the larger portion of the catches from shallow waters while mature specimens dominated the recordings observed between the depth contours 50 and 100 m.

During spring 1976 (Cruise 4) the dense concentrations in the Gulf of Masira were found in waters shallower than 30 m. The behaviour of the fish, mainly Indian oil sardinella, was as before; schools, of maximum size of 20 tonnes, during the day, and scattering layers in the upper 20 m at night.

The curve for the estimates of pelagic biomass density in this sector has been discussed above; it presents special difficulties: the extremely low value for April 1975 (Cruise 1/2) is inconsistent with the values obtained at other times, perhaps most particularly in contrast with the values obtained 10 and 12 months later; but even supposing that to be a gross underestimate, and suggesting that the true value might have been closer to the level of the values estimated from the data of the other cruises, at best the curve would suggest a cycle of 16 months or more.

Demersal Fishes:

The predominant species belonging to this category was the threadfin bream, which was recorded in quantities along the entire coast between Kuria Muria Islands and Ras al Hadd. The most dense concentrations were found in Sauqara Bay at depths between 75 and 150 m. The fish occurred as small schools at the bottom in daytime; and during the night as a rather weak scattering layer 10-20 m off the bottom. Many good catches, ranging from 5 to 11 tonnes per hour trawling, were obtained when fishing the stocks from which these recordings were obtained, both with bottom trawl in daytime and pelagic trawl during the night. Other species were: Ponyfish, catfish, seabreams and scavengers, the three latter being caught in quantities in bottom trawl hauls during spring 1976 (Table 8).

The estimates of demersal stocks of this sector are lower than those for any other sector and are the most unchanging.

Total Biomass:

The pelagic biomass maximum density of 72 ∓ 7 t/nm^2 gives a total pelagic biomass of 730,000 to 903,000 tonnes; the demersal figures are 11 ∓ 3 t/nm^2 and from 98,000 to 156,000 tonnes. The sum maximum ranges from 846,000 to 1,017,000 tonnes.

Sectors 6 and 7 Gulf of Oman 22^0 30' N 59^o 40' E to 25^o N 62^o E with an ill-defined dividing line in the north-west toward Hormuz Strait.

Pelagic Fishes:

During the four first coverages (Cruises 1/2, 3, 4 and 5) the abundance of small pelagic fish was rather low, with scattered recordings in both sectors, but significantly higher abundance was observed during the last cruise. A variety of species of carangids was observed. On the Iranian side of the Gulf, djeddaba crevalle (Alepes djeddaba), threadfin trevally (Alectis indicus), cavala (Carangoides spp.) and hairtail scad (Megalaspis cordyla) were frequently caught while bigeye scad (Selar crumenophthalmus), Malabar cavalla (Carangoides Malabarieus) and frigate mackerel (Auxis thazard) were observed along the Oman side. The three latter species were observed also in small surface schools from the shore to 20 nautical miles offshore. However, as explained earlier, the data of the last cruise, with regard to these two sectors, had to be discarded because of misidentification.

The curves for the two sectors (Figures 22 f and g) are similar, insofar as they can be compared; the maxima are virtually the same and occur at the same time.

Demersal Fishes:

The curve for Sector 6 demersal biomass density closely approximates the curve for pelagic biomass; the curve for Sector 7 demersal biomass density is nondescript and puzzling with regard to the very low values for Cruises 4 and 5 and that for Cruise 3 not much higher.

Total Biomass:

Following the pattern adopted for the other sectors the figures are:

		Sector 6	Sector 7
Pelagic stocks			
	max. density	31 ∓ 2 t/nm^2	31 ∓ 6 t/nm^2
	total biomass	123,000 to 142,000 tonnes	113,000 to 161,000 tonnes
Demersal stocks			
	max. density	12 ∓ 1 t/nm^2	28 ∓ 4 t/nm^2
	total biomass	94,000 to 108,000 tonnes	106,000 to 139,000 tonnes
Both types		150,000 to 317,000 tonnes	140,000 to 214,000 tonnes

Conspectus

Putting the foregoing estimates together, we have the following result:

Sector	Demersal	Pelagic thousand tonnes	Both
1	392 - 822	953 - 1,214	1,258 - 1,527
2	67 - 128	128 - 225	194 - 307
3	55 - 116	112 - 224	190 - 315
4	164 - 238	376 - 495	528 - 645
5	98 - 156	730 - 903	846 - 1,017
6	94 - 108	123 - 142	150 - 317
7	106 - 139	113 - 161	140 - 214
Totals	976 - 1,707	2,535 - 3,364	3,306 - 4,342

To repeat, these are estimates of maximum biomass of each type of resource, and of the two combined, in each sector and, as totals, in the entire region. Maximum values are given here, rather than average or other level, for several reasons. In the first place, there are grounds for believing that we can put more confidence in the maximum values that we can put in minimum or intermediate values. With respect to a maximum biomass-density observed in some locality we can say, subject to any necessary reservations with regard to the possibilities of instrumental or observer errors which, however, hold *pari passu* for all values, that the density can be at least as great as that maximum which then sets a lower bound to the phase space within which the true maximum must lie. Such a value is taken to be representative of the biomass of some space, as is each other value, but, whereas a maximum observed value may be something less than the true maximum, each other value may be an undervaluation of the biomass of which it is thought to be representative) by the difference between true maximum and observed maximum *plus* the difference between it and the observed maximum. In other words, the error to which a maximum value may be subject must be less than the error possible for every lesser value. And that which holds between values observed in some short period within a specified locality holds also between values at different times of an extended period; at least the density can be as great as the maximum, always bearing in mind the necessary technical reservations, whereas with regard to each of the other values we must, in the absence of other evidence, have in mind the possibility that it might have been greater, and might even have been as much as the maximum.

This is, of course a sampling problem and a matter of survey-grid design, a matter referred to expressly above in the discussion of the results with regard to Sector 4. The issue is one of representativeness of the "samples" taken by acoustic equipment and in particular of what may be missed by the equipment at the time of observation as well as by the successive cruises. In the course of this work five important causes of "miss" have been noted:

(1) aggregation, such that a survey path may have passed mainly between concentrations, resulting in underestimate, or mainly through concentrations, resulting in overestimate; (see, for example, pp 32-33);

(2) seasonal changes in aggregation and behaviour, a counterpart in time of (1), such that a cruise may have been conducted at a time of highest chance of success of observing or at a time of lowest chance;

(3) sub-surface aggregation, such that only some proportion of the biomass was observed by the equipment, resulting in underestimate; (see pp 32-33);

(4) sheltering by the stock in shallow littoral waters which the vessel could not enter, resulting in underestimate; (see pp 32-33);

(5) inability of the equipment to observe demersal stocks in the bottom 1 - 2 metres, resulting in underestimate; (see pp. 28-29).

Whilst it might be held that the two possible outcomes of cause (1) could cancel one another out, such an expectation could not be entertained with regard to cause (2), hence the attention we have given in the preceding sections to the values represented in the curves of Figures 23 a to g, and we return to this matter below.

Causes (3), (4) and (5) are of different effect, all negative; but, while it is probable that some underestimate from these causes has resulted in every cruise in every sector, no measure of its magnitude can be made; furthermore, it is probable that the intensity of these causes varies in time, that of cause (3) diurnally and that of causes (4) and (5) seasonally. In sum, it is to be assumed that whatever overestimate there may be from other causes, in every case it will be to some degree offset by an underestimate resulting from three causes.

To the foregoing causes of non-representativeness of particular observations of biomass density must be added the more general effects, in broader sense, of migrations. Two principal classes of effects must be considered: first, those resulting from inter-sectorial migration, second those resulting from migration into and out of the survey space. Both can affect an estimate of average total biomass: inter-sectorial migration could result in all or part of a stock being credited to two sectors, or to neither of them thus causing either underestimate or overestimate; migration between survey-space and non-survey space must lower the biomass average, the degree of reduction depending upon the proportion of each year spent by the stock in non-survey space.

Conversion of the biomass-density data to absolute estimates of biomass has been effected through the two programme segments described in section 1.4, of contouring to demarcate the patches, and of weighting, averaging, and multiplication by area and by the factor C. These are data processing operations which assume the validity of the data (while recognising that any or all of the above causes may have operated to vitiate some or all of them) and produce biomass estimates which can be compared within sectors (as in the above sectorial sections) with moderate confidence, but with less confidence between sectors. The next step is to formulate arguments for estimation of the exploitable biomass and, from that, of the catch that might be allowable.

We take as starting point the formula by which FAO, in its "Fish Resources of the Ocean" (1971), made some of its estimates of production potentials, namely:

$$Y_{max} = 0.5 \times M \times B_0$$

in which Y_{max} stands for maximum yield, M for natural mortality (equal to total mortality in the unexploited population), and B_0 for the biomass of the virgin (unexploited) population. This equation has its origins in the exposition of the "sigmoid curve" theory developed by Hjort, Jahn and Ottestad (1933) and Graham (1935, 1939); the theory is discussed in Beverton and Holt (1957) and it is clear that in that work B_0 stands for "annual mean biomass" (the symbol in B & H is P). Thus, for the purposes of approximate estimation, values for maximum biomass should be transformed, to annual mean values. Whether transformation is necessary depends on the life cycle of the fish and the distribution in time of the fishery; if the biomass is produced in less than one year and the fishery takes its share around, for example, the time of maximum biomass, then a transformation to mean annual is not necessary. In the present case we have concluded that transformation to a mean annual value is desirable. Unfortunately, as shown in the preceding sectorial sections, this transformation cannot be made from the present survey results. We therefore take recourse to the easily demonstrable fact that the mean ordinate of any curve such as we might draw to trace the regular fluctuation of biomass in a twelve-month cycle is not less than 1/2 the maximum ordinate. The precise value of the proportion depends in part on the duration of the period of replenishment (by recruitment and rapid growth of juveniles) and in part, but probably more, on the mortality rate; the former determines, by its excess over mortality, the slope of the left-hand ascending limb of the curve, the latter determines the slope of the right-hand limb. In simulation exercises the value of the proportion was found to be greater than 0.7 for most values of M reported for scale fishes and even for the high mortality of species with a 1 or 2-year life-cycle the proportion is little less than 0.7. Of course, for a species whose mean biomass fluctuates greatly from year to year the mean for some twelve months not placed symmetrically about a maximum may be somewhat less or greater than the mean for the symmetrically placed twelve months. On the basis of this argument we suggest that the mean biomass in each sector will lie at least between the values given above, each divided by 2, and might lie between limits given by dividing those values by 1.5. In our view, the evidence that causes 4 and 5 were operative is such that the probability of underestimation because of these causes outweighs the possibility of overestimation because of other causes, and we therefore believe that the estimates are conservative.

The confidence limits to the weighted mean recordings have been calculated from the variances of the sets of recordings and therefore reflect only the statistical properties of the data, arranged (again, only from a consideration of numerical characteristics) as patches and adjusted by reference to areas (in the weighting). If administrative or economic considerations should indicate the advisability of obtaining more precise estimates of average biomass, particular to spaces smaller than those signified by sectors, and with narrower confidence limits from reliable estimates of the probabilities of events which are the outcome of the causes discussed above, it will be necessary to obtain more information on the bionomics of the important species of interest and to carry out further surveys designed to measure more accurately the effects of those causes.

3.3 Bionomic Aspects

In addition to the extensive material relating to composition of the stocks (discussed in Section 3.1) a considerable body of data relating to the life-history of many of the species was built up during the cruises. Although these data are not such as to support a full account of the bionomics of any one species they provide useful indications of distributional and other characteristics which play important roles in determining the 'display' of the stocks that, observed acoustically, constitutes the fundamental argument of our calculations. Since the development of a theoretical picture of this 'display' occupies such an important place in the formulation of a survey strategy and in the algorithm of data processing, we venture to give an account of our concept of the 'display' before proceeding to further examination of the items of evidence with regard to bionomic aspects.

By 'display' we mean, what a species shows of itself, through the distribution and behaviour of its individuals and its aggregations, in the several parts of its biogeographic range and in each part of the year, from which we are able to deduce those characteristics of the species population, such as average annual biomass, that interest us. A 'display' is a pageant, a sequence of variable tableaux rather than a single set-piece, and each tableau has its own properties and its own biotic significance. Preferably the tableaux are to be named and described by seasons, rather than by bionomic phases, in order to comprehend the entire species population; a spawning tableau is distinctive enough, but its actors are only the mature individuals.

We see the operation of processes at two distinct levels and of different time scale as determinative of the features of each tableau. There are processes of extended time scale (extended in terms of species life span) that determine the composition and average size (during the year) of the population; and there are short-term processes which determine the distribution of the individual of each age at each particular time and determine their behaviour at that time. These short-term processes, within each organism and in its environment, determine the day to day and hour to hour changes in distribution and behaviour. In our view, the scope and accuracy of the results of a survey are likely to be considerably affected by the extent to which the survey strategy is designed at these two levels, the timing, duration and location of each cruise being related primarily to the longer-term processes, while the finer details of itinerary, location of fishing operations and use of special techniques (e.g. with sonar) are related to the short-term processes. How far this can be done depends, of course, on the information available, and in the present case the information was rather scanty and therefore the survey was pretty much exploratory and its results will serve as much for the planning of future work of the kind as for the planning of industrial development.

The most valuable bionomic data relate to size composition and gonad condition of stocks of pelagic species; the data relating to size are summarised in Table 14. On the eastern part of the Yemen coast (Sector 4) specimens of Indian oil sardinella shorter than 12-13 cm were as a rule observed to be immature, while larger individuals were found to be maturing. This is in accordance with the work of the Fisheries Training and Research Centre in Aden (Anon 1975) in which it was found that the Indian oil sardinella becomes mature in its first year of life at a length of 13 cm. That work also showed that a wide spread to the length frequency distribution of this species along the coast at all times. Skrikov (1975) stated that the sardines in the area spawned mainly in May - August. Observations of the Indian oil sardinella during the present survey support Skrikov's findings: Small juvenile fish occur in the catches in autumn while maturing fish dominate during spring.

The occurrence of small sardine in May 1976 indicates that this species, however has a spawning season also in autumn.

Skrikov (l.c.) also reported that the life cycle of the sardines in the area is 4-5 years, and that fish of age 2 years or more made up more than 50 percent of the samples. This is in contradiction to results from the Pelagic Fishery project in Cochin (Anon 1976) which indicated that individuals older than 1 year were very scarce in the population of Indian oil sardinella off the west coast of India.

On the south-east Omani coast (Sector 5) in October 1975, the small Indian oil sardinellas were immature while bigger fishes were spawning: the round herring newly spent. In May 1976 the Indian oil sardinella were ripening and nearly ripe while the adult round herring had somewhat less developed gonads. If we adopt a growth rate similar to that for Indian oil sardinella in Yemen waters then the 8-11 cm round herring observed in May, may originate from a spawning in July-August the previous year, and the 4-7 cm long individuals observed in October may originate from a spawning in June-August. Hence, we arrive at a possible spawning season from June to early October for the Indian oil sardinella and a similar one for round herring. However, the observations of 10-14 cm (mainly immature) Indian oil sardinella in October 1975 indicate that the spawning season for this species may last longer than to October.

3.4 Catch Rates and Fishing Prospects

The averge catch per hour of species of each of 55 important families is given in Table 7a. However, it is unlikely that these rates can be taken to indicate the catch rates to be expected in sustained fishing operations. The more realistic indications are in the demonstration of substantial concentrations of stocks, in surface waters consistently, in three localities:

(1) on the north-east Somali coast, between Ras Hafun and Ras Asir;
(2) on the east coast of Yemen, from Ras al Kalb to Quanr Bay; and
(3) on the south-east coast of Oman, in the Gulf of Masira,

and of prospects of profitable trawling along the Yemen and Oman coasts down to depths of 300 metres provided that the species caught will be marketable.

More generally, an estimate of the average annual catch that might be available can be made from the formula discussed above on p. 39.

$$Y = 0.5 \times M \times B_0$$

For this purpose we take a value of M, equal to 0.5, as a weighted mean natural mortality rate for the observed dermal fish stocks and a corresponding value of M equal to 1.0 for pelagic fish. Further as discussed on page 40 we take B_0 to be equal to 0.7 B_{max} both for dermsal and pelagic stocks. The above formula is the reduced to two simple expressions:

$$Y_{dem} = 0.175\ B_{max}, \qquad Y_{pel} = 0.35\ B_{max},$$

by which the average catch of demersal, Y_{dem}, and pelagic, Y_{pel}, fish can be computed.

Applying these formulae to the maximum biomass figures on page 37 we obtain the following result

Sector	Demersal	Pelagic	Demersal plus pelagic Sum	Demersal plus pelagic Direct
		(thousand tonnes)		
1	69 - 144	333 - 425	402 - 569	385 - 534
2	12 - 22	45 - 79	57 - 101	34 - 107
3	10 - 20	39 - 78	59 - 98	33 - 110
4	34 - 42	132 - 173	166 - 215	92 - 225
5	17 - 27	256 - 316	273 - 343	148 - 360
6	15 - 19	43 - 50	58 - 69	26 - 111
7	19 - 24	40 - 56	59 - 80	25 - 75
Totals	176 - 298	888 -1177	1064 -1475	743 -1522

Where "Sum" colums are obtained by addition of the preceding columns, the "Direct" columns result from application of the lower values of B_{max} (combined estimates) on page 37 in the expression $Y_{dem} = 0.175\ B_{max}$, and the higher values of B_{max} on page 37 in the expression $Y_{pel} = 0.35\ B_{max}$.

The range of these estimates is, wide on the average, the upper value is 1.6 times the lower and the values are somewhat lower than previous estimates. Shomura (1971), for example, gave (in his Table H3) estimates for the region reported on here which totalled nearly 1.5 million tonnes for demersal stocks alone, and in his Table H5 suggested almost as much from pelagic stocks, thus suggesting a total potential about 2-4 times the estimate given here.

However, subsequent fishing experience and research in other sectors indicate that Shomura's estimates were very high; for example, current Australian estimates of the potential of the north-west grounds of Australia are of some tens of thousands rather than Shomura's 950,000 tonnes.

It should be noted that the values for potential catches arrived at here, include all species observed regardless of their commercial value. Further, the computations of yield do not consider the fact that profitable fishing can only be carried out above a certain lower limit of catch per unit effort. For these reasons we should expect the present estimates of potential catches to be higher than those to be experienced through a regular fishery. The possibility of over-estimation of annual catch figures for these reasons, however, might be outweighed by the estimates of mean annual biomass being conservative.

3.5 Environmental Information

The results of the oceanographic work carried out during the survey have been analysed by Sandven (1979). His conclusions are as follows:

> "The water structure is characterized by a well mixed surface layer, which is separated from the subsurface waters by a high stability boundary layer. This layer can easily be identified in the temperature field, the density field, the oxygen field, and less pronounced in the salinity field. Its position and strength have marked seasonal and geographical variations. It is relatively weak in the northern area during the NE-monsoon, while it is clearly notable at about 100m depth in the Gulf of Aden and the Somali region. During the SW-monsoon the boundary layer rises and increases in strength in the whole Arabian Sea, except near the equator where it remains at about 100m depth throughout the year. The depth of the boundary layer is closely related to the depth penetration of the mixed layer, which in turn is influenced by the heat balance and the wind stirring at the surface. The observation that the mixed layer is deepest in northern winter and gradually shallows from March to August, is confirmed by Wyrtki's atlas (1971), and has also been reported by Patzert (1972) in his investigation of the Red Sea.

"The surface layer is throughout the year characterized by warm, saline water with oxygen content above saturation values, while the subsurface water is cooler, lower in salinity and has extremely low oxygen content (below 0.5 ml/l). The Somali coast is an exception because the low oxygen water is absent in this area. The outflow of warm, high salinity water from the Red Sea is easily recognized in the Aden Gulf 1 section, where it sinks and mixes with surrounding water masses and penetrates into the Arabian Sea at 700-800 m depth. This outflow is considerably weaker in September-October than in January-February, as can be noted in the temperature, the salinity and the oxygen sections. This is in accordance with monthly observations of the water exchange through the strait of Bab el Mandeb (Patzert, 1972). Analogous seasonal variations in the outflow of water from the Persian Gulf to the Gulf of Oman is not found in the present data set. Throughout the year a core of warm high salinity water is observed at 200-300m depth in the Gulf of Oman, and it is most pronounced along the southern side of the gulf. Its further advection is not so well known, but salinity maxima of variable significance are noted at different positions of the northern Arabian Sea at 200-300m depth (as is noted by Rochford 1964).

"On the Somali Coast and in the area north of Socotra, marked seasonal variations in the flows and water masses are indicated both in the geostrophic velocity sections and in the salinity structure in the upper 150 m. During the NE-monsoon a southwestward flow of high salinity water (S 36.00) characterizes the upper 100m of this area. In the period of the SW-monsoon a northeastward flow of relatively low salinity and oxygen-rich water from equatorial regions is present in the upper 200m in the Somali Basin. A part of it penetrates past Cape Guardafui and into the region north of Socotra and continues along the coast of Oman. Coastal upwelling is evident in this area in April-May, while it is most pronounced in August on the Somali Coast. The geostrophic velocities, calculated relative 500m, reveal an irregular flow pattern in the whole investigated area, indicating the presence of a number of cyclonic or anticyclonic vortices. This is in accordance with maps of dynamic topographies of the sea surface, presented by W. Duing (1970), and based on observational results from the International

Indian Ocean Expedition. A more detailed description of the seasonal variation of currents and water masses could be desirable, but the present data set, with each section occupied maximum five times in a period of two years, cannot fulfill this desire. However, it is hoped that this data presentation should illustrate some major features of the coastal oceanography of the Arabian Sea."

Essentially this is a confirmation of previous accounts and presents nothing extraordinary from which it might be thought that an explanation could be found of particular features of what we report here with regard to fish stocks.

4. DISCUSSION

Perhaps the most important outcome of this further examination of the results of the survey has been the light it has thrown on the numerous technical and methodological problems of this kind of work. Even if the estimates here of biomass and yield potentials are no great improvement on the estimates in the Final Report, their presentation with upper and lower values derived from an estimate of confidence limits (even if admittedly the calculation of those limits is not very satisfactory) suggests the bounds within which planning decisions ought, at present, to be set. Moreover, the structure of the argument leading to these estimates is described so that as new information becomes available the estimates can be adjusted with respect to particular components of the system; which means that adjustment of the estimates need not await some repetition of work such as was done on ths survey but should be achieved by systematic testing of the assumptions described in this report and by intensive work designed expressly to measure the effects of the causes discussed in Section 3.3 and to obtain a better measure of the conversion factor C.

Given the magnitude of the task undertaken for the survey -- to traverse some 44,000 nm^2 of continental shelf five times in less than two years, given also the large number of species and the relative scarcity of information with regard to the display of almost all of these, allowing for weather conditions which made work impossible in at least one month and brought some difficulties at other times, and recognising the inevitability of contingencies and of human error, it is obvious that the results would be marked by a number of important uncertainties. In particular it could be expected that the results would have to be with regard to aggregates of species and could not provide a precise and detailed account of any one species.

On these terms, however, the survey was a successful exploration which has characterised the distribution and main compositional features of the fish stocks and has provided fair approximations to the annual mean biomass and yield potential of those stocks. Admittedly those estimates are low in comparison with others which have been made; indeed, we are convinced that significant upward revision of them will be made when the stocks in very shallow waters and in the 1-2 m bottom stratum can be assessed. The degree to which the estimates might be increased after such a revision, or might have to be increased for other reasons, is a matter on which nothing can be said at this stage. However we believe that industrial development based on the present estimates could be planned safely and would soon yield information from which to improve the estimates.

5. CONCLUSIONS

(a) The work carried out with the R/V "Dr Fridtjof Nansen" in the north-west Indian Ocean in 1975-1976, off the coasts of Somalia, Yemen, Oman and of Iran in the Gulf of Oman, effected an integrated survey of the fish stocks inhabiting the continental shelf off those coasts of which the principal results were:

(i) a preliminary account of the distributional and compositional characteristics of the species aggregates of those waters, showing considerable seasonal variation of those characteristics within each sector and differences between the sectors;

(ii) estimates of the annual mean biomass of the stocks as at least 50%, and perhaps 67% or more of the following figures:

Sector	Demersal	Pelagic thousand tonnes	Both
1	392 - 822	953 - 1,214	1,258 - 1,527
2	67 - 128	128 - 225	194 - 307
3	55 - 116	112 - 224	190 - 315
4	164 - 238	376 - 495	528 - 645
5	98 - 156	730 - 903	846 - 1,017
6	94 - 108	123 - 142	150 - 317
7	106 - 139	113 - 161	140 - 214
Totals	976 -1,707	2,535 - 3,364	3,306 - 4,342

(iii) the following conservative estimates of yield potentials:

Sector	Demersal	Pelagic	Demersal plus pelagic Sum	Direct
		(thousand tonnes)		
1	69 - 144	333 - 425	402 - 569	385 - 534
2	12 - 22	45 - 79	57 - 101	34 - 107
3	10 - 20	39 - 78	59 - 98	33 - 110
4	34 - 42	132 - 173	166 - 215	92 - 225
5	17 - 27	256 - 316	273 - 343	148 - 360
6	15 - 19	43 - 50	58 - 69	26 - 111
7	19 - 24	40 - 56	59 - 80	25 - 75
Totals	176 - 298	888 -1177	1064 -1475	743 -1522

Where "Sum" colums are obtained by addition of the preceding columns, the "Direct" columns result from application of the lower values of B_{max} (combined estimates) on page 37 in the expression $Y_{dem} = 0.175 B_{max}$, and the higher values of B_{max} on page 37 in the expression $Y_{pel} = 0.35 B_{max}$.

(iv) a demonstration of the presence of substantial concentrations of stocks in surface waters, consistently, in three localities:

(1) on the north-east Somali coast, between Ras Hafun and Ras Asir;
(2) on the east coast of Yemen, from Ras al Kalb to Quanr Bay; and
(3) on the south-east coast of Oman, in the Gulf of Masira,

and of prospects of profitable trawling along the Yemen and Oman coasts down to depths of 300 metres provided that the species caught can be commercialy marketed.

(b) The estimates of biomass and yield are not only conservative but do not include a measure of some stocks lying in shallow littoral waters nor of others lying in the deepest 1-2 metres of deeper waters; for this reason, if for no other, the estimates are likely to be revised upwards in the future.

SUMMARY

The Institute of Marine Research, Bergen, operating the Research Vessel "Dr Fridtjof Nansen" made a survey in 1975-76 of the fishery resources of the North-west Arabian Sea, from near Mogadiscu on the Somali coast, through the Gulfs of Aden and Oman, to the Iran/Pakistan border. The survey was accomplished by six cruises which effected 5 complete traverses, or coverages, of the region.

The work of each cruise was described in a Cruise Report issued soon after completion of the cruise (Cruises 1 and 2 were reported together), and a final report was made. These documents were transmitted to FAO and were discussed at a workshop, in Karachi, Pakistan in January 1978, "on the fishery resources of the north Arabian Sea". From those discussions emerged agreement that still more information could be drawn from the data obtained in the course of the survey and that perhaps a more accurate estimate might be made of biomass. Further analysis of the data was therefore undertaken and is reported here.

For the sake of completeness, so that this document should be quite self-contained, much material has been taken from the previous reports.

A brief account is given of the conduct of the survey. Some notable events which affected operations are mentioned. The equipment and methods are described. The execution of the work is described briefly and a tentative assessment is made of its efficiency. Data processing methods are described in detail.

A brief summary is given of meteorological, biological and oceanographic information available before the survey which served as background to the plans for it.

The principal results of the survey are measurements of biomass observed in each of the several sectors of the region and, from these measurements, estimates of catches which might be expected. These results are given below as lower and upper values.

Biomass:

Sector	Demersal	Pelagic thousand tonnes	Both
1 South Somalia	392 - 822	953 - 1,214	1,258 - 1,527
2 North Somalia	67 - 128	128 - 225	194 - 307
3 Socotra	55 - 116	112 - 224	190 - 315
4 South Yemen	164 - 238	376 - 495	528 - 645
5 South Oman	98 - 156	730 - 903	846 - 1,017
6 North Oman	94 - 108	123 - 142	150 - 317
7 Iran	106 - 139	113 - 161	140 - 214
Totals	976 - 1,707	2,535 - 3,364	3,306 - 4,342

Prospective Catch:

Sector	Demersal	Pelagic	Demersal plus pelagic Sum	 Direct
		(thousand tonnes)		
1 South Somalia	69 - 144	333 - 425	402 - 569	385 - 534
2 North Somalia	12 - 22	45 - 79	57 - 101	34 - 107
3 Socotra	10 - 20	39 - 78	59 - 98	33 - 110
4 South Yemen	34 - 42	132 - 173	166 - 215	92 - 225
5 South Oman	17 - 27	256 - 316	273 - 343	148 - 360
6 North Oman	15 - 19	43 - 50	58 - 69	26 - 111
7 Iran	19 - 24	40 - 56	59 - 80	25 - 75
Totals	176 - 298	888 -1177	1064 -1475	743 -1522

Where "Sum" colums are obtained by addition of the preceding columns, the "Direct" columns result from application of the lower values of B_{max} (combined estimates) on page 37 in the expression $\gamma_{dem} = 0.175$ B_{max}, and the higher values of B_{max} on page 37 in the expression $\gamma_{pel} = 0.35 B_{max}$.

The procedures by which the biomass values were calculated are described in detail with special reference to particular circumstances of this survey and features of the stocks. This account of the procedures shows clearly the nature of the results obtained and gives a basis for judging the confidence that can be placed in them.

Two major difficulties were encountered in applying these procedures. The first concerned the setting of a value for the factor for conversion of a unit of integrator recording into a biomass value. The value of the factor depends, for any set of integrator recordings, upon the size and other characteristics of the individuals of the target stocks at the time of observation; these characteristics are primarly particular to each species although the biomass of species similar in form, size and other characteristics can be estimated from a single factor. In this connection the information from fishing and surface observations and from biological examination of samples from catches is of critical importance and has been discussed in detail in the report. The conclusion must be drawn that while the information as to stock composition obtained by these methods is fully in conformity with what was to have been expected from existing knowledge of the biota of this region, the frequency of sampling and intensity of analysis were not such as to yield good estimates of the conversion factor. Conservative values of this factor have therefore been applied and in general it is thought that the estimates are more likely to be below the true values than to be above them.

The other difficulty arose in seeking an estimate of annual mean biomass, which is the stock characteristic from which potential yield is properly to be calculated. For this purpose it is necessary to have a reliable picture of the annual cycle of events in a stock, with such increase in abundance as there may be from recruitment of juveniles and from their rapid growth and such decline in abundance as mortality causes. The effect of these processes may be augmented or nullified by migration into and out of a particular area. Some evidence on these matters was obtained in the survey and is discussed in the report, but it is inadequate, and the timing of observations in each sector was such that a true measure of the annual cycle is not available, and therefore mean annual biomass cannot be calculated from the data. A rough estimate can be made, however, on the principle that the annual mean is unlikely to be less than 50% of the maximum observed and more probably is close to 70% of that maximum. For these reasons the above measurements of biomass are the maximum observed values, presented as lower and upper values calculated from the confidence limits of the mean integrator recording of each sector.

The estimates of likely catch level have been obtained from the measurements of biomass by application of the familiar formula:

$$C = 0.5 \times M \times B_{max}$$

taking two values of M (0.3 and 0.5) and two values of B_{max} (0.5 and 0.7).

Perhaps the most important outcome of this further examination of the results of the survey has been the light it has thrown on the numerous technical and methodological problems of this kind of work. Even if the estimates here of biomass and yield potentials are no great improvement on the estimates in the Final Report, their presentation with upper and lower values derived from an estimate of confidence limits (even if admittedly the calculation of those limits is not very satisfactory) suggests the bounds within which planning decisions ought, at present, to be set. Moreover, the structure of the argument leading to these estimates is described so that as new information becomes available the estimates can be adjusted with respect to particular components of the system; which means that adjustment of the estimates need not await some repetition of work such as was done on this survey but should be achieved by systematic testing of the assumptions described in this report and by intensive work designed expressly to measure the effects of the causes discussed in Section 3.3 and to obtain a better measure of the conversion factor C.

Given the magnitude of the task undertaken for the survey -- to traverse some 44,000 nm^2 of continental shelf five times in less than two years, given also the large number of species and the relative scarcity of information with regard to the display of almost all of these, allowing for weather conditions which made work impossible in at least one month and brought some difficulties at other times, and recognising the inevitability of contingencies and of human error, it is obvious that the results would be marked by a number of important uncertainties. In particular it could be expected that the results would have to be with regard to aggregates of species and could not provide a precise and detailed account of any one species.

On these terms, however, the survey was a successful exploration which has characterised the distribution and main compositional features of the fish stocks and has provided fair approximations to the annual mean biomass and yield potential of those stocks. Admittedly those estimates are low in comparison with others which have been made; indeed, we are convinced that significant upward revision of them will be made when the stocks in very shallow waters and in the 3 m bottom stratum can be assessed. The degree to which the estimates might be increased after such a revision, or might have to be increased for other reasons, it is a matter on which nothing can be said at this stage. However we believe that industrial development based on the present estimates could be planned safely and would soon yield information from which to improve the estimates.

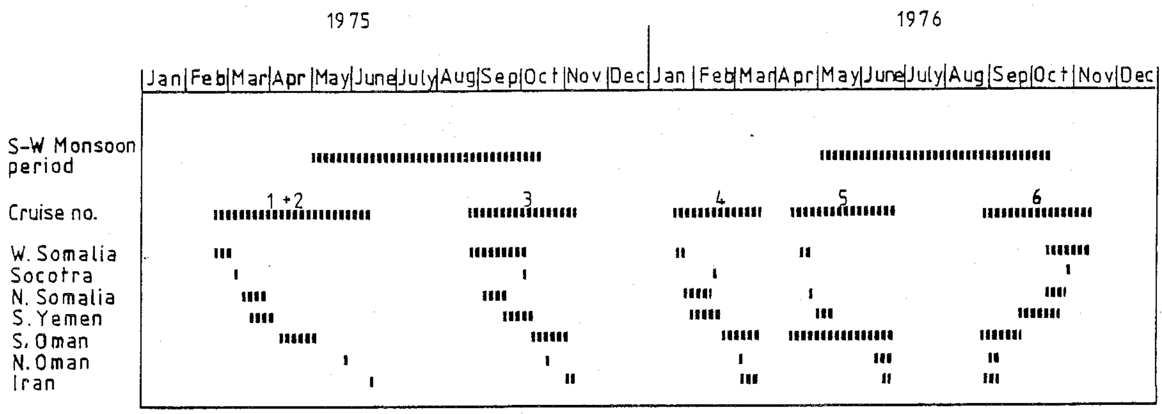


Figure 1. Timing of the survey work in each sector of the surveyed region.

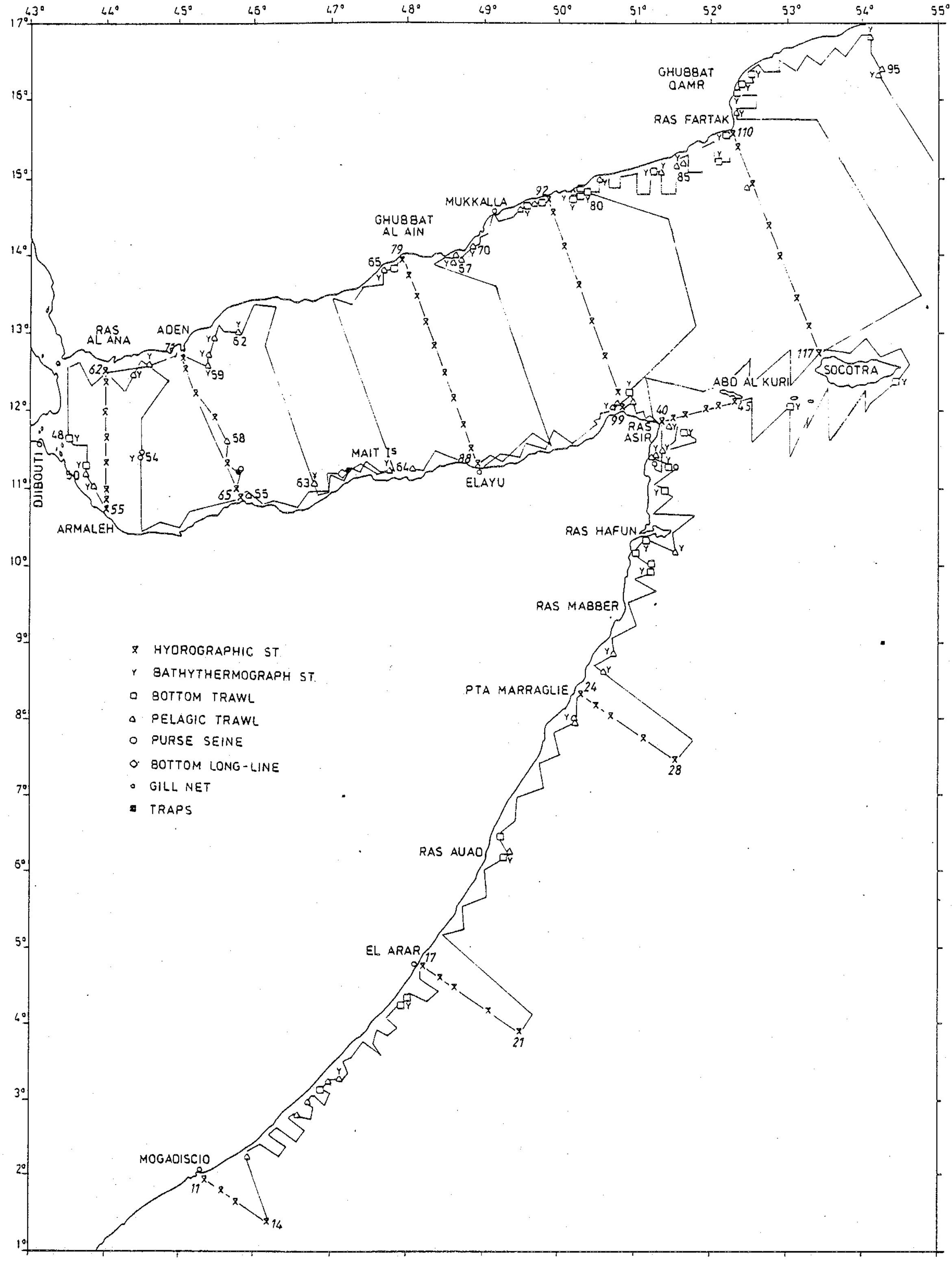


Figure 2a. Survey grid and stations Cruise 1&2, Feb-Mar 1975, Somalia East Coast - Gulf of Aden.

