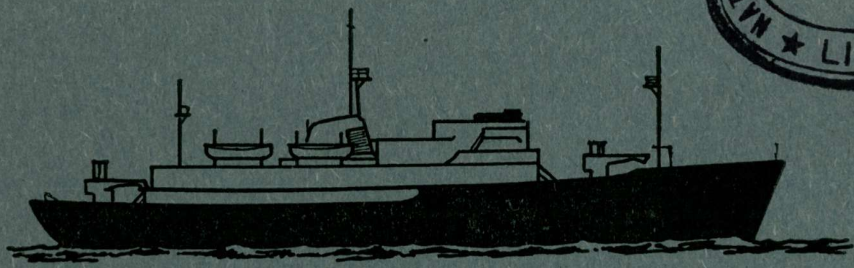
NATIONAL INSTITUTE OF OCEANOGRAPHY

WORMLEY, GODALMING, SURREY



R.R.S. DISCOVERY CRUISE 8 REPORT

N.I.O. CRUISE REPORT SERIES: CR 8

R.R.S. DISCOVERY

SOND Cruise 1965

Cruise 8

Cruise Report

N.I.O. INTERNAL REPORT No. B5

National Institute of Oceanography

December 1965

B5

CONTENTS

B5.

CONTENTS

Cruise Report

Introduction

SOND[*] cruise was intended primarily to study the vertical distribution and migrations of animals in the upper 1000 metres of a selected area of ocean and to assess the potential of sonic methods for more general use in such studies. The ship programme thus comprised two essentially independent series of observations, one biological, the other acoustical, between which correlations will be examined in the subsequent analysis.

Biological sampling with a range of different sizes and types of net was designed to obtain as complete a collection as is presently possible of the whole population of animals at different depths during the day and night. Closing hauls were taken at about 50 metre depth intervals over the range covered and altogether nets were towed for nearly 1000 miles, most of this within an area some 25 miles in diameter south-east of the island of Fuerteventura in the Canary Islands.

These collections will make it possible to examine not only the taxonomic composition of the fauna but also the acoustic characteristics of the animals at different depths, while stomach content analyses should make it possible to examine trophic interrelationships which may have a bearing on the observed behaviour patterns.

Acoustical studies were designed to obtain a measure of the target strengths of larger individual organisms and the volume scattering coefficient at different frequencies. Continuous paper records were maintained during the cruise at 10, 26, 36 and 70 kc/s. and periodically at 54 kc/s. on different echo-sounders and during trawls and migrating periods, successive transmissions were recorded on a high-speed ultra-violet recorder. Attempts to use lower frequencies were defeated by high ambient noise levels. On the homeward passage of the ship an integrator was used to summate the scattering over a selected depth interval on the 36 kc/s. sounder with a view to the future use of such a device in surveying the relative density of scattering in different geographical locations.

To make it possible to examine the underlying causes of the observed distributions of animals, a good deal of attention was paid to measurements of environmental parameters. In particular ambient irradiance level was measured continuously on deck and frequently at selected depths down to 500 m. Special attention was paid to such measurements at the migratory sunrise and sunset periods and later analysis should make it possible to examine the relationship to behaviour pattern and the effects of cloud, moonlight, etc., on the migrations. Attempts were also made to influence movements by means of artificial underwater light sources.

Temperature and salinity were measured in some detail and nutrients were estimated in the earlier part of the cruise while the possible significance of internal waves was examined by making bathythermograph observations at ten minute intervals over a 24-hour period.

In relation to the ambient irradiance and the migrations of the animals, electro-physiological studies were made to measure the spectral and intensity

---

[*] Contrary to a popular misconception that the name SOND has any association with the acoustic work of the cruise it should be noted that it derives from the initial letters of the months during which the voyage was undertaken.

responses of different organisms to calibrated stimuli in the laboratory and visual pigments were extracted and measured independently. The physiological work proved to need very calm conditions and was a major factor in selecting the eventual locality of operation on the cruise. Light generation by the animals was also studied in situ by means of specially designed luminescence meters.

While these major projects dovetailed together to form the main work of the cruise, several subsidiary projects particularly concerned with the development of new gear were also undertaken. These included an examination of near surface temperature profiles, a test of the acoustically released sub-surface buoy presently being developed at the N.I.O. and an experimental acoustic control system for operating net closing mechanisms. An experimental version of a free-floating net which drops ballast by means of a pressure release and rises to the surface unaided was also tested and a special series of net hauls was taken to examine the patchiness in distribution of the neuston.

It will be evident that the cruise represents only the sampling and experimental phase of the project and the laboratory analysis and examination of the results has barely started. Little can thus be said yet of the outcome of the project but it may be fairly said that the work of the ship has provided a unique and substantial collection of data. The success of the operation in no small measure has depended on the close cooperation of everyone concerned and I would like to take this opportunity of thanking visitors and staff, ship's officers and crew alike for the willingness and enthusiasm with which they have participated. We all owe our gratitude to Captain Davies who has suffered the whims and unpredictable demands of scientists without protest and contrived to make the voyage not only a success but also a happy and memorable experience.

The relevant parts of the report which follows have been prepared by the scientists concerned with each aspect of the work.

Ronald I. Currie

Itinerary

R.R.S. Discovery sailed from Plymouth at 1530 hrs. on 7th September, 1965. After swinging compasses and fitting the asdic, etc., a course was made to the west and two runs were taken on the measured mile at Looe to calibrate the ship's log and slow speed log which was installed for trawling This was completed by 2200 hrs. and the vessel then headed south in rapidly deteriorating weather for La Chapelle Bank. By the morning of 9th September however, both wind and swell had dropped away and being in deep water it seemed a suitable opportunity to pay out and re-tension the three trawl warps. This took from 0930 until 1730 hrs. after which the vessel lay-to until 2200, testing the 26 kc/s. transducer. Course was then resumed for Galicia Bank and echo-soundings were commenced. Meanwhile the boomer was prepared and at 1845 hrs. on the 10th it was streamed for a run across Galicia Bank. A fault developed in the instrument, however, and it had to be retrieved at 2130 after which course was altered to the east to make the Portugese coast. A trawl (Station 5765) was taken en route to obtain some experimental material and by 2045/11th we were in shallow water north of Oporto and commenced the calibrations of the echo-sounders. This was followed by trials of net gear, pressure tests of equipment and some water sampling. The ship then proceeded southwards along the Portugese coast making $\frac{1}{2}$ hourly neuston net hauls to collect fish eggs and larvae for experimental work. At 0700/13th we headed out towards Madeira, making further pressure tests en route and at 0930/15th a trawl for experimental material. Porto Santo was reached at 2300/15th and then for some days the ship worked in the vicinity of the Desertas Islands. Gear was tested, calibrated and brought into service. During the day-light hours of 19th September the ship lay at anchor in Porto Santo Bay for measurements of the performance of the sonic transducers and preliminary trials of the electro-retinogram measurements. This was followed by further work off the Desertas Islands until the 23rd September when a passage was made to Madeira and Funchal was reached at 0700 hrs. Lord Bowden was embarked, the vessel was fuelled and departure made at 0700/24th returning to the vicinity of the Desertas Islands. Shortly after commencing work, however, information was received that Mr. Bowers would have to be landed for personal reasons on the 26th and the intervening two days were spent assessing the potential of the Madeira area for the general programme ahead. Plankton catches turned out to be small, the sound scattering rather poor - perhaps all a result of the rather late time of year - and it soon became apparent that more productive waters would be a better venue for our studies. Mr. Bowers was landed at Funchal at 1300/26th and Lord Bowden at 1800/27th. During the latter call, Dr. G.E. Maul, director of the museum in Funchal joined the cruise and the ship sailed from Funchal at 0700/28th September.

From Funchal a direct passage was made towards the north end of Lanzarote in the Canary Islands and thence across to the Moroccan coast where it was anticipated that the upwelling region might provide more fertile waters for our studies. Some trial sampling was commenced at 1830/29th and the results looked considerably more promising than in the Madeira area. . Further fish larvae and egg collections were made for Mr. Blaxter and various nets and experiments were tried until at 0000/2nd October it was necessary to depart to meet our scheduled call at Tenerife. Further trawls for material and trials of nets were conducted en route and in the lee of Tenerife an attempt was made to examine the patchiness of distribution in the neuston. Some 30 hauls were made on a star shaped pattern relative to a free floating dhan buoy and on recovering the buoy a course was made towards Tenerife where Santa Cruz was reached at 0800/4th. During the stay in Santa Cruz, Messrs. Herring and Tundisi left the ship while Professor Abbott and Mr. Gaunt joined for the next part of the cruise.

Discovery sailed from Santa Cruz at 0803/7th October and after lowering the asdic, etc., made way towards a position which had been selected off the southern end of the island of Fuerteventura. The reason for this choice lay in the proximity of the area to the richer waters of the Canary Current, the accessibility of sheltered anchorages for the physiological work which was scheduled to be an all important aspect of the programme on this leg of the cruise, and the presence of an area of water of such a depth (750 fms) that the bottom trace on the echo sounder records was well removed from the shallower midwater scattering. The generally sheltered aspect of the site chosen later proved a considerable advantage in the rather variable weather experienced and on only two occasions in the six weeks spent there, was it necessary to cancel any overside operation on account of the weather. For convenience this position will henceforth be referred to as the "Fuerteventura station".

The Fuerteventura station was reached after trawling for experimental material, at 0400/8th October and from then until 24th October the sampling programme was commenced.

For several days a similar routine was followed commencing with irradiance measurements over the sunrise period, 1 m^2 net hauls in the morning, irradiance measurements at noon, Isaacs Kidd trawls in the afternoon and a further irradiance measurement in the evening at sunset. Most nights were spent lying in sheltered water for the physiological work. It soon became evident, however, that the percentage failure of the 1 m^2 nets closed with the Leavitt release gear was unacceptably high. This seemed largely to be the fault of the flowmeter mounting which added an assymmetrical drag to the nets tending to twist them and preclude their correct operation. Clearly some alternative had to be found and until this could be done they were abandoned, the free time being devoted to further Isaacs-Kidd trawls. While lying-to during the nights, water-sampling, underwater light experiments and various acoustic measurements were also conducted while periodically additional short trawls were made for experimental material.

On 22nd October a second attempt was made to study the patchiness problem in the neuston and again some 30 hauls were made on a moonless night relative to a free floating buoy.

Work continued at the Fuerteventura station until 0730/24th October when the vessel departed for a position between Gran Canaria and Fuerteventura where in deep water it was planned to test the acoustic system of the 'pop-up buoy' in preparation for laying it for a protracted period. The explosive link operated well but some trouble was experienced with the "pinger" and it was clear that the buoy could not be laid before we were scheduled to call at Madeira. A course was therefore made northwards to Madeira where after a deep Isaacs Kidd trawl for Dr. Maul, and a shallower trawl for more experimental material, Funchal was reached at 1400/27th October.

In Funchal a change over of several of the scientific staff took place, three of the visiting workers being replaced by N.I.O. staff with a consequent change in emphasis of the programme which followed. The physiological work was for the most part discontinued and emphasis was placed on intensive sampling.

