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RV G.A. REAY

CRUISE 1/86

6 – 10 MAY 1986

GEOCHEMICAL STUDIES IN THE ENGLISH CHANNEL

CRUISE REPORT NO. 192

1987

INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY

NATURAL ENVIRONMENT RESEARCH COUNCIL

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RV G.A. REAY

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Geochemical studies in the English Channel

Principal Scientist

D.J. Hydes

1987

DOCUMENT DATA SHEET

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ABSTRACT

Water column sampling was carried out from RV *G.A. Reay* at 20 stations in the English Channel from Dover to Falmouth between 6 and 10 May 1986. Nutrient, salinity and aluminium samples were taken from standard N.I.O. bottles, a "clean" system of GO-FLO bottles suspended on a Kevlar line was used for trace metal sampling. All the station positions, and hydrographic data collected during the cruise are listed here.

This was the second of a three cruise programme aimed at determining both the concentrations of biogeochemically active metals which are potential pollutants in coastal waters, and how concentrations of such metals vary seasonally. Nutrient and chlorophyll measurements suggest *G.A. Reay* 1/86 sampled in the Channel during a spring period of patchy growth which is indicated by variations in the nutrient concentrations and their ratios to one another.

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SHIP'S PERSONNEL

S. Mayl	NERC Liaison Officer
A. Barkworth	Master
K. Herron	First Officer
G. Petty	Second Officer
L. Kiel	Chief Engineer
B. Carrick	Second Engineer
G. MacDonald	Third Engineer
D. Espina	Electrical Engineer

SCIENTIFIC PERSONNEL

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P. Daly	Liverpool University	
P. Newton	Liverpool University	
M. Nimmo	Liverpool University	
A. Reeves	Liverpool University	
A. Jones	RVS, Barry	
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A. Tappin	Southampton University	

ACKNOWLEDGEMENTS

The willing help, co-operation and advice of the Master, Officers and Crew of R.V. G.A. Reay are gratefully acknowledged. S. Mayl, NERC RVS liaison officer, greatly facilitated the smooth running of the cruise. Special thanks are due to all the people of RVS and elsewhere who made this cruise possible after the breakdown of RRS Frederick Russell.

ITINERARY

Depart Hull, U.K.	6 May 1986
Arrive Falmouth, U.K.	10 May 1986

OBJECTIVES

This was the second of a three-cruise programme. The cruises were aimed at determining the concentrations of biogeochemically active metals which are potential pollutants in coastal water. The three cruises (November 1985, May 1986, August 1986) will make possible an assessment of how metal concentrations vary in relation to the biological and other processes which create the well-documented annual cycle in nutrient element concentrations in coastal waters. The intention was to work a grid of 48 stations across the English Channel from 0°00' to 5°30'W. However, due to the breakdown of the RRS Frederick Russell and transfer of the cruise to the RV G.A. Reay and the severe time constraints arising from this, on this cruise we planned a more closely spaced set of 26 stations through the middle of the grid, starting at the Dover Straits. Three areas of work were conducted on this cruise:

1. Collection and shipboard analysis of samples to determine the hydrography of the water being sampled - temperature, salinity and micronutrients.
2. Collection of samples for trace metal and metalloid analysis by established methods.
3. Development of electrochemical methods for the continuous determination of metals on board ship.

NARRATIVE

Gear for the cruise was loaded in Hull on 1 May. Fitting out by the scientific party commenced on the evening of 4 May. Extra benching had been fitted in the aft hold and constant temperature laboratory the preceding week by RVS personnel. The clean bench (which was too large to be got into the clean laboratory a further deck down) was set up in the aft hold, as were the NIO bottle racks. The GOFLO bottle rack was set up in the constant temperature laboratory next to the gas bottle rack. On the fish deck the auto-analyser was

fitted on the roller bench between the bottom of the hoist and the store room exit. In the clean laboratory were installed the salinometer, CTD data, acquisition equipment, fluorimeter and continuous metal monitor. A water supply line for the monitor was fed to the main deck via trunking. Fitting out was completed by 2100 on 5 May. G.A. Reay sailed at 0400 on 6 May. After clearing the mouth of the Humber, the IMER overside water pump and the PES fish were deployed.