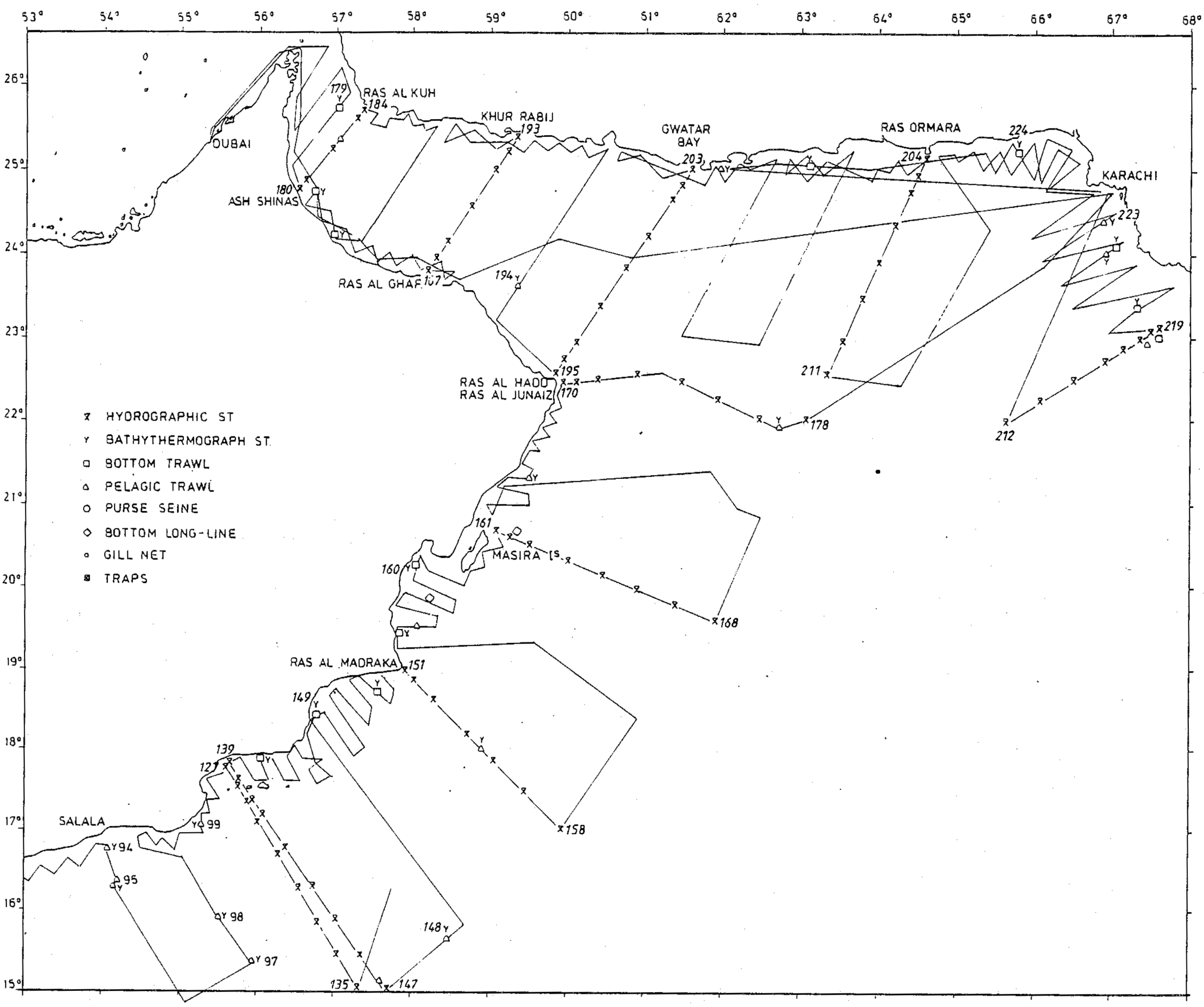


Figure 2b. Survey grid and stations Cruise 1&2, Apr-Jun 1975, Oman Coast - Gulf of Oman - Pakistan Coast.

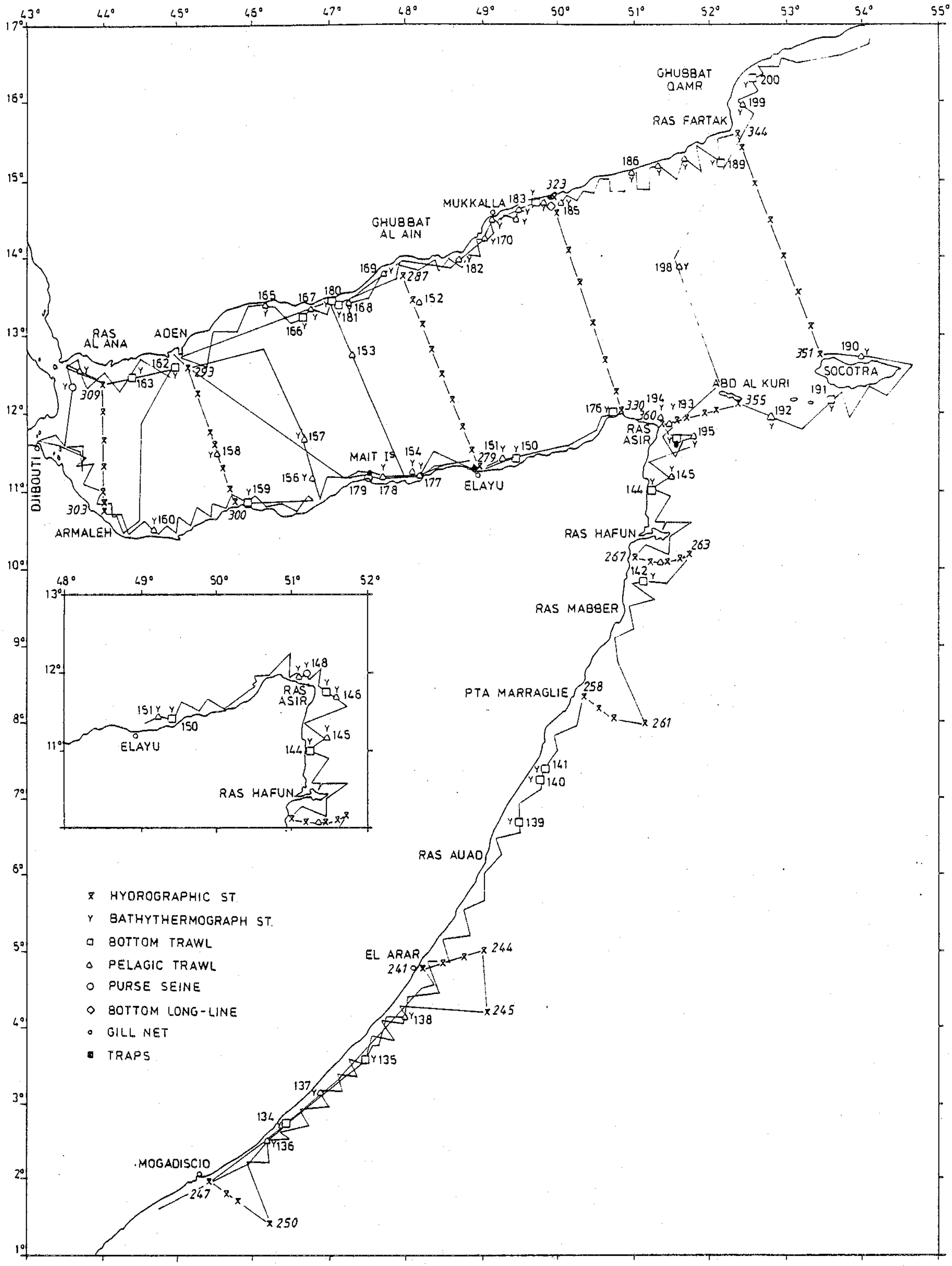


Figure 3a. Survey grid and stations Cruise 3, Aug-Oct 1975, Somalia East Coast - Gulf of Aden.

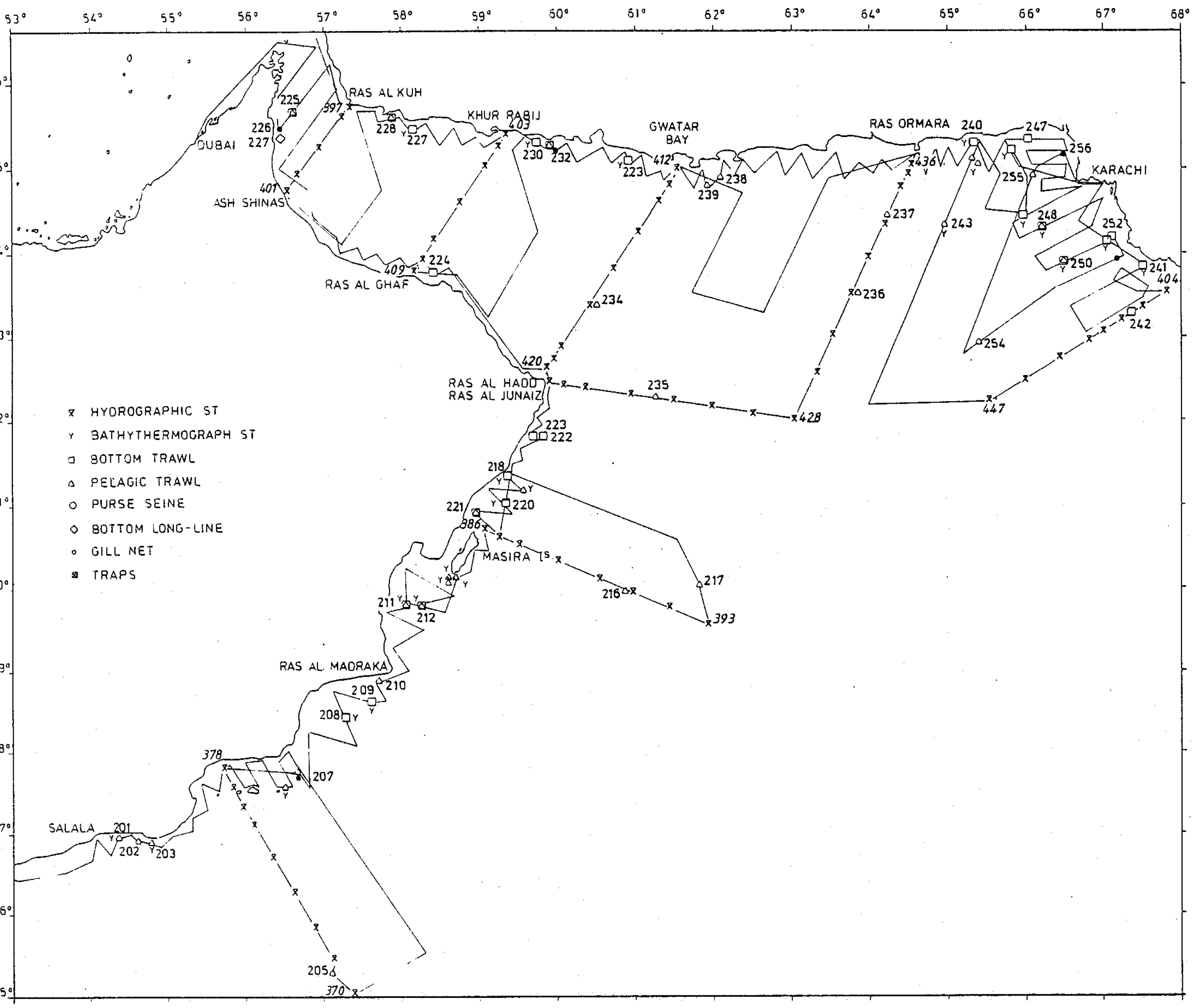


Figure 3b. Survey grid and stations Cruise 3, Oct-Nov 1975, Oman Coast - Gulf of Oman - Pakistan Coast.

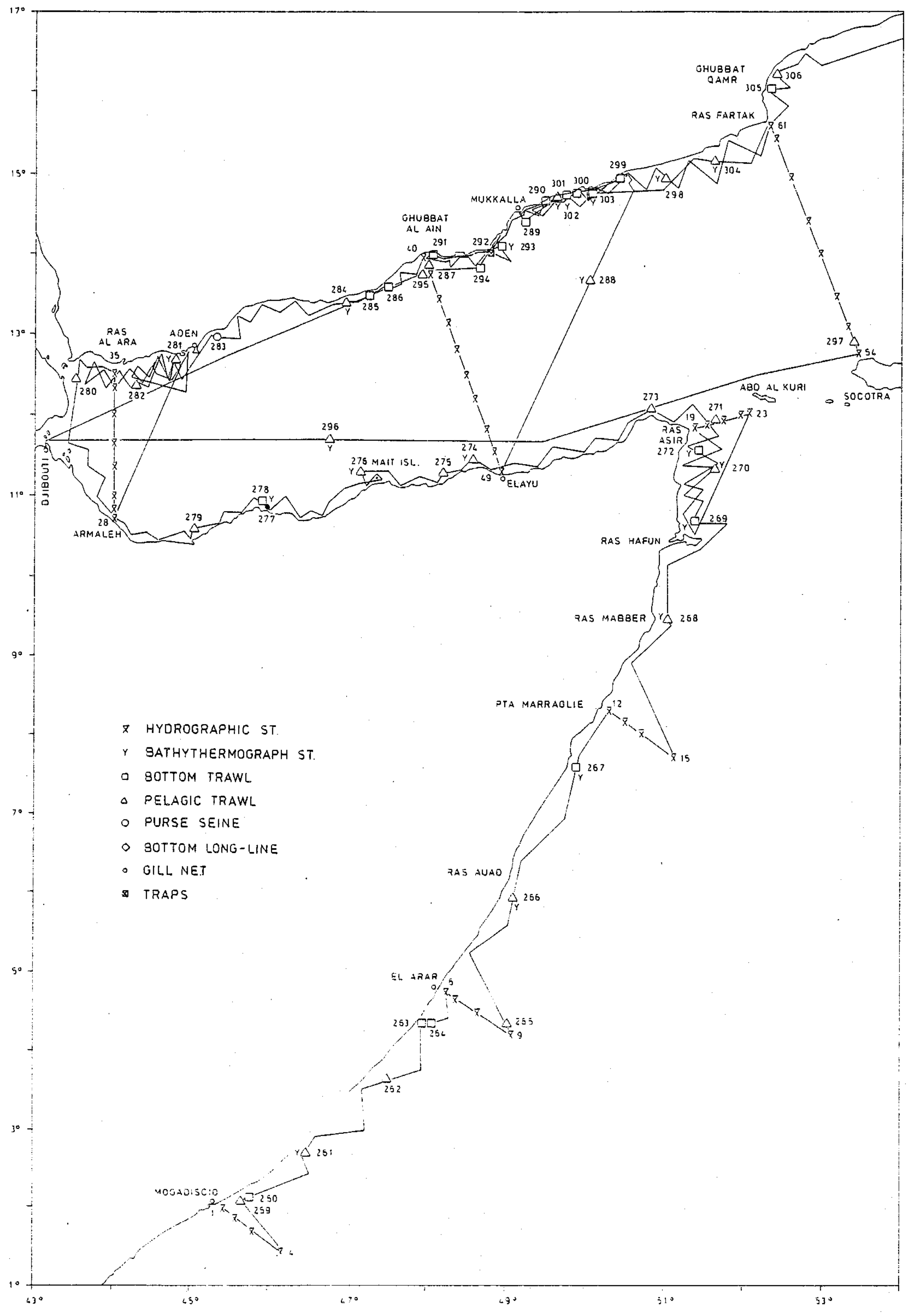


Figure 4a. Survey grid and stations Cruise 4, Jan- Feb 1976, Somalia East Coast - Gulf of Aden.

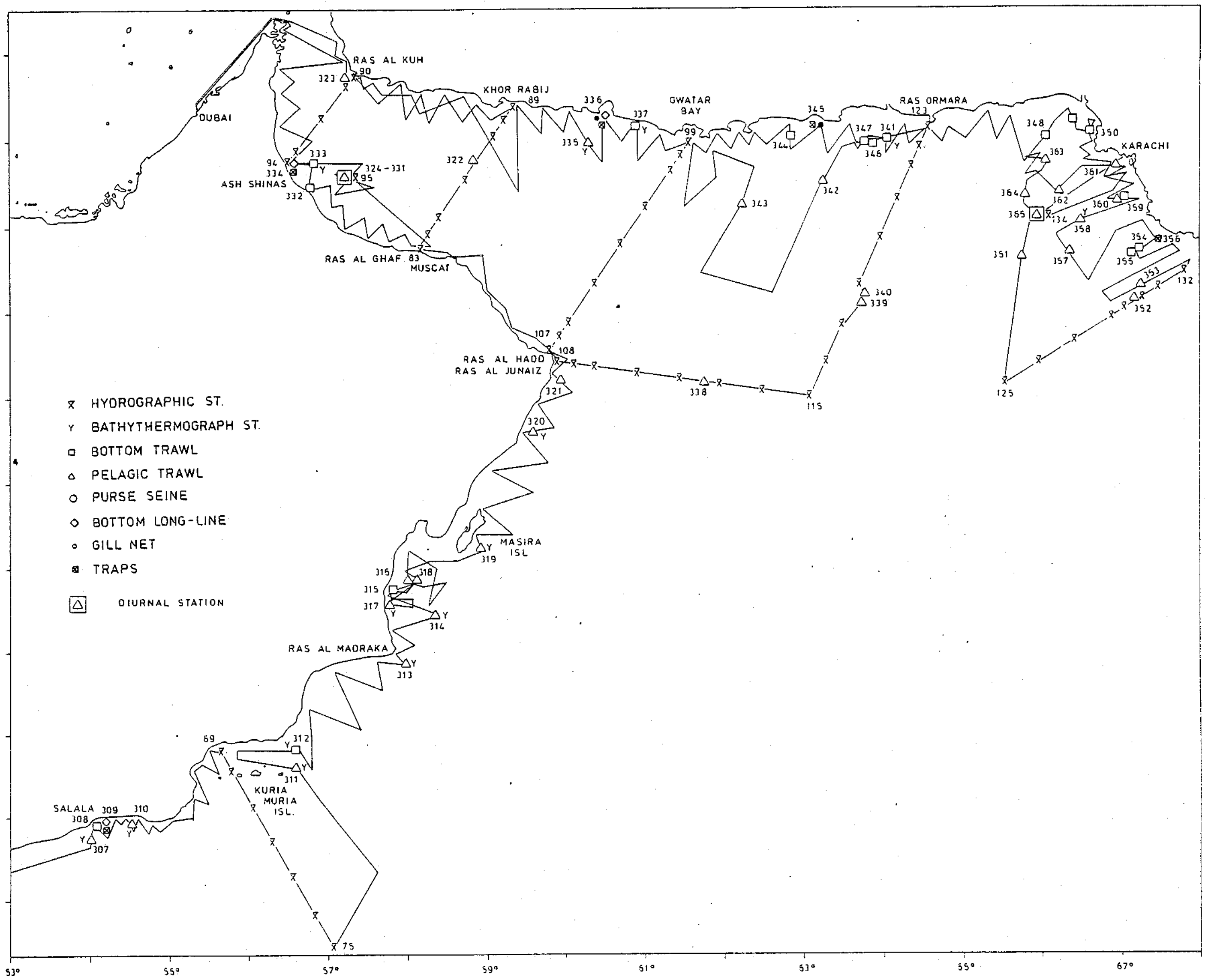


Figure 4b. Survey grid and stations Cruise 4, Feb-Mar 1976, Oman Coast -Gulf of Oman - Pakistan Coast.

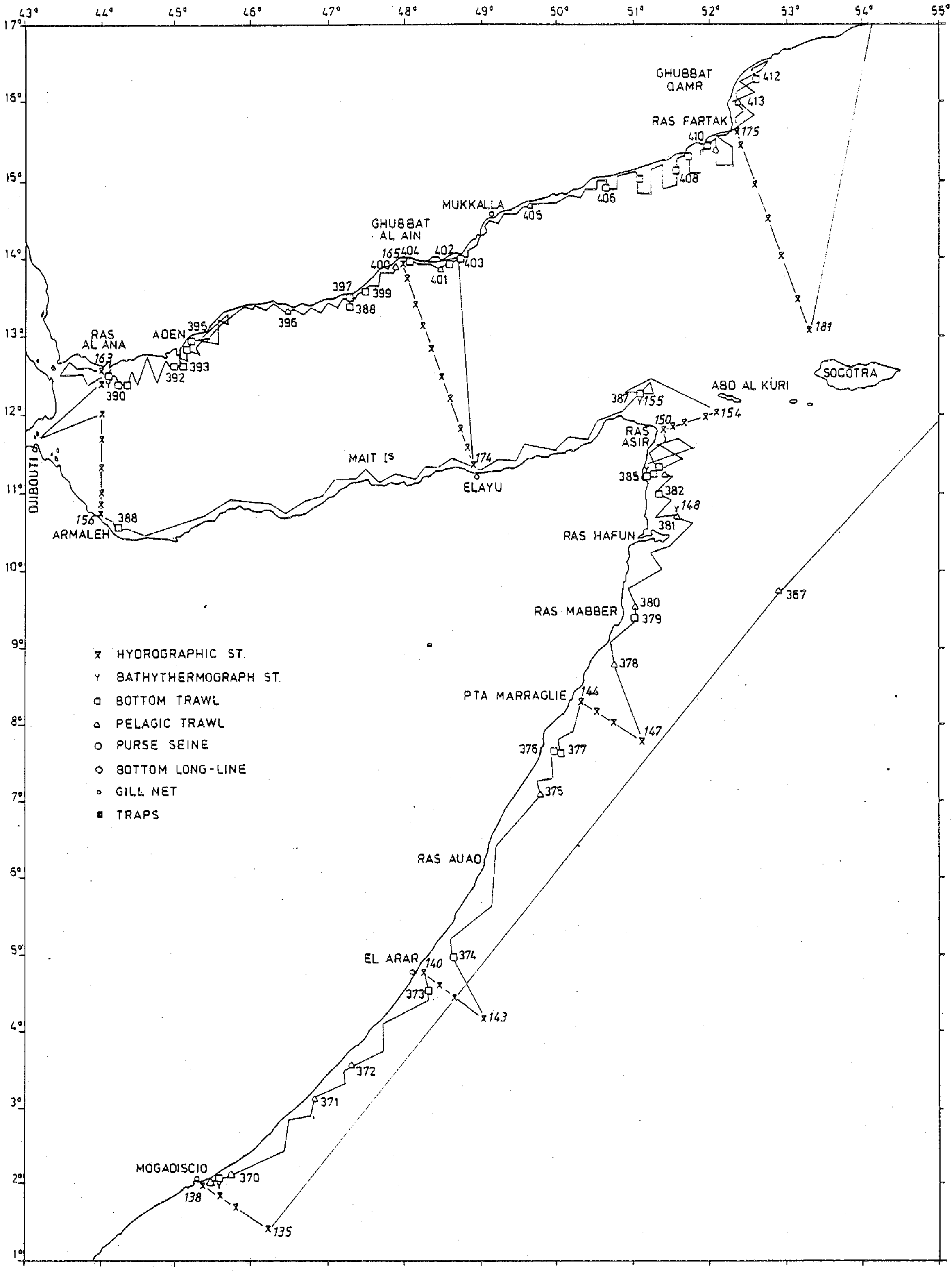


Figure 5a. Survey grid and stations Cruise 5, Apr-May 1976, Somalia East Coast - Gulf of Aden.

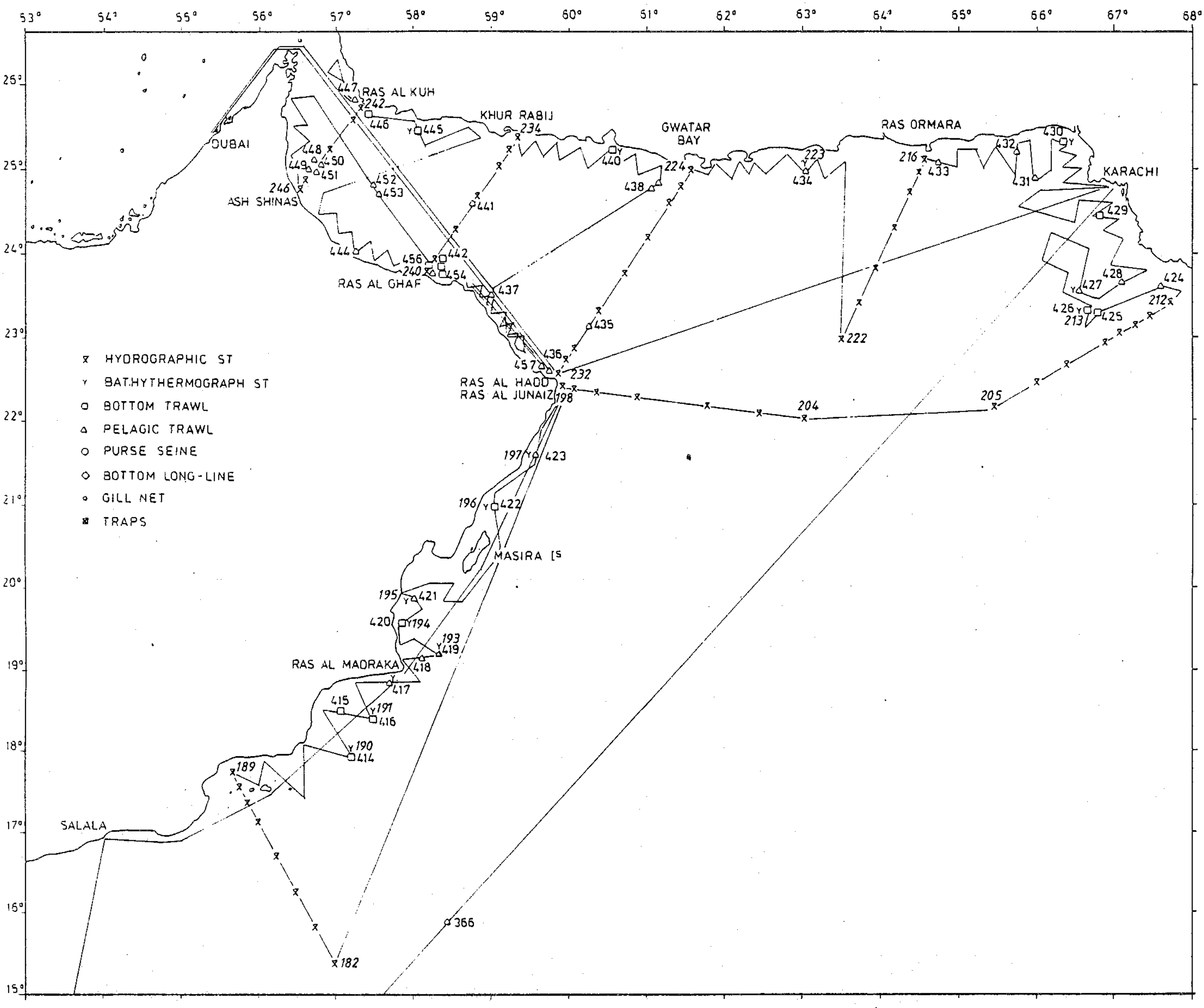


Figure 5b. Survey grid and stations Cruise 5, Apr-Jun 1976, Oman Coast - Gulf of Oman - Pakistan Coast.

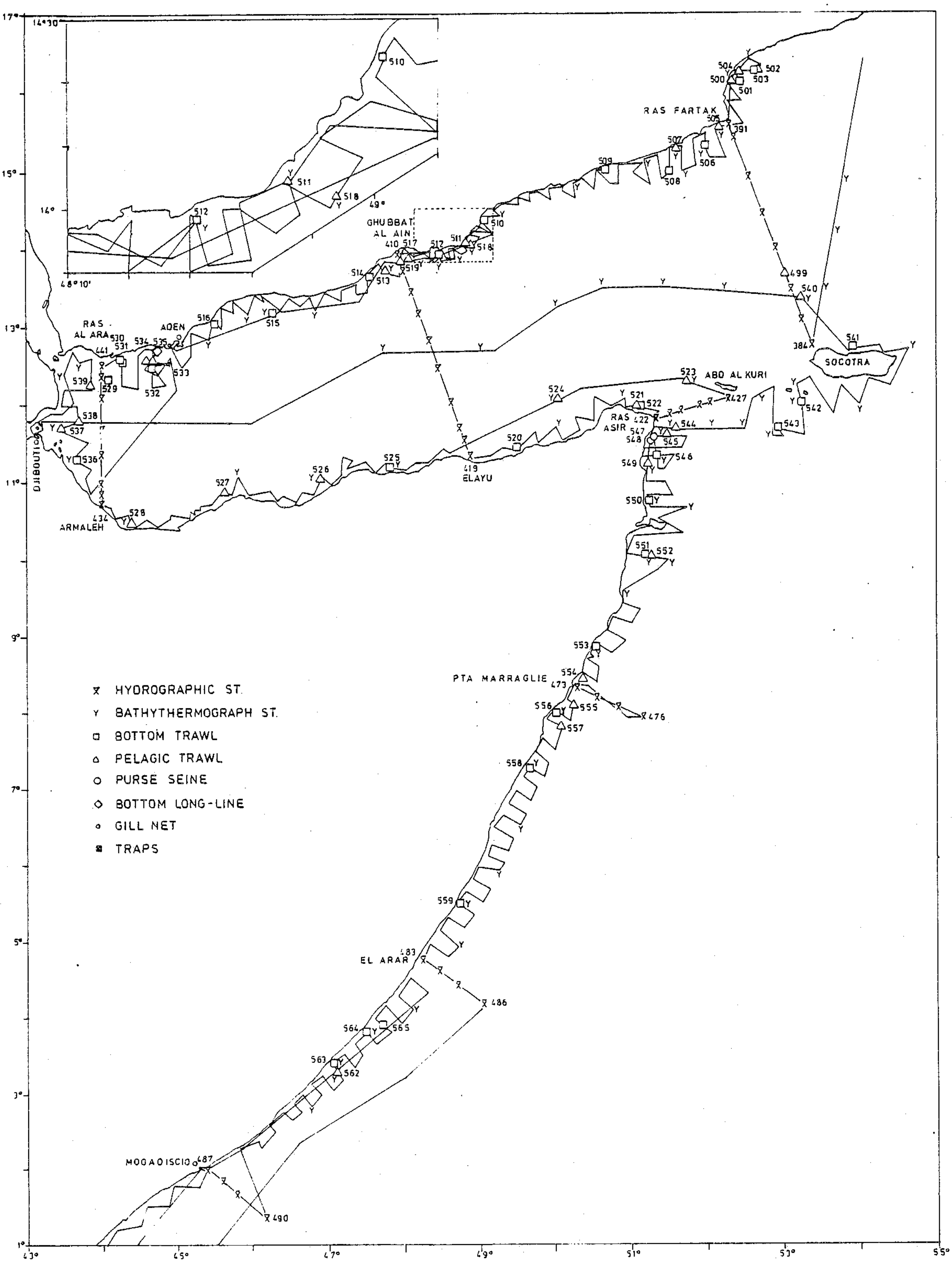


Figure 6a. Survey grid and stations Cruise 6, Sep-Nov 1976, Somalia East Coast - Gulf of Aden.

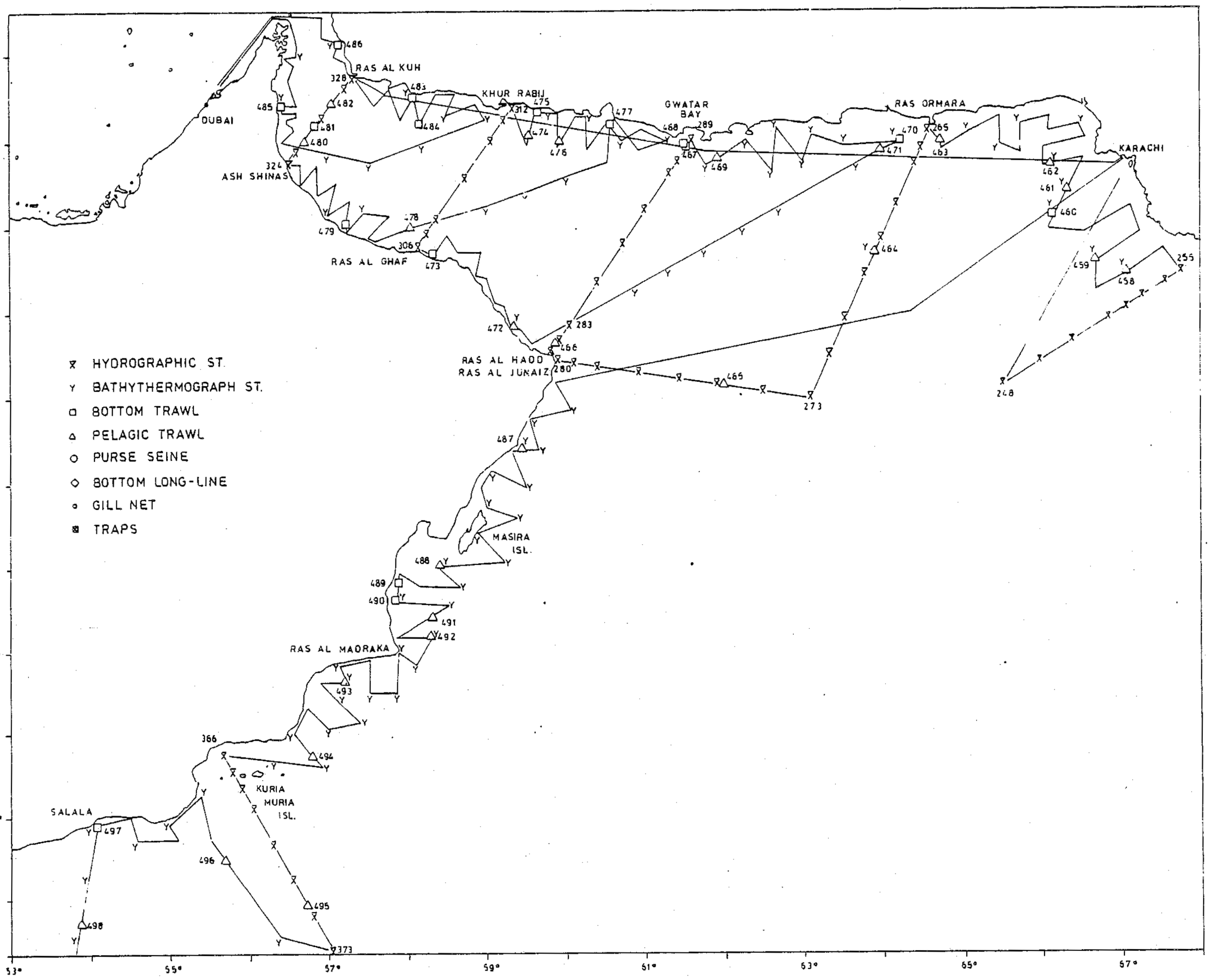
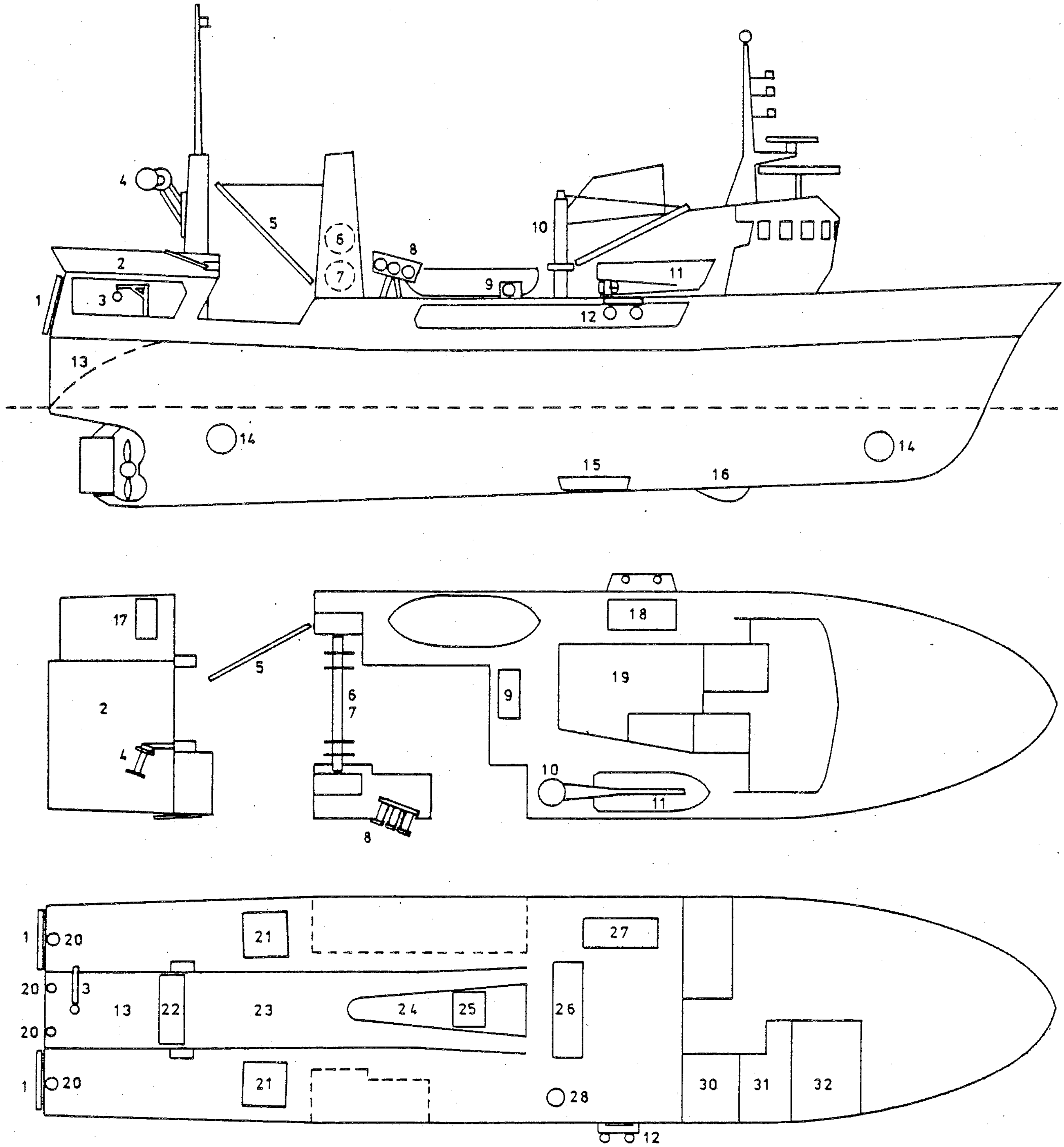


Figure 6b. Survey grid and stations Cruise 6, Aug-Sep 1976, Oman Coast - Gulf of Oman - Pakistan Coast.