Discovery left Funchal at 0700 hrs. on 31st October and after fitting the asdic a course was made south towards Gran Canaria. At 1330 hrs. on 1st November we reached a position some 25 miles NE of Gran Canaria where it had been planned to lay the "pop-up" buoy. Finding a suitable area of bottom of the required depth took some time and a first attempt was made at the lay. By the time the sinkers reached the bottom, however, the water had shallowed to a depth which would have left the floats on the surface and so the wire was retrieved, a new position sought and a second and successful lay was completed at 2345 hrs./1st November. The ship lay to awhile to check on the operation of the pinger and when this switched off at 0300 we departed for the Fuerteventura position, reaching it at 0945/2nd.

The 26/76 kc/s. transducer was lowered and vertical nets commenced, the first of three day series. In the evening, light measurements had to be abandoned and at 1930 hrs. the night series of Isaacs-Kidd Trawls was commenced. Neuston net hauls were taken over the sunrise period next morning and a second day series of vertical nets. A similar routine was followed on the 4th but on the 5th when the night Isaacs-Kidd Trawls had been completed, the day was spent water sampling and on underwater light experiments. The first night series of vertical nets was then started and on the 6th the day was devoted to a trawl for experimental material, further work with underwater lights, the underwater camera, luminescence meters, etc. The work of the next few days was concentrated on the vertical nets and Isaacs-Kidd trawls with these other operations and light measurements occupying the remainder of the time. The 3 kc/s. transducer which had been mounted in "Fred", the fibre-glass dinghy, was towed on the 8th and on the 9th attempts were made to fish the 1 m^2 nets vertically. While in practise this worked all right, it was clear that the net was not filtering sufficient water in a vertical tow to obtain an appreciably different catch from the 70 cm vertical net and so while the one series was completed no more were taken. By 10th November the night series of Isaacs-Kidd trawls had all but been completed and the day series was commenced while the following night the last of the 70 cm vertical net series was taken.

It was clearly imperative that some means must be found of towing the 1 m^2 nets and opening and closing them at selected depths and on 11th November one was rigged with the catch-dividing bucket. This looked very successful and a full day and night series was planned. The same day, the first trials of the 'pop-up' net were undertaken. Two successful lowerings and recoveries were made.

At 0400/12th November a 24-hour station of continuous light measurements and 10 minute BT dips was taken in conjunction with the acoustic records. U/W recordings of the scattering at all available frequencies were taken every 15 minutes during the day and night and every 5 minutes over the sunrise and sunset periods. This was completed at 0400/13th and on the 13th, the first day series of 1 m^2 nets was towed. Echo-sounder calibrations and the camera occupied the following night and on the 14th while flowmeters, etc., were being calibrated, a start was made on rigging the Engel's trawl. An underwater light experiment in the afternoon failed because of bad wire angles and at night some more Isaacs-Kidd trawls were taken. The 15th was devoted again to rigging the Engel's trawl, overside operations being confined to light measurements, the camera and an attempt to record sounds in the water. The next two nights were devoted to the 1 m^2 net hauls while on the 16th the Engel's trawl was shot for a trial tow. It towed quite successfully without undue difficulty for about 4 hours and was all aboard by 2140.

On the 17th it was necessary to leave the Fuerteventrura station so that sufficient time would be available for recovering the pop-up buoy and after some towing tests on hydrophones we got underway at 1600 reaching the site of the pop-up buoy at 2200/17th. Although the pinger should have switched on at 2230 there was no evidence of it and at 0800/18 it was decided to commence transmissions to release the buoy. This was done on the expected position of the buoy but by noon no result had been obtained. The next step seemed to be to commence transmission from the centres of a series of overlapping circles of 2 miles radius, roughly the expected range of the transmitter and on the third transmission, some four miles south-west of the buoy anchorage, the buoy was sighted to the south-west. It appears most probable that it had been released by one of the earlier transmissions, probably not been sighted as it would have lain in the direct rays of the sun, and drifted to the south-west. The buoy was recovered at 1940 hrs. on the 18th November. A course was then made towards the east coast of Tenerife, where at 1400/19th the Engel's trawl was shot for a tow at 570 metres. The camera was used during the night after recovering the trawl and Santa Cruz, Tenerife, was reached at 1000/20th.

Four of the N.I.O. staff left the ship in Santa Cruz and Mr. Craig joined. Our departure was delayed some hours by the failure of two of the crew to join the vessel but eventually the ship left Santa Cruz at 1000/23rd and returned to the Fuerteventura station. On arrival there the 'pop-up' net was again tested during the night and after the morning light measurements the Engel's trawl was shot for a tow at 500 metres. After recovering the trawl, night hauls of the 1 m^2 nets were made and in the morning this was followed by water sampling and measurements on the performance of the 'boomer'. Noon time light measurements were made and in the afternoon the Engel's trawl was again laid out and shot at 1810 hrs. for a shallow night tow. The wind had steadily been freshening, bearing with it a heavy dust haze and further work during the night had to be suspended. On the morning of the 26th still in heavy weather, a day series of 1 m^2 nets was worked followed after sunset by a night series. At 0900/27th the Engel's trawl was shot and after recovering it at 1915, trials of the acoustic control of the catch dividing bucket were carried out. At 0200/20th a final series of echo-sounder calibrations were run and during the day another series of 1 m^2 net tows was taken. On the evening of the 28th an Isaacs-Kidd trawl was taken for material, the depressor being rigger with an array of luminescence meters. On the 29th our last day on the Fuerteventura station the final 1 m^2 net tows were taken and three further trials were done with the acoustically controlled catch-dividing bucket. Then after some hydrophone towing tests with the 3 kc/s transducer the ship left for Tenerife at 0000/30th. The two missing seamen were recovered at Santa Cruz, and a passage was made to Madeira where Mr. Harrisson left the ship. Course was then laid for Plymouth and on the northwards passage, continuous echo-soundings were taken until Cape Finisterre was cleared. The weather which had until then been fair, rapidly deteriorated and from Finisterre to Plymouth most of the passage was made in force 9 or 10 westerly winds with a heavy swell on the quarter. The ship anchored in Plymouth sound at 2000/6th December and berthed in Millbay at 1500/7th December.

Biological sampling

Clearly a study of the vertical distribution of organisms called for a means of opening and closing nets at different depths and doing this with some considerable degree of precision. One of the main inadequacies of earlier sampling has indeed been a lack of such precision and any conclusive information about how a net has operated during its tow. Within the intended programme of sampling it was essential to be able to operate nets in a precise manner at depths down to 1000 m. and to know what had happened to them. The second requirement evolved from the need to sample as much as possible of the living communities at different depths so that a full understanding of the inter-relationships of the organisms could be sought.

With these two criteria to meet, it was clear that a comparatively wide range of net hauls would be required, adequately monitored in their performance but the range had to be kept within reasonable limits of practical operation within the time available. The selection of devices used was thus chosen in the light of past experience of their performance and limitations.

Neuston net

The neuston net (David, 1965) was chosen to sample the surface layer, in particular to study the times of arrival at and departure from the surface layer of the diurnally migrant fauna. Four series of hauls were made over sunrise periods, generally commencing a little before nautical twilight and running through till sunrise, and three series over the sunset period. Moonlight proved rather a difficulty and where possible hauls were taken close to the period of new moon or on dark cloudy nights.

70 cm. nets (N70)

For the smaller animals in the water column, the NF70V was chosen, a 70 cm. diameter closing net with a mesh size of about 180 x 180μ. This net is metered for depth and flow and is towed vertically through selected water columns being lowered open and closed by means of a messenger at the end of the haul. Three day and three night series of these nets were operated at the Fuerteventura station sampling the layers 1000-900, 900-800, 800-700, 700-600, 600-500, 500-400, 400-300, 300-200, 200-150, 150-100, 100-50 and 50-0 metres.

1 m² nets (N113)

For the rather more active organisms (euphausiids and the like) it had been planned to tow a 1 m² net (a modified version of the Indian Ocean Standard Net) opening and closing the net by means of a Leavitt closing gear at the same time monitoring the flow and depth of operation in a manner similar to that used with the 70 cm. nets. Unfortunately this proved impractical as the flowmeter mountings appeared to exert an assymmetrical drag on the nets which twisted the release and closing ropes. The frequency of failure to operate was too high and some other means of operation had to be found. After trying vertical operation which although it worked well clearly did not filter sufficient water to take a large enough sample, we resorted to using these nets towed but opened and closed by means of the catch-dividing bucket (see below). 19 day and 19 night hauls at approximately 50 metre intervals of depth to 950 metres were operated on the Fuerteventura station.

Isaacs-Kidd midwater trawl (IKMT)

The smaller nektonic organisms or macro-plankton were sampled by means of a 5 mm. mesh Isaacs-Kidd midwater trawl, having a 10 foot wide depressor plate. The open area of the mouth of this net is about 7.8 m² and again the means of opening and closure employed was the catch dividing bucket. A standard procedure of fishing the net was adopted and as with the other towed nets, the depth of tow and its speed were rigorously controlled by using the acoustic depth-telemeter (D.N.I., N.I.O. Internal Report No. A 16A) and a slow speed log. The latter was a Brooks and Gatehouse yatch's log mounted in a streamlined hydrophone case and towed alongside the vessel: it gave an accurate measure in the range of 0.8 to 5.0 knots. As with the 1 m^2 nets a series of 20 day and 18 night hauls were worked at 50 metre intervals down to 950 m. From these hauls the fish (Dr. G.E. Maul and Mr. C.M.H. Harrisson) and decapods (Mr. P. Foxton) have been roughly sorted. Several other Isaacs-Kidd trawls were also made, sometimes in the course of testing equipment, at others for experimental material and some during the exploratory phase of the cruise. Altogether 83 hauls were made, 11 of these with a new net designed at Scripps Institution of Oceanography. The latter is of smaller mesh and is constructed of black knotless netting.

Catch dividing bucket (CDBE)

The catch-dividing bucket used on these Isaacs-Kidd (IKMT) and 1 m^2 net hauls (N113) was an electrical pattern at present being developed at the N.I.O. It was used on 105 occasions, a comparatively rigorous test, and on only 5 did it fail to operate. The "bucket" is an opening-closing device situated in the cod-end of the sampler and consists essentially of a cylinder enclosing a flap that acts as a two way valve directing catch from the main net into one or other of two 12' collecting nets. The flap is driven by a 12 v. electric motor running off a self contained power pack attached to the bucket, and it is triggered by a pressure switch which can be pre-set to operate at any selected depth between 50 and 1000 m. An alternative arrangement uses remote acoustic control. The device also incorporates a depth-time recorder on which each movement of the flap is monitored.

The sequence of operation is as follows. The depth of operation having been selected and pre-set on the pressure switch the net is lowered with the flap in the shallow position. Catch taken while paying out is directed into one of the collecting nets. When the net reaches the operating depth the pressure switch triggers the motor which rotates the flap through 90°, closing the shallow leg and opening the deep leg. Catch taken during the subsequent horizontal tow is thus collected in a separate leg. On hauling, the net once again reaches the operating depth and the flap rotates back so as to close the deep leg and re-open the shallow one. The deep catch of the horizontal tow is thus effectively separated from that taken whilst paying out and hauling in the net. Should the net descend still further beyond the intended depth horizon of operation, the flap will again operate so that any catch taken below the selected depth limits also ends up in the "shallow" leg of the bucket.