At 1400 the ship was stopped for equipment trials. Three winches were used for three different wires: 6 mm Kevlar (GOFLO bottles), 6 mm steel hydro-wire (NIO bottles) and 6 mm conducting wire (CTD). All proved satisfactory in operation. Wire out was measured by counting marks at 5 and 10 m intervals rather than using the metre wheels which were difficult to read. At 1830 the ship was stopped to recover the overside water pump for the first time. This was repaired and redeployed. Later that night it failed again and was not repairable. The design was not robust enough for deployment on the side of a ship doing 10 knots.

Progress was slow down the North Sea due to a combination of head winds and fouling on the hull. The G.A. Reay rode the sea well and the scientific party was intact to work the first sampling station at 0900 on 7 May. Between Dover and Falmouth we were able to occupy 20 out of a planned 26 stations. These were at one to two-hour intervals. Winds varied between south-westerly 5 and 6 and sea varied from moderate to heavy swell. The last station was completed at 1900 on 9 May.

The cruise was completed with G.A. Reay alongside in Falmouth at 0800 on 10 May. Discharge of gear commenced at 0830.

HYDROGRAPHIC SAMPLING

At each station a string of up to six NIO bottles was deployed on 6 mm steel hydrowire. The bottles were fitted with reversing thermometers. The thermometers were checked before the GOFLO bottles were deployed to see if any structure was present in the water column. The bottles were subsampled for salinity (250 ml glass medicine bottle), nutrients (30 ml acrylic vial) and aluminium (300 ml linear polyethylene bottle). The filled salinity bottles were allowed to equilibriate with laboratory temperature and then measured on an Autosal salinometer. Conductivity ratios were recorded and converted to

salinities on shore. Nutrient samples were stored in the refrigerator until run on the Autoanalyser.

After the NIO bottles, up to four GOFLO bottles were used from the Kevlar line at each station. Three people were required for bottle deployment: a winch operator, one person hooked to a safety line to hang the bottles and one person to carry bottles up and down from the aft hold.

P. Daly, A. Campbell, A. Jones
S. Mayl, N. Morley, R. Powell
A. Reeves, C. Symon, A. Tappin

NUTRIENT AND ALUMINIUM ANALYSES

The nutrients were measured using a Chemlab continuous-flow automatic analyser system coupled to a data reduction system based on a Commodore Pet microcomputer. Nitrate, phosphate and silicate were determined on each sample collected using standard methods described in IOS Report No. 177. The system worked well and no problems were experienced during the cruise.

The shipboard system for aluminium analyses using the fluorimetric dye lumogallion was set up on board the G.A. Reay. The Perkin Elmer LS2 fluorimeter used for this failed to work on board, although it had functioned well before on three different ships. It was returned to Wormley immediately after the cruise and was found to work there.

D. Hydes

TRACE METALS AND METALLOIDS

Trace metal and metalloid element samples were obtained using a 'clean' system. This consisted of 2.5 litre Teflon-coated GOFLO bottles deployed from a separate winch on the aft deck which had been wrapped with plastic sheeting and wound with 6 mm Kevlar line (polycarbonate core, Dacron sheath). The Kevlar line was led over the ship's side via an all-plastic sheave fitted to the navigation deck crane and was weighted with a polyester-coated lead hydroweight. The use of this system was considered necessary to prevent adventitious contamination of the seawater samples. Up to four GOFLO bottles were deployed

per station, with no more than two bottles on the line at any one time.