1. Otter boards
2. Seine bin
3. Cable block
4. Seine transport drum
5. Beam
6. Trawl drum
7. Trawl drum
8. Seine winch
9. Net sonde winch
10. CCrane
11. Basboat
12. Purse gallow
13. Slipway
14. Side propellers
15. Echo sounder transducers
16. Sonar transducer
17. Paravane winch
18. Hydrographic winch
19. Instrument room
20. Trawl blocks
21. Trawl winches
22. Hatch
23. Trawl deck
24. Bottom trawl bin
25. Hatch
26. Trawl winch
27. Purse winch
28. Line hauler
29. Hydrography laboratory
30. Biology laboratory (wet)
31. Biology and chemistry laboratory
32. Library

Figure 7. Main arrangement of R/V"Dr. Fridtjof Nansen"

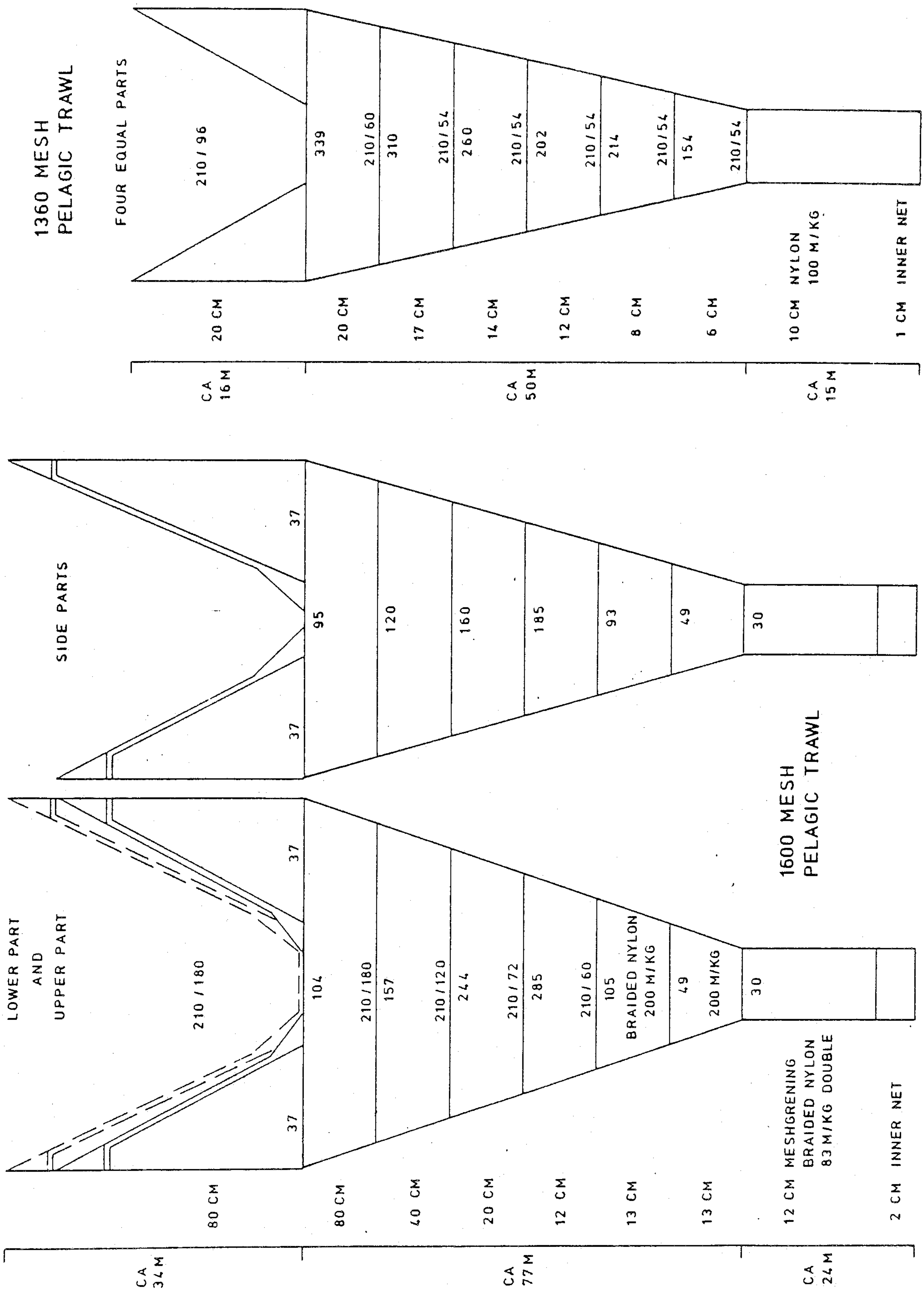


Figure 8. The pelagic trawls onboard R/V "Dr. Fridtjof Nansen".

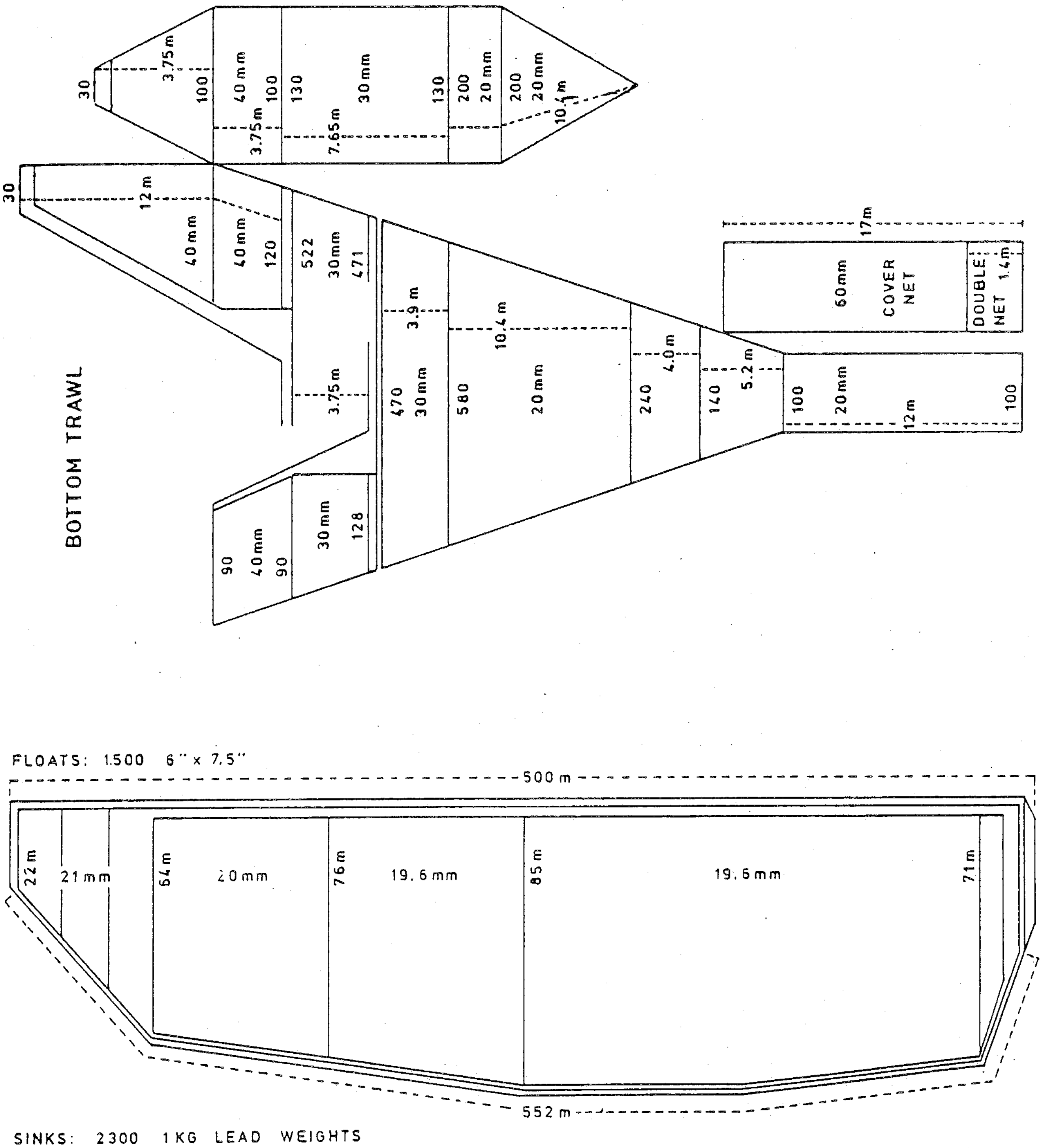


Figure 9. The bottom trawl and purse seine onboard R/V "Dr. Fridtjof Nansen".

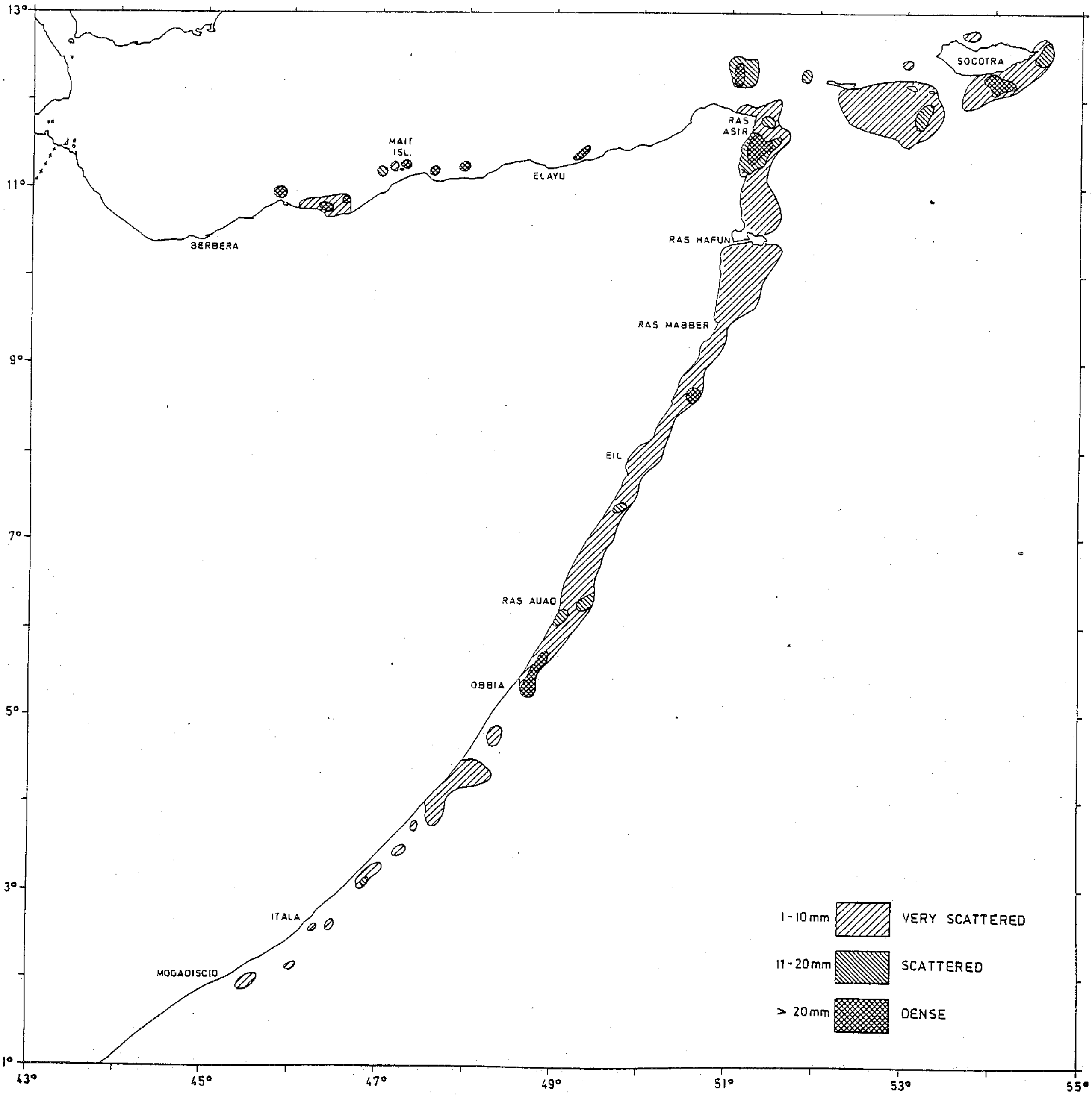


Figure 10 Distribution of demersal and pelagic fish on the Somalia Coast and the Socotra Shelf during Cruise 1&2, Feb-Mar 1975.

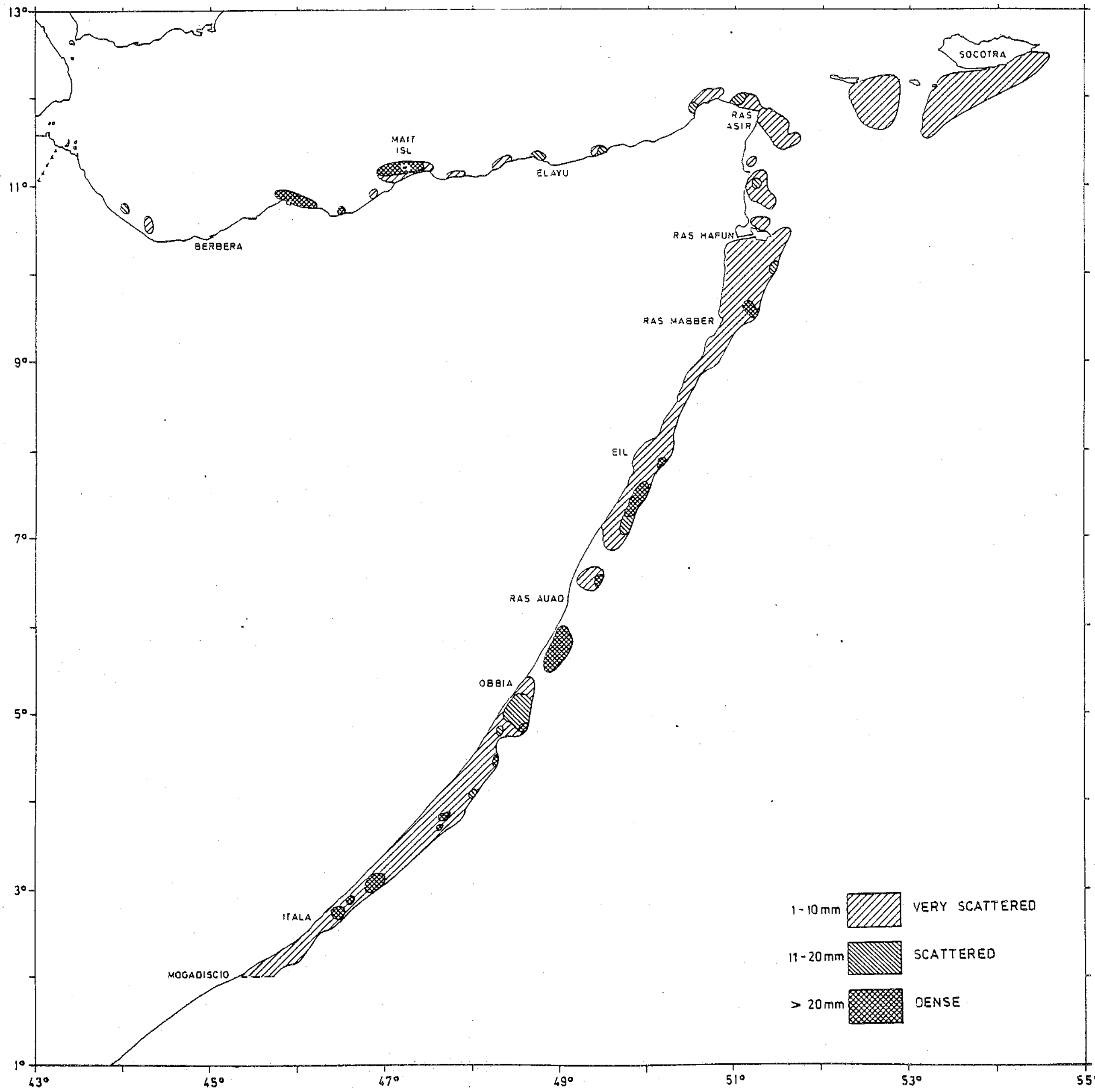


Figure 11. Distribution of demersal and pelagic fish on the Somalia Coast and the Socotra Shelf during Cruise 3, Aug-Oct 1975.

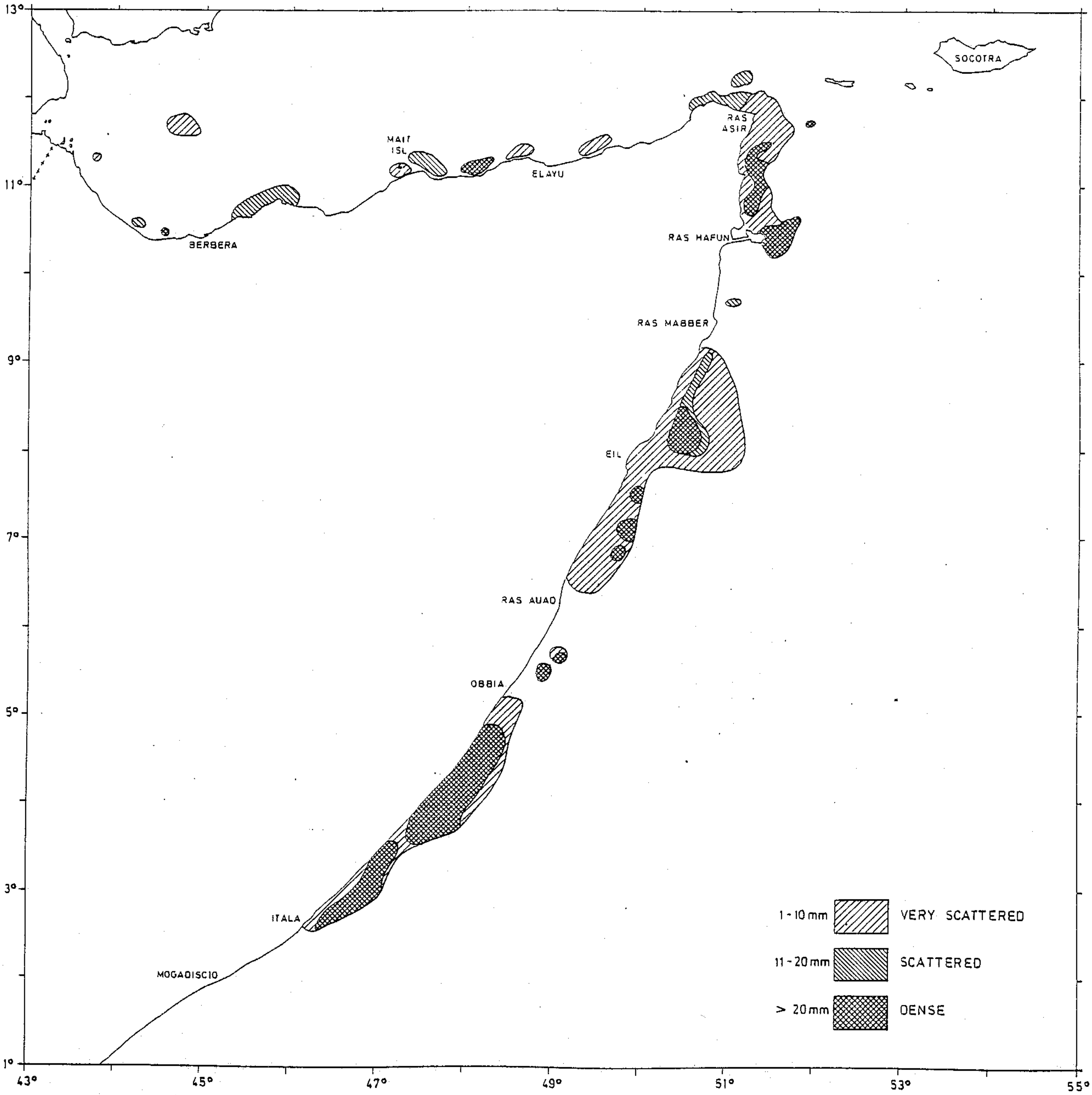


Figure 12. Distribution of demersal and pelagic fish on the Somalia Coast during Cruise 4, Jan-Feb 1976.

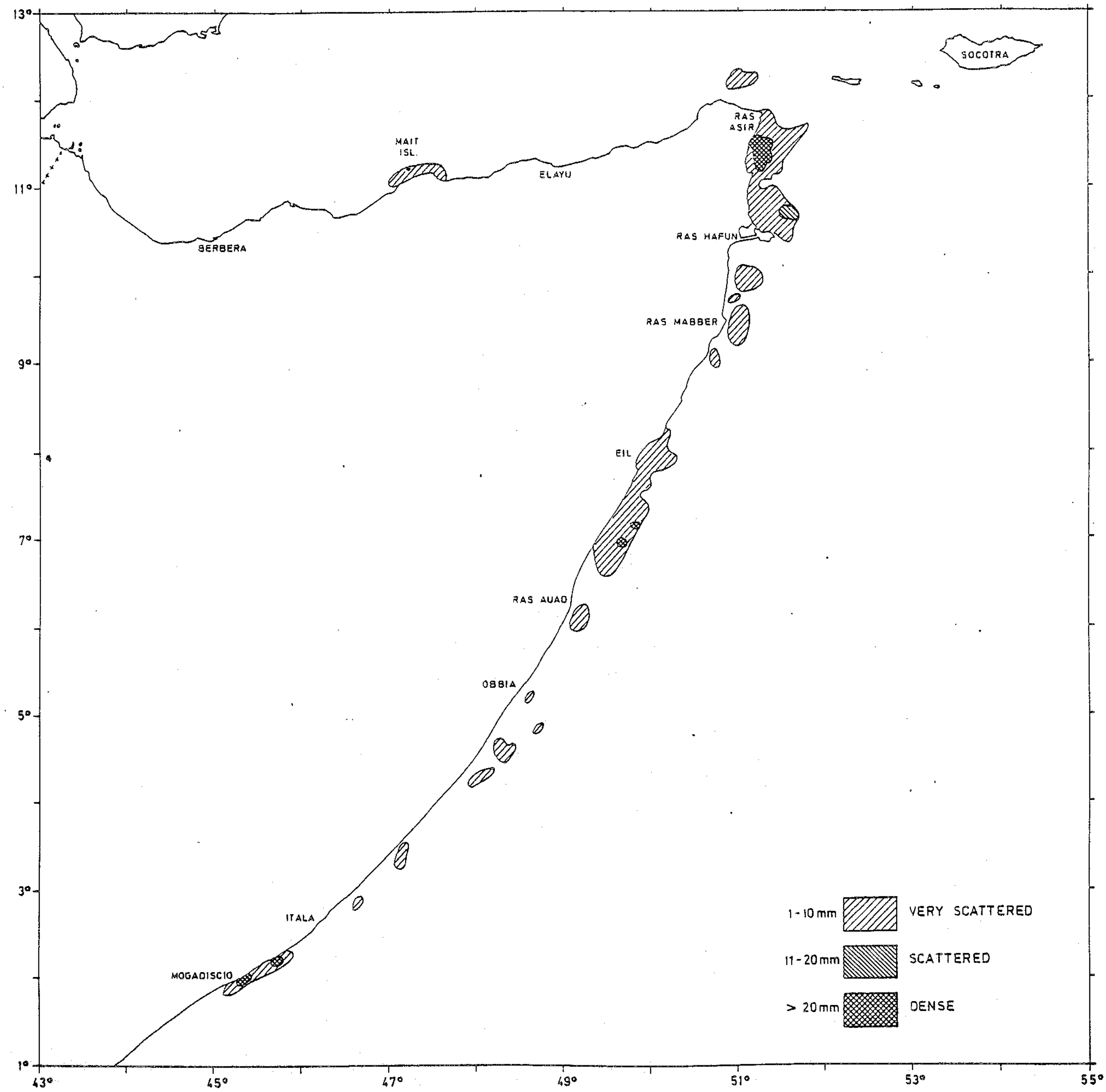


Figure 13. Distribution of demersal and pelagic fish on the Somalia Coast during Cruise 5, Apr 1976.

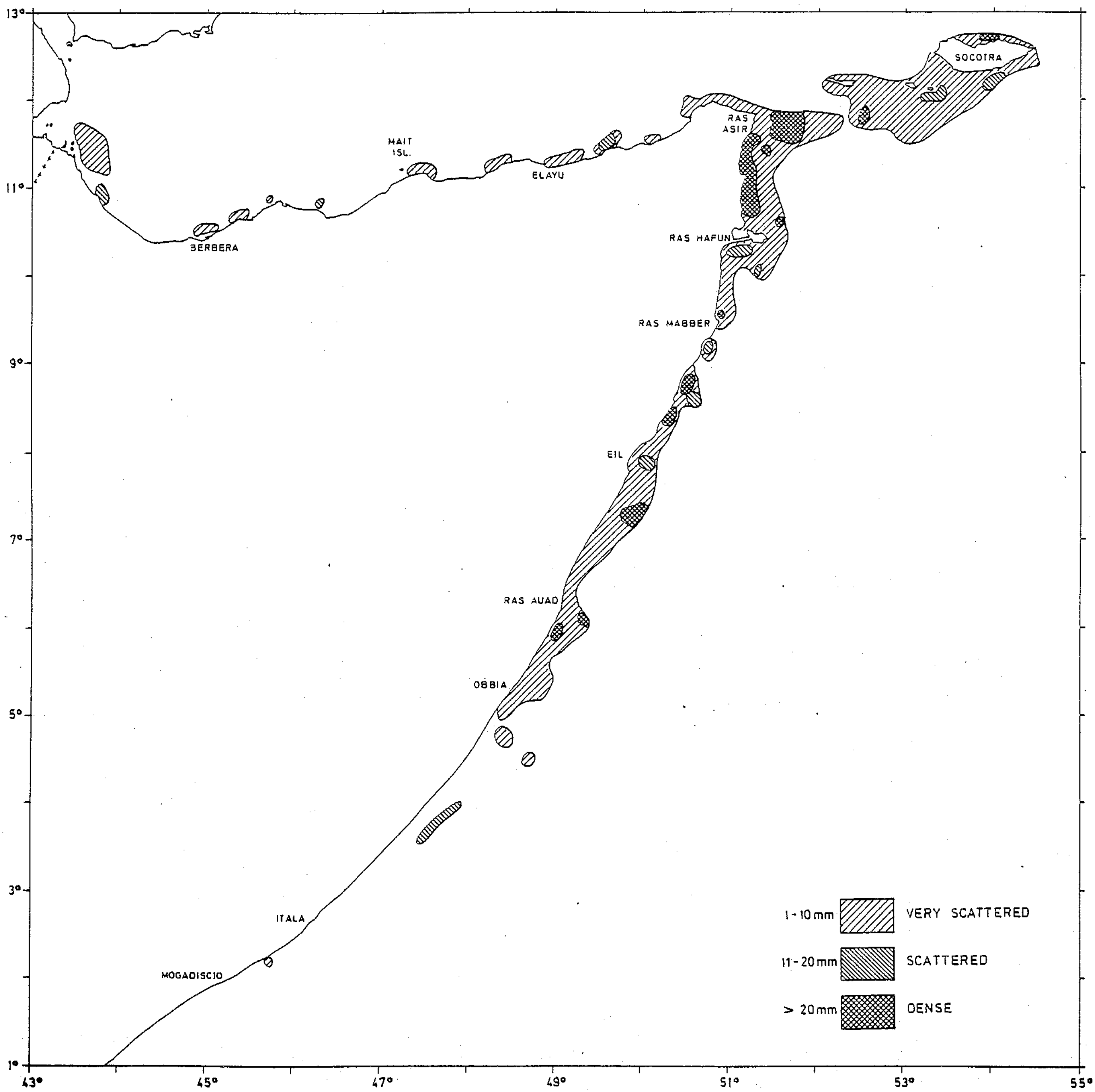


Figure 14. Distribution of demersal and pelagic fish on the Somalia Coast and the Socotra Shelf during Cruise 6, Oct-Nov 1976.

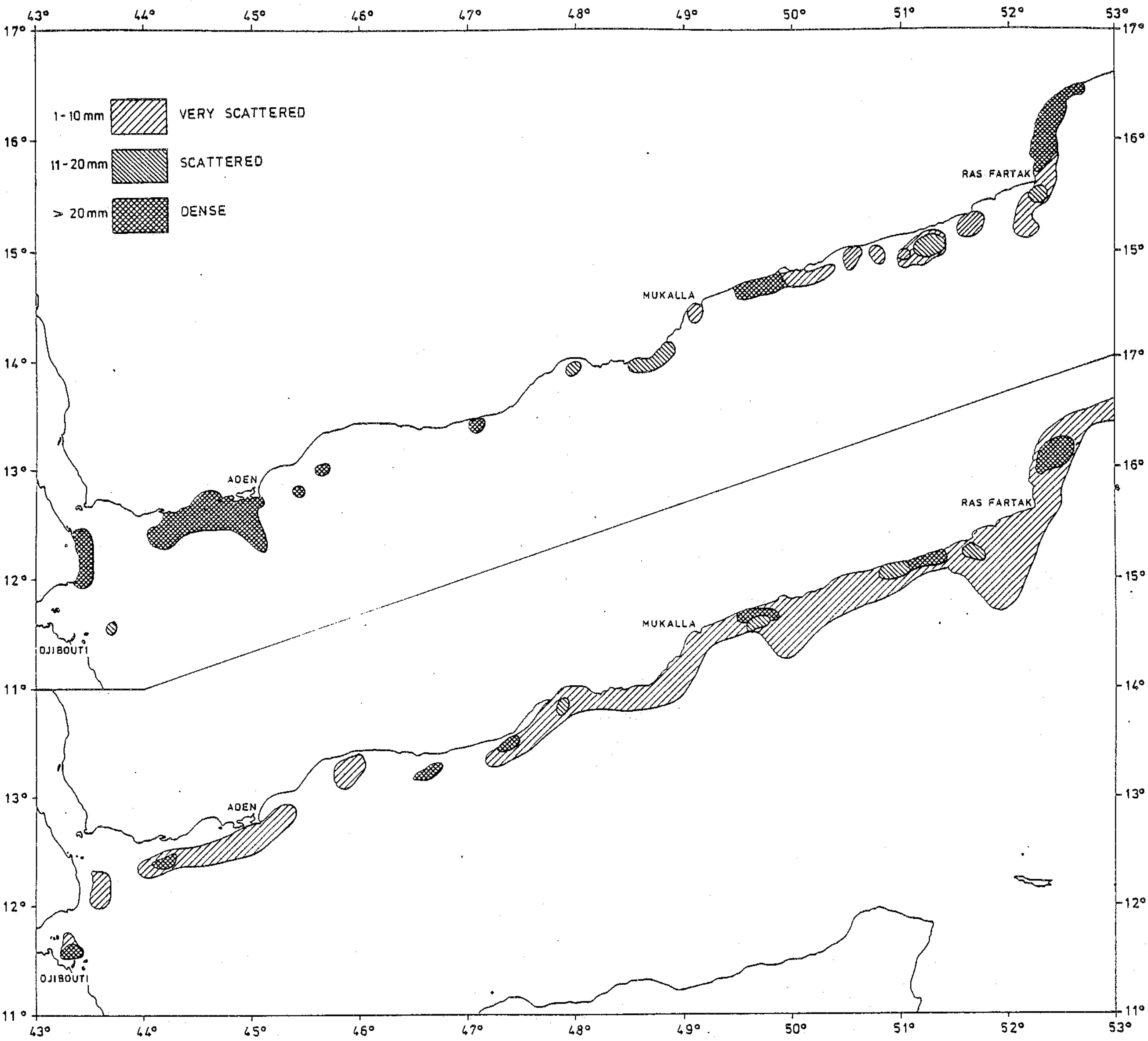


Figure 15. Distribution of demersal and pelagic fish on the South-Yemen Coast during Cruise 1&2, Mar-Apr 1975 (upper), and during Cruise 3, Sep-Oct 1975 (lower).

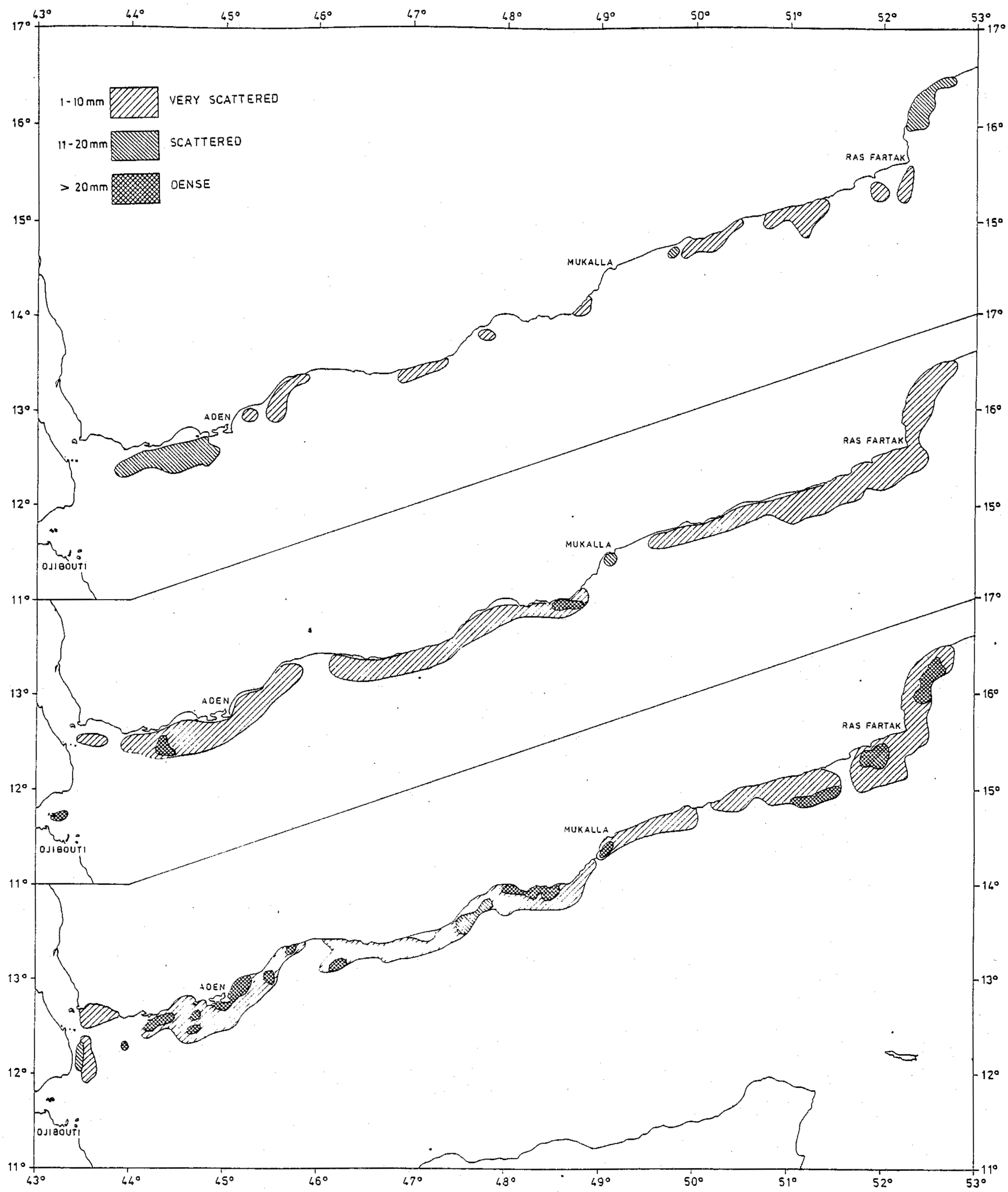


Figure 16. Distribution of demersal and pelagic fish on the South-Yemen Coast during Cruise 4, Jan-Feb 1976 (upper), during Cruise 5, Apr-May 1976 (middle), and during Cruise 6, Sep-Oct 1976 (lower).

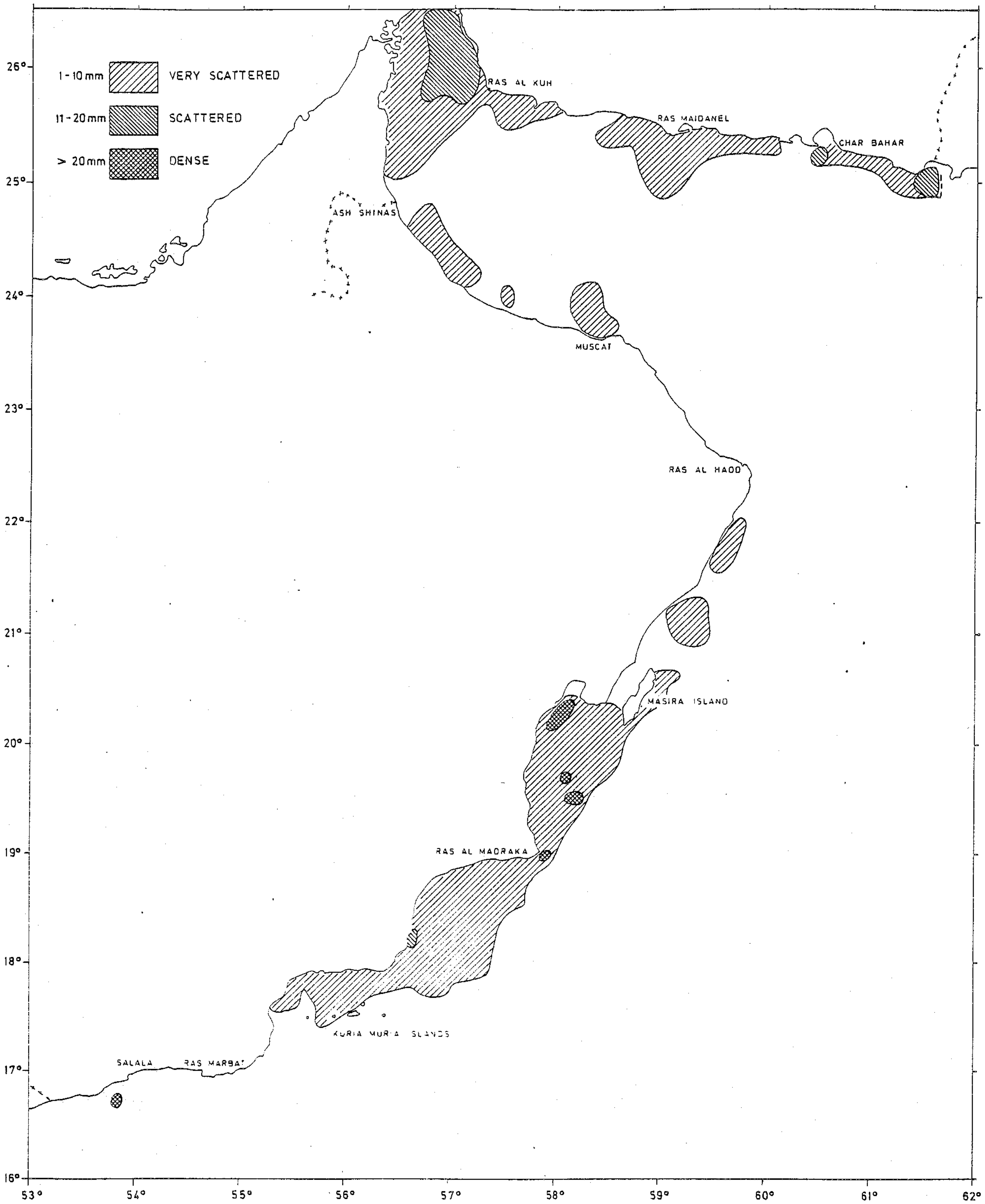


Figure 17. Distribution of demersal and pelagic fish on the Oman Coast and the South-Iran Coast during Cruise 1&2, Apr-Jun 1975.

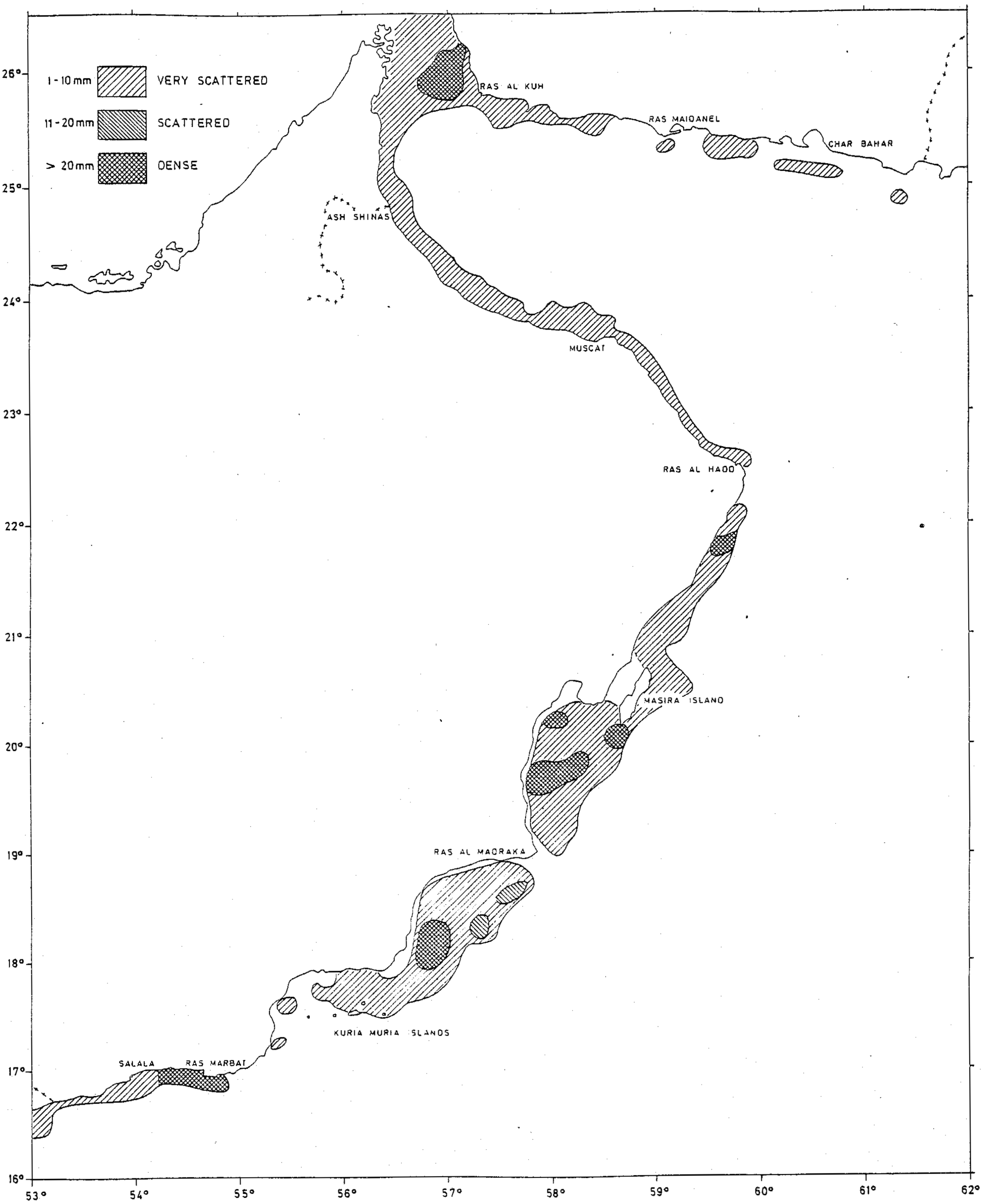


Figure 18. Distribution of demersal and pelagic fish on the Oman Coast and the South-Iran Coast during Cruise 3,Oct-Nov 1975.