The success of operation of the CDB is due entirely to the efoorts of Messrs. Dobson, Boxell and Gaunt who in the course of the cruise rebuilt all the buckets used.

Acoustic control of CDBE

Opportunity was taken, ih collaboration with Messrs. Harris and Gaunt, to test a new method of remotely controlling the operation of the CBDE using a modification of their acoustic control unit initially developed for the 'Pop-up' Buoy System. These tests were extremely successful and on the fifth and final test with the Isaacs-Kidd midwater trawl the operation of the bucket was controlled with the net at a depth of 950 m. (2250 m. wire out).

This is most encouraging and it is clear that in the future it will be possible to operate the CDBE with a precision hitherto unknown.

Engel's trawl

The problem of catching the larger, more active animals has engaged our attention for some time and the results so far obtained indicate that large, slowly towed nets are probably the most satisfactory. We thus elected to try on this cruise the large (1200 mesh) Engel's trawl, opened by two 5 m^2 Suberkrüb otter doors. The opening of this net is some 20 metres high and 35 metres wide while the net itself, of graded mesh (from 20 cm. at the front to 3 cm. at the cod end, the latter lined with 7 mm. mesh) is some 70 metres long. The net is opened by 100 headline floats and chain and depressors on the footrope and wings and it was towed at about 2 knots on the paired trawl warps of ~~the~~ ship. Five hauls were made, three at about 500 metres (two during the day, one at night) and two at 100 metres at night, generally towing for about six hours.

The catches of the net were rather typical for an oceanic mid-water trawl consisting largely of fish and squid of a size substantially greater than those taken in, say, the Isaacs-Kidd trawl.

Cephalopods in excess of 1' 4" were taken and included several rare and poorly known species. In 4 trawls 266 squids were caught. These include:

15 Calliteuthis (3 species)
29 Abraliopsis
25 Enoploteuthis
79 Pyroteuthis (a few possibly Pterygioteuthis)
4 Lycoteuthis
17 Ctenopteryx
12 Tracheloteuthis
2 Octopoteuthis
1 Cranchia
1 Liocranchia
1 Taonius
6 Phasmatopsis
2 Onychoteuthis (2 species)
16 Todarodes
20 Heteroteuthis

Among the fish were some unusually large hatchet fish and myctophids.

Acoustic work

The object of the main acoustic experiment was to measure quantitatively the scattering from different depths at different frequencies (300 c/s - 2 kc/s, 3.3 kc/s, 10 kc/s, 26 kc/s, 36 kc/s, 54 kc/s, 67 kc/s and 100 kc/s) for comparison with the biological samples obtained with various nets. Echo-sounders when operational were recording continuously and all scientific personnel shared the sounder watches.

Quantitative measurements of diurnal migration rates, depths and thicknesses of layers, the responses of layers to lowered lights and the monitoring of various gear overside can be obtained from the mufax "intensity" records. To calculate volume scattering coefficients of the layers and acoustic target areas (or strengths) of single scatterers, the sounders were calibrated and the signal levels recorded for several successive transmissions to allow suitable averaging. An ultra-violet galvanometer recorder (6 channels available) has been used to record signal levels at 10 kc/s, 26 kc/s, 36 kc/s, 54 kc/s and 67 kc/s. The other sounders did not show sufficient scattering at depths exceeding a few tens of metres and were not used for long periods to make level records worthwhile. The technique used for calibrating the sounders requires no assumptions about the hydrophone sensitivity or target areas of the targets used. Briefly, a hydrophone was lowered into the beam of the sounder with one or more targets suspended beneath it. The levels of the direct pulse transmitted and the echo(es) from the target(s) as received on the hydrophone were measured. The ratio of these levels determines, with the known geometry, the target's acoustic area. The echo level from the target as received on the sounder itself is then measured and hence knowing the transmitter voltage and receiver sensitivity, the complete calibration can be obtained. As a calibrated hydrophone was in fact used, it is possible to cross-check this calibration by using[x] the transmitted source level and transducer directionality. On sounders whose transducer impedance diagrams have been measured a further check on the calibration can be obtained. The level records from the U.V. recorder can then be converted to true scattering coefficients and target areas as functions of frequency and depth and are independent of echo-sounder directionality, power level and receiver gain. Some preliminary calculations indicate scattering coefficients of the same order as found by other workers in the Eastern mid-Atlantic.

U.V. records have been obtained to co-incide with a good proportion of the day time Isaacs-Kidd hauls, for several representative night hauls and a few coinciding with the vertical net and Engel's trawl hauls. Records were usually taken in 8 to 10 second bursts at a paper speed of 10 inches per second, enabling individual scatterers to be resolved.

Over the 24 hr. period from 0400 12/XI/65 to 0400 13 XI 65, whilst continuous bathythermograph and irradiance measurements were in progress, U.V. records lasting 8 seconds were made very 15 minutes, except during the sunrise and sunset migration periods, when the sampling interval was reduced to 5 minutes. Several other recordings of migration periods were also made.

The noise levels of the sounders were measured at different ship speeds and engine revs. The 67 kc/s and 26 kc/s echo-sounder transducers shared the same starboard towed fish, which was the old design with slab side and fins. These became too noisy at between 4 and 5 knots. The P.E.S. (10 kc/s) and Asdic (36 kc/s or 54 kc/s) could be used satisfactorily up to 8 knots, the maximum test speed. The P.E.S. is sensitive to propellor noise at high speeds, whilst the main limitation on the Asdic arises in poor weather when bubbles drawn under the ship cause cavitation and noise. The noise level received on the 3.3 kc/s line hydrophone was also measured. Owing to the yawing of the dinghy from which it was towed, the five foot long hydrophone also yawed, causing the hydrophone spheres to bang against the side of the tube. The more viscous castor oil was used to replace the transformer oil in the line hydrophone tube and the test repeated.

---

[x] See N.I.O. Internal Report A13. (M.J. Tucker and A.R. Stubbs)

One deep listening experiment was made whilst hove-to on 15/XI/65. A hydrophone was lowered on the armoured cable to 1000 m. in stages, and the sound level reproduced on a loud-speaker and recorded on magnetic tape. Down to about 850 m. the predominant background was noise generated by the ship, though there were also several scrapes, thumps and other unrecognisable noises. Cable movement also produced some noise. At 870 m. the hydrophone went dead and a fracture was suspected. However on raising above 850 m. again the signal returned and was similar in character to that recorded during the lowering stages. The cause of this loss of signal is not known but a pressure sensitive connection or component could be the source; the hydrostatic pressure is transmitted through the oil filled p.v.c. tube to the hydrophone pre-amplifier in this type of hydrophone design.

Tape recordings were also made on two occasions of the noise (as received on a hydrophone at 200 m.) made by the explosive link of the 'pop-up' buoy. These recordings were replayed into the U.V. recorder and the waveforms of the explosion and its surface echo observed. The output power level transmitted by the 10 kc/s 'pop-up' buoy transducer was also measured, to enable the estimation of maximum operating range. Impedance diagrams of this and several other transducers were taken.

The signal level integrator was used for a 36 hr. period during the homeward run. It was connected to the 36 kc/s E.S. (Asdic beam set vertical) and was set to cover the layer at about 500 m. It was shown that the layer caused a considerable increase over the background level, which at this time was quite high, and that instrumental drift could be reduced to negligible proportion. Intensity changes on the mufax record correlated well with changes in the integrator output signal rate - due to patchiness in the layer.

Besides the acoustic work above assistance with electronics and electrical work was given to other scientific experiments. (Bercotrol, u/w lights, plankton counter, depth telemeters and 'pop-up' buoy).

Acoustic instrumentation

Much time was spent during the first half of the cruise (to Madeira, 28th October) on designing and developing the equipment. On the second half it was decided to leave the 67 kc/s and 26 kc/s echo-sounders as they were and concentrate on taking results since there were less personnel available, although .. considerable improvement can yet be made on these sets. The following records briefly the major equipment behaviour.

(a) P.E.S. (10 kc/s) This was operated continuously between ports for a total of 1,760 hrs. The pulse length was erroneously set to 2 mS: early on in the cruise and to avoid confusing the records was left at that setting although all other sounders used 1 mS pulses. Apart from recurrent faults on the March-Marine plug at the end of the towing strop the set was generally satisfactory.

(b) Asdic (36 kc/s or 54 kc/s) The Asdic beam was turned to the vertically down position and operated satisfactorily at 1 mS pulse length for a total of 1,363 hrs. The modulator balance required occasional adjustment. A fault in the d.c. supply to the servo-motors was corrected. Generally the 36 kc/s transmission was used though some U.V. records at 54 kc/s have been taken. Some work has been done on a twin-helix mufax recorder which will enable the set to work on alternate transmissions at 36 kc/s and 54 kc/s; this is unfinished. The T.V.G. was not used to avoid complicating the U.V. recordings and calibrations, though better intensity records could undoubtedly have been made with it on.

(c) 67 kc/s E.S. This eventually became operational on 9/XI/65 after considerable difficulty with the main amplifier which tended to oscillate. It was found that diode protection of the receiver was very noisy at this frequency and so this was replaced by a reed-relay-controlled transmit/receive switch. The reed-relays had limited life even with gold plated contacts, probably because the voltage was higher than that recommended. Records amounting to a total of 280 hrs. were taken using 1 mS, 200 w pulses.

(d) 26 kc/s E.S. After the difficulty with the main amplifier of the 67 kc/s E.S. a heterodyne method was used for the 26 kc/s E.S; this enabled a high gain to be achieved without oscillation but at the expense of carrier breakthrough, which gave a persistent grey background. The set seemed to be prone to interference, both acoustic from the bow propeller and othe electrical interference, the source of which was never identified. Records amounting to 510 hrs. were obtained with 1 mS, 200 w pulses.

(e) Boomer (or Thumper, 300 c/s - 2,000 c/s) This was first tried out over Galicia Bank on the outward journey, mainly to test the sound source, but also in the hope of getting sub-bottom echoes. It worked for about 20 minutes when the sound output appeared to diminish. When recovered and dismantled it was discovered that the insulating sheets of paxolin between the coils and plates had broken down. These paxolin sheets were removed and replaced with layers of araldite and tufnol and the system tried again over medium depth water. No fish echoes and very slight evidence of sub-bottom echoes were observed. Very few large fish shoals had been observed on the other sounders in the Fuerteventura area and so further work with the boomer was limited to the measurement of pressure waveform, amplitude and directional characteristics at 1000 Joules and 5000 Joules using a hydrophone positioned from a rubber dinghy.

(f) 3.3 kc/s E.S. Originally it was intended to operate this sounder on station only, from the starboard midships winch. The first records using it in this manner were poor owing to the very poor directionality of the transducer array. The transducer was then fitted into the fibreglass dinghy "Fred" formerly used for the Mk 1 thumper. A hydrophone array, five feet long with ten hydrophones, tuned pre-amp and main amplifier was then constructed. This gave good directional gain in the fore and aft plane on reception and the hydrophone was towed behind the dinghy at 3-4 kts. Although the bottom echo was detected down to 550 fms, using the maximum power without cavitation (270 watts approx.), no fish echoes or scatterers were observed. The pulse length though set to 1 mS was lengthened due to the narrow bandwidth of the transducer. Some U.V. records of bottom echoes were made.