The GOFLO bottles were sub-sampled on board for nutrients (PO_4, NO_3, SiO_4) and chlorophyll. Samples of particulates for chlorophyll analysis were collected by vacuum filtration on Whatman GF/F filters and stored frozen until land-based laboratory fluorometric analysis. To obtain samples for dissolved trace metal analysis, each GOFLO was pressurised to 5 psi (using filtered nitrogen) and the seawater was filtered through an in-line acid-cleaned 0.4 μm Nuclepore membrane into an acid-cleaned polyethene bottle. These samples were acidified (1 ml sub-boiling concentrated HNO_3 per litre of seawater) to a pH of approximately 2 and stored at room temperature. At all times during filtering and storage the polyethene bottles were kept in resealable polyethene bags. Membranes used for filtration were retained and stored frozen. All membrane handling and acidification were carried out in a laminar-flow hood. Samples (ca 130 ml) of filtered water were collected for the determination of arsenic species. These were frozen as soon as possible after collection.

On shore, a series of trace metals (Cd, Mn, Co, Cu, Ni, Pb, Zn and possibly Fe) will be determined in the seawater samples using chelation followed by solvent extraction as a preconcentration and separation step prior to measurements of the metal concentrates by graphite furnace atomic absorption spectrophotometry. Correlations between metal concentrations and other parameters (salinity, nutrients, chlorphyll) will be identified in order to gain insights into the biogeochemical cycling of these metals in the coastal environment.

Analysis of the particulates for trace metals using a sequential leaching technique will also be carried out in order to assist in the intepretation of metal cycling.

A. Campbell, N. Morley, A. Tappin

SHIPBOARD ELECTROCHEMICAL METAL DETERMINATIONS

The purpose of the cruise was testing of the metal monitor and collection of water samples for metal speciation studies. The metal monitor is based on a cathodic stripping voltametric system. Two major problems were encountered on this cruise. Firstly, the IMER overside pump failed before the first station was reached. It was possible, however, because the clean laboratory on G.A. Reay is below the water line, to supply sea water to the lab by a syphon

effect but at a much lower rate than the pump. The second and most severe problem was caused by the amount of engine vibration in the clean lab. The core of the metal monitor is a dropping mercury electrode. It proved impossible to shield the monitor from the vibration and to get the drop to form reproducibly.

Samples were also collected from the GOFLO bottles for the determination of aluminium, copper, nickel and zinc by electrochemical methods on shore.

P. Daly, P. Newton, M. Nimmo

TECHNICAL REPORT

The IMER overside pump was troublesome. The first fault was due to strumming of the electrical supply cable, which caused it to abrade on the end of the pole and caused a short circuit when the insulation broke down. The second fault which rendered the unit unserviceable occurred when the plastic water-feed outlet fitting snapped off. No spares had been supplied with the pump. The 9400 CTD system worked after early teething troubles. Due to time constraints it was not used extensively. The PES worked without trouble during its limited use, except for the winch, which kept cutting out when it was used to bring it in-board before deploying the water bottles.

A. Jones, R. Powell

BRIEF DESCRIPTION OF HYDROGRAPHIC, NUTRIENT AND ALUMINIUM DATA

Table 1 lists the station positions, time of arrival at the station and the water depth. Result for salinity, temperature, silicon, phosphate, nitrate and aluminium for each water sample are listed in Table 2, along with the chlorophyll and phaeophytin measurements made on the filtered particles. In Table 3, the data in Table 2, averaged for each station, are listed.

The salinity distribution follows the expected pattern, decreasing from west to east, except for the salinity minimum encountered at Stations 6 and 7. Any vertical structure in the water was absent, except at Station 20 where some temperature structure was present. This was associated with clear differences in nutrient and chlorphyll concentrations above and below the thermocline.

Nutrient and chlorophyll measurements suggest we were sampling in the Channel during the spring period when the effects of patchy growth can be seen both in terms of the overall nutrient concentrations and on the ratios of the nutrients to one another. Aluminium concentrations, as well as the nutrients, are reduced to lower levels than were observed on the November cruise. A much poorer correlation with salinity exists, and is in the opposite sense to that observed in November. Both aluminium and silicon concentrations are lower in the fresher water at the eastern end of the Channel, whereas nitrate and phosphate are lower further west. This suggests aluminium and silicon may be being removed by diatoms at the eastern end of the Channel.

