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R.R.S. DISCOVERY
CRUISE 30 REPORT

OCTOBER - DECEMBER 1969

VERTICAL DISTRIBUTION OF ZOOPLANKTON AT 18°N 25°W

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ABBREVIATIONS

NN	Neuston net
N113	Ring net with mouth 1 sq m
7.4 W/B	7.4 litre water bottle
50 W/B	50 " " "
B/T	Bathythermograph
TSD	Temperature, salinity, depth probe
RMT 1	Rectangular midwater trawl with a sampling area of 1 sq m
RMT 8	" " " " " " " " 8 " "
RMT 90	" " " " " " " " 90 " "
RMT 150	" " " " " " " " 8 " "
	mesh size 6" - ¼" towed at 5 kts.
DTP	Depth telemetering pinger
BN	Bottom net
LHS	Longhurst Hardy Sampler
PES	Precision echo-sounder
BLL	Bottom longlines
TDL	Tuna drop lines

INTRODUCTION

Most of the work on Cruise 30 was planned to follow up observations and ideas developed on Cruise 21 in January/April 1968. The main object was to work a day and night series of horizontal opening/closing midwater trawls from the surface to 1000m and if possible deeper at a position just to the north of the Cape Verde Islands. Exploratory hauls made on Cruise 21 in March 1968 had indicated an apparently abrupt faunal change at about latitude 19° or 20°N in the longitude of San Antao Island, where the distinct southern pelagic fauna sampled at 11°N was largely replaced by a more northerly fauna similar to that studied on the SOND cruise at Fuerteventura. A similar change in the fish fauna had been observed by the Woods Hole Oceanographic Institution's ships further to the west and it seemed possible that hydrological conditions like those described by Backus et al 1965 at their faunal boundary might occur in the area we planned to examine.

Hydrological observations off the N.W. African Coast on Cruise 21 had shown a most interesting upwelling situation and it was planned to repeat one line of stations on Cruise 30. Hauls made with a bottom net in 1968 on Endeavour Bank (25°24'N, 19°28'W) had revealed a rather remarkable fauna which seemed to justify more intensive study. In addition several new kinds of nets and electronic net-monitoring apparatus had been developed and needed to be tested. A close examination of the distribution of animals in the top 100m layer was planned and hauls with the Hardy/Longhurst sampler were planned in conjunction with the vertical series as well as at the Fuerteventura position where the vertical distribution was comparatively well known.

Professor Denton with two colleagues joined the cruise to study various aspects of the physiology of deep-sea animals, in particular the functioning of photophores in Argyropelecus - a study which he began on Discovery Cruise 18 in July/August 1967.

ITINERY

Discovery sailed from Barry on the afternoon of 15th October and set course towards Las Palmas in the Canary Islands. On the 20th, 21st and 22nd at stations 7034 to 7036 various gear trials were undertaken and some of the depth pingers were calibrated. On the 22nd the ship lay to off Las Palmas to take aboard a Senior Electrical Officer who had flown out from U.K.

Discovery then proceeded towards the N.W. African Coast where on the 23rd and 24th October a line of TSD observations (St. 7037-7054) were made which repeated the Leven Head line worked in January 1968. Course was then set for a position 20°N, 23°W. At 0900 on 25th October hourly bathythermograph observations commenced and a series of net hauls were made with a combined RMT 8 and RMT 1. No distinct hydrological boundary was found nor did the net hauls show as marked a faunal boundary as had been observed in the same area in 1968, on reaching the latitude of 18°N it was decided to turn due North and to work a line of TSD and RMT 1/8 1000.0m hauls (St. 7069-7073) up to the latitude of 21°N where various other net hauls and pelagic lines were fished. The net hauls suggested that there was a fairly broad region of mixed fauna intermediate between that found for example at 11°N and in the latitude of the Canaries. The ship then turned South again and more gear testing was undertaken followed by bottom longlines and RMT 90 hauls. Passage was then made to the West to clear the Cape Verde Islands and two more TSD and RMT 1/8 1000.0m stations were worked to the South the second being in latitude 17°N on 4/5th November. The ship then sailed for Dakar arriving early on 6th November. Four scientists from N.I.O. returned to U.K. and three joined from U.K., James E. Craddock from W.H.O.I. also joined the ship. After leaving Dakar on the evening of 8th November Discovery sailed for the San Vincente/San Antao Channel. Longlining, net hauls and underwater cameras were used in this area on 10/11th November. The ship then proceeded to a position about 40 miles North of San Antao for the intensive day and night series of RMT 1 and 8 and N113 nets for determining vertical distribution. The series was given one station number St. 7089 and began on 11th November with 7089 # 1 and finished on 22nd November with # 55. The N113 acoustically operated catch dividing bucket was fished on the same warp simultaneously with the RMT 1/8 thus a successful haul resulted in 4 samples. Initially there were some failures in the release gear and in the electronics but the main part of the series 1000m was completed in six days, a great improvement on the previous cruise when the nets were fished separately. However the continuation of the series to 2000m proved unsuccessful as the signals from the depth telemeter were so faint that they were not recorded on the E/S Mufax. This may have been in part caused by the strong thermocline. In future some provision needs to be made to overcome the difficulty.

The series terminated with a series of hauls with the Hardy-Longhurst sampler and finally a short series of hauls with the RMT 90.

Discovery then proceeded to the North to carry out hauls with the bottom net, these began at St. 7090 on 24th November and continued to St. 7093 when the ship reached Endeavour Bank. Here camera stations, bottom nets, bottom longlines, dredges, RMT 1 and 8 nets and TSD observations were made until 29th November. The ship then proceeded to a position about 30 miles South of Grand Canary Island which was reached early on 30th November, RMTs and bottom nets were fished but strong winds and high seas made work so difficult that it was decided to seek a lee at the position near Fuerteventura where the SOND cruise observations had been made. Early in the morning of 1st December work again commenced, RMTs, the Longhurst sampler and bottom longlines were fished and various experiments with an activity chamber and with an air lift system for emtying the cod end of a trawl were tried. In the evening of the 3rd December Discovery sailed for Santa Cruz de Tenerife, securing alongside at 0900 on 4th December. After sailing on 6th December the ship returned to the Fuerteventura position to make a short vertical series of RMTs in the top 100m of water by day and night. This work was completed at 2000 hrs on 8th December and the ship then sailed northwards completing her programme with three half hour neuston net tows on the nights of the 9th, 10th and 11th of December (Stns 7138, 7139 and 7140). Discovery secured alongside in Barry docks at a.m. hrs on 15th December.

ZOOLOGY

1. Ostracods

Histochemical tests were carried out on a variety of species for lipids, phospholipids, disulphydryl bonds, and acid mucopolysaccharides. Lipids are stored mostly as fat droplets in the general haemocoel, and the carapace glands are rich in lipids. The other tests showed differential staining between the various carapace glands and revealed some previously undescribed glands in the trunk limbs.

Bioluminescence was observed for the first time in four species Conchoecia atlantica, C. haddoni, C. loricata, and C. concentrica. Conchoecia concentrica was found for the first time in the North Eastern Atlantic in nets fished at the surface in the vicinity of the Cape Verdes. The juveniles of this species ressembled the description of C. pectinata (Leveau 1965), suggesting that this species is synonomous with C. concentrica.

Some measurements of the sinking rates of males of C. spinirostris were made giving a range of values of 0.84 - 1.06 cm/sec. While making these observations it was seen that the normal pattern of behaviour was for the animals to sink head first with the second antennae 'feathered' back along the carapace and the first antennal setae held straight out. The exopodites of the mandibles and the 5th trunk limbs underwent feeding movements. Some of the animals were observed to dramatically reduce their rate of sinking and even become neutrally buoyant. Two animals in this state were observed with a horizontally mounted microscope, and their carapace valves were closed and there were no limb movements, although the vibratory plates of the 5th and 6th trunk limbs continued to beat intermittently. Thus it appears that these animals may possess a mechanism for rapidly regulating their buoyancy.

2. Copepods

The copepod fauna sampled during the horizontal series at St. 7089 is apparently very similar in species composition to that taken in 1965 off Fuerteventura. The most obvious difference being the large numbers of Undinula spp. in the surface hauls of the current series whereas there is a complete absence of this genus off Fuerteventura.