(g) 100 kc/s E.S. This A100 set belonging to M.A.F.F., Lowestoft, was tried several times and short range fish echoes were detected but the power transmitted was insufficient to detect deep layers or fish deeper than about 30 fms. The bottom echo was observed to 150 fms. A transducer designed to operate about 100 kc/s using N.I.O. ceramic tubes along the axis of a cone, as in the successful 26 kc/s and 67 kc/s transducers, was built to replace the M.A.F.F. transducer for better efficiency, but impedance measurements indicated heavy losses in this also and it was not pursued further.

(h) Timing circuits and Mufax drive oscillator It was not possible to achieve the original plan of using the same time and depth marks on all recorders, though all the 19" recorders were driven from the same 1000 c/s supply. Consequently there were 3 different time mark systems and a depth scale (in fms) only on the P.E.S.

(i) U.V. Recorder With a maximum deflection of 10 cms. and a minimum detectable signal amplitude of 1 mm. the dynamic range is 40 db, compared with about 20 dB for the subjective intensity record. Between short range echoes and the noise level there is 100 dB range. The galvanometer drive amplifier gains were increased so that the 40 dB range available covered the depth range 100 m to 1000 m for scattering layers and 60 m to 200 m for single scatterers. There is a need here for logarithmic amplifiers in each channel. The programme unit designed to switch the recorder on and off remotely for 2,4,8 or 16 seconds every 5,10 or 15 minutes operated satisfactorily. The fan bearing in the recorder needs to be replaced.

Irradiance measurements

The irradiance measurements were made principally by Dr. and Mrs. Boden but Mr. Blaxter on a number of occasions made comparisons with their measurements with the Aberdeen photometer (*Craig and Lawrie, 1962). The instruments used by Dr. and Mrs. Boden were the following:

1. Mast photometer The collector on this instrument is a translucent plastic sphere, the sensor a 931-A multiplier phototube. Schott BG12 and GG5 filters (1 mm thick) are in the light path at all times. A 3-position shutter with a rectangular opening (exposing the entire photocathode), a pinhole (area approximately 0.001 that of the rectangular opening), and an opague position can be changed at will from the control panel in the laboratory. By varying shutter position it is possible to measure incoming radiation throughout the 24-hour cycle and to monitor the dark current of the system. The instrument operated continuously from our departure from Plymouth until our return.

2. Bathy-thermo-irradiance meter The light sensor is a 931-A multiplier phototube selected from about 40 for low dark current and high sensitivity. In front of the phototube window is a collimating tube with a flat-plate cosine collector at its outer end. The collimator has pinholes at its base, such that it is free-flooding in water. Three of the shutter positions are identical with those in the mast photometer; the other two positions are opaque and are in the light path when depth and temperature are determined.

An 8-position filter holder carrying 7 interference and tail-blocking filters is in the light path as well. The eighth position is left empty to allow for an easy check of filter sequence. The effective half-peak band widths of the filter combinations are 9-12 mμ. The spectral region from 410 to 537 mμ was examined with the filters in the instrument during the cruise. The pressure sensor is a Bourdon-operated potentiometer, and a thermistor senses changes in temperature. Shutter (and hence, function) and filter-changer positions are controlled from the laboratory.

On 20 mornings during the cruise, Table 8, the Bathy-irradiance meter (BIM) was lowered to the depth of a migratory sonic-scattering layer at the beginning of the twilight descent. The intensity of irradiance at a given wavelength was

* Limnology and Oceanography Vol. 7, 259-261.

25.

determined at that depth. The instrument was then lowered in steps, without further reference to the echo-sounder traces, and the time at which the initially-measured intensity of irradiance reached each depth was noted.

Similarly, on 10 evenings the ascent of the levels of irradiance with which the migratory sonic-scattering layers had been associated during the day was observed.

In addition to the twilight measurements, 13 lowerings were made during mid-day periods to determine the spectral characteristics and the extinction co-efficients of the water columns. Spectra were obtained at regular intervals of depth from about 50 to greater than 500 metres. Whenever possible, the instrument was returned from depth with the thermistor circuit in action to obtain continuous temperature profiles.

One entire 24-hour period was devoted to irradiance studies. Penetration of the water column by sun-, sky-, and moon-light was measured during all of the twilight periods as well as during the times when irradiance levels were nearly constant. Bioluminescence was appreciable during this "light day", and an *in situ* spectrum of it was obtained from the sonic-scattering layer.

Luminescence

Dr. and Mrs. Boden also conducted luminescence measurements using a newly developed radiance meter. The sensors in these instruments are, again, 931-A multiplier phototubes, selected as matched pairs with nearly equal sensitivities and dark currents. Each instrument has a collimating tube with a clear plastic window at the outer end. The window is superfluous optically, but prevents animals from lodging in the tube and obscuring observations. A pair of instruments is mounted at the ends of a rigid frame, and, depending upon the angle of this mounting and the angle of acceptance of the collimating tubes, the pair views a common volume remote from the distrubance occasioned by the sensors themselves and by the supporting wire.

Each individual instrument contains a wire recorder with a 4-hour capacity. Coincident circuitry is employed, such that, although each unit records all of the flashes within its field of view, only those flashes recorded simultaneously by both units are significant.

Three pairs are usually used at the same time: one below, one in and one above a particular sonic-scattering layer. Such measurements were made at night, at midday and during the twilight migration of the layers. A pair has been mounted on the depressor beam of an Isaacs-Kidd midwater trawl to measure luminescence in a volume of about 1 litre at a distance of about 1 metre ahead of the trawl. One one occasion, 3 pairs were mounted on the trawl beam: one pair looking ahead of the trawl, one looking into the trawl, and one pair viewing ambient light above and below the trawl.

The records have been transferred from wire to tape for later analysis.

Visual Physiology, Chemistry and Histology

1. Electroretinograms Crustaceans collected from scattering-layer depths were dark adapted for several hours in the constant temperature room. They were then immobilized and placed in a shallow bath of sea water at 10°C. A capillary electrode (KCl, Ag-AgCl wire) was inserted into eye; the indifferent electrode

(ag-AgCl gauze) floated in the bath. This preparation was placed in a light-proof box and stimulated with a beam of collimated light. The colour and the intensity of the stimulating light were regulated by use of a series of interference filters (in 10-mμ steps from 420 to 570 mμ) and by neutral density filters (in 0.1-ND steps from 0 to 2.0 ND).

The response to each stimulus was amplified by a Grass P-6 preamplifier, observed on a Tektronix 502 CRO and recorded on a Sanborn 320 pen-writer.

With the assistance of Prof. B.C. Abbott 17 successful experiments were made. In each of these an eye responded reliably to each of 150-200 stimuli of graded colour and intensity. From these data, levels of equal biological response to each wave length will be determined, and spectral sensitivity curves will be constructed.

The animals responding reliably were the euphausiids, _Thysanopoda pectinata_, _Euphausia brevis_, _Nematoscelis megalops_, and the decapod, _Funchalia villosa_.

Preliminary analysis of the electroretinogram results has been completed; the final analysis will be made later. A comparison will then be made of the colour of light at the depth of capture and the spectral sensitivity of the animals.

2. Visual pigments Aqueous digitonin extracts were made from the eyes of various dark-adapted crustaceans. Spectrophotometric analysis of these extracts has indicated the presence of at least one new visual pigment with a maximum absorption between 480 and 490 mμ. This pigment is found in extracts of the eyes of _Funchalia villosa_. A large-(for small crustaceans)-volume of extract from 60 eyes is currently in the ship's deep freeze. It will be subjected to an exhaustive examination when we reach Plymouth.

3. Histology A large variety of crustaceans have been light or dark adapted and preserved specifically for eye studies. These, in addition to samples of other forms from the plankton collections will be shipped to Scripps Institution where the eyes will be sectioned.

Underwater light experiments

On sixteen occasions attempts were made to influence the depth or the movement of sonic scattering layers by means of artificial light sources. After trying a wide range of sources from car bulbs to projection lamps, two finally proved to be of some use. These were a 1500 watt Admiralty pattern diver's lantern, which was used to a depth of about 100 metres and a free flooding 1000 watt projection bulb which had been designed at the Admiralty Research Laboratory for use with underwater television. The latter bulb was used to a depth of 500 metres, although a bulb in which the filament had burnt out was tested to destruction and imploded at 606 metres.

The shallower night time experiments proved little of a problem and quite dramatic results emerged. Attempts to influence layer depth during the day proved much more difficult. The main problem lay in getting a sufficient voltage at the end of a long wire to keep up the output of the bulb. Several attempts were made with the heaviest available cables on board and although success was achieved another difficulty was encountered. This was the overheating of the rubber sleeve around the neck of the bulb. So far the deep experiments have proved inconclusive and one difficulty may well be that of getting a light field wide enough to affect a significant area of the echo-sounder beam.

Other projects

Neuston

One of the main problems in the interpretation of the neuston collections is that of patchiness. The hauls seem to be characterised by singular degree of patchiness and to examine the smaller scale dimensions two series of hauls were taken on a star-shaped pattern some two miles in radius. The first series was taken on a night when the moon was up and catches were small and may hardly be significant. The second series should be more promising.

Mr. Blaxter used the neuston net to collect fish eggs and larvae for histological work concerned with the development of the eye.

Squid-fishing and underwater camera

Altogether 125 squid were taken on hand lines during the cruise - 111 were Ommastrephes caroli and 14 O. pteropus. Two large Histioteuthis bonellii were found dead at the surface, but still in a reasonable state of preservation and both were collected.

The camera was used 14 times (Table 9) with a baited paternoster trigger. Fifteen photographs of squid were obtained; all appear to be Todarodes sagittatus.

Nutrient excretion

Mr. Tundisi carried out the nutrient chemistry on board and conducted some experiments on the rate of excretion of nitrogenous compounds from euphausiids kept in the laboratory.

"Pop up Net"

Trials with a "pop up net", which fishes from a pre-set depth to the surface by means of its own buoyancy, were carried out on five occasions. The mouth of the net was held open by a stiff polypropylene ring, 8 feet in diameter. to which ten or twenty Phillips deep sea floats were attached by jubilee clips. The net was carried down by scrap iron weights which were released by a "Benthos" hydrostatic release gear at a predetermined depth and the floats then carried the net to the surface. Depths to which the net descended were variously determined by means of a pinger on the net, the precision echosounder and the slackening of a string attached to the net and payed out from the surface. On each occasion the net was easily recovered although in one trial the net did not descend as far as intended. Descents were made to 300 m, 560 m, 550 m and somewhere about 600 m in depth. The buoyancy gave ascent rates of 16.5, 16.7, 22.6, 29 m. per minute (discounting a rate of 68.5 m/min. which almost certainly started ascending at a much shallower depth than intended). Two types of net were used; a seven mm. mesh knotless net with a large canvas "bucket" on the end and one trial was made with a standard 2 m. TYF with a narrow canvas "bucket" on the end. While the 7 mm. mesh net caught virtually nothing, the TYF caught a haul comparable in volume with a horizontally towed N113. This shows some promise as a sampling tool for use from small boats which lack winches. Trials were carried out at night and during the daylight; a light on the net made recovery at night very simple.

