intergovernmental oceanographic commission

information paper 8

UNESCO/NS/10C/INF-62

FOREWORD

The International Oceanographic Commission met for its Third Session in Paris at Unesco Headquarters, from 10 to 19 June 1964. The International Indian Ocean Expedition was one of the important topics on the Agenda of this Session. The Commission approved the report of the International Co-ordination Group Meeting as of January 1964 and authorized the secretary to take immediate action thereon.

Two ad hoc Working Groups were formed by the Commission to discuss (a) general problems of IIOE co-ordination and (b) the fisheries aspects of the Expedition. The first ad hoc group devoted considerable time to the problem of preparing atlases on the basis of IIOE results. It was felt that since ship operations of the IIOE would terminate by the end of 1965, there would be no real need to continue co-ordination of ship operations after this date but the new and important function of the Co-ordination Group will be to guide data exchange and publication of data reports and atlases. It was suggested, therefore, that the next meeting of the International Co-ordination Group be held sometime around the autumn of 1965 prior to the Fourth IOC Session. The ad hoc group on Fisheries Aspects of the IIOE discussed at length the report of the Fisheries Subject Leader, Dr. D.N.F. Hall, and came to a number of recommendations. Both ad hoc groups produced draft resolutions summarizing their recommendations which were subsequently adopted by the Commission. The more complete report on the IOC Session, as well as texts of these two resolutions, will appear in the next issue of the IIOE Information Paper.

unesco

Unesco Office of Oceanography
Paris, July 1964

IIOE INFORMATION PAPER
No. 8

1. Exchange of Information

1.1 National Reports and Newsletter

(1) Ceylon. The Newsletter of the Ceylon Association for the Advancement of Science, of which the first issue appeared in May 1963, contains a section entitled International Indian Ocean Expedition. The contents are generally national and foreign IIOE activities which are of particular interest to the country, and they are not reproduced here since they have already been announced in previous issues.

(2) Japan. The IIOE Newsletter of Japan No.5 was published, in March 1964, and distributed by the IIOE Data Centre of Japan. It contains the cruise summary of Japanese vessels which participated in the Expedition during October 1963 to February 1964. Following are extracts of the cruises' summaries:

KAGOSHIMA-MARU

(i) Itinerary (see Annex VIII, Station maps)

Port of Call	Arrival	Departure	Observations
Kagoshima		Nov. 8, 1963	
Penang	Nov. 18	Nov. 23	86°E;78°E, north of 6°S
Colombo	Dec. 19	Dec. 24	78°E, south of 6°S L.L. fishing
Penang	Jan. 31,1964	Feb. 3	
Kagoshima	Feb. 15		

(ii) Scientific Work

Hydrographic cast:	To the depth of 4,000m. at 33 stations, 6 stations were occupied twice.
BT observations:	At the hydrographic stations and two between the neighbouring stations, 77 in total, with surface sampling.
Current measurements:	a) At 10,20,50,100,150,200,300 and 400m. layers with 800m. layer as reference. b) GEK measurements at south of 8°S.
Chemical analysis:	Dissolved oxygen, phosphate, silicate, nitrite, nitrate, pH, zinc, cadmium and nicotinic acid.
Biology:	a) IOS-net; 200-0m., vertical haul at all stations b) Juday net; divided vertical haul (200-0, 500-200, 1000-500 and 2000-1000) at 11 stations. c) Larva-net; surface horizontal haul at 11 stations. d) Middle layer trawl net; at 11 stations. e) High-speed sampler; at all stations.
Productivity:	a) ^{14}C technique; tank experiment at all stations, in situ experiments at 13 stations. b) Chlorophyll measurement; at 11 stations. Continuous recording of the solar radiation; at all stations.

Bathymetry:	Continuous recording.
Geology:	a) Core sampling with piston corer; at 11 stations. b) Dredging; twice off the Cape Comorin.
Meteorology:	a) Surface observation; every two hours, with continuous surface water-temperature recording. b) Air-sea interaction; wind observation at 1,2,4, 8,10m. above the sea level; humidity at 0.5, 1, 2,4,8,10m. above the sea level; sea salt nuclei at 1,2,4,8m. above the sea level.
Experimental fishing:	Tuna fishing at 12 stations.
Eye observations:	Birds, animals and other phenomena.

KOYO MARU

(i) Itinerary

Port of Call	Arrival	Departure	Observations
Shimonoseki		Oct. 25, 1963	
Tokyo	Oct. 27	Nov. 6	
Hong Kong	Nov. 12	Nov. 15	
Penang	Dec. 5	Dec. 8	
Djakarta	Dec. 25	Dec. 29	
Fremantle	Jan. 14, 1964	Jan. 18	
Singapore	Feb. 2	Feb. 7	
Shimonoseki	Feb. 18		

(ii) Lines and stations of observation

Oceanographic stations: 21 stations in total.
Along 94°E, from 8°N to 13°S, 13 stations
Along 100°E, from 12°30'S to 21°30'S, 7 stations
1 reference station at 32°S, 111°50'E
Fisheries stations: 12 stations

(iii) Scientific work

Hydrographic cast:	Down to 5000m.
BT observations:	At the station and in between stations; 70 stations.
Surface sampling and temperature:	One hour intervals underway.
Current measurements:	a) 10,50,100,120,200,400 and 600m. layers with 800m. layer as reference; 12 stations. b) GEK at station south of 5°S.
Chemical analysis:	Cl, O_2, pH, Si, total-P. NO_3 at the station of productivity study.
Biology:	a) IOS-net (night-haul) at 21 stations. b) Divided hauling from 3000m., with 80cm. net, at 11 stations (5 layers). c) Middle layer trawl hauling at 13 stations. d) Oblique haulings with 160cm. ring net at 22 stations. e) High speed hauling at 21 stations.
Productivity:	a) Photo-synthesis and chlorophyll measurements at 24 stations.

b) ^{14}C enriched measurements at 9 stations. Continuous recording of solar radiation at all stations; no underwater radiance measurements but a transparency was measured.

Bacteriology: a) Sampling of water at 11 stations.
b) Bottom sampling at 3 stations.

Bathymetry: Continuous recording.

Meteorology: a) Surface observation; 6 hourly.
b) Aerological observation; daily (at 12Z)

	Number	Mean Altitude	Maximum Altitude
Radio-sonde	30	20,201m.	27,230m.
Pilot-balloon	30	4,744	11,710

Experimental fishing: Tuna fishing with hydrographic cast down to 100m., IOS-net hauling; 12 stations.

OSHORO MARU

(i) Itinerary (see Annex VIII, Station maps)

Port of Call	Arrival	Departure	Remarks
Hakodate		Nov. 11, 1963	
Maizuru	Nov. 13	Nov. 15	
Nagasaki	Nov. 17	Nov. 20	
Bangkok	Nov. 29	Dec. 4	
Singapore	Dec. 7	Dec. 10)	- occupied 31 stations
Port Darwin	Jan. 9, 1964	Jan. 13)	
Kobe	Jan. 27	Jan. 30	
Tokyo	Feb. 1	Feb. 4	
Hakodate	Feb. 6		

(ii) Scientific work

Hydrographic cast:
a) Down to 1500m.; at 14 stations.
b) To the shallow bottom on the trawl grounds; at 17 stations.

Biology:
a) IOS-net hauls (200-0m.); at 14 stations.
b) Horizontal hauls in 5 - 7 layer between 0 to 3000m.; at 7 stations.
c) Larva net surface haul; at 14 stations.
d) Surface haul with high-speed plankton sampler (at night); at 14 stations.
e) Microplankton sampling from several depths; at 12 stations.
f) D.S.L. observations and plankton net haul; at 16 stations.

Productivity:
a) In situ experiments; at 6 stations.
b) Tank experiments; at 19 stations.
c) Chlorophyll-a measurements; at 12 stations.
d) Underwater light intensity measurements; at 21 stations.

Experimental fishing:
a) Tuna long-line cast; at 13 stations.
b) Trawling; at 17 stations (20 trawlings).

UMITAKA MARU

(i) Itinerary (See Annex VIII, Station maps).

Port of Call	Arrival	Departure	Observations
Tokyo		Oct. 30, 1963	
Darwin	Nov. 15	Nov. 18	Along 120°E, 5 stations Tuna long-line, 5 stations
Broom	Nov. 28	Nov. 30	Along 112°E, 7 stations
Geraldtown	Dec. 13	Dec. 17	Coring, dredging and one hydrographic station
Fremantle	Dec. 27	Jan. 2, 1964	Along 105°E and 100°E, 13 stations; coring, trawling.
Penang	Jan. 27	Jan. 31	
Tokyo	Feb. 17		

(ii) Scientific work

Hydrographic cast:	At 27 stations.
BT observations:	-
Current measurements:	a) Oceanic current observed with both GEK and Ekman-Merz Currentmeter. b) 100-200 drift bottles were liberated at noon in each station except 4 stations (Nos. 5,6, 13 and 28).
Chemical analysis:	pH, dissolved oxygen, phosphate, nitrate and silicate.
Biology:	a) IOS-net vertical hauling (200-0m.); at 28 stations. b) Larva net and "Umitaka's large square net" hauls for macroplankton; at 29 stations, 89 hauls in total.
Productivity:	a) ^{14}C in situ and tank experiments. b) Underwater radiant illumination were measured by chemical method as well as photovoltaic cell. Continuous recording of solar radiation with Robitzsch's actinometer was carried out.
Bathymetry:	Continuous recording.
Marine geophysics and geology:	a) Continuous recording of earth's magnetism (with towed proton magnetometer) and gravity (with shipborne gravimeter - Tokyo University Surface Ship Gravimeter) throughout the whole course. b) Core-sampling with piston corer; at 7 stations. c) Dredging at 23 stations.
Meteorology:	Three hourly synoptic observations.
Experimental fishing:	a) Long-line fishing at 10 stations. b) Trawling at 2 localities; 14 casts.
Eye-observations:	Current-rip, floatages, discoloured water, accumulation of plankton, megaplankton, squid, fish and fish-shoals, marine animals, turtles, birds, fishing boats and gears. Meteorological phenomena.

During the cruise, a new sea mount was discovered on January 7, 1964, in the vicinity of 22°12'S and 104°40'E, below a minimum depth of 1,923 meters. The diameter covering the area of less than 2,000 meters is about 13 nautical miles. The sea mount was tentatively named "Zenith Sea Mount".

(3) United Kingdom. The Royal Society has published a report entitled "INTERNATIONAL INDIAN OCEAN EXPEDITION, RRS DISCOVERY. CRUISE 2 REPORT; Geology and Geophysics in N.W. Indian Ocean, 23 August to 4 December 1963". The report compiled by Dr. M. N. Hill and the note on geological work in the Sychelles prepared by Dr. D. H. Matthews. (See IIOE Information Paper No.6, p.13, 4.3 Cruise Summary (3) United Kingdom and p.22, 4.4 Report of Fieldwork.)

1.2 Cruise Reports

(1) Australia

H.M.A.S. GASCOYNE

Summary of the H.M.A.S. GASCOYNE Cruise G 1/64 has been received from the Australian National Coordinator. Following is an extract of this summary and a station map appears in Annex VIII; for details of the programme, please refer to 1.3 Cruise Plan of this issue.

Scientific Personnel

B. Hamon (Cruise Leader)
F. Davies
K. Fleming

Itinerary

13/1/64	0830	Departed Sydney
24/1/64	0830	Arrived Sydney
28/1/64	1145	Departed Sydney
6/2/64	1730	Arrived Hobart

Programme - Stations

80 stations	G1/1/64 - G1/80/64	
	bathythermograms	at 79 stations
	surface sampling	at 29 stations
	subsurface hydrology	at 51 stations
	GEK zero check	at 75 stations

(2) U.S.A.

R/V ANTON BRUUN

The News Bulletin, Nos. 4, 5 and 6 of U.S. PROGRAM IN BIOLOGY, INTERNATIONAL INDIAN OCEAN EXPEDITION have been received from the Woods Hole Oceanographic Institution, which contains narrative reports of R/V ANTON BRUUN Cruises 3, 4-A and 4-B. Following is an abstract of these reports:

R/V ANTON BRUUN, CRUISE III

I. Objectives

The primary purpose of Cruise III was to sample the deep-sea ichthyofauna in the western Indian Ocean, and to relate the distribution of species and biomass to the physicochemical and biological properties of the water masses sampled on a north-south transect. Midwater trawling stations were occupied at approximately 3-degree intervals from 12°N to 13°S and from 23°S to 44°S along the 60°E meridian.

II. Itinerary (See Annex VIII, Station maps)

Bombay to Mauritius (Aug. 8 - Sept. 3, 1963)
Occupied 9 stations along 60°E from 12°N to 12°S (approx.)

Mauritius to Mauritius (Sept. 3 - Sept. 20, 1963)
Occupied 8 stations along 60°E from 23°S to 44°S (approx.)

III. Scientific programme

Hydrographic cast: at 17 stations down to 2,000m. except one station (st. 151, at 5°03'S, 60°10'E) where observations were extended to 4,000m. Measurements and determination at each depth include temperature, salinity, dissolved oxygen, phosphate, nitrite, nitrate and silicate.

BT cast: at the stations and at intervals of one hour between stations.

Primary production: at 16 stations, water was sampled from depths corresponding to 100, 50, 25, 10 and 1% penetration, by ^{14}C technique both with 24 hours exposure in a simulated in situ incubator on deck and 4 hours in an artificially illuminated incubator at 1,000 foot-candles.

Plankton samples: a) IOS-net hauling 200-0m., at 16 stations.
b) Zooplankton samples with Bé net, at 11 stations (125-0m., 250-125m, 500-250m, 1000-500m and 2000-1000m.)
c) Surface and oblique zooplankton hauls with 1 meter diameter No. 0 mesh net were taken on 11 occasions at night.

Midwater trawling: a total of 28 midwater trawl hauls were taken at 17 stations with the 10' Isaacs-Kidd midwater trawl.

Submarine light penetration and bathyluninescence: sunlight penetration to the depths as great as 800m. and of bioluminescence as great as 3400m. with photomultiplier-type photometer at 9 stations during the first section of the cruise, and at all standard stations during the second section.

Marine yeast studies: at hydrographic stations with sterile water sampler.

R/V ANTON BRUUN, CRUISE IV-A

I. Objectives

The Cruise IV of the ANTON BRUUN was planned as a three month multi-disciplinary exploration of the Arabian Sea during the fall of 1963, but because of the highly diversified programme envisioned, the cruise was split into two sections, IV-A and IV-B, both to work in the same general but with different objectives, scientific programmes and personnel.

Cruise IV-A was planned for the basic biological programme of hydrography, chemistry and plankton biology with extra sampling time provided for additional work in chemistry and microbiology.

II. Itinerary (See Annex VIII, Station maps)

Port of Call	Arrival	Departure
Port Louis, Mauritius		Sept. 25, 1963
Port Victoria, Seychelles	Oct. 1	Oct. 4
Aden	Oct. 10	Oct. 12
Karachi	Oct. 24	Oct. 28
Bombay	Nov. 8	

III. Scientific programme

Hydrography: at 40 stations; for 20 stations between Mauritius and Aden, down to 2000m. and for the other 20 stations in the Arabian Sea observations were extended to the bottom. Temperature, salinity, dissolved oxygen, phosphate, nitrite, nitrate and silicate were measured at all stations.

Primary productivity and pigments: a) primary production measurements were made at all stations with the similar techniques as in Cruise III.

b) pigment determinations were made for two-litre portions of the same samples used for productivity determinations. Extra samples from 125, 200 and 300 meters respectively were obtained for pigments determination on Stations 164-175.

c) at Stations 176-200, three additional depths were sampled between the surface and bottom of euphotic zone for both pigments and primary productivity.

Chemistry: determinations for the following substances were made:- particulate and dissolved carbon (348 and 500 samples respectively); particulate phosphorus (from the same samples as for particulate carbon); dissolved and particulate iron (approx. 600 determinations); dissolved molybdenum at selected stations in the Arabian Sea; particulate and dissolved organic nitrogen for 276 samples from 34 stations.

Studies of Nitrogen Cycle: at 18 stations in the Arabian Sea with ^{15}N tagged nitrogen compounds.

Enrichment experiments: on 10 occasions in deep oceanic water away from the influence of land.

Plankton sampling: a) IOS-net; at all stations, vertical hauls of 200-0m.

b) vertical 200m-surface tows with a fine-mesh (No.25) plankton net, at Stations 161-163; at five stations in the Arabian Sea horizontal tows with small (No.20) mesh nets spaced 10m. from the surface to 40 or 50 meters were made.

c) oblique plankton sampling with Bé net at 19 stations, depth intervals are similar as in Cruise III; at other stations oblique hauls with two nets (No.0 and No.3 meshes) were made.

VI. Some Preliminary Results:

The completion of certain analyses, both on shipboard and at the Woods Hole Oceanographic Institution, permit the presentation at this time of some preliminary results and conclusions which are believed to be of general interest, particularly to those individuals who will be working in the Arabian Sea during the latter stages of the IIOE.

A. Hydrography, chemistry and primary productivity

Hydrographic and bathythermographic sections normal to the Arabian Coast made by DISCOVERY in July, 1963, showed an upward tilting of isotherms and phosphorus isopleths towards shore, with phosphate values as high as 2.0 µgA/l in the coastal waters. This is typical of a coastal upwelling situation and could be expected in that region during the summer, Southwest monsoon. Similar sections made in the same general area by the ANTON BRUUN in October-November, after the monsoon had ceased, revealed no evidence of upwelling. This can be seen from the three sections running from the coast seaward consisting of Stations 190-185, 193-190 and 175-180. In none of the three sections do the isopleths tilt up in a shoreward direction as was observed in July.

From the set of the ship between stations and the drift while on station, it was obvious that a rather strong southerly flowing current was flowing out of the Gulf of Oman and along the Arabian coast. On the other hand, the drift was northeasterly at the stations occupied at the seaward end of the above mentioned sections, indicative of a clockwise gyre in the central part of the Arabian Sea. Presumably it is the front between these currents, some 150-200 miles from shore, that can be seen at Stations 186, 198, and most impressively at 179. On the shoreward side of this front the isopleths for temperature, phosphate and oxygen bulge or dome upward, typical of an area of divergence. For example, water at 15°C, which lies at a depth of approximately 200m. on either side of the front, rises to nearly 100m. at the front itself.

The nutrients which were brought up into the euphotic zone by the divergence gave rise to extremely high rates of primary productivity. The resulting phytoplankton populations apparently spread in a southwesterly direction, for the entire area between shore and the divergence was characterized by dense blooms of the bluegreen alga Trichodesmium, the dinoflagellate Noctoluca, and several species of diatoms, notably of the genera Rhizosolenia, Chaetoceros and Skeletonema. These blooms were often patchy and highly localized, but the entire area was extremely rich and fertile in contrast to the clear water east of the current front.

It could also be argued that the dense phytoplankton populations encountered in these coastal waters were the end result of the earlier upwelling. However, it seems doubtful that unnourished populations could persist for very long, and the strong thermal stratification and nutrient impoverishment of the surface coastal waters do not suggest any recent instability. Whatever the cause, the levels of primary productivity in the general region were uniformly high and included values at two stations of 5.6 and 6.8g. carbon assimilated/m^2/day, considerably higher than ever before reported for the open sea.

The physical and chemical characteristics of the water in the central Arabian Sea are of interest for several reasons. A sharp thermocline was present at about 50m. below which the concentrations of nutrients (phosphate, nitrate, silicate) increased sharply. At depths of 1000-1500m. concentrations were measured of >3.0 µgA/l PO_4-P and >40 µgA/l NO_3-N, values which approach the highest levels known for these substances in any ocean. Silicate, too, reached exceptionally high concentrations (>160 µgA/l) but increased steadily to the bottom rather than passing through a maximum at mid-depths as did phosphate and nitrate.

Accompanying and undoubtedly directly correlated with the sharp increase in nutrients with depth was a rapid decrease in dissolved oxygen concentrations to less than 1.0 ml/l at 100m. and to less than 0.1 ml/l at mid-depths of 500-1000m. at some stations. Although the concentrations increased again below 1000m. they never approached saturation in the bottom waters.

It is noteworthy that no anoxic water was observed anywhere on the cruise and that hydrogen sulfide could not be detected analytically or by odor in the samples which contained low (<0.1 ml/l) concentrations of oxygen. This is in contrast to the situation reported by the Vityaz during their cruise in the same area in November, 1960 (Ivanorenkov and Rozanov, Okeanologia 1:443, 1961).