G.A. Reay Cruise 1/86

TABLE 1 - Station Positions

STATION Number	POSITION		DATE d/m	TIME GMT	DEPTH m
	Lat. N	Long. W			
1	51°07'	01°30'(E)	7/5	0858	30
2	50°55'	01°09'(E)	7/5	1243	33
3	50°45'	00°45'(E)	7/5	1545	27
4	50°35'	00°25'(E)	7/5	1825	38
5	50°35'	00°00'	7/5	2200	56
6	50°30'	00°30'	8/5	0125	69
7	50°25'	01°00'	8/5	0428	33
8	50°20'	01°30'	8/5	0800	49
9	50°10'	01°30'	8/5	1125	73
10	50°06'	02°00'	8/5	1415	67
11	50°16'	02°00'	8/5	1645	51
12	50°16'	02°30'	8/5	1950	57
13	50°06'	02°30'	8/5	2210	60
14	50°00'	03°00'	9/5	0135	64
15	50°10'	03°00'	9/5	0416	59
16	50°00'	03°30'	9/5	0740	68
17	49°50'	03°30'	9/5	0945	71
18	49°40'	04°00'	9/5	1250	68
19	49°50'	04°00'	9/5	1520	73
20	49°50'	04°30'	9/5	1815	82

G.A. Reay Cruise 1/86

TABLE 2 - Hydrographic Results

Station Number	Sample Depth m	Salinity	Temp. °C	Silicon µM	Phosphate µM	Nitrate µM	Aluminium nM	Sample Depth m	Silicon µM	Phosphate µM	Nitrate µM	Aluminium nM	Chlorophyll a. ug/l	Phaeophytin ug/l
		NIO						GOFLO						
1	0	34.780	8.40	0.2	0.16	1.8	21.5	5	0.1	0.15	1.7	23.9	4.5	0.6
	5	34.779	8.20	0.1	0.14	2.0	24.9	5	0.4	0.14	2.0		4.3	0.5
	10	34.776	8.20	0.1	0.17	1.8	23.2	15	0.1	0.14	1.7			
	15	34.775	8.20	0.1	0.14	1.8	23.9	15	0.1	0.13	1.6			
2	0	34.882	8.00	0.3	0.30	4.5	18.3 (19.6)	5	0.3	0.28	4.4	14.6	2.7	0.3
	5	34.872	8.00	0.4	0.30	4.6	18.3	20	0.3	0.28	4.4	14.6	2.5	0.4
	10	34.870	-	0.3	0.31	4.5	18.9	30	0.3	0.28	4.6	13.4	3.8	0.6
	20	34.874	-	0.3	0.30	4.5	21.4							
	30	34.869	-	0.4	0.30	4.5	22.0							
3	0	34.849	-	0.3	0.23	4.6	17.1	5	0.3	0.25	4.6	20.8	1.7	0.2
	5	34.854	8.27	0.3	0.22	4.6	17.7	20	0.3	0.22	4.6	18.9	2.6	0.5
	10	34.847	8.49	0.3	0.22	4.6	17.7							
	15	34.850	-	0.3	0.22	4.6	20.8							
	25	34.853	8.15	0.3	0.24	4.6	-							
4	0	34.927	8.20	0.3	0.19	3.4	15.8	5	0.2	0.17	3.2	19.5	3.6	0.3
	5	34.925	8.23	0.2	0.19	3.4	16.5	20	0.2	0.18	3.2	15.8	3.3	0.4
	10	34.926	8.26	0.2	0.19	3.4	15.2	30	0.2	0.18	3.2	17.1	3.4	0.4
	20	34.924	?	0.2	0.19	3.4	15.4							
	30	34.924	?	0.2	0.20	3.4	16.2							
5	0	34.837	7.97	0.2	0.20	3.5	15.7	5	0.2	0.18	3.2	13.5	2.4	0.4
	5	34.833	8.03	0.2	0.21	3.6	-	20	0.2	0.18	3.0	15.7	3.7	0.5
	10	34.834	8.04	0.2	0.20	3.4	15.2	30	0.2	0.18	2.6	17.9	4.0	0.3
	20	34.864	7.94	0.2	0.19	3.2	16.2							
	30	34.898	(19.90)	0.2	0.17	2.9	16.9							
	40	34.907	8.30	0.2	0.19	2.9	(20.2)							
6	0	34.750	8.08	0.5	0.28	4.3	15.1	5	0.5	0.28	4.3		2.1	0.6
	5	34.749	8.07	1.1	0.33	4.0	15.2	20	0.5	0.35	4.0		2.3	0.4
	20	34.770	8.11	0.5	0.28	3.7	14.1	30	0.5	0.37	4.8		2.2	0.3
	40	34.779	8.09	0.5	0.29	3.8	14.5	55	0.5	0.28	4.3	16.8	2.2	0.5
	65	34.781	8.71	0.5	0.28	4.0	(51.6)							
7	0	34.506	7.92	0.4	0.32	5.2	20.8	5	0.4	0.31	5.2	36.5	2.8	0.6
	5	34.501	7.98	0.4	0.31	5.2	21.9	20	0.4	0.19	5.2	25.2	2.6	0.6
	10	34.504	7.91	0.4	0.31	5.2	21.9	25	0.4	0.30	5.2	16.8	2.3	0.5
	15	34.505	7.93	0.4	0.34	5.2	(27.5)							
	25	34.506	7.94	0.4	0.31	5.2	(40.7)							