Plankton counter and volume meter.

The plankton counter is based on the principle that an object interposed in a column of water alters its electrical conductivity if the conductivity of the object is appreciably different from that of water. The electrodes of the instrument were mounted in the entrance of a $\frac{1}{2}$ scale model of the "Jet net".

First tests on the circuitry after several short tows showed that it would require considerable modification for sea towing. Earlier trials on the 'Sarsia' had shown a good correlation between objects counted and the sample obtained in the net, but it soon became evident that more amplification would be needed and Dr. McCartney redesigned part of the circuit, eliminating the post-office counter and taking the signal directly from the output amplifier to the U/V recorder.

Several 12 and 24 hour tows have since been made and U/V records taken about 25% of the time. The samples from the tows have been preserved.

Blood cultures

Mr. Harrisson collected blood from a number of specimens of deep-sea fish and cultured the samples to obtain metaphase plates for microscopical examination. The technique looks extremely promising and may be a useful tool in genetical studies of these animals.

Live plankton chamber

Experiments were made with a cylindrical perspex chamber designed to facilitate microscopic examination of planktonic animals while reducing handling to a minimum. By moving a piston up the cylinder by means of hydrostatic pressure the animal can be confined to a small volume of water in an upper chamber which can then be removed while the animal is observed through the glass top. By replacing the upper chamber and lowering the piston the animal can be returned to a large volume of water between observations.

The apparatus works satisfactorily but could be improved by a few modifications.

A modification to the apparatus makes it possible to introduce an electrode for dissolved oxygen measurement and this was used on a number of occasions to determine respiratory rates of selected decapod crustaceans.

BS

Table 1

Summary of Dates

September	7	Left Plymouth	Part I
September	23-24	Called Funchal, Madeira	
September	26	Called Funchal, Madeira	
September	27-28	Called Funchal, Madeira	
October	4	Arrived Santa Cruz, Tenerife	
October	7	Left Santa Cruz, Tenerife	Part II
October	27	Arrived Funchal, Madeira	
October	31	Left Funchal, Madeira	Part III
November	20	Arrived Santa Cruz, Tenerife	
November	23	Left Santa Cruz, Tenerife	Part IV
November	30	Called Santa Cruz, Tenerife	
December	1	Called Funchal, Madeira	
December	7	Arrived Plymouth	

35. -

Table 2

Scientific Staff

Prof. B.C. Abbott	University of Illinois	7.10 - 27.10.65.
Mr. K.J.H. Andrews	National Institute of Oceanography	29.10 - 7.12.65.
Mr. A. de C. Baker	National Institute of Oceanography	29.10 - 7.12.65.
Mr. G. Barlow	Scripps Institution of Oceanography	7. 9 - 27.10.65.
Mr. D. Bishop	National Institute of Oceanography	7. 9 - 27.10.65.
Dr. J. Blaxter	University of Aberdeen	7. 9 - 27.10.65.
Mr. R. Blei	Scripps Institution of Oceanography	7. 9 - 7.12.65.
Dr. B.P. Boden	Scripps Institution of Oceanography	7. 9 - 7.12.65.
Lord Bowden	Minister of State for Science	23. 9 - 28. 9.65.
Mr. R. Bowers	National Institute of Oceanography	7. 9 - 26. 9.65.
Mr. A.F. Boxell	National Institute of Oceanography	7. 9 - 22.11.65.
Dr. M.R. Clarke	National Institute of Oceanography	29.10 - 7.12.65.
Mr. R.E. Craig	Marine Laboratory, Aberdeen	22.11 - 7.12.65.
Mr. R.I. Currie	Nat. Inst. of Oceanography (In charge)	7. 9 - 7.12.65.
Mr. P.M. David	National Institute of Oceanography	7. 9 - 27.10.65.
Mr. R. Dobson	National Institute of Oceanography	7. 9 - 7.12.65.
Mr. G. Fox	Fisheries Laboratory, Lowestoft	29.10 - 22.11.65.
Mr. P. Foxton	National Institute of Oceanography	7. 9 - 7.12.65.
Mr. J. Francis	National Institute of Oceanography	7. 9 - 7.12.65.
Mr. D. Gaunt	National Institute of Oceanography	7.10 - 22.11.65.
Mr. M.J. Harris	National Institute of Oceanography	29.10 - 7.12.65.
Mr. C.M.H. Harrisson	National Institute of Oceanography	29.10 - 1.12.65.
Mr. P.J. Herring	Jesus College, Cambridge	7. 9 - 4.10.65.
Mary Johrde	National Science Foundation	7. 9 - 27.10.65.
Elizabeth Kampa	Scripps Institution of Oceanography	7. 9 - 7.12.65.
Mr. H. Keating	Scripps Institution of Oceanography	29.10 - 7.12.65.
Dr. G.E. Maul	Museu Municipal, Funchal	27. 9 - 27.10.65.
Dr. B.S. McCartney	National Institute of Oceanography	7. 9 - 7.12.65.
Mr. N. McLeod	National Institute of Oceanography	29.10 - 7.12.65.
Mr. B. Page	National Institute of Oceanography	7. 9 - 7.12.65.
Mr. C.W.A. Pettitt	National Institute of Oceanography	7. 9 - 22.11.65.
Mr. M. Somers	National Institute of Oceanography	7. 9 - 27.10.65.
Mr. R. Stubbs	National Institute of Oceanography	7. 9 - 7.12.65.
Mr. J. Tundisi	Instituto Oceanografica, Sao Paulo	7. 9 - 4.10.65.

B5

Table 3

Station List Conventions

BIM	Bathy-irradiance meter	A - Aberdeen	B - Scripps
CDB	Catch-dividing bucket		
DNI	Depth of net indicator		
EMT	Engel's midwater Trawl. 1200 mesh with 5 m^2 boards		
ERG	Electro-retinograms		
IKMT	Isaacs-Kidd midwater Trawl		
N 113	1 m^2 net		
NF 70	70 cm net with flowmeter		
NN	Neuston net		
O_2	Oxygen probe		
TSD	Temperature, salinity, depth probe		
UC	Underwater camera		
W/S	Water sampling		

35

Table 4

x Starting positions

Station observations

Station	Position x Lat.	Long.	Date Sept 65	Time From	To	Gear used
5765	42°24'N	10°50'W	11	0545	0810	IKMT
5766	41°48.6'N	09°10'W	12	1025	1107	N 113H
				1119	1152	N 113H
5767	41°50.4'N	09°24'W	12	1313	1445	BIM tests
				1500	1735	Asdic cals.
5768	41°46.4'N	09°14'W	12	2030	2058	W/S 1,10,20,30,40,60,80,100
5769	38°25'N	10°15'W	13	2145		NN
				2200		Luminescence meter tests
			14		0106	
5770	37°08'N	11°40'W	14	0945	1347	IKMT 950-(0)
5771	32°34'N	16°24.3'W	16	0845		Flowmeter cals. CDB cals. BIM tests 3 kc/s transducer tests.
				1605	2315	Luminescence meters.
5772	32°36'N	16°23'W	17	0900	1300	NF 113H 3 nets
				1330	1542	BIM
				1600	1850	NF 113H 3 nets
				2000		26/67 kc/s transducer tests
				2020	2145	DNI cals.
5773				0500		BIM tests
	32°32'N	16°11.2'W	18	0920	1219	IKMT 320-(290), 290-0
				1338	1618	IKMT 225-(190), 190-0
				1700	1745	W/S
				1750		BT
				1800		Squid fishing
5774			20	0615	0730	BIM
				0741	0912	NF 113H 3 nets
				1023	1200	NF 113H 3 nets
				1215	1335	BIM (A and B)
				1346	1646	IKMT
5775	32°29.6'N	16°35'W	20	1900	2020	BIM (A and B)
				2020		Squid fishing
5776	32°29.8'N	16°41.4'W	21	0600	0720	BIM (A and B)
				0740	0855	NF 113H 3 nets
				1005	1145	NF 113H 3 nets
				1200	1330	BIM
				1355	1700	IKMT 560-(550), 550-0
				1900	2100	BIM (A and B)
				2115	2145	W/S 1,100,200,300,400,500,600 700,800,900m.
				2242	0010	Luminescence meters
			22	0015		Squid fishing

Table 4 continued

Station	Position* Lat.	Long.	Date	Time From	To	Gear used
5777	32°28.9'N	16°44.4'W	22	0545	0730	BIM
				0748	0903	NF 113H 3 nets
				0915	1045	NF 113H 3 nets
				1130	1330	BIM (A)
				1335	1651	IKMT 555-(525), 525-0
				1755	2000	BIM (A and B)
				Called at FUNCHAL		
5778	32°45.5'N	16°21.2'W	24	1335	1702	IKMT 860-(760), 875-0
				1800	1900	W/S for nutrient expts.
				1900	2030	BIM (B) and TSD probe
				2029	2211	NF 70V 50-0, 100-50, 200-100, 500-200, 1000-500.
				2230		Squid fishing
5779	32°32.2'N	16°23.4'W	25	0605	0720	BIM (B)
				0733	0918	IKMT
				1008	1117	IKMT
				1149	1335	IKMT
				1355	1608	IKMT
				1623	1835	IKMT
				2130	2200	TSD probe DNI cals.
				2215		U/W light expt.
			26		0030	
5780	32°32.5'N	16°41.4'W	26	0515	0725	BIM (B)
				0810	0900	NF 113H trials
				0920	0945	NF 113H 1 net
				0952	1034	NF 113H 1 net
				Called at FUNCHAL		
5781	32°25'N	16°22.5'W	26	1840	2020	NN (9 hauls)
				2030		
			27		0020	U/W light expts.
5782	32°33'N	16°23.7'W	27	0555	0715	BIM (A and B)
				0735	1042	IKMT 550-(350), 350-0
	At Funchal and passage to Moroccan coast.					
5783	29°20'N	11°46.5'W	29	1825	2000	BIM (A)
				2030	2310	IKMT 240-(170), 170-0
				2158	2245	NN fine mesh with T° probe.
			30	0000	0200	U/W light expt.
5784	29°19'N	11°37.7'W	30	0507	0605	Luminescence meters
				0545	0715	BIM (A and B)
				0740	0900	N 113H 3 nets
				0915	1030	N 113H 3 nets
				1030		O_2 probe and W/S
					1200	Chlorophylls
				1215	1345	BIM (A and B)