The horizontal series will provide a useful comparison between the catches of the N113 and RMT 1 when fished in conjunction with the RMT 8.

Most of the observations on board concerned the larger species. Colour notes were made on a large number of species and it would appear that the same species can be a variety of different colours or colour patterns. A fairly large number of specimens from different families were investigated for bioluminescence. An attempt was made to rear the eggs of Valdiviella insignis and V. brevicornis. Eggs survived for up to 12 days and although segmentation occurred no larva stages hatched out. Specimens of 4 species were frozen for future chemical analysis.

3. Euphausiids

Analysis of the euphausiids in the samples was not possible on board and only a few general observations can be made.

Euphausia americana, E. tenera, E. pseudogibba, E. gibboides and E. mutica were the characteristic Euphausia spp. at 11°N in 1968. All but E. mutica were also abundant in the samples taken during the vertical series at St. 7089. The most abundant Thysanopoda sp. was T. monacantha; the catches were notable also for the numbers of T. cornuta, T. egregia and T. cristata. At 11°N, the catches of Nematoscelis microps and N. atlantica consisted almost exclusively of specimens with saddles on one or two abdominal segments and having one or two enlarged abdominal light organs. Specimens with the same characteristics were present at St. 7089 but in what proportions is not yet known.

At Fuerteventura, the nets fished in the upper 25 m at night, including the RMT 8 with air lift, contained large numbers of Euphausia brevis and E. hemigibba, both of which were taken only in small numbers in the night samples during the SOND cruise vertical series.

4. Amphipods

As has been apparent from material gathered on previous cruises, amphipods form a numerically relatively insignificant part of the fauna in those waters.

It has not been possible to identify more than some of the larger specimens obtained. Despite this, several differences between the 1965 Fuerteventura series and the Cape Verde material are apparent. Primino, although probably the commonest amphipod in the Cape Verde collections, does not form such a dominant part of the fauna as was the case in the Fuerteventura material. In contrast to this both Cyphocaris challengeri and Scina crassicornis are much more abundant in the collections of this cruise. Scypholanceola, absent from the Fuerteventura collections was the commonest amphipod in the deeper samples taken off the Cape Verde Islands.

All specimens of the family Oxycephalidae recognized in catches have occurred in shallow samples - 300m or less - thus confirming previous suspicions that they are normally absent from deep water. Examples of Eurythenes and Cystisoma will aid the solution of taxonomic problems while specimens of the rare genera Chousenxiella and Minonectes extend the known ranges of those genera.

Hemityphis is the commonest amphipod found in surface samples although on one occasion an Oxfam sample was completely dominated by Anchylomera. Bottom net samples were, on the whole, disappointing, although the deepest station worked with this net (3311m between the Cape Verde Islands and Endeavour Bank) produced eight species of Lysianassids, Lepechinellids and oedicerotids. A dredge sample taken in shallow water off the African Coast (St. 7045) contained ca 25 species of amphipods in a fauna that was otherwise very sparse.

The great excess of larger amphipods caught in the RMT 8 suggest that the RMT 1 and N113 are not able to sample adequately the whole amphipod population. The observed excess may be due in part to a downward escape reation.

Colour notes on 40-50 species were made. In several cases closely related species were found to have quite distinct colour patterns.

5. Decapod Crustacea

Our main interest lay in the region between 20°N and the Cape Verde Islands in which, during Cruise 21 (January to March 1968), marked changes in the decapod fauna had been observed. During the present cruise intensive sampling, supplemented by hydrological observations, was conducted in this area to investigate these faunal changes in detail, and to see whether or not they were associated with any physical or chemical discontinuity.

From a provisional analysis of the RMT 8 samples and the associated hydrological data it is clear that conditions differed from those observed in 1968. The northern and southern decapod faunas were not clearly separated and it would appear that the area, as far south as we were able to sample, represented a broad zone of transition in which northern and southern faunal elements were intermixed. Thus Acanthephyra purpurea and A. pelagica, which typify the northern fauna, occurred as far south as 17°N while their southern counterparts A. sexspinosa and A. acanthitelsonis occurred as far north as 20°N. These species pairs were sampled together, contrasting with our observation of 1968.

A position north of the Cape Verdes, (series at Stn. 7089) was selected in which to investigate the vertical distribution and diurnal migration of this mixed fauna, and to provide a comparison with data previously obtained at Fuerteventura (1965) and 11°N (1968). The decapod catches were numerically small but rich in species. Both A. sexspinosa and A. acanthitelsonis occurred relatively deeper than at 11°N and were associated with their northern counterpart. By day A. sexspinosa and A. purpurea occurred together at depths of 700-1000m, migrating at night to 200-400m while the deeper living species, A. acanthitelsonis and A. pelagica occurred by day at 800-1000m and at night at 400-800m. It is probable that a similar distributional pattern will emerge when the numerous species of Sergestes and Gennadas are analysed.

The deeper hauls at this station, and elsewhere in the general area south of 20°N, were remarkable for the presnece of a number of species usually considered to be rare. Included were 12 individuals of Physetocaris microphthalma, and 50 specimens of an undescribed species of Acanthephyra.

Deep hauls with the bottom net (BN) also yielded some interesting decapods, including Plesiopenaeus edwardsianus Polycheles sp. and Glyphocrangon sp. (Stn. 7090) and, as in 1968, specimens of Acanthephyra microphthalma (Stns. 7091, 7092). The hauls on Endeavour Bank were somewhat disappointing in that the spectacularly large Plesionika longirostris of 1968 was not sampled. Nevertheless the catches were rich in carideans and penaeids and it is clear that some of the shallower areas of the bank support a rich fauna of decapods.

6. Cephalopoda

A total of over 700 cephalopods were picked out on board and these included the very rare species Cycloteuthis sirventi, Discoteuthis laciniosa, Galiteuthis armata, Valdemaria danae, young of Phasmatopsis, Lepidoteuthis grimaldii and Taningia danae. A second specimen of an undescribed taonid having dorsally directed eyes was collected.

During the vertical series of the RMT 8 196 cephalopods, including 59 octopods, were collected. This represented an average of 6.5 cephalopods per haul. Hauls above 100m contained an average of 19 (6 hauls) and hauls from 100-1250m an average of 3.6 (24 hauls). Above 100m 43 cephalopods were taken in daylight and 70 were taken in darkness. Below 100m, 53 were taken in daylight and 30 were taken in darkness. The commonest species taken were Liocranchia rheinhardti (53), Japtella diaphana (23), Cranchia scabra (22), Onychia carribaea (20), Vampyroteuthis infernalis (12) and Pyroteuthis margaritifera (10).

The cephalopod collection in this series differed from that taken in 1968 at 20°N11°W by including twice as many species (over 33 against 17), in having only a single specimen of Mastigoteuthis flammea, the species dominant in 1968, and in having no peak in the distribution of cephalopods at a depth of 600-700m.

7. Fish

The main collections of mesopelagic fishes centred around the vertical series fished with the RMT 8. Superficial analysis of the catches indicated that the number of species represented was fewer than in the similar distribution series made at 11°N (Cruise 21), although the species composition at depth was similar. Once again, Cyclothone was numerically the best represented genus (7 spp.). Myctophids were the second most abundantly sampled group, with at least 42 spp. present.

Of the general collection, the captures of the rare fshes Lampadena anomola (Myctophidae) and Pachystomias (Melanstomiatidae) are noteworthy. A further 2 specimens of Argyripnus atlanticus (Gonostomatidae) were obtained. As was the case with the specimens caught in 1967 (cruise 18), the captures were coincident with net fishing close to the bottom in fairly shallow water. Several specimens of Benthabella ?infans (Scopelarchidae) were taken throughout the cruise, and also at least one specimen of B. ?dubius. Apogonids were not infrequently caught.

Few deep benthic fishes were caught by the bottom net, but small macrurids, biotulids and bathypteroids were all represented in the catches. Of special interest was a specimen of Bathytyphlops. This specimen, in excellent condition, was caught 3311m depth, and was 288mm S.L.

Luminescence was observed in a wide variety of species; searsids, gonostomatids, sternoptychids, astronesthids, melanostomiatids, malacosteids, myctophids, melanscetids. The most spectacular display was that of Echiostoma barbatum, whilst that of most interest was from Pachystomias.

