NATIONAL INSTITUTE OF OCEANOGRAPHY
Wormley, Godalming, Surrey.

"DISCOVERY" CRUISE 20 REPORT

(20th October - 18th December 1967)

CURRENT MEASUREMENTS IN THE BAY OF BISCAY

AND OBSERVATIONS OF DEEP STRATIFICATION

N.I.O. CRUISE REPORT SERIES: CR 20

AIMS

Long-term current measurements in Bay of Biscay.
Studies of stratification in deep water.
Trial measurements of near-surface and near-bottom currents.
Various related observations and instrument trials.

LIST OF PROJECTS

1. Location and attempted recovery of test moorings laid during Cruise 17.
2. Deep current measurements with moored current meters.
3. Deep current measurements with neutrally-buoyant floats.
4. Near-surface drogues.
5. Trials of E.M.I. - Cossor radar transponder.
6. Bottom current profiles (camera and tripod).
7. Testing Vickers' "dracones" in deep water.
8. Trials of tilt-telemetering float.
9. Bathysonde profiles.
10. TSD profiles.
11. Thermistor chain trials.
12. Sensitive temperature profiler.
13. Water sampling.
14. Trials of recording sea-floor magnetometer.
15. Moored thermistor array.
16. Thermistor array suspended from ship.
17. Recording 2-component E.M. log.

ITINERARY (see track chart)

First half (20th October - 17th November)

"Discovery" sailed from Plymouth p.m. 20th October, calling at Falmouth for fuel and leaving there at 1330/21st October. Course was set for the test mooring position near 47° 30'N. 8° 20'W. On reaching this area at 1000/22nd October, contact was made immediately with the command pinger and a rough fix obtained, but the mooring could not be released. Proceeding southwards, the middle of the Biscay abyssal plain was reached by 2230/22nd October and preparations were begun for laying moorings. Work continued in this area (laying moorings, making bathysonde dips, tracking neutrally-buoyant floats) until 1st November, when persistent bad weather made it seem more profitable to move southwest.

More moderate conditions were found in the area 43° - 42°N 11½° - 12½°W, where trials were made with various near-surface

drogues and a radar transponder, and the 2-component log was calibrated, during 3rd - 5th November. Returning then to the central Biscay area, the first mooring was recovered and re-laid, more neutrally buoyant floats were started, and the second mooring recovered in the period 7th - 14th November. Remarkably calm weather prevailed during that period, and bathysonde dips and water samples were taken in conjunction with the current measurements. The return passage to Plymouth was via the test mooring site, where unsuccessful attempts were made on 15th and 16th November to recover the mooring by dragging. "Discovery" entered Millbay Docks p.m. 17th November.

Second half (21st November - 18th December)

Sailing again for the Biscay area p.m. 21st November, there were some changes in the scientific party (see list of participants) and in the nature of the work to be done. Additional equipment included the Hytech TSD, and means for recording its output (and that of the bathysonde) in an expanded form.

A mooring which had been left in position at the end of the first half of the cruise was located again a.m. 23rd November, and another laid in the same area. Work continued on various projects, (including neutrally-buoyant floats, bottom current tripod, bathysonde and TSD lowerings) in the central Biscay area until 30th November.

An excursion southwards was then started, towards the Gulf of Cadiz, with stations at approximately 90 mile intervals where TSD or bathysonde lowerings, or both, were made. The station spacing was made closer at the southern end, and some station positions were reoccupied on returning northwards. This excursion yielded a number of detailed temperature and salinity profiles through the Mediterranean water, at various distances from its source.

"Discovery" returned to the central Biscay area on 10th December, another mooring was laid and various other projects continued (more floats, water sampling, TSD lowerings, thermistor array trials). Leaving the area on 16th December with both moorings recovered, the ship reached Plymouth Sound late on 17th December and entered Millbay Dock early the next morning.