The presence of such unusually high levels of nutrients and low oxygen concentrations at or in close proximity to the base of the euphotic zone (50-75m. for most stations) is indicative of a situation which is potentially both highly productive and biologically unstable. Any process, such as the divergence described above, which causes even a slight degree of vertical transport may be expected to result in greatly enhanced biological productivity. By the same token, sinking and decomposition of the organic matter so produced in water already low in oxygen could be expected periodically to create anaerobic conditions. Subsequent mixing of this anoxic water to the surface could easily lead to mass fish mortalities. While the latter situation was not actually encountered during Cruise IV-A, it is not difficult to reconstruct the history of such phenomena which apparently are well known in the Arabian Sea.

B. The distribution of dissolved and particulate organic carbon

Dissolved carbon decreased from 1 gram/m^3 or more at the surface to about one third of that amount in deep water. Particulate carbon values were about one tenth those for the dissolved fraction and were also highest at the surface. These figures are typical of the values observed throughout the Arabian Sea.

Using the mean concentration of 1.0 mg/m^3 of chorophyll a in the 50 meter euphotic zone at Station 196 and assuming a carbon : chlorophyll ratio of 50 : 1 in the phytoplankton, it may be calculated that living carbon (excluding animals) constitute about one third of the total particulate matter in these surface waters, a negligible portion of the total in the water below this.

The total amounts of dissolved and particulate carbon integrated over a one-meter-square column of water from surface to bottom at Station 196 are 1275 and 123 grams respectively. When this is compared to the estimated standing crop of living phytoplankton within the same water column at the same station (some 2.5 grams of carbon) it is obvious that the latter is negligible compared to the vast reservoir of dead and dissolved organic matter in the sea.

No apparent correlation was observed between the concentration of dissolved organic carbon and the rate of primary production. The latter varied by two orders of magnitude in the Arabian Sea while dissolved carbon varied by only about three fold. This fact suggests that the dissolved carbon is not an immediate by-product of phytoplankton growth. Confirmation for this is the presence of appreciable quantities of dissolved carbon in the deep water. Finally, significant variations in the concentrations of dissolved organic carbon in the deeper water may be correlated with the different water masses in the Arabian Sea, as distinguished by temperature-salinity characteristics. The preceding evidence leads to the conclusion that dissolved organic carbon in the ocean is extremely stable and refractory to decomposition, and may be considered one of the more conservative properties of seawater.

R/V ANTON BRUUN, CRUISE IV-B

I. Objectives

The major objectives of the cruise was to study the distribution, relative abundance and taxonomy of the benthic fauna on the continental shelf and upper continental slope in the Arabian Sea. Other interests represented in the scientific party included fish parasite, biochemistry of invertebrates, meteorological phenomena and radiological properties of sediments and selected fishes and invertebrates.

II. Itinerary (See Annex VIII, Station maps)

Port of Call	Arrival	Departure
Bombay		Nov. 12, 1963
Karachi	Nov. 23	Nov. 26
Karachi	Dec. 10	

III. Scientific programme

The bottom sampling programme was carried out primarily with a Gulf of Mexico shrimp trawl measuring 42 feet along the footrope (86 occasions in total). Additional samples were obtained by means of a biological dredge on 17 occasions. A few collections were made by means of set-line (one occasion), hand-line (one occasion), dip net (one occasion), under night lights (three occasions) and at one shore station. Trolling efforts were also made usually during the daylight hour while running between stations and surface plankton samples of 15 to 20 minutes duration were taken at 17 stations.

No standard series of hydrographic observation was carried out because of the intensive hydrographic study in the region on Cruise IV-A; at each station, however, temperature and salinity at the surface and the bottom, and dissolved oxygen at the bottom were measured. Mr. J. R. Naidu, a guest investigator from the Indian Atomic Energy Commission made surface and bottom phosphate determinations. Bathythermograph lowerings were made at all trawl stations and between stations at intervals of 3 hours.

IV. Preliminary Results:

A. Trawling - A total of 16,000 pounds of fish, 209 pounds of shrimp and 1,840 pounds of swimming crabs (Portunidae) were caught in the 86 trawl hauls made during the cruise. Approximately 80 families of fishes were represented in the trawl catches. A major feature of the cruise was the large concentration of fishes and swimming crabs encountered off Muscat and Oman, Arabia, where one 30-minute haul yielded 5,600 pounds of fish and a 45-minute haul yielded 1,700 pounds of fish and 1,800 pounds of swimming crabs. These catch rates were exceedingly high for the relatively small trawl use in the survey.

Another highlight of the cruise was the rich hauls of shells brought up in the shrimp trawl in the Gulf of Oman; one 5-minute haul in 45 fathoms yielded 200 pounds of shells. One of the hauls contained a live adult, 4 fully-grown dead specimens, and about 12 juveniles of strombus listeri Gray. On Cruise I of the ANTON BRUUN shells of immature specimens had been found in dredge hauls made in the Bay of Bengal. Only five specimens have previously been reported in the literature and these were found at Ceylon, and off Burma nearly 70 years ago. Other exciting shells were the dozens of rare bivalves of the genus Clementia (family Veneridae) and the nearly 400 live species of Tibia delicatula Nevill taken in the Gulf of Oman.

B. Dredging - Of the 17 dredge hauls made during the cruise, 2 were made off northwest India, 7 off West Pakistan, 7 in the Gulf of Oman, and 1 off Muscat and Oman.

C. Trolling - Surface trolling during daylight hours between stations yielded 48 fish consisting of 35 tunas, 12 dolphins (Coryphaenidae) and 1 wahoo (Acacanthosibum solandri). Tentative identifications of 31 of the 35 tunas caught indicated that 26 were skipjack and 5 were yellowfin. Most of the tunas were small, averaging about 3 pounds in weight with the largest weighing approximately 10 pounds. Highest tuna catch rates were obtained offshore from Karachi, West Pakistan. Almost without exception the tunas were caught at the edge of the continental shelf or over the slope just beyond the edge of the continental shelf.

D. Handline, Setline and Pot Fishing - Handlining was conducted three times during the cruise: twice on Angria Bank southwest of Bombay and once near Astola Island west of Karachi. No fish were caught at the two handline stations on Angria Bank. The handline station near Astola Island yielded 5 Balistidae, 2 Lutjanidae, 14 Serranidae, 2 Sparidae and 20 Carangidae.

Six crab and shrimp pots and a string of bottom setline gear containing 100 hooks were set in 12 fathoms of water near Astola Island. Nothing was caught in the pots while the string of setline gear yielded three relatively large Lethrinidae weighing from 4 to 5 pounds each.

E. Plankton - Of the 17 plankton hauls made, one sample taken off northwest India provided about 16 pounds of material which appeared to consist mainly of ostracods. Three small sea snakes were also taken in the plankton net.

F. Shore Collecting - Rotenone was used to obtain intertidal collections of fishes and invertebrates on the west end of Astola Island, West Pakistan on November 27, 1963. These collections included several species not taken in the shrimp trawl.

G. Miscellaneous - An excellent series of colored slides was made of most of the species of fish and many of the invertebrates collected on the cruise. The photographs were taken of freshly-caught specimens and thus portray their natural coloration.

1.3 Cruise Plans

The following cruise plans have been received from national coordinators:-

H.M.A.S. DIAMANTINA, CRUISE 1/64

Date: 28/I-6/II/64 and 14-18/II/64

Objective: To study the distribution and growth of late larval stages of the Western Australian crayfish (Panulisus cygnes)

To sample sediments on the continental shelf.

To examine the hydrological conditions of water masses on, and adjacent to the continental shelf.

Area and Stations: (see Annex IX, Scheduled IIOE Tracks)

Twelve traverses across the continental shelf between North-West Cape and Cape Naturalist.

Itinerary:	Depart Fremantle	January 28
	Arrive Fremantle	February 6
	Depart Fremantle	February 14
	Arrive Fremantle	February 18

Scientific programme:

Hydrology: sampling to a maximum depth of 500m. for temperature, salinity, oxygen and inorganic phosphate.
Biology: IOS-net haul, 200-0m; oblique tow by midwater trawl 200-0m, duplicate series of horizontal hauls by Isaacs-Kidd trawl and Japanese larval net for comparison.
Bottom photography, dredge and beam trawl in 13C-150m.
Sediment sampling: on the shelf by Petersen grab.
Scientists: R.G.Chittleborough (Cruise Leader), J.Prothero, L.Thomas, J.Betjeman.

H.M.A.S. DIAMANTINA, CRUISE 2/64

Date: 24/III-24/IV/64

Objectives: To study in detail the hydrographic structure in the equatorial region along the 92° and 95°E meridian and to examine suggestions based on recent studies in the region of the development of an Indian Ocean under-current.

Area and stations: (see Annex IX, Scheduled IIOE Tracks)
From Fremantle to Ref. St.1, then to the 95°E meridian and to Prai
From Prai to the 92°E meridian and to Fremantle.

Itinerary:	Depart Fremantle	March 24, 1964
	Arrive Prai	April 7
	Depart Prai	April 10
	Arrive Fremantle	April 24

Scientific programme:
Hydrography:
Reference Station: to the bottom, for temperature, salinity, oxygen, nitrate, inorganic phosphate, particulate phosphate and total phosphorus.
Position Stations (X): as above, but particulate phosphate and total phosphorus on about half of these.
Position Stations (O): to 1,500m. for temperature, salinity, oxygen, nitrate and inorganic phosphate.
Planktology: IOS-net hauls, (200-0m.) at the Ref. St. and Position Stations (X).

Scientists: D. Rochford (Cruise Leader), F. Davies, N. Dyson, J. Prothero.

H.M.A.S. GASCOYNE, CRUISE 1/64

Date: 13/I-20/II/64

Objective: To study the physical and chemical structure of the water in the East Australian Current System.

To compare two different techniques for collecting samples for the determination of carbon.

To test a temperature-salinity-depth (T.S.D.) recorder.

Area and stations: (see Annex IX, Scheduled IIOE Tracks)
At Reference Station (34°S, 153°20'E in 5000m.) and Position Stations and at Periodic Stations.

Itinerary:	Depart Sydney	January 13
	Arrive Sydney	January 25
	Depart Sydney	January 28
	Arrive Hobart	February 7
	Depart Hobart	February 14
	Arrive Adelaide	February 20

Scientific programme:
Hydrography:
Reference Station: to the bottom for temperature, salinity, oxygen nitrate, inorganic and total phosphate. Sampling for particulate carbon.
Position Stations (X): to 2,500m. as above except total phosphate.
Position Stations (O): surface salinity

Physics:
  Reference Station: T.S.D., B.T. and GEK zero check
  Position Station (X): as above
  Position Station (O): B.T. and GEK zero check
The GEK will be towed continuously while underway.

Scientists: B. Hamon (Cruise Leader), R. Blick, F. Davies, K. Fleming, P. Lockwood.

H.M.A.S. GASCOYNE, CRUISE 2/64

Date: 21-29/II/64

Objective: To examine the chemical and physical environment during the South Australian tuna season.

Area and stations: (see Annex IX, Scheduled IIOE Tracks)
From Adelaide through Investigator Strait to the continental shelf and adjacent areas off Cape Catastrophe, Investigator Islands and Spencer Shelf.

Itinerary:	Depart Adelaide	February 21, 1964
	Arrive Port Lincoln	February 27
	Depart Port Lincoln	February 29

Scientific programme:
  Hydrology: to the bottom or 2,500m. for temperature, salinity, oxygen, and inorganic phosphate.
  Echo-sounding: continuous.
  Meteorology: at the station.

Scientists: D. Vaux (Cruise Leader), R. Bradley, L. Olsen.

H.M.A.S. GASCOYNE, CRUISE 3/64

Date: 5-23/III/64

Most of this cruise was planned to be worked off the east coast of Australia; a few stations were to be occupied from Adelaide to Hobart. The following work was planned at the position stations in the Indian Ocean (see Annex IX, Scheduled IIOE Tracks)

Hydrography: to the bottom, for temperature, salinity, oxygen, nitrate and inorganic phosphate. Total phosphorus and particulate phosphate at selected layers.
T.S.D. recorder lowering.
BT cast to 274m.
GEK zero check.

Itinerary:	Depart Adelaide	March 5, 1964
	Arrive Hobart	March 9
	Depart Hobart	March 11
	Arrive Sydney	March 23

Germany

R. V. METEOR (October 1964 - April 1965)

The plans of German participation in IIOE, which have been received from the National Coordinator through the German Permanent Delegate to Unesco, is attached in Annex I of this issue.

South Africa

S.A.S. NATAL

Four cruises of S.A.S. NATAL are planned in 1964, scheduled tracks are shown in Annex IX, Scheduled IIOE Tracks.

August

Depart Simonstown — August 10, 1964
Hydrographic observations at Stations Nos. 1 - 12, along the lines No. 1 and 300° to Durban
Arrive Durban — August 17
Depart Durban — August 18
Hydrographic observations at Stations Nos. 13 - 24, along lines Nos. 3 and 4.
Arrive Port Elizabeth — August 22
Depart Port Elizabeth — August 23
Hydrographic observations at Stations Nos. 25 - 36, along lines Nos. 5 and 6.
Arrive Simonstown — August 28

September

Depart Simonstown — September 7, 1964
Arrive Durban — September 10 (Embarkation of scientists and equipment)
Depart Durban — September 11
Current measurements along lines Nos. 1, 2, and 3; observations at 28 stations. These lines will be occupied twice.
Arrive Durban — September 24 (Disembarkation of scientists and equipment)
Depart Durban — September 25
Arrive Simonstown — September 28

October

Depart Simonstown — October 5, 1964
Arrive Durban — October 8 (Embarkation of scientists and equipment)
Depart Durban — October 8
Observations at 14 stations, with midwater trawling at 9 stations, scoop netting, current measurements and additional investigation near Watter's Shoal.
Arrive Durban — October 22
Depart Durban — October 26
Arrive Simonstown — October 28

November

Depart Simonstown	November 9, 1964
Hydrographic observations at Stations Nos. 1 - 12 along lines 1 and 2.	
Arrive Durban	November 16
Depart Durban	November 17
Hydrographic observations at Stations Nos. 13 - 24 along lines 3 and 4.	
Arrive Port Elizabeth	November 21
Depart Port Elizabeth	November 22
Hydrographic observations at Stations Nos. 25 - 36 along lines 5 and 6.	
Arrive Simonstown	November 27

1.4 Other Information

South Africa

Information relating to items on the agenda of the IIOE Coordination Meeting (see IIOE Inf. Pap. No.6) has been received from the Secretary, Coordinating Committee for Oceanographic Research, South Africa; an extract is reproduced below:

"1. National Reference Stations

I attach, for your information, a further copy of the list of the national oceanographic reference stations established by our Co-ordinating Committee for Oceanographic Research, together with a list of the observations and disciplines to be carried out at each of these stations."

"3. Exchange of Data : World Data Centre

All the data obtained during the various South African IIOE cruises have been forwarded to Mr. William L. Molo of World Data Centre A, with the exception of the data obtained during Cruise 8 of S.A.S. NATAL and the August, 1962, cruise of the QUEEN. These will be forwarded as soon as they come to hand.

"4. Bathymetric Plotting Sheets

I have been informed by the South African Naval Hydrographer that bathymetric plotting sheets (1:1,000,000) from 18°S to 50°S and from 0° to 55°E will be available by the end of June.

"5. IIOE Inter-ship Radio Communications

I have been informed by our Naval Hydrographer that the following frequencies have been allocated for use by S.A.S. NATAL during the four cruises planned for August - November, 1964:

South Africa S.A.S. NATAL (Naval Vessel) Call sign Z.S.R.L.

Calling frequencies:	4185 Kc/s
	8370 Kc/s
	12,555 Kc/s
Group B working frequencies:	4213 Kc/s
	8426 Kc/s
	12,639 Kc/s

The Officer Commanding has been informed of the proposal and will maintain the schedule as proposed.

"Regarding AFRICANA II, the Director of Sea Fisheries has indicated that no special steps will be taken in regard to inter-ship radio communications as their active participation in the IIOE has virtually come to an end. For your information, AFRICANA II (25VK) can only operate on R/T on frequencies 1650, 1700, 2182, 2203, 2607, 2730, 4137.5, 6276, 8275 and 12552 Kc/s."

STANDARD OBSERVATIONS MADE AT NATIONAL OCEANOGRAPHIC REFERENCE STATIONS.

National Oceanographic Reference Stations have been established at the following positions:-

STATION	LATITUDE	LONGITUDE	DEPTH
S.A. 1	30° 00' S	31° 24' E	1000 M
S.A. 2	35° 06' S	26° 25' E	5000 M
S.A. 3	36° 13' S	22° 55' E	1500 M
S.A. 4	37° 54' S	20° 20' E	4700 M

2. At the above Reference Stations the following observations and disciplines are carried out:-

(a) Temperature) at 0, 20, 50, 75, 100, 150, 200, 300
(b) Salinity) 400, 500, 600, 800, 1000, 1200
(c) Oxygen) 1500, 2000, 2500, 3000, 4000 metres
(d) Total and Inorganic Phosphates at 100, 500, 1000, 1500, 2000, 3000 and 4000 M.
(e) Marine Biological Vertical sampling nets (Indian Ocean Standard Net) 50 - 0, 100 - 50, 250 - 100, 500 - 250, 750 - 500, 1000 - 750, 1500 - 1000 metres.
(f) Phyto-plankton net sample N 50 V 100 - 0 metres or Water Samples for Phyto-plankton cell counts at 0, 20, 50, 75, 100 & 150 M.
(g) Primary Productivity Water Samples at light intensity levels of 1%, 10% and 100%.
(h) Bathythermograph Cast to depth of instrument used preferably 300 metres.
(i) Standard Meteorological Observations.

2. Exchange of Data

From copy of correspondence between WDC-A and national coordinators, we have learned the following time-tables for the despatch of IIOE data to the World Data Centre. Further information from national coordinators or responsible institutes relating to data exchange is highly welcome.

Australia

CRUISE	CRUISE REPORT No.	PROVISIONAL DATA	FINAL REPORT
Dm2/61	9		Published 1963
Dm3/61	11	June, 1964	1965
G3/61	12	June, 1964	1965
G1/62	13	June, 1964	1965

CRUISE	CRUISE REPORT No.	PROVISIONAL DATA	FINAL REPORT
Dm1/62	14	June, 1964	1965
Dm2/62	15	June, 1964	1965
G4/62	17	August, 1964	1965
Dm3/62	18	August, 1964	1965
Dm4/62	20	July, 1964	1965
G1/63	21	September, 1964	1965
Dm1/63	23	September, 1964	1965
Dm2/63	24	September, 1964	1965
Dm3/63	25	September, 1964	1965
Dm4/63	27	1965	1966
Dm5/63	28	1965	1966
Dm6/63	30	1965	1966
Dm1/64	33	1965	1966
Dm2/64	36	1965	1966
Dm3/64	37	1965	1966

France

Data from cruises of COMMANDANT ROBERT GIRAUD are expected to be sent by December 1964 at the latest.

South Africa

R.S. AFRICANA II Cruise 251	June 7 - July 20, 1961
R.S. AFRICANA II Cruise 263	June 15 - July 14, 1962
R.S. AFRICANA II Cruise 273	April 2 - 20, 1963
S.A.S. NATAL Cruise 1	April 2 - 24, 1962
S.A.S. NATAL Cruise 2	May 7 - 24, 1962
S.A.S. NATAL Cruise 3	June 4 - 22, 1962
S.A.S. NATAL Cruise 4	July 2 - 24, 1962
S.A.S. NATAL Cruise 5	August 6 - 30, 1962
S.A.S. NATAL Cruise 6	October 1 - 22, 1962
S.A.S. NATAL Cruise 7	January 7 - 29, 1963

Physical and chemical data of above cruises have been received by the World Data Centre A.

3. Meteorological Observations

An extract from "INTERNATIONAL INDIAN OCEAN EXPEDITION, METEOROLOGY PROGRAMME, News from the Scientific Director's Office", No. 10; April 1964:

"The research aircraft have returned to the United States after a highly successful operation. Many of their flights were coordinated with the University of Washington air-sea interaction study. The first meteorological rocket in the IIOE/IQSY programme was successfully launched, while satellite picture reception and rectification is now routine at IMC.