TABLE 2 - Hydrographic Results - continued (2)

		NIO						GOFLO						
Station Number	Sample Depth m	Salinity	Temp. °C	Silicon µM	Phosphate µM	Nitrate µM	Aluminium nM	Sample Depth m	Silicon µM	Phosphate µM	Nitrate µM	Aluminium nM	Chlorophyll a. ug/l	Phaeophytin ug/l
8	0	34.924	8.15	0.2	0.10	< 0.5	17.4	5	0.2	0.16	2.6	-	5.2	0.5
	5	34.924	8.10	0.2	0.11	< 0.5	15.8	20	0.2	0.20	1.6	19.6	6.7	0.6
	10	34.926	8.00	0.1	0.10	1.2	15.5	30	0.2	0.16	2.3	20.7	5.7	0.8
	15	34.924	8.16	0.1	0.11	0.9	16.9							
	25	34.924	8.18	0.1	0.15	1.5	18.0							
	35	34.924	8.55	0.1	0.10	< 0.5	(36.7)							
9	0	35.204	9.02	0.2	0.13	< 0.5	13.9	5	0.2	0.10	0.5	21.3	7.6	1.1
	5	35.200	9.01	0.2	0.13	0.4	16.9	20	0.2	0.14	0.8	15.7	7.0	0.6
	10	35.201	9.01	0.2	0.13	0.8	16.9	50	0.2	0.11	0.7	19.6	6.5	0.4
	20	35.202	8.02	0.2	0.13	0.4	21.9							
	35	35.200	9.02	0.2	0.12	0.8	23.0							
	55	35.202	9.59	0.2	0.12	0.4	(33.3)							
10	0	35.381	9.14	0.2	0.13	0.3	19.1	5	0.2	0.14	0.4		5.0	0.9
	5	-	9.14	0.2	0.13	0.4	(25.3)	20	0.2	0.14	0.4		4.7	0.7
	10	35.376	9.13	0.2	0.13	0.4	17.9	40	0.2	0.14	0.3		4.6	0.7
	20	35.386	9.19	0.2	0.13	0.3	19.1							
	35	35.381	9.15	0.2	0.14	0.3	-							
	50	35.379	9.15	0.2	0.14	0.4	-							
11	0	35.277	8.45	0.2	0.12	< 0.5	12.8	5	0.2	0.11	< 0.5		6.7	1.8
	5	35.275	8.46	0.2	0.12	< 0.5	18.0	20	0.2	0.11	< 0.5		8.0	0.7
	10	35.275	8.45	0.2	0.13	< 0.5	14.6	30	0.2	0.00	< 0.5		7.6	0.5
	20	35.272	8.50	0.2	0.13	< 0.5	16.3							
	30	35.267	8.47	0.2	0.12	< 0.5	15.8							
	35	35.271	8.48	0.2	0.13	< 0.5	(27.6)							
12	0	35.251	8.42	0.2	0.11	< 0.5	16.8	5	0.2	0.13	< 0.5		5.6	0.4
	5	35.251	8.44	0.2	0.11	< 0.5	-	20	0.2	0.14	< 0.5		6.5	0.7
	10	35.252	8.45	0.2	0.11	< 0.5	19.7	40	0.2	0.12	< 0.5		6.4	0.7
	20	35.252	8.00	0.2	0.13	< 0.5	20.2							
	30	35.254	8.49	0.2	0.11	< 0.5	-							
	45	35.255	8.51	0.2	0.12	< 0.5	(24.2)							
13	0	35.373	8.99	0.6	0.12	< 0.5	22.5	5	0.5	0.13	< 0.5		3.6	0.5
	5	35.373	8.98	0.6	0.15	< 0.5	-	20	0.5	0.12	< 0.5		4.7	0.6
	10	35.369	9.00	0.6	0.12	< 0.5	20.8	45	0.5	0.12	< 0.5		5.8	0.7
	20	35.371	8.97	0.6	0.13	< 0.5	21.4							
	35	35.376	8.97	0.5	0.11	< 0.5	-							
	50	35.373	8.98	0.5	0.14	< 0.5	20.8							