SCIENTIFIC PERSONNEL

1st Half	2nd Half			
	X	Mr D.G. Bishop	N.I.O.	
X	X	Mr S.A. Blackmore	N.I.O.	
	X	Mr R. Bowers	N.I.O.	
X	X	Mr R. Dobson	N.I.O.	
	X	Mr C.K. Folland	N.I.O.	
X		Mr D.I. Gaunt	N.I.O.	
X	X	Mr W.J. Gould	N.I.O.	
X		Mr M. Hands	N.I.O.	Resident scientist
X		Mr M.J. Harris	N.I.O.	
X	X	Mr C.A. Hunter	N.I.O.	
X		Mr D. Nevitt	N.I.O.	
X		Mr N.D. Smith	N.I.O.	
X	X	Dr J.C. Swallow	N.I.O.	Principal scientist
	X	Dr S.A. Thorpe	N.I.O.	
X		Dr R.B. Whitmarsh	N.I.O.	
X		Mr M. Beliard	Museum d'Histoire Naturelle, Paris.	

SCIENTIFIC PERSONNEL (Cont.)

1st Half	2nd Half		
	X	Dr. L.H.N. Cooper	M.B.A., Plymouth.
X	X	Mr A. Dyer	Dept. of Oceanography, Southampton.
X		Mr J. Gascard	Museum d'Histoire Naturelle, Paris.
X		Mr F.J. Harris	Vickers Limited.
	X	Mr A. Hecht	Dept. of Oceanography, Liverpool
X		Mr R. Jackson	Mar. Sci. Lab., Menai Bridge.
	X	Mr V. Owens	Mar. Sci. Lab., Menai Bridge.
X	X	Mr R. Pingree	Dept. of Oceanography, Southampton.
X		Mr A. Roberts	Mar. Sci. Lab., Menai Bridge.
	X	Mr J. Sunderland	Geophysics Dept., Cambridge.

SCIENTIFIC PROJECTS

These notes are intended only as an indication of the kind of work done and progress made, in each project. The persons named should be consulted for fuller details.

1. Test mooring laid during Cruise 17 (Gaunt, Harris, Swallow)

Passing near the nominal position a.m. 22nd October, the command pinger was switched on at the first attempt and its position fixed (47°31.5'N, 8°23.4'W). Three attempts to fire the release gave no result, the release pinger was not heard and no floats were seen. From the appearance of the command pinger signal it seemed likely that the whole mooring was on the bottom. This likelihood was confirmed a few days later by a radio report of the floats (without the rest of the mooring) having been found floating and recovered by a French fishing vessel.

An attempt was made on 15th November to raise the mooring by dragging. A dan buoy was anchored nearby to provide a reference point. A transponder was put on the trawl wire, 500m. above the grapnels. This relayed the command pinger signal and made it possible to try to manoeuvre the drag deliberately towards the command pinger. After about 1½ hours dragging, something was caught, which on recovery proved to be a disused submarine cable. This was dropped back in, and dragging resumed next morning, this time starting nearer to the command pinger and making smaller manoeuvres. At one time the transponder, 100m. above the grapnels, passed within 30m. of the command pinger, but nothing was hooked. Weather conditions were not ideal (wind 30 kts).

2. Moored current meters (Gaunt, Gould, M. Harris, Swallow)

Five moorings with current meters were laid during the cruise, all in 4600m. depth in the centre of the Biscay abyssal plain. Meter depths and durations were:

No.	Approx. depths of meters	Laid	Recovered	Duration
1	400, 1400(2), 2860m.	24.X.	7.XI	14 days
2	400, 1400(2), 2860.	30.X.	10.XI	11
3	400, 1400(2), 2860.	9.XI.	12.XII.	33
4	40, 90, 380, 1380(3).	23.XI	30.XI.	7
5	60, 110, 400, 1400(2), 2600.	11.XII.	15.XII	4

Three types of current meter were used - Bergen, Braincon and Plessey. The latter were on loan from the Fisheries Laboratory, Lowestoft. Different pairs of meters were included, closely spaced, in each mooring, so that some instrumental comparisons can be made. The shallow meters on moorings 4 and 5 were added in conjunction with the moored thermistor array (item 15).