RESEARCH AIRCRAFT

The three aircraft of the U.S. Weather Bureau (RFF) and the Woods Hole Oceanographic Institution flew during their visit a total of 50 scientific missions lasting 370 hours. Besides the flights reported previously, disturbed weather over the southern Arabian Sea was investigated between 19 and 22 February while weather along and just off the Arabian coast came under scrutiny on 9 March when the RFF was homeward bound. Many flights were made in support of the University of Washington's air-sea interaction study and to investigate the Indian sea breeze.

In addition to the cooperative data gathering already mentioned, the Woods Hole programme included three special projects.

Mr. A. F. Bunker is studying the turbulent exchange of heat, water vapour, and momentum; the radiative flux; the cloud and the rainfall distribution; and the kinetic and thermal structure of the atmosphere, in order to determine the energy budget and understand interactions between the Indian Ocean and the overlying air. The necessary data were obtained from instruments on the aircraft measuring the turbulent flux and short- and long-wave radiation, from cameras recording cloud distribution and radarscope presentation of precipitation and from dropsondes released at frequent intervals.

Dr. K. Rooth, interested in maritime shower formation, measured the load of salt particles in air samples taken during the flights. Fluctuations apparently associated with the sea breeze circulation lend support to the hope that salt distribution may usefully reveal details of some small-scale atmospheric motions. Dr. Rooth has also been investigating the potential of tritium as an atmospheric tracer. He froze the water out of numerous samples, which will be analysed for tritium at the International Meteorological Institute in Stockholm.

Dr. W. Bischof, of the International Meteorological Institute in Stockholm collected numerous air samples which were then analysed for carbon dioxide content at the Tata Institute for Fundamental Research, Bombay. Dr. Bischof's project is part of a world-wide survey of the large-scale horizontal and vertical variations in atmospheric CO_2. There is some evidence of seasonal and latitudinal variations and that the Indian sea breeze affects distribution. Flight crews of Air India have collected samples in the course of regular flights between Bombay and Aden.

AIR-SEA INTERACTION

When the University of Washington's MENTOR buoy was towed back to Bombay on 10 March, 150 hours of continuous recordings had been made at stations varying from 40 to 180 miles west of Bombay. In addition, by making an excellent series of pilot balloon soundings the officers of the tug-tender OCEAAN materially contributed to the sea-breeze study. Data from MENTOR, and the research aircraft are now being analysed at the University of Washington.

The University of Michigan project, reported in News No.4 is obtaining data from installations aboard ANTON BRUUN, ATLANTIS II, TE VEGA and CHAIN and at Bombay, Port Blair, Fort Dauphin, Mauritius, Mahe and Christmas Island.

METEOROLOGICAL ROCKET PROGRAMME

On 18 March, the Pakistan Space and Upper Atmosphere Research Committee's Sonmiami Range (25°09'N; 65°50'E) successfully launched the first rocket in the programme, obtaining wind data 20 to 54 km above the earth.

LOW LATITUDE STRATOSPHERIC WINDS

Additional meteorological services collaborating in Dr. Belmont's Programme (see News No.9) include Rhodesia (Broken Hill), Sudan (Khartoum and Malakal), Australia (Cocos and Honiara) and Indonesia (Djakarta).

INTERNATIONAL METEOROLOGICAL CENTRE

Staff

Mr. H. K. Soo of the University of Michigan returned to the United States on 21 February. Dr. Colon will be leaving Bombay for Miami on 15 April.

In transferring my base of operations back to the University of Hawaii, I shall be leaving Bombay on 13 April. However, for several months more, my office in IMC will handle routine data questions.

The APT continues to function satisfactorily. On an average, one orbit daily, within range of Bombay, provides pictures. These are then rectified and used to aid analysis and to facilitate preparation of weather inferences distributed from IMC to other branches of the India Meteorological Department.

The computer is being increasingly applied to data processing now that many more programmes have been checked out. 180,000 cards, comprising radiosonde, upper wind and ship data have been punched.

On 13 and 14 March eight IMC meteorologists presented four papers relating to turbulence and supersonic flights at the annual meeting of the Indian Aeronautical Society.

METEOROLOGICAL ATLASES FOR IIOE

A majority of the nine comments so far received urge that charts for levels above 200 mb be included in the upper air atlas. This can certainly be done for 100 mb; the rather scanty data for higher levels might well be tabulated.

4. Indian Ocean Biological Centre

Report of the activity at the I.O.B.C. Ernakulam-6, India*

On March 1, 1964, a total of 1079 samples had been received of which 304 were taken with other nets than the IOSN. 249 samples have been sorted. Only the position of 957 samples are plotted as the positions of 123 samples are not yet available. The non-plotted samples do not however fill in the gaps in the following 3 areas where no, or only a few samples, were taken.

1. South of 40°S Lat. from 20°E to 150°E.
2. 10°S to 40°S and 80°E to 105°E.
3. 5°S to 40°S and 40°E to 55°E.

Area 3 will to a certain degree be covered in the future by South African and USA Expeditions.

However, every effort should be made when expeditions are operating in the areas mentioned to collect zooplankton with the IOS Net.

*Footnote: This report had to be attached to the map showing distribution of plankton samples received by the Centre (IIOE Inf. Paper No.7).

In order to facilitate the work at the I.O.B.C., expeditions and institutes dispatching samples to the Curator, are requested to send two copies of a list of station numbers and number of samples. One list should accompany the samples, the other together with another list of positions of stations or a chart of station positions should be mailed to the Curator. When time of operation is given please inform what time is used (G.M.T., local time, etc.)

5. National Coordinators

Japan	Prof. Michitaka Uda	Tokyo University of Fisheries, Shiba Kaigandori, Minato-ku, Tokyo, Japan.

6. Publications

6.1 Collected Reprints

The Office of Oceanography, UNESCO, has received to date about 100 copies of reprints of scientific papers relating to the International Indian Ocean Expeditions, with copy-right clearance, for inclusion in Collected Reprints. The two first volumes of the IIOE Collected Reprints have been compiled by the Office and are at present being submitted for printing. A list of reprints related to marine physics, chemistry, geophysics and geochemistry which will make up the first volume is given in Annex X.

6.2 Other publications

(1) Bathymetric and Magnetic Results obtained on passage. RRS DISCOVERY, Cruise 2, August-November 1963.

A mimeographed copy of the above has been prepared by the Department of Geodesy and Geophysics, Cambridge University, under the signature of Dr. D. H. Matthews. An ozalid copy of the profiles is attached to this mimeographed copy.

(2) Oceanus, Vol.X, No.3, March 1964, published by The Woods Hole Oceanographic Institution (not for sale)

The above issue of this widely distributed quarterly is particularly devoted to the IIOE, with the emblem of the Expedition on the front cover. Following are articles and features particularly relating to the Expedition:

Articles

With "ATLANTIS II" to the Indian Ocean, by A. R. Miller
The Indian Ocean Bubble, by P. Tchernia
With "DISCOVERY" in the Indian Ocean, by G.E.R. Deacon
New Submarine Canyons Found off the Indian Coast, by E.C. LaFond
A Rocky Puzzle, by C. Bowin

Features

The International Indian Ocean Expedition
How It Started
U.S. Biological Programs
Miscellaneous Notes

(3) The National Science Foundation of U.S.A. has released a news-sheet on the IIOE Biological Programme of the U.S.A., entitled "Scientist Believes Mass Fish Deaths due to Asphyxiation". The whole text of this release is reproduced in Annex III.

7. The List of IIOE Cruises

7.1 The Meeting of the International Coordinating Group for the International Indian Ocean Expedition, which was held 22-24 January 1964 in Paris, has requested the Secretariat to prepare a list of IIOE Cruises, to be sent to National Coordinators for reviewing and clearance. This has been done and the list thus established and corrected is attached as Annex II of this Information Paper No.8.

7.2. The track charts

The track charts of recently completed cruises, with the positions of stations are attached as Annex VIII, and scheduled ones as Annex IX. The IIOE Coordinating Meeting requested the Secretariat to devise a simple code which might be used in track charts. These codes are shown in Annex VII.

8. Miscellaneous

8.1 List of Scientists - Marine-geology, Marine-geophysics and Bathymetry for the Indian Ocean

Following the recommendation of the International Coordination Group, Dr. R. L. Fisher has prepared a list of persons participating in, working up materials from, or otherwise directly interested in the geological-geophysical-bathymetric investigations carried out by IIOE. A hectographed copy of this list has already been distributed among the national coordinators, but it is alos reproduced in Annex V.

8.2 Methods for Sea-Water Analysis in R.R.S. DISCOVERY

At the last meeting of the IIOE Coordinating Group, it was pointed out that a simple statement on the type of method used, accompanying IIOE Data submitted to WDCs, was not sufficient, since many laboratories used adaptations of standard methods. The description of methods used by R.R.S. DISCOVERY have been received from the National Coordinator of the U.K., and is reproduced in Annex IV. The Secretariat is of the opinion that the exchange of information of this kind is very useful for coordination of the Expedition, and it is for this reason that it is included in this Information Paper.

8.3 Extremely Low Productivity Water Mass in the Bay of Bengal

Mr. H. Rosa, Jr., Chief, Marine Resources Section, Fisheries Biology Branch of FAO has forwarded to the IOC Secretariat a letter and a short report from Mr. Kenneth H. Bain, marine fisheries biologist, working on an EPTA project in East Pakistan, concerning his findings in the area which he has been investigating. With the permission of Mr. Rosa, an extract of the report is reproduced in Annex VI.

ANNEX I

"METEOR"-Expedition as a German Contribution to the International Indian Ocean Expedition (IIOE) October 1964 - April 1965

Working Plan

After the commissioning of the new German research vessel "METEOR" the Federal Republic of Germany has now the possibility to realize the planned cooperation in the International Indian Ocean Expedition. One of the main problems of the IIOE is the influence of the monsoons on the environment of the Indian Ocean. "METEOR" will investigate the conditions during the winter (NE-) monsoon 1964/65 in the Arabian Sea. It is to be expected that the effects of the monsoon will be most evident in the near-shore regions of the sea, i.e. on the shelf, on the continental slope and the bordering deep sea. When planning the cruise program, this and the programs of the research vessels of other nations have been taken into consideration (see Annex IX, Scheduled IIOE Tracks). The water of the Arabian Sea is not only influenced by the circulation caused by the monsoons, but is also influenced in the deeper layers by the outflow of the water coming from the Red Sea through the Strait of Bab el Mandeb and to a smaller extent from the Persian Gulf through the Strait of Hormus. Therefore, both straits and the two adjacent seas were included in the "METEOR" program.

Scientists of the following fields take part in the expedition:

1. Physical Oceanography
2. Chemical Oceanography
3. Maritime Meteorology
4. Marine Geology
5. Marine Geophysics
6. Planktology
7. Marine Botany
8. Marine Zoology
9. Ichthyology
10. Marine Microbiology

In detail the following investigations are planned:

To 1: Physical Oceanography

Red Sea and Strait of Bab el Mandeb: Observations of stratification of temperature, salinity and transparency in vertical sections through the Red Sea as well as in cross sections through the inner part of the Gulf of Aden. Anchoring of current meters and thermographs in order to record the movements of water masses.

Arabian Sea: Observations of temperature, salinity and transparency in order to study circulation processes on selected sections normal to the shelf edge, with sinking water on the African side and upwelling water on the Indian side. Investigation of the equatorial currents in 46°E and 58°E.

Persian Gulf: Stratification of temperature, salinity and transparency. Anchoring of current meters and thermographs in the Strait of Hormus.

To 2: Chemical Oceanography

Red Sea, Arabian Sea, Persian Gulf: Characterizing of the water masses. Exchange of substances at the sea floor and the sea surface. At all hydrographic stations determinations of the vertical distribution of PO_4-P, Si, NO_3, NO_2, NH_3, pH, Ca, O_2 (H_2S) as well as the fine structure of O_2 by continuous registrations are planned.

To 3: Maritime Meteorology

Red Sea: Radiation budget in desert climate.

Arabian Sea: Profiles taken by radio sonds, especially normal to the Equator in order to study the high equatorial jet.

To 4: Marine Geology

Red Sea and Arabian Sea: Sedimentation of carbonates at the outer margin of coral reefs. Examination of facies changes in the sediments from the coastal region down to the deep sea. Effect of monsoons on sedimentation. Transport of sediments within a greater limit of the mouth of the Indus river (the latter partly in cooperation with Pakistan authorities).

Persian Gulf: Relation between currents and sedimentation in the Strait of Hormus and in the tidal banks off the Euphrates-Tigris-Delta. Distribution and formation of sediments in the northern part of the Gulf. Diagenesis of carbonates in a selected shallow area.

To 5: Marine Geophysics

Red Sea: Measurements of the total intensity of the earth's magnetic field and the gravimetric conditions.

Arabian Sea: The same as Red Sea, and in addition seismic investigations off the west coast of India and Pakistan.

Persian Gulf: Geophysical investigation of deep subbottom layers.

To 6: Planktology

Red Sea, Arabian Sea, Persian Gulf: Primary production of organic matter and content of micro-biomass; net catches in accordance with the international standard program.

Arabian Sea: Also hauled plankton 0-500m. depth and oxidizable substances.

To 7: Marine Botany

Red Sea: Study of macro and micro algae in the areas bordering coral reefs. Disembarking on a group of islands in the southern Red Sea for special shore investigations. Study of phytoplankton.

Arabian Sea and Persian Gulf: Study of phytoplankton and of fossil diatoms in sediment cores.

To 8: Marine Zoology

Red Sea: Study of the adaptation of marine animals to the different conditions of life in the area of the Red Sea and in the Gulf of Aden. Study of plankton and bottom fauna. Temporary disembarkation on a group of islands in the southern Red Sea to study litoral areas of life.

Arabian Sea: Study of meso-bathypelagics as well as of plankton and bottom fauna.

Persian Gulf: Study of plankton and bottom fauna.

To 9: Ichthyology

Red Sea, Arabian Sea, Persian Gulf: Study of fish and fish brood in the monsoon areas. Occurence and distribution of bottom fish (to 500m. depths) and of pelagic fish as well as their dependence from hydrographical conditions.

To 10: Marine Microbiology

Arabian Sea: Distribution of bacteria and fungi in relation to abiotic and biotic factors.

Persian Gulf: Influence of bacteria on the formation of carbonates and sulphides. Study of nitrification in water and sediments.

Time Schedule

	nm	Stat.	Days	Date
Hamburg - Naples	2620	3	11	1.10.1964 - 12.10.1964
Naples	-	-	2	12.10.1964 - 14.10.1964
Naples - Suez	1250	3	5	14.10.1964 - 19.10.1964
Suez	-	-	1	19.10.1964 - 20.10.1964
Suez - Aden	1300	10	6	20.10.1964 - 26.10.1964
Aden	-	-	3	26.10.1964 - 29.10.1964
Aden - Aden (Bab el Mandeb)	1000	26	17	29.10.1964 - 15.11.1964
Aden	-	-	1	15.11.1964 - 16.11.1964
Aden - Mogadischu	1960	46	23	16.11.1964 - 9.12.1964
Mogadischu	-	-	2	9.12.1964 - 11.12.1964
Mogadischu - Dar es Salaam	1000	18	11	11.12.1964 - 22.12.1964
Dar es Salaam	-	-	3	22.12.1964 - 25.12.1964
Dar es Salaam - Cochin	2600	28	19	25.12.1964 - 13. 1.1965
Cochin	-	-	3	13. 1.1965 - 16. 1.1965
Cochin - Bombay	960	17	9	16. 1.1965 - 25. 1.1965
Bombay	-	-	3	25. 1.1965 - 28. 1.1965
Bombay - Karachi	720	16	15	28. 1.1965 - 12. 2.1965
Karachi	-	-	3	12. 2.1965 - 15. 2.1965
Karachi - Kuwait	2500	-*	26	15. 2.1965 - 13. 3.1965
Kuwait	-	-	3	13. 3.1965 - 16. 3.1965
Kuwait - Aden	2120	-	9	16. 3.1965 - 25. 3.1965
Aden	-	-	2	25. 3.1965 - 27. 3.1965
Aden - Suez	1300	-	5	27. 3.1965 - 1. 4.1965
Suez - Kiel	3650	-	13	1. 4.1965 - 14. 4.1965
	22980	167	195	*many shallow stations

Participating Scientists

	x	on board from	to
BOJE, R. cand.	1	Dar es Salaam	- Karachi
CLOSS, Prof. Dr. H.	3	Bombay	- Kiel
DEFANT, Prof. Dr. F.	1	Aden (2)**	- Bombay
DIETRICH, Prof. Dr. G.	1	Hamburg	- Karachi
DÜING, Ing. W.	1	Aden (2)	- Bombay
BUNGENSTOCK, H. Dipl. Geophys.	3	Bombay	- Kiel
EINSELE, Dr. G.	2	Naples	- Aden (2)
FLÜGEL, Dr. H. J.	1	Suez	- Aden (2)
GENSER, Dr. H.	7	Hamburg	- Aden (1)
*GERLACH, Prof. Dr. S.	6	Suez	- Aden (2)
GESSNER, Prof. Dr. F.	1	Karachi	- Kiel
GILLBRIGHT, Dr. M.	4	Aden (2)	- Bombay
GRASSHOFF, Dr. K.	1	Hamburg	- Karachi
GUNKEL, Dr. W.	4	Aden (2)	- Aden (3)
HARTMANN, Dr. M.	2	Karachi	- Kiel
HINZ, Dipl. Geol. K.	3	Bombay	- Kiel
HINZPETER, Dr. H.	1	Suez	- Aden (2)
HÖHNK, Dr. W.	9	Cochin	- Karachi
HOHENDORF, Dr. K.	1	Aden (1)	- Cochin
KINZER, Dr. J.	5	Aden (2)	- Karachi
*KLAUSEWITZ, Dr. W.	8	Suez	- Aden (2)
KÖGLER, Dr. F. C.	2	Karachi	- Kiel
KOSKE, Dr. P. H.	1	Naples	- Aden (3)
KOTTHAUS, Dr. A.	4	Hamburg	- Karachi
KRAPPINGER, Dozent Dr. J.	10	Hamburg	- Naples
KRAUSE, Dr. G.	1	Naples	- Aden (3)
KREY, Prof. Dr. J.	1	Hamburg	- Karachi
KRUUM, Dr. H.	2	Karachi	- Kiel
LENZ, Dr. J.	1	Naples	- Dar es Salaam
LUTZE, Dr. G. F.	2	Karachi	- Kiel
MERGNER, Dr. H. Dozent	11	Naples	- Aden (2)
NELLEN, Dr. W.	1	Cochin	- Kiel
PFANNENSTIEL, Prof. Dr. M., Dr.Hc.	7	Hamburg	- Aden (1)
PLAUMANN, K., Dipl. Geophys.	3	Hamburg	- Suez
REINECK, Dr. H., Dozent	12	Aden (2)	- Cochin
RHEINHEIMER, Dr. G.	1	Karachi	- Aden (3)
ROESER, H.A., Dipl. Phys.	3	Hamburg	- Aden (2)
*SCHÄFER, Prof. Dr. W.	8	Suez	- Aden (2)
SCHLIEPER, Prof. Dr. C.	1	Suez	- Aden (2)
SCHOTT, Prof. Dr. W.	3	Aden (2)	- Karachi
SEIBOLD, Prof. Dr. E.	2	Karachi	- Aden (3)
SIEDLER, Dr. G.	1	Hamburg	- Aden (2)
*SIMONSEN, Dr. R.	1	Hamburg	- Aden (3)
THIEL, Dr. H.	5	Aden (1)	- Dar es Salaam
ULRICH, Dr. J.	1	Hamburg	- Suez
VOLLBRECHT, Dr. K.	2	Karachi	- Kiel
WALGER, Dr. E.	2	Karachi	- Kiel
WERNER, Dr. B.	4	Aden (2)	- Bombay
WERNER, Dr. F.	2	Naples	- Aden (2)
*ZANDER, Dr. C. D.	6	Suez	- Aden (2)
ZEITZSCHEL, B. cand.	1	Karachi	- Kiel.

