P.O.L.

RRS 'Challenger'

Cruises 98, 100

and RV 'Belgica' cruises

CSTAB - Circulation and Sediment Transport Around Banks

Cruise Report No. 16

1993

Natural Environment Research Council

PROUDMAN OCEANOGRAPHIC LABORATORY

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PROUDMAN OCEANOGRAPHIC LABORATORY

CRUISE REPORT NO. 16

INCORPORATING:

RRS CHALLENGER 98, *29 NOVEMBER - 5 DECEMBER 1992*;

RV BELGICA 92/14, *15 - 23 DECEMBER 1992*;

RRS CHALLENGER 100, *25 FEBRUARY - 3 MARCH 1993*; and

RV BELGICA 93/6, *18 MARCH 1993*.

FIELDWORK CONDUCTED FOR MAST II PROJECT

CSTAB - CIRCULATION AND SEDIMENT TRANSPORT AROUND BANKS

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ABSTRACT

Five fieldwork campaigns, centered on Middelkerke Bank, Belgium, were conducted between November 1992 and March 1993 using the vessels RRS Challenger and RV Belgica to deploy and recover instrumented moorings. In addition, the NERC aircraft was used for aerial surveys. The work forms part of the MAST II CSTAB project which combines mathematical modelling, oceanographic and sedimentological field measurements and geological/geophysical surveys. The broad aims of the project are to assess the environmental impact of offshore sandbanks in European shelf seas and through modelling, address a number of possible coastal impact scenarios in the event of a significant change in sea level and in the magnitude and frequency of storms. As a consequence, assessment of artificial sandbanks as an engineering option for coastal protection may then be possible.

During the principal measurement period, encompassing both storm and calm conditions, nine moorings were deployed around Middelkerke Bank for a period of 20 days. Moorings included: STABLE II; two ADCP/WLR rigs; two waverider buoys; and four current meter moorings with both Aanderaa and S4 meters. In addition, fluorescent tracer sand was deployed on either side of Middelkerke Bank and sampled during subsequent campaigns. Colour aerial photography provided useful information concerning wave diffraction over the bank and bedforms. Data return from all instruments was 100%. The contrasting range of hydrodynamic conditions provide sufficient high quality data to meet all the principal aims of the project.

This work was undertaken as part of the MAST II "Circulation and Sediment Transport Around Banks" (CSTAB) programme. It was funded by NERC and by the Commission of the European Communities Directorate General for Science and Education, Research and Development under contract number MAS2-CT92-0024C.

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CRUISE AND FIELDWORK REPORT

CSTAB - CIRCULATION AND SEDIMENT TRANSPORT AROUND BANKS

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Sincere thanks are also given to the Master, Officers and crew of RV Belgica without whom it would not have been possible to complete CSTAB fieldwork successfully. In particular the skill and enthusiasm of everyone in the execution of mooring recovery tasks in March 1993 contributed significantly to the successful conclusion of work at Middelkerke Bank. A special thank you is extended to André Pollentier of Ministerie van Volksgezondheid en Leefmilieu in Oostende for both overseeing the OSCR deployment and for organization of shiptime on RV Belgica in December and March.

The work of Simon Boxall and Robert Palmer from the University of Southampton in setting up the NERC OSCR system is greatly appreciated and has lead to the acquisition of a good data set. The cooperation of various Belgian military authorities and the provision of secure field sites simplified fieldwork and contributed significantly to the success of the experiment.

Finally, thanks are given to POL and to all members of the MAST II CSTAB and STARFISH groups for their advice and encouragement during the planning of the experiment.

PART ONE

RRS Challenger 98 and RV Belgica 92/14

1.0.0 BACKGROUND

The work described below forms part of the MAST II **CSTAB** project involving Belgian, Danish, Dutch, French, German, Portuguese and UK partners and is concerned principally with the origin and present day dynamics of offshore sandbanks. The project builds on results and experience gained during MAST I projects lead by the University of Liverpool (**LSB**), the University of Gent (**RESECUSED**) and Delft Hydraulics (**G6M**) and combines mathematical modelling, oceanographic and sedimentological field measurements and geological and geophysical surveys. The broad aims of the project are to assess the environmental impact of offshore sandbanks in present day conditions and to address a number of possible coastal impact scenarios in the event of significant changes in sea level and changes in the frequency of severe storms. As a consequence it may then be possible to assess the value of artificial sandbanks as an engineering option for European coastal protection.