For the first 3 moorings the main buoyancy was subsurface, nominally 200m. depth, with a stray line to a dan buoy at the surface. These moorings had acoustic releases, but only one of them (on No.2) worked. The other two were put out of action by slight leakages. No. 3 mooring lost its surface buoy and, with an inoperative acoustic release, had to be recovered by dragging. Fortunately the command pinger in that mooring was still working, which made it possible to drag systematically towards the mooring. Without it the whole mooring would most probably have been lost. Moorings 4 and 5 had surface buoyancy, since a near-surface thermistor array was included in them, and no acoustic releases were fitted. The seabed magnetometer was included in mooring 5 but was lost, though all the upper part of the mooring was recovered.

Although no N.I.O. current meters were lost, and none leaked, they have not all produced satisfactory records. However, more than half seem likely to be useful.

3. Neutrally-buoyant floats (Swallow)

These were used in the same area as the moorings, and at the same nominal depths as most of the current meters, i.e. 400, 1400 and 2860m. 14 floats were used, one of which failed electrically within an hour of being laid. The others were tracked for varying periods of 1 to 6 days. They showed predominantly north-eastward movement, with some variability at all depths. Speeds were generally in the range 10-20 cm/sec at 400m, and about 5 cm/sec at 1400 and 2860 m. Comparisons with the current meter records have yet to be made.

4. Near-surface drogues (Dyer, Pingree, Swallow)

Trials were made drogues that might be suitable for Ekman layer studies (say, the top 20m) where the available current meters are ineffective. Flashing lights were rejected in favour of acoustic beacons, as means of making the drogues detectable. A promising form of drogues was made from a 4-ft. current cross with a type B pinger attached to it, suspended below an elliptical float. Only one attempt was made to observe the vertical profile of current in the Ekman layer; the floats separated downwind with no detectable tendency to form a right-handed spiral.

5. E.M.I. - Cossor radar transponder (Hunter)

This device, recently developed by E.M.I. - Cossor in Canada, sends back a VHF radio signal on receiving a radar pulse. It is much cheaper and more economical on power supplies than the Alpine-Decca transponder which replies with a radar pulse when triggered. Working ranges obtained were only 4 to 5 miles, the limits for triggering the transponder and detecting the VHF signal being reached at about the same range. Both the available transponders were tried, with similar results: one was lost while recovering a buoy in poor weather.

6. Bottom current tripod (Thorpe)

The tripod was constructed to examine the variation of current direction with height above the bottom. A camera recorded the direction of neutrally-buoyant vanes arrayed on, and free to rotate about, a vertical wire whilst the tripod rested on the sea floor. A compass set in the field of view of the camera gave a reference direction, and two Savonius rotors, which operated post office counters, were intended to record the speed of the current.

The tripod was lowered at two stations on the Biscay Abyssal Plain at depths of 4830m. At station 6493 it was found on recovery that the tube containing the post office counters had flooded, but the camera worked well and showed that the current was towards the S.W. and had a speed (estimated from the movement of the cloud of mud stirred up as the tripod arrived at the sea floor) of about 1.5cm/sec. Photographs suggested a rotation of some 12° in the direction of the current from the bottom to a height of 12 feet above the bottom. The second station, 6507, was less successful. The tripod was damaged as it was being lowered and although it was maintained in a steady upright position on the sea floor for over 30 minutes no current measurement was possible.

7. Testing Vickers' "dracones" (F. Harris, Gaunt)

This "dracone" was a miniature version of a rubber bag that could be filled with hexane to provide buoyancy at great depths. The bag used for this test had approx. 70 lb. buoyancy, and the purpose of the test was to see whether any unforseen effects might arise in lowering such a device quickly to a great depth (>4000m) and recovering. One lowering was made, without anything abnormal being noticed.

8. Tilt-telemetering float (Bishop, Swallow)

This float was intended to be used for detecting current shear. Differences of current within the length of the float would cause it to be tilted from the vertical, and the amount of tilt could be telemetered as a variable delay between two sound pulses. There were difficulties in making the tilt sensor sufficiently sensitive and repeatable in operation, which delayed completion of the electronics, and the float could not be balanced to the desired accuracy before the cruise. Trials were limited to the surface, with the float streamed on a light line in small waves, where its tilting could be estimated visually for comparison with its acoustic signals. These still suffered from troubles inherent in the tilt sensor and its potentiometer, which will need to be made more robust before further trials.