*Temporary disembarkation on a group of islands in the southern Red Sea.
**Numbers (1), (2) or (3) following Aden, mean first, second or third call at Aden.
*Number means address of institute mentioned below:

Addresses of Institutes concerned:

1 Institut für Meereskunde der Universität Kiel,
23) Kiel, Hohenbergstrasse 2
2 Geologisch-Paläontologisches Institut der Universität Kiel,
23) Kiel, Neue Universität
3 Bundesanstalt für Bodenforschung,
3) Hannover, Wiesenstrasse 1
4 Biologische Anstalt Helgoland,
2) Hamburg - Altona, Palmaille 9,
5 Institut für Hydrobiologie und Fischereiwissenschaft,
2) Hamburg - Altona, Olbersweg 24
6 Zoologisches Staatsinstitut der Freien und Hansestadt Hamburg,
2) Hamburg 13, Von-Melle-Park 10
7 Geologisch-Paläontologisches Institut der Universität Freiburg,
78) Freiburg/Br., Hebelstrasse 40
8 Natur-Museum und Forschungsinstitut Senckenberg,
8) Frankfurt/M., Senckenberger Anlage 25
9 Institut für Meeresforschung,
285) Bremerhaven, Am Handelshafen 12
10 Institut für Schiffsbau der Universität Hamburg,
2) Hamburg 33, Lämmersieth 90
11 Zoologisches Institut der Justus-Liebig-Universität,
63) Giessen, Ludwigstrasse 23
12 Forschungsanstalt "Senckenberg am Meer",
294) Wilhelmshaven, Schleuseninsel

ANNEX II

LIST OF IIOE CRUISES
(31 May 1964)

COUNTRY & SHIP	PERIOD	DISCIPLINES AND ITEMS OF OBSERVATION	TRACK
AUSTRALIA			
Diamantina	11/X-19/XI/59	Do1-5,7,8;Ps1,2g,4,5.	(1)
ditto	2/II-23/III/60	Do1-5,7,8;Ps1,2g,4,5;Gg4.	(1)
ditto	11/VII-26/IX/60	Do1-5,7,8;Ps1,2g,4,5.	(1)
ditto	16/X-15/XI/61	Do1-5,7,8.	(1)
ditto	14/II-10/III/61	Do1-5,7;Ps1,2f,g,4,5.	(1)
ditto	1/V-12/VI/61	ditto	(1)
ditto	20/VII-26/VIII/61	Do1-5,7,8;Ps1,2f,g,4,5;Ph2.	(1)
ditto	12/II-25/III/62	Do1-5,7,8;Ps1,2g,4,5;Mt3.	(1)
ditto	16/VII-25/VIII/62	Do1-5,7,8;Ps1,2a,4,5.	(1)
ditto	24/IX-6/X/62	Do1-5,7,8;Ps1,2a,b,g,4,5.	(1)
ditto	15/X-13/XI/62	ditto	(1)
ditto	28/III-27/IV/63	ditto	(3)
ditto	6/V-6/VI/63	ditto	(3)
ditto	9/VII-9/VIII/63	ditto	(3)
ditto	20-23 & 27-29/VIII/63	Do1-5,7,8;Ps2b;Ab1,2;Gg2a,b,4.	(3)
ditto	4-28/IX/63	Do1-5,7,8;Ps1,2a,b,g,4,5.	(3)
ditto	5-12/X/63	Do1-5,7,8;Ps2b;Ab1,2;Gg2a,b.	(3)
ditto	28/I-6/II & 14-18/II/64	Do1-5,7,8;Ps2a,b,d,3;Ab1,2;Gg2b.	(3)
ditto	24/III-21/IV/64	Do1-5,7,8;Ps2a.	(3)
ditto	4/V-15/VI/64	Do1-5,7,8;Ps2a,4,5;Mt3.	(3)
ditto	20/VII-3/VIII/64	Do1-5,7,8;Ps2a,b,d,3;Ab1,2;Gg2b.	(3)
ditto	10/VIII-7/IX/64	Do1-5,7,8;Ps2a,4,5;Mt3.	(3)
ditto	5/-20/X/64	Do1-5,7,8;Ps2a,b,d,3;Ab1,2;Gg2b.	(3)
Gascoyne	21/II-15/III/61	Do1-5,7,8;Ps2g,4,5;Mt3.	(1)
ditto	4-5/VI, 18/VI-12/VII/62	Do1-5,7,8;Ps1,2g;Ab1,2.	(1)
ditto	3-13/VIII/62	ditto	(1)
ditto	19/VIII-16/IX/62	Do1-5,8;Ps1,2a,b,f,g,4,5;Mt3.	(1)
ditto	17/I-17/II/63	Do1-5,7,8;Ps1,2a,b,g,4,5.	(3)
ditto	4-9/III/63	Do1-5,7,8.	(3)
ditto	13/I-6/II/64	Do1-5,7,8;Cm1;Ps4.	(3)
ditto	21-26/II/64	Do1-5,7,8.	(3)
ditto	5-25/III/64	Do1-5,7,8;Cm1.	(3)

COUNTRY & SHIP	PERIOD	DISCIPLINES AND ITEMS OF OBSERVATION	TRACK
EAST AFRICA			
Manihine	Two cruises in 1965	Do;Ps;Fr;Mt.	(4)
FRANCE			
R. Giraud	1/VII-27/IX/60	Do1,2,3,7,8.	(1)
ditto	4/IV-16/VI/61	Do1,2,3,7,8.	(1)
ditto	3/VII-10/X/62	Do1,2,3,7,8;Cm1,4.	(1)
ditto	19/XII/62-18/II/63	Do1,2,3,7,8;Cm1.	(2)
GERMANY			
Meteor	1/X/64-14/IV/65	Do1-8;Cm2;Ps1-3,5-7;Ab1,2;Ph2;Ch1,2;Fr2,3,6;Gg1-4,6,7;Mt1-3.	(2)
INDIA			
Kistna	23/IX-4/X/62	Do1-5,8;Ps1,2;Ch4.	(2)
ditto	13-21/X/62	Do1-5,8;Ps1,2;Mt2.	(2)
ditto	3-14/XI/62	Do1-5,8;Ps1,2;Fr1;Mt2.	(2)
ditto	26/XI-6/XII/62	Do1-5,8;Ps1,2;Fr1.	(2)
ditto	17-29/I/63	Do1-5,8;Ps1,2a;Mt2.	(2)
ditto	5-15/II/63	Do1-5,8;Ps1,2;Ch4.	(2)
ditto	21-28/II/63	Do1-5,8;Ps1,2.	(2)
ditto	14-20/III/63	Do1-5,8;Ps1,2a;Fr1.	(2)
ditto	18-24/VI/63	Do1-5,7,8;Ps1,2a.	(2)
ditto	1-15/VII/63	Do1-5,7,8;Ps1,2a.	(2)
ditto	17-22/VII/63	Do1-5,7,8;Ps1,2a;Gg2a.	(2)
ditto	25-31/VIII/63	Do1-5,7,8;Ps1,2a.	(2)
ditto	7-13/VIII/63	Do1-5,7,8;Ps1,2.	(2)
ditto	19-27/VIII/63	Do1-5,7,8;Ps1,2;Ch4.	(2)
ditto	2-18/IX/63	Do1-5,7,8;Ps1,2a;Fr1.	(2)
ditto	22/V-17/VIII/64	Do1-8;Ps1,2a;Fr1,6;Gg1,4;Mt1,2.	(3)
Varuna	IX-X/62	Do1-5,7,8;Ps1,2;Fr1.	(2)
ditto	X-XII/62	ditto	(4)
ditto	VI-IX/63	ditto	(4)
ditto	IX-XII/63	ditto	(4)
ditto	Programme not ready yet		(4)

COUNTRY & SHIP	PERIOD	DISCIPLINES AND ITEMS OF OBSERVATION	TRACK
Bangada	Programme not ready yet		(4)
Conchi	ditto		(4)
INDONESIA*			
Jalanidhi	1-7/IV/63	Do1-5;Ps1,2e;Cm1;Ab.	(3)
ditto	6-26/VI/63	Do1-5,7,8;Cm1;Ps1,2;Ab1;Fr2;Gg1.	(2)
ditto	-	ditto	(1)
JAPAN			
Hokusei-Maru	5/XI/61-1/II/62	Do;Fr.	(4)
Kagoshima-Maru	12/VII-1/IX/61	Do;Ps;Fr.	(4)
ditto	5/VII-29/VIII/62	ditto	(4)
ditto	10/XI/63-18/II/64	Do1-8;Cm1,2,4;Ps1,2a-c,f,3-5;Fr1;Mt1.	(2)
Keiten-Maru	22/V-4/VII/61	Do;Ps;Fr.	(4)
ditto	10/V-7/VIII/62	ditto	(4)
ditto	5/V-2/VIII/62	ditto	(4)
Koyo-Maru	24/X/62-18/II/63	Do1-8;Cm1,2;Ps1,2a-c,3-5,7;Fr1;Mt1-3.	(2)
ditto	25/X/63-18/II/64	Do1-6,8;Cm1,2;Ps1,2a-d,f,3-5,7;Fr1;Mt1-3.	(2)
Oshoro-Maru	17/XI/62-12/II/63	Do;Cm;Ps;Fr.	(3)
ditto	11/XI/63-9/II/64	Do1-7;Ps1-5;Fr.	(4)
Umitaka-Maru	12/XI/60-12/I/61	Do1-6;Ps1,2;Fr1,2.	(1)
ditto	28/X/61-16/III/62	Do1-8;Ps1-3;Fr1;Gg2,7.	(4)
ditto	29/X/62-11/II/63	Do1-8;Cm1,2,4;Ps1,2a,c-f,4-6,8;Ab1;Fr3;Gg1,2a;Mt3.	(2)
ditto	XI/63-II/64	Do1-8;Cm1,2,4;Ps1,2a,3,5;Fr1;Ch3;Gg1;2a,6,7;Mt1,3.	(3)
PAKISTAN*			
Zulfiquar	XII/61-IV/62	Do1-5,8;Cm;Ps1,2;Ch,2,3;Fr6;Gg1,6;Mt1,3.	(1)
ditto	18-22/X/62	Do1-5,8;Ps;Ph2;Gg1;Mt3.	(2)
ditto	2-5/XII/62	Do1-5,8;Ps2a;Ph2;Mt1,3.	(2)
ditto	I-V/63	Do1-8;Cm;Ps1,2,5;Ch1,3,4;Gg1;Mt2,3.	(1)
ditto	X/63-II/64	ditto	(3)
ditto	1964	-	(3)
Madagar	1962	Do;Cm;Ps;Ab;Ch;Fr;Gg;Mt.	(3)
ditto	1-IV/63	ditto	(3)
ditto	X-XII/63	ditto	(3)

*Confirmation by the National Coordinator has not yet been received.

COUNTRY & SHIP	PERIOD	DISCIPLINES AND ITEMS OF OBSERVATION	TRACK
PORTUGAL*			
Lacerda	IV-V/64	Do1-5,7,8;Cm1;Ps1,2c,d,4;Ph2;Ab;Fr1;Gg1,2a;Mt1,2.	(1)
ditto	IX-X/64	ditto	(1)
SOUTH AFRICA			
Africana II	7/VI-20/VII/61	Do1,2,4,5,7,8;Cm4;Ps1,2,4,8;Fr1,6;Gg1,2;Mt1,2.	(1)
ditto	15/VI-14/VII/62	Do1-5,8;Ps1,2,4;Ch3;Fr1,6;Gg1;Mt1.	(1)
ditto	2-20/IV/63	Do1-5,7,8;Ps1,2a,4,5;Ch3;Fr1;Gg9;Mt1.	(1)
Natal	2-24/IV/62	Do1-4,6-8;Ps1,2;Ch4;Fr6;Gg1;Mt1.	(1)
ditto	7-24/V/62	Do1,2,7,8;Gg1,4,6;Mt1.	(1)
ditto	4-22/VI/62	ditto	(1)
ditto	2-24/VII/62	Do1-8;Ps1,2;Fr6;Mt1.	(1)
ditto	6-30/VIII/62	Do1,2,7,8;Cm3;Ps2b;Ch4;Fr1;Mt1,2.	(1)
ditto	1-22/X/62	Do1-8;Ps1,2,4;Ch4;Fr6;Mt1.	(1)
ditto	5-22/XI/62	Do1.2,7;Ps2b;Ab1;Fr6;Gg1,2b,6;Mt1.	(1)
ditto	7-29/I/63	Do1-8;Ps1,2a,4,5;Ch4;Mt1.	(1)
ditto	11/II-8/III/63	Do1,2,7,8;Ps2b;Fr1;Gg1.	(1)
ditto	10-28/VIII/64	Do.	(3)
ditto	2/IX-1/X/64	Do;Cm.	(3)
ditto	5/X-28/X/64	Do;Ps;Cm;Fr.	(3)
ditto	9/XI-7/XII/64	Do.	(3)
Lady Theresa	Monthly since 1960	-	**
J.D.Gilchrist	-	Fr.	(2)
A. Queen	VIII/62	Mt3.	(3)
THAILAND*			
Oceanogr.V.II	XII/62-I/63	Do1-4,7;Cm;Ps1,2;Fr2;Gg1,2b;Mt1.	(1)
U.K.			
Dalrymple	8/X/61-10/III/62	Do7;Ab1;Gg1,2a,b,3,7;Mt1.	(3)
ditto	13/X/62-8/IV/63	Do7;Ab1;Gg1,2a,b,3,7;Mt1.	(3)
Discovery	14/VI-20/VIII/63	Do1-5,7,8;Cm1-3;Ps1,2a-f,4-8;Ch1,3;Ab1;Ph2;Fr4,6;Mt1-3.	(1)
ditto	23/VIII-22/XI/63	Do1-4,7;Ch3;Ps2a,2f;Gg1,2a,4-9(photograph);Mt1-3.	(2)
ditto	28/II-14/IX/64	Do1-5,7,8;Cm1-3;Ps1,2a-f,3-8;Fr6;Gg6,7;Mt1-3.	(2)

*Confirmation by the National Coordinator has not yet been received.
**Occupies two permanent stations.

COUNTRY & SHIP	PERIOD	DISCIPLINES AND ITEMS OF OBSERVATION	TRACK
Owen	31/X/61-13/V/62	Do2,3,7;Gg2b,6,7;Mtl.	(3)
ditto	21/X/62-30/V/63	Do2,3,7;Gg6,7;Mtl.	(2)
ditto	29/IX/63-27/VI/64	Gg4;Mtl.	(3)
U.S.A.			
A. Bruun	12/III-7/V/63	Do1-5,7,8;Ps1,2a,d,4,5;Ab1;Fr1-3;Mt2,	(1)
ditto	22/V-23/VII/63	Do1-5,7,8;Ps1,2a,d,4,5;Fr1,2,3;Mt2.	(1)
ditto	8/VIII-20/IX/63	Do1-5,7,8;Ps1,2a,b,d,4,5;Mt2.	(1)
ditto	25/IX-1/XII/63	Do1-5,7,8;Ps1,2a,d,4,5;Ab1;Fr3;Mt2.	(2)
ditto	1/I-28/III/64	Do1-5,7,8;Ps1,2a,d,4,5;Fr1,4;Mt2,	(1)
ditto	9/IV-1/VI/64	Do1-5,7,8;Ps1,2a,b,d,4,5;Mt2,	(1)
ditto	12/VI-26/VII/64	Do1-5,7,8;Ps1,2a,d,4,5;Fr2;Gg1,2b,	(1)
ditto	6/VIII-25/IX/64	Do1-5,7,8;Ps1,2a,d,4,5;Ab1;Fr2;Mt2.	(1)
ditto	3/X-25/XI/64	Do1-5,7,8;Ps1,2a,b,d,4,5;Fr2;Mt2.	(1)
Argo	19/X/60-22/I/61	Do1-4,7,8;Ab1,2;Ps2b,e,6,8;Ch2-4;Gg1,2a,b,4-7.	(1)
ditto	28/VI-29/IX/62	Do1-8;Ps1,2a,c,d;Ch2-4;Gg6,7.	(2)
ditto	4/X-23/XII/62	Do1-4,7,8;Ab2;Ph2;Ch2-4;Gg1,2a,b,4-7.	(2)
ditto	1/I-12/II/63	Do7,8;Gg1,6-7.	(2)
ditto	16/II-15/V/63	Do1-5,7,8;Gg1,6-7.	(2)
ditto	18/V-29/V/63	Do1-4,7,8;Ps2a;Gg1,5-7.	(2)
ditto	15/VII-31/VII/64	Do2,7-8;Ps1,2a,d;Ab2;Ch2;Gg1,2a,b,5,7;Mt1-3.	(3)
ditto	4/VIII-7/IX/64	Do1-8;Cm1-4;Ps1,2a,d;Ch2-4;Gg7;Mt1-3.	(3)
ditto	10/IX-6/X/64	Do2,7-8;Ch2;Gg1,2a,4,5,7;Mt1-3.	(3)
Atlantis II	1/VII-19/XII/63	Do;Cm;Gg.	(2)
ditto	II-VI/65	Do;Cm;Gg.	(1)
Chain	IX/64-III/65	Do;Gg.	(1)
Conrad	6/I-2/III/64	Do1,2,7,8;Ps1,2;Ab1,2;Gg1,3-7;Mt1,2;ULF Navigation Study.	(3)
East Wind	V/61	Do.	(1)
Horizon	4/X-23/XII/62	Do2,7,8;Ch4;Gg1,2a,4,5,7.	(2)
Pioneer	11/II-23/IX/64	Do1-5,7,8;Gg1,2a,6,7,9(photograph)	(1)
Requisite	I-III/61	Do.	(1)
Serrano	III-VI/61	Do;Cm;Gg.	(1)
ditto	XI-XII/61	ditto	(1)
ditto	I-II/63	-	(1)

COUNTRY & SHIP	PERIOD	DISCIPLINES AND ITEMS OF OBSERVATION	TRACK
S.F.Baird	VII-X/64	Gg.	-
Te Vega	X-XII/63	Ps;Gg.	(1)
ditto	II-IV/64	Ps;Gg.	(1)
ditto	VI-IX/64	Ps;Fr;Gg.	(1)
Vema	27/XII/59-31/III/60	Do1-4,7,8;Ps1,2;Ab1,2;Ph1;Ch4;Gg1,4,5,7.	(1)
ditto	31/V-1/VIII/62	Do1-4,7,8;Ps1,2;Ab1,2;Ph1;Ch4;Gg1,4-7;Ph2;Ab1.	(2)
ditto	10/VII-14/IX/63	Do1-3,7,8;Ps1,2,6;Ch3,4;Ph2;Ab1,2;Gg1,3-7.	(2)
U.S.S.R.			
Vityaz	IX/59-III/60	Do1-8;Ps1-3,5;Cm2;Ab1,2;Ph2;Fr2,6;Gg1,2,4;Mt1-3.	(1)
ditto	X/60-IV/61	ditto	(1)
ditto	23/VI-23/XI/62	ditto	(1)
ditto	IX/64-II/65	Do;Ps;Ab;Gg;Mt.	(3)
Acad.Y.M.Shokalski	VII/60	Do;Mt.	(4)
Vorobyev	X/61-II/62	Do1,3,4;Ps1,2;Ab1;Fr2;Mt.	(4)
ditto	VI-X/62	ditto	(4)
ditto	IV/63-II/64	ditto	(4)
ditto	VI-X/64	Do;Ps;Fr;Mt.	(4)
Orlik	XI/62-III/63	Do1,3,4,5;Ps;Fr.	(4)
ditto	XI/63-IV/64	ditto	(4)

LEGEND

Do Descriptive oceanography

1 Temperature with reversing thermometer
2 Temperature with BT
3 Salinity
4 Oxygen
5 Naturient salts
6 pH
7 Bathymetry
8 Surface weather observation at the station

Cm Current measurement

1 With GEK
2 With current meter
3 With Swallow float or drogue
4 With drift-bottle

Ps Plankton study

1 Phyto-plankton
2 Zoo-plankton
  a Indian Ocean Standard Net
  b Isaacs-Kidd midwater trawl
  c Vertical haul with closing net
  d Oblique haul
  e Horizontal haul
  f High-speed surface sampler
  g Clarke-Bumpus sampler
3 Larva net
4 Pigments
5 Primary production, standing crops
6 Micro-biology
7 Marine bacteria
8 DSL

Ab Biological study in deep layer

1 Benthic sample
2 Bottom photography

Ph Physical study

1 Sound velocity
2 Turbidity

Ch Chemical study

1 H_2S
2 CO_2
3 Trace elements
4 Radio-activity & isotops

Fr Fisheries research

1 Experimental fishing
2 Fish sampling
3 Bionomics
4 Gear experiment
5 Tagging
6 Visual observation

Gg Geology and Geophysics

1 Coring
2 Sediment sampling
  a Dredging
  b Grabbing
3 Sparker
4 Seismic study
5 Heat flow
6 Gravity
7 Magnetism
8 Drilling
9 others (specify)

Mt Meteorology

1 Synoptic observation
2 Upper-air observation
3 Radiation & energy exchange
4 Wave recording

for Column TRACK

(1) as it appears in the IIOE Track Chart (Sept. 1962, H.O. 17, 138 B and C).
(2) different as it appears in the IIOE Track Chart.
(3) does not appear in the IIOE Track Chart.
(4) cruise track is not available.