Otoliths were removed from 473 specimens, representing 6 orders (12 suborders), 25 families, 49 genera and 85 species. In addition, another 100 otoliths were removed from three bottom net collections. As otoliths are the only fish remains in the stomachs of larger pelagic fishes and cetaceans, the primary purpose of the otolith removal was to ascertain whether otoliths are useful specific characters (in shape and/or size).

Surface collections were made throughout the cruise. Comparison of the catches made off the Cape Verde Islands with those from off Fuerteventura, Canary Islands, showed that fewer individuals of more species were collected in the former area. The main families represented were the Gonostomatidae, Astronesthidae, Myctophidae and the Exocoetidae. At St. 7089 # 43, a wooden champagne crate was taken in the surface net together with approximately two dozen each of juvenile rainbow runners (Elagatis bipinnulatus) and 2 species of trigger fish (Balistidae).

A number of surface forms were caught by hook and line during the cruise. The most numerous were dorade (Coryphaena hippurus), while several white-tip shark (Carcharhinus longimanus) and one blue shark (Prionace glauca) were also taken. Specimens of two genera of remora (Remora and Echineus) were collected from these sharks. A single hammerhead was observed at the surface close to the ship.

8. Decapod development and eggs

Eggs of eleven species of decapod crustacea were maintained on shipboard to obtain the early larvae and for comparative studies of their development times. Particular emphasis has been placed on comparative development times of different species of Acanthephyra and the effect of temperature on the development of A. purpurea.

Density/lipid/size relationships in some decapod eggs have also been investigated.

9. Animal colouration

Several species of euphausiid and decapod have been collected and deep-frozen for carotenoid pigment determination in relation to their vertical distribution.

Observations have been made on the purple colours of some deepwater plankton species, in conjunction with reflectance measurements on certain decapods and mysids, and on the structural basis of the blue colours of some neuston species.

10. Bioluminescence

Observations have been made on the bioluminescence of a considerable number of zooplankton species, in conjunction with recordings of the intensity and temporal characteristics of many of the responses. Particular attention has been paid to the amphipods, Scina, Proscina, Cyphocaris and Paraprontie (with M.H. Thurston) and deepwater copepods including Megacalanus, Gaussia and Euangaptilus species (with H.S.J. Roe). Among the decapods the luminescence of the photophores of Oplophorus, Systellaspis, Parapandalus, and the organs of Pesta of some Sergestes species has been observed, as well as that of the secretions of Heterocarpus, Acanthephyra acutifrons and Oplophorus.

The effect of drugs, in particular serotonin metabolites, has been tested on the initiation of luminescence in three species of euphausiid, and the angular distribution of light from three species of euphausiid and one decapod has been determined.

Luminescence has also been observed in the cephalopods Spirula, Histioteuthis and Onychoteuthis and, in a number of species of fish. Recordings having been obtained of most of the responses. Of the fish the shallow species such as Gonichthys, Myctophum, Centrobranchus, Diplophos and Astronesthes have been studied most frequently, but the most striking display observed was that of the cheek organ and luminescent epidermal tissue of Echiostoma barbatum. Cheek organ flashes have also been obtained from species of Heterophotus, Chauliodus, Gonostoma, Photonectes, Borostomias and Melanostomias. The luminescence from the ventral photophores of some of the above species, as well as from others such as Idiacanthus, and that of the lines and barbels of certain angler-fish and stomiatoids has also been investigated. Of particular interest was the luminescence of the shoulder organs of several species of searsid, which appears to be produced by a system very similar to that of Chaetopterus.

11. Moulting experiments with euphausiids

Previous experiments on the moulting rate of euphausiids have been carried out at constant temperatures. Since many of the species used are diurnal migrants it was considered important to try to determine the effect, if any, on the moulting rate of the environmental changes experienced during the migration.

As the moulting rate is known to increase, within certain limits, with increasing temperature, and this is the parameter most easily varied these first experiments consisted simply of keeping specimens at a high temperature at night and a low temperature during the day. Control specimens were maintained constantly at the two temperatures and for others the normal cycle was reversed, that is they were kept at the high temperature during the day and the lower temperature at night.

Two species, Euphausia tenera and E. americana were used for the experiments, they were fed on Artemia nauplii and examined for moults at approximately four hourly intervals.

Euphausia tenera was kept at 10°C and 18°C. When subjected to these temperatures by day and night respectively a mean intermoult period of 4.1 days was obtained compared with 2.8 days for those held at a constant 18°C. Specimens with the normal cycle reversed also moulted at approximately 4 day intervals but showed a much higher mortality. At a constant 10°C only a single specimen moulted and mortality was very high.

Euphausia americana was kept at 12°C and 19°C. Those subjected to a normal temperature cycle showed a mean intermoult period of 2.7 days and those at a constant 19°C a mean intermoult period of 2.1 days. As with E. tenera the mortality was higher when the cycle was reversed; only a single specimen moulted twice, the intermoult period being between 3.5 and 3.9 days. At a constant 12°C specimens each moulted once only and thus no intermoult period is available. Unfortunately the experiments with E. americana were terminated abruptly when the animals were put into high salinity surface water.

It seems probable that the lower temperatures used, although near to the daytime temperatures for the species, were too low for the animals in culture, although E. americana was kept at 14°C for up to 46 days in 1968. The difference in the mortality for animals exposed to the normal as opposed to a reversed cycle suggest that the experiments would be worth repeating but using temperatures rather closer together.

12. Physiological work

The photophores of mesopelagic fish In oceanic fish photophores often have chambers with highly reflecting walls, within which light is generated, opening into structures with reflecting surfaces which distribute the light. Between the generating and distributing structures there is often a layer of coloured tissue. The histology of a number of these tissues has been well studied by Bassot but their function is not known for certain.

Photophores in freshly caught specimens of a number of mesopelagic fish were studied. These, when freshly trawled, often emit light spontaneously and the injection or local application of adrenaline usually increases and prolongs this light.

In general the coloured tissues were found to transmit a relatively small fraction of light, even for the wave bands which they preferentially transmit, but there was no evidence that they are concerned in the production of light; on the contrary when they were cut away the emission of light was always very much increased. In the photophores which shine mainly downwards these 'filters' usually have a band of transmission in the blue-green (λ around 480 nm) i.e. the light to which the oceans are most transparent; and where photophores with filters of this kind were seen to emit light, this light was always blue-green. In several species of *Argyropelecus* and *Sternoptyx* the 'pigment' in the 'filters' seemed, from its absorption spectrum, to be largely reduced Cytochrome C which suggested the possibility that the transmission of light could be altered by oxidation-reduction mechanisms.

It has been suggested that the purpose of many photophores is to obliterate the shadows of the possessors' ventral surfaces and so make them difficult to dee. If this were so the 'filters' in fish like *Argyropelecus* could have the important function of allowing the light from the photophores to match the colour of the light which penetrates best into the ocean.

Close to the eyes of some fish there are large photophores which are covered with tissues which transmit only red light. In one such fish, *Pachystomias*, these photophores were seen to emit flashes of red light. The photosensitive retinal pigments of the eye of this fish indicate that it is probably more sensitive to red light than those of any other eye which has been studied. The maximal retinal absorption is for light of wavelength about 575 nm and its maximal optical density is about 1.0. Another fish with red photophores, *Malacosteus niger*, has a bright red tapetum (E.J. Denton with P.J. Herring showed that the red pigment of the tapetum is astaxanthine). Clearly animals which can emit, and are exceptionally sensitive to, red light will have a considerable advantage in hunting, or avoiding, red and brown animals in an environment where the eyes of other animals are relatively insensitive to red light. The photophores on the ventral surfaces of *Pachystomias* have filters of exactly the same colour as those of *Argyropelecus* and emit not red but blue-green light.

In all the fish examined there was then no evidence that the coloured tissues in photophores have any other function than acting as filters which determine the spectral properties of the light emitted.

On two species of Argyropelecus and Chauliodus sloanei the distributions of light in two vertical planes one containing the antero-posterior axis of the fish and the other at right angles to this axis were measured. These distributions are those required to match, over a wide range of angles of viewing, the external light field in the oceans. These observations give strong support to the hypothesis that the function of many photophores is that of camouflage.