9. Bathysonde (Roberts Jackson, Owens, Gould, Gascard, Smith)

This instrument, the property of the Marine Science Laboratory, Menai Bridge, gives continuous profiles of temperature and conductivity as functions of pressure. Forty-seven lowerings were made with it, most of them to 1900m.(full scale on the pressure gauge). On five stations, parts of the profiles were recorded digitally with the data logger; three of these stations were repeated lowerings in nearly the same piece of water (labelled by a neutrally-buoyant float). Calibrations were done using a water bottle on the same wire just above the bathysonde.

Most of the observations were made in the Bay of Biscay, but a few lowerings were made during the excursion into the Gulf of Gibraltar, for further comparison with the TSD.

10. TSD profiles (Bishop, Bowers, Cooper, Folland, Swallow)

This was available only during the second half of the cruise. It provides profiles of temperature and salinity (derived from conductivity) as functions of pressure. The output frequencies corresponding to temperature and salinity were also recorded as functions of time, on a greatly expanded scale on a separate recorder. The same form of expanded scale recording was applied to some of the later Bathysonde records. Successive lowerings of both instruments at the same station will allow their performances to be compared, but this has not yet been done in detail. Twenty-seven lowerings of the TSD were made, most of them to 2500m (limit set by length of conductor-cored wire available). Observations were made both in the Bay of Biscay, where six lowerings were made at successive fixes on a neutrally-buoyant float, and in a section southwards into the Gulf of Gibraltar, giving a series of detailed profiles through the Mediterranean water at varying distances from its source.

11. Thermistor Chain (Bishop, Bowers, Dobson, Thorpe)

The drive to the new take-up winch on the helical capstan gave some trouble at first, but this was overcome and the thermistor chain was tested.

With 200m. of wire out, an 8-pointed star pattern was done at 6 kts, on 26th - 27th November, revealing some variability of temperature but no clear indication of internal waves. Recordings were also made with the ship hove-to, at the same time as the Liverpool thermistor array (16) was in use.

12. Sensitive Temperature Profiler (Bowers)

This instrument was intended to provide a record of temperature and pressure on a greatly expanded scale. Difficulties were encountered with noise in the conducting cable and slip rings, but the same purpose was achieved by applying this instrument's recording system to the TSD and bathysonde.

13. Water sampling (Gould, Swallow)

This was done to enable geostrophic currents to be calculated in the area of the direct current measurements. Three squares of four stations each were worked, in the central Bay of Biscay. Single samples were also taken, on most dips of the bathysonde and TSD, for calibration, and at two stations (6517 and 6533) closely spaced casts were made in relation to the detailed temperature-salinity structure revealed by the TSD.

14. Sea-floor magnetometer (Sunderland)

The acoustic release for this insturment was tested with the magnetometer suspended below a drifting surface buoy, but instrumental troubles caused delay so that no opportunity was left for laying it in a suitable depth of water. In an attempt to get some record from the magnetometer, it was included in the lower part of No. 5 mooring, but was unfortunately lost when an eye in the terylene rope jammed in the winch spreader rollers while the mooring was being recovered.

15. Moored thermistor array (Hecht)

This instrument consisted of a string of thermistors spaced over a 50m. vertical interval, connected to a Plessey data logger, It was included in moorings 4 and 5, placed so as to be in the steepest part of the near-surface temperature gradient. Current meters were placed in the mooring immediately above and below the array. On recovering mooring No. 5, the lower of these two current meters (a Plessey meter belonging to the University of Liverpool) had disappeared from its frame. The thermistor logger appeared to have worked properly in both moorings.

16. Suspended thermistor array (Hecht)

This was another vertical array of thermistors, but intended to be suspended over the ship's side while hove-to, and connected to a data logger so that more rapid recording was possible. Three recordings were made, each of a few hours' duration, while the moored thermistor array was in operation.