ANNEX III

NATIONAL SCIENCE FOUNDATION - May 13, 1964

SCIENTIST BELIEVES
MASS FISH DEATHS
DUE TO ASPHYXIATION

A top U.S. marine biologist believes that millions of tons of fish occasionally found floating in certain areas of the Indian Ocean were killed by asphyxiation.

The fish probably died from being suddenly exposed to water lacking in dissolved oxygen, and paradoxically, the mass deaths probably took place in water heavy with natural fish food.

Dr. John Ryther, biological oceanographer at Woods Hole Oceanographic Institution and director of the U.S. Program in Biology for the International Indian Ocean Expedition (IIOE), has suggested the theory following his return from a research cruise in the Arabian Sea. It was near this area that a Russian merchant ship in 1957 reported passing through millions of tons of dead fish floating in an area 125 miles wide and about 600 miles long.

The 28 million square miles of Indian Ocean, as large as Asia and Africa combined, is undergoing intensive study during the IIOE. The Expedition is a cooperative effort by scientists of 28 nations working from shore stations and more than 40 research vessels.

The stage is set for the wholesale deaths, Dr. Ryther suggested, by the development and interaction of several factors: subsurface water extremely rich in inorganic nutrients but very poor in dissolved oxygen; the carrying of this nutrient-rich water to the surface by "upwelling" processes caused by winds and currents; the rapid growth and reproduction of plankton which use these nutrients and sunlight to produce organic matter through the process of photosynthesis; and the subsequent sinking of the organic matter beneath the surface where it decomposes, depleting further or exhausting the oxygen supply of the water.

Measurements made in the Arabian Sea showed areas where concentrations of nutrients approached the highest levels known for these substances in any ocean, he said. High concentrations first appeared 100-150 feet below the surface and increased with depth. Paradoxically, said Dr. Ryther, "the sharp increase in nutrients accompanies and is undoubtedly directly correlated with a rapid decrease in dissolved oxygen concentrations.

"The presence of such unusually high levels of nutrients and low oxygen concentrations at or near the base of the photosynthesis zone," he said, "indicates a situation that is potentially both highly productive and biologically unstable. Because phytoplankton use these nutrients to produce organic matter, any upwelling of nutrient-bearing water into the zone of photosyntheses may be expected to result in greatly enhanced biological productivity." There is an explosive increase of phytoplankton, zooplankton multiply, and larger animals and fish move into the area to feed.

At the same time, Dr. Ryther pointed out, the organisms produced in the surface water die, sink and decompose. The decomposition uses up the remaining oxygen in water already low in oxygen. Further upwelling to the surface of such anoxic water traps masses of fish in an oxygenless environment and they become asphyxiated.

Large areas of upwelling of nutrient-laden water were found by Dr. Ryther and other scientists participating in the IIOE. No anoxic water was found during his cruise, however, though the presence of such water was reported by the Russian research vessel VITYAZ in the same area in 1960.

Studies of the living resources of the Indian Ocean, and the factors effecting them, are of prime concern since about 28 per cent of the world's population lives in areas bordering this ocean. Some of these areas suffer chronic food shortages that could be alleviated through the discovery and development of seafood resources.

Dr. Ryther conducted his studies aboard the ANTON BRUUN, an ocean-going research vessel operated by the Woods Hole Oceanographic Institution for the National Science Foundation. The Foundation, a federal agency, is responsible for planning and coordinating U.S. participation in the IIOE and is supporting much of the research. U.S. support for its share of the multi-nation project will total nearly $20 million by the end of the IIOE in 1965. Fourteen U.S. research vessels and five airplanes will have taken part in the project when the field work is concluded.

Twenty countries - Australia, Ceylon, East Africa, France, Germany, India, Indonesia, Israel, Japan, Malagasy Republic, Malaysia, Mauritius, Netherlands, Pakistan, Portugal, Thailand, Union of South Africa, Union of Soviet Socialist Republics, United Kingdom, and the United States - have provided or planned to provide research vessels or shore stations for the Expedition. Nine others - Austria, Brazil, Burma, Canada, China, Denmark, Rumania, Sweden and the United Arab Republic - either have or will have scientists conducting research aboard ship or at shore facilities of other nations.

Major areas of interest in the IIOE, other than the biological, include: the formation of the ocean basin and the forces that have shaped and are continuing to shape it; the chemical and physical description of the waters of the Indian Ocean, and the study of their motions; and the interaction between the ocean and the atmosphere, particularly, with respect to the monsoon winds.

All United States vessels participating in the IIOE are contributing to at least two of these four areas of interest, many contribute to three, and some to all four.

ANNEX IV

METHODS FOR SEA WATER ANALYSIS IN R.R.S. DISCOVERY

The methods appended are laboratory working sheets. Some small corrections have been made and extra notes added since they were first used in the Arabian Sea programme 1963. The following remarks apply.

Oxygen. This is basically that given in Fish. Invest. Ser. II, 18 No.3 which in turn was based on U.S. Hydrographic Office research vessel practise. Dr. Cooper has used it exclusively for his deep sea work. In comparative tests at Plymouth it gave results similar to those of Bull. 125 method 1.3 (Strickland and Parsons 1960). The azide modification is most unlikely ever to be needed for sea water, since interference is negligible up to about 2.5 µg atom NO_2-N/l.

Hydrogen sulphide. The volumetric method is suitable for quantities of more than about 1 ml H_2S/litre, and is suggested as the best method of standardising sulphide solutions for the colorimetric method.

Inorganic phosphate. When tested at Plymouth in February 1963 this method (Murphy and Riley 1962 Anal. Chim. Acta 27, 31-36) gave results virtually identical (using English Channel water) with those by the Harvey stannous chloride method, which had been found satisfactory in the Honolulu inter-calibration tests of 1961.

Total phosphorus. This combines the perchloric acid digestion (Bulletin 125 II.3) with the Murphy and Riley phosphate finish. The digestion has been slightly adapted for ship-board use to avoid bumping and the need for continuous attention.

Nitrate. This sulphuric acid method (Anal. Chem. 1963, 35, 1292) is undesirable at sea, but at the time it was proposed neither of the alternatives looked very good. These alternatives were: the reduction to nitrite with hydrazine, which is generally agreed to give rather variable yields, or reduction to nitrite in a cadmium reductor. This latter method usually works very well, but in tests at Plymouth and in R.R.S. Discovery the columns sometimes became inactive and were rather unpredictable. When this difficulty can be overcome the method will be preferable to others now known.

Nitrite. This is taken almost unchanged from Bulletin 125 method II.6.

Silicate. This is the metol-sulphite method of Mullin and Riley 1955 (Anal. Chim. Acta 12, 162). When tested at Plymouth it gave results identical with those by a stannous chloride method (Armstrong 1951 J. Mar. Biol. Ass. 30, 149-60) but was much more convenient in use for high silicate contents.

Reference

Strickland, J.D.H. and Parsons, T.R., 1960. A manual of sea water analysis. Fisheries Res. Board of Canada, Bulletin No. 125.

DETERMINATION OF DISSOLVED OXYGEN IN SEA WATER

Note. In samples containing appreciable nitrite, the alternative alkaline iodide reagent containing sodium azide must be used.

Reagents.

Manganous chloride.	400 g $MnCl_2\ 4H_2O$ per litre.
NaOH - KI	360 g NaOH + 150 g K I per litre.

(Alternative reagent with sodium azide.

Dissolve 10 g NaN_3 in 40 ml water and add to 1 litre of the NaOH - KI reagent above.)

KI 15%	150 g KI per litre
Thiosulphate	0.005 N (1 B.D.H. ampoule in 10 1 water)
Potassium iodate 0.01 N	0.3567 g KIO_3 (dried at 110°C for 30 min) is dissolved in 800 ml water, one pellet NaOH added, and the volume made to 1 litre.
Starch 1%	To 2 g starch add a little cold water to make a paste, and then add 200 ml boiling water. Mix well, and boil for 1 min. Cool before using.

Sampling

The water sample is transferred from the hydrographic water bottle through a rubber tube to the bottom of the oxygen determination bottle. Care must be taken to avoid bubbles of air, and the sample bottle is filled until it overflows, when at least 100 ml sample must be run to waste. The stopper must not be allowed to entrap bubbles.

Procedure

1) Add the following reagents, avoiding exposure of the sample to air:

   0.5 ml $MnCl_2$ solution
   0.5 ml alkaline-iodine

   Shake thoroughly, allow to settle, shake again, and stand for at least three hours. If samples are to stand overnight, immerse sample bottle in water.

2) Add 1 ml concentrated hydrochloric acid, restopper, and shake until precipitate dissolves. Keep in a dark place until titrated.

3) Transfer contents to 250 ml conical flask, washing out the sample bottle with about 20 ml water.

4) Titrate with thiosulphate solution until almost colourless. Add 2 ml starch solution and continue titration until the blue colour has disappeared. Record titre (V) to the nearest 0.05 ml.

Standardisation of thiosulphate.

5) In 250 ml conical flask place 100 ml distilled water.

6) Add 10.00 ml 0.01N KIO_3

   5 ml 15% KI
   1 ml conc. HCl

7) Titrate with thiosulphate as in 4 above, recording titre to nearest 0.05 ml.

8) Repeat standardisation. Duplicates must agree within 0.05 ml. Take mean titre V2

9) Carry blank (in duplicate) through stages 5 - 8, omitting KIO_3
   Take mean blank titre V_B

   With freshly prepared, colourless KI there may be no blue colour on adding starch. Check that addition of 0.05 ml (one drop) KIO_3 gives a blue colour. If so, the blank is neglected.

10) Calculate normality of thiosulphate N^t

$$= \frac{10.00}{V_2 - V_B} \times 0.01 \text{ N (when iodate is exactly 0.01N).}$$

11) Calculate oxygen content of sample thus:

$$\text{Oxygen content} = \frac{V \times N^t \times 5600}{B - 1} \text{ ml } O_2\text{/litre.}$$

Where B = Bottle Volume.

DETERMINATION OF HYDROGEN SULPHIDE IN SEA WATER

Introduction

The usual method of addition of excess iodine and back titration with thiosulphate is unsatisfactory because of interference by reducing substances, and because, if the sample is added to the iodine as it should be to avoid side reactions, it is difficult to prevent contact with the air and loss or oxidation of sulphide. These difficulties can be avoided by adding excess standard arsenite to an acidified solution, filtering off the precipitated As_2S_3 and back titrating with iodine.

Apparatus

Oxygen determination bottles, approx. 110 ml, marked with volume to nearest 0.1 ml.

Reagents

Sodium arsenite 0.025 M.

Dissolve 4.946 g AnalaR As_2O_3 in 100 ml 5% w/v NaOH solution and make to 1000 ml. This solution is poisonous.

Iodine 0.01 N.

Dissolve 1.27 g AnalaR iodine in 20 ml 10% w/v KI solution and make to 1000 ml.

Starch 1%

Make 2 g starch to a paste with a little water, add 200 ml boiling water, mix and boil for 1 minute.

Method

1) Fill oxygen determination bottle, with precautions against contact with air. Run at least 100 ml to waste, after bottle is full.

2) Add 1.00 ml conc. HCl and 1.00 ml 0.025 M arsenite solution. Allow to stand overnight.

3) Filter on No. 1 Whatman paper, washing once with 20 ml sea water containing 10 ml conc. HCl per litre. Collect filtrate and washings in 250 ml conical flask.

4) Add 1 - 2 g $NaHCO_3$ and titrate excess arsenite with 0.01 N iodine, using 2 ml 1% starch as indicate. (T_2).

5) To 100 ml sulphide-free sea water add 1 ml conc. HCl and 1.00 ml 0.025 M arsenite, 1-2 g $NaHCO_3$, and titrate with 0.01 N iodine (T_1).

6) Sulphide content of sample = $\frac{1680 \times (T_1 - T_2)}{(B-2) \times T_1}$ ml H_2S per litre

Where B = Bottle Volume.

THE COLORIMETRIC DETERMINATION OF SULPHIDE IN SEA-WATER
MODIFIED FROM L. GUSTAFSSON. TALANTA 4, 228-235

Reagents.

All reagents must be made up with metal-free water.

1) Zinc acetate solution (0.25 M). Dissolve 54.7 g of zinc acetate and 136 g of hydrated sodium acetate in water and dilute to 1 litre. Co-precipitate heavy metals by adding 0.2 ml. of 0.05 M sodium sulphide drop by drop with rapid stirring. Allow to stand overnight. Decant the solution through a fine filter paper.

2) "Amino" reagent. Dissolve 0.68 g of p-amino-N, N-dimethylaniline in 750 ml of metal-free water, add 194.2 mls. of concentrated sulphuric acid, cool and dilute to 1 litre with metal-free water.

3) Ferric solution (0.25 M). Prepare a solution of 120.5 g of ferric ammonium sulphate in 0.5 M sulphuric acid, dilute to 1 litre with the same acid.

NOTE: In order to obtain accurate results it is essential that all glassware used for the colour development should be kept free from traces of heavy metals. Wash with 50/50 HCl and then with metal-free water.

Standard sulphide solution

Sulphide solutions are easily oxidised and should be prepared immediately before use. The solution should be made up in metal-free water which has been boiled to expel oxygen and then cooled.

0.1875 g of sodium sulphide ($Na_2S.9H_2O$) dissolved in 500 ml of water gives a solution containing ca. 50 µg S/ml. This should be standardised iodometrically. It should be diluted as required.

Anoxic sea-water.

The sulphide ion only occurs in anoxic sea-water as it is readily oxidised to sulphate by dissolved oxygen. To prepare anoxic sea-water pass a stream of nitrogen gas through it for several hours, to strip out oxygen. Store in a well stoppered flask taking care to fill the space between liquid surface and stopper with nitrogen.

Procedure.

Pipette 10 ml of zinc acetate solution into a 100 ml graduated flask, and to this add 50 ml of the sample to be analysed, holding the tip of the pipette near the surface of the liquid. Swirl gently. Using fast running pipettes for the next two additions, add 10 ml of the "amino" reagent so that the solution flows down the wall of the flask and forms a layer on the bottom. Swirl and immediately add 2 ml of the ferric solution. Shake vigorously, and make up to the mark with metal-free water. Measure the extinction co-efficient after at least 15 minutes and not more than 3 hours at 667 mµ in 1 cm cell. Perform a blank using redistilled water. Calibrate the method using 50 ml. portions of the anoxic sea-water, to which standard additions of sulphide (0-5 µg S^{2-}) have been made.

NOTES:

50 µg S will give an optical density of ca. 0.5 in a 1 cm. cell.

There is a salt-error of about 7% for sea-water in the range Cl ‰ 10-20.

The precision is approximately ± 4%.

DETERMINATION OF INORGANIC PHOSPHATE IN SEA WATER

Reagents

Ammonium molybdate. Dissolve 15 g AnalaR ammonium paramolybdate $(NH_4)_6Mo_7O_{24}$ $4H_2O$ in 500 ml water and store in a polyethylene bottle out of direct sunlight.

Sulphuric acid. Add 140 ml concentrated sulphuric acid to 900 ml water. Cool and store in a glass bottle.

Ascorbic acid. Dissolve 27 g ascorbic acid in 500 ml water and store in a polyethylene bottle frozen solid in a freezer. Thaw for use and refreeze at once.

Potassium antimonyl tartrate. Dissolve 0.34 g potassium antimonyl tartrate in 250 ml water.

Mixed reagent. Mix 100 ml ammonium molybdate, 250 ml sulphuric acid, 100 ml ascorbic acid and 50 ml potassium antimonyl tartrate. Prepare immediately before use and do not keep for more than 6 hours.

Standard phosphate. Dissolve 0.1361 g potassium dihydrogen phosphate KH_2PO_4 in 1 litre water saturated with chloroform. This solution is stable indefinitely.

$$1 \text{ ml} \equiv 1.00 \ \mu g \text{ atom } PO_4 - P$$

Dilute standard phosphate. Dilute 10 ml of standard phosphate above to 100 ml.

$$1 \text{ ml} \equiv 0.10 \ \mu g \text{ atom P.}$$

Method.

1) Samples should be between 15 and 30°C.

2) Measure extinction (E_o) in 10 cm cuvette, at 882 mμ, as a correction for turbidity (Note a).

3) Measure 50 ml sample with a cylinder and place in 100 ml conical flask. Add 10 ml ± 0.5 of mixed reagent and mix at once.

4) After 5 min and within 3 hours, measure extinction (E_1). Unless adjacent samples have extinction within 25% of each other, rinse the cuvette with the new solution.

5) Correct the measured extinction by subtracting both the turbidity and reagent blanks, and calculate the phosphate concentration by multiplying by a factor F, where F is the concentration required to give unit extinction.

6) Blank determination.

a) When both cuvettes are filled with distilled water there may be a measurable difference in extinction between them, and this "cell-to-cell blank" must be known.

b) The reagent blank is found by carrying 50 ml of distilled water through steps 3 and 4 above. The resultant extinction is corrected for the "cell-to-cell blank". It should not exceed 0.02.

7) Calibration. About 250 ml of clean sea water, preferably of low phosphate content are required. In each of 2 conical flasks place 49 ml of sea water and 1.00 ml distilled water. In another two flasks place 49 ml sea water and 1.00 ml dilute standard phosphate. Carry through stages 3 and 4 above.

Then factor $F = \dfrac{2.00}{E^P - E^W}$ μg atom P/l where E^P = mean extinction with phosphate addition

E^W = mean extinction with water addition

Note. a) In the open ocean, E_o readings for water below 100 m may not be measurably different from distilled water. There is then no need to make this measurement; the "cell-to-cell blank" correction may be substituted.

DETERMINATION OF TOAL PHOSPHORUS IN SEA WATER

Reagents

Ammonia 10% v/v. Dilute 100 ml AnalaR ammonia (S.G. 0.88) to 1 litre with water. Keep in a tightly stoppered polyethylene bottle.

Hydrochloric acid 10% v/v. Dilute 100 ml AnalaR Hydrochloric acid (S.G. 1.18) to 1 litre with water. Keep in polyethylene bottle.

Potassium iodide 5% w/v. Dissolve 5 g AnalaR potassium iodide in 100 ml water.

Molybdate reagents. As for inorganic phosphate method.

Procedure.

1) Measure 25 ml of sample direct from hydrographic water sampler into 50 ml silica beaker.

2) Evaporate to dryness on sand bath at 180 ± 30°C.

3) Add 0.1 ml (2 drops) potassium iodide and 1 ml 10% HCl and again evaporate to dryness. Note a.

4) Add 1.5 ml perchloric acid (72% w/w), cover with clock-glass and heat to fuming for 10 min. Cool.

5) Add 5 ml 10% ammonia, evaporate (without clock glass) again to dryness on sand bath.

6) Add 1.0 ml hydrochloric acid 10% and about 25 ml water, and heat until salts have dissolved. Boil gently for 5 min, cool, transfer to measuring cylinder, make to 25 ml. Note b.

7) Add 5 ml mixed molybdate solution, mix and measure extinction in 10 cm cuvette at 882 mμ, after 5 min and within 3 hours.

8) Carry through blank with 1.5 perchloric acid + 0.1 ml KI + 1 ml HCl which is allowed to evaporate until only a film of perchloric acid remains. Add ammonia, and proceed as in 5, 6 and 7 above.

9) A calibration factor obtained in determination of inorganic phosphate may be used to calculate the results.

NOTES:

a) The procedure removes arsenic but the extra manipulation may cause undesirable errors. It may be justifiable to omit this stage when working on shipboard.

b) There may be difficulty in redissolving all perchlorates and sulphates at this stage. If the solution is slightly turbid with fairly large crystals in suspension these will often settle out completely on standing for about one minute in the cuvette, and the extinction may be read. An immediate check at a wavelength of about 500 mμ will show if the turbidity must be allowed for. There seems to be no chemical interference but this requires investigation.