The neuro-physiology of ammoniacal squid   On earlier cruises it had been shown that a number of families of squid accumulate large concentrations of ammonium to bring themselves to neutral buoyancy. During this cruise it was shown that nerves from such squid (which accumulate ammonium in concentrations of 500mM in some parts of their bodies) cannot conduct impulses when the ammonium concentration in the external medium is raised to around 50 mM. It seems evident, therefore, that although such nerves can be closely associated with tissues containing high ammonium concentrations (for instance, the axial nerves of the arms of Calliteuthis) they must always be protected from this substance.

Buoyancy in crustacea and oceanic fish   With P. Foxton the buoyancy mechanisms of a number of crustaceans were studied and further measurements of buoyancy in oceanic fish were made.

Silvery layers in fishes   The distributions and organisations of the guanine crystals in the silvery layers in a number of oceanic fish were studied. Particular attention being directed at such layers in the swmibladders of fishes.

GEAR

1. RMT 8 and RMT 1

For the first time, an RMT 8 was used in combination with an RMT 1 using the same release gear so that the two nets operated at the same time. In this way, fewer lowerings were necessary during a vertical series to 1000 m and considerable ship's time was saved. After only two opening-closing trials of the combination net the series was commenced. In all, 52 attempts to open and close the combination RMT 8-1 net were made, 36 were successful and of the 16 failures, 6 were due to failures of the release gear, 5 to tangling of bridles or carbine hooks and 3 to pinger failure. Probably 5 of the 6 failures of the release were due to a lack of acoustic sensitivity particularly at the greater ranges. 2 of the 3 pinger failures were at depths in excess of 1000m and these, and possibly failures of the acoustic release, are thought to be caused by cooling of the batteries.

Considering the complexity of the combination nets a failure of 16 in 52 hauls is not unreasonable at the present stage of development. A haul in which the nets failed to open and another in which closure took place immediately after opening showed that virtually no leakage takes place when the nets are closed in either the top or the bottom positions.

A new type of conical cod end bucket was introduced which proved easier to use and the condition of the catch was better than in previous years.

2. <u>RMT 90</u>

Six hauls were made with a new stepped-mesh RMT 90. In quantity, the catches were all similar to average catches made with an Engel's midwater trawl although none of them were as large as the best Engel's trawl catches. Four of the hauls contained a spectacular assortment of fish and squid. Two hauls each contained a squid larger than any previously taken in any net used aboard "Discovery" or "Discovery II". One of these was a large <u>Ommastrephes caroli</u>, a very fast swimming species, and the other was a large <u>Calliteuthis</u>. The net proved easy to handle after initial modifications and the condition of the catch was better than that of most Engel's and British Columbia midwater trawls previously used by N.I.O.

3. <u>Net monitor</u> (Flowmeter pinger)

A new depth telemetering pinger which incorporated a flowmeter, temperature probe, acoustic release and batteries in one housing was used for the first time. After considerable trouble with screening between the various circuits, modifications were made to the design by Mr. M. Harris and Mr. N. Millard, Mr. R. Wild made modifications to the casing to overcome leakage. The monitor was used on 26 opening-closing hauls and, on the whole, proved extremely successful although a few modifications could improve the system further. The traces on the Mufax recording 'locked in' at a position one second from the reference pulse as well as 'locking' into one another when they crossed. On one occasion, such a disappearance of the depth trace at a critical period led to the net hitting bottom and being seriously torn. Interpretation of the flow trace would be easier if it could be made more linear. Failures of this gear occurred at the greater depths and is thought to be caused by temperature effect on batteries.

While many small improvements could be made to the monitor, it has many advantages over the 'E' type pinger with its multiplicity of external leads, its step-like trace and its more restricted potential.

4. <u>Bottom net</u>

The modified net as described in the Cruise 21 report was used, with some modifications. A chafing net protected the main net, into which a liner of approximately 1 mm netting was fitted. Coarse netting was attached to the sides and top of the frame to reduce loss of the more active animals. Two tickler chains were fitted to the front of the frame with a small shackle as a weak link. 40lb of weight was added on either side of the back bottom bar, and on the later hauls, to ensure that the entire surface of the skids was in contact with the substratum, an additional 60lb was added to the front of each of the skids. Buoyancy, previously in the form of a piece of 4" x 3" timber, was omitted and this did not affect the towing of the net. The net was used ten times and in each case fished the right way up. A 'D' type pinger was attached 50m up the towing wire, though this was not very satisfactory in the deep hauls.

4 hauls were made in depths between 3300m and 2300m, and 6 hauls on Endeavour Bank in depths between 385m and 300m, with wire-out to depth ratios between 1.2 and 1.5. The catches were very varied, depending on the substratum of the area sampled, which varied from oozes to coarse sand. The frame was damaged during one of the later hauls, probably due to the tickler chains catching on an obstruction and causing the poles to bend before the weak link broke; the shackle was replaced by string.

5. Longhurst Hardy Sampler

A sampler based on Longhurst's modification of the Hardy plankton recorder, has been designed and built at N.I.O. This was the first cruise on which this prototype was used. The first two trials gave incomplete series of samples, but after some minor adjustments four successful series of samples were collected. All four hauls were made at Fuerteventura, two to a depth of 550m by day and another by night, and the fourth in the region of the thermocline at 100-120m. The sampler, used in conjunction with the net monitor giving simultaneous in situ records of depth, temperature and flow, promises to be a most powerful tool in the study of the microdistribution and of species associations of oceanic plankton.

6. Tuna dropline

A pelagic dropline for tuna was used from "Discovery" for the first time during the cruise. This fishing method is currently being developed experimentally by the Japanese. The gear consisted of a vertical line, lightly weighted at the bottom end and suspended from a buoy at the surface. In contrast to a conventional tuna longline, each dropline bore only 8 hooks on short branch lines at its lower end.

Three different lengths (90m, 140m, and 190m) of mainline were used to connect the buoys to the lower hook-bearing portions of the lines fished. In this way it was estimated that, when the lines equilibrated with the prevailing forces of wind and current the hooks would lie from the thermocline to some 100m below it.

A total of 7 lines were fished on four separate occasions.

Strips of squid were used as bait and the lines were left to drift freely in the water for periods of 3 to 10 hours. No catch was made on any of these lines. On every occasion the hook-bearing branch lines were found to be tangled around the vertical line with the baits intact. More tests are necessary, however, to evaluate this new method since, by comparison with an average tuna longline catch of 3 fish per 100 hooks, the chances of taking tuna on the 56 hooks fished were low.

7. Bottom longline

Bottom longlines were fished off the Cape Verde Is. (2 lines - 90 and 27 hooks), on the Endeavour Bank (2 lines - 56 and 53 hooks), and off Fuerteventure, Canary Is. (3 lines - 6, 51, and 23 hooks). From the total of 306 hooks fished, 18 fish of 9 species were caught. This catch rate of 6% is considerably lower than on the two previous cruises, and may have resulted from the heavy tangling of ground lines which occurred.

At the Cape Verde Is. the lines were fished in 3333m and 1396m depth, and caught 1 Chalinura ?leptolepis and 1 C. ?leptolepis and 2 Synaphobranchus ?kaupi respectively. Bait loss on the first occasion amounted to less than 1%, but was 7% on the shallower line. Both these lines were weighted only at the far end, and it is considered significant that the catches were made on the hooks close to the weight. Despite the wire ground line, the distribution of catch along its length suggests that the proximal end was held clear of the bottom.

The first line fished on Endeavour Bank, at a depth of 366m, was weighted at each end of the ground line. It caught 3 Polymixia ?nobilis and 1 Carcharhinus obscurus. The latter, a mesopelagic species, was probably caught as the line sank and caused considerable tangling of the ground line. The second line was laid in 852m and was again fished with a single weight. This caught 1 Ruvettus pretiosus at the proximal end, thought to be above the bottom, and 1 Hexanchus ?griseus at the weighted end. After a prolonged attempt to land the Hexanchus, the hook broke loose and the fish was lost.

No catch was made on the first line laid up the slope from 620m to 207m, off Fuerteventura as the ground line broke and only 6 hooks were retrieved. This line, and the other two fished in this area, was weighted at each end of the ground line. The second line laid in 865m caught 1 Deania sp. and 4 Mora mora. However the ground line was considerably tangled and severl hooks were missing, presumably from catching on the bottom. The last line fished was at 1289m depth and caught 3 Centroscymnus coelolepis, but again the ground line was badly tangled and some hooks lost.