Table 4 continued

Station	Position[x] Lat.	Long.	Date	Time From	To	Gear used
5784 to	29°11.5'N 28°57.3'N	11°29'W 11°34'W	30 01/X	1530	0200	NN hauls for fish eggs
			October			
5785	29°12.8'N	11°46.5'W	01	0530	0700	BIM (B)
				0740	0900	NF 113H 3 nets
				0915	1050	NF 113H 3 nets
				1100	1300	BIM (A)
				1318	1640	NF 113H 3 nets
				1655	1810	NF 113H 3 nets
				1855	1948	NN (4 mm. mesh) 5 hauls
				2000	2100	U/W light expts.
				2125	2340	Luminescence meters
			Passage towards Tenerife			
5786	28°42'N	14°35.5'W	02	1708	2024	IKMT 440-(420), 420-0.
5787	28°11.5'N	16°17.7'W	03	0500	0600	W/S and BT
				0600	0730	BIM (A and B)
				0745	0920	NF 113H 3 nets
				0925	1100	NF 113H 3 nets
				1200	1300	BIM (A and B) B to 650 m!
				1345	1730	IKMT 930-(0) m.
				2011		NN "Star", 30 hauls.
			04		0126	
		at Santa Cruz : passage to Fuerteventura				
5788	28°15'N	15°15.2'W	07	1910	2050	IKMT (SIO net)
				2100	2225	IKMT (SIO net)
			On position off Fuerteventura			
5789			08	0400		ERG work : TSD probe
				0950	1200	NF 113H
				1200	1350	BIM (A and B)
				1513	1820	IKMT 410-(0) m.
				1835	2000	NN
				2200		U/W light expts.
5790	28°05.1'N	14°08.2'W	09	0535	0651	BIM (A)
				0800	1000	NF 113H 3 nets
				1015	1210	NF 113H 3 nets
				1215	1330	BIM (B)
				1405	1705	IKMT 440-(360), 360-0
				1450	1830	NN with T° probe
				1840	1930	BIM (A and B)
				2200	2330	U/W light expts.
			10	0000	0115	BIM (A and B)

Table 4 continued

Station	Position* Lat.	Position* Long.	Date	Time From	Time To	Gear used
5791	28°03.3'N	14°07.8'W	10	0530	0700	BIM (B)
				0745	1035	IKMT 450-(350), 350-0.
				1050	1350	IKMT 450-(370), 370-0.
				1600	1930	NN with T° probe
				2200	2359	U/W light expts.
				2225	2359	Luminescence meters
5792	28°03.5'N	14°05.7'W	11	0045	0345	IKMT 450-(345), 345-0.
				0545	0730	BIM (B)
				0805	1100	NF 113H 3 nets
				1115	1230	BIM (B)
				1340	1725	IKMT 950-(620)
				1800	2000	U/W light expts.
				2033	2147	IKMT (SIO net)
				2202	2318	IKMT (SIO net)

At anchor ERG work and calibration

Station	Lat.	Long.	Date	From	To	Gear used
5793	28°04.5'N	14°05.5'W	13	0745	1055	IKMT 575-(350), 350-0.
				1115	1315	BIM (B)
				1339	1645	IKMT 455-(325), 325-0.
				1830 ↘		3 kc/s transducer tests
					1930	BIM
				2000	2312	IKMT 450-(340), 340-0.

ERG work

Station	Lat.	Long.	Date	From	To	Gear used
5794	28°04.2'N	14°11.6'W	14	0520	0730	BIM
				0746	1100	IKMT 570-(450), 450-0.
				1100	1300	BIM
				1335	1708	IKMT 650-(500), 500-0.
				1745	1950	U/W light expts.

ERG work

Station	Lat.	Long.	Date	From	To	Gear used
5795	28°05.3'N	14°09'W	15	0737	1122	IKMT 1000-(650)
				1145	1432	IKMT 350-(290), 290-0.
				1450	1730	IKMT 250-(200), 200-0.
				1905	2359	Boomer out
5796	28°04.2'N	14°11'W	16	0415	0548	IKMT (SIO net)
				0745	1130	IKMT 875-(700), 700-0.
				1148	1437	IKMT 435-(340), 340-0.
				1450	1735	IKMT 305-(260), 260-0.
				2243 ↘		W/S
			17		0045	
5797	28°05'N	14°09.5'W	17	0600	0720	BIM
				0745	1115	IKMT
				1345	1712	IKMT 775-(650), 650-0.
				2000	2350	U/W light expts.

Table 4 continued.

Station	Position Lat.	Position Long.	Date	Time From	Time To	Gear used
5798	28°04.8'N	14°09.5'W	18	0615	0715	BIM
				0735	1107	IKMT 700-(575), 575-0.
				0830	1200	NN with T° probe
				1127	1445	IKMT 600-(495), 495-0.
				1503	1737	IKMT 208-(160), 160-0.
				1500	1740	Boomer out
				1925		Plankton light trap
			19		0400	
5799	28°05'N	14°09.3'W	19	0600	0720	BIM
				0750	1135	IKMT (SIO net)
				1420	1804	IKMT 810-(675), 675-0.
				1815	1915	BIM
				2200	2359	U/W light tests
5800	28°05'N	14°09.5'W	20	0545	0730	BIM
				0740	1040	IKMT 505-(430), 430-0.
				1055	1325	IKMT 170-(110), 110-0.
				1400		3 kc/s transducer tests
					1830	70 kc/s E/s calibration
				2038	2110	IKMT (SIO net)
				2122	2245	IKMT (SIO net)
5801	28°05'N	14°09.8'W	21	0545	0730	BIM
				0740	1138	IKMT 940-(800), 800-0.
				1145	1300	U/W light tests
				1333	1555	IKMT 100-(60), 60-0.
				1603	1816	IKMT 50-(0).
				1830	2215	U/W light expt.
5802	28°04.5'N	14°09.5'W	22	0600	0715	BIM
				0900	1230	Calibrations of CDB etc.
				1335	1610	IKMT
				1930		NN "Star" 36 hauls
			23		0213	

ERG work

Station	Lat.	Long.	Date	From	To	Gear used
5803	28°02.7'N	14°04.6'W	23	0745	1045	IKMT 500-(415), 415-0.
				1200	1700	Boomer measurements
				1955	2245	IKMT 350-(310), 310-0

ERG work

Departure from SOND position off Fuerteventura

Passage N to Madeira

Station	Lat.	Long.	Date	From	To	Gear used
5804	32°28.4'N	16°48.0'W	26	0745	1607	IKMT 2700/(0) m.
				1630	1945	Pop up buoy tests
				2012	2220	IKMT (SIO net) : Luminescence meter
				2230		Pop-up buoy tests
			27		0200	

Table 4 continued

At Funchal

Return passage to Gran Canaria and Fuerteventura

On SOND position off Fuerteventura

Station	Lat.	Long.	Date Nov. 65	From	To	Gear used
5805	28°04.5'N	14°10.7'W	02	1031	1629	NF 70V 50-0, 100-50, 150-100, 200-150, 300-200, 400-300, 500-400, 600-500, 700-600, 800-700, 900-800, 1000-900.
				1700		BIM
				1936	2238	IKMT 490-(460), 460-0
				2300		IKMT 380-(0)
			03		0200	
				0215	0515	IKMT 410-(0)
5806	27°49.5'N	13°58.5'W	03	0550	0659	NN 8 hauls
				0700	0745	BIM pressure test
				0915	1429	NF 70V 50-0, 100-50, 150-100, 200-150, 300-200, 400-300, 500-400, 600-500, 700-600, 800-700, 900-800, 1000-900.
				1630	1900	BIM
				1936	2230	IKMT 415-(350), 350-0m.
				2250		IKMT 310-(260), 260-0.
			04		0142	
				0156	0430	IKMT 205-(150), 150-0.
5807	28°04.4'N	13°57.0'W	04	0548	0649	NN 7 hauls
				0812	1352	NF 70V 50-0, 100-50. 150-100, 200-150, 300-200, 400-300, 500-400, 600-500, 700-600, 800-700, 900-800, 1000-900.
				1500	1630	Calibrations
			04	1630	1845	BIM
				1935	2315	IKMT 900-(0)
				2335		
			05		0312	IKMT 800-(700), 700-0.
5808	28°03.6'N	14°02.3'W	05	0547	0656	NN 9 hauls
				0830	1135	W/S 0-1300m.
				1230	1610	UC 1000m.
				1630	2015	U/W light expts.
				2005		NF 70V 50-0, 100-50, 150-100, 200-150, 300-200, 400-300, 500-400, 600-500, 700-600,
			06		0117	800-700, 900-800, 1000-900
				0330		Squid fishing
5809	28°05.6'N	14°04.8'W	06	0601	0659	NN 8 hauls
				0735	0950	IKMT (SIO net) Luminescence meters 510-0m.
				1305	1703	UC : Luminescence meters
				1950	2337	IKMT 900-(800), 800-0.
			07	0035	0410	IKMT 750-(630), 630-0.
				0545	1000	BIM
				1100	1300	U/W light expts
				1400	1700	Pressure release tests.
				1706	1758	UC 527 m.

Table 4 continued

Station	Lat.	Long.	Date	From	To	Gear used
5810	28°03.9'N	13°51'W	07	1819	1920	NN 8 hauls
				1935	2342	IKMT 925-(800),800-0.
			08	0013	0335	IKMT 625-(475),475-0.
5811	28°04.8'N	14°09.4'W	08	0545	1000	BIM
				1030	1615	3 kc/s transduce in "Fred"
				1740	1923	UC and pinger tests.
				1933	2258	IKMT 710-(600),600-0.
				2315		IKMT 565-(475),475-0.
			09		0225	
5812	28°05.1'N	14°09.8'W	09	0440	0730	BIM
				0912		NF 113V 50-0,100-50,150-100, 200-150,300-200,400-300, 500-400,600-500,700-600,
					1647	800-700,900-800,1000-900.
				1645	1915	BIM
				2024		NF 70V 50-0,100-50,150-100, 200-150,300-200,400-300, 500-400,600-500,700-600,
			10		0200	800-700,900-800,1000-900.
			09	2005		UC 200 m.
			10		0213	
				0220	0630	Acoustically controlled net trials.
5813	28°05.1'N	14°10.6'W	10	0740	1120	IKMT 950-(800),800-0.
				1145	1325	UC 600m.
				1336	1440	IKMT (acoustic control)
				1450	1630	IKMT (acoustic control)
				1630	-	BT
				1730	1930	U/W light expts.
				1946		NF 70V 50-0,100-50,150-100, 200-150,300-200,400-300, 500-400,600-500,700-600,
			11		0129	800-700,900-800,1000-900.
				0156	0720	UC
5814	28°04.2'N	14°10.7'W	11	0730		N 113H trials with CDB.
				0750	0928	N 113H 450-(410),410-0.
				0934	1116	N 113H 500-(460),460-0.
				1141	1250	Pop-up net trials.
				1520	1640	Pop-up net trials.
				1936	2220	IKMT 265-(200),200-0.
				2230		
			12		0057	IKMT 150-(90),90-0.
5815	28°03.6'N	14°09'W	12	0400		BIM BT U/V records.
			13		0400	(24 hour station).
				0520	0715	UC 300 m.
5816	28°03.5'N	14°11.9'W	13	0745	0913	N 113H 390-(340),340-0.
				0925	1053	N 113H 350-(280),280-0.
				1103	1221	N 113H 295-(240),240-0.
				1230	1350	N 113H 250-(190),190-0.
				1400	1515	N 113H 200-(0).
				1528	1645	N 113H 215-(150),150-0.
				1655	1810	N 113H 160-(90),90-0.
				2035	2359	E/S calibrations
			14	0010	0717	UC 300 m.

