

R.R.S. DISCOVERY

Cruise 26 Report

April - May, 1969

Physical and chemical study of the upwelling area
off North-west Africa

(Liverpool University cruise, LUDO 1X)

Aims

The main objective was to investigate the physical and chemical features of the region off North-west Africa, from the Canary Islands southwards to Cape Verde, in which upwelling is known to occur. After carrying out a survey of the whole area the intention was to make detailed observations in limited areas where the survey had indicated active upwelling to be in progress or to have occurred recently.

A further objective was to test the practicability of using at sea certain chemical procedures which had previously been used only in a shore laboratory.

Narrative.

Left Barry	3rd April
Arrived Dakar	19th April
Left Dakar	21st April
Arrived	
Southampton	9th May

Part 1 : Barry - Dakar.

"Discovery" sailed from Barry on 3rd April and on passage across the Bay of Biscay the equipment was prepared for use and chemical apparatus set up in the laboratory. Two test stations were worked, on 6th and 8th April respectively, to check the operation of the Bissett-Berman TSD system, including a new digital recorder, and to obtain samples for testing the methods of chemical analysis.

The first station of the planned survey was reached early on 10th April, but owing to rough weather the TSD was not lowered and a water bottle cast to 500m only was made. At the second station, six hours later, the TSD was lowered successfully to 2000m and both normal and large water bottle casts were made to 2,200m. The rest of the survey was then carried out as planned, with lines of stations running diagonally towards and away from the coast, as shown on the Track Chart. The outermost stations were about 100 ml from the coast. The spacing between the outer stations was 30-35 miles but this was reduced towards the coast to give an adequate coverage of conditions over the continental slope and shelf.

At the four outer stations (Nos. 6905, 6917, 6930 and 6947) TSD records were obtained to 1500 or 2000m and casts of both normal and large water bottles made to 2,500m. The large samples were required for trace metal and rare element analysis. At the rest of the stations the TSD was lowered to 500 or 750m and water bottle casts made to 500m for pH, alkalinity, nitrate, phosphate and silicate analyses. At certain stations a 50 l sample of surface water, for the analysis of suspended detritus, was obtained by pumping. A continuous record of chlorophyll concentration was obtained by pumping water through a fluorometer and on several occasions phytoplankton was collected for periods of up to 3 hours while underway.

The north-east trade winds prevailed over the whole area during this survey but decreased considerably in strength from north to south. From the Canaries to Cape Blanc (latitude 21°N), they blew from the north-east at 20-30 kt., the speed being greatest during the night and early morning and decreasing in the afternoon. From Cape Blanc to Cape Verde the wind speed decreased gradually from 20 kt. to 10kt. or less, the direction remaining between north-east and north.

In the neighbourhood of Cape Blanc a fleet of about 20 Russian trawlers, with a mother ship, was seen in action.

The last station of the survey was completed at 1500 hours on 18th April and, before proceeding to Dakar, four echo-sounding traverses were made across the Fosse de Cayar, a steep-sided canyon about 20ml. north of Cape Verde.

A preliminary study of the data from the first part of the cruise was made before leaving Dakar, and it was encouraging to find that the effects of

upwelling were evident throughout the region surveyed. The surface temperature and salinity decreased towards the coast on all sections; nutrients were low offshore in the surface waters and higher concentrations were found on the continental shelf, particularly near Cape Blanc; biological activity was also high in the coastal region with a maximum near Cape Blanc. Generally speaking the chemical and physical properties on the shelf were correlated with subsurface conditions offshore. The most promising area for a more intensive survey in the second part of the cruise undoubtedly appeared to be in the vicinity of Cape Blanc.

Part 2 : Dakar - Southampton.

"Discovery" left Dakar on 21st April and proceeded northwards. On passage the continuous flow fluorometer was kept in operation so that, when significant concentrations of phytoplankton were indicated, pumped samples could be taken for plant pigment analysis by thin layer chromatography. Other chemical measurements by continuous flow techniques were maintained. At 1115 BST 22nd April the first dust collection meshes were suspended from the main mast and were exposed in the northerly wind for 9 $\frac{1}{2}$ hours. A good sample of wind-borne dust was obtained. The meshes were subsequently renewed at regular intervals whenever there was no risk of contamination from the ship. To supplement this work two cores were obtained at stations 6956 and 6957.