8. Activity Chamber

The aim of this prototype device is to continuously monitor on deck the swimming activity of a pelagic animal (previously taken in a net haul), as it is lowered progressively on a vertical conducting cable, to the depth at which it was caught. In this way it is hoped to gain some relative measure of the activity of migrating organisms at their day and night depths. It is also possible to record the activity of an animal for long periods of time under controlled laboratory conditions.

Initial tests revealed a number of design faults which were rectified by Messrs. R. Wild and N. Millard. Subsequent trials with the decapods Acanthephyra purpurea and Oplophorus spinosus showed that it is possible to record swimming at depths down to 1000m. It is too early to assess the significance of these preliminary results but they are encouraging and future work is planned.

9. Underwater Camera

Bottom net hauls on the Endeavour Bank in 1968 appeared to indicate a rich decapod fauna in which the relatively large Plesionika longirostris was common. Because of this a camera survey of Endeavour Bank was planned with a view to establishing existing bottom conditions and also to record if possible these large decapods in their natural habitat.

For this purpose we had borrowed an O.E.C. "Shipek" 70mm deep sea camera from the Research Vessel Unit. This was set on remote bottom switching and fitted on board with a pinger which indicated (by doubling its ping rate) when a picture had been taken. Opportunity was taken on the second leg of the cruise to become familiar with the working of this camera on a shoal between the Cape Verde Islands of S. Antonio and St. Vincent (St. 7086, sounding 90m). Electrical faults caused incorrect film winding resulting in double and treble exposures. Only 2 printable frames were obtained which showed a rich sessile fauna existing on the volcanic substratum. The 70mm camera was again used on Endeavour Bank (St. 7093) but a complete failure occurred since it was found on bringin the camera inboard that the bottoming switch had jammed in the off position. Although we had intended to use the camera again a fault which remained unidentified prevented us from doing so.

Consequently the survey was carried out using the standard shutterless N.I.O. 35mm camera fitted with bottoming switch and pinger. Apart from battery failure, due in part to the camera motor being operated on medium speed, and also inexperience in operation, the camera performed well throughout the survey.

Camera settings were as follows:
Lens focussed at 14', aperture: f 8.
Camera angle

Flash angle
Distance from camera pivot to flash pivot 2' 6"
Distance from flash pivot to end of triggering wt 7'

4 lowerings were made, namely as stations 7096, 7105, 7107 and 7108. A preliminary examination of the negatives indicates a rocky shallow region at St. 7107 (sounding: 245-283m) supporting a variable fauna and flora while the less shallow regions of St. 7096 7105 and 7108 (soundings between 343m and 379m) are blanketed with fine sediment. The negatives from St. 7107 looked promising and it is hoped that a complete series of enlargements of these and those from the other stations will tell us much more of the character of Endeavour Bank. Until these become available the full value of the survey cannot be assessed.

Stn.	Date	Position N.	Position W.	Gear	Depth (m)	Time(hrs)	Sounding (m)
7034	20.X.69	33°37'	13°40'	RMT 8 RMT 1 DGP	1260-(0)	1145-1554	
7035	20.X.69	32°52'	13°58'	RMT 8 RMT 1 DGP	240-(0)	2221-2344	
7036	21,X.69			RMT 8 RMT 1 DTP	250-190	2339-0158	
7037	23.X.69	25°15'	16°33'	TSD+W/B	to 1200	0840-1040	1364
7038	23.X.69	25°11'	16°24'	TSD+W/B	to 900	1120-1220	938
7039	23.X.69			TSD+W/B	to 490	1308-1347	512
7040	23.X.69			TSD+W/B	to 290	1429-1454	311
7041	23.X.69			TSD+W/B	to 90	1533-1544	102
7042	23.X.69	25°00'	16°02'	TSD+W/B	to 80	1621-1632	90
7043	23.X.69	24°55'	15°54'	TSD+W/B	to 55	1740-1748	64
7044	23.X.69	24°51'	15°43'	TSD+W/B	to 40	1857-1901	49
7045	23.X.69			Dredge	30	2056-2102	30
7046	23.X.69	24°49'	15°44'	TSD	to 45	2243-2246	
7047	23.X.69	24°54'	15°33'	TSD	to 60	2356-2359	68
7048	24.X.69	25°00'	16°03'	TSD	to 80	0107-0116	89
7049	24.X.69	25°03'	16°07'	TSD	to 90	0150-0156	100
7050	24.X.69	25°05'	16°12'	TSD+W/B	to 306	0235-0251	316
7051	24.X.69	25°08'	16°17'	TSD+W/B	to 514	0334-0400	527
7052	24.X.69	25°12'	16°22'	TSD+W/B	to 870	0448-0527	877
7053	24.X.69	25°17'	16°32'	TSD+W/B	to 1200	0636-0725	1537
7054	24.X.69	25°23'	16°41'	TSD+W/B	to 1200	0836-0944	2726
7055	24.X.69	24°10'	18°16'	50 1 W/B	200	1927-1949	2609
		24°20'	18°03'	RMT 90 DTP	350-(0)	2047-0144	
-	25.X.69			BT		0900	
-	25.X.69			BT		1000	
-	25.X.69			BT		1100	
-	25.X.69			BT		1200	
-	25.X.69			BT		1300	
-	25.X.69			BT		1400	
7056	25.X.69	22°36'	20°02'	RMT 8 RMT 1 DTP	1000-0	1508-1715	3962
-	25.X.69			BT		1615	
-	25.X.69			BT		1800	

Stn.	Date	Position N.	Position W.	Gear	Depth (m)	Time(hrs)	Sounding (m)
-	25.X.69			BT		1900	
-	25.X.69			BT		2000	
7057	25.X.69			RMT 8 RMT 1 DTP	110-0	2032-2320	
				Inclinometer			
-	26.X.69			BT		0030	
7058	26.X.69	22°18'	20°41'	RMT 8 RMT 1 DTP	250-(0)	0121-0417	
				Inclinometer			
-	26.X.69			BT		0500	
-	26.X.69			BT		0600	
-	26.X.69			BT		0700	
-	26.X.69			BT		1000	
-	26.X.69			BT		1100	
-	26.X.69			BT		1200	
-	26.X.69			BT		1300	
-	26.X.69			BT		1405	
-	26.X.69			BT		1505	
-	26.X.69			BT		1600	
7059	26.X.69			RMT 8 RMT 1 DTP	1000-0	1617-1725	
-	26.X.69			BT		1900	
-	26.X.69			BT		2100	
-	26.X.69			BT		2200	
7060	26.X.69	20°38'	22°32'	RMT 8 RMT 1 DTP	1000-0	2215-0040	4353
-	27.X.69			BT		0200	
	27.X.69			BT		0300	
	27.X.69	20°10'	22°51'	BT		0400	
7061	27.X.69	20°15'	22°49'	RMT 8 RMT 1 DTP	1000-0	0420-0600	4164
7062	27.X.69	20°17'	22°49'	TDL TDL	90 145	0745-0250	4331
		20°17'	22°49'	TSD	to 1200	0900-1009	
		20°19'	23°01'	RMT 1 N113 DTP	400-(0)	1145-1337	
7063	27.X.69	20°19'	23°04'	RMT 1 N113 DTP DGP	300-(0)	1516-1654	