DETERMINATION OF NITRATE IN SEA WATER

Reagents

Sulphuric acid. AnalaR sulphuric acid (SG 1.84) is heated to boiling (preferably in a silica flask for safety) for 2 hours and allowed to cool. For each 100 ml of acid, 1 ml 0.2% hydrazine sulphate solution is added, cautiously, with mixing, and the acid is again heated to boiling for 30 minutes, cooled and stored in a glass-stoppered bottle.

Hydrazine sulphate 2%. 2 g hydrazine sulphate is dissolved in water and made to 100 ml.

Hydrochloric acid 0.1 M. 10 ml concentrated acid (SG 1.18) is diluted to 1 litre.

Standard nitrate solution. 1.01 g potassium nitrate KNO_3 is dissolved in water and made to 1 litre.

$$1 \text{ ml} \equiv 10.0 \ \mu g \text{ atom } NO_3\text{-}N$$

Dilute standard nitrate. 10.0 ml standard nitrate solution is diluted to 100 ml. This solution does not keep well.

$$1 \text{ ml} \equiv 1.00 \ \mu g \text{ atom } NO_3\text{-}N$$

Procedure

1) Samples containing much suspended matter should be filtered (Note a)

2) In each of two dry (150 x 20 mm) stoppered test-tubes place 10.0 ml sample (pipette). To one portion add 0.1 ml hydrazine sulphate solution.

3) To each tube add 10.0 ml sulphuric acid, from a burette, taking care that mixing is insufficient to cause boiling (Note b).

4) Stopper tubes, cool in running water, mix and cool again.

5) Measure extinctions in 4 cm or 1 cm silica cuvette at 230 mμ with distilled water in reference path (Note c). Record that of (sample + hydrazine sulphate) as E_o, and that of sample as E_1.

Blank determination.

6) Place 10 ml 0.1 M hydrochloric acid in each of 4 tubes, and to two tubes add 0.1 ml hydrazine sulphate solution.

7) Carry through stages 3, 4 and 5 above, and find mean blank $(E_1 - E_o)$ (Note d).

Calibration

About 200 ml sea water is required, preferably of low nitrate content.

8) In a 100 ml volumetric flask place 2.00 ml (or 10.0 ml Note e) distilled water, make up to 100 ml with sea water and mix.

9) In a second flask place 2.00 ml (or 10.00 ml Note e) of dilute standard nitrate solution, make to 100 ml with sea water and mix.

10) Place two 10.0 ml portions of each solution in stoppered test-tubes and carry through stages 3 to 5 above. E_o readings are not needed. Calculate the conversion factor thus:

$$F \text{ (4 cm cuvette)} = \frac{20.0}{E^n - E^w} \text{ ug atom } NO_3\text{-N/l}$$

where E^n is mean E_1 with nitrate addition, E^w is mean E_1 with water addition.

$$F \text{ (1 cm cuvette)} = \frac{100}{E^n - E^w} \text{ ug atom } NO_3\text{-N/l}$$

Notes

a) Tolerance of suspended matter is not known yet. Filtration should be on well-washed glass filter paper or sintered glass filter.

b) Burette tap lubricated only with sulphuric acid.

c) 4 cm cuvette for range 0.5 to 25 µg atom NO_3N/l
1 cm cuvette for range 2.5 to 125 µg atom NO_3N/l

d) Nitrate in HCl is usually negligible. If this is doubted, retest blanks with 0.05 M and 0.2 M NCl. If the higher concentration gives appreciably higher blanks, the NCl is unsuitable.

e) 2.00 ml for 4 cm cuvettes
10.00 ml for 1 cm cuvettes

Important

The sulphuric acid solutions are viscous, highly refractive and very corrosive. Care is needed, in transfer to cuvettes, to avoid streaks due to imperfect mixing, and time may be needed before reading extinctions, to allow small bubbles to clear.

A beaker containing about 1 litre saturated sodium bicarbonate solution should be at hand in case of accident.

DETERMINATION OF NITRITE IN SEA WATER

Reagents

Sulphanilamide. Dissolve 5 g sulpahnilamide in a mixture of 50 ml concentrated hydrochloric acid and about 300 ml water. Make to 500 ml. This solution is stable for many months.

N- (1-naphtyl)-ethylenediamine dihydrochloride. Dissolve 0.5 g of the reagent in 500 ml water. Store in a dark brown bottle, and renew if a strong brown coloration develops.

<u>Standard nitrite solution.</u> Dissolve 0.690 g AnalaR sodium nitrite (dried at 110°C for 1 h.) in water and make to 100 ml. Add 2 ml chloroform as a preservative. Renew monthly.

$$1.00 \text{ ml} \equiv 10.0 \ \mu\text{g atom } NO_2\text{-N}$$

<u>Dilute standard nitrite.</u> Dilute 1.00 ml of standard nitrite to 100 ml.

$$1.00 \text{ ml} \equiv 0.100 \ \mu\text{g atom } NO_2\text{-N}$$

This solution is stable for a few hours only.

<u>Procedure.</u>

1) Place 50 ml sample in 100 ml conical flask and add 1.0 ml sulphanilamide solution.

2) Measure extinction of sample in 10 cm cuvette at 543 mμ, as turbidity correction E_o, (Note a)

3) Between 2 and 8 minutes after adding sulphanilamide add 1.0 ml naphthyl ethylenediamine solution and mix immediately.

4) Between 10 minutes and 2 hours later, measure extinction E_1 (10 cm cuvette at 543 mμ).

5) Correct this extinction by substracting, both the turbidity (E_o) and reagent blanks (see below) and calculate the nitrite/-N concentration by multiplying by the factor F, where this is the concentration required to give unit extinction.

6) <u>Blank determination.</u>

   a) The reagent blank is found by carrying 50 ml of nitrite free distilled water through stages 1, 3 and 4 above. The resultant extinction is corrected, for "cell-cell" blank.

   b) When both sample and reference cuvettes in the absorptiometer are filled with distilled water there may be a measurable difference of extinction between them. This "cell-cell" blank must be known.

7) <u>Calibration.</u>

   Distilled water may be used. In each of two 100 ml concical flasks place 50 ml distilled water, and in each of a second pair of flasks place 49 ml distilled water and 1.00 ml dilute standard nitrite solution. Carry through stages 1, 3 and 4 above.

   The factor $F = \frac{2.00}{E^{NO_2} - E^{w}}$ where E^{NO_2} mean extinction with nitrite added
   E^{w} mean extinction with no nitrite.

<u>Notes.</u>

a) In the open ocean E_o readings for samples below about 100 m may not be measurably different from those for distilled water. There may be no need for this measurement and the "cell-cell" blank correction can be substituted.

b) The method is extremely sensitive and can be upset by oxides of nitrogen produced by flames or electrical apparatus, or by nitrite in tobacco ash.

DETERMINATION OF SILICATE IN SEA WATER

Reagents.

Molybdate. Dissolve 8.0 g ammonium paramolybdate $(NH_4)_6Mo_7O_{24}.4H_2O$ in about 600 ml water, add 24 ml concentrated hydrochloric acid (S.G. 1.18) six, and make to 1 litre. Keep in a polyethylene bottle.

Metol-sulphite. Dissolve 12 g anhydrous sodium sulphite Na_2SO_3 in 1 litre water and then add 20 g metol (p methyl aminophenol sulphate). When this has dissolved filter through a No. 1 Whatman paper into a polyethylene bottle.

Oxalic acid. Shake 100 g oxalic acid dihydrate $(COOH)_2$ $2H_2O$ with 1 litre water. Decant the solution from the undissolved crystals and keep in a glass bottle.

Sulphuric acid 50% v/v. Add 500 ml concentrated sulphuric acid (S.G. 1.84) to 500 ml water (CAUTION). Cool and adjust volume to 1 litre.

Reducing agent. Mix 100 ml metol-sulphite solution with 60 ml oxalic acid. Add slowly, with mixing, 60 ml 50% sulphuric acid and make volume to 300 ml. Prepare just before use.

Standard silicate solution. Fuse 0.1201 g silica with 0.6 g Na_2CO_3 in a platinum crucible. Dissolve salt, when cold, in water, and make to 100 ml. Keep in polyethylene bottle. 1 ml $\equiv$ 20.0 μg atom Si.

Dilute standard silicate. Dilute 5 ml of standard silicate above to 100 ml. Mix and transfer to polyethylene bottle. This diluted solution does not keep well. 1 ml $\equiv$ 1.00 μg atom Si/l.

Procedure.

1) Sample solutions should be between 18 and 25°C.

2) In a 100 ml conical flask place 10 ml molybdate solution, add 25 ml sample (note a), mix and allow to stand 10 minutes.

3) add 15 ml reducing agent, mix, and allow to stand 3 hours.

4) Measure extinction in 1 cm cuvette at 810 mμ. (Note b).

5) Correct the measured extinction by substracting a reagent blank obtained by carrying through stages 2, 3 and 4 with 25 ml distilled water.

6) Calculate the silicate concentration by means of a calibration factor F where F is silicate concentration required to give unit extinction, and obtained as follows.

7) Calibration. About 100 ml sea water, preferably of low silicate concentration is required.

i) In each of 4 flasks place 10 ml molybdate reagent, and 24 ml sea water and mix.

ii) To two flasks add 1.00 ml distilled water and mix.

iii) To two flasks add 1.00 ml dilute standard silicate and mix.

iv) Allow to stand 10 minutes and carry through stages 3 and 4 above.

Then $F = \frac{40.0}{E^{Si} - E^{W}}$ µg atom Si/l

Where E^{Si} is mean extinction with silicate added

E^{W} is mean extinction with water added.

Notes

a) If the sample has a silicate content greater than about 100 µg atom Si/l, dilution is necessary. Take 10 ml sample (pipette) and 15 ml distilled water. Since the method has an appreciable salt error, calibration should be done with diluted (40%) sea water.

b) For samples of silicate concentration of less than 10 µg atom Si/l the precision can be increased by using 4 or 10 cm cuvettes. A blank in the same size cuvette will of course be needed, and the factor F reduced in proportion, or better, redetermined.

ANNEX V

Persons participating in, working up material from, or otherwise directly interested in the geological-geophysical-bathymetric investigations carried out by IIOE - Robert L. Fisher, January 1964.

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ANNEX VI

Extracts from Mr. Bain's letter

I have made mention in my past monthly reports of a considerable water-mass which has intruded into our area of investigation and has shown to be of extremely low productivity. Trawling results have remained below 50 lbs. per trawling hour and occasional small, fast-moving shoals of pelagic fish have been observed; shoals in no way comparable with those noted at the end of the last fishing season in the same areas.

Briefly, the facts regarding this water-mass, as I know them, are as follows:-

1) It appeared in November and is still present. In the Cox's Bazar area, which is our particular area of investigation, it has covered more than half of the trawling grounds but appears to be gradually receding, though there are daily fluctuations due to tide, current and wind.

2) There is a clear line of demarcation between it and the more northerly water, with an extinction factor of ca. 34 against the latter's ca. I.2.

3) There is a decided difference in salinity, approximately 20%, although this could only be assessed for surface water.

4) Fish concentrations along the coast disappeared as this water spread over the shallower area; the sea was particularly calm during this period, November and December, and I consider only little aeration of these coastal waters could be expected.

5) No apparent radical temperature differences were recorded between the two areas, between 26.8'C and 28'C nor did there appear to be any undue current influence. The observations in the "intruding" water showing the same direction and velocity pattern as the other, i.e. SSE and SSW or NNW and NNE.

6) The line of demarcation has been observed as far as the "Swatch of No Ground" the westward limit of our area of investigation and is generally between the 10 and 8 fathom isobar.

I intend to continue observing this phenomenon in the course of the next three months; I am trying also to find means to estimate the absorbed oxygen in the two fields at varying vertical levels, as well as salinities.

It is my contention that this has resulted from an upwelling in the Indian Ocean causing the oxygen minimum layer to rise along the continental shelf with marine life preceding it. (There is no indication of plankton, though I will confirm this when a plankton net is available). As this mass proceeded northwards and eastwards the fish along the coast would tend to concentrate in pockets until conditions became intolerable, then by-pass the upwelling to the south and north. (cf. fishing map for November).

I understand that, although their vessels rarely enter the Bay, I.I.O.E. are operating to the south and it would be of extreme interest to learn if, in the past six months, evidence of an upwelling has been recorded, what data is available, and whether concentrations of pelagic fish on the southernmost fringe have been noted in the last two or three months.

ANNEX **VII.**

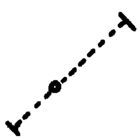
SUGGESTED CODE FOR IIOE TRACK CHART

STATION

◇ SCOR-IIOE Reference Station

○ Position Station

• BT and/or Surface Station



Seismic study

Area of Extensive Studies

Works undertaken at Station
(to be superimposed on position station/reference station)

Physical and Chemical Observation (Do, Cm, Ph, Ch)

Biological Observations (Ps, Ab)

Experimental Fisheries (Fr)

Geology and Geophysics (Gg, Mt)