At Station 6958, 75ml west of Cape Blanc, our deep station procedure was repeated and in addition a 4 ft. core was obtained. From this outer position a line of stations was worked eastwards towards the coast and a landfall was made at Cabo Dubouchage about 5 ml north of Cape Blanc. The nearest station to the coast was 5964 at a distance of 12 ml. A westward section of 5 stations was then made during which large peaks were recorded on the fluorometer. As a result of a study of the running plots of temperature and salinity against depth and the generally high level of fluorescence, it was decided to steam back to a position between 5967 and 5968 and to carry out a two-day time series station. A dahn buoy was laid at station 6970 on the continental slope, in 746 m of water, and during the following two days T.S.D. lowerings were made to 300m every half hour whilst the ship maintained its position relative to the buoy. Parachute drogues released at 50m and 300m were tracked by radar and despite the strong northerly wind they indicated a slow movement northwards at both levels. W.B. casts were made to 300m every four hours for chemical determinations. This station was completed at 2100 BST, 26 April, after which the section towards Cabo Dubouchage was repeated before "Discovery" turned northwards again.

Temperature and salinity sections from the first half of the cruise had shown definite indications of upwelling also in the vicinity of Cabo Bojador, where the continental shelf is quite narrow. The nutrient concentrations had been lower than expected and contrasted with the higher values further south. It therefore seemed an interesting area meriting more intensive observations.

Cabo Bojador, which is about 120 ml south of the Canary Isles, was reached at 2030 BST 28 April and on a course of 310°T a line of eight stations 5 ml apart was then worked. The first position on the section was 5ml from the coast and the last was at a distance of 40ml. Since leaving Cape Blanc the wind had been from the NNE with a speed of about 20 knots but now it dropped and the sea became calm with a slight swell from the north. These conditions continued to the end of the station work. A shallow water site about 13 ml from the coast was chosen for the second time series and on arrival a marker buoy was anchored in a depth of 145m. The procedure of the previous time series station (6970) was repeated at station 6985 and observations were continued until 1124 BST on 1st May. T.S.D. records were obtained every half hour to within 5m of the seabed and water bottle casts were made at intervals of 4 hours. At this station the temperature and salinity at the bottom were similar in character to the offshore water at 250m depth. There was a sharp thermocline and the overlying water appeared to have the characteristics of oceanic surface water with very low concentrations of nutrients and low productivity as indicated by negligible fluorescence. The clear blue surface water was in marked contrast to the shallow water near Cape Blanc where it was discoloured brown-green. At the end of this long station the section towards Cabo Bojador was repeated.

The rise in surface temperature and the consolidation of the thermocline during the period of observations in the Cabo Bojador area were quite evident. It is not yet known if the change in conditions was due mainly to local solar heating but the constant values of the water properties close to the bottom during the time series suggest that upwelling was dying out, as a result of the

calm and warm conditions at the surface. Despite the low nutrient concentrations there was ample evidence that the upwelling process had been active in the area. The relatively low nutrient levels seemed to reflect the conditions in the deeper source waters offshore.

At both time series stations the T.S.D. records showed much fine structure and the general impression was that the shorter period fluctuations were probably caused by advected patches, rather than by internal waves. Any definite conclusions must await a detailed analysis.

From Cabo Bojador course was set for the Canaries and 5 stations were worked at the same positions as those on the first leg of the original survey. This was the last of the station work but on the homeward passage the P.F.S. was operated and the routine meteorological measurements were continued. Certain chemical determinations relying on pumped surface water samples were also continued as far as the English Channel. "Discovery" arrived in Southampton on 9th May.

Notes on performance of Chemical Equipment.

1. Auto Analyzers.

Technican AutoAnalyzers were used for the determination of silicate and nitrate in samples taken at all water bottle stations. The instruments functioned well at all states of the sea, but trouble was encountered in the determination because of contamination of the distilled water.

2. Peristaltic pump for determination of phosphate.

Since only 2 AutoAnalyzers were available, phosphate was determined semiautomatically using a peristaltic pump to mix the sample and reagent. The adsorbances of the resultant solutions were measured manually on a Unicam SP500 spectrophotometer. This system was at least twice as fast as the AutoAnalyzer and gave results which agreed to $\pm 1\%$ with those obtained by the manual method.

3. Thin layer chromatography and use of Joyce Loebel Chromoscan with thin layer attachment.

Thin layer chromatography of plant pigments was carried out in glass tanks maintained at 20°C in a thermostatic bath. Ship's motion caused no difficulty in the development of the chromatographic plates even with force 8 winds. The Chromoscan behaved well throughout the cruise and highly reproducible traces were obtained.

4. Fluorimeter.

A Turner Fluorimeter fitted with high intensity lamp and coupled to a Sunvic Millivolt recorder was used for the determination of "chlorophyll" in water pumped from ca. 3m. The instrument ran continuously for two periods of about two weeks, and with the exception of minor trouble caused by dirt on the recorder slide wire it proved highly satisfactory.

5. Use of Chelex columns for uptake of trace metals.

Columns of Chelex 100 ion exchange resin (50 - 100 mesh) measuring 8cm x 1cm diam., were used for the concentration of trace metals. Vibration and movement of the ship did not cause appreciable compaction of the resin bed and satisfactory flow rates were maintained.