17. Two-component E.M. Log (Smith, Swallow)

This instrument was in use throughout both halves of the cruise. Calibration runs were made on 3rd November. Its output was recorded along with the two components of relative wind, on a Speedomax recorder, but in strong winds the appearance of the record became so confused and scattered that the wind recording was discontinued. Some fluctuations of sensitivity occurred towards the end of the cruise, possibly due to fouling, though the electrodes appeared clean when the instrument was removed.

STATION LIST

Abbreviations:

BCT	:	Bottom current tripod
BS	:	Bathysonde
CM	:	Current meters
FNB	:	Neutrally-buoyant floats
TCL	:	Liverpool thermistor chain (Hecht)
TML	:	Liverpool moored thermistor array (Hecht)
TSD	:	Hytech TSD recorder
WB	:	Water sampling

(Numbers in brackets after gear denote length of wire out)

CRUISE 20 STATION LIST

Stn. No.	Date	Time GMT	Lat.	Long.	Gear Used	
6471	23/X	0215-0500	45°52.0'N	08°20.1'W	BS (500, 1900)	
6472	23/X	0724-1113	45°50.2'N	08°21.7'W	BS (300, 1900)	
6473	23/X	1410-1650	45°50.7'N	08°22.7'W	BS (1900, 500)	
6474	24/X 1658 7/X1 1330		45°49.3'N	08°21.3'W	CM, FNB	Mooring No.1
6475	27/X	1010-1106	45°50.0'N	08°13.3'W	BS (1900)	Stn. abandoned due to weather
6476	30/X 1326 10/X1 1424		45°55.6'N	08°06.5'W	CM, FNB	Mooring No. 2
6477	31/X 2023 1/X1 0001		45°58.0'N	08°08.0'W	BS (1900, 500)	
6478	5/X1	0544-1057	41°58.3'N	12°25.0'W	BS (1900, 500)	
6479	5/X1	1655-1939	41°57.5'N	12°24.0'W	BS (1900)	
6480	9/X1 0926 12/X11 1425		45°51.1'N	08°20.2'W	CM, FNB	Mooring No.3
6481	9/X1 2337 10/X1 0250		45°50.7'N	08°17.8'W	BS (1900)	
6482	10/X1 1925 11/X1 0319		45°57.7'N	08°29.0'W	BS (1900) WB (4800)	
6483	11/X1	0530-1203	46°00.5'N	08°07.0'W	BS (1900) WB (4800)	
6484	11/X1 1810 12/X1 0136		45°43.8'N	08°30.3'W	BS (1900) WB (4800)	
6485	12/X1	0446-1225	45°43.9'N	08°10.5'W	BS(1900) WB (4800)	
6486	12/X1 1945 13/X1 0220		45°58.2'N	08°31.3'W	BS (1900) WB (4800)	
6487	13/X1	1810-2130	45°48.1'N	08°14.5'W	BS (1900)	
6488	14/X1	0740-0850	46°19.1'N	07°51.5'W	BS (1900)	
6489	14/X1	1659-1947	45°48.9'N	08°13.3'W	BS (1900)	