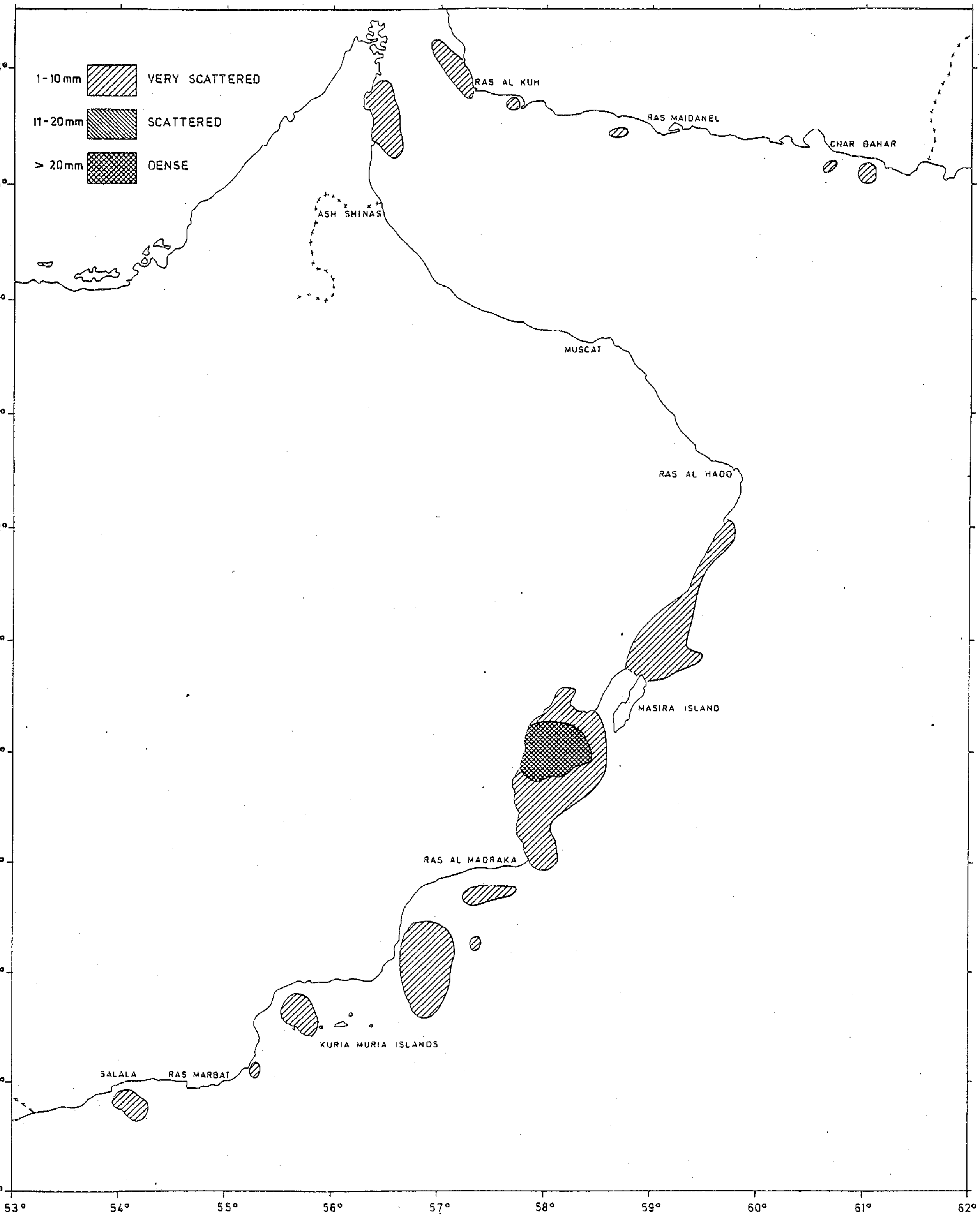


Figure 19. Distribution of demersal and pelagic fish on the Oman Coast and the South-Iran Coast during Cruise 4, Feb-Mar 1976.

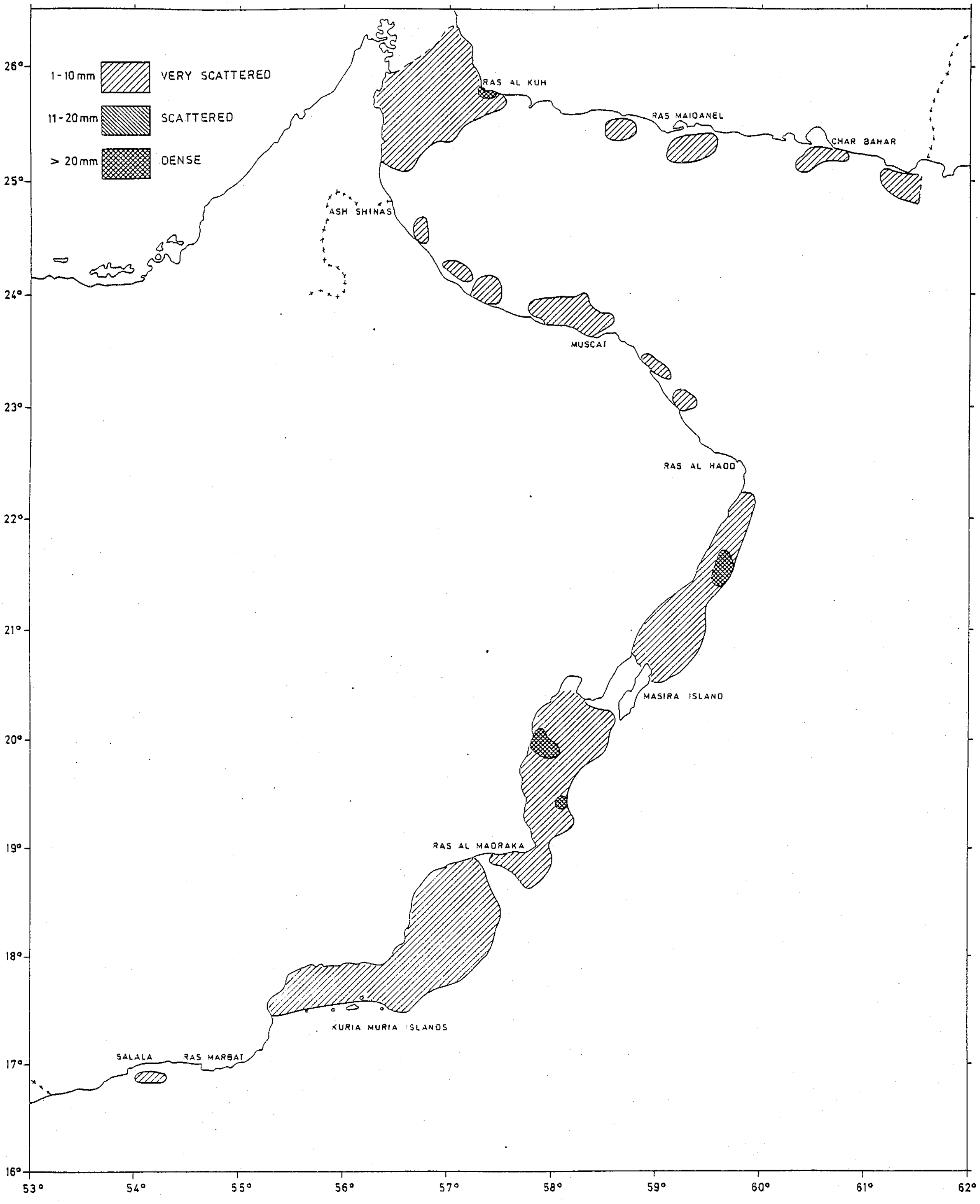


Figure 20. Distribution of demersal and pelagic fish on the Oman Coast and the South-Iran Coast during Cruise 5, Apr-Jun 1976.

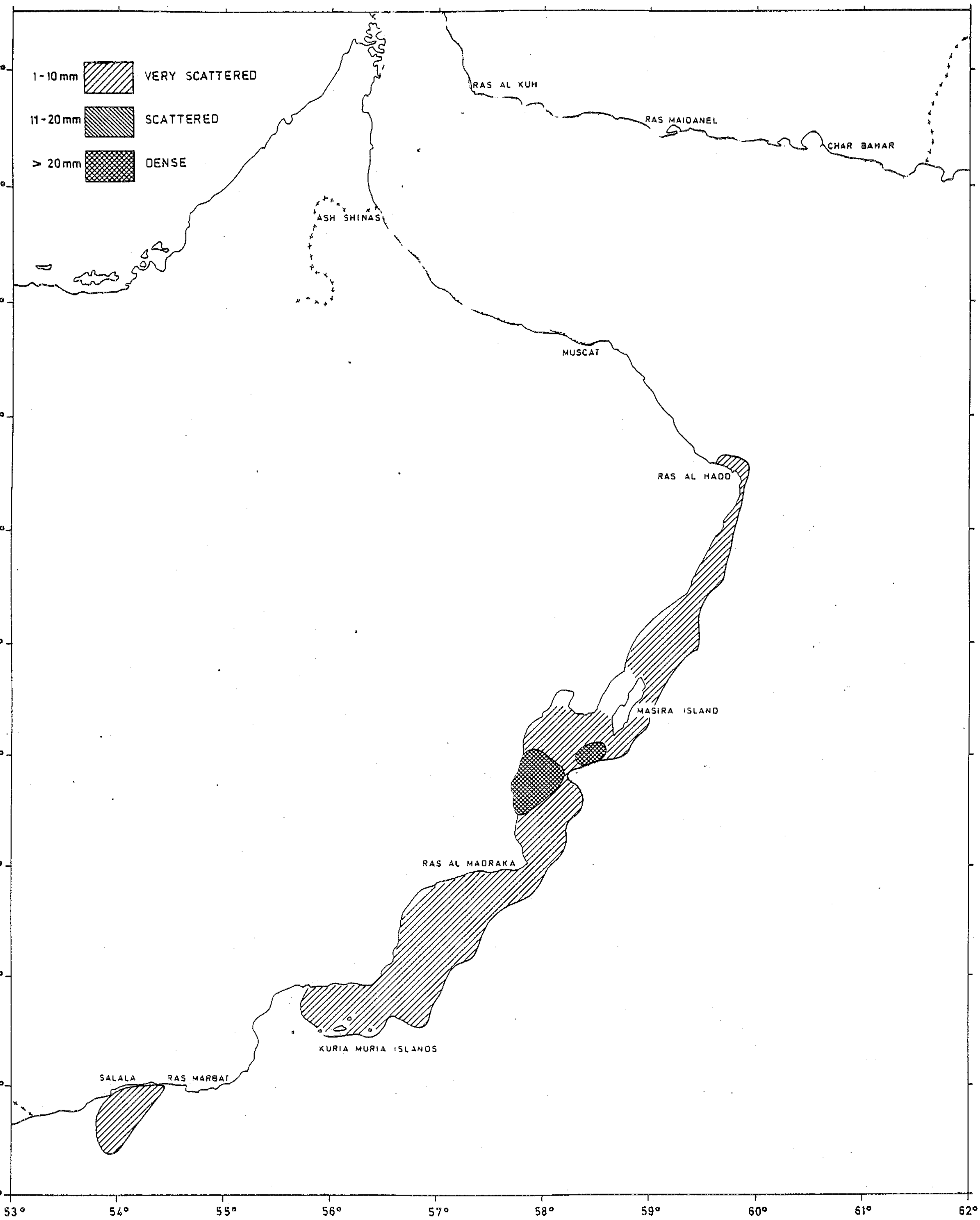


Figure 21. Distribution of demersal and pelagic fish on the Oman Coast and the South-Iran Coast during Cruise 6, Aug-Sep 1976.

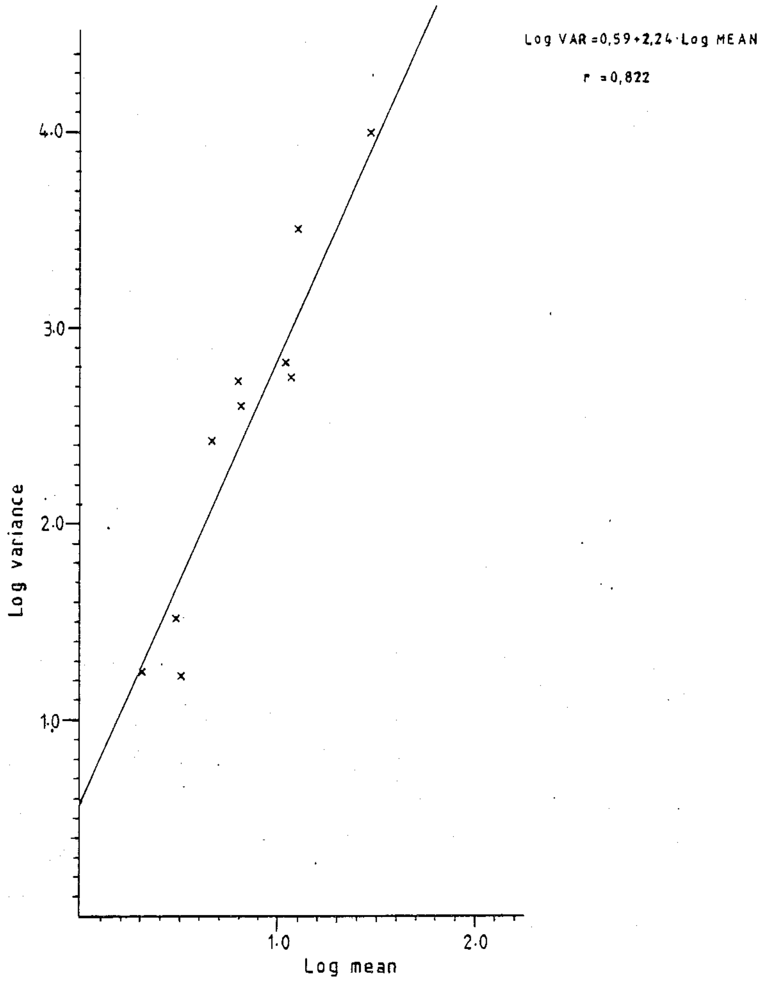


Figure 22. Variation in cruise/type means and variance in Sector 1 (somalia East Coast)

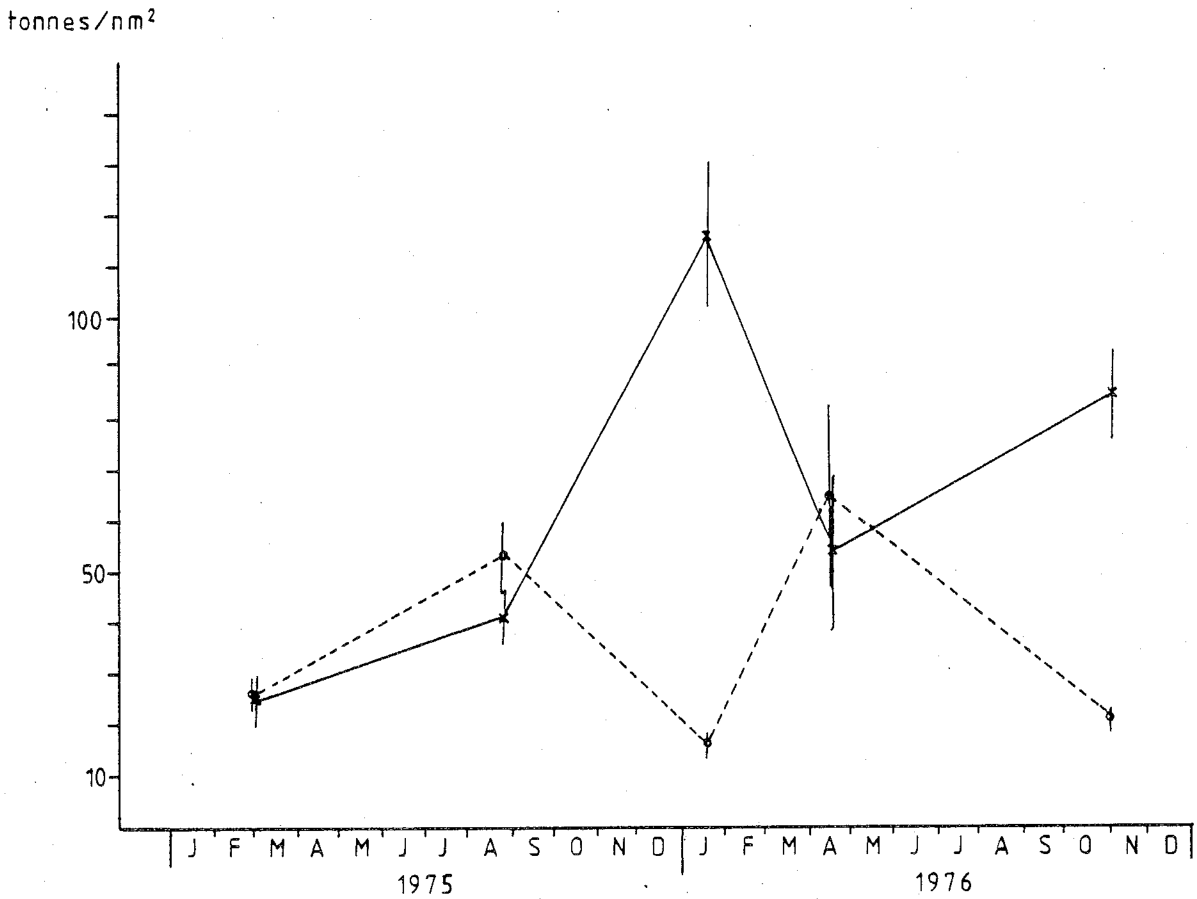


Figure 23a. Estimated biomass per nm^2 in Sector 1 (Somalia East Coast) in the period 1975-1976.

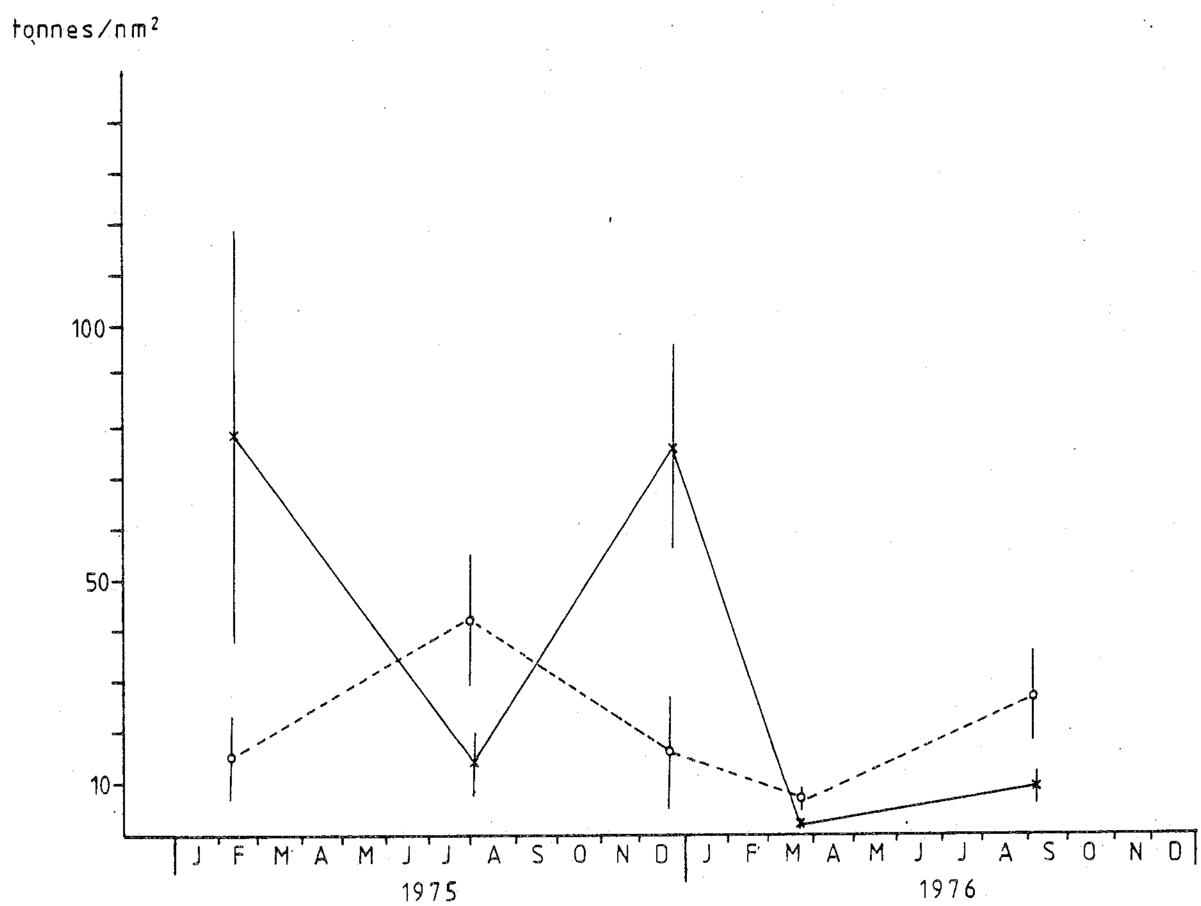


Figure 23b. Estimated biomass per nm^2 in Sector 2 (Somalia North Coast) in the period 1975-1976.

————————:pelagic ----------:demersal

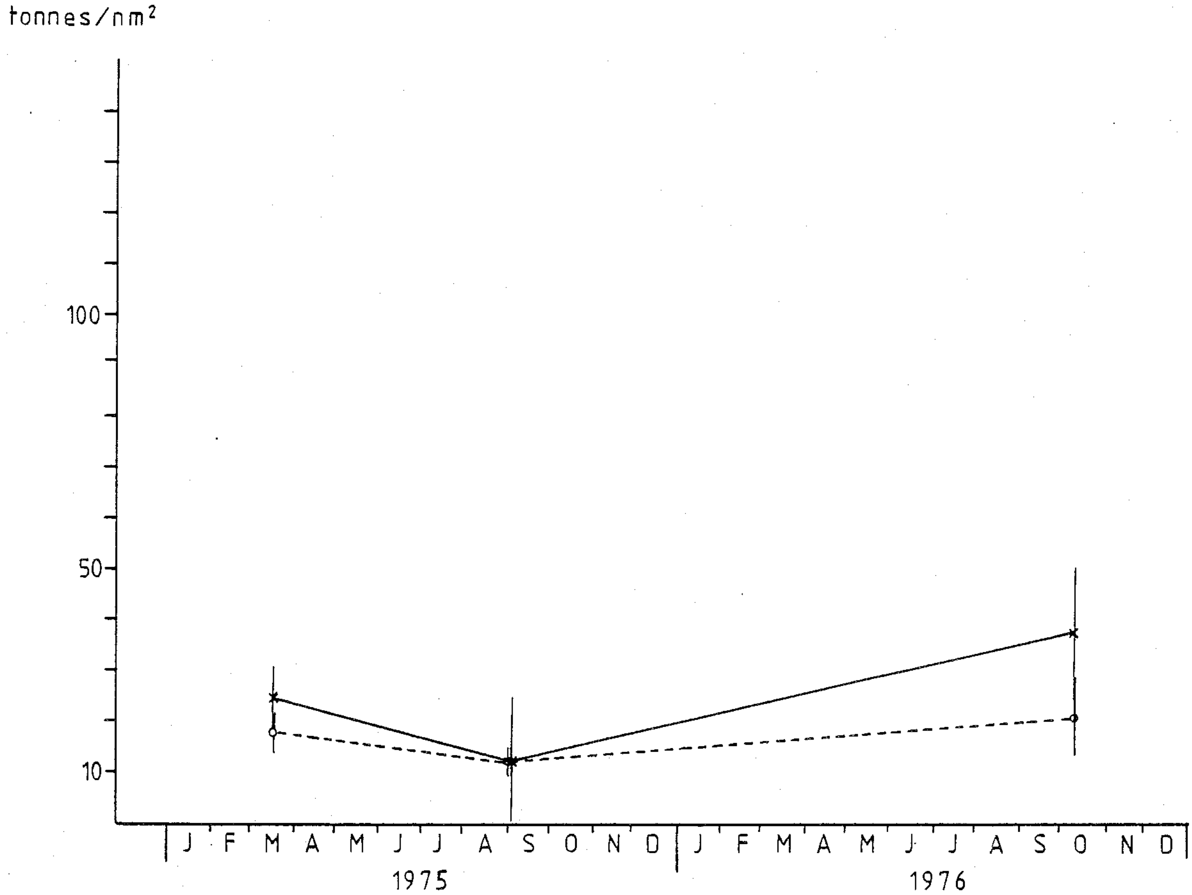


Figure 23c. Estimated biomass per nm^2 in Sector 3 (Socotra Shelf) in the period 1975 1976.

————:pelagic ---------:demersal

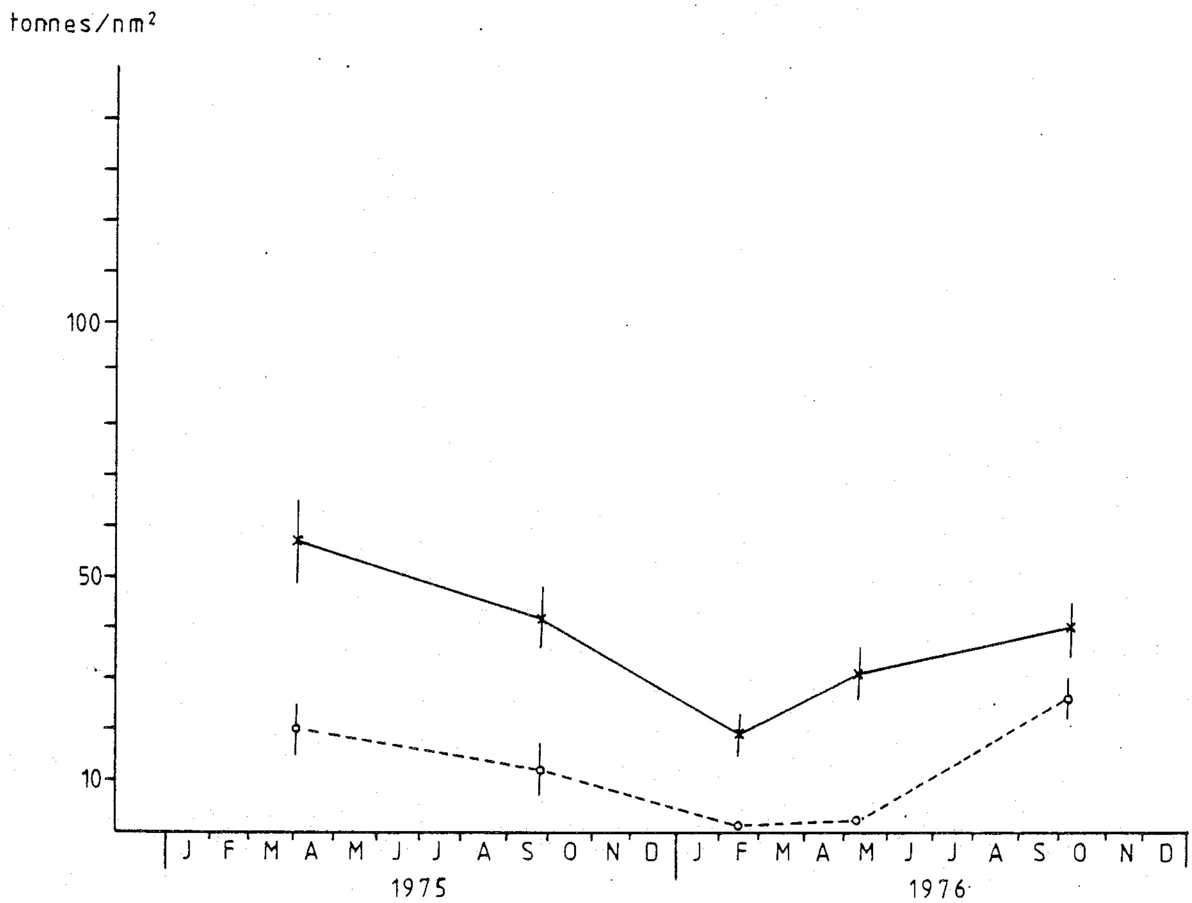


Figure 23d. Estimated biomass per nm^2 in Sector 4 (South-Yemen Coast) in the period 1975-1976.

————:pelagic --------:demersal

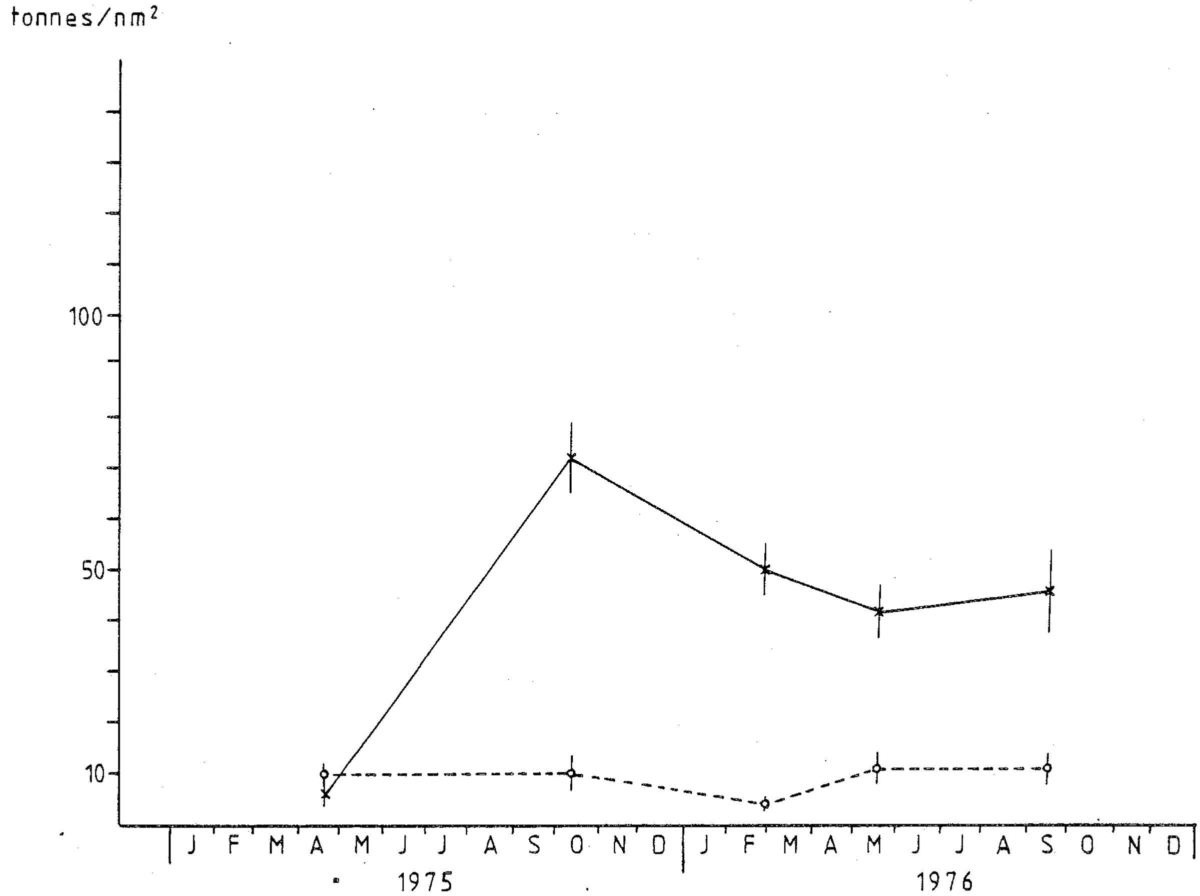


Figure 23e. Estimated biomass per nm^2 in Sector 5 (South-Oman Coast) in the period 1975-1976.

———————:Pelagic -------:demersal

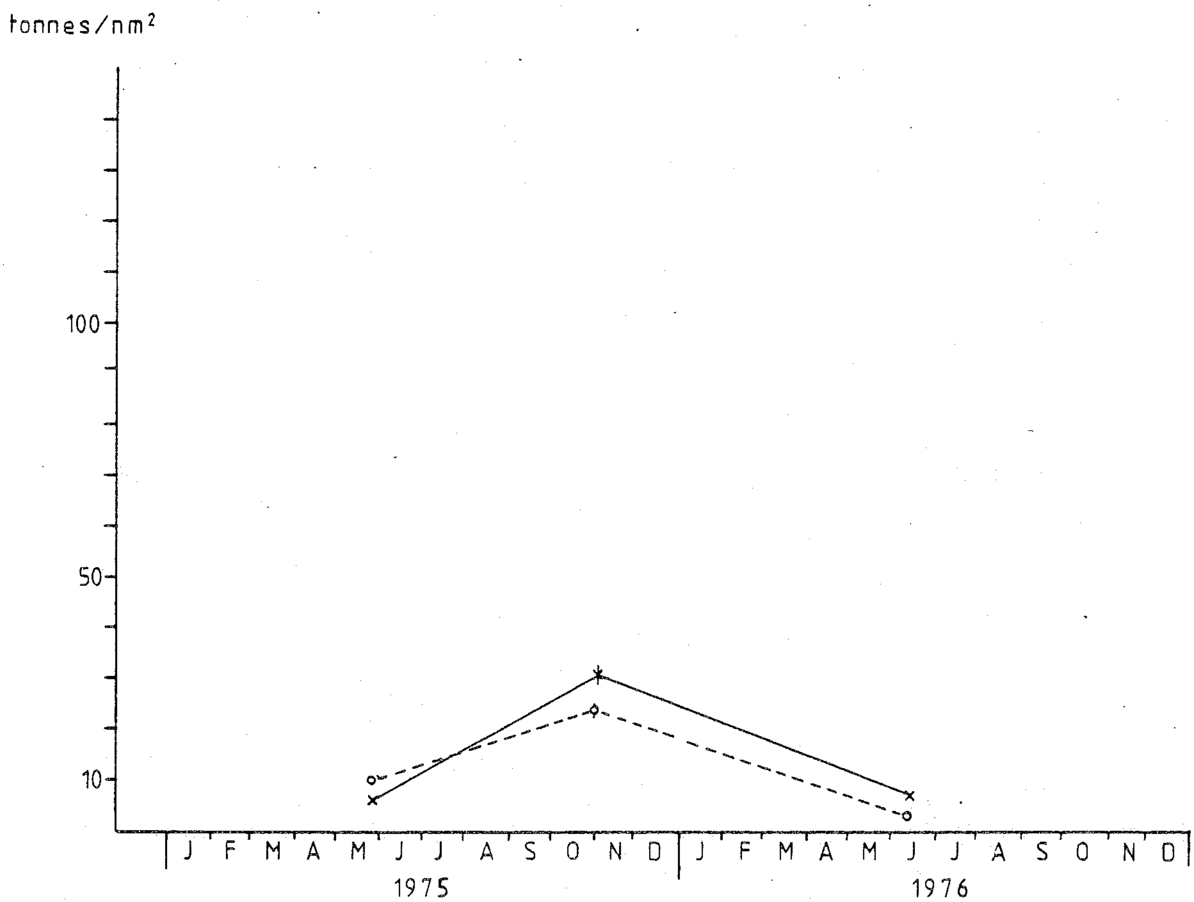


Figure 23f. Estimated biomass per nm^2 in Sector 6 (North-Oman Coast) in the period 1975-1976.

———————:pelagic --------:demersal

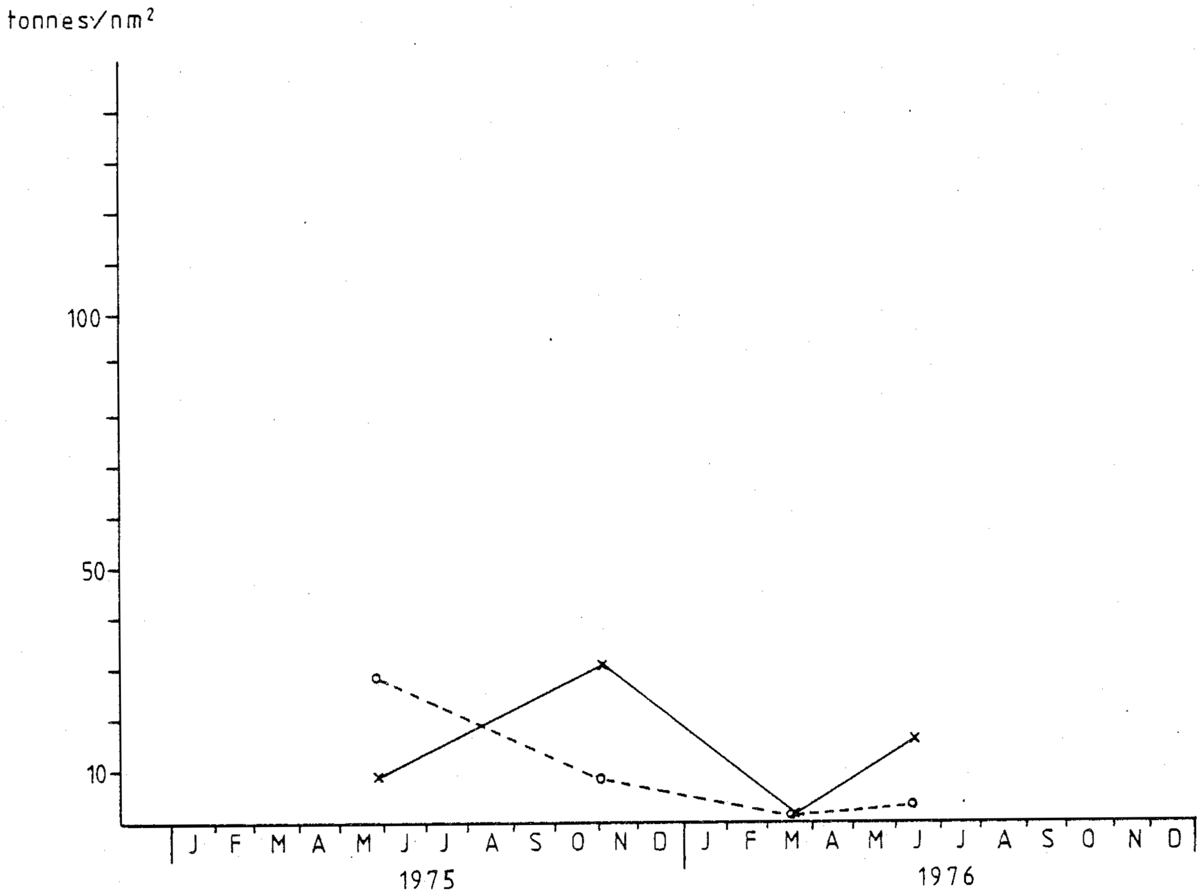


Figure 23g. Estimated biomass per nm^2 in Sector 7. (south-Iran Coast) in the period 1975-1976.