Acknowledgment.

The Liverpool University personnel wish to express their gratitude to the Director, National Institute of Oceanography, for making the ship available for this investigation. They are also glad to express their keen appreciation to Captain Davies and the officers and crew of R.R.S. "Discovery" for their willing cooperation throughout the cruise.

Scientific Personnel.

1 - 2	Mr. C. Bonner	Liverpool University	
1	Prof. K. F. Bowden	" "	Principal Scientist (1)
1 - 2	Mr. D. Bromley	N.I.O.	
1 - 2	Mr. D. Brown	" "	
2	Dr. R. Chester	Liverpool University	
1 - 2	Miss J. Collard	" "	
1 - 2	Mrs. D. Gardner	" "	
1 - 2	Mr. C. Garside	" "	

Scientific Personnel (continued)

1 - 2	Mr. P. Hinchcliffe	Inverpool University	
2	Dr. M. R. Howe	" "	
1 - 2	Mr. P. Hughes	" "	Principal Scientist (2)
1 - 2	Mr. L. Johnson	" "	
1 - 2	Miss C. Knight	" "	
1 - 2	Mr. N. Lynn	" "	
1 - 2	Mr. N. Mathers	" "	
1 - 2	Mr. A. Mathews	" "	
1 - 2	Mr. J. Murphy	" "	
1 - 2	Mr. C. N. Murray	" "	
1	Dr. J. P. Riley	" "	
1	Dr. R. I. Tait	" "	
1 - 2	Mr. D. Taylor	" "	

1 3 - 19 April

2 19 April - 9 May

CRUISE 26 STATION LIST

Abbreviations

- TSD Temperature - salinity - depth probe.
 WB Water bottle cast.
 LWB Large water bottle cast.
 50S 50 l sample of surface water for detritus analysis.

Station No.	Date	Time (GMT + 1)	Lat.N	Long.W.	Gear used
6893	6/IV	1000-1155	41°30.5'	10°11.5'	TSD, WB.
6894	8/IV	0430-1000	34°22'	12°46'	TSD, LWB
6895	10/IV	0010-0320	27°31'	14°47'	WB
6896	"	0620-1045	27°02'	14°41'	TSD, WB, 50S
6897	"	1355-1535	26°31.5'	14°31.9'	" "
6898	"	1620-1720	26°25'	14°32.5'	" "
6899	"	1800-1856	26°17'	14°32'	" "
6900	"	1950-2027	26°08'	14°38'	" "
6901	"	2120-2245	26°06.5'	14°49.5'	" " 50S
6902	11/IV	0012-0108	26°05.3'	17°05.8'	" "
6903	"	0447-0627	26°03'	15°44'	" "
6904	"	0925-1035	26°01'	16°23'	" "
6905	"	1240-1737	25°42'	16°41'	" " LWB, 50S.
6906	"	2110-2210	25°15'	16°24'	" "
6907	12/IV	0157-0254	24°32'	16°17'	" "
6908	"	0500-0535	24°16'	16°11'	" "
6909	"	0744-0813	23°56'	16°06'	" "
6910	"	0917-0942	23°47.2'	16°03'	" "
6911	"	1050-1125	23°35.6'	16°11.5'	" "
6912	"	1220-1255	23°33.2'	16°22.2'	TSD, WB
6913	"	1455-1535	23°28.7'	16°43.5'	" "
6914	"	1710-1830	23°23'	17°06'	" " 50S.
6915	"	2056-2242	23°15'	17°37.5'	" "
6916	13/IV	0140-0242	23°07.8'	18°09.7'	" "
6917	"	0536-1450	23°00'	18°42'	" " LWB
6918	"	1825-1953	22°31'	18°21'	corer
6919	14/IV	0000-0053	22°02.5'	17°59'	TSD, WB
6920	"	0407-0541	21°38'	17°41'	" "
6921	"	0646-0811	21°29.5'	17°35'	" "
6922	"	0951-1020	21°17'	17°26.5'	" "
6923	"	1135-1158	21°09'	17°20'	" "
6924	"	1547-1612	20°28.5'	17°19.5'	" "
6925	"	1745-1815	20°16.5'	17°29'	" "
6926	"	1915-2010	20°10.4'	17°37'	" "