TABLE 2 - Hydrographic Results - continued (3)

				NIO				GOFLO						
Station Number	Sample Depth m	Salinity	Temp. °C	Silicon µM	Phosphate µM	Nitrate µM	Aluminium nM	Sample Depth m	Silicon µM	Phosphate µM	Nitrate µM	Aluminium nM	Chlorophyll a. ug/l	Phaeophytin ug/l
14	0	35.377	9.28	0.9	0.17	0.4	26.5	5	0.9	0.16	0.4		4.8	0.7
	5	35.376	9.20	0.9	0.17	0.4	24.7	20	0.9	0.15	0.4		4.3	0.7
	10	35.380	9.01	0.9	0.15	0.4	24.2	45	0.9	0.16	0.4		4.3	0.8
	20	35.380	9.20	0.9	0.16	0.4	21.9							
	35	35.380	9.21	0.9	0.15	0.4	-							
	50	35.381	9.21	0.9	0.14	0.4	-							
15	0	35.341	8.86	0.3	0.11	0.3	20.8	5	0.3	0.12	0.3		2.1	0.4
	5	35.339	8.89	0.3	0.11	0.3	19.1	20	0.3	0.12	0.3		2.0	0.3
	10	35.339	8.90	0.3	0.11	0.3	23.0	40	0.3	0.10	0.3		2.8	0.6
	20	35.335	8.92	0.3	0.11	0.3	21.9							
	30	35.337	8.90	0.3	0.11	0.3	25.8							
	45	35.335	9.34	0.3	0.10	0.3	(29.9)							
16	0	35.385	9.20	0.9	0.14	0.5	24.8	5	0.9	0.15	0.5		4.7	0.7
	5	35.385	9.20	0.9	0.14	0.5	-	20	0.8	0.14	0.5		4.7	0.7
	10	35.387	9.20	0.9	0.14	0.5	25.8	45	0.9	0.16	0.5		5.0	1.0
	20	35.389	9.30	0.9	0.15	0.5	29.8							
	30	35.381	9.20	0.9	0.14	0.5	-							
	45	35.384	9.30	0.9	0.18	0.5	(42.4)							
17	0	35.334	9.29	1.8	0.35	4.7	25.3	5	1.7	0.35	5.0		1.1	0.2
	5	35.332	9.25	1.8	0.35	5.2	-	20	1.7	0.35	5.1		1.3	0.3
	10	35.331	9.25	1.8	0.35	5.1	28.1	65	1.7	0.34	5.0		1.3	0.3
	20	35.334	9.30	1.8	0.34	5.1	28.6							
	35	35.333	9.26	1.8	0.34	5.2	-							
	50	35.333	9.32	1.7	0.35	5.1	31.0							
18	0	35.261	9.55	2.5	0.28	4.6	25.9	5	2.3	0.21	3.8		2.0	0.3
	5	35.263	9.55	2.3	0.18	3.4	-	20	2.4	0.27	4.8		1.9	0.3
	10	35.264	9.54	2.3	0.20	3.3	36.5	60	2.3	0.18	3.2		1.1	0.2
	20	35.267	9.34	2.3	0.20	3.7	32.0							
	35	35.272	9.33	2.4	0.27	4.5	-							
	55	35.267	9.49	2.4	0.27	4.7	34.4							
19	0	35.355	9.41	1.8	(0.25)	2.5	29.3	5	1.6	0.16	2.3		2.3	0.5
	5	35.350	9.41	1.6	0.15	2.0	-	20	1.6	0.16	2.4		2.3	0.6
	10	35.349	-	1.6	0.15	1.9	25.8	60	1.6	0.17	2.4		2.3	0.6
	20	35.359	9.30	1.6	0.18	2.1	34.3							
	40	35.354	9.36	1.6	0.16	2.3	-							
	65	35.360	9.56	1.6	0.16	2.3	33.9							