————————:pelagic --------:demersal

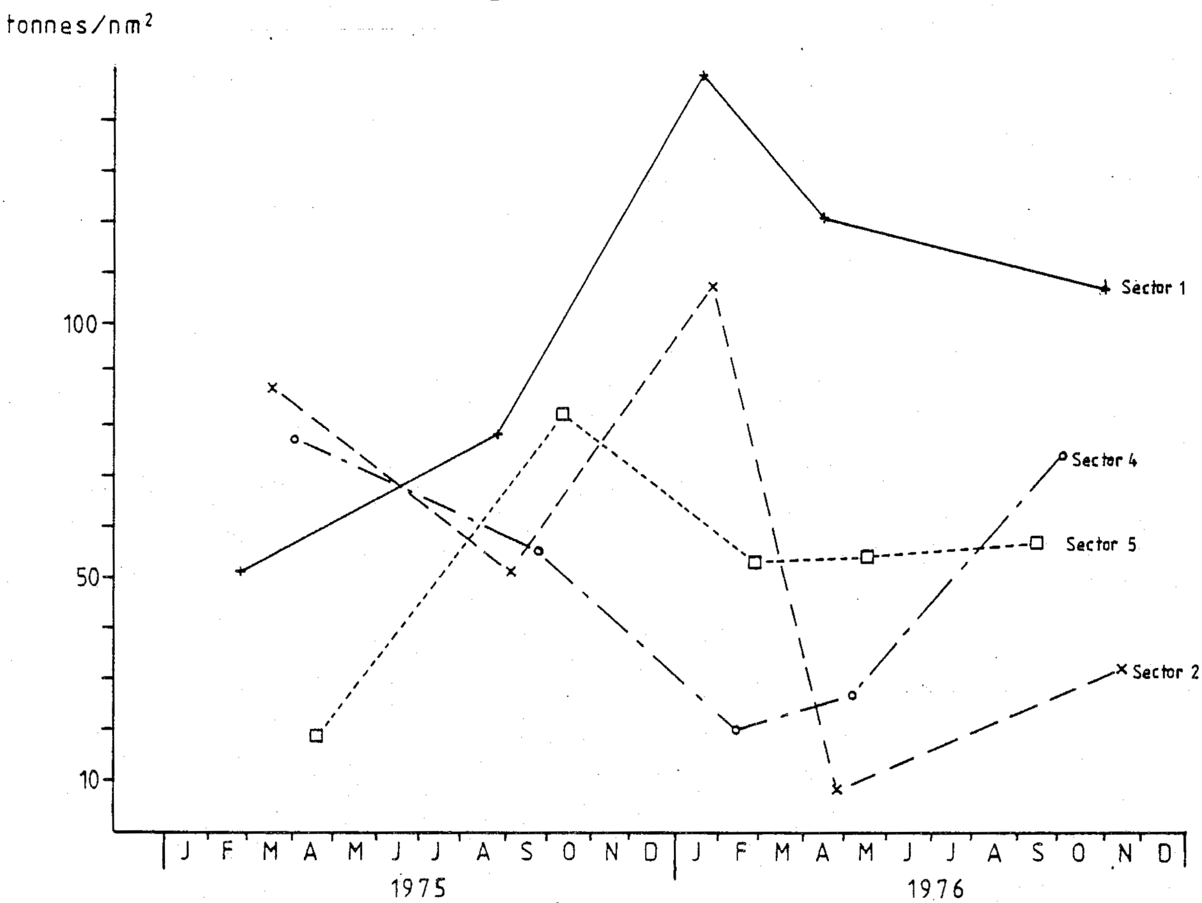


Figure 23h. Estimated biomass (pelagic+demersal) per nm^2 in four sectors in the period 1975-1976.

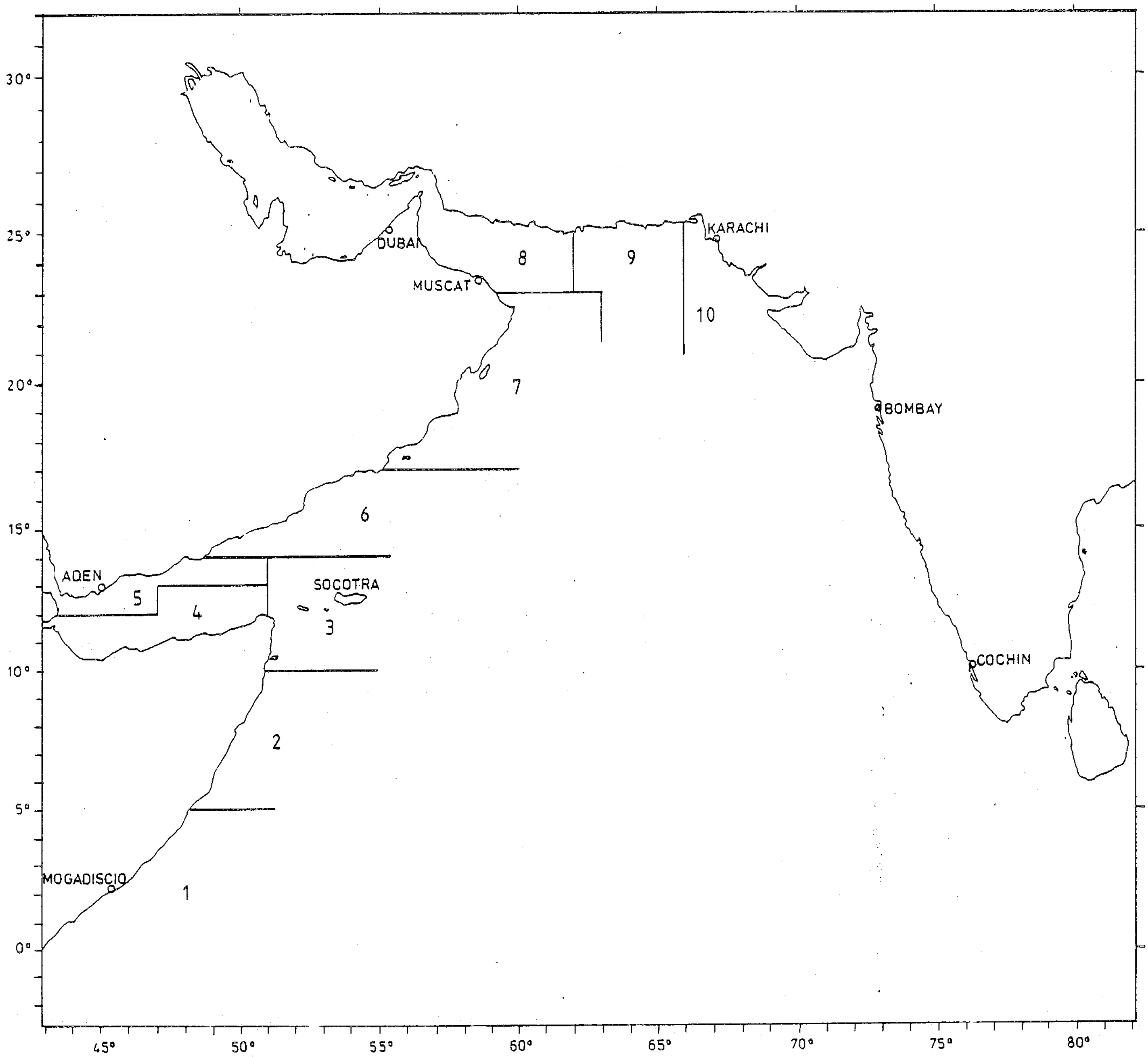


Figure 24. The subareas refered to in Table 14.They must not be interpreted as the Sector-divisions used in the report.

TABLE 1. Main operational features of the cruises.

Cruise no.	Dates	Days at sea	Distance* travelled in survey area	Numbers** fishing stations	Hydro-graphic stations	Plankton samples
1 & 2	14/2-75 - 14/4-75 19/4-75 - 3/7-75	52 + 57	6970	104 (129)	219	106
3	16/8-75 - 24/11-75	84	7055	99 (127)	221	119
4	11/1-76 - 1/4-76	71	6140	77 (109)	132	-
5	6/4-76 - 25/6-76	66	5675	75 (92)	113	-
6	20/8-76 - 24/11-76	78	7700	96 (113)	254	-
Total		408	33540	451 (570)	939	

* Within the shelf area only.

** Within survey area of relevance to this report. Within total survey area in brackets.

TABLE 2. Geographic specifications of the sectors of the surveyed region.

Sector No	Name	Geographic limits	Coast-line length	Continental Shelf area
1	South Somalia	1^{O} - 12^{O}N	853	9340
3	Socotra	12^{O}-14^{O}N 52^{O}-55^{O}E	151	4400
2	North Somalia	44^{O}-51^{O}E	551	2330
4	South Yemen	$43^{O}30'$-53^{O}E	668	7620
5	South Oman	53^{O}E-$23^{O}30^{O}$N	616	11320
6	North Oman	North to St. Hormuz	363	4280
7	Iran	St. Hormuz-62^{O}E	330	4360
	Total		3530	43720

Table 3. Number of Acoustic Recordings, during each Cruise in each Sector.

Cruise Number	Sector Name	Dates (the beginning and end dates of vessel prescence)	Area of the continental shelf (nm^2)	Area of the surveyed space*	Surveyed space as percentage of continental shelf.	Recordings Total number	Recordings Positive	Recordings over continental shelf per $100nm^2$	Positive recordings per $100nm^2$ of surveyed space	Number of fishing stations	Number of fishing st. per 1000 nm^2 of surveyed space
1	South Somalia	Mar-Apr-75	9338	8084	86.6	307	192	3.29	2.38	26	3.2
+	Socotra	Mar -75	4404	3570	81.1	49	49	1.11	1.37	2	0.6
2	North Somalia	Mar -75	2330	522	22.4	106	27	4.55	5.17	19	36.0
	Yemen	Mar-Apr -75	7620	4232	55.5	227	118	2.98	2.79	37	8.8
	South Oman	Apr-May -75	9190	8787	95.6	232	200	2.52	2.28	17	1.9
	North Oman	Apr-May -75	4277	3159	73.9	133	91	3.11	2.88	3	0.9
	Iran	May -75	4362	5820	133.6	107	92	2.45	1.58	4	0.7
	TOTAL		41521	34180	82.3	1703	769	4.10	2.25	104	3.0
3	South Somalia	Aug-Sep -75	9338	8397	59.9	318	264	3.41	3.14	20	2.4
	Socotra	Sep -75	4404	2858	64.9	138	37	3.13	1.29	2	0.7
	North Somalia	Sep -75	2330	968	41.6	64	64	2.75	6.61	15	15.5
	Yemen	Sep-Oct -75	7620	7954	104.4	303	229	3.98	2.88	27	3.4
	South Oman	Oct-Nov -75	9190	9270	100.9	256	190	2.79	2.05	24	2.6
	North Oman	Oct-Nov -75	4277	3706	86.7	112	98	2.62	2.64	4	1.1
	Iran	Nov -75	4362	2548	58.4	98	58	2.25	2.28	7	2.8
	TOTAL		41521	35701	86.0	1289	940	3.10	2.63	99	2.8
4	South Somalia	Jan-Feb -76	9338	11753	125.9	202	155	2.10	1.32	11	0.9
	Socotra	-	4404	-		-	-			1	-
	North Somalia	Jan-Feb -76	2330	2079	89.2	134	55	5.75	2.65	8	3.8
	Yemen	Jan-Feb -76	7620	2465	32.4	280	156	3.67	6.33	25	10.1
	South Oman	Feb-Mar -76	9190	5899	54.2	241	121	2.62	2.05	16	2.7
	North Oman	Mar -76	4277	487	11.4	99	10	2.31	2.05	12	24.6
	Iran	Mar -76	4362	401	9.2	142	25	3.26	6.23	4	10.0
	TOTAL		41521	23084	55.6	1098	522	2.64	2.26	77	3.3
5	South Somalia	April -76	9338	5061	54.2	228	127	2.44	2.51	17	3.4
	Socotra	-	4404	-	-	-	-			-	-
	North Somalia	April -76	2330	513	22.0	103	12	4.42	2.34	1	1.9
	Yemen	Apr-May -76	7620	7054	92.6	293	233	3.85	3.30	26	3.7
	South Oman	May-June -76	9190	8936	97.2	188	145	2.05	1.62	12	1.3
	North Oman	June -76	4277	2630	61.5	132	83	3.09	3.16	13	4.9
	Iran	June -76	4362	2088	47.9	95	51	2.18	2.44	6	2.9
	TOTAL		41521	26282	63.3	1039	651	2.50	2.48	75	2.9
6	South Somalia	Sep-Nov -76	9338	8381	89.8	367	193	3.93	2.30	26	3.1
	Socotra	Sep -76	4404	3949	89.7	50	50	1.14	1.27	2	0.5
	North Somalia	Oct -76	2330	1228	52.7	119	51	5.11	4.15	9	7.3
	Yemen	Sep-Oct -76	7620	6511	85.4	255	203	3.35	3.12	31	4.8
	South Oman	Aug-Sep -76	9190	9673	105.3	168	127	1.83	1.31	11	1.1
	North Oman	Aug-Sep -76	4277	8376	195.8	136	109	3.18	1.30	5	0.6
	Iran	Aug -76	4367	5828	133.6	138	122	3.16	2.09	12	2.1
	TOTAL		41521	43946	105.8	1233	855	2.97	1.95	96	2.2
	TOTAL		41521	163193	78.6	6.362	3.737	3.90	2.29	451	2.8

*Surveyed space here, includes all space enclosed by the density-contour lines in Figures 10-21

TABLE 4a. Frequency with which each species, or other taxonomic group, appeared in the catches taken in the course of all cruises in each sector.

Number [1] of cruises	SECTORS 1	2	3	4	5	6	7	8	9	10	Total	Mean
1	119	80	89	105	114	161	111	141	95	107	1122	112.2
2	31	21	27	25	31	52	32	28	32	34	313	31.3
3	12	6	16	14	14	26	11	24	10	14	147	14.7
4	2	2	5	5	8	7	5	7	5	7	53	5.3
5	2	0	0	0	1	7	1	2	0	2	15	1.5
$\overline{X}$	1.416	1.358	1.540	1.456	1.518	1.604	1.456	1.52	1.472	1.555	1.5	1.5
SD	0.78	0.674	0.84	0.801	0.882	0.973	0.808	0.904	0.778	0.984	0.855	0.857
n =	166	109	137	149	168	253	160	202	142	164	1650	165

1) Number of cruises in which each species appeared in catches.

TABLE 4b. As for Table 4a, but relating to only the more important species and groups.

Number of cruises	SECTORS 1	2	3	4	5	6	7	8	9	10	Total
1	71	52	57	66	74	106	80	97	61	71	735
2	19	14	18	19	18	30	20	20	23	22	203
3	6	2	11	8	9	18	10	14	7	11	96
4	1	0	1	2	5	4	4	6	3	4	30
5	0	0	0	0	0	6	0	1	0	1	8
$\overline{X}$	1.351	1.265	1.494	1.432	1.481	1.622	1.456	1.507	1.489	1.55	1.482
SD	0.646	0.507	0.761	0.739	0.842	1.023	0.8	0.898	0.772	0.89	0.7993
n	97	68	87	95	106	164	114	138	94	109	1072

TABLE 4c. As for Table 4b, but relating to families only.

Number of cruises	SECTORS 1	2	3	4	5	6	7	8	9	10	Total
1	17	11	8	10	7	12	13	11	7	8	104
2	4	8	8	6	8	7	7	5	6	7	66
3	7	6	5	12	10	11	5	7	7	3	73
4	4	2	7	6	3	1	5	6	4	12	50
5	2	0	3	0	4	12	8	8	4	3	44
$\overline{X}$	2.118	1.963	2.645	2.412	2.656	2.86	2.684	2.865	2.714	2.848	2.596
SD	1.32	0.98	1.355	1.104	1.285	1.567	1.579	1.549	1.384	1.395	1.394
n	34	27	31	34	32	43	38	37	28	33	337

Table 5a. Frequency with which each species, or other taxonomic group, appeared in the catches taken in one or more sectors during each cruise.

Number* of sectors	Cr. 1, 2	Cr. 3	Cr. 4	Cr. 5	Cr. 6	Cr. 1-6	Percent
1	124	114	109	85	138	570	49
2	57	60	43	48	72	280	24
3	24	30	36	22	41	153	13
4	9	16	22	7	23	77	7
5	4	14	9	3	12	42	4
6	4	2	4	3	8	21	2
7	2	2	4	3	7	18	2
8				4		4	
9	2		1			3	
10		1	1		4	6	
$\bar{X}$	1.867	2.067	2.214	2.063	2.275	2.11	
SD	1.379	1.419	1.596	1.569	1.735	1.56	
n	226	239	229	175	305	1174	

*Number of sub-areas in which each species appeared in catches.

TABLE 5b. As for 5a, but relating to only the important species and groups.

Number of Sectors	Cr. 1& 2	Cr.3	Cr. 4	Cr. 5	Cr. 6	Total
1	81	68	73	62	79	363
2	34	44	24	35	49	186
3	19	23	28	17	31	118
4	3	9	12	6	15	45
5	4	10	9	1	10	34
6	2	1	4	3	5	15
7	1			1	4	6
8				2		2
9						
10						
$\bar{X}$	1.785	2.045	2.147	1.992	2.269	2.064
SD	1.178	1.229	1.397	1.428	1.49	1.363
n	144	155	150	127	193	769

TABLE 5c. As for Table 5b, but limited to families.

Number of sectors	Cr. 1 & 2	Cr. 3	Cr. 4	Cr. 5	Cr. 6	Total
1	12	7	2	7	5	33
2	6	9	9	3	11	38
3	6	5	7	4	4	26
4	2	6	3	5	4	20
5	7	3	6	2	2	20
6	2	3	8	4	4	21
7	2	4	2	3	7	18
8	1	4	2	5	4	16
9	2	2	1	1	4	10
10	1	0	1	0	2	4
	41	43	41	34	47	206

TABLE 6a. Frequency with which the commercially important species or other taxonomic group appeared in one or more sectors and in one or more cruises that is combining Tables 4b and 5b.

Number of sub-areas	Number of cruises					
	Cr. 1	Cr. 2	Cr. 3	Cr. 4	Cr. 5	Total
1 sub-area	103	3	1	0	0	107
2 "	33	35	4	0	0	72
3 "	7	23	19	3	1	53
4 "	3	11	15	8	0	27
5 "	2	3	5	7	9	26
6 "	1	4	4	7	3	19
7 "	0	1	3	3	10	17
8 "	0	0	0	6	5	11
9 "	0	0	1	3	2	6
10 "	0	0	0	0	2	2
	149	80	52	27	32	340

TABLE 6b. As for Table 6a, but limited to families.

Number of sub-areas	Number of cruises Cr. 1	Cr. 2	Cr. 3	Cr. 4	Cr. 5	Total
1 sub-area	3	0	0	0	0	3
2 "	3	1	1	0	0	5
3 "	0	1	1	0	1	3
4 "	0	2	2	1	2	7
5 "	0	1	0	1	2	4
6 "	0	0	0	0	2	2
7 "	0	2	1	3	3	9
8 "	0	0	0	0	3	3
9 "	0	0	0	1	5	6
10 "	0	0	0	0	12	12
	6	7	5	6	30	54

Table 7a. The appearance of families in pelagic and demersal catches showing for each family the number of stations in which it appeared, the percentage that that number is of the total number of hauls of the type to which the number relates, and the rate of catch (kg/hour) at stations of its occurrence.

FAMILY	PELAGIC			DEMERSAL		
	fn	%	C kg/h	fn	%	C kg/h
Acropomidae				11	5	54.0
Ariidae	10	3	310.3	36	17	711.5
Ariommidae	7	2	28.8	10	4	24.0
Balistidae	2	0	17.2	21	10	12.7
Bothidae	2	0	0.1	25	12	1.5
Bramidae	9	3	2.9			
Carangidae	91	32	105.7	120	57	198.3
Centropomidae	2	0	0	7	3	246.6
Chironemidae	6	2	3.1	11	5	16.8
Clupeidae	53	19	387.5	55	26	79.5
Congridae	4	1	17.1	4	1	3.7
Coryphaenidae				1	0	40.0
Cynoglossidae				2	0	1.0
Drepanidae	1	0	0	20	9	18.8
Engraulidae	40	14	172.4	39	18	139.9
Formionidae	1	0	96	16	7	45.4
Gempylidae	30	10	1.3	6	2	17.9
Gerridae				18	8	8.2
Harpadontidae	15	5	4.5	2	0	42.9
Lactaridae	3	1	0.5	13	6	147.1
Leiognathidae	17	6	43.1	52	25	179.8
Lethrinidae	2	0	57.9	41	19	235.2
Menidae	1	0	1.6	2	0	0.8
Mullidae	1	0	4.8	57	27	24.2
Muraenesocidae	1	0	1.4	10	4	49.5
Nemipteridae	18	6	171.5	85	41	396.1
Parapercidae	4	1	0.3	2	0	18.0
Pentapodidae				12	5	19.8
Peristedidae	1	0	1.0	9	4	68.8
Pleuronectidae				24	11	55.4
Platycephalidae	29	10	49.6	37	17	10.1
Plectorynchidae				2	0	54.0
Polynemidae				13	6	17.1
Pomatomidae	5	1	-	38	18	137.6
Priacanthidae	4	1	0.4	23	11	5.7
Psettodidae				13	6	7.9
Rachycentridae	2	0	6.5	17	8	18.4
Sciaenidae	3	1	0.3	34	10	213.9
Scolopsidae				4	1	5.9
Scombridae	41	14	30.2	42	20	58.8
Scorpaenidae	3	1	0.2	20	9	2.1
Scombropidae	1	0	0	4	1	17.3
Serranidae	1	0	1.4	49	23	45.6
Siganidae				9	4	24.7
Sillaginidae	1	0	6.8	2	0	16.8
Soleidae				1	0	0.8
Sparidae	11	3	16.2	82	39	102.1
Sphyraenidae	20	7	78.0	52	25	42.9
Stromateidae	74	26	31.7	37	17	215.2
Synodontidae	10	3	206.4	96	46	50.7
Theraponidae				12	5	209.9
Trichiuridae	44	15	25.1	48	23	164.2

Table 7b. Citations in the texts of Cruise Reports of the sighting and catching of various species.

Species name	Cruise number 1+2	3	4	5	6
Alectis indicus					+
Alepes djeddaba			+	+	+
Alepes melanoptera		+			
Alepes sp.		+			
Auxis rochei		+			
Auxis thazard	+	+			+
Bregmaceros macclelandi					+
CARANGIDAE		+			
Carangiodes chrysophrys					+
Carangoides malabaricus	+				+
Carangoides oblongus					+
Carangoides sp.					+
Coryphaena hippurus		+			
Decapterus dayi	+		+		
Decapterus macrosoma		+			
Decapterus maruadsi		+			+
Decapterus sp.		+	+	+	+
Diodon maculifier	+	+	+	+	
Drepane punctata					+
Dussumiera acuta	+	+	+	+	+
Engraulis japonicus		+			
Engraulis sp.					+
Etrumeus teres	+	+	+	+	+
Euthynnus affinis	+				
Formio niger					+
Gazza minuta					+
Herclotsichthys sp.		+			
Hilsa sp.		+			
Leiognathus bindus	+				+
Leiognathus elongatus					+
Leiognathus equulus					+
Leiognathus sp.				+	+
Megalaspis cordyla		+		+	+
Nemipterus sp.		+			
Pampus argenteus					+
Pellona ditchela					+
Rastrelliger kanagurta					+
Sardinella albella	+		+		+
Sardinella gibbosa	+			+	+
Sardinella jussieu	+				
Sardinella longiceps	+	+	+	+	+
Sardinella sirm					+
Sardinella sp.		+	+		
Scomber sp.	+	+		+	+
Scomberomorus commersoni	+	+			
Scomberomorus guttatus		+			+
Scomberomorus sp.			+		
Selar crumenphthalmus	+		+		+
Stolephorus buccaneri	+		+		
Stolephorus commersoni	+				
Stolephorus heterolobus		+			+
Stolephorus sp.				+	
Synargrops sp.			+	+	
Thryssa mystax					+
Thryssa sp.				+	
Thryssa vitrirostris	+	+	+		
Trachurus sp.	+	+	+	+	

Table 8. Frequency distribution of number of species per shot, for demersal gears and pelagic gears separately and for all gears.

Number of species per shot	Frequency in shots		
	with demersal gears	with pelagic gears	with all gears
0	4	1	5
1	18	36	54
2	12	32	44
3	14	41	55
4	11	28	39
5	18	13	31
6	10	20	30
7	8	14	22
8	6	10	16
9	15	7	22
10	12	7	19
11	8	3	11
12	10	3	13
13	8	2	10
14	8	2	10
15	7	3	10
16	4	0	4
17	3	0	3
18	5	1	6
19	7		7
20	3		3
21	1		1
22	0		0
23	3		3
24	2		2
25	2		2
26	4		4
27	0		0
28	2		2
29	2		2
30	0		0
31	1		1
32	0		0
33	3		3
34	0		0
35	2		2
Totals:	213	223	436
Without transformation			
Mean =	10.08	4.56	7.24
S.D. =	7.81	3.35	6.53
With transformation			
Mean =	7.41	3.70	5.25
S.D. =	0.3528	0.2514	0.3303

Table 9: Estimates of biomass in each sector during each cruise. A lower and an upper estimate is given in each case, derived from the confidence limits of the mean biomass-density index.

Cruise number	Demersal, pelagic or both	South Somalia	North Somalia	Yemen	Socotra	South Oman	North Oman	Iran	Total
1+2	D	210.751	17.007	111.493	58.667	93.758	40.911	105.734	638.321
		267.882	52.673	195.212	95.931	131.359	61.729	139.369	944.155
	P	199.977	90.339	376.332	78.751	54.935	12.073	29.245	841.652
		276.616	279.664	494.585	138.026	100.903	34.962	48.317	1373.073
	B	435.249	110.114	528.373	122.269	172.109	63.335	134.975	1566.344
		520.680	296.466	645.293	175.566	228.120	99.307	187.750	2154.182
3	D	428.628	66.934	52.029	37.736	83.896	94.386	24.385	787.994
		552.792	127.884	135.212	63.558	145.870	108.007	49.896	1183.219
	P	340.369	16.254	282.004	-	730.471	122.877	113.020	1604.995
		429.285	47.681	362.697	52.728	903.258	141.990	161.492	2099.131
	B	668.442	85.716	378.828	55.469	846.045	150.740	140.235	2325.495
		790.810	152.086	466.559	91.579	1016.761	316.519	214.147	3048.461
4	D	117.542	11.306	2.645		26.590		2.504	160.587
		172.845	62.631	9.877		54.241		9.481	309.075
	P	4239.511	127.562	113.575		502.207		249.000	5231.855
		6774.101	225.073	175.572		631.815		5.077	7811.638
	B	4706.722	194.364	119.711		540.609		6.363	5507.768
		6609.040	306.059	181.983		674.239		10.949	7782.270
5	D	272.099	11.384	6.136		94.633	9.353	9.395	403.000
		938.566	22.119	19.366		153.962	15.050	17.414	1166.477
	P	366.380		194.712		433.245	12.831	60.266	1067.434
		648.224	4.343	272.845		534.198	48.106	76.401	1584.117
	B	803.767	10.702	224.508		550.127	28.676	73.273	916.418
		1448.373	25.003	309.092		667.496	41.739	93.325	1608.44
6	D	172.382	42.570	163.810	55.193	98.228			368.373
		225.484	85.382	238.225	116.263	156.483			583.612
	P	712.189	11.305	260.810	112.054	435.892			1271.44
		875.221	28.759	342.492	223.631	618.998			1746.609
	B	916.267	56.722	451.863	191.509	558.694			2175.055
		1077.805	92.926	547.552	315.009	743.147			2776.439

Tables 10a-h. Recordings (index of biomass density) during each cruise in each sector.

Table 10a Sector 1 West-Somalia Coast

	DEMERSAL	PELAGIC	DEMERSAL AND PELAGIC
<u>Cruise 1 + 2</u>:			
N =	177	177	177
Mean X =	3.16	6.22	9.38
Sum X =	559.99	1100.90	1660.89
Sum X^2 =	4688.11	98656.66	105878.01
SD =	4.07	22.83	22.65
<u>Cruise 3</u>:			
N =	244	244	244
Mean X =	6.37	4.84	11.21
Sum X =	1554.02	1180.79	2734.35
Sum X^2 =	116948.15	68275.92	188137.58
SD =	20.99	16.05	25.46
<u>Cruise 4</u>:			
N =	114	114	114
Mean X =	1.97	18.77	20.75
Sum X =	224.77	2140.16	2364.93
Sum X^2 =	2413.98	149705.79	161367.49
SD =	4.18	31.13	31.53
<u>Cruise 5</u>:			
N =	106	106	106
Mean X =	12.5	10.71	23.22
Sum X =	1325.06	1135.71	2460.90
Sum X^2 =	337745.32	81066.84	420209.19
SD =	55.31	25.62	58.80
<u>Cruise 6</u>:			
N =	193	193	193
Mean X =	2.93	11.43	14.35
Sum X =	564.77	2205.32	2770.11
Sum X^2 =	7918.66	131473.08	149920.85
SD =	5.71	23.52	23.95
<u>Cruise 1-6</u>:			
N =	834	834	834
Mean X =	5.15	9.31	14.38
Sum X =	4298.63	7762.89	11991.19
Sum X^2 =	470787.02	529177.29	1025512.13
SD =	23.21	23.42	32.00

Table 10b Sector 2 North-Somalia Coast

	DEMERSAL	PELAGIC	DEMERSAL AND PELAGIC
Cruise 1 + 2:			
N =	27	27	27
Mean X =	7.67	36.62	44.30
Sum X =	207.33	988.66	1195.99
Sum X^2 =	6564.87	218861.44	225426.25
SD =	13.83	83.82	81.44
Cruise 3:			
N =	44	44	44
Mean X =	10.38	5.18	15.57
Sum X =		228.03	685.07
Sum X^2 =		5616.83	22632.70
SD =		10.16	16.68
Cruise 4:			
N =		54	54
Mean X =		11.11	14.55
Sum X =		600.09	800.09
Sum X^2 =		26253.45	23627.06
SD =		19.22	14.90
Cruise 5:			
N =	12	12	12
Mean X =	3.75	0.25	4.01
Sum X =	45.04	3.04	48.08
Sum X^2 =	241.20	9.03	262.49
SD =	2.56	0.87	2.52
Cruise 6:			
N =	43	43	43
Mean X =	4.81	2.47	7.27
Sum X =	207.01	106.01	313.02
Sum X^2 =	2723.27	1452.14	4953.76
SD =	6.41	5.32	7.98
Cruise 1-6:			
N =	181	181	181
Mean X =	6.17	10.64	16.81
Sum X =	1116.41	1925.83	3042.25
Sum X^2 =	30379.32	252192.90	276902.28
SD =	11.43	35.88	35.41

Table 10c Sector 3 Socotra

	DEMERSAL	PELAGIC	DEMERSAL AND PELAGIC
Cruise 1 + 2:			
N =	49	49	49
Mean X =	3.02	4.09	7.12
Sum X =	148.01	200.65	348.67
Sum X^2 =	1330.44	2730.91	5895.64
SD =	4.29	6.31	8.43
Cruise 3:			
N =	37	37	37
Mean X =	2.19	0.97	3.16
Sum X =	80.94	36.01	116.96
Sum X^2 =	280.67	155.93	570.37
SD =	1.70	1.83	2.36
Cruise 4:			
N =			
Mean X =			
Sum X =			
Sum X^2 =			
SD =			
Cruise 5:			
N =			
Mean X =			
Sum X =			
Sum X^2 =			
SD =			
Cruise 6:			
N =	50	50	50
Mean X =	3.42	5.52	8.94
Sum X =	171.08	276.06	446.78
Sum X^2 =	2275.30	4062.23	7711.24
SD =	5.87	7.20	8.72
Cruise 1-6:			
N =	136	136	136
Mean X =	2.94	3.77	6.71
Sum X =	400.04	512.71	912.41
Sum X^2 =	3886.41	6949.08	14177.26
SD =	4.48	6.10	7.73

Table 10d Sector 4 South-Yemen Coast

	DEMERSAL	PELAGIC	DEMERSAL AND PELAGIC
Cruise 1 + 2:			
N =	118	118	118
Mean X =	4.42	13.35	17.78
Sum X =	522.70	1575.29	2098.01
Sum X^2 =	9866.94	61583.78	75588.79
SD =	8.03	18.61	18.09
Cruise 3:			
N =	222	222	222
Mean X =	1.84	11.40	13.25
Sum X =	410.00	2530.47	2940.40
Sum X^2 =	12589.54	307324.36	319469.14
SD =	7.32	35.50	35.63
Cruise 4:			
N =	156	156	156
Mean X =	0.35	9.71	10.07
Sum X =	55.13	1515.71	1570.97
Sum X^2 =	575.18	81163.09	82012.69
SD =	1.89	20.70	20.67
Cruise 5:			
N =	233	233	233
Mean X =	0.29	5.84	6.13
Sum X =	67.68	1361.16	1428.85
Sum X^2 =	257.53	34601.68	35503.72
SD =	1.01	10.72	10.74
Cruise 6:			
N =	236	236	236
Mean X =	4.73	8.86	13.59
Sum X =	1117.92	2090.96	3206.21
Sum X^2 =	50471.34	108646.58	177334.27
SD =	13.87	19.58	23.86
Cruise 1-6:			
N =	965	965	965
Mean X =	2.25	9.40	11.65
Sum X =	2173.43	9073.60	11244.44
Sum X^2 =	74560.52	593319.50	689908.61
SD =	8.50	22.96	24.08

Table 10e Sector 5 South-Oman Coast

	DEMERSAL	PELAGIC	DEMERSAL AND PELAGIC
Cruise 1 + 2:			
N =	194	194	194
Mean X =	2.29	1.5	3.80
Sum X =	444.88	291.00	735.86
Sum X^2 =	3068.37	3405.68	7546.48
SD =	3.25	3.92	4.96
Cruise 3:			
N =	190	190	190
Mean X =	1.84	15.26	17.09
Sum X =	351.12	2896.73	3247.67
Sum X^2 =	6487.56	215456.41	223497.34
SD =	5.56	30.11	29.81
Cruise 4:			
N =	115	115	115
Mean X =	1.12	15.68	16.81
Sum X =	129.00	1802.92	1932.85
Sum X^2 =	1199.99	143949.55	147689.49
SD =	3.03	31.85	31.79
Cruise 5:			
N =	145	145	145
Mean X =	2.43	13.17	15.61
Sum X =	352.71	1909.55	2263.27
Sum X^2 =	2670.22	604935.92	637957.91
SD =	3.55	63.45	64.69
Cruise 6:			
N =	127	127	127
Mean X =	2.80	8.61	11.42
Sum X =	355.90	1093.86	1450.21
Sum X^2 =	6891.37	37664.07	65131.27
SD =	6.84	14.97	19.63
Cruise 1-6:			
N =	771	771	771
Mean X =	2.12	10.37	12.49
Sum X =	1634.54	7994.06	9629.86
Sum X^2 =	20317.52	1005441.64	1081822.48
SD =	4.68	34.61	35.34

Table 10f Sector 6 North-Oman Coast

	DEMERSAL	PELAGIC	DEMERSAL AND PELAGIC
Cruise 1 + 2:			
N =	91	91	91
Mean X =	2.56	1.17	3.65
Sum X =	232.96	107.19	332.64
Sum X^2 =	1657.58	834.76	3236.69
SD =	3.43	2.81	4.73
Cruise 3:			
N =	98	98	98
Mean X =	4.3	6.08	10.38
Sum X =	421.44	596.00	1017.44
Sum X^2 =	21713.82	22420.18	45383.55
SD =	14.32	13.92	18.95
Cruise 4:			
N =	10	10	10
Mean X =	0	2.0	2.0
Sum X =	0	20.0	20.0
Sum X^2 =	0	100.0	100.0
SD =	0	2.58	2.58
Cruise 5:			
N =	83	83	83
Mean X =	0.76	1.81	2.67
Sum X =	63.13	150.12	213.23
Sum X^2 =	97.27	2130.82	2372.60
SD =	0.78	4.76	4.72
Cruise 6:			
N =			
Mean X =			
Sum X =			
Sum X^2 =			
SD =			
Cruise 1-6:			
N =	282	282	282
Mean X =	2.54	3.10	5.61
Sum X =	717.52	873.30	1583.31
Sum X^2 =	23468.67	25485.77	51092.83
SD =	8.77	9.00	12.25

Table 10g Sector 7 Iran Coast

	DEMERSAL	PELAGIC	DEMERSAL AND PELAGIC
Cruise 1 + 2:			
N =	92	92	92
Mean X =	3.62	1.16	4.78
Sum X =	333.41	106.65	440.11
Sum X^2 =	2635.80	546.58	4683.90
SD =	3.96	2.16	5.32
Cruise 3:			
N =	58	58	58
Mean X =	2.45	8.98	11.43
Sum X =	142.03	520.88	662.91
Sum X^2 =	4009.87	22964.19	26987.43
SD =	8.01	17.91	18.45
Cruise 4:			
N =	19	19	19
Mean X =	2.37	1.11	3.42
Sum X =	45.06	20.02	64.94
Sum X^2 =	275.24	100.05	374.65
SD =	3.06	2.14	2.91
Cruise 5:			
N =	51	51	51
Mean X =	1.06	8.45	9.57
Sum X =	54.07	431.14	488.22
Sum X^2 =	120.16	42827.78	43917.59
SD =	1.12	27.99	28.01
Cruise 6:			
N =			
Mean X =			
Sum X =			
Sum X^2 =			
SD =			
Cruise 1-6:			
N =		220	220
Mean X =		4.93	7.53
Sum X =		1078.69	1656.18
Sum X^2 =		66438.60	75963.58
SD =		16.74	17.03

Table 10h All Sectors

	DEMERSAL	PELAGIC	DEMERSAL AND PELAGIC
Cruise 1 + 2:			
N =	748	748	748
Mean X =	3.27	5.84	9.11
Sum X =	2449.28	4370.34	6812.18
Sum X^2 =	29812.11	386619.83	428254.78
SD =	5.40	21.99	22.14
Cruise 3:			
N =	893	893	893
Mean X =	3.83	8.95	12.77
Sum X =	3416.49	7988.90	11404.79
Sum X^2 =	177236.36	619816.08	826678.12
SD =	13.57	24.79	27.63
Cruise 4:			
N =	469	469	469
Mean X =	1.40	13.00	14.40
Sum X =	654.89	6098.90	6753.79
Sum X^2 =	10108.13	401300.94	415171.38
SD =	4.43	26.23	26.06
Cruise 5:			
N =	630	630	630
Mean X =	3.03	7.92	10.96
Sum X =	1907.69	4990.73	6902.55
Sum X^2 =	341131.70	765572.07	1140223.50
SD =	23.09	33.97	41.14
Cruise 6:			
N =	649	649	649
Mean X =	3.72	8.89	12.61
Sum X =	2416.68	5772.22	8186.34
Sum X^2 =	70279.95	293298.12	405051.39
SD =	9.72	18.92	21.58
Cruise 1-6:			
N =	3389	3389	3389
Mean X =	3.22	8.62	11.99
Sum X =	10915.14	29221.09	40657.66
Sum X^2 =	630441.04	2479004.79	3497162.50
SD =	13.25	25.64	29.80

Table 11. Summary of mean Sector/cruise recordings*

a. Demersal stocks

Sectors	Cruises					
	1/2	3	4	5	6	ALL
1	3.2	6.4	2.0	12.5	2.9	5.2
2	7.7	10.4	3.6	3.8	4.8	6.2
3	3.0	2.2			3.4	2.9
4	4.4	1.8	0.4	0.3	4.7	2.3
5	2.3	1.8	1.1	2.4	2.8	2.1
6	2.6	4.3		0.8		2.5
7	3.6	2.4	2.4	1.1		2.6
ALL	3.2	3.8	1.4	3.2	3.7	3.5

Without transformation: Mean 3.52, SD 2.80 — With transformation: Mean 3.35, SD 0.224

a. Pelagic stocks

Sectors	Cruises					
	1/2	3	4	5	6	ALL
1	6.2	4.8	18.8	10.7	11.4	9.3
2	36.6	5.2	11.1	0.3	2.5	10.6
3	4.1	1.0			5.5	3.8
4	13.4	11.4	9.7	5.8	8.9	9.4
5	1.5	15.2	15.7	13.2	8.6	10.4
6	1.2	6.1	2.0	1.8		3.1
7	1.2	9.0	1.1	8.5		4.0
ALL	5.8	8.9	13.1	7.9	8.9	8.0

Without transformation: Mean 8.03, SD 7.30 — With transformation: Mean 7.92, SD 0.332

* See p.9 for definition of recording.