Stn.	Date	Position N.	Position W.	Gear	Depth (m)	Time (hrs)	Sounding (m)
-	27.X.69			BT		1900	
-	27.X.69			BT		2100	
7064	27.X.69	19°55'	23°27'	RMT 8 RMT 1 DTP	1000-0	2115-2400	4348
-	28.X.69			BT		0200	
-	28.X.69			BT		0400	
7065	28.X.69	19°31'	23°54'	RMT 8 RMT 1 DTP	1000-0	0427-0708	
-	28.X.69			BT		0930	
-	28.X.69			BT		1130	
7066	28.X.69	19°18'	24°27'	RMT 8 RMT 1 DTP	1000-0	1257-1520	
7067	28.X.69	19°25'	24°37'	RMT 8) RMT 1) DTP)	800-600	1721-2123	4181
				N113H) CDBF)	800-600 dp 600-0 sh		
-	28.X.69			BT		2330	
-	29.X.69	19°00'	25°03'	BT		0137	
7068	29.X.69	19°03'	24°59'	RMT 8 RMT 1 DTP	1000-0	0205-0422	4002
	29.X.69			BT		0630	
	29.X.69			BT		0830	
	29.X.69	18°02'	23°07'	BT		1030	
7069	29.X.69	18°06'	25°06'	RMT 8 RMT 1 DTP	1000-0	1040-1308	3568
		18°08'	25°08'	TSD	to 1200	1332-1432	
7070	29.X.69	18°50'	25°13'	RMT 8 RMT 1 DTP	1000-0	1841-2032	3943
				TSD	to 1200	2055-2131	
7071	30.X.69	19°35'	25°18'	TSD	to 1200	0135-0211	4327
		19°38'	25°21'	RMT 8 RMT 1 DTP	1000-0	0225-0439	
7072	30.X.69	20°18'	25°26'	TSD	to 1200	0918-1021	4684
		20°24'	25°32'	RMT 8 RMT 1 DTP	1000-0	1039-1305	

Stn.	Date	Position N.	W.	Gear	Depth (m)	time(hrs)	Sounding (m)
7073	30.X.69			RMT 8 RMT 1 DTP	1000-0	1716-1955	4967
				TSD	to 1200	2015-2105	
7074	31.X.69	21°33'	25°27'	RMT 90	200-(0)	0100-0503	5079
7075	31.X.69	21°38'	25°27'	RMT 90	400-(0)est	0528-0950	5120
				TDL		0950	
				TDL		1015	
				TSD	to 1200	1052-1145	
				RMT 1) DTP)	410-320	1709-1850	
				N113H) CDBF)	410-320 dp 320-0 sh		
7076	1.XI.69	19°44'	25°26'	TDL		0750-0805	
				TDL		0805-1825	
				RMT 1	6-3	1918-2025	
				NNP	0	1930-2000	
7077	2.XI.69	17°26'	25°31'	BLL	3333	0800-1430	3333
				NNP	0	1620-1640	
7078	2.XI.69	17°29'	25°40'	RMT 90 DTP	1000-(0)	1929-0353	
7079	3.XI.69	17°42'	27°07'	TSD	to 1200	0942-1035	4365
		17°40'	27°06'	RMT 8 RMT 1 DTP	1000-0	1125-1336	
7080	3.XI.69	16°56'	27°03'	TSD	to 1200	1806-1857	4498
# 1		16°54'	27°03'	RMT 8 RMT 1 DTP	1000-0	1915-2155	
# 2				RMT 8 RMT 1	30-(0) est	2232-2326	
# 3				RMT 8 RMT 1	500-0 est	2341-0115	
7081	5.XI.69	15°33'	19°59'	RMT 8 RMT 1 DTP	450-0	1535-1635	
7082	10.XI.69	16°54'	24°38'	W/B+N.M DGP	1000	1023-1140	
				W/B,N.M DGP	500	1150-1225	
				W/B,N.M DGP	1500	1235-1450	
				TSD	to 500	1422-1445	

Stn.	Date	Position N.	Position W.	Gear	Depth (m)	time(hrs)	Sounding (m)
7083	10.XI.69	16°57'	24°51'	BLL	1396	1603-2120	1396
				TDL	190	1714-2010	
				50 1 W/B	200	1745-1800	
				Depressor test		1815-1910	
7084	10.XI.69			NN	0	2134-2146	
7085	10.XI.69			NN	0	2217-2229	
7086	10.XI.69	16°58'	25°02'	NN	0	2259-2311	
		16°57'	25°03'	70mm UC	90	2345-0015	90
7087	11.XI.69	16°58'	25°00'	RMT 8 RMT 1 DTP	70-(0)	0032-0148	563
7088	11.XI.69	17°00'	24°59'	RMT 8 RMT 1 DTP	210-(0)	0202-0333	
7089	11.XI.69	17°5[illegible]'	25°27'	TSD	to 1200	0952-1036	
* 1	11.XI.69	17°47'	25°22'	RMT 8) RMT 1) DTP)	990-910	1457-1839	
				N113H) CDBA)	990-910 dp 910-0 sh		
* 2	11.XI.69	17°47'	25°26'	RMT 8) RMT 1) DTP)	1000-910	2100-0031	
				N113H) CDBA)	1000-(0) dp 1000-0 sh		
* 3	12.XI.69	17°41'	25°23'	RMT 8) RMT 1) DTP)	300-210	0138-0425	
				N113H) CDBA)	300-210 dp 210-0 sh		
* 4	12.XI.69			RMT 8) RMT 1) DTP)	890-800	0850-1217	
				N113H) CDBA)	890-800 dp 800-0 sh		
* 5	12.XI.69	17°50'	25°29'	RMT 8) RMT 1) DTP)	790-700	1357-1738	
				N113H) CDBA)	790-700 dp 700-0 sh		
	12.XI.69	17°56'	25°30'	TSD	to 1200	2011-2112	
* 6	12.XI.69	17°56'	25°29'	RMT 8) RMT 1) DTP)	-	2135-2250	
				N113H) CDBA)	900-0		

Stn.	Date	Position N.	Position W.	Gear	Depth (m)	time(hrs)	Sounding (m)
* 7	13.XI.69			RMT 8 RMT 1 DTP	-	0005-0158	
				N113H CDBA	900-0		
* 8	13.XI.69	17°45'	25°17'	RMT 8 RMT 1 DTP	1010-900	0320-0659	
				N113H CDBA	1000-(0)		
* 9	13.XI.69	17°51'	25°25'	RMT 8 RMT 1 DTP	700-610	0938-1216	
				N113H CDBA	700-610 dp 610-0 sh		
*10	13.XI.69	17°45'	25°27'	RMT 8 RMT 1 DTP	600-(0) 600-500	1432-1743	
				N113H CDBA	600-500 dp 500-0 sh		
	13.XI.69	17°53'	25°27'	TSD	to 1200	1910-1951	
*11	13.XI.69			RMT 8 RMT 1 DTP	400-300	2013-0023	
				N113H CDBA	400-300 dp 300-0 sh		
*12	14.XI.69	17°34'	25°26'	RMT 8 RMT 1 DTP	900-800	0230-0606	
				N113H CDBA	900-800 dp 800-0 sh		
*13	14.XI.69	17°48'	25°29'	RMT 8 RMT 1 DTP	600-515	0950-1137	
				N113H CDBA	600-515 dp 515-0 sh		
*14	14.XI.69	17°48'	25°28'	RMT 8 RMT 1 DTP	1020-910	1307-1640	
				N113H CDBA	1020-910 dp 910-0 sh		
	14.XI.69			50 1 W/B	200	1822-1831	

Stn.	Date	Position N.	Position W.	Gear	Depth (m)	time(hrs)	Sounding (m)
*15	14.XI.69	17°54'	25°23'	RMT 8)		1931-2237	
				RMT 1)	785-700		
				DTP)			
				N113H)	785-700 dp		
				CDBA)	700-0 sh		
*16	14.XI.69	17°46'	25°17'	RMT 8)		2318-0237	
				RMT 1)	700-610		
				DTP)			
				N113H)	700-610 dp		
				CDBA)	610-0 sh		
*17	15.XI.69	17°39'	25°08'	RMT 8)		0257-0608	
				RMT 1)	600-505		
				DTP)			
				N113H)	600-505 dp		
				CDBA)	505-0 sh		
*18	15.XI.69			RMT 8)		0836-1150	
				RMT 1)	300-210		
				DTP)			
				N113H)	530-210 dp		
				CDBA)	500-0 sh		
*19	15.XI.69	17°48'	25°22'	RMT 8)		1307-1537	
				RMT 1)	194-112		
				NM)			
				N113H)	194-(0)		
				CDBA)			
*20	15.XI.69	17°45'	25°23'	RMT 8)		1613-1827	
				RMT 1)	100-55		
				NM)			
				N113H)	100-55 dp		
				CDBA)	55-0 sh		
	15.XI.69	17°52'	25°27'	TSD	to 1200	1959-2044	
*21	15.XI.69			RMT 8)	500-(0)	2138-0025	
				RMT 1)	500-415		
				NM)			
				N113H)	500-415 dp		
				CDBA)	415-0 sh		
*22	16.XI.69	17°41'	25°18'	RMT 8)		0135-0418	
				RMT 1)	500-410		
				NM)			
				N113H)	500-410 dp		
				CDBA)	410-0 sh		
*23	16.XI.69	17°39'	25°17'	RMT 8)		0439-0712	
				RMT 1)	200-110		
				NM)			
				N113H)	200-110 dp		
				CDBA)	110-0 sh		