Table 4 continued

Station	Lat.	Long.	Date	From	To	Gear used
5817	28°04.7'N	14°09.7'W	14	0730	1200	Flowmeter calibrations
				1400	1630	U/W light expts.
				1940	2253	IKMT 600-(500),500-0.
				2305 ↘		IKMT 120-(50),50-0.
			15		0125	
				0138	0355	IKMT 50-(0).
5818	27°48'N	13°55'W	15	0430	0550	Pop-up net trials.
				0840	1015	UC 300 m.
				1020	1130	BIM
				1220	1324	UC 400 m,
				1355	1911	UC 400 m.
				1630	1753	Deep hydrophone trial
				1920	1940	BIM test.
				1950	2135	N 113H 490-(450),450-0.
				2145	2335	N 113H 460-(400),400-0.
				2338 ↘		N 113H 400-(350),350-0.
			16		0114	
				0125	0253	N 113H 350-(280),280-0.
				0308	0430	N 113H 290-(240),240-0.
				0443	0605	N 113H 250-(180),180-0.
				0659	0720	Pop-up net trial.
5819	28°04.0'N	14°05.2'W	16	1100	1335	UC.
				1520	2140	EMT 100-(0)
				2308 ↘		N 113H 220-(150),150-0.
			17		0023	
			17	0040	0150	N 113H 150-(100),100-0.
				0204	0310	N 113H 100-(50),50-0.
				0320	0455	N 113H 560-(500),500-0.
				0505	0610	N 113H 50-(0).
5820				0930		Hydrophone tests.
				1318	1600	Fred streamed. Noise level measurements.

U/W for Pop-up buoy station

Station	Lat.	Long.	Date	From	To	Gear used
5821	28°24.4'N	15°04.6'W	18	1030		BT
				1730	1940	Picking up buoy.
				2000 ↘		UC and squid fishing.
			19		0445	
5822	28°01.7'N	16°17.2'W	19	1400	2305	EMT 570 m.
			20	0250	0844	UC 100 m.

At Santa Cruz de Tenerife

Return passage to Fuerteventura

Station	Lat.	Long.	Date	From	To	Gear used
5823	28°05.5'N	14°08'W	24	0236	0424	Pop-up net trials.
				0530	0730	BIM
				0918	1800	EMT 500 m.
				1942	2125	N 113H 700-(550),550-0.
				2135	2320	N 113H 800-(650),650-0.
				2330 ↘		
			25		0120	N 113H 830-(775),775-0.
				0130	0335	N 113H 960-(800),800-0.
				0345	0518	N 113H 580-(440),440-0.

Table 4 continued

Station	Lat.	Long.	Date	Time	To	Gear used
5824	28°05.0'N	14°09.5'W	25	0730	1125	W/S 350 in [illegible] m. to 670 m.
				1000	1236	Boomer outboard
				1130	1342	BIM
				1810		EMT 90 m.
			26		0105	
5825	28°06.6'N	14°06.9'W	26	0745	0935	N 113H 570-(475),475-0.
				0942	1135	N 113H 625-(550),550-0.
				1145	1355	N 113H 940-(700),700-0.
				1430	1605	N 113H 800-(700),700-0.
				1618	1750	N 113H 600-(475),475-0.
				1935	2125	N 113H 660-(510),510-0.
				2138	2335	N 113H 720-(600),600-0.
				2345		N 113H 910-(825),825-0.
			27		0155	
5826	28°07.2'N	13°54.5'W	27	0915	1905	EMT 560 m.
				2010	2335	IKMT acoustic control tests.
5827	28°05.3'N	14°04.5'W	28	0200	0700	E/S calibrations,
	28°05.1'N	14°06.2'W		0755	0940	N 113H 720-(600),600-0.
				0950	1142	N 113H 780-(650),650-0.
				1152	1355	N 113H 900-(750),750-0.
				1405	1600	N 113H 950-(800),800-0.
				1613	1725	N 113H 50-(0).
				2005		IKMT (SIO net) with
			29		0011	luminescence meters.
				0230	0703	UC 100 m.
5828	28°05'N	14°09.7'W	29	0755	0907	N 113H 100-(50),50-0.
				1015	1130	IKMT acoustic control
				1155	1415	IKMT acoustic control
				1425	1655	IKMT acoustic control
				1940	2300	"Fred" overboard. E/S noise level measurements.

Passage to Tenerife.

Table 5

Log of Echo-sounder rolls

Precision echo-sounder (10 kc/s)

Roll No.	Start	Finish	Roll No.	Start	Finish
1	1635. 8. 9	1445.11. 9	19	1836.23.10	1833.25.10
2	1500.11. 9	0500.13. 9	20	1838.25.10	0915. 1.11
3	0506.13. 9	0015.15. 9	21	0918. 1.11	0514. 3.11
4	0024.15. 9	2106.17. 9	22	0520. 3.11	0900. 5.11
5	0845.18. 9	0300.22. 9	23	0911. 5.11	1120. 7.11
6	0305.22. 9	2315.25. 9	24	1128. 7.11	1325. 9.11
7	2320.25. 9	1340.27. 9	25	1329. 9.11	1315.11.11
8	1054.28. 9	1105.30. 9	26	1330.11.11	1650.13.11
9	1110.30. 9	2345. 1.10	27	1655.13.11	2200.15.11
10	0002. 2.10	1747. 3.10	28	2230.15.11	2230.17.11
11	1930. 7.10	2227. 9.10	29	2230.17.11	1800.19.11
12	2230. 9.10	1801.11.10	30	1800.19.11	0839.25.11
13	1815.11.10	1800.13.10	31	0840.25.11	1440.27.11
14	1800.13.10	1530.15.10	32	1445.27.11	2245.29.11
15	1540.15.10	1725.17.10	33	2246.29.11	0315. 2.12
16	1730.17.10	1703.19.10	34	0345. 2.12	0812. 4.12
17	1707.19.10	2001.21.10	35	0814. 4.12	0000. 6.12
18	2002.21.10	1834.23.10			

Asdic (36 or 54 kc/s)

Roll No.	Start	Finish	Roll No.	Start	Finish
1	0900.10. 9	1645.11. 9	30	0000.26.10	2315.26.10
2	1500.12. 9	1500.17. 9	31	1200.31.10	1410. 1.11
3	1510.17. 9	1210.20. 9	32	1414. 1.11	1710. 2.11
4	1215.20. 9	2200.21. 9	33	1710. 2.11	1903. 3.11
5	2205.21. 9	2000.22. 9	34	1905. 3.11	2120. 4.11
6	1200.24. 9	1400.25. 9	35	2122. 4.11	2340. 5.11
7	1405.25. 9	1615.26. 9	36	2345. 5.11	0143. 7.11
8	1617.26. 9	1548.28. 9	37	0146. 7.11	0300. 8.11
9	1600.28. 9	1800.29. 9	38	0315. 8.11	0340. 9.11
10	1802.29. 9	2017.30. 9	39	0815. 9.11	1015.10.11
11	2022.30. 9	2045. 1.10	40	1025.10.11	1230.11.11
12	2054. 1.10	2259. 2.10	41	1230.11.11	0355.12.11
13	2301. 2.10	1107. 8.10	42	0356.12.11	0630.13.11
14	1108. 8.10	1045. 9.10	43	0640.13.11	0925.14.11
15	1330. 9.10.	1540.10.10	44	0927.14.11	1201.15.11
16	1545.10.10	1823.11.10	45	1206.15.11	1414.16.11
17	1830.11.10	1705.12.10	46	1418.16.11	1658.17.11
18	0520.13.10	0730.14.10	47	1702.17.11	1903.18.11
19	0745.14.10	0825.15.10	48	1905.18.11	2027.19.11
20	0325.15.10	1035.16.10	49	1339.23.11	1627.24.11
21	1049.16.10	1125.17.10	50	1632.24.11	1752.25.11
22	1125.17.10	1515.18.10	51	1815.25.11	2015.26.11
23	1715.18.10	1343.19.10	52	2040.26.11	2315.27.11
24	1345.19.10	1153.20.10	53	2340.27.11	0130.29.11
25	1155.20.10	1446.21.10	54	0135.29.11	0508.30.11
26	1448.21.10	1658.22.10	55	0510.30.11	0740. 1.12
27	1701.22.10	1447.23.10	56	0748. 1.12	1005. 1.12
28	1500.23.10	1315.24.10	57	1010. 2.12	1231. 3.12
29	2210.24.10	2345.25.10	58	1234. 3.12	0812. 4.12

Table 5 continued

67 kc/s Echo-sounder

Roll No.	Start	Finish	Roll No.	Start	Finish
1	0515. 9.10	0500.10.10	16	0845. 4.11	1402. 5.11
2	1040.10.10	1800.11.10	17	1410. 5.11	2140. 6.11
3	1830.11.10	0840.13.10	18	2145. 6.11	0130. 8.11
4	1051.13.10	0810.15.10	19	0150. 8.11	0815. 9.11
5	0815.15.10	1301.16.10	20	0817. 9.11	1335.10.11
6	1304.16.10	1900.17.10	21	1340.10.11	2300.11.11
7	1900.17.10	0000.19.10	22	2310.11.11	0600.13.11
8	0005.19.10	0426.20.10	23	0615.13.11	1430.14.11
9.	0439.20.10	1440.20.10	24	1430.14.11.	2245.15.11
10	1442.20.10	1843.21.10	25	2255.15.11	0445.17.11
11	1845.21.10	2145.22.10	26	0447.17.11	0259.25.11
12	2212.22.10	0245.24.10	27	0259.25.11	0915.26.11
13	0300.24.10	0900.24.10	28	0930.26.11	1745.27.11
14	1100. 2.11	0215. 3.11	29	1747.27.11	0615.29.11
15	0219. 3.11	0840. 4.11	30	0645.29.11	1415.29.11

26 kc/s Echo-sounder

Roll No.	Start	Finish	Roll No.	Start	Finish
1	1920.26.10	0917.27.10	10	0410.12.11	1100.13.11
2	1930. 2.11	0840. 3.11	11	1105.13.11	2015.14.11
3	0845. 3.11	1502. 4.11	12	2030.14.11	0300.16.11
4	1545. 4.11	2215. 5.11	13	0325.16.11	1000.17.11
5	2220. 5.11	0316. 7.11	14	1020.17.11	0930.25.11
6	0525. 7.11	1045. 8.11	15	0940.25.11	2000.26.11
7	1600. 8.11	1722. 9.11	16	2000.26.11	1132.28.11
8	1725. 9.11	2310.10.11	17	1136.28.11	2130.29.11
9	2313.10.11	0406.12.11			

Table 6

U-V Recordings

Date	Station No.	Net Haul
22/9	5777	NF 113H
1/10	5785	NF 113H
14/10	5794	IKMT (1) IKMT (2)
15/10	5795	IKMT (1) IKMT (2) IKMT (3)
16/10	5796	IKMT (2) IKMT (3) IKMT (4)
17/10	5797	IKMT (1) IKMT (2)
18/10	5798	IKMT (1) IKMT (2) IKMT (3)
19/10	5799	IKMT (1) IKMT (2)
20/10	5800	IKMT (1) IKMT (2)
21/10	5801	IKMT (1) IKMT (2) IKMT (3)
2/11	5805	NF 70V IKMT (1)
3/11	5805	IKMT (3)
4/11	5806	IKMT (1)
5/11	5807	IKMT (2)
7/11	5809	IKMT (3)
8/11	5810	IKMT (2)
29/11	5828	IKMT (1)
24/11	5823	EMT
27/11	5826	EMT
17/9	5772	- SUNSET MIGRATION
22/9	5777	- DAWN MIGRATION
24/10	5803	- DAWN MIGRATION
12/11 13/11	5815	24 hour series including sunset and dawn migrations.