TRACK

——— With underway observations

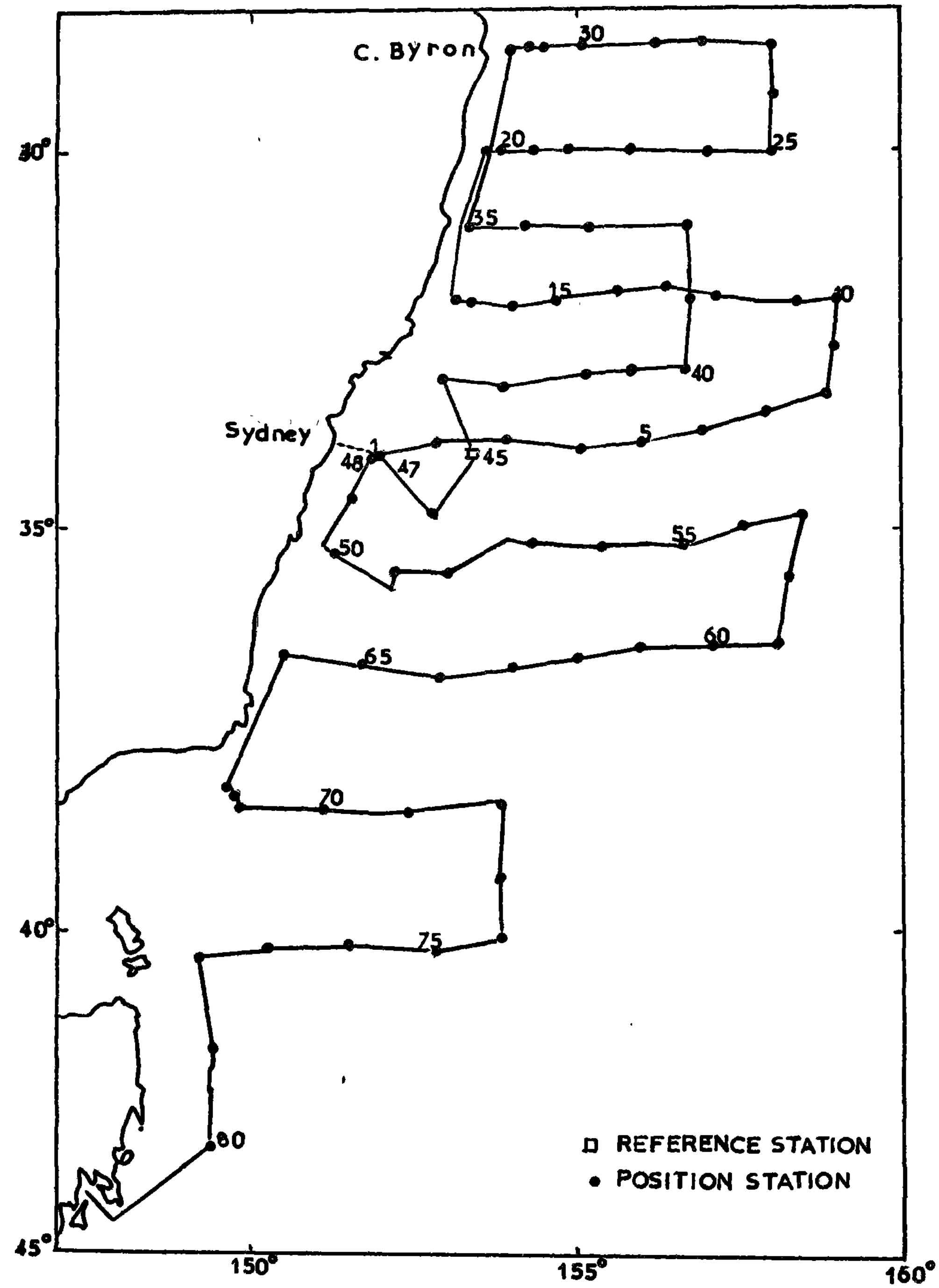
— — — Without underway observations

ANNEX VIII

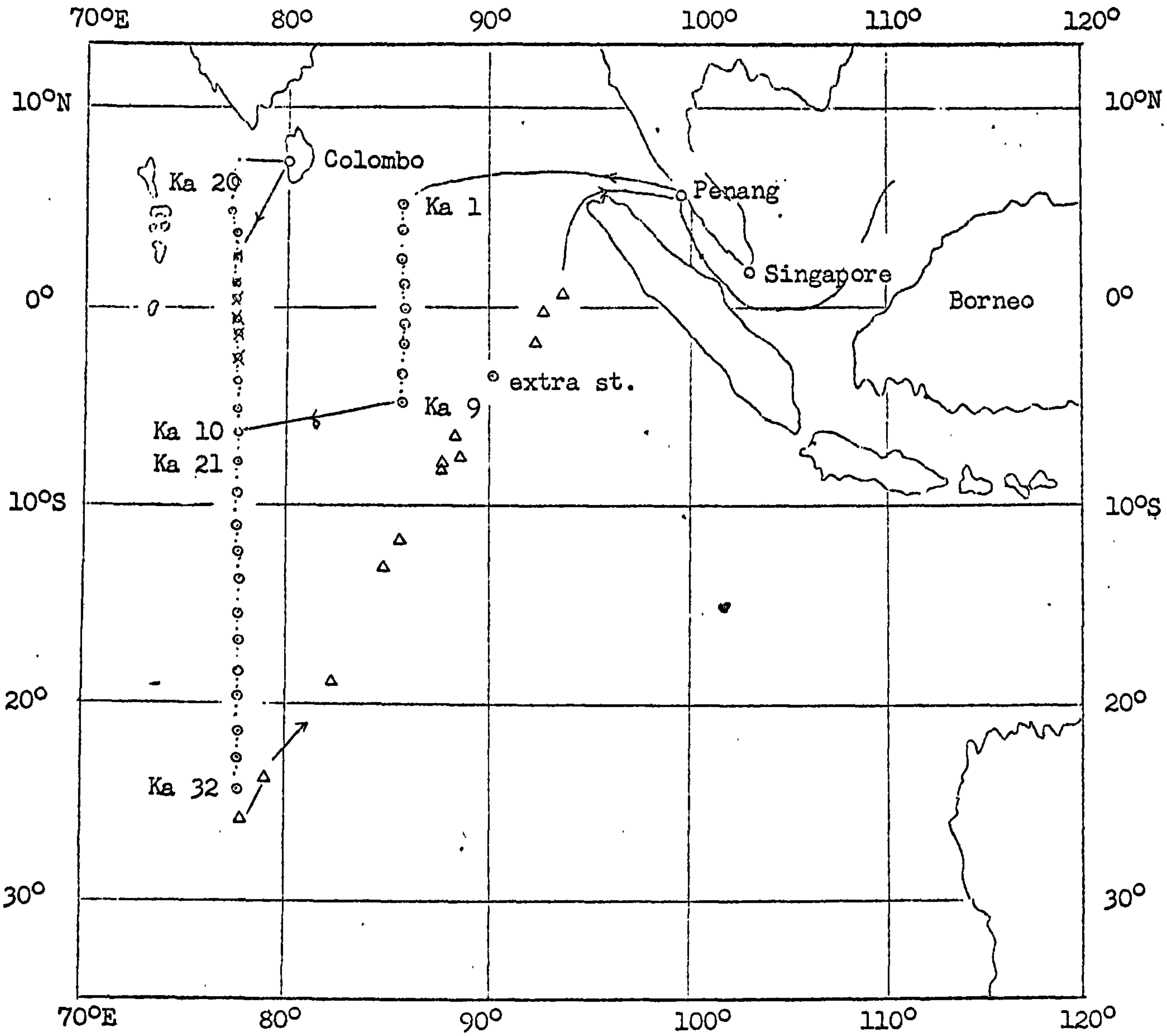
GASCOYNE

CRUISE G1/64

Jan.13 - Feb.6,1964

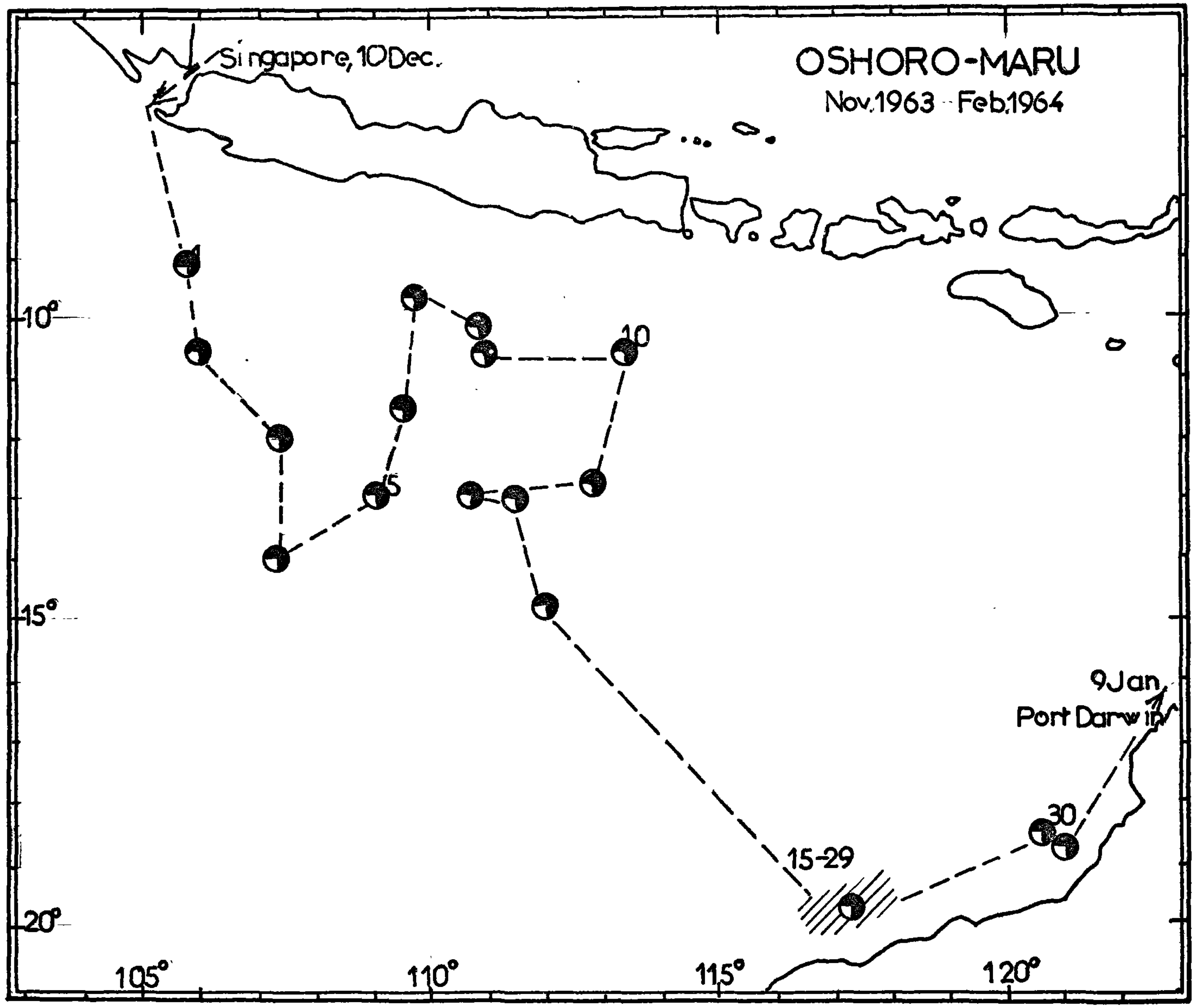


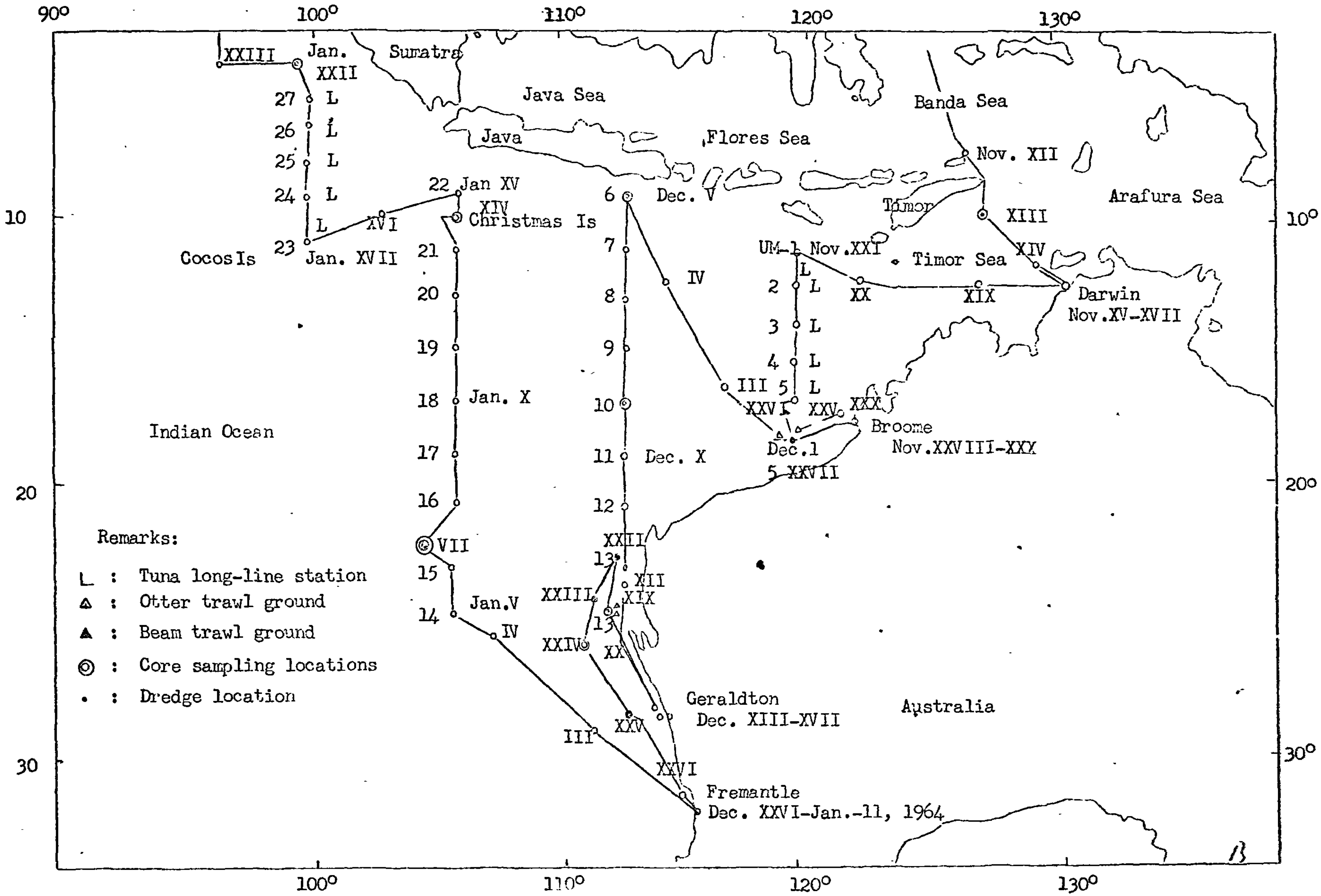
Track chart of the Kagoshima Maru, IIOE, 1963-1964



○ : Observation point (hydrographic cast)
• : Observation point (BT only)
× : Recaptured observation point after the departure of Colombo
△ : Site of tuna long line fishing operation

Observation points, 32 in total.


OSHORO-MARU
Nov.1963 - Feb.1964
Singapore, 10Dec.
9Jan.
Port Darwin
10
5
15-29
30
10°
15°
20°
105°
110°
115°
120°

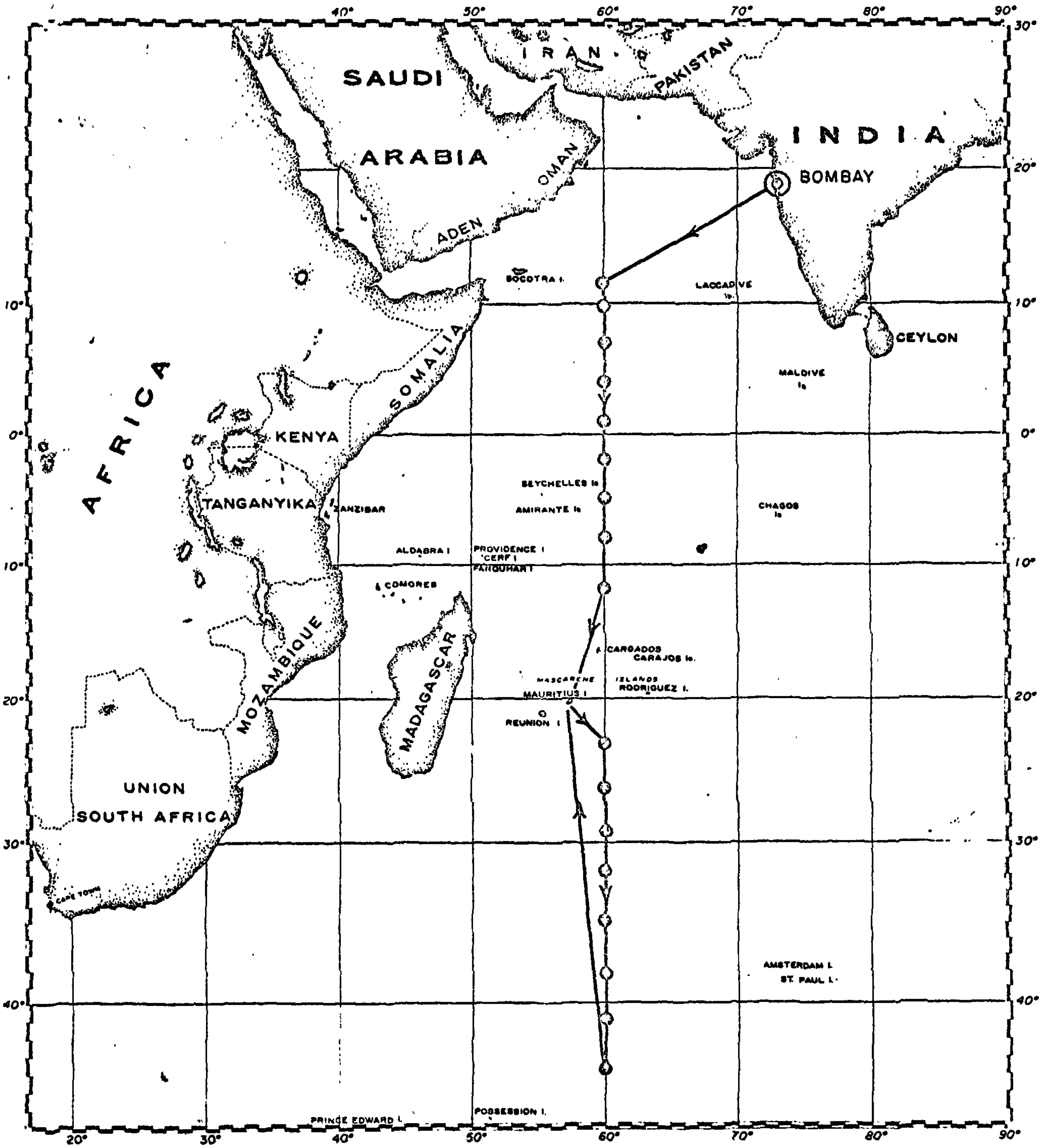


Remarks:

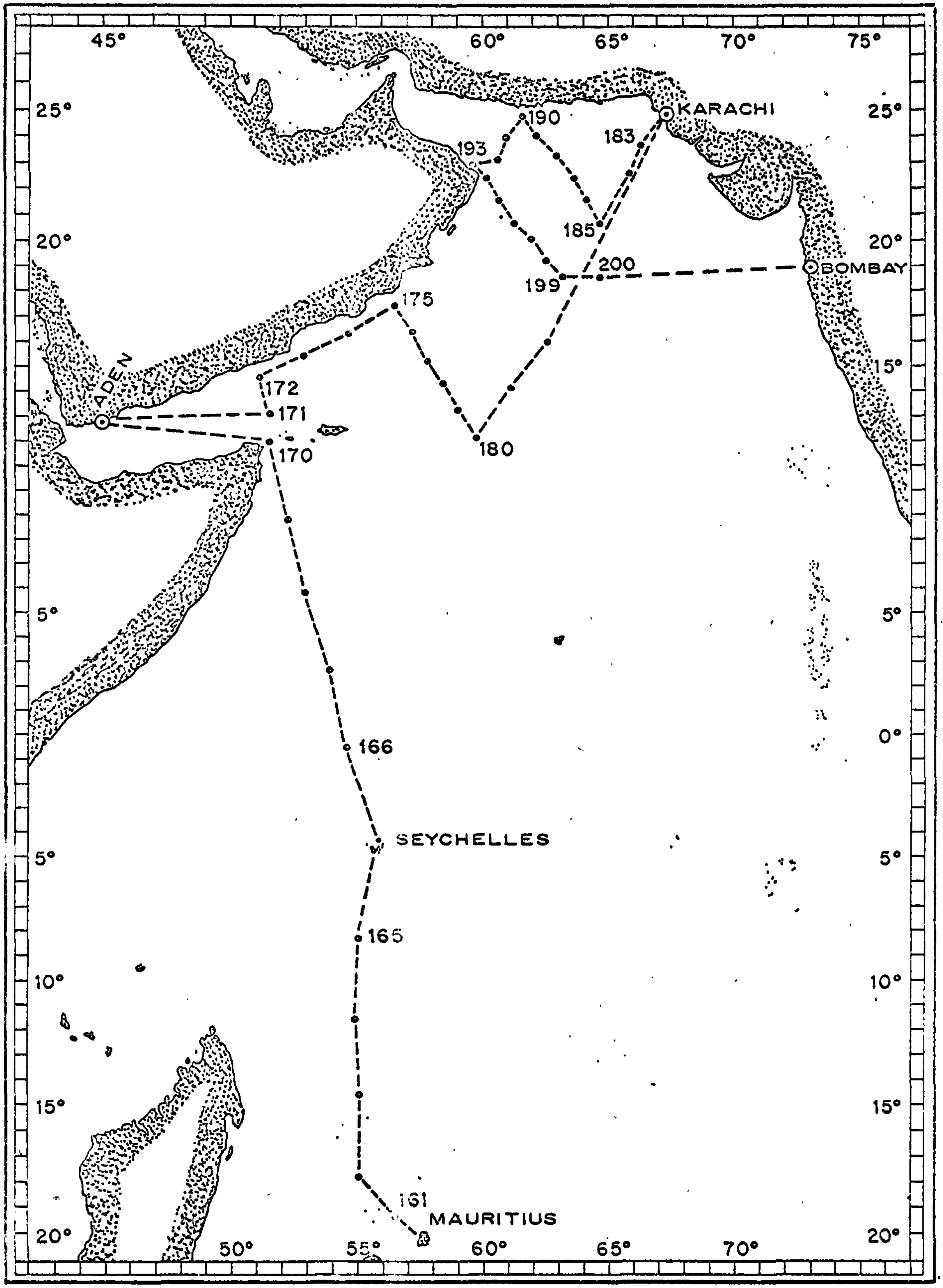
- L : Tuna long-line station
- △ : Otter trawl ground
- ▲ : Beam trawl ground
- ◎ : Core sampling locations
- • : Dredge location

UMITAKA-MARU

Showing positions at Noon, station number and ship's track.



ANTON BRUUN CRUISE III



ANTON BRUUN IV-A

Track of Cruise IV-A showing station positions.