Stn.	Date	Position N.	Position W.	Gear	Depth (m)	time(hrs)	Sounding (m)
*24	16.XI.69	$17^{\circ}50'$	$25^{\circ}27'$	RMT 8 RMT 1 NM	500-410	0920-1231	
				N113H CDBA	500-410 dp 410-0 sh		
*25	16.XI.69	$17^{\circ}47'$	$25^{\circ}25'$	RMT 8 RMT 1 NM	290-210	1349-1623	
				N113H CDBA	290-210 dp 210-0 sh		
	16.XI.69			NM DGP	to 2500	1900-2025	
*26	16.XI.69	$17^{\circ}52'$	$25^{\circ}25'$	RMT 8 RMT 1 NM	100-49	2051-2318	
				N113H CDBA	100-49 dp 49-0 sh		
*27	17.XI.69			RMT 8 RMT 1 NM	60-25	0138-0350	
				N113H CDBA	60-25 dp 25-0 sh		
*28	17.XI.69	$17^{\circ}36'$	$25^{\circ}18'$	RMT 8 RMT 1 NM	25-10 est	0411-0627	
				N113H CDBA	10-1 est dp 1-0 est sh		
*29	17.XI.69	$17^{\circ}52'$	$25^{\circ}27'$	RMT 8 RMT 1 NM	400-305	0932-1215	
				N113H CDBA	400-(0)		
*30	17.XI.69	$17^{\circ}54'$	$25^{\circ}28'$	RMT 8 RMT 1 NM	50-20	1316-1531	
				N113H CDBA	45-15 dp 45-0 sh		
*31	17.XI.69	$17^{\circ}51'$	$25^{\circ}31'$	RMT 8 RMT 1 NM	20-12	1607-1826	
				N113H CDBA	20-12 dp 12-0 sh		
	17.XI.69	$17^{\circ}52'$	$25^{\circ}27'$	TSD	to 1200	1951-2032	
*32	17.XI.69	$17^{\circ}45'$	$25^{\circ}22'$	RMT 8 RMT 1 NM	1250-1000est	2122-0405	
				N113H CDBA	1250-1000 dp 1000-0 sh		

Stn.	Date	Position N.	Position W.	Gear	Depth (m)	time(hrs)	Sounding (m)
*33	18.XI.69	17°45'	25°26'	RMT 1	10-0 est	0435-0650	
*34	18.XI.69	17°46'	25°30'	RMT 8)	1200-(0)	0853-1652	
				RMT 1)	1220-1000est		
				NM)			
				N113H)	1220-1000dp		
				CDBA)	1200-0 sh		
*35	18.XI.69			RMT 1	10-0est	1420-1620	
*36	18.XI.69	17°41'	25°33'	RMT 8)		1800-2004	
				RMT 1)	500-300-(0)		
				NM)			
*37	18.XI.69	17°50'	25°29'	RMT 8)		2258-0551	
				RMT 1)	-		
				NM)			
				N113H)	1500-(0)		
				CDBA)			
*38	19.XI.69	17°40'	25°33'	RMT 8)		0617-0917	
				RMT 1)	800-390-(0)		
				NM)			
*39	19.XI.69			RMT 8)		1132-1412	
				RMT 1)	-		
				NM)			
				N113H)	800-(0)		
				CDBA)			
*40	19.XI.69	17°51'	25°24'	RMT 8)		1544-1831	
				RMT 1)	400-305		
				NM)			
				N113H)	400-(0)		
				CDBA			
*41	19.XI.69			RMT 8)		2030-2220	
				RMT 1)	400-200(0)		
				NM)			
*42	19.XI.69	17°49'	25°31'	RMT 8)		2250-0254	
				RMT 1)	1000-0		
				NM)			
				N113H)	1000-900 dp		
				CDBA)	900-0 sh		
*43	20.XI.69	17°41'	25°30'	RMT 8)		0319-0606	
				RMT 1)	470-250-(0)		
				NM)			
*44	20.XI.69			RMT 8)		0927-1208	
				RMT 1)	400-310		
				NM)			
				N113H)	400-310 dp		
				CDBA)	310-0 sh		
*45	20.XI.69	17°49'	25°26'	RMT 8)	800-(0)	1259-1552	
				RMT 1)	800-694		
				NM)			
				N113H)	800-694 dp		
				CDBA)	694-0 sh		

Stn.	Date	Position N.	Position W.	Gear	Depth (m)	time(hrs)	Sounding (m)
*46	20.XI.69	17°43'	25°25'	LHS	100-(0) est	1830-1940	
*47	20.XI.69			RMT 8) RMT 1) NM)	500-400	2148-0050	
				N113H) CDBF)	500-400dp 400-0 sh		
*48	21.XI.69			RMT 8) RMT 1) NM)	500-410	0129-0421	
				N113H) CDBF)	500-410dp 410-0 sh		
*49	21.XI.69	17°42'	25°32'	RMT 8) RMT 1) NM)	700-600-(0)	0448-0822	
				N113H) CDBF)	700-600dp 600-0 sh		
*50	21.XI.69	17°46'	25°30'	RMT 8) RMT 1) NM)	200-105	1038-1304	
				N113H) CDBA)	200-105dp 105-0 sh		
*51	21.XI.69			LHS NM	505-0	1409-1612	
*52	21.XI.69	17°43'	25°25'	RMT 150 Depressor DTP	540-410-(0)	1636-2000	
*53	21.XI.69	17°43'	25°23'	RMT 90 DTP	510-(0)	2202-0450	
*54	22.XI.69	17°31'	25°15'	RMT 90 DTP	1000-500-(0)	0457-1152	
*55	22.XI.69	17°28'	24°50'	RMT 90 DTP	2000-1300-(0)	1202-2030	
7090	24.XI.69	24°01'	17°52'	BN D type Pinger	2336-(0)	2121-0024	2336
7091	25.XI.69	24°32'	18°32'	BN D type Pinger	2869-(0)	0613-0925	2869
7092	25.XI.69	25°07'	19°10'	BN D type Pinger	3311-(0)	1505-2020	3311
7093	26.XI.69			BN D type Pinger	379-358-(0)	1405-1512	379
		25°21'	19°19'	70mm UC	399	1535-1659	399
7094	26.XI.69	25°14'	19°26'	BN D type Pinger	307-301-(0)	1820-1920	307
7095	26.XI.69	25°24'	19°25'	BN D type Pinger	332-(0)	2055-2216	332

Stn.	Date	Position N.	Position W.	Gear	Depth (m)	time(hrs)	Sounding (m)
7096	26.XI.69	25°25'	19°24'	NIO UC	343-339	2340-0115	343
7097	27.XI.69	25°22'	19°27'	BLL	377	1000-1605	377
7098	27.XI.69	25°24'	19°29'	BLL	877	1125-1810	877
7099	27.XI.69			Dredge	397-394-(0)	1955-2025	397
		25°22'	19°27'	Dredge	392-(0)	2026-2106	392
7100	27.XI.69	25°24'	19°26'	BN D type Pinger	352-(0)	0057-0206	352
7101	28.XI.69	25°27'	19°23'	RMT 8) RMT 1) NM)	320-(0)	0334-0500	
7102	28.XI.69			BN D type Pinger	365-362-(0)	0957-1102	365
				Dredge	377-371-(0)	1131-1211	377
7103	28.XI.69	25°23'	19°23'	BN D type Pinger	384-(0)	1305-1414	384
7104	28.XI.69	25°24'	19°23'	RMT 150) DTP) Depressor)	300-(0)	1638-1835	
7105	28.XI.69	25°24'	19°25'	NIO UC	373	2015-2113	373
7106	28.XI.69			TSD	to 350	2132-2151	377
7107	28.XI.69	25°25'	19°24'	TSD NIO UC	to 225 283-245	2213-2227 2231-2317	281 283
7108	29.XI.69	25°27'	19°20'	TSD NIO UC	to 350	0014-0032 0048-0115	379
7109	29.XI.69	25°30'	19°15'	TSD	to 1200	0200-0246	2707
7110	30.XI.69	27°10'	15°39'	RMT 8) RMT 1) NM)	1000-0	0148-0329	3183
7111	30.XI.69	29°10'	15°41'	RMT 8) RMT 1) NM)	400-300-(0)	0449-0747	3360
7112	30.XI.69	27°12'	15°22'	BN D type Pinger	2992-2921-(0)	1345-1900	2992
7113	1.XII.69	28°06'	14°09'	RMT 8) RMT 1) NM)	300-270-(0)	0613-0837	
7114	1.XII.69	28°07'	14°11'	LHS NM	570-550-(0)	0941-1115	
7115	1.XII.69	28°09'	14°08'	BLL	620-207	1140-1517	620
7116	1.XII.69	28°08'	14°05'	BLL	865	1300-1754	865
7117	1.XII.69	28°06'	14°10'	LHS NM	560-540-(0)	1917-2047	
7118	1.XII.69	28°04'	14°11'	Activity Meter		2152-0136	
7119	2.XII.69	28°00'	14°06'	RMT 8) RMT 1) NM)	900-800-(0)	0220-0706	