Table 7

Bathymetric E/S runs

Date	Time		Date	Time	
ix.09	1200	to	ix.10	1900	Bay of Biscay to Galicia Bank
ix.13	0700	to	ix.15	2300	Portugese coast to Porto Santo
ix.28	1100	to	ix.29	1800	Madeira to Moroccan coast
x.02	0000	to	x.03	0415	Moroccan coast to Tenerife
x.24	2230	to	x.26	0400	Gran Canaria to Madeira
x.31	2000	to	xi.01	1600	Madeira to Gran Canaria
xi.30	1300	to	xii.01	1600	Tenerife to Madeira
xii.01	1600	to	xii.04	0812	Madeira to Finisterre

Table 8

Bathy-irradiance Measurements

Date	Dawn	Midday	Dusk	Moon
ix.12		1313-1445		
ix.17		1330-1430		
ix.20	0615-0730	1215-1335	1906-2020	
ix.21	0600-0720	1200-1330	1900-2100	
ix.22	0545-0730		1755-1935	
ix.24			1900-2030	
ix.25	0605-0720			
ix.26	0515-0725			
ix.27	0555-0715			
ix.30	0545-0715	1215-1345		
x.01	0530-0700			
x.03	0600-0730	1200-1300		
x.08		1200-1350		
x.09		1215-1330	1840-1930	
x.10	0530-0700			0000-0115
x.11	0545-0730	1115-1230		
x.13		1115-1315		
x.14	0520-0730	Midday-time Marker Off		
x.18	0615-0715			
x.19	0600-0720		1815-1915	
x.20	0545-0730			
x.21	0545-0730			1930-2045
x.22	0600-0715			(Measurement of intensity of U/W lights)
xi.03			1630-1900	
xi.04			1630-1845	
xi.07	0545-1000			
xi.08	0545-1000			
xi.09	0440-0730		1645-1915	
xi.12-13	0600/12 -	- - - - - - - - - - - - - -	0400/13	
xi.15				
xi.24	0530-0730			
xi.25		1130-1342		

Table 9

Underwater Camera Stations

Station No.	Depth	Time at depth From	To	f.	focus	film	Bait	Pictures
5808	1000	1248	1600					3
5809	527	1712	1753	8	5'	HP3		-
5809	1000	1345	1640		"	"		-
5811	500	1747	1917		"	"		2
5812	200	2013	0205		"	"		-
5813	400	0205	0713		"	"	Mackerel	8
5813	600	1200	1315		"	"	"	-
5815	300	0533	0710	4	5'6"	HP3		-
5816	300	0023	0712	3.5	5'6"	FP3	Squid	2
5818	300	0853	1010	3.5	5'6"	FP3	"	-
	400	1228	1320	"	"	"	"	-
	400	1415	1900	"	"	"	"	-
5819	600	1121	1320	"	"	"	"	-
5821	300	2010	0440	"	"	"		-
5822	100	0255	0840	"	"	"	Mackerel	-
5827	100	0235	0700	"	"	"	Kipper	-

Table 10

NF 70V hauls on Fuerteventura station

	Day hauls	Night hauls
Station	5805	5808
	5806	5812
	5807	5813

Table 11

N 113H series on Fuerteventura station

DAY Station	DAY Depth of deep catch	NIGHT Station	NIGHT Depth of deep catch
5827	50-(0)	5819	50-(0)
5828	100-(50)	5819	100-(50)
5816	160-(90)	5819	150-(100)
5816	215-(150)	5819	220-(150)
5816	250-(190)	5818	250-(180)
5816	295-(240)	5818	290-(240)
5816	350-(280)	5818	350-(280)
5816	400-(360)	5818	400-(350)
5814	450-(410)	5818	460-(400)
5814	500-(460)	5818	490-(450)
5825	570-(475)	5819	560-(500)
5825	600-(475)	5823	580-(440)
5825	625-(550)	5825	660-(510)
5827	720-(600)	5823	700-(550)
5827	780-(650)	5825	720-(600)
5825	800-(680)	5823	800-(650)
5827	900-(750)	5823	830-(775)
5825	940-(700)	5825	910-(825)
5827	950-(800)	5823	960-(800)

Table 12

IKMT series on Fuerteventura station

DAY Station	DAY Depth of deep catch	NIGHT Station	NIGHT Depth of deep catch
5801	50-(0)	5817	50-(0)
5801	110-(60)	5817	120-(50)
5800	170-(110)	5814	150-(90)
5793	200-(160)	5806	210-(150)
5795	250-(200)	5814	265-(200)
5796	305-(260)	5806	310-(260)
5795	350-(290)	5803	350-(310)
5796	435-(340)	5806	415-(350)
5793	455-(325)	5793	450-(340)
5803	500-(425)	5805	490-(460)
5800	505-(430)	5811	565-(475)
5794	570-(450)	5817	600-(500)
5798	600-(495)	5810	625-(475)
5794	650-(500)	5811	710-(600)
5798	700-(575)	5809	750-(630)
5797	775-(650)	5807	800-(700)
5799	810-(675)	5809	900-(800)
5796	875-(700)	5810	925-(800)
5801	940-(800)		
5813	950-(800)		

Table 13

IKMT NIGHT HAULS (33)

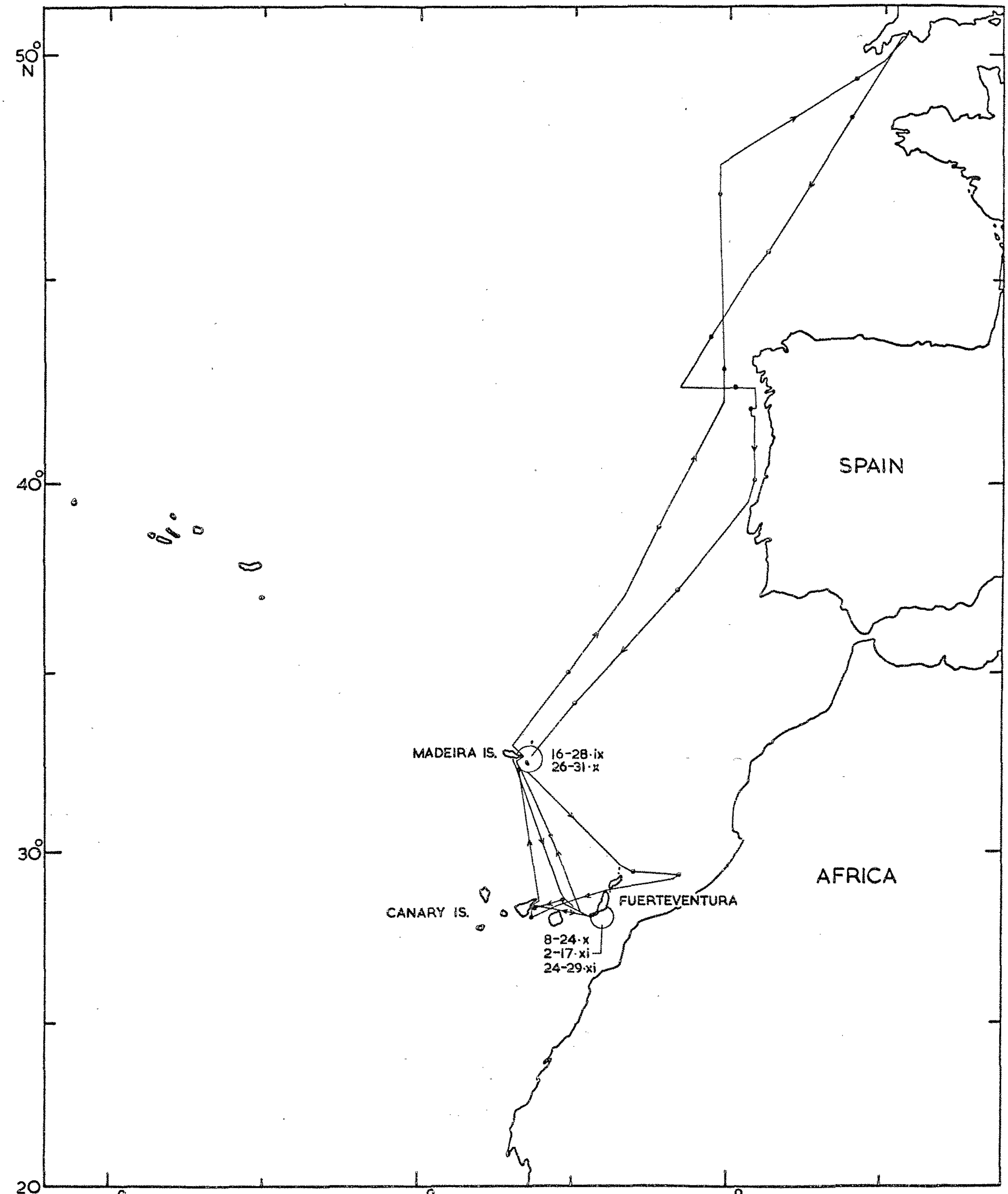
Nominal depth (m)	Standard 2 hr. tows	Miscellaneous
50	5817	
100	5817	
150	5814	5804
200	5806	
250	5783,5814	5788,5792(1),5792(2),5800
300	5806	5827
350	5803	
400	5805(1),5805(2),5806	5796
450	5792,5793	
500	5805	5788
550	5811	
600	5817	
650	5810	
700	5811	
750	5809	
800	5807	
850		
900	5807,5809	5826
950	5810,5813	
1000		

Table 14

IKMT DAY HAULS (55)

Nominal depth (m)	Standard 2 hr. tows	Miscellaneous
50	5801	
100	5801	
150	5800	
200	5783,5798	
250	5773,5795	5779
300	5773,5796	
350	5790,5795,5803	5828
400	5789	5765
450	5774,5790,5791(1), 5791(2),5793,5796	5799,5786
500	5800,5801,5803	5809
550	5776,5777,5782,5793,5794	5802,5813,5828
600	5798	5779
650	5794	
700	5798	
750		
800	5797(1),5797(2),5799	5779,5798
850	5778	
900	5796	
950	5787,5792,5801,5813	5770
1000	5795	5828
2700	5804	

B5


50°
N
40°
30°
20
30°
20°
10°W
SPAIN
AFRICA
MADEIRA IS.
16-28·ix
26-31·x
CANARY IS.
FUERTEVENTURA
8-24·x
2-17·xi
24-29·xi