Table 12. Summary of estimates of mean biomass of each sector during each cruise (in thousand tonnes).

a. Demersal stocks

Sectors	Cruises				
	1/2	3	4	5	6
1	239	491	145	605	199
2	35	97	37	17	64
3	77	51			86
4	153	94	6	13	20
5	113	115	40	124	127
6	51	101		12	
7	123	37	6	13	

b. Pelagic stocks

Sectors	Cruises				
	1/2	3	4	5	6
1	238	385	1.087	507	794
2	185	32	176	4	20
3	108	53			168
4	435	322	145	234	302
5	78	817	567	484	527
6	24	132		30	
7	39	137	3	68	

c. Demersal and pelagic stocks

Sectors	Cruises				
	1/2	3	4	5	6
1	478	730	1.393	1.126	997
2	203	119	250	18	75
3	149	73			253
4	587	423	151	207	564
5	200	931	607	609	651
6	81	234		35	
7	161	177	9	83	

Table 13. Estimates of biomass per square nautical mile in each sector during each cruise (tonnes/nm^2).

a. Demersal stocks

Sector	Cruises				
	1/2	3	4	5	6
1	25.59	52.57	15.52	64.78	21.31
2	15.02	41.63	15.88	7.30	27.47
3	17.50	11.59			19.55
4	20.08	12.34	0.79	1.71	26.38
5	9.92	10.10	3.51	10.89	11.15
6	11.92	23.60		2.80	
7	28.21	8.49	1.38	2.98	

b. Pelagic stocks

Sector	Cruises				
	1/2	3	4	5	6
1	25.48	41.22	116.38	54.28	85.01
2	79.40	13.73	75.54	1.72	8.58
3	24.55	12.05			38.18
4	57.09	42.26	19.03	30.71	39.63
5	6.85	71.73	49.78	42.49	46.27
6	5.61	30.84		7.01	
7	8.89	31.42	0.69	15.60	

c. Demersal and pelagic stocks

Sector	Cruises				
	1/2	3	4	5	6
1	51.2	78.2	149.1	120.6	106.8
2	87.1	51.1	107.3	7.7	32.2
3	33.9	16.6			57.5
4	77.0	55.5	19.8	27.2	74.0
5	17.6	81.7	53.3	53.5	57.2
6	18.9	54.7		8.2	
7	36.9	40.6	2.1	19.0	

Table 14. Length measurements on Carangidae, Clupeidae and Engraulidae during all cruises. The subareas correspond to the ones defined in Figure 24, and is not to be mixed with the Sectors in the report.

FAMILY/Species	Subarea	Station	Lengths in sample Lowest	Highest	Mean	St. dev.	N
CARANGIDAE							
Alectis indicus	9	470	30.0	40.0	35.0	7.07	2
Alepes djeddaba	6	73	13.0	15.5	14.4	.84	7
		306	29.0	40.0	32.3	2.33	53
		500	35.0	38.0	36.5	.94	10
	7	207	32.0	34.5	33.0	1.10	8
		317	22.0	35.0	27.2	4.64	28
		490	31.0	33.0	32.3	.82	6
	8	468	25.0	30.0	27.5	2.07	6
	9	128	23.0	37.0	28.0	2.22	115
		240	18.0	27.5	24.0	1.58	93
		245	24.0	32.0	26.4	2.11	36
		246	12.5	19.5	14.3	1.39	23
		470	30.0	32.0	30.8	.84	5
	10	242	18.5	18.5	18.5	.00	1
Alepes melanoptera	6	84	22.0	36.0	31.9	3.75	19
	7	212	27.0	34.0	29.1	1.65	21
		215	19.0	33.0	26.5	3.50	21
	8	224	22.0	36.0	33.1	3.59	28
Atule mate		118	25.0	33.0	29.6	1.76	82
Carangoides malabaricus	4	536	7.0	12.0	8.6	1.14	31
	5	530	9.5	14.5	12.1	1.50	15
		531	11.5	13.0	12.5	.71	4
	6	504	41.0	45.0	43.0	2.83	2
	7	109	15.0	31.0	22.4	3.55	13
	8	224	11.5	20.5	18.4	2.59	16
		475	12.5	21.0	17.9	3.38	6
		479	18.0	30.0	24.8	3.34	59
		483	11.0	12.5	12.0	.37	23
		485	15.5	24.5	19.2	2.27	181
		486	9.0	13.0	12.1	.98	14
	9	240	13.0	20.0	16.6	2.88	5
	10	123	12.0	17.0	14.9	1.17	116
		242	12.5	19.0	15.3	1.60	23
Caranx chrysophrys	4	159	52.0	68.0	58.8	4.98	19
	7	212	60.0	60.0	60.0	.00	2
		488	51.0	61.0	57.6	4.22	5
	8	224	38.0	55.0	46.4	6.42	11
		475	56.0	56.0	56.0	.00	1
	9	240	23.0	30.0	26.2	2.99	4
	10	241	58.0	58.0	58.0	.00	1
Selar crumenopthalmus	1	9	8.0	25.0	19.0	7.80	6
	4	51	11.0	12.5	11.7	.65	4
		520	9.0	15.5	11.2	1.99	26
	5	52	13.0	14.5	13.6	.40	42
		69	13.5	16.0	14.5	.61	42

Table 14 (cont.)

FAMILY/Species	Subarea	Station	Lengths in sample Lowest	Highest	Mean	St. dev.	N
S. crumenopthalmus (cont.)							
		394	12.0	16.0	13.4	.95	50
		398	13.0	14.0	13.3	.48	50
		399	12.0	18.0	13.5	1.34	40
		400	13.0	17.0	15.0	.72	49
		402	14.0	16.0	15.0	.58	42
		516	9.5	18.0	13.4	2.62	209
		517	12.0	17.5	16.7	1.29	16
	6						
		299	15.0	18.0	16.1	.62	53
	8						
		481	22.5	22.5	22.5	.00	1
Decapterus sp.							
	1						
		137	11.0	15.5	12.7	1.07	41
	4						
		150	5.5	9.5	6.9	.67	108
		157	5.0	10.5	7.9	1.08	131
	6						
		175	17.0	25.5	20.0	1.47	82
	7						
		472	12.0	12.0	12.0	.00	1
Decapterus maruadsi							
	1						
		9	9.5	16.0	13.1	1.92	33
		373	16.0	26.0	22.3	2.22	51
		569	17.0	17.5	17.2	.35	2
	2						
		377	30.0	36.0	34.0	1.37	210
	3						
		33	16.0	20.0	17.6	.94	70
		34	16.0	18.0	16.9	.86	8
		381	18.0	24.0	20.7	1.42	46
		386	14.0	18.0	15.8	.82	50
		545	14.5	14.5	14.5	.00	1
		549	17.0	17.0	17.0	.00	1
		550	15.0	21.0	16.9	.96	129
	4						
		536	8.0	13.5	12.2	1.19	18
	5						
		52	12.5	14.5	13.1	..50	43
		169	7.5	11.0	9.6	.84	16
		389	12.0	16.0	13.3	.96	76
		391	13.0	17.0	15.0	.86	50
		393	13.0	19.0	15.7	1.26	59
		395	12.0	16.0	13.4	.83	50
		396	15.0	22.0	16.8	1.33	50
		402	14.0	20.0	17.2	1.31	50
		512	9.0	11.5	10.7	.85	8
		516	15.5	19.5	17.5	1.02	12
		534	12.0	21.5	14.8	2.26	18
	6						
		72	13.0	15.5	14.3	.60	24
		73	13.0	16.0	14.1	.92	8
		78	13.0	16.5	14.6	.73	66
		93	14.5	20.5	16.6	1.31	99
		173	13.5	22.5	18.2	3.28	6
		199	15.5	23.0	17.8	1.50	42
		504	20.0	25.5	22.1	1.58	32
	7						
		208	19.0	19.0	19.0	.00	1
		209	20.5	22.5	21.7	1.04	3
		221	18.5	18.5	18.5	.00	1
		488	7.5	16.5	14.8	1.72	47
	8						
		225	15.0	18.0	16.6	.69	28
		230	18.0	24.5	21.1	1.63	91
	9						
		240	5.0	10.0	8.1	.91	90
		248	15.0	17.5	16.4	.66	43
	10						
		426	14.0	19.0	16.4	1.25	50
Megalaspis cordyla							
	6						
		173	43.0	47.0	45.2	1.71	4
		188	48.0	53.0	50.5	3.54	2
	7						
		317	42.0	52.0	48.1	2.51	28
	8						
		225	27.0	37.0	33.0	5.29	3
		475	42.0	42.0	42.0	.00	1
		479	39.0	42.0	40.3	1.53	3
		483	31.5	38.0	34.7	4.60	2
		486	13.0	17.0	14.6	1.03	40
	9						
		245	27.0	40.0	35.0	2.42	100
	10						
		247	37.0	44.0	39.5	3.11	4
Scomberoides commersonianus							
	1						
		563	106.0	106.0	106.0	.00	1

Table 14 (cont)

FAMILY/Species	Subarea	Station	Lengths in sample Lowest	Highest	Mean	St. dev.	N
S. commersonianus (cont.)							
	7						
		488	60.0	68.0	64.0	5.66	2
	9						
		240	49.0	49.0	49.0	.00	1
		245	43.0	50.0	46.0	3.61	3
		246	32.0	40.0	36.0	5.66	2
		470	51.0	70.0	56.0	6.37	8
	10						
		242	41.0	58.0	49.9	6.36	7
		247	31.0	43.0	38.0	3.85	15
Seriolina nigrofaciata							
	5						
		517	5.0	5.0	5.0	.00	1
Trachinotus blochii							
	6						
		92	42.0	60.0	47.0	5.50	8
		500	40.0	43.0	41.8	1.61	3
		502	37.0	40.0	38.5	2.12	2
Trachurus sp.							
	2						
		553	16.5	17.0	16.9	.22	5
	3						
		31	18.0	21.0	19.2	.79	100
		382	16.0	22.0	17.5	1.55	110
		385	12.0	17.0	12.6	.97	50
		550	12.5	20.5	15.8	1.63	46
	5						
		512	18.0	19.5	18.7	.76	3
	6						
		184	16.0	20.5	17.9	.83	100
		299	14.5	17.0	15.6	.52	51
		407	15.0	21.0	17.7	2.00	52
		510	16.0	24.5	19.5	1.62	176
	7						
		107	14.0	33.0	25.0	2.73	96
		109	13.0	32.0	24.8	3.15	98
		211	8.0	10.5	9.7	.81	7
		212	11.0	12.0	11.5	.71	2
		316	13.5	15.5	14.5	.50	14
		421	14.0	16.0	14.8	.56	29
Alepes kalla							
	8						
		224	17.0	26.5	24.5	1.72	64
Alepes sp.							
	5						
		165	7.0	17.0	12.7	1.84	110
	6						
		175	8.5	17.5	15.2	1.61	120
		183	11.0	14.5	12.1	.63	70
		201	4.5	5.0	4.7	.35	2
	7						
		223	21.0	39.0	30.1	5.91	15
	8						
		475	49.0	62.0	56.3	4.46	8
		486	19.0	26.0	21.2	2.07	8
	9						
		470	20.0	26.0	22.9	1.83	14
Decapterus macrosoma							
	1						
		373	22.0	31.0	28.1	2.25	32
	2						
		553	22.0	24.0	23.1	1.03	4
		556	15.5	19.0	17.2	1.76	3
	3						
		39	30.0	34.0	32.2	1.01	214
		193	18.5	18.5	18.5	.00	1
		195	18.0	21.0	19.7	.91	14
		197	17.0	20.5	18.5	.62	100
		381	17.0	20.0	18.5	.78	24
		382	18.0	20.0	19.0	1.00	3
		384	14.0	22.0	18.9	1.80	22
		386	15.0	21.0	18.1	1.44	80
	5						
		52	14.0	19.0	17.0	1.23	67
		69	14.0	19.5	16.2	2.05	8
		516	15.0	16.5	15.6	.62	8
	7						
		416	20.0	26.0	22.5	1.74	17
Carangoides sp.							
	2						
		556	9.5	11.5	10.5	1.41	2
	5						
		530	7.5	10.5	9.4	1.21	7
	8						
		332	22.0	30.0	26.7	2.31	15
		475	25.0	27.0	26.0	1.00	3
		481	33.0	33.0	33.0	.00	1

Table 14 (cont.)

FAMILY/Species	Subarea	Station	Lengths in sample Lowest	Highest	Mean	St. dev.	N
Atule sp.							
	3						
		382	15.0	20.0	18.6	1.66	17
Selar sp.							
	8						
		479	36.0	36.0	36.0	.00	1
Decapterus dayi							
	7						
		114	18.0	24.5	21.6	1.60	73
	9						
		347	13.0	17.0	14.7	1.06	83
	10						
		360	4.0	8.5	6.5	1.09	80
Trachurus indicus							
	5						
		69	13.5	15.5	14.1	.70	9
	6						
		72	10.5	12.5	11.5	.48	128
		82	12.5	15.0	13.3	.49	112
		93	13.0	21.5	15.2	1.00	204
Caranx sp.							
	5						
		517	6.5	7.0	6.7	.35	2
	6						
		495	10.5	10.5	10.5	.00	1
	7						
		493	3.5	4.5	3.9	.39	9
Selaroides leptolepis							
	4						
		528	10.0	12.0	10.8	.56	23
		536	10.0	14.5	12.4	.83	50
	5						
		530	8.5	16.5	11.3	1.20	50
		531	10.0	16.0	11.2	.81	85
		534	11.0	18.0	12.1	1.45	125
	6						
		509	11.0	16.0	12.5	.81	75
	7						
		490	17.0	24.5	21.7	2.71	15
	8						
		483	20.0	27.0	23.5	4.95	2
Trachinotus bailloni							
	6						
		500	30.5	30.5	30.5	.00	1
Carangoides oblongus							
	5						
		531	5.5	11.0	8.5	2.48	4
CLUPEIDAE							
Dussimiera acuta							
	1						
		9	13.5	16.0	14.7	.55	47
	4						
		536	12.5	14.0	13.1	.63	4
	6						
		82	15.0	17.5	15.8	.66	85
		85	14.0	17.0	15.5	.66	165
		90	12.5	15.5	13.5	.80	33
		199	11.5	14.5	13.1	.52	100
		405	15.0	18.0	16.4	.84	23
		409	7.0	16.0	10.5	3.45	27
		411	14.0	17.0	15.7	.72	15
	7						
		212	8.0	15.5	10.3	2.96	7
		221	13.0	13.0	13.0	.00	2
		423	10.0	14.0	11.4	.99	50
		489	12.0	15.5	14.0	.54	132
	8						
		129	13.0	17.0	14.7	.69	103
		484	11.0	13.0	12.4	.70	50
	9						
		246	10.5	10.5	10.5	.00	1
	10						
		247	13.0	13.0	13.0	.00	2
		250	16.5	17.0	16.7	.35	2
Ilisha melastoma							
	9						
		245	20.5	23.5	22.3	1.61	3
	10						
		247	18.0	20.0	18.9	.82	5
		251	21.5	25.0	23.0	1.58	4

Table 14 (cont.)

FAMILY/Species	Subarea	Station	Lengths in sample Lowest	Highest	Mean	St. dev.	N
Opistopterus tardoore							
	8						
		467	7.5	15.5	10.8	1.69	26
	9						
		128	14.0	20.0	16.5	1.46	33
		128	14.0	20.0	16.5	1.46	33
Sardinella albella							
	1						
		263	12.0	14.0	13.0	.56	59
	7						
		488	12.0	15.5	13.4	.55	168
	8						
		468	15.0	17.0	15.9	.66	43
Sardinella complex							
	1						
		137	8.5	13.0	10.7	.94	100
	5						
		165	8.0	11.0	9.3	1.30	5
	7						
		211	11.5	14.5	13.3	.67	100
		212	12.0	15.0	13.7	.66	100
		221	9.5	15.0	13.3	.83	36
	9						
		246	13.0	16.0	14.8	.71	17
	10						
		247	14.5	15.0	14.9	.25	4
		256	13.0	16.0	14.7	.98	12
Sardinella gibbosa							
	1						
		565	14.0	14.0	14.0	.00	1
	2						
		553	15.0	17.5	16.3	.51	116
		554	8.5	12.0	10.5	1.80	3
	3						
		33	15.0	18.0	16.5	.89	8
	4						
		536	10.0	11.0	10.3	.58	3
	5						
		47	11.5	14.0	12.6	.48	129
		389	12.0	14.0	12.8	.65	100
		391	13.0	14.0	13.4	.50	22
		395	12.0	14.0	13.0	.64	50
		400	10.0	14.0	12.5	1.05	50
		516	10.5	15.5	13.5	1.03	52
		531	9.5	12.0	11.2	1.19	4
	6						
		73	10.0	11.5	10.6	.37	32
		78	12.5	15.0	13.6	.55	75
		83	13.0	16.0	14.6	.77	94
		86	12.5	16.0	14.7	.71	50
		90	11.0	14.5	12.4	1.00	22
		90	5.0	9.0	7.1	1.24	16
		305	12.5	15.0	13.7	.73	20
		405	11.0	14.0	12.9	.83	50
		409	11.0	15.0	12.3	1.38	45
	7						
		421	12.0	15.0	13.7	.76	50
		423	7.0	11.0	9.8	1.00	50
		489	11.0	14.5	12.6	.77	81
Sardinella jussieu							
	5						
		530	12.0	13.0	12.7	.58	3
	7						
		106	5.0	9.0	7.2	.70	133
		106	5.0	9.0	7.2	.70	133
	8						
		129	11.0	16.0	14.3	.68	132
Sardinella longiceps							
	3						
		34	12.0	17.0	14.8	1.55	111
		39	13.0	17.0	15.1	1.13	88
		193	15.5	19.0	17.2	.63	98
		195	15.0	18.0	16.7	.63	100
		384	15.0	18.0	15.8	.79	42
		386	15.0	18.0	15.9	.73	50
		545	14.0	15.0	14.5	.71	2
		549	12.5	18.0	15.2	1.47	18
		550	13.5	15.0	14.3	.57	7
	5						
		52	13.0	17.0	15.4	.63	137
		69	14.0	16.0	15.2	.45	39
		391	15.0	18.0	16.0	.67	32
		393	15.0	18.0	16.3	.57	79
		395	13.0	18.0	15.4	1.20	21
		516	15.0	19.5	17.1	.88	160
		517	11.5	11.5	11.5	.00	2
		534	12.0	14.0	12.6	.61	13
	6						
		73	10.5	15.0	12.4	1.11	225
		74	10.5	15.5	13.1	1.09	100

Table 14 (cont.)

FAMILY/Species	Subarea	Station	Lengths in sample Lowest	Highest	Mean	St. dev.	N
S. longiceps (cont.)							
		78	12.5	14.0	13.3	.50	12
		93	13.0	16.5	14.3	.52	78
		186	7.5	12.5	8.6	1.04	91
		187	12.0	14.0	12.7	1.15	3
		201	9.5	12.0	11.1	.68	57
		202	11.0	17.0	13.0	1.57	100
		203	11.0	11.0	11.0	.00	1
		403	14.0	16.0	14.6	.74	8
		412	14.0	18.0	15.7	1.07	24
		502	11.0	16.5	12.1	1.28	56
		504	8.5	12.0	10.3	.83	129
	7						
		207	16.0	19.5	18.1	1.16	6
		209	19.0	19.0	19.0	.00	1
		211	10.5	13.0	11.9	.71	63
		212	9.0	17.5	13.6	1.50	100
		215	15.5	20.0	17.6	.95	100
		421	14.0	18.0	15.5	.85	35
Macrura sp.							
	5						
		165	14.5	14.5	14.5	.00	1
	6						
		175	4.5	7.5	6.1	.63	112
Sardinella sirm							
	1						
		565	14.5	15.5	15.1	.38	6
	4						
		520	10.0	10.0	10.0	.00	1
	5						
		47	13.0	16.0	14.4	.77	69
		52	16.0	18.0	16.8	.55	32
		69	13.5	18.5	15.8	2.04	6
		516	15.0	18.5	16.9	1.21	7
	6						
		78	15.5	18.5	16.5	.81	28
Pellona ditchela							
	8						
		486	12.0	21.5	15.9	3.22	39
Etrumeus teres							
	1						
		137	15.5	19.5	17.8	.82	95
		263	10.5	16.0	13.2	.99	103
		368	12.0	16.0	13.9	.77	74
		370	14.0	17.0	15.6	.84	59
		373	20.0	21.0	20.7	.50	4
		565	11.0	15.0	13.1	.76	165
	2						
		554	7.5	16.0	8.7	.96	123
	3						
		33	15.0	20.0	17.1	1.03	98
		34	11.0	17.0	13.0	.97	119
		39	12.0	17.0	13.9	1.02	92
	3						
		195	18.5	20.5	19.7	.59	13
		197	17.0	20.0	18.5	.64	100
		381	15.0	20.0	17.3	1.23	84
		384	13.0	16.0	15.1	.71	73
		386	12.0	18.0	14.0	1.30	124
		545	12.0	15.0	13.2	.60	100
		549	10.5	17.0	11.5	.75	117
	6						
		184	11.5	15.5	12.9	1.12	66
		186	13.5	14.5	14.0	.50	3
	7						
		215	12.5	18.5	16.6	.86	100
		421	11.0	15.0	13.0	.84	50
		423	8.0	14.0	10.3	1.91	29
		488	10.0	14.5	12.5	.93	134
		490	3.5	6.5	5.3	.64	55
Nematolosus nasus							
	8						
		486	15.0	17.5	16.0	.65	53
Herclotsichtus punctatus							
	1						
		15	7.0	8.0	7.4	.30	28
	2						
		554	8.5	9.0	8.8	.35	2
Herclotsichtus quadrimaculatus							
	6						
		90	6.5	9.0	7.6	.52	22

Table 14 (cont.)

FAMILY/Species	Subarea	Station	Lengths in sample Lowest	Highest	Mean	St. dev.	N
ENGRAULIDAE							
Thryssa setirostris		187	13.0	13.0	13.0	.00	1
Thryssa vitrirostris	9	127	9.0	17.0	11.8	1.41	134
		128	5.5	13.5	9.2	2.42	159
		246	8.5	13.0	10.0	1.04	109
		345	15.0	19.5	16.9	1.26	18
	10	125	8.5	16.0	12.5	1.12	111
		241	13.0	15.0	13.7	.75	8
		247	8.5	13.0	10.3	.75	106
		251	11.0	16.5	13.4	.98	99
Stolephorus buccaneeri		124	3.0	6.0	4.0	.68	110
		126	3.5	7.5	5.9	.78	112
		360	8.0	9.0	8.5	.32	36
Stolephorus commersoni	7	112	6.5	7.5	7.0	.37	19
Engraulis japonicus	1	9	4.5	7.0	5.8	.57	76
	3	190	6.5	9.0	8.3	.52	30
	6	201	8.0	10.0	8.7	.45	109
		504	7.0	10.0	8.3	.55	126
Stolephorus heterolobus	2	554	7.0	9.5	7.9	.62	111
	4	528	7.0	8.0	7.5	.41	4
	6	186	6.5	8.0	7.2	.39	100
Stolephorus indicus	3	549	13.5	13.5	13.5	.00	1
	5	47	11.0	13.0	11.7	.50	17
		516	12.0	13.0	12.4	.42	5
		530	9.5	11.0	10.5	.71	5
	6	71	10.5	13.5	11.9	.55	77
		73	10.0	12.0	10.8	.49	105
		79	10.0	12.0	10.6	.49	85
Thryssa mystax	8	467	7.0	13.5	10.7	1.65	97
		468	8.0	13.5	10.0	1.49	85
		486	13.0	18.0	15.4	1.74	22
Engraulis australis	2	554	8.0	10.5	9.3	.47	128
	3	545	10.0	10.5	10.2	.27	5
		549	6.5	11.0	7.7	1.44	53

APPENDIX 1.

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APPENDIX 2. Scientific staff of each cruise

Cruise 1.	A. Ghaddaf, J. Kamanyi, G.f. Losse, E. Molvær, S. Myklevoll, O. Nakken, B. Ullebust.
Cruise 2.	A. Dommasnes, a. Ghaddaf, B.d.l. Joseph, J. Kamanyi K. Lauvås, E. molvær, O. Smedstad, H. Solli
Cruise 3.	O. Alvheim, S. Brattås, F.M. Ismail, H. Jakupsstovu, R. Nzioka, N.H.A. Rehman, R. Sætre, B. Ullebust.
Cruise 4.	A.k. Beltestad, J. Gjøsæter, O. Knutsen, E. Molvær, S. Myklevoll, A. nikouyan, A. Vosughi.
Cruise 5.	T. Heyerdahl, O. Knutsen, O. Martinsen, E. Molvær, S. Mohuiddin, T. Monstad, K. Strømsnes, A. Vosughi, B. Ullebust.

APPENDIX 3. Record of fishing operations.

CRUISE 1&2. R/V "Dr. Fridtjof Nansen". Record of fishing operations. BTR: bottom trawl, LPT: large pelagic trawl, SPT: small pelagic trawl, PSE: purse seine, GIN: gillnet, BLL: bottom long-line. Fish names: FAO Species Identification Sheets for Fishery Purposes.

Date	Time Start GMT	St no	Gear type	Bottom depth m	Gear depth m	Position South North	East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
						South:				
15.2	1155	1	BTR	290	290	02°58'	40°35'	55	165	Brushtooth lizardfish <u>Saurida undosquamis</u> (14), <u>Neoscombrops annectens</u> (11)
15.2	1950	2	LPT	830	50	03°00'	41°01'	60	51	Lantern fishes MYCTOPHIDAE 2spp. (60)
16.2	1105	3	BTR	75	75	02°30'	40°56'	1	1	-
16.2	1220	4	BTR	77	77	02°30'	40°56'	500	1000	Sponges, sea fans (499)
16.2	-	5	SPT	-	-	-	-	-	-	(Trial)
17.2	1000	6	SPT	190	90	02°10'	41°17'	120	180	Swimming crab <u>Charybdis edwardsi</u> (120)
17.2	1757	7	SPT	300	40/90	01°49'	40°40'	29	47	Lantern fishes MYCTOPHIDAE 3 spp. (22)
18.2	0900	8	SPT	1200	365	00°42'	42°40'	4	8	Lantern fishes MYCTOPHIDAE 3 spp. (-)
18.2	1610	9	SPT	47	25	00°05'	43°00'	32	32	Squid (15)
						North:				
19.2	1200	10	BTR	160	160	01°20'	44°20'	77	154	Swimming crab <u>Charybdis edwardsi</u> (76)
22.2	1335	11	SPT	114	80	02°17'	45°54'	92	368	Porcupine fish <u>Diodon maculifer</u> (92)
23.2	0515	12	SPT	550	0/25	02°47'	46°36'	-	-	-
23.2	1054	13	SPT	35	20	02°57'	46°56'	-	-	-
23.2	1548	14	BTR	35	35	03°08'	46°54'	52	223	Porcupine fish <u>Diodon maculifer</u> (40)
23.2	1705	15	SPT	28	10	03°08'	46°54'	2	4	Squid (2)
23.2	1930	16	SPT	202	100	03°16'	47°05'	5	10	-
24.2	1150	17	BTR	70	70	04°12'	47°55'	175	332	Snappers <u>Lutjanus</u> spp. (75), Groupers <u>Epinephelus</u> spp. (33)
24.2	1334	18	BTR	73	73	04°18'	47°59'	325	234	Snappers <u>Lutjanus</u> spp. (188), Groupers <u>Epinephelus</u> spp. (55)
26.2	0855	19	BTR	225	225	06°12'	49°18'	814	1384	Mackerel <u>Scomber sp.</u> (775)
26.2	1055	20	SPT	240	40	06°12'	49°18'	1	1	Salps
26.2	1404	21	BTR	20	20	06°27'	49°11'	17	20	Cobia <u>Rachycentron canadus</u> (11)
27.2	0538	22	SPT	470	300	07°57'	50°13'	40	120	Lantern fish <u>Myctophum</u> sp. (39)
27.2	0647	23	SPT	438	40	07°59'	50°14'	325	520	Porcupine fish <u>Diodon maculifer</u> (324)
28.2	1125	24	SPT	270	30-50	08°35'	50°34'	97	107	Porcupine fish <u>Diodon maculifer</u> (65)
28.2	1545	25	SPT	425	25	08°48'	50°43'	5	10	Planktonic crustacea, fish larvae (4)
1.3	0405	26	BTR	54	54	09°52'	51°10'	-	-	-
1.3	0500	27	BTR	60	60	09°56'	51°12'	8	21	Groupers <u>Epinephelus</u> spp. (5)
1.3	0910	28	BTR	22	22	10°08'	50°55'	49	98	Threadfin trevally <u>Alectis indicus</u> (13) Greater lizardfish <u>Saurida tumbil</u> (10)
1.3	1150	29	BTR	24	24	10°20'	51°07'	54	108	Squid (36)
1.3	1557	30	SPT	225	50-120	10°08'	51°31'	3000	5400	Porcupine fish <u>Diodon maculifer</u> (3000)
2.3	0400	31	BTR	230	230	10°59'	51°24'	410	410	Boarfish <u>Antigonia rubescens</u> (133) Greater lizardfish <u>Saurida tumbil</u> (111)
2.3	1025	32	BTR	427	427	11°14'	51°27'	470	517	Lantern fishes MYCTOPHIDAE (178) Lobster <u>Puerulus sewelli</u> (132)
2.3	1600	33	PSE	340	-	11°16'	51°27'	52	-	Round herring <u>Etrumeus teres</u> (35)
2.3	1722	34	SPT	55	30	11°20'	51°14'	24	50	Oil sardine <u>Sardinella longiceps</u> (12) Round herring <u>Etrumeus teres</u> (11)
2.3	1940	35	SPT	38	20	11 23'	51 13'	13	39	Oil sardine <u>Sardinella longiceps</u> (13)
3.3	0145	36	BTR	82	82	11°41'	51°36'	16	35	Sharks, rays (10)
3.3	0654	37	SPT	68	30	11°48'	51°23'	1500	2400	Porcupine fish <u>Diodon maculifer</u> (1500)
3.3	1225	38	PSE	59	-	11°21'	51°16'	30	-	Devilray <u>Mobula</u> sp. (30)
3.3	2230	39	SPT	59	30	11°24'	51°20'	85	114	Round herring <u>Etrumeus teres</u> (67)
4.3	2021	40	BTR	34	34	12°07'	53°00'	89	256	Scavengers <u>Lethrinus</u> 4 spp. (57)
7.3	1135	41	BTR	37	37	12°23'	54°25'	2	4	Tobies LAGOCEPHALIDAE (1)
9.3	1608	42	SPT	496	35	12°06'	50°47'	30	90	Lantern fishes MYCTOPHIDAE (17)
9.3	1715	43	SPT	540	150	12°02'	50°39'	22	55	Lantern fishes MYCTOPHIDAE (-)
10.3	1545	44	SPT	345	20	11°40'	48°03'	2100	4500	Cardinal fish <u>Synagrops sp.</u> (2000)
10.3	2355	45	GIN	60	0	11°12'	47°15'	-	-	-
11.3	0500	46	BLL	60	60	11°12'	47°15'	46	0.5§	Areolated grouper <u>Epinephelus areolatus</u> (23), §: kg per hook
16.3	1822	47	SPT	45	25	12°36'	44°35'	23	69	Goldstripe sardinella <u>Sardinella gibbosa</u> (20)

CRUISE 1&2. (cont.)

Date	Time start GMT	St no	Gear type	Bottom depth m	Gear depth m	Position North	Position East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
17.3	0930	48	BTR	283	283	11°39'	43°30'	228	457	Cardinal fish Synagrops sp. (52) Brushtooth lizardfish Saurida undosquamis (41), Acropoma japonicum (36)
17.3	1438	49	BTR	212	212	11°19'	43°45'	276	828	Brushtooth lizardfish Saurida undosquamis (178)
17.3	1637	50	SPT	180	25	11°13'	43°45'	124	372	Lantern fishes MYCTOPHIDAE (123)
17.3	1920	51	SPT	100	25	11°04'	43°50'	32	96	Lantern fishes MYCTOPHIDAE (31)
18.3	2058	52	SPT	63	30	12°29'	44°23'	36	108	Round scad Decapterus dayi (12), Bigeye scad Selar crumenophthalmus (11)
19.3	0845	53	PSE	839	-	11°27'	44°29'	1	-	Squid
19.3	1038	54	PSE	829	-	11°24'	44°29'	-	-	-
20.3	0250	55	SPT	39	12	10°53'	45°48'	1	1	Fish larvae (-)
20.3	0744	56	PSE	890	-	11°16'	45°45'	-	-	-
20.3	0915	57	GIN	1700	0	11°15'	45°43'	-	-	-
20.3	1333	58	SPT	890	280	11°39'	45°38'	6	8	Lantern fishes MYCTOPHIDAE (-)
21.3	0440	59	SPT	1000	190	12°36'	45°25'	1	1	-
21.3	0720	60	LPT	860	260	12°43'	45°22'	44	88	Lantern fish Myctophum sp. (44).
21.3	1124	61	SPT	54	35	12°56'	45°26'	1	1	Fish larvae (-)
21.3	1540	62	SPT	71	25	13°01'	45°36'	1	1	Swimming crab Charybdis edwardsi (-)
22.3	1410	63	SPT	1500	155	11°04'	46°47'	73	109	Lantern fish Myctophum sp. (73)
23.3	0252	64	SPT	270	250	11°12'	47°42'	490	784	Cardinal fish Synagrops sp. (460)
23.3	0230	65	SPT	25	0	13°52'	47°44'	67	101	Narrow-barred Spanish mackerel (Kingfish) Scomberomorus commerson (67)
24.3	0400	66	BTR	31	31	13°52'	47°41'	48	48	Great barracuda Sphyraena barracuda (24)
26.3	1415	67	SPT	78	40-60	13°58'	48°38'	1	1	Fish larvae (-)
26.3	1555	68	SPT	75	0	13°58'	48°38'	1	1	Squid (-)
26.3	1725	69	SPT	83	65	13°55'	48°35'	9	18	Bigeye scad Selar crumenophthalmus (2), Oil sardine Sardinella longiceps (2)
26.3	2113	70	SPT	140	80-120	14°07'	48°48'	514	1542	Cardinal fish Synagrops sp. (479)
28.3	1055	71	SPT	40	30	14°42'	49°37'	52	155	Orangefin ponyfish Leiognathus bindus (35)
28.3	1155	72	BTR	33	33	14°42'	49°37'	481	962	Orangefin ponyfish Leiognathus bindus (259)
28.3	1342	73	SPT	22	0	14°45'	49°39'	67	201	Orangefin ponyfish Leiognathus bindus (20) Oil sardine Sardinella longiceps (16)
28.3	1712	74	BTR	20	20	14°45'	49°39'	837	1167	Oil sardine Sardinella longiceps (717)
30.3	0435	75	SPT	81-164	60-80	12°07'	50°57'	1	1	Fish larvae (-)
30.3	0615	76	BTR	79-102	79-102	12°16'	50°49'	9	29	Areolated grouper Epinephelus areolatus (4), Bigeye Priacanthus hamrur (3)
31.3	0443	77	SPT	30-40	10	14°50'	50°08'	-	-	-
31.3	0550	78	BTR	33	33	14°52'	50°14'	44	132	Round scad Decapterus dayi (16), Goldstripe sardinella Sardinella gibbosa (12)
31.3	0857	79	BTR	22	22	14°48'	49°56'	42	126	Sea bream Pagellus natalensis (14), Ponyfishes Leiognathus 3 spp. (10)
31.3	1007	80	BTR	36	36	14°47'	49°51'	28	60	Mantis prawn Oratosquilla investigatoris (6), Guitarfish Rhyncnobatus djeddensis (6)
31.3	1338	81	BTR	135-204	135-204	14°43'	50°10'	11	63	Swimming crab Charybdis edwardsi (8)
31.3	1850	82	SPT	55	20-30	15°01'	50°32'	281	562	Horse mackerel Trachurus sp. (143) Rainbow sardine Dussumieria acuta (113)
1.4	0538	83	BTR	42	42	15°05'	51°15'	607	1214	Orangefin ponyfish Leiognathus bindus (241) Shark Scoliodon sp. (112)
1.4	0910	84	SPT	50	25	15°07'	51°18'	14	25	Blackfin crevalle Alepes melanoptera (11)
1.4	1550	85	LPT	89	40	15°10'	51°35'	17	33	Rainbow sardine Dussumieria acuta (8) Catfish Arius sp. (6)
1.4	1715	86	SPT	85	70	15°10'	51°32'	162	486	Rainbow sardine Dussumieria acuta (139)
2.4	0422	87	BTR	190	190	15°12'	52°04'	29	58	Acropoma japonicum (12), Swimming crab Charybdis edwardsi (8)
2.4	0820	88	BTR	73	73	15°34'	52°13'	1048	1796	Largeheaded hairtail Trichiurus lepturus (644), Shark Scoliodon vagatus (199)
2.4	1625	89	SPT	2200	20-50	14°56'	52°34'	29	50	Porcupine fish Diodon maculifer (22)
4.4	2155	90	SPT	25	0	15°50'	52°15'	28	83	Blackfin crevalle Alepes melanoptera (10)

CRUISE 1&2. (cont.)