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TABLE 2 - Hydrographic Results - continued (4)

	NIO						GOFLO						
Station Number	Sample Depth m	Salinity	Temp. °C	Silicon µM	Phosphate µM	Nitrate µM	Aluminium nM	Sample Depth m	Silicon µM	Phosphate µM	Nitrate µM	Aluminium nM	Chlorophyll a. ug/l	Phaeophytin ug/l
20	0	35.331	9.15	1.1	0.12	1.0	26.5	5	0.9	0.02	0.6		3.9	0.4
	5	35.330	9.11	0.9	0.02	0.2	-	20	0.9	0.02	0.2		3.5	0.5
	10	35.321	9.10	0.9	0.04	0.3	22.5	60	1.9	0.24	2.7		1.3	0.4
	20	35.324	9.30	1.2	0.09	1.3	27.0							
	40	35.332	9.21	1.9	0.24	3.1	-							
	65	35.327	9.20	1.9	0.24	3.3	33.9							

Note: Data in brackets not used in calculation of averaged data in Table 3.

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TABLE 3 - Averaged Results for Each Station

STATION Number	SALINITY	ALUMINIUM nM	SILICON µM	PHOSPHATE µM	NITRATE µM	CHLOROPHYLL a µg/l
1	34.78	23	0.1	0.15	1.8	4.4
2	34.87	20	0.3	0.30	4.5	3.0
3	34.85	18	0.3	0.22	4.6	2.1
4	34.93	16	0.2	0.19	3.4	3.4
5	34.87	16	0.2	0.20	3.3	3.4
6	34.77	15	0.5	0.29	4.0	2.2
7	34.50	22	0.4	0.32	5.2	2.6
8	34.92	17	0.1	0.11	0.5	5.9
9	35.20	19	0.2	0.13	0.5	7.0
10	35.38	19	0.2	0.13	0.4	4.8
11	35.27	16	0.2	0.13	< 0.5	7.4
12	35.25	19	0.2	0.11	< 0.5	6.2
13	35.37	21	0.6	0.13	< 0.5	4.7
14	35.38	24	0.9	0.16	0.4	4.5
15	35.34	23	0.3	0.11	0.3	2.3
16	35.39	27	0.9	0.14	0.5	4.8
17	35.33	28	1.8	0.18	5.1	1.2
18	35.26	32	2.4	0.23	4.0	1.7
19	35.35	31	1.6	0.16	2.2	2.3
20S	35.33	27	1.0	0.03	0.3	3.7
D	35.33		1.9	0.24	3.2	1.3