Stn. No.	Date	Time GMT	Lat.	Long.	Gear Used
6490	23/X1	0947-1020	45°57.6'N	08°06.2'W	BS (500)
6491	23/X1 30/X1	1226 1357	45°57.9'N	08°05.5'W	CM, FNB, TML. Mooring No.4
6492	23/X1 24/X1	2200 0150	45°58.2'N	08°00.6'W	BS (1900) TSD (2500)
6493	24/X1	1127-1620	45°58.6'N	08°10.7'W	BCT
6494	24/X1	1653-1901	46°00.2'N	08°07.8'W	WB (bottom)
6495	24/X1	2045-2340	46°01.5'N	08°06.6'W	TSD (2500)
6496	25/X1	0112-0530	46°02.2'N	08°07.5'W	TCL
6497	25/X1	1322-1507	46°04.5'N	08°08.0'W	BS (1900)
6498	26/X1	0521-0838	46°06.5'N	08°08.5'W	BS (1900) TSD (2000)
6499	26/X1 27/X1	1905 0055	46°02.2'N	08°05.5'W	BS (500) TCL
6500	27/X1	1537-1813	46°30.6'N	07°59.0'W	BS (1900)
6501	27/X1	2136-2324	46°12.3'N	08°09.0'W	BS (1900)
6502	28/X1	0422-0759	46°01.6'N	08°16.4'W	WB (4200)
6503	28/X1	1220-1548	46°14.6'N	08°15.7'W	WB (4200)
6504	28/X1	1747-2115	46°15.0'N	07°54.0'W	WB (4200)
6505	28/X1 29/X1	2335 0307	46°01.3'N	07°53.5'W	WB (4200)
6506	29/X1	0630-0942	46°15.8'N	08°09.5'W	BS (1900)
6507	29/X1	1550-2056	45°59.25'N	08°08.1'W	BCT
6508	30/X1	0502-0800	46°18.3'N	08°11.0'W	BS (1900)
6509	30/X1 1/X11	2224 0453	44°53.8'N	09°22.2'W	BS (1900), TSD (2500)
6510	1/X11	1849-2227	43°50.6'N	10°43.7'W	TSD (2500)
6511	2/X11	0815-1200	42°19.2'N	10°22.2'W	BS (1900)
6512	2/X11 3/X11	1945 0238	41°01.3'N	11°11.1'W	BS (1900), TSD (2500)
6513	3/X11	1100-1427	39°31.3'N	11°11.0'W	TSD (2500)
6514	3/X11 4/X11	2314 0621	37°58.8'N	10°58.8'W	BS (1900), TSD (2500)
6515	4/X11	1549-1841	36°54.5'N	09°38.5'W	TSD (1800)

Stn. No.	Date	Time GMT	Lat.	Long.	Gear Used
6516	4/X11 5/X11	2342 0300	36°30.2'N	08°52.0'W	TSD (1900)
6517	5/X11	0750-1433	36°06.0'N	08°03.0'W	TSD (1780), BS (1720) WB (1180)
6518	5/X11	1710-2154	36°22.0'N	08°24.8'W	TSD (2000)
6519	6/X11	0220-0535	36037.2'N	09°19.0'W	TSD (2000)
6520	6/X11	1548-1913	38°13.5'N	10°25.8'W	TSD (2500)
6521	7/X11	0334-0950	39°31.9'N	11°11.5'W	TSD (2500), BS (1900)
6522	7/X11	1340-1540	40°07.5'N	11°01.8'W	Diffusion expt. (Thorpe)
6523	7/X11 8/X11	2055 0033	40°58.0'N	10°42.0'W	TSD (2500)
6524	8/X11	0932-1635	42°19.6'N	10°23.8'W	BS (1900), TSD (2500)
6525	9/X11	0800-1235	44°21.4'N	10°07.8'W	TSD (2500)
6526	10/X11	1850-2103	45°43.4'N	08°31.3'W	WB (4200)
6527	10/X11 11/X11	2258 0345	45°44.1'N	08°10.6'W	WB (4200)
6528	11/X11	0540-0903	45°58.3'N	08°10.5'W	WB (4200)
6529	11/X11 15/X11	0945 1635	45°56.3'N	08°17.0'W	CM, FNB, TML, Mooring No.5
6530	11/X11	1833-2206	45°56.5'N	08°33.0'W	WB (4200)
6531	11/X11 12/X11	2330 0605	45°53.8'N	08°19.6'W	TSD (2500) TD
6532	12/X11	1508-1821	45°55.7'N	08°19.0'W	TCL
6533	12/X11 13/X11	2340 0711	45°58.0'N	08°20.0'W	TSD (2500) WB (2225)
6534	13/X11	0918-1242	45°57.3'N	08°21.4'W	TSD (2500)
6535	13/X11 14/X11	2130 0111	46°00.3'N	08°21.0'W	TSD (2500)
6536	14/X11	1140-1500	46°03.6'N	08°22.9'W	TSD (2500)
6537	14/X11 15/X11	2244 0256	46°04.2'N	08°22.3'W	TSD (2500)
6538	15/X11	1647-1958	45°56.9'N	08°17.7'W	TSD (2500)
6539	15/X11 16/X11	2130 0045	46°08.3'N	08°23.6'W	TSD (2500)
6540	16/X11	0245-0938	46°09.0'N	08°03.9'W	TSD (2500)