Date	Time start GMT	St no	Gear type	Bottom depth m	Gear depth m	Position North	Position East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
5.4	0425	91	BTR	16	16	16°05'	52°17'	11	22	Ponyfish Leiognathus sp. (7)
5.4	0620	92	BTR	33-42	33-42	16°14'	52°24'	264	529	Cobia Rachycentron canadus (125)
5.4	0938	93	BTR	98	98	16°18'	52°31'	5000	6598	Horse mackerel Trachurus sp. (2994), Swimming crab Charybdis edwardsi (1255)
6.4	0555	94	LPT	590	250-280	16°46'	54°01'	1	1	-
6.4	1115	95	LPT	2500	340	16°20'	54°13'	3	4	Hatchet fish STERNOPTYCHIDAE (1)
6.4	1525	96	SPT	2500	0	16°19'	54°10'	9	17	Lantern fishes MYCTOPHIDAE 2 spp. (4)
7.4	1005	97	LPT	3000	330-350	15°21'	55°55'	8	12	Lantern fishes MYCTOPHIDAE 2+ spp. (4)
7.4	1538	98	SPT	3100	50	15°56'	55°32'	99	199	Lantern fishes MYCTOPHIDAE 2+ spp. (78)
8.4	1034	99	SPT	2000	315-330	17°05'	55°18'	59	80	Lantern fishes MYCTOPHIDAE 2+ spp. (39)
20.4	0435	100	BTR	100	100	25°42'	57°01'		24	Jellyfish and salps (23)
21.4	0106	101	SPT		45	22°41'	59°41'		0.4	Small squids (0,4)
23.4	0540	102	BTR	63	63	17°54'	56°03'		-	
23.4	0635	103	BTR	62	62	17°54'	56°03'		-	A few salps
24.4	1827	104	SPT	3400	65	15°05'	57°17'		84	Cubiceps sp. (29), squids (20)
25.4	0603	105	SPT	4000	330	13°43'	58°31'		7	Lantern fish MYCTOPHIDAE (7)
26.4	0415	106	BTR	14	14	18°25'	56°51'		752	Scavenger Lethrinus nebulosus (417) Rabbitfish Siganus canaliculatus (172)
27.4	0835	107	BTR	90	90	18°32'	57°34'		315	Threadfin bream Nemipterus sp. (241)
28.4	0547	108	SPT	3600	260	17°58'	58°55'		44	Lanternfish MYCTOPHIDAE (43)
30.4	0138	109	BTR	30	30	19°22'	57°47'		1428	Grunter Rhonciscus stridens (694)
30.4	0500	110	HL	20	20	19°28'	58°04'		22	Grouper Epinephelus areolatus (17)
30.4	1455	111	BLL	14	14	19°54'	58°13'		39*	Catfish Arius thalassinus (23*) *Total catch
1.5	0049	112	BTR	18	18	20°13'	58°02'		1904	Ponyfish Leiognathus sp. (1452)
1.5	1545	113	BLL	130	130	20°35'	59°14'		-	One small shark
4.5	1530	114	SPT	2100	20	21°15'	59°29'		356	Lanternfish MYCTOPHIDAE (334)
6.5	0535	115	SPT	3000	200	21°57'	62°41'		8	Squids (8)
23.5	1225	116	BTR	99	99	25°48'	57°02'		245	Stingray Dasyatis uarnak (102) Largehead hairtail Trichiurus lepturus (69)
24.5	0300	117	SPT	500	125	25°22'	57°00'		208	Lanternfish MYCTOPHIDAE (200)
25.5	0533	118	BTR	24	24	24°12'	56°58'		767	Scavengers Lethrinus lentjan (146) L. nebulosus (101) Kingfish Atule mate (112)
25.5	1116	119	BTR	150	150	24°45'	56°44'		348	Grouper Epinephelus albomarginatus (68) Snapper Lutjanus gibbus (48)
28.5	0545	120	SPT	3000	340	23°33'	59°22'		80	Squids (58), Lanternfish MYCTOPHIDAE (11)
9.6	1012	121	SPT	95	75	23°05'	67°24'		469	Orangefin ponyfish Leiognathus bindus (221) Lanternfish MYCTOPHIDAE (186)
9.6	1230	122	BTR	26	26	23°11'	68°34'		764	Largehead hairtail Trichiurus lepturus (206) Tiger-toothed croaker Otalithes ruber (156)
10.6	0210	123	BTR	36	36	23°20'	67°21'		1959	Malabar cavalla Carangoides malabaricus (1343)
11.6	1141	124	SPT	78	55	24°00'	66°57'		147	Toothed ponyfish Gazza minuta (83)
11.6	1400	125	BTR	33	33	24°06'	67°04'		1708	Orangemouth thryssa Thryssa vitrirostris (372) Grunter Pomadasys guoraka (368) Largehead hairtail Trichiurus lepturus (271)
12.6	0225	126	SPT	30	0	24°23'	66°53'		534	Anchovy Stolephorus buccaneeri (437)
13.6	0600	127	BTR	25	25	25°12'	65°50'		1700	Catfish Hemipimelodus sp. (580)
14.6	0020	128	BTR	18	18	25°03'	63°08'		1204	Croaker Johnius belangerii (208)
14.6	0930	129	SPT	45	25	25°01'	61°59'		418	Rainbow sardine Dussumieria acuta (221)

CRUISE 3. R/V "Dr. Fridtjof Nansen". Record of fishing operations. BTR: bottom trawl, LPT: large pelagic trawl, SPT: small pelagic trawl, DTR: bottom trawl towed pelagic, PSE: purse seine, FDN: floating driftnet, BLL: bottom long line, FLL: floating long line. Fish names: FAO Species Identification Sheets for Fishery Purposes.

Date	Time Start GMT	St no	Gear type	Bottom depth m	Gear depth m	Position South North	East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
						South:				
17.8	0745	130	BTR	300	300	02°58'	40°37'	7	14	Snake mackerel Thyrsitoides sp. (1), Unident. (2).
17.8		131	SPT	184	90	02°45'	40°37'	2	4	Round herring Etrumeus teres (1).
18.8	1635	132	BTR	136	136	02°22'	41°05'	25	43	Lizard fish Saurida sp. (22).
19.8	2018	133	SPT	220	50	01°24'	44°30'	2	4	0-group fish.
						North:				
20.8	0719	134	BTR	50	50	02°47'	46°28'	17	34	Blood snapper Lutjanus sanguineus (16), Rabbit fish Siganus sp. (1).
22.8	1110	135	BTR	40	40	03°36'	47°25'	6	12	Spilotichthys sp. (3), Grouper Epinephelus sp. (3).
26.8	0930	136	SPT		175	02°32'	46°12'	<1	<1	Snake mackerel Thyrsitoides marleyi
26.8	2046	137	SPT	30	5	03°09'	46°51'	58	79	Narrow barred spanish mackerel Scomberomorus commerson (6), Round herring Etrumeus teres (40).
27.8	1255	138	SPT	200	183	04°06'	48°00'	1	2	0-group fish.
28.8	1350	139	BTR	335	335	06°37'	49°30'	12	12	Shrimps (5).
28.8	1945	140	BTR	19	19	07°16'	49°44'	1	2	Cardinal fish Synagrops japonicus (1).
28.8	2120	141	BTR	200	200	07°21'	49°49'	0	0	No catch.
30.8	0605	142	BTR	43	43	09°46'	51°04'	394	789	Scavenger Lethrinus nebulosus (328).
30.8	1035	143	SPT	100	85	10°50'	51°23'	200	400	Jelly fish (200), 0-group fish (2).
01.9	1158	144	BTR	35	35	10°59'	51°11'	4000	3333	Jelly fish (3000), Orangefin pony fish Leiognathus bindus (1000).
01.9	1730	145	SPT	480	15	11°09'	51°27'	9	19	Fox shark Alopias vulpinus (6).
02.9	0523	146	SPT	80	32	11°41'	51°33'	4	6	Swimming crab Charybdis edwardsi (3).
02.9	0950	147	SPT	74	15	11°44'	51°27'	40	80	Swimming crab Charybdis edwardsi (40).
02.9	1130	148	PSE	127	0-60	11°58'	51°10'	0	0	No catch.
02.9	1423	149	SPT	270	15	11°56'	51°04'	40	80	Swimming crab Charybdis edwardsi (40).
03.9	0935	150	BTR	34	34	11°25'	49°27'	214	475	Slender ponyfish Leiognathus elongatus (50), Red sea herder Emmelichthys indicus (39).
03.9	1255	151	SPT	650	275	11°27'	49°16'	61	123	Salps (60).
04.9	1835	152	SPT	277	20	13°26'	48°09'	103	206	Cubiceps sp. (100).
05.9	0740	153	SPT	456	75	12°45'	47°14'	5	10	Swimming crabs Charybdis edwardsi (4), Bullet mackerel Auxis rochei (1).
06.9	2305	154	SPT	350	35	11°18'	48°05'	358	716	Cardinal fish Synagrops japonicus (281), Psenopsis sp. (74).
06.9	1508	155	FDN	193	0-5	11°16'	47°28'	150	150	Sail fish Istiophorus gladius (24). Dolfin fish Coryphaena hippurus (3), Bullet mackerel Auxis rochei (1).
07.9	1323	156	SPT		250	11°26'	46°47'	10	20	Lantern fishes MYCTOPHIDAE (8).
07.9	1735	157	SPT	1800	25-50	11°41'	46°39'	38	76	Cubiceps gracilis (8), Scad Decapterus sp. (11).
08.9	1825	158	SPT	715	20	11°31'	45°31'	15	30	Cubiceps gracilis (15).
09.9	1355	159	BTR	35	35	10°52'	45°55'	1109	2218	Golden toothless trevally Gnathanodon speciosus (228), Blue streak emperor Lethrinus coerorhynchus (177), Naso sp. (178).
10.9	0557	160	SPT	850	35	10°31'	44°37'	1	1	0-group fishes.
11.9	1033	161	PSE	150	0-60	12°21'	43°36'	0	0	No catch.
17.9	0610	162	BTR	80-140	80-140	12°34'	44°58'	0	0	No catch.
17.9	1100	163	BTR	70	70	10°31'	44°37'	400	800	Cardinal fish Synagrops japonicus (398).
17.9	2015	164	SPT	49	15	12°31'	43°43'	300	600	Cardinal fish Synagrops japonicus (300).
18.9	1932	165	SPT	45	15	13°25'	46°00'	49	93	Crevalle Alepes sp. (37).
19.9	0025	166	BTR	350	350	13°26'	46°38'	505	252	Nettastoma sp. (209), Lobster and shrimp (100).
19.9	0400	167	SPT	50	20	13°20'	46°42'	22	44	Swimming crabs Charybdis edwardsi (15).
19.9	1000	168	SPT	187	170-185	13°26'	47°14'	5210	9769	Lantern fishes MYCTOPHIDAE (5000) squids (200).
19.9	1638	169	SPT	40	15	13°48'	47°41'	3	9	Palinurichthys sp. (1), Cardinal fish Synagrops japonicus (1).
20.9	0531	170	LPT	634	200	14°13'	49°00'	2	3	Swimming crab Charybdis edwardsi (1).
20.9	1015	171	SPT	300	15	14°28'	49°06'	23	43	Swimming crab Charybdis edwardsi (23).
21.9	0935	172	SPT	770	250	14°29'	49°23'	4	8	Swimming crab Charybdis edwardsi (3).

CRUISE 3. (cont.)

Date	Time Start GMT	St no	Gear type	Bottom depth m	Gear depth m	Position North	Position East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
21.9	1800	173	FDN	39	0-5	14°45'	49°48'	62		Frigate mackerel Auxis thazard (44), Streaked Spanish mackerel Scomberomorus lineolatus (7).
21.9	1840	174	FLL	42	0	14°45'	49°48'	0	0	No catch.
21.9	1904	175	SPT	57	15	14°44'	49°47'	318	636	Shad Hilsa sp. (6), Crevalle Alepes sp. (62), Scad Decapterus sp. (67).
23.9	0637	176	BTR	50	50	12°00'	50°47'	17	34	Red stumpnose Chrysoblephus gibbiceps (5), Lethrinus sp. (11).
23.9	2309	177	SPT	230	220	11°11'	48°07'	9	18	Cardinal fish Synagrops japonicus (3), Shrimps (3).
24.9	0238	178	SPT	250	200	11°10'	47°42'	1	2	Searobin Peristedion adeni (0,5).
24.9	0653	179	PSE	75	0-60	11°14'	47°26'	0	0	No catch.
28.9	2325	180	BTR	200	200	13°27'	47°01'	50	120	Lantern fishes MYCTOPHIDAE (10), salps (40).
29.9	0110	181	BTR	290	290	13°22'	47°04'	240	480	Brush-tooth lizard fish Saurida undosquamis (96), shrimp (75).
29.9	1137	182	SPT	70	10-30	14°00'	48°40'	250	500	Swimming crab Charybdis edwardsi (250).
29.9	1840	183	SPT	250	0-15	14°37'	49°26'	63	117	Swimming crab Charybdis edwardsi (18), Palinurichthys sp. (18), lantern fish MYCTOPHIDAE (12).
29.9	2152	184	BTR	27	27	14°43'	49°40'	74	149	Horse mackerel Trachurus sp. (66), Round herring Etrumeus teres (12).
30.9	0115	185	SPT	434	24	14°42'	49°59'	60	120	Mantis prawn Oratosquilla investigatoris (39), Palinurichthys spp.
30.9	1320	186	SPT	<15	0-15	15°06'	50°54'	1448	2896	Catfish Arius spp. (1171), Indian oil sardinella Sardinella longiceps (15).
30.9	2045	187	SPT	33	20	15°10'	51°16'	330	707	Bregmaceros sp. (220), catfish Arius spp. (73).
01.10	0223	188	SPT	50	25	15°16'	51°35'	152	304	Squids (150).
01.10	1020	189	BTR	193	193	15°10'	52°05'	2000	4600	Palinurichthys sp. (1166), smallhead hairtail Lepturacanthus savala (763).
02.10	1745	190	SPT	245	75	12°42'	53°55'	8	16	Mantis prawn Oratosquilla investigatoris(4)
03.10	1125	191	BTR	26	26	12°13'	53°33'	0	0	No catch.
03.10	1843	192	SPT	70	15	11°56'	52°54'	3	6	Frostels baracuda Sphyraena forsteri (2).
04.10	0637	193	SPT	75	15-27	11°51'	51°28'	17	25	Indian oil sardinella Sardinella longiceps (15).
04.10	1018	194	SPT	114	20-75	11°45'	51°21'	8	8	Mantis prawn Oratosquilla investigatoris (5), Swimming crab Charybdis edwardsi (2).
04.10	1708	195	SPT	227	15	11°42'	51°46'	320	519	Indian oil sardinella Sardinella longiceps (250), Slimy mackerel Scomber japonicus (40).
04.10	2050	196	FDN	76	0-5	11°30'	51°30'	0	0	No catch.
05.10	0837	197	BTR	80-125	80-125	11°42'	51°36'	1000	1000	Layang scad Decapterus macrosoma (965), Round herring Etrumeus teres (32).
06.10	0525	198	SPT	1900	240	13°51'	51°32'	30	60	Mantis prawn Oratosquilla investigatoris (20), Lantern fish MYCTOPHIDAE (10).
06.10	1923	199	SPT	42	35	15°57'	52°20'	105	210	Rainbow sardine Dussumeria acuta (18), Catfish Arius sp. (27).
07.10	0030	200	BTR	50	50	16°14'	52°23'	11	22	Parascolopsis eriomma (6).
07.10	0525	201	SPT	250	0-20	16°59'	54°20'	34	67	Swimming crab Charybdis edwardsi (23), Japanese anchovy Engraulis japonicus (5).
07.10	2024	202	SPT	500	0-20	16°56'	54°33'	74	147	Indian oil sardinella Sardinella longiceps (40).
08.10	1155	203	SPT	800	15	16°54'	54°43'	1200	1440	Shortfin lizardfish Saurida micropectoralis (1103).
08.10	2209	204	SPT	525	20-30	17°34'	56°30'	44	81	Palinurichthys sp. (31), Bregmaceros macclellandi (14).
10.10	0611	205	LTP	3300	850	15°17'	57°03'	30	60	Various deep water fish species.
11.10	1200	206	SPT	70	35-50	17°45'	56°40'	0	0	No catch.
11.10	1400	207	FDN	70	0-5	17°44'	56°40'	15		Cobia Rachycentron canadus (6), Djeddaba crevalle Alepes djeddaba (5).
12.10	0620	208	BTR	85	85	18°26'	57°15'	3000	6000	Threadfin bream Nemipterus spp. (3000).
12.10	1254	209	BTR	84	84	18°35'	57°33'	4000	8000	Threadfin bream Nemipterus spp. (4000).
12.10	1758	210	SPT	38	20-38	18°52'	57°39'	0	0	No catch.
13.10	1745	211	DTR	23	0-15	19°47'	58°03'	370	1100	Jelly fish (800), Fringescale sardinella Sardinella complex (fimbriata?) (58), Indian oil sardinella Sardinella longiceps (20)

CRUISE 3. (cont.)

Date	Time Start GMT	St no	Gear type	Bottom depth m	Gear depth m	Position North	Position East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
14.10	0537	212	DTR	31	10-15	19°46'	58°12'	64	127	Indian oil sardine Sardinella longiceps (16), Fringescale sardinella Sardinella complex (fimbriata?) (19).
14.10	1443	213	SPT	100	10-27	20°03'	58°33'	8000	16000	Jelly fish (8000).
14.10	1822	214	SPT	80	35	20°06'	58°39'	2010	8040	Threadfin bream Nemipterus spp. (1670).
14.10	2024	215	SPT	47	25	20°04'	58°34'	10000	20000	Jelly fish (8000), Rhoniscus stridens (1500), blackfin crevalle Alepes melanoptera (200), round herring Etrumeus teres (80), Indian oil sardinella Sardinella longiceps (120)
15.10	1750	216	SPT	1350	15-25	19°56'	60°52'	60	90	Squids (35), Lantern fishes MYCTOPHIDAE (25).
16.10	0634	217	SPT	1150	300-315	20°00'	61°47'	25	50	Salps (20).
17.10	0220	218	BTR	70	70	21°20'	59°22'	500	1000	Jelly fish (500).
17.10	0530	219	SPT	800	180	21°07'	59°32'	1500	3000	Lantern fish MYCTOPHIDAE (1500).
17.10	1145	220	BTR	85	85	20°59'	59°20'	100	200	Champsodon capensis (43), Uraspis sp. (20).
17.10	1740	221	DTR	26	8-10	20°52'	58°56'	10000	20000	Jelly fish (10000).
18.10	0710	222	BTR	66	66	21°41'	59°42'	0	0	No catch.
18.10	0815	223	BTR	63	63	21°41'	59°42'	1059	2118	Brushtooth lizardfish Saurida undosquamis (600).
19.10	0448	224	BTR	25-33	25-33	23°41'	58°21'	422	844	Crevalle Alepes kalla (41), Greater lizardfish Saurida tumbil (39), Dasyatis sp. (120).
20.10	1508	225	DTR	79	35	25°40'	56°30'	7	14	Banded barracuda Sphyraena jello (2), Round scad Decapterus maruadsi (2), Hardtail scad Megalaspis cordyla (2).
20.10	1820	226	FDN	43	0	25°27'	56°24'	3		Dog shark Scoliodon vagatus (2).
20.10	1820	227	BLL	43	43	25°27'	56°24'	10	1	Dog shark Scoliodon vagatus (9).
30.10	0520	228	DTR	175	80-100	25°37'	57°51'	0,2	0,4	Lantern fish MYCTOPHIDAE (0,2).
30.10	0925	229	BTR	168	168	25°27'	58°08'	360	720	Acropoma japonicum (240), Threadfin bream Nemipterus spp. (42), Brushtooth lizardfish Saurida undosquamis (37).
1.11	0952	230	BTR	67	67	25°19'	59°37'	153	307	Smallhead hairtail Lepturacanthus savala (140), Round scad Decapterus maruadsi (13).
1.11	1300	231	DTR	145	120-135	25°15'	59°51'	35	210	Lantern fish MYCTOPHIDAE
1-2.11	1415	232	FDN	145	0-5	25°20'	59°52'	27		Catfish Arius sp. (13), Tylosurus sp. (7).
2.11	1405	233	SPT	100	25	25°07'	60°54'	10	21	Lantern fish MYCTOPHIDAE (10), Smallhead hairtail Lepturacanthus savala (0,4).
3.11	1548	234	SPT	3500	40	22°52'	60°04'	300	515	Lantern fish MYCTOPHIDAE (230).
4.11	1109	235	SPT	3200	285-300	22°13'	61°17'	400	370	Lantern fish MYCTOPHIDAE (400).
5.11	1225	236	SPT	2800	150	23°24'	63°44'	0	0	No catch.
6.11	0113	237	SPT	2000	50	24°24'	64°14'	100	200	Jelly fish.
7.11	0505	238	SPT	290-350	130-140	24°50'	62°06'	50	100	Lantern fish MYCTOPHIDAE (50).
7.11	0735	239	SPT	462	240-255	24°48'	61°56'	610	1220	Lantern fish MYCTOPHIDAE (600).
9.11	0610	240	BTR	20	20	25°15'	65°21'	465	620	Grunter Pomadysus gouraka (155), Grouper Epinephelus sp. (150), Djeddaba crevalle Alepes djeddaba (36), Banded barracuda Sphyraena jello (25).
14.11	0110	241	BTR	38-43	38-43	23°44'	67°27'	740	1480	Lesser tigertoothed croaker Otolithes cuvieri (220), Spotted croaker Protonibia diacanthus (160), Coitor croaker Johnius coitor (90).
15.11	0621	242	BTR	27-29	27-29	23°12'	67°22'	3000	4000	Blotched grunt Pomadysus maculatus (1220), Dasyatis sp. (500), Indo-Pacific Spanish mackerel Scomberomorus guttatus (250).
17.11	0105	243	SPT	2800	40-55	24°15'	64°53'	5	16	Squid (3), Lantern fish MYCTOPHIDAE (2).
17.11	0850	244	SPT	45-50	25	25°07'	65°19'	0	0	No catch.
17.11	1019	245	SPT	43-48	18-35	25°06'	65°21'	500	1500	Hardtail scad Megalaspis cordyla (420), Black pomfret Formio niger (32).
18.11	0228	246	BTR	19	19	25°12'	65°47'	3000	6000	Catfish Arius sp. (1200), Orangemouth thryssa Thryssa vitrirostris (570), Smallhead hairtail Lepturacanthus savala (350), Tiger toothed croaker Otolithes ruber (190).
18.11	0620	247	BTR	35	35	25°14'	66°06'	3500	7000	Orangemouth thryssa Thryssa vitrirostris (1500), False trevally Lactarius lactarius (290), Catfish Arius spp. (735), Black pomfret Formio niger (250), Spotted croaker Protonibia diacanthus (220).
19.11	0348	248	BTR	144-162	144-162	24°22'	65°57'	750	1125	Threadfin bream Nemipterus spp. (550), Acropoma japonicum (40), Lantern fish MYCTOPHIDAE (32).

CRUISE 3. (cont.)

Date	Time Start GMT	St no	Gear type	Bottom depth m	Gear depth m	Position North	Position East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
19.11	1022	249	DTR	90	80-86	24°14'	66°14'			No catch.
20.11	0322	250	DTR	120	100	23°47'	66°28'	51	102	Lantern fish MYCTOPHIDAE (50).
20.11	0812	251	BTR	60	60	24°04'	67°01'	475	950	Grunt *Pomadysus argyreus* (115), Smallhead hairtail *Lepturacanthus savala* (60), Orangemouth thryssa *Thryssa vitrirostris* (30).
20.11	1028	252	BTR	15	15	24°09'	67°10'	200	400	*Triacanthus* sp. (170), Squid (25).
20.11	1330	253	FDN	23	0	23°53'	67°11'	0	0	No catch.
21.11	1600	254	SPT	2100	700-900	22°53'	65°20'	4	2	Lantern fish MYCTOPHIDAE (4).
22.11	0920	255	SPT	130	100	24°52'	66°05'	3	8	Ponyfish *Leiognathus* sp. (3).
22.11	1330	256	FDN	24	0	25°09'	66°30'	15		*Ablennes hians* 8, Smallhead hairtail *Lepturacanthus savala* (4).

CRUISE 4 R/V "Dr. Fridtjof Nansen". Record of fishing operations. BTR: bottom trawl, LPT: large pelagic trawl, SPT: small pelagic trawl, DTR: bottom trawl towed pelagic, PSE: purse seine, FDN: floating driftnet, BLL: bottom long line, FLL: floating long line. Fish names: FAO Species Identification Sheets for Fishery Purposes.

Date	Time start GMT	St. no.	Gear type	Bottom depth m	Gear depth m	Position South North	Position East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
14/1	0200	257	SPT	2000	1000	South: 01° 03'	42° 32'	11	11	Meso- and bathypelagic fish.
15/1	1613	258	SPT	200	15-110	North 00° 58'	43° 56'	44	88	Swimming crab Charybdis edwardsi (34)
18/1	0930	259	SPT	180	25	02° 06'	45° 40'	17	68	Swimming crab C. edwardsi (17)
18/1	1035	260	BTR	178	178	02° 07'	45° 41'	69	69	Porcupine fish Diodon sp (32) Swimming crab C. edwardsi (31)
18/1	2047	261	SPT	210	100-90	02° 40'	46° 25'	2500	5000	Cardinal fish Synagrops adeni (2500)
19/1	0940	262	SPT	120	100-75	03° 38'	47° 30'	0		
19/1	1715	263	BTR	33-36	33-36	04° 22'	47° 56'	17,5	35	White sardinella Sardinella albella (8), Round herring Etrumeus teres (3,6)
19/1	1945	264	BTR	136	136	04° 20'	48° 03'	0		
20/1	1352	265	SPT	2000	250	04° 19'	49° 00'	2	4	Lantern fish MYCTOPHIDAE (1)
21/1	0430	266	SPT	128	80	05° 57'	49° 04'	3,5	7	Swimming crab C. edwardsi
21/1	1715	267	BTR	45	45	07° 35'	49° 52'	480	960	Snappers Lutjanus spp. (88), Goatfish Parupeneus spp. (37), Scavengers Lethrinus spp. (21)
22/1	1910	268	SPT	220	35-45	09° 27'	51° 01'	1000	2000	Porcupine fish Diodon sp. (1000)
23/1	0755	269	BTR	35	35	10° 39'	51° 18'	432	846	Red snapper Lutjanus gibus (22) Scavengers Lethrinus sp. (21) Reys (100)
23/1	1615	270	SPT	-	0-20	11° 21'	51° 36'	4,5	9	Porcupine fish Diodon sp. (4.5)
24/1	0225	271	SPT	435	70-27	11° 53'	51° 39'	12	24	Swimming crab C. edwardsi (9)
25/1	0535	272	BTR	61-66	61-66	11° 33'	51° 22'	8,7	17	Blacksaddle goatfish Parupeneus fraterculus (3.5), Groupers Epinephelus sp. (4)
25/1	2030	273	SPT	450	80	12° 04'	50° 47'	25	50	Lantern fish MYCTOPHIDAE (10), Swimming crab C. edwardsi (7)
26/1	1350	274	SPT	527	240-260	11° 25'	48° 35'	10	20	Meso- and bathypelagic fish
26/1	1640	275	SPT	500	10-15	11° 18'	48° 10'	71,5	143	Bigeye scad Selar crumenophthalmus (61)
27/1	0150	276	SPT	2000	370	11° 17'	47° 09'	27	54	Squids (11)
27/1	1820	277	Gillnet	35	35	10° 52'	45° 54'	0	-	
28/1	0608	278	BTR	40-35	40-35	10° 55'	45° 52'	337	595	Groupers Epinephelus spp. (67), Surgeonfish Acanthurus sp. (43), Snappers Lutjanus spp. (30), Scavengers Lethrinus spp. (27)
28/1	1410	279	SPT	800	125-115	10° 34'	45° 00'	18,3	36	Lantern fish Benthosema pterotum (17)
29/1	1718	280	SPT	267	80-100	12° 28'	43° 32'	7	14	Lantern fish B. pterotum (7)
30/1	1820	281	SPT	35	12-30	12° 40'	44° 47'	300	720	Sardinella spp. (250)
31/1	0200	282	SPT	170	85	12° 24'	44° 18'	410	820	Lantern fish B. pterotum (405)
4/2	1400	283	PSE	33		12° 57'	45° 18'	1600	-	White sardinella Sardinella albella (1500)
5/2	0505	284	SPT	360-210	30-40	13° 23'	46° 56'	8,5	17	Mantis prawn Oratosquilla investigatoris (5,2)
5/2	0808	285	BTR	50-56	50-56	13° 28'	47° 15'	0	-	
5/2	1055	286	BTR	51-58	51-58	13° 35'	47° 28'	26,3	36	Longface emperor Lethrinus miniatus (9,8), Grouper Epinephelus sp. (6,4)
5/2	1750	287	SPT	240-175	10-20	13° 50'	47° 57'	400	800	Mantis prawn O. investigatoris (386)
7/2	0815	288	SPT	2050	300	13° 41'	50° 02'	15	20	Lanternfish Diaphus spp. (5)
8/2	1411	289	BTR	313-338	313-338	14° 25'	49° 12'	1500	1500	Psenes sp. (1400)
8/2	1905	290	BTR	17	17	14° 40'	49° 30'	770	1540	Indian oil sardin Sardinella longiceps (171), Orangefin ponyfish Leiognathus bindus (414)
9/2	1108	291	BTR	32-29	32-29	14° 00'	48° 02'	13	26	Indian oil sardin S. longiceps (4.5)
9/2	1640	292	Traps	30	30	14° 03'	48° 44'	0		
10/2	0710	293	BTR	263-268	263-268	14° 05'	48° 50'	1400	2800	Psenes sp. (1009), Greeneye Chlorophthalmus sp. (117)
10/2	1230	294	BTR	489-515	489-515	13° 50'	48° 35'	250	1000	Atractophorus armatus (?) (148), Sting ray Dasyatis sp. (40)

CRUISE 4. (cont.)

Date	Time start GMT	St. no.	Gear type	Bottom depth m	Gear depth m	Position South North	Position East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
10/2	1650	295	SPT	320	20	13° 48'	47° 59'	50	100	Lanternfish Benthosema pterotum (26)
15/2	0700	296	SPT	2000	175-200	11° 41'	46° 44'	45	90	Lanternfish B. pterotum (45)
17/2	0127	297	SPT	1900	55	12° 53'	53° 19'	186	372	Lanternfish Diaphus spp.
18/2	1240	298	SPT	150-172	5-20	14° 56'	50° 59'	3.6	7	Swimming crab Charybdis edwardsi (2.8)
18/2	1905	299	BTR	33-45	33-45	14° 57'	50° 22'	428	856	Painted sweetlip Plectorhynchus pictus (100), Emperor Lethrinus nebulosus (100)
19/2	0002	300	BTR	17-14	17-14	14° 46'	49° 49'	452	452	Grouper Aethaloperca sp. (178),
19/2	0945	301	SPT	31-40	10	14° 44'	49° 38'	100	133	Mantis prawn Orathosquilla investigatoris (100)
19/2	1240	302	BTR	36-43	36-43	14° 45'	49° 43'	2000	4000	Yellow goatfish Upeneus sulphureus (800), Orangefin ponyfish Leiognathus bindus (550)
19/2	1750	303	BTR	130-114	130-114	14° 45'	50° 02'	0		
20/2	0534	304	SPT	125	85-100	15° 09'	51° 38'	104	208	Squids (100)
20/2	1530	305	BTR	17-15	17-15	16° 01'	52° 15'	250	500	Orangefin ponyfish Leiognathus bindus (133), Pugnose ponyfish Secutor insidiator (66)
20/2	1825	306	SPT	34	19	16° 10'	52° 20'	93	280	Djeddaba crevalle Alepes djeddaba (81)
21/2	0815	307	SPT	600-700	270	16° 46'	54° 01'	45	60	Champsodon sp. (45)
21/2	1125	308	BTR	28	28	16° 54'	54° 07'	50	100	Emperor Lethrinus nebulosus (20), Triggerfishes Sufflamen spp. (13)
21/2	1545	309	longline traps	23	23	16° 54'	54° 07'	19	-	Carcharhinus altimus (?) (11)
22/2	1025	310	SPT	400-700	270-290	16° 56'	54° 32'	2000	6000	Lanternfish Benthosema fibulatum (2000)
24/2	1533	311	SPT	500-300	30-40	17° 37'	56° 37'	50	100	Champsodon sp. (31), Squids (15)
25/2	0103	312	BTR	65-67	65-67	17° 48'	56° 37'	35.5	71	Shrimps (9), Sharks (4.5), Pagellus natalensis (7.4)
25/2	2322	313	SPT	1500	50	18° 51'	57° 59'	180	360	Lanternfish MYCTOPHIDAE 4 spp. (165)
26/2	0725	314	SPT	740	250-300	19° 26'	58° 21'	250	500	Lanternfish Benthosema pterotum (230)
26/2	1500	315	BTR	18-14	18-14	19° 43'	57° 50'	10 000	20 000	Catfish Arius sp. (9520), Rays (1000), Tiger-toothed croaker Otolithus ruber (190)
26/2	1820	316	SPT	25	10-20	19° 54'	58° 00'	6500	13 000	White sardinella Sardinella albella (6192), Indian oil sardin Sardinella longiceps (200)
27/2	1018	317	SPT	34	20-30	19° 33'	57° 47'	746	748	Round herring Etrumeus teres (282), Rays 2 spp. (290), Narrow-barred spanish mackerel Scomberomorus commerson (50)
27/2	1645	318	SPT	30	15	19° 52'	58° 08'	400	1600	White sardinella Sardinella albella (255), Round herring Etrumeus teres (72)
28/2	0120	319	SPT	1200	15-35	20° 14'	58° 55'	900	1800	Lanternfish Benthosema pterotum (793)
29/2	0000	320	SPT	700-175	15-20	21° 37'	59° 37'	1500	3000	Lanternfish B. pterotum (1500)
29/2	0700	321	SPT	2200	150	22° 11'	59° 57'	2	8	Squids (1.8)
3/3	0625	322	SPT	2000	80-100	24° 38'	58° 50'	120	240	Lanternfish B. pterotum (120)
4/3	0535	323	SPT	175	135-155	25° 40'	57° 17'	4500	9000	Lanternfish B. pterotum (4500)
5/3	0740	324	SPT	820	265	24° 36'	57° 11'	60	120	Lanternfish B. pterotum (51)
5/3	0945	325	SPT	810	130-150	24° 36'	57° 11'	800	1600	Lanternfish B. pterotum (780)
5/3	1530	326	SPT	340	20	24° 37'	57° 11'	450	900	Lanternfish B. pterotum (438)
5/3	1740	327	SPT	340	90-110	24° 37'	57° 11'	450	900	Lanternfish B. pterotum (426)
5/3	2100	328	SPT	800	15	24° 38'	57° 12'	150	300	Lanternfish B. pterotum? (137)
6/3	0020	329	SPT	700	15-20	24° 37'	57° 11'	5000	10 000	Lanternfish B. pterotum (4979)
6/3	0455	330	SPT	300	120-140	24° 37'	57° 11'	650	1300	Lanternfish B. pterotum (650)
6/3	0710	331	SPT	300	250	24° 37'	57° 11'	150	300	Lanternfish B. pterotum (148)
7/3	0715	332	BTR	36	36	24° 28'	57° 46'	38	76	Great barracuda, Sphyraena barracuda (8), Ponyfish, Leiognathus leuciscus (8)
7/3	0945	333	BTR	270	270	24° 43'	56° 50'	135	270	Croaker, Artrobucca sp. (98), Sharks (17)
7/3	1245	334	long line	20	20	24° 45'	56° 31'	21	-	Sharks (18)

CRUISE 4. (cont.)

Date	Time start GMT	St. no.	Gear type	Bottom depth m	Gear depth m	Position North	Position East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
15/3	0805	335	SPT	300	1000	25° 00'	60° 17'	16,5	33	Lanternfish, B. pterotum (13)
15/3	1430	336	gillnet longline	-	-	25° 14'	60° 29'	38	-	Sharks (21)
16/3	0820	337	BTR	58-84	58-84	25° 09'	60° 52'	184	368	Longspine seabream Argyrops spinifer (38), Slender lizardfish Saurida elongata (31), Malabar cavalla Carangoides malabaricus (25)
18/3	0935	338	SPT	2900	450	22° 09'	61° 46'	2	4	Lanternfish, MYCTOPHIDAE 5 spp. (1)
19/3	0925	339	SPT	3500	425	22° 06'	63° 46'	0,5	1	Lanternfish, Benthosema pterotum
19/3	0420	340	SPT	3500	170-180	23° 07'	63° 47'	5,5	11	Lanternfish, B. pterotum
20/3	0400	341	BTR	80	80	25° 00'	64° 04'	157	314	Cownose ray Rhinoptera sp. (57) John's snapper Lutjanus johni (15) Black pomfret Formio niger (14)
20/3	1155	342	SPT	2000	800	24° 32'	63° 16'	3	6	Lanternfish MYCTOPHIDAE 9 spp.
21/3	0855	343	SPT	2300	300	24° 15'	62° 14'	9	18	Lanternfish MYCTOPHIDAE 6 spp.
22/3	1013	344	BTR	24-28	24-28	25° 03'	62° 51'	544	1088	Sting rays Dasyatis spp. (186) Grunt Pomadasys sp. (103), Long-spine seabream Argyrops spinifer (72)
22/3	1420	345	Gillnet	-	-	25° 07'	63° 09'	38,5	-	Sharks Rhizoprionodon sp. (20), Djeddaba crevalle Alepes djeddaba (6)
22/3	1320	346	BTR	85	85	24° 57'	63° 48'	0		
23/3	1420	347	BTR	78	78	24° 57'	63° 48'	185	370	Japanese threadfin bream Nemipterus japonicus (27), Larghead hairtail Trichiurus lepturus (18), Black pomfret Formio niger (16)
24/3	0445	348	BTR	106	106	25° 02'	66° 03'	717	1434	Larghead hairtail Trichiurus lepturus (500), Croaker Megalonibea fusca (66), Orangemouth thryssa Thryssa vitrirostris (21)
24/3	0810	349	BTR	24-27	24-27	25° 15'	66° 23'	3500	3500	Catfish Arius sp. (2180), False trevally Lactarius lactarius (433) Japanese treadfin bream Nemipterus japonicus (428)
24/3	1115	350	SPT	17	17	25° 06'	66° 35'	3500	7000	Grunt Pomadasys sp. (1257) Sardinella Sardinella spp. (1657)
25/3	0830	351	SPT	1200	350	23° 38'	65° 45'	9,4	19	Lanternfish MYCTOPHIDAE 6 spp. (9.3)
26/3	0900	352	SPT	105	80-95	23° 07'	67° 12'	300	600.	Lanternfish Benthosema pterotum (196), Shark Rhizoprionodon sp. (21)
26/3	1825	353	SPT	430	15	23° 18'	67° 16'	75	150	Lanternfish B. pterotum (50)
27/3	0815	354	BTR	68	68	23° 41'	67° 10'	5	10	Spanish mackerel Scomberomorus spp. (5)
27/3	0925	355	BTR	68	68	23° 41'	67° 10'	1000	2000	Larghead hairtail Trichiurus lepturus (346), Ponyfish Leiognathus sp. (170), Japanese threadfin bream Nemipterus japonicus (80)
27/3	1400	356	Traps	25	25	23° 49'	67° 25'	0	-	
28/3	1340	357	SPT	214	130-150	23° 41'	66° 20'	100	240	Lanternfish Benthosema pterotum (100)
28/3	1800	358	SPT	89	20	24° 02'	66° 27'	200	400	Jellyfish (195), Frigate mackerel Auxis thazard (5)
29/3	0015	359	BTR	25	25	24° 17'	67° 01'	55	110	Japanese threadfin bream Nemipterus japonicus (14), John's snapper Lutjanus johni (11), Grunt Pomadasys sp. (11)
29/3	0155	360	SPT	25	5	24° 18'	67° 01'	350	480	Shad Decapterus dayi (129) Anchovy Stolophoons buccaneeri (77), Frigate mackerel Auxis thazard (57)
29/3	1100	361	SPT	20	0-15	24° 40'	66° 53'	40	120	Rainbow sardine Dussumieria acuta (22)
29/3	1555	362	SPT	76	20-40	24° 32'	65° 42'	28	56	Jellyfish (22), Largehead hairtail Trichiurus lepturus (6)
30/3	0100	363	SPT	750	20	24° 44'	66° 02'	30	60	Jellyfish (30)
30/3	0555	364	SPT	400-800	260-310	24° 25'	65° 48'	24	48	Bombay-duck Harpodon sp. (15)
31/3	1755	365	SPT	230	20-40	24° 03'	65° 56'	20	40	Krill (12) Lanternfish Benthosema pterotum (5)

CRUISE 5. R/V "Dr. Fridtjof Nansen". Record of fishing operations. BTR: bottom trawl, LPT: large pelagic trawl, SPT: small pelagic trawl, KT: krill trawl.