Stn.	Date	Position N.	Position W.	Gear	Depth (m)	time(Hrs)	Sounding (m)
7120	2.XII.69	28°07'	14°11'	LHS NM	140-94-(0)	1114-1235	
7121	2.XII.69	28°07'	14°10'	RMT 8) RMT 1) NM)	700-0	1710-1816	
7122	2.XII.69	28°05'	14°11'	RMT 8 Air lift	10-5 est	1930-2215	
7123	3.XII.69	28°01'	14°05'	RMT 8) RMT 1) NM)	500-400-(0)	0047-0359	
7124	3.XII.69	28°06'	14°11'	RMT 8) RMT 1) NM)	205-180-(0)	0545-0721	
7125	3.XII.69	28°03'	14°09'	TSD	to 1200	0750-0848	1443
				Activity Meter	to 1000	0900-1225	
7126	3.XII.69	28°05'	14°10'	BLL	1289	1245-1712	1289
7127	3.XII.69	28°04'	14°10'	LHS NM	560-540-(0)	1405-1540	
7128	3.XII.69	28°06'	14°09'	RMT 8) RMT 1) NM) 4 jaw release)	550-515	1807-1959	
7129	7.XII.69	28°05'	14°03'	RMT 8) RMT 1) NM)	50-30	0855-1111	1231
7130	7.XII.69	28°04'	14°09'	RMT 8) RMT 1) NM)	50-25	1236-1445	
7131	7.XII.69	28°05'	14°10'	RMT 8) RMT 1) NM)	25-10	1540-1755	
7132	7.XII.69	28°06'	14°10'	RMT 8) RMT 1) NM)	50-25	1937-2150	
7133	7.XII.69	28°04'	14°08'	RMT 8) RMT 1) NM)	25-12	2243-0110	
7134	8.XII.69	28°03'	14°05'	RMT 1	10-0 est	0205-0408	
7135	8.XII.69	28°03'	14°08'	TSD	to 1200	0714-0751	
				Activity Meter		0845-1410	
7136	8.XII.69	28°05'	14°10'	RMT 1	10-0 est	1425-1640	

Stn.	Date	Position N.	Position W.	Gear	Depth (m)	time(hrs)	Sounding (m)
7137	8.XII.69	28°01'	14°07'	RMT 8) RMT 1) NM)	1220-1100-(0)	1703-1957	
7138	9.XII.69	32°08'	13°58'	NN	●	2000-2030	
7139	10.XII.69	37°12'	14°10'	NN	0	2200-2230	
7140	11.XII.69	41°28'	14°22'	NN	0	2047-2116	

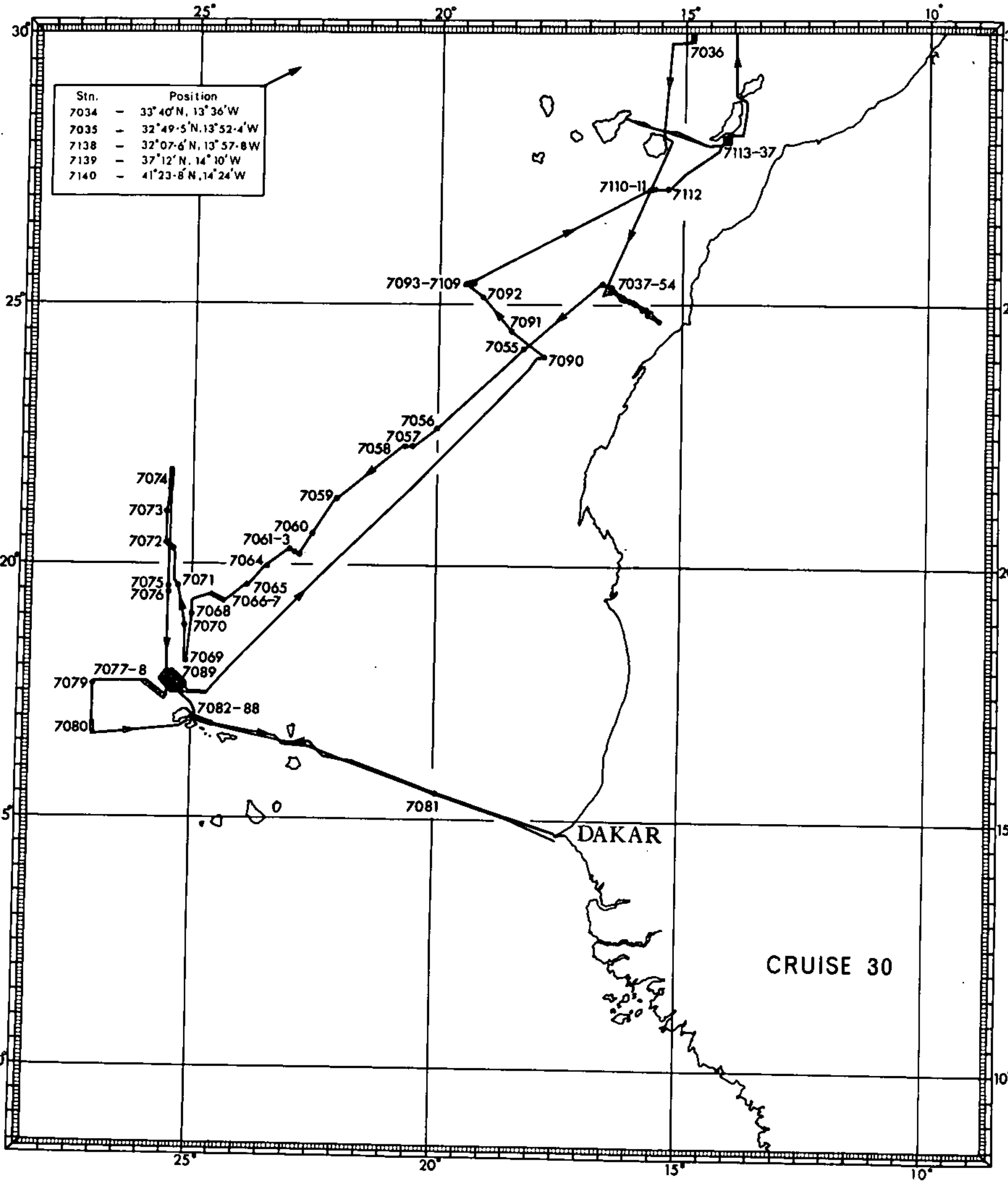
25°
20°
15°
10°
30°
25°
20°
15°
10°
Stn. Position
7034 – 33°40'N, 13°36'W
7035 – 32°49·5'N, 13°52·4'W
7138 – 32°07·6'N, 13°57·8W
7139 – 37°12'N, 14°10'W
7140 – 41°23·8'N, 14°24'W
7036
7113-37
7110-11
7112
7093-7109
7092
7037-54
7091
7055
7090
7056
7057
7058
7059
7074
7073
7072
7060
7061-3
7064
7075
7076
7071
7065
7066-7
7068
7070
7069
7077-8
7089
7079
7082-88
7080
7081
DAKAR
CRUISE 30

FIG. 1