Station No	Date	Time (GMT + 1)	Lat.N	Long.W	Gear used
6927	14/IV	2115-2230	20°03'	17°44.6'	TSD, WB
6928	15/IV	0004-0207	19°51.5'	17°55.2'	" "
6929	"	0521-0640	19°25.5'	18°20'	" "
6930	"	0950-1430	19°00'	18°45'	" " , LWB, 50S.
6931	"	1742-1847	18°47.5'	18°10.5'	" "
6932	"	2215-2349	18°35.6'	17°36'	" "
6933	16/IV	0320-0420	18°23.3'	17°01.8'	" "
6934	"	0555-0654	18°16'	16°42'	" "
6935	"	0740-0823	18°09.5'	16°34.5'	" "
6936	"	0920-0957	18°12'	16°30'	" "
6937	"	1045-1116	18°10.2'	16°25'	" "
6938	"	1220-1250	18°15'	16°14.8'	" "
6939	"	1450-1507	17°53.5'	16°14.5'	" "
6940	"	1607-1633	17°48.5'	16°23.5'	" "
6941	"	1715-1737	17°45'	16°29'	" "
6942	"	1820-1930	17°42'	16°35.5'	" "
6943	"	2030-2130	17°36.2'	16°43'	" "
6944	16/IV -				
	17/IV	2336-0037	17°24'	17°03'	" "
6945	17/IV	0325-0420	17°08'	17°29.5'	" "
6946	"	0735-0841	16°49'	17°59'	" "
6947	"	1200-1840	16°30'	18°30'	" " , LWB, 50S.
6948	"	2200-2308	15°58.8'	18°13.5'	" "
6949	18/IV	0216-0238	15°32.4'	17°58.5'	" "
6950	"	0507-0707	15°18'	17°50'	" "
6951	"	0830-0939	15°05'	17°42.5'	" "
6952	"	1040-1138	14°56.5'	17°39.4'	" "
6953	"	1212-1250	14°53'	17°38.5'	TSD
6954	"	1320-1342	14°50'	17°35.3'	TSD
6955	"	1429-1500	14°46.3'	17°33.4'	" WB
6956	21/IV	2003-2104	16°02.5'	17°00'	Corer, 50S
6957	22/IV	0952-1015	17°28'	16°29.2'	Corer,
6958	23/IV	0958-1300	20°51'	18°27.5'	Corer, TSD, WB.
6959	"	1610-1759	20°51'	18°01'	TSD, WB, "
6960	"	1939-2106	20°51'	17°47'	" " "
6961	"	2200-2242	20°51'	17°40.5'	" " "
6962	"	2319-2342	20°50'	17°34.5'	" "
6963	24/IV	0033-0056	20°50'	17°29.5'	" "
6964	"	0212-0234	20°50.4'	17°18.4'	" "
6965	"	0339-0405	20°50'	17°29.8'	" "
6966	"	0438-0509	20°50'	17°34.3'	" "
6967	"	0543-0642	20°50'	17°40'	" "
6968	"	0729-0841	20°50'	17°45'	" "
6969	"	0948-1110	20°50'	17°56.8'	" "
6970	24/IV	1240-	20°50'	17°45.4'	100 TSD, Corer,
	26/IV	2103			Parachute Drogues, Dahn Buoy
6971	"	2137-0000	20°50'	17°46.8'	TSD, WB,
6972	27/IV	0050-0219	20°50.2'	17°42'	TSD, WB
6973	"	0308-0329	20°50.1'	17°36.7'	TSD, WB
6974	"	0415-0436	20°50.1'	17°31.2'	" "
6975	"	0522-0552	20°50.8'	17°27'	" "
6976	"	0650-0710	20°51'	17°25'	" "
6977	28/IV	2205-2228	26°10.9'	14°35'	" "
6978	"	2305-2328	26°14'	14°38.5'	" "
6979	29/IV	0005-0030	26°17'	14°43.2'	" "
6980	"	0104-0219	26°19'	14°48'	" "
6981	"	0257-0354	26°23'	14°51.7'	" "
6982	"	0429-0554	26°27'	14°55'	" "
6983	"	0630-0806	26°29.5'	14°59'	" "
6984	"	0845-1020	26°33'	15°03'	" " "
6985	29/IV	1312-	26°15'	14°43'	85 TSD, WB,
	1/V	1124			Parachute Drogues, Grab, Dahn Buoy.

Station No.	Date	Time (GMT + 1)	Lat. N	Long. W	Gear used
6986	1/V	1416-1710	26°33'	15°03.4'	TSD, WB
6987	"	1548-1645	26°29.6'	14°59.3'	" "
6988	"	1718-1827	26°27'	14°55'	" "
6989	"	1906-1958	26°25.5'	14°51'	" "
6990	"	2043-2123	26°20'	14°47'	" "
6991	"	2209/2237	26°17'	14°43'	" "
6992	"	2310/2335	26°14'	14°39'	" "
6993	2/V	0008-0022	26°11'	14°35'	" "
6994	"	0102-0113	26°14.5'	14°31'	" "
6995	"	0217-0239	26°21.6'	14°33.8'	" "
6996	"	0336-0440	26°30'	14°35'	" "
6997	"	0752-0940	27°00'	14°40.5'	" "
6998	"	1235-1604	27°28.5'	14°45.5'	" " LW