Date	Time Start GMT	St no	Gear type	Bottom depth m	Gear depth m	Position North	Position East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
9.4	0730	366	SPT		450	15°53'	58°25'	35	70	Squid (20)
11.4	0555	367	SPT	5000	350	09°45'	52°49'	14	84	Krill Euphausiids (10)
15.4	1555	368	SPT	151	60	02°04'	45°28'	60	120	Round herring Etrumeus teres (56)
15.4	1700	369	BTR	140	140	02°04'	45°30'	30	30	Sea bream Pagellus natalensis (10)
15.4	2110	370	SPT	192	82	02°07'	45°44'	25	50	Round herring Etrumeus teres (18.5)
16.4	0955	371	SPT	16	0	03°08'	46°49'	1	4.5	Various fish larvae (1)
16.4	1615	372	SPT	35	27	03°33'	47°18'	22	44	Various fish larvae (20)
17.4	0325	373	BTR	243	243	04°32'	48°20'	162	324	Drift fishes Ariomma sp. (22), Boarfishes Anitigonia sp. (Smith,49) (57), Round scad Decapterus maruadsi (46), Mackerel Scomber sp. (11)
18.4	0140	374	BTR	338	338	04°58'	48°37'	147	147	Sharks (50), Lantern fishes MYCTOPHIDAE (23) Chlorophthalmus sp. (Smith, 49) (39)
18.4	1945	3755	SPT	337	180	07°06'	49°45'	230	690	Mackerel Scomber sp. (230)
19.4	0500	376	BTR	165	165	07°37'	49°59'	60	120	Sea bream Pagellus natalensis (31.5) Sharks (22.5)
19.4	0650	377	BTR	340	340	07°37'	50°01'	790	632	Mackerel Scomber sp. (28.5), Langusts CRUSTACEA (255)
20.4	0504	378	SPT	500	388	08°47'	50°41'	68	204	Lantern fish MYCTOPHIDAE (68)
20.4	1035	379	BTR	176	176	09°23'	50°56'	9	108	Sea bream Pagellus natalensis (8)
20.4	1150	380	SPT	100	60	09°32'	50°59'	-	-	Planktonic organisms (-)
20.4	2317	381	SPT	120	47	10°42'	51°30'	6000	6000	Porcupine fish Diodon maculifer (2151) Round scad Decapterus maruadsi (1392) Round herring Etrumeus teres (1248)
21.4	0730	382	BTR	80	80	10°59'	51°16'	489	838	Lizardfish Saurida sp. (147.5), Horse mackerel Trachurus sp.(110)
21.4	1125	383	SPT	79	63	11°14'	51°21'	-	-	No catch
21.4	1315	384	BTR	72	72	11°20'	51°18'	625	833	Round herring Etrumeus teres (462)
22.4	0533	385	BTR	40	40	11°12'	51°09'	240	480	Brown marbled grouper Epinephelus fuscoguttatus (61.5), Bluestreak emperor Lethrinus chaerorynchus (41.5), Areolated grouper Epinephelus areolatus (24.5), Ponyfish Leiognatus sp. (22), Striped Karantun, Bamboo Fish Sarpa salpa (Smith, 49) (24), Horse mackerel Trachurus sp. (19)
22.4	0715	386	BTR	69	69	11°14'	51°15'	550	733	Sea bream Pagellus natalensis (335.5)
23.4	0410	387	BTR	71	71	12°13'	51°03'	190	380	Areolated grouper Epinephelus areolatus (190)
25.4	0605	388	BTR	161	161	10°32'	44°13'	1404	2808	Swimming crab Charybdis sp. (841), Catfish Arius sp. (162)
27.4	0915	389	BTR	44	44	12°29'	44°02'	120	240	Goldstripe sardinella Sardinella gibbosa (56), Round scad Decapterus maruadsi (39)
27.4	1355	390	BTR	208	208	12°22'	44°16'	105	315	Lantern fish MYCTOPHIDAE (100)
27.4	1520	391	BTR	68	68	12°26'	44°17'	82	164	Atule mate (38), Round scad Decapterus maruadse (34)
28.4	0310	392	BTR	62	62	12°38'	45°00'	-	-	No catch
28.4	0355	393	BTR	60	60	12°38'	45°00'	126	378	Round scad Decapterus maruadsi (73), Oil sardinella Sardinella longiceps (26)
28.4	0810	394	BTR	17	17	12°56'	45°08'	1022	3066	Orangefin ponyfish Leiognathus bindus (413), Mantis prawn Oratosquilla investigatoris (275), Big eye scad Selar crumenophthalmus (110)
28.4	1120	395	BTR	35	35	13°01'	45°03'	315	1260	Mantis prawn Oratosquilla investigatoris (105), Round scad Decapterus maruadsi (78), Goldstripe sardinella Sardinella gibbosa (67)
3.5	0135	396	SPT	87	40	13°20'	46°26'	220	377	Mantis prawn Oratosquilla investigatoris (69), Swimming crab Charybdis sp.(53), Round scad Decapterus maruadsi (53)
3.5	0945	397	BTR	53	53	13°29'	47°13'	7	14	Mantis prawn Oratosquilla investigatoris (7), Unsuccessful catch.
3.5	1050	398	BTR	50	50	13°29'	47°11'	822	1233	Redspot emperor Lethrinus lentjan (155)
3.5	1320	399	BTR	30	30	13°35'	47°26'	585	1170	Orangefin ponyfish Leiognathus bindus (370)
3.5	2000	400	SPT	38	15	13°55'	47°52'	71	142	Orangefin ponyfish Leiognathus bindus (19), Round scad Decapterus maruadsi (16), Big eye scad Selar crumenophthalmus (15)

CRUISE 5. (cont.))

Date	Time Start GMT	St no	Gear type	Bottom depth m	Gear depth m	Position North	Position East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
4.5	0215	401	SPT	55	38	13°55'	48°27'	0.5	1	Mantis prawn Oratosquilla investigatoris (0.5), Unsuccessful catch.
4.5	0330	402	BTR	70	70	13°56'	48°26'	500	1200	Delagoa threadfin bream Nemipterus delagoae (221), Round scad Decapterus maruadsi (172), Big eye scad Selar crumenophthalmus (51)
4.5	0800	403	BTR	18	18	14°01'	48°40'	1000	2000	Orangefin ponyfish Leiognathus bindus (744)
4.5	1320	404	BTR	47	47	13°56'	47°57'	350	700	Sea bream Pagellus natalensis (102) Orangefin ponyfish Leiognathus bindus (102), Delagoa threadfin bream Nemipterus delagoae (75)
7.5	0210	405	SPT	57	40	14°44'	49°39'	59	708	Orangfin ponyfish Leiognathus bindus (27), Goldstripe sardinella Sardinella gibbosa (17)
7.5	1230	406	BTR	393	393	14°53'	50°45'	600	600	Lobster Puerulus sp. (153)
7.5	1730	407	BTR	96	96	15°01'	51°03'	6000	6000	Horse mackerel Trachurus sp. (4641)
8.5	0500	408	BTR	128	128	15°08'	51°30'	3000	6000	Swimming crab Charybdis sp. (2100), Cardinal fish APOGONIDAE (800)
8.5	0805	409	BTR	46	46	15°19'	51°42'	159	159	Cuttle fish (46), Mantis prawn Oratosquilla investigatoris (27), Largehead hairtail Trichiurus lepturus (26), Threadfin bream Nemipterus sp. (20)
9.5	0322	410	BTR	20	20	15°28'	51°56'	58	174	Sharks (19), Lizardfish SYNODONTIDAE (13)
9.5	0540	411	SPT	65	55	15°25'	52°30'	158	316	Hardtail scad Megalaspis cordyla (100), Djeddaba crevalle Alepes djeddaba (45)
10.5	0215	412	BTR	53	53	16°10'	52°23'	141	188	Swimming crab Charybdis sp. (35), Orangefin ponyfish Leiognathus bindus (24)
10.5	0515	413	SPT	29	3	15°58'	52°18'	138	276	Djeddaba crevalle Alepes djeddaba (68), Pomfret Pampus sp. (27.5), Hardtail scad Megalaspis cordyla (17)
23.5	2230	414	BTR	148	148	17°57'	57°14'	2500	5000	Treadfin bream Nemipterus sp. (2400)
24.5	0520	415	BTR	40	40	18°29'	57°06'	84	168	Cuttlefish (27), Sea bream Pagellus natalensis (12)
24.5	1033	416	BTR	153	153	18°23'	57°30'	5500	11000	Treadfin bream Nemipterus sp. (5400)
24.5	1545	417	KT	42	15	18°52'	57°39'	1	2	Round herring Etrumeus teres (0.5), Various 0-group fish (0.5)
25.5	0120	418	SPT	100	75	19°09'	58°05'	0	0	0-group fish and plankton
25.5	0320	419	KT	750	200	19°11'	58°18'	1500	3000	Lantern fish MYCTOPHIDAE (1500)
25.5	1100	420	BTR	20	20	19°35'	57°51'	8000	16000	Longspine sea breams Arygrops spinifer (1600), Blustreak emperor Lethrinus chaeroynchus (1600), Therapon Therapon sp. (1490)
25.5	1725	421	SPT	24	0	19°51'	58°00'	770	1540	Round herring Etrumeus teres (260), Goldstripe sardinella Sardinella gibbosa (253)
26.5	0840	422	BTR	48	48	20°58'	59°04'	100	335	Treadfin bream Nemipterus sp. (88)
26.5	1415	423	SPT	52	15	21°37'	59°34'	92	276	Spanish mackerel Scomberomorus commerson (50), Rainbow sardine Dussumieria acuta (26)
2.6	0235	424	SPT	31	15	23°36'	67°38'	138	276	Rainbow sardine Dussumieria acuta (32), Mangrove red snapper Lutjanus argentimaculatus (32)
2.6	0835	425	BTR	122	122	23°17'	67°50'	400	600	Treadfin bream Nemipterus sp. (204), Glassy Ambassis commersoni (90)
2.6	1240	426	BTR	131	131	23°19'	66°42'	1000	1714	Round scad Decapterus maruadsi (848)
3.6	0845	427	SPT	162	130	23°30'	66°35'	10000	20000	Lantern fish MYCTOPHIDAE (10000)
3.6	1425	428	SPT	65	22	23°39'	67°09'	22	44	Largehead hairtail Trichiurus lepturus (10.5)
4.6	0128	429	BTR	44	44	24°24'	66°52'	300	600	Largehead hairtail Trichiurus lepturus(100)
8.6	2335	430	BTR	14	14	25°18'	66°22'	250	500	False trevalle Lactarius lactarius (25), Blackmouth croaker Atrobucca nibe (26), Fringescale sardinella Sardinella fimbriata (27.5), Orangemouth thryssa Thryssa vitrirostris (20)
9.6	0600	431	SPT	270	150	24°53'	66°00'	65	195	Lantern fish MYCTOPHIDAE (60)
9.6	1107	432	BTR	20	20	25°11'	65°46'	1490	2980	Largehead hairtail Trichiurus lepturus (563), Giant catfish Arius thalassinus (422)

CRUISE 5. (cont.)

Date	Time Start GMT	St no	Gear type	Bottom depth m	Gear depth m	Position North	Position East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
10.6	0205	433	SPT	640	100	25°03'	64°47'	1000	2000	Lantern fish MYCTOPHIDAE (998)
12.6	0243	434	SPT	550	175	24°57'	63°04'	600	1200	Lantern fish MYCTOPHIDAE (500)
13.6	1455	435	SPT	-	15	23°07'	60°13'	200	400	Cubiceps sp. (197)
13.6	2245	436	SPT	1000	20	22°36'	59°48'	300	600	Lantern fish MYCTOPHIDAE (300)
14.6	0938	437	SPT	900	10	23°30'	58°58'	-	-	Some 0-group fish, Unsuccessful haul.
15.6	1750	438	SPT	740	38	24°46'	61°05'	30	30	Lantern fish MYCTOPHIDAE (17.5), Cubiceps sp. (11)
15.6	1935	439	KT	675	35	24°45'	61°04'	300	300	Lantern fish MYCTOPHIDAE (300)
16.6	0330	440	BTR	27	27	25°15'	60°35'	226	252	Largehead hairtail Trichiurus lepturus (60), Croaker Johnius sp. (77), Lined silver grunt Pomadasys hasta (52), Mangrove red snapper Lutjanus argentimaculatus (70)
17.6	0505	441	SPT	1800	150	24°35'	58°49'	20	35	Lantern fish MYCTOPHIDAE (20)
17.6	1355	442	BTR	63	63	23°52'	58°19'	-	-	No catch
17.6	1450	443	BTR	65	65	23°53'	58°18'	95	190	Longface emperor Lethrinus miniatus (36), Barracuda (23), Round scad Decapterus maruadsi (11.5)
18.6	0040	444	SPT	37	11	24°00'	57°15	-	-	Some fish larvae
19.6	0105	445	BTR	242	242	25°27'	58°03'	3	6	Mixed deep water fishes
19.6	0510	446	BTR	52	52	25°40'	57°27'	41	123	Treadfin bream Nemipterus sp.(14)
20.6	0720	447	SPT	66	38	25°47'	57°15'	800	1600	Anchovy Stolephorus sp. (590)
20.6	1530	448	SPT	205	15	25°00'	56°42'	1500	3000	Lantern fish MYCTOPHIDAE (1300)
20.6	1650	449	KT	210	20	25°01'	56°42'	800	1600	Lantern fish MYCTOPHIDAE (697.5)
20.6	1807	450	KT	200	30	25°04'	56°43'	1500	3000	Lantern fish MYCTOPHIDAE (1300)
20.6	1925	451	SPT	219	30	25°04'	56°43'	500	1000	Lantern fish MYCTOPHIDAE (400).
21.6	1745	452	KT	1450	20	24°47'	57°30'	0.5	1	Squids (0.5)
21.6	1850	453	SPT	1450	20	24°50'	57°27'	2	4	Lantern fish MYCTOPHIDAE (0.5)
22.6	0235	454	BTR	63	63	23°45'	58°23'	3.5	7	No catch
22.6	0555	455	SPT	30	22	23°47'	58°10'	3	6	0-group fish and squids (3)
22.6	0740	456	BTR	24	24	23°48'	58°10'	379	758	Rays and sharks (350)
23.6	0540	457	SPT	60	40	22°32'	55°46'	28	56	Filefish Alutera sp. (20)

CRUISE 6. R/V "Dr. Fridtjof Nansen". Record of fishing operations. PTR: Pelagic trawl, BTR: bottom trawl, BLL: bottom long line, KTR: "Krill trawl", PSE: Purse seine, Fish names: FAO Species Identification Sheets for Fishery Purposes.

Date	Time start GMT	St. no.	Gear type	Bottom depth m	Gear depth m	Position North	Position East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
22.8	1210	458	PTR			23°24'	67°05'	8	15	Jellyfish (5), Cubiceps natalensis (2)
22.8	1740	459	PTR	95	25	23°33'	66°41'	10	20	Champsodon sp. (4), various 0-group fish (4)
23.8	0715	460	BTR	165	165	24°07'	66°10'	0	0	No catch
23.8	1035	461	PTR	83	30	24°25'	66°18'	15	30	Jellyfish(12), Cubiceps natalensis (1).
23.8	1705	462	PTR	110	20	24°44'	66°11'	23	46	Cardinal fish Synagrops japonicus (7), jellyfish (7), lantern fish MYCTOPHIDAE (6).
24.8	1745	463	PTR		25	25°00'	64°44'	20	24	Jellyfish (7), lantern fish MYCTOPHIDAE (6), Bombay-duck Harpadon nehereus (3).
25.8	0910	464	PTR	2100	325	23°42'	63°54'	16	16	Lantern fish MYCTOPHIDAE (8), swimming crab Charybdis sp. (5).
26.8	0900	465	PTR		290	22°07'	62°00'	28	28	Squids (18.5), swimming crab Charybdis sp. (6).
27.8	0735	466	PTR	880	260	22°39'	59°53'	68	58	Lantern fish MYCTOPHIDAE (50), squids (13), Cubiceps natalensis (2), swimming crab Charybdis sp. (2).
28.8	0640	467	BTR	15	15	24°56'	61°33'	143	96	Smallhead hairtail Lepturacanthus savala (40), tiger-toothed croaker Otolithes ruber (36), silver pomfret Pampus argenteus (20), giant catfish Arius thalassinus (11.5).
28.8	1008	468	BTR		13	24°58'	61°31'	1000	1000	Giant catfish Arius thalassinus (350), Indian pikeconger Congresox talabanoides (150), tiger toothed croaker Otolithes ruber (123).
29.8	0653	469	PTR	1200	300	24°49'	61°57'	1004	1004	Lantern fish MYCTOPHIDAE (1000).
30.8	0405	470	BTR	24	24	24°59'	64°13'	1660	1107	Rays (700), croaker Johnieops sp. (0-gr.), (380), smallhead hairtail Lepturacanthus savala (250), croaker Johnius sp. (160), mangrove redsnapper Lutjanus argentimaculatus (100), lined silver grunt Pomadasys hasta (90).
30.8	0930	471	PT		280	24°54'	63°59'	24	24	Lantern fish MYCTOPHIDAE (20), Bombay-duck Harpadon nephereus (4).
31.8	1810	472	PT	900	40	22°50'	59°21'	27	54	Lantern fish MYCTOPHIDAE (25).
1.9	0555	473	BTR	36	36	23°40'	58°21'	2	2	Jelly fish (2).
2.9	0446	474	PTR	500	275	25°05'	59°32'	8	15	Lantern fish MYCTOPHIDAE (7).
2.9	0810	475	BTR	32	32	25°19'	59°40'	390	780	Spotted sicklefish Drepane punctata (156), dog shark Scoliodon palasorrah (116), catfish Arius sp. (45).
2.9	1235	476	PTR		325	24°59'	59°55'	8	8	Lantern fish MYCTOPHIDAE (3), Nemichtyes scolopacea (3), Bombay-duck Harpadon nehereus (1.3).
3.9	0743	477	BTR	56	56	24°12'	60°34'	700	700	Japanese threadfin bream Nemipterus japonicus (650).
4.9	0350	478	PTR	340	325	24°00'	58°02'	14	17	Lantern fish MYCTOPHIDAE (8), squids (4), frigate mackerel Auxis thazard (1.4).
4.9	1342	479	BTR	40	40	24°04'	57°16'	150	300	Japanese threadfin bream Nemipterus japonicus (46), brush-tooth lizardfish Saurida undosquamis (23), Malabar cavalla Carangoides malabarius (23).
5.9	0600	480	PTR	240	155	25°00'	56°43'	74	148	Lantern fish MYCTOPHIDAE (70), swimming crab Charybdis sp. (4).
5.9	0835	481	BTR	275	275	25°06'	56°50'	1500	1500	Tiger-toothed croaker Otolithes ruber (1035), cardinal fish Apagon sp. (305).
5.9	1345	482	PTR	300	250	25°28'	57°08'	34	68	Lantern fish MYCTOPHIDAE (30), smallhead hairtail Lepturacanthus savala (2), jellyfish (2).
6.9	0345	483	BTR	30	30	25°30'	58°05'	335	670	Dog shark Scoliodon palasorrah (300), ray Rhinoplera gavanice (15).
6.9	0640	484	BTR	290	290	25°12'	58°10'	1500	3600	Tiger-toothed croaker Otolithes ruber (570) seapearch, Ambassis sp (570), Bleekers threadfin bream Nemipterus bleekeri (116), squids (52).

CRUISE 6. (cont.)

Date	Time start GMT	St no	Gear type	Bottom depth m	Gear depth m	Position North	Position East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
7.9	0930	485	BTR	68	68	25°23'	56°26'	120	240	Dog shark Scoliodon palasorrah (30), Malabar cavalla Carangoides malabaricus (28), longspine seabream Argyrops spinifer (19), palefinned threadfin bream Nemipterus marginatus (11), aerolated grouper Epinephelus aerolatus (11).
13.9	1000	486	BTR	30	30	26°08'	57°08'	1800	3600	Orangefin ponyfish Leignathus bindus (750), brush tooth lizardfish Saurida undosquamis (210), Bloch's gizzard-shad Nematalosa nasus (145), Indian pellona Pellona ditchella (130).
20.9	1130	487	PTR	70	20	21°23'	59°27'	300	600	Jellyfish (300).
21.9	0625	488	PTR	30	28	20°02'	58°25'	370	1110	Round herring Etrumeus teres (260), white sardinella Sardinella albella (48), longnose cavalla Carangoides crysophrys (17), narrow-barred Spanish mackerel. Scomberomorus commerson (13).
21.9	1505	489	BTR	16	16	19°49'	57°53'	645	1290	Rainbow sardine Dussumieria acuta (376), spotted catfish Arius maculatus (200), gold-stripe sardinella Sardinella gibbosa (24), dog shark Scoliodon palasorrah (19).
21.9	1800	490	BTR	19	19	19°35'	57°52'	64	128	Bluefish Pomatomus saltator (54), Djeddaba crevalle Alepes djeddaba (3), yellowstripe trevally Selaroides leptolepis (3).
22.9	2335	491	PTR	30	30	19°29'	58°21'	70	168	Mantis prawn Oratosquilla investigatoris (60), Bombay-duck Harpadon nehereus (6), swimming crab Charybdis sp. (3).
22.9	0720	492	PTR	900	200	19°10'	58°20'	57	86	Lantern fish MYCTOPHIDAE (50), mantis prawn Oratosquilla investigatoris (2), swimming crab Charybdis sp. (2).
23.9	0025	493	PTR	40	15	18°38'	57°14'	240	576	Bregmacereos macclellandi (216), spotted catfish Arius maculatus (15), jellyfish (8).
23.9	1513	494	PTR	70	60	17°45'	56°48'	80	160	Bregmaceros macclellandi (40), swimming crab Gharybdis sp. (40).
24.9	1705	495	PTR	50	50	15°57'	56°44'	1500	1517	Mantis prawn Oratosquilla investigatoris (1500).
25.9	1220	496	PTR	320	310	16°45'	55°43'	536	800	Salps (500), lantern fish MYCTOPHIDAE (10), swimming crab Charybdis sp. (10), hatchet fish Argyropelecus sp. (15), mantis prawn Oratosquilla investigatoris (5).
26.9	1030	497	BTR	38	38	16°54'	54°05'	83	83	Cuttlefish (71), cardinal seabream Euyinnis cardinalis (10).
26.9	1530	498	PTR	2500	0	15°44'	53°54'	45	90	Salps (30), krill Euphaciacea (10).
27.9	1655	499	PTR	2400	0	13°39'	53°02'	50	100	Lantern fish MYCTOPHIDAE (29), swimming crab Charybdis sp. (17).
28.9	1115	500	PTR	35	10	16°07'	52°19'	27	53	Djeddaba crevalle Alepes djeddaba (9), angel fish Platax piunatus (8), snubnose pompano Trachinotus blochii (5).
28.9	1215	501	BTR	29	29	16°05'	52°19'	0	0	No catch.
28.9	1730	502	PTR	500	10	16°17'	52°40'	200	400	Mantis prawn Oratosquilla investigatoris (140), Palinurichthys sp. (51).
28.9	2320	503	BTR	275	275	16°15'	52°38'	2000	18000	Slime head Hoplostethus mediterraneus (9245), Laemonema globiceps (1080), Palinurichthys pingeli (620) greeneye Chloropthalmus sp (290).
29.9	2240	504	PTR	57	10	16°11'	52°24'	168	250	Bregmaceros macclellandi (62), Indian oil sardinella Sardinella longiceps (38), anchovy Engraulis sp. (24).
29.9	0725	505	PTR	44	15	15°33'	52°09'	1000	1000	Jellyfish (1000).
29.9	1305	506	BTR	115	115	15°18'	51°58'	1050	1050	Bully Gobius sp. (741), seapearch Ambassis sp. (268).
30.9	0040	507	PTR	44	10	15°18'	51°36'	6	12	Bregmaceros sp. (5).

CRUISE 6. (cont.)

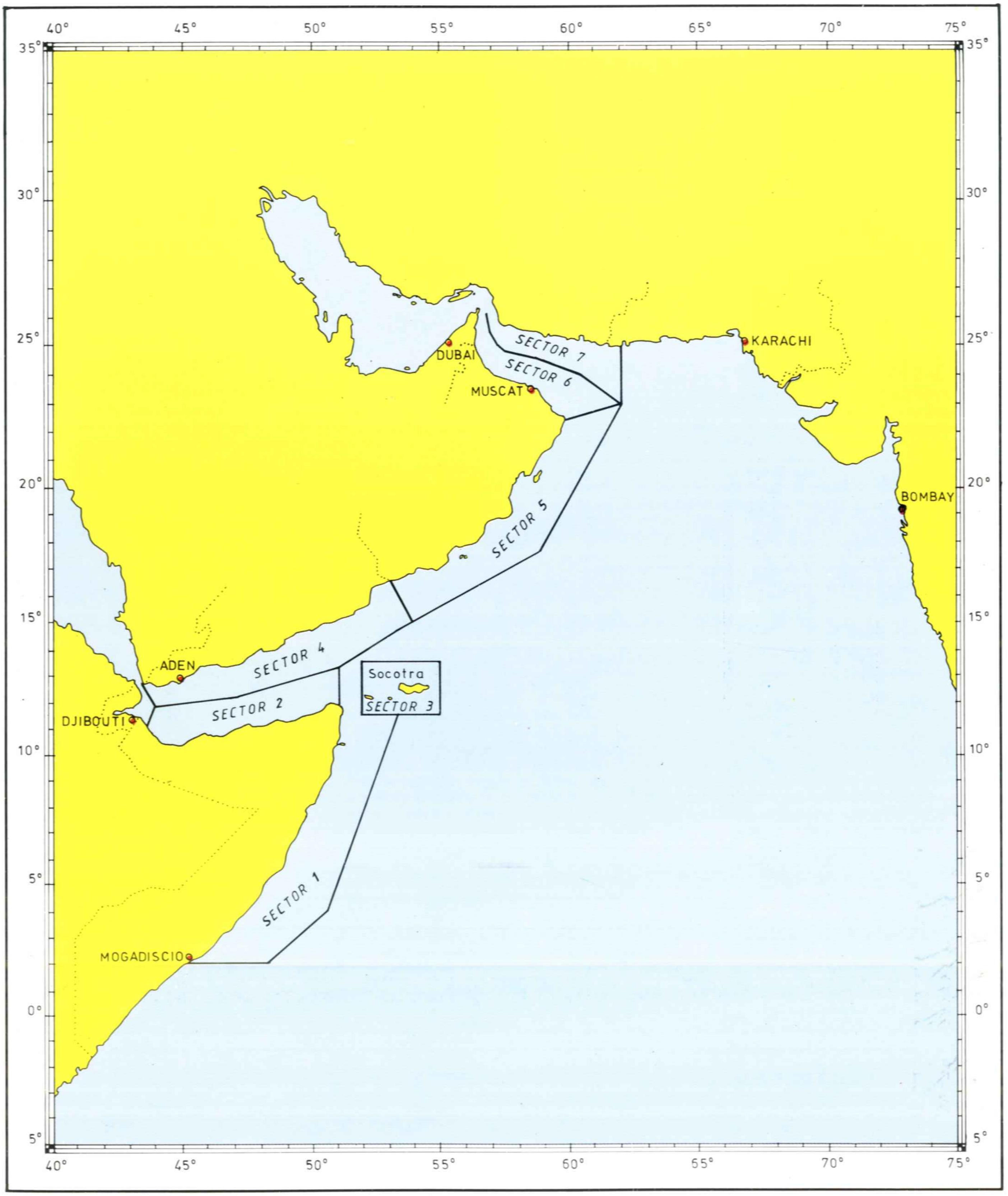
Date	Time start GMT	St no	Gear type	Bottom depth m	Gear depth m	Position North	Position East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
30.9	0425	508	BTR	265	265	14°59'	51°31'	1000	2000	Palinurichthys sp. (370), Bathyclupea (270), Nemichthyes scolopacea (117), Slime head Hoplostethus mediterraneus (75), Laemonema globiceps (70), shrimp Parapenaeus sp. (27), Bombay-duck Harpadon nehereus (24).
30.9	1648	509	BTR	20	20	15°02'	50°40'	26	51	Obtuse barracuda Sphyraena obtusata (8), cuttlefish (6), gurnard Lepidotrigla natalensis (4), dog shark Scoliodon palasorrah (3), yellowstripe trevally Selaroides leptolepis (2).
1.10	0728	510	BTR	47	47	14°24'	49°01'	430	760	Bream Pagellus natalensis (356), Japanese threadfin bream Nemipterus japonicus (30), horse mackerel Trachurus sp. (21), boarfish Histiopterus spinifer (18).
1.10	1155	511	PTR	100	15	14°02'	48°45'	0	0	No catch.
1.10	1655	512	BTR	32	32	13°58'	48°31'	740	1480	Bream Pagellus natalensis (678), Japanese threadfin bream Nemipterus japonicus (62)
2.10	0100	513	PTR	839	15	13°41'	47°45'	4	8	Cubiceps natalensis (1), squid (1), lantern fish MYCTOPHIDAE (0,5), krill Euphasiacea (0,5).
2.10	0406	514	BTR	15	15	13°40'	47°30'	0	0	No catch.
3.10	1145	515	BTR	280	280	13°11'	46°17'	960	1920	Brushtooth lizardfish Saurida undosquamis (783), stinggray Dasyatis sp. (73), lobster Puerulus sp. (24), shrimp (18), squid (18).
7.10	2315	516	BTR	26	26	13°05'	45°30'	130	260	Stingray Dasyatis sp. (60), bigeye scad Selar crumenophthalmus (16), Japanese threadfin bream Nemipterus japonicus (13), Indian oil sardinella Sardinella longiceps (11).
8.10	2220	517	PTR	375	15	13°51'	48°04'	29	58	Swimming crab Charybdis sp. (22), squid (5), Bigeye scad Selar crumenophthalmus (1).
9.10	1120	518	PTR	583	250	14°02'	48°54'	4	6	Swimming crab Charybdis sp. (2.5), lantern fish MYCTOPHIDAE (0.5).
9.10	1827	519	PTR	500	15	13°46'	47°59'	3	3	Salps (2), swimming crab Charybdis sp. (1).
10.10	2125	520	BTR	32	32	11°25'	49°29'	170	340	Slender ponyfish Leiognathus elongatus (80), longface emperor Lethrinus miniatus (35), snappers Lutjanus spp. (5 spec.)(28), painted sweetlip Plectorhynchus pictus (10).
11.10	1215	521	PTR	50	15	11°56'	51°04'	11	23	Narrow-barred Spanish mackerel Scomberomorus commerson (11).
11.10	1315	522	BTR	47	47	11°56'	51°04'	1	2	John Dory Zeus japonicus (1).
12.10	0615	523	PTR	880	290	12°17'	51°44'	32	42	Lantern fish MYCTOPHIDAE (30).
12.10	1710	524	PTR	2200	15	12°02'	50°02'	54	108	Salps (30), lantern fish MYCTOPHIDAE (20).
13.10	0842	525	BTR	295	295	11°11'	47°49'	144	288	Shrimps (60), lobster Puerulus sp. Bathyclupea sp. (25), greeneye Chlorophthalmus sp. (8).
13.10	1930	526	PTR		20	11°01'	46°54'	120	160	Palinurichthys sp. (86), cardinal fish Synagrops japonicus (27).
14.10	0702	527	PTR	500	15	10°52'	45°39'	2	4	Swimming crab Charybdis sp. (1), jellyfish (1).
14.10	1840	528	PTR	500	15	10°26'	44°24'	44	59	Lantern fish MYCTOPHIDAE (19), Palinurichthys sp. (10).
15.10	1400	529	BTR	285	-	12°20'	44°00'	0	0	No catch.
15.10	1700	530	BTR	21	21	12°35'	44°10'	54	107	Delagoa threadfin bream Nemipterus delagoae (16), Cuttlefish (12), toby Arathron stellatus (4), ponyfish Leiognathus sp. (3).

CRUISE 6. (cont.)

Date	Time start GMT	St no	Gear type	Bottom depth m	Gear depth m	Position North	East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
15.10	1824	531	BTR	23	23	12°35'	44°10'	141	282	Duck bill skate Stoasodon narinari (105), Delagoa threadfin bream Nemipterus delagoae (7), catfish Arius sp.(6) Banded barracuda Sphyraena jello (5)
16.10	0815	532	BTR	62	55	12°32'	44°40'	0	0	No catch.
16.10	1120	533	PTR	58	45	12°33'	44°46'	10	14	Jellyfish (10).
16.10	1300	534	PTR	55	40	12°34'	44°41'	39	62	Yellowstripe trevally Selaroides leptolepis (28), jellyfish (10).
16.10	1500	535	BLL	25	25	12°41'	44°43'	6	-	Catfish Arius sp. (4), shark (2).
18.10	0540	536	BTR	39	39	11°17'	43°38'	25	50	Slender ponyfish Leiognathus elongatus (10), bluestreak emperor Lethrinus choerorynchus (3), Orangefin ponyfish Leiognathus bindus (3).
18.10	1140	537	PTR	175	25	11°41'	43°28'	3	3	Various 0-group fish (2.5).
18.10	1425	538	PTR	360	30	11°46'	43°40'	8	10	Palinurichthys sp. (3.5), cardinal fish Synagrops japonicus (2.0), swimming crab Charybdis sp. (2).
18.10	2125	539	PTR	400	-	12°14'	43°50'	412	825	Palinurichthys sp. (365), cardinal fish Synagrops japonicus (23).
25.10	0713	540	PTR	2600	-	12°57'	51°58'	6	8	MYCTOPHIDAE, STERNOPTYCHIDAE and STOMIATIDAE (4).
25.10	1415	541	BTR	34	34	12°42'	53°52'	2427	2913	Longface emperor Lethrinus miniatus (1214), sponges (300), surgeonfish Acanthurus strigosus (155), mangrove red snapper Lutjanus argentimaculatus (102), orange-spotted emperor Lethrinus kallopterus (92).
26.10	1400	542	BTR	33	33	12°00'	53°13'	1716	3430	Sponges (1500), blacksaddle goatfish Parupeneus fraterculus (44), grouper Epinephelus sp. (36).
26.10	1830	543	BTR	120	120	11°40'	52°57'	10000	20000	Lantern fish MYCTOPHIDAE (9562), PARALEPIPIDAE (418).
27.10	1010	544	PTR	82	65	11°40'	51°37'	5	10	Swimming crab Charybdis sp. (3).
27.10	1545	545	PTR	76	30	11°35'	51°29'	27	55	Round herring Etrumeus teres (27).
28.10	0615	546	BTR	70	70	11°18'	51°21'	0	0	No catch.
28.10	0930	547	PSE	52	-	11°31'	51°18'	0	0	No catch
28.10	1215	548	PSE	50		11°31'	51°18'	15	-	Diamond ray Mobula diabolus (15) (1 no.).
28.10	1550	549	PTR	58	25	11°13'	51°13'	41	83	Round herring Etrumeus teres (37), Obtuse barracuda Sphyraena obtusata (1.5) Indian oil sardinella Sardinella longiceps (1).
28.10	2230	550	BTR	32	32	10°47'	51°13'	13	32	Round scad Decapterus maruadsi (8), horse mackerel Trachurus sp. (2).
29.10	1430	551	PTR	67	45	10°02'	51°14'	1	2	Squid (0.5), porcupine fish Diodon maculifer (0.3).
29.10	1535	552	BTR	68	68	10°00'	51°14'	8	15	Red bigeye Priacanthus macracanthus (2.5), sand-shark Rhinobates sehlegeli (2).
30.10	1025	553	BTR	35	35	08°51'	50°30'	475	950	Teixeirichthys mossambicus (190), sponges (100), bream Pagellus natalensis (85).
31.10	1430	554	PTR	36	-	08°23'	50°22'	180	360	Anchovy Engraulis sp. (100), mantis prawn Oratosquilla investigatoris (59), short-head anchovy Stolephorus heterolobus (10), round herring Etrumeus teres (9).
1.11	1343	555	PTR	150	90	08°03'	50°15'	5000	60000	Mantis prawn Oratosquilla investigatoris (3500), swimming crab Charybdis sp. (1500).
1.11	1730	556	BTR	27	27	08°00'	49°57'	1186	2372	Great barracuda Sphyraena barracuda (193), painted sweetlip Plectorhynchus pictur (157), bream Pagellus natalensis (137), slender goldband goatfish Mulloidichthys flavolineatus (101).

CRUISE 6. (cont.)

Date	Time start GMT	St no	Gear type	Bottom depth m	Gear depth m	Position North	East	Total catch kg	Catch per hour kg	Dominant species (total catch, kg)
1.11	2213	557	PTR	190	-	07°47'	50°05'	22	442	Krill Euphacacea (10), mantis prawn Oratosquilla investigatoris (6), swimming crab Charybdis sp. (4).
2.11	0825	558	BTR	39	39	07°16'	49°38'	71	122	Red stumpnose Chrysoblephus gibbiceps (40), narrow-barred Spanish mackerel Scomberomorus commerson (24).
3.11	1150	559	BTR	39	39	05°30'	48°42'	155	310	Emperor red snapper Lutjanus sebae (48), sponges (40), triggerfish Sufflamen capistratus (8), squid (8), grouper Epinephelus sp. (8).
4.11	1150	560	PTR	2500	900	04°09'	49°04'	5	5	Meso- and bathypelagic fish species (4).
11.11	1350	561	PTR	220	170	00°47'	42°21'	0	0	No catch.
14.11	1600	562	KTR	251	35	03°17'	47°07'	9	17	Krill Euphacacea (5), squid (3).
15.11	0533	563	BTR	18	18	03°25'	47°03'	34	67	Areolated grouper Epinephelus areolatus (17), narrow-barred Spanish mackerel Scomberomorus commerson (8), painted sweetlip Plectorhynchus pictus (7).
15.11	1305	564	BTR	19	19	03°48'	47°29'	427	854	Sponges (300), areolated grouper Epinephelus areolatus (57), blacksaddle goatfish Parapeneus fraterculus (11), painted sweetlip Plectorhynchus pictus (10), emperor Lethrinus sp. (9).
15.11	1735	565	BTR	36	36	03°55'	47°40'	57	114	Stary triggerfish Abalisted stellaris (16), bream Pagellus natalensis (10), emperor red snapper Lutjanus sebae (7), round herring Etrumeus teres (5).
21.11	0828	566	BTR	61	61	02°20'	41°05'	125	416	Snapper Lutjanus sp. (55), parrot fish Callyodon sp. (30), scavenger Lethrinus nebulosus (15).
21.11	1300	567	BTR			02°29'	41°00'	0	0	No catch.
22.11	1310	568	BTR	160	160	02°38'	40°48'	2	5	Squid (0.5), mantis prawn Oratosquilla investogatoris (0.5), swimming crab Charybdis sp. (0.5).
22.11	1620	569	BTR	60	60	02°44'	40°33'	863	5178	Sponges (600), humpnose large-eye-bream Monotaxis grandoculis (65), ray (40), mantis prawn Oratosquilla investigatoris (35), redspot emperor Lethrinus lentjan (19), blacksaddle goatfish Parapeneus fraterculus (18), bigeye snapper Lutjanus lineolatus (17).
23.11	0540	570	BTR	235	235	02°57'	40°23'	57	171	Brush-tooth lizard fish Saurida undosquamis (17), lobster Puerulus sp. (9), prawn (9), smallhead hairtail Lepturacanthus savala (6), Neocyttus (rhomboidalis ?) (4).



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