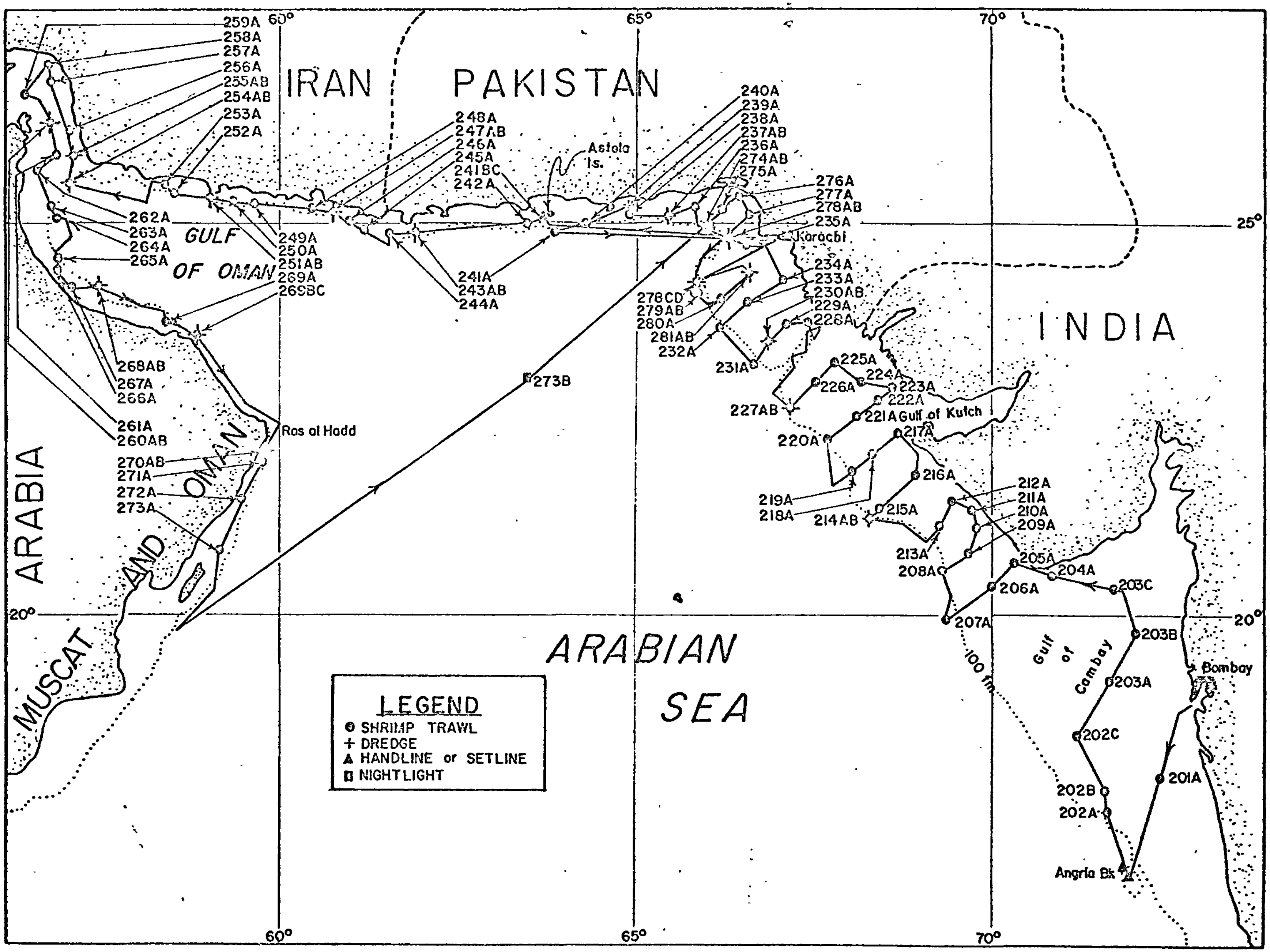
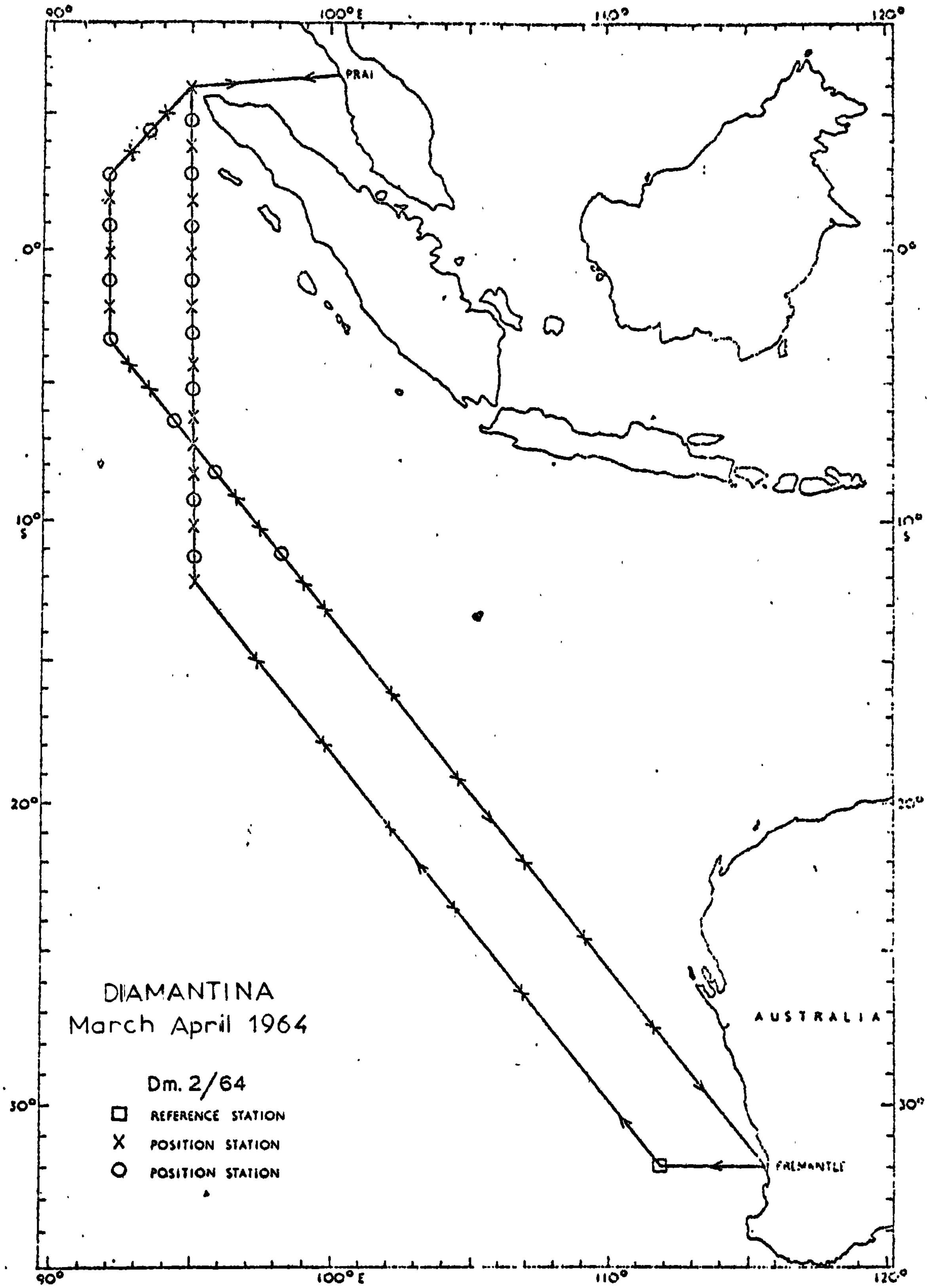
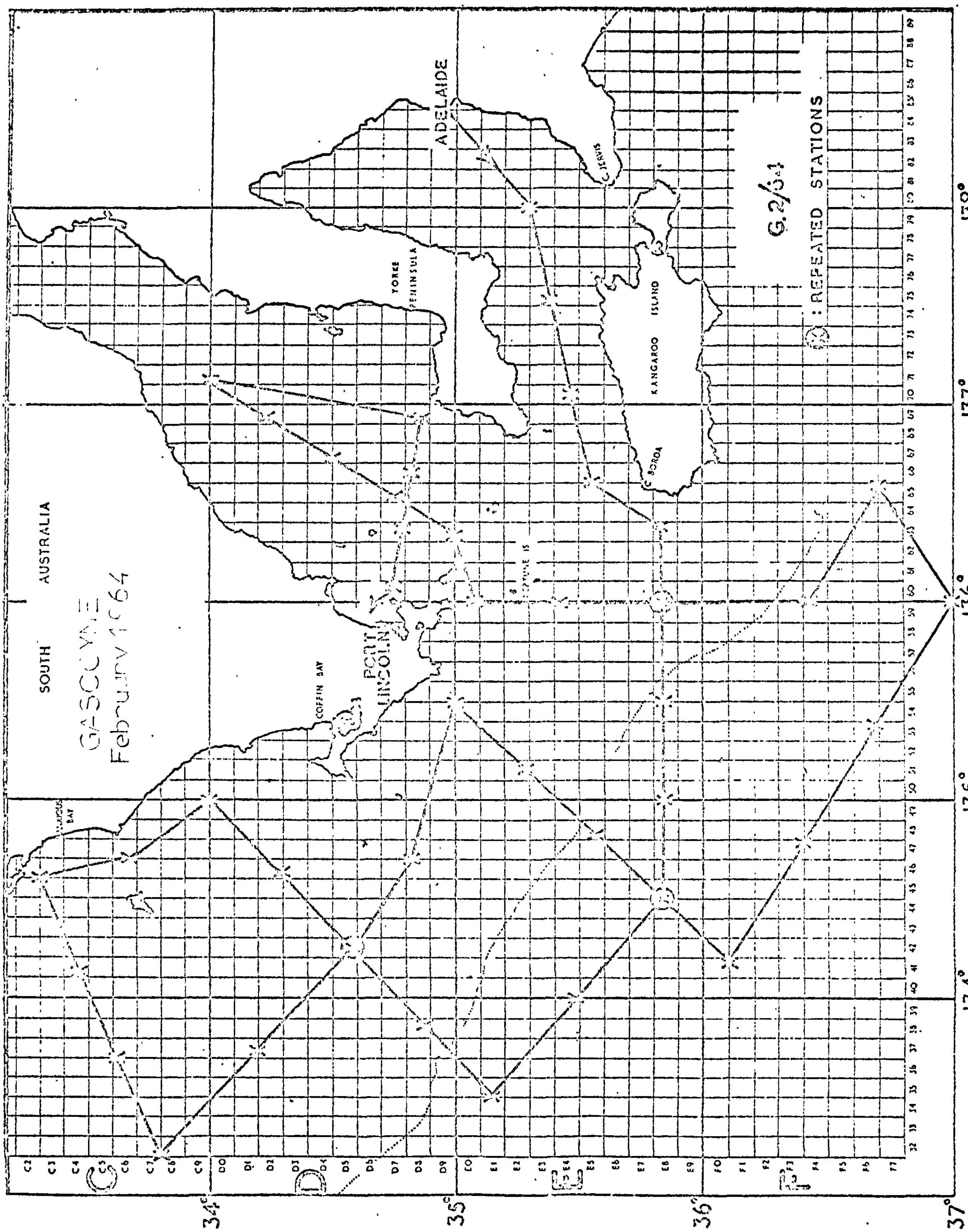
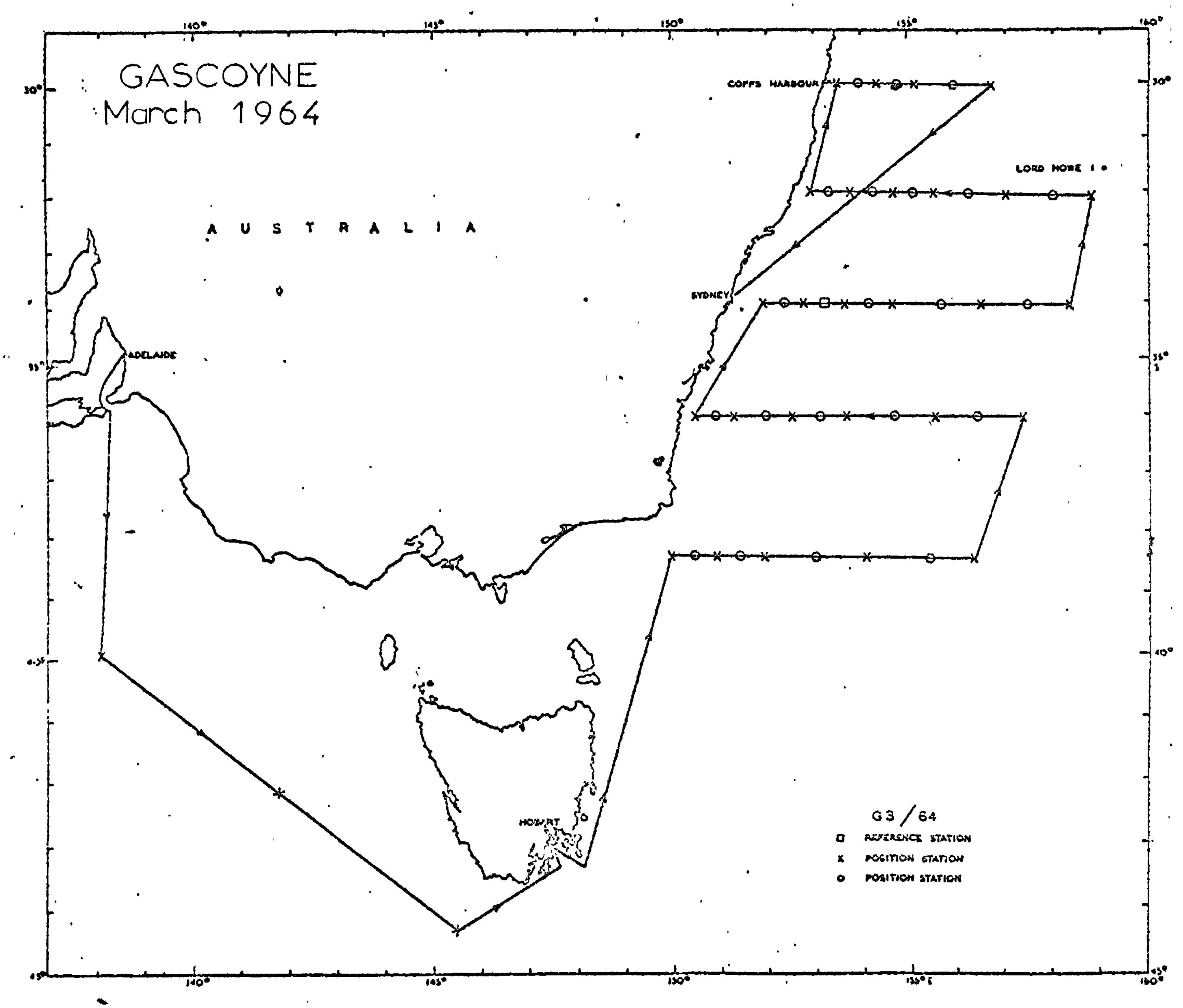
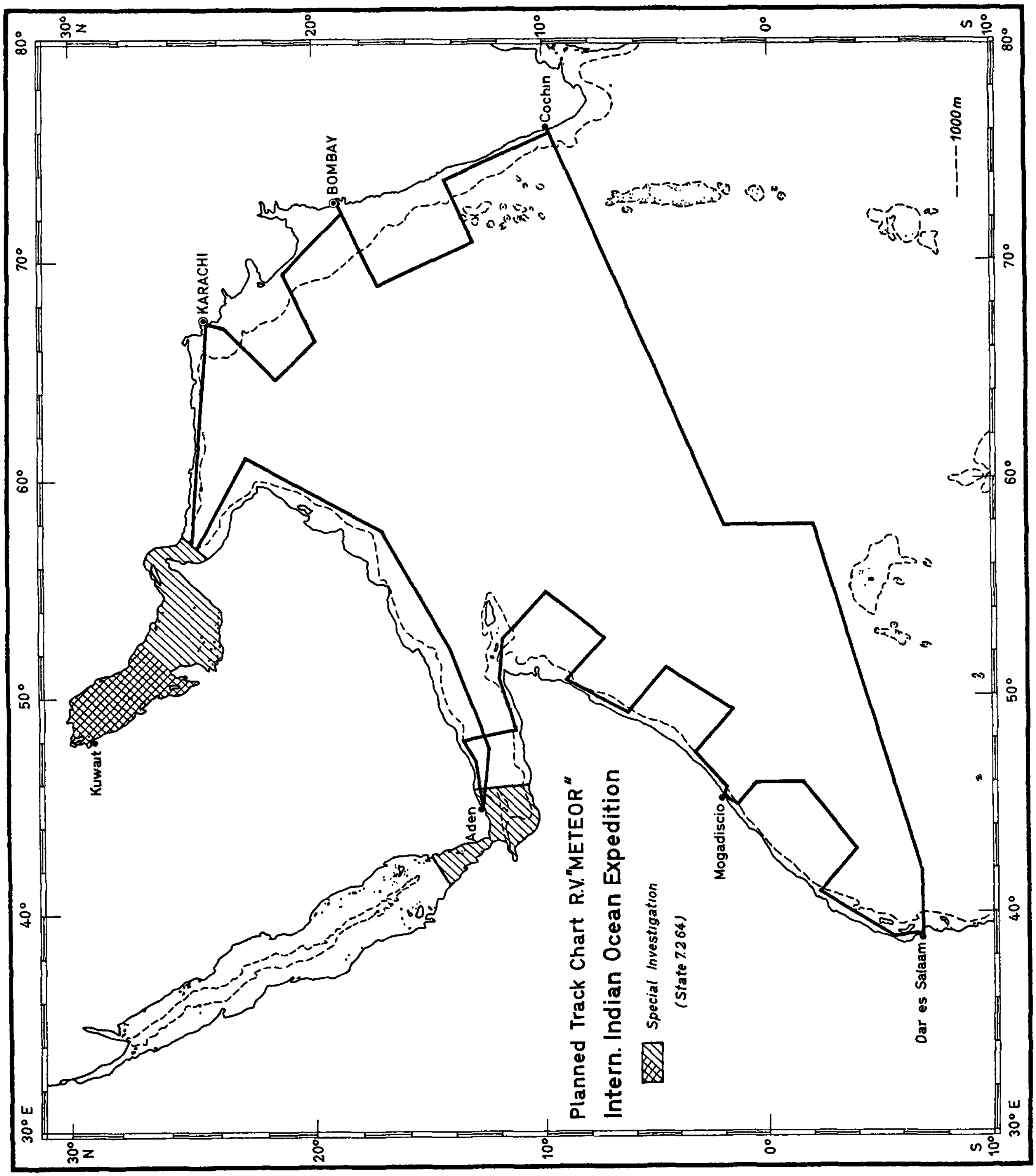


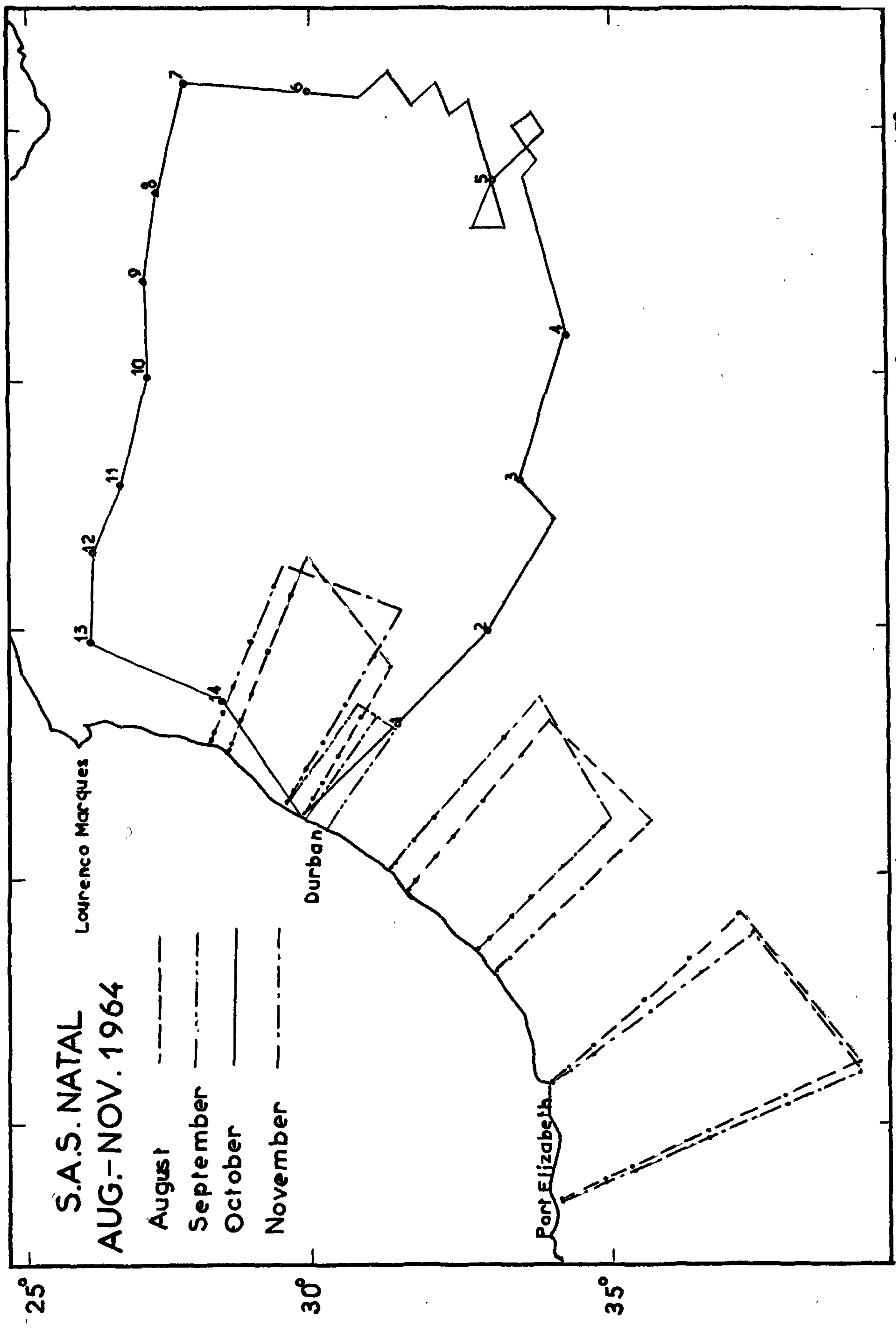
Figure 1.--Track chart of the Anton Bruun, Cruise 4B, November 12 - December 10, 1964


90°
100° E
110°
120°
0°
10° S
20°
30°
PRAI
AUSTRALIA
FREMANTLE
DIAMANTINA
March April 1964
Dm. 2/64
REFERENCE STATION
POSITION STATION
POSITION STATION


SOUTH AUSTRALIA
GASCOYNE
February 1964
ADELAIDE
YORKE PENINSULA
KANGAROO ISLAND
C. JERVIS
C. BORDA
PORT LINCOLN
COFFIN BAY
REPEATED STATIONS
134°
135°
136°
137°
138°
34°
35°
36°
37°


GASCOYNE
March 1964
AUSTRALIA
COFFS HARBOUR
LORD HOWE I.
SYDNEY
ADELAIDE
HOBART
G3 / 64
REFERENCE STATION
POSITION STATION
POSITION STATION
140°
145°
150°
155°
160°
30°
35°
40°
45°


Planned Track Chart R.V. "METEOR"
Intern. Indian Ocean Expedition
Special Investigation
(State 7.2.64)
Kuwait
KARACHI
BOMBAY
Cochin
Aden
Mogadiscio
Dar es Salaam
1000 m
30° E
40°
50°
60°
70°
80°
30° N
20°
10°
0°
10° S


S.A.S. NATAL
AUG.-NOV. 1964
August
September
October
November
Lourenco Marques
Durban
Port Elizabeth
25°
30°
35°
40°
45°
1
2
3
4
5
6
7
8
9
10
11
12
13
14

ANNEX X

LIST OF REPRINTS
comprising the first volume of the I.I.O.E. Collected Reprints

Reprint No.

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33. ROZANOV, A.G. Distribution of phosphates and silicates in the water of the northern part of the Indian Ocean. Ibid. pp. 102-114, 1964. (In Russian).

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48. BEZRUKOV, P.L. Non-uniformity of the distribution of the deep ocean sediments. Okeanologia, Vol. II, No.1, pp. 9-25, 1962. (In Russian).

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