1.1.0 EXPERIMENTAL OBJECTIVES

(a) To deploy the NERC OSCR system on the Belgium coastline to provide measurements of surface current speeds and directions over a wide area including the Kwinte, Middelkerke and Oostende sandbanks for a period of two months.

(b) To obtain hydrodynamic measurements of tidal currents in the vertical, waves and near-bed turbulence at selected sites in the vicinity of Middelkerke Bank.

(c) To obtain measurements of residual currents in the vicinity of Middelkerke bank using Decca/Argos drifting buoys.

(d) To determine net non-cohesive sediment transport pathways around Middelkerke bank over a period of two years through deployment of fluorescent sand tracers and subsequent grab sampling campaigns using RV Belgica and RRS Challenger.

1.2.0 NARRATIVE

(NOTE: Unless stated, all times are in **GMT**.)

With help from the Belgian authorities, the NERC ocean surface current radar (OSCR) system was deployed by the University of Southampton, UK at

secure military sites north and south of Oostende during the week 23-27 November 1992, (Figure 1.5.1). In tests, the range of the instrument was estimated to be approximately 20 Km offshore. Personnel from Ministerie van Volksgezondheid en Leefmilieu in Oostende were responsible for data recovery and routine maintenance of the equipment during the deployment.

POL instrumentation and materials including: 4 current meter moorings; 1 ADCP; 1 precision water level recorder; 2 waverider buoys; and fluorescent sand tracers were transshipped to RRS Challenger in Barry, South Wales on 26 November 1992. Owing to unfavorable weather conditions, RRS Challenger sailed 1 day late for the Middelkerke Bank field site at 09h30 on 30 November. Following an uncomfortable passage to Dover, UK, poor weather conditions persisted and prevented any work at the field site. Consequently Challenger cruise 98 was abandoned two days early on 3 December 1992 and the ship returned to Great Yarmouth, UK. During the same week, the Belgian research ship RV Belgica was also unable to work in the rough sea conditions and remained in Zeebrugge.

Through liaison with members of the Gent based MAST II STARFISH group and with the Ministerie van Volksgezondheid en Leefmilieu in Oostende, an opportunity arose to use the Belgian research vessel RV Belgica to deploy and recover instrumentation at Middelkerke Bank. Given the limited time available and the possibility of further bad weather it was agreed to deploy only essential equipment and materials. This included; 1 waverider buoy; 1 ADCP; and 1000 Kg of red and blue fluorescent sand. This equipment was shipped from the UK on 14 December 1992 and loaded onto the Belgica at 10h00 on 15 December.

Following an annual inspection by Belgian Navel officials, Belgica sailed from Zeebrugge at 17h30 and reach Middelkerke Bank at 19h00. During the following 3 hours all the equipment and materials were deployed without incident. The location of deployment sites, measured using the Syledis navigation system, deployment times and water depths are given in Table 1.4.1. The fluorescent sand tracers were deployed as close to slack water as was feasible at the same depth of water on opposite sides of Middelkerke Bank. To prevent the loose dry sand from blowing out of the container, the surface was dampened just before deployment. Echo soundings indicated the presence of well developed sandwaves in the vicinity of both deployment sites. Following acoustics tests, the ADCP rig was deployed at the eastern end of the bank close to the crest line of a large sandwave. The waverider buoy was deployed in the inshore swale of Middelkerke Bank.

For the following two days, tests using trawling gear were conducted by scientists from the Fisheries Ministry in Oostende and no further work was possible. These tests, using modified trawl gear were designed to assess the forces on the sea bed during normal trawling operations and to quantify both the species and size of fish passing through a given mesh size.

Sampling of the bottom sediments in the vicinity of the blue fluorescent sand deployment site (B) commenced at 22h20 on 17 December using a van Veen grab. In total 25 samples were obtained along a line running approximately parallel with Middelkerke Bank and passing through site B. The same procedure was followed at the red fluorescent sand deployment

site (site R). The location, time and water depth for each of the grab samples for sites B and R are given in Tables 1.4.2 and 1.4.3respectively. All samples were place in sealed plastic bags for subsequent laboratory analysis.

Belgica remained at anchor until 05h00 on 18 December and following final trawling trails the ship returned to Zeebrugge. All remaining equipment was then off loaded and scientific personnel disembarked at 14h00.

The scientific party from POL joined personnel from the University of Gent aboard RV Belgica at 09h00 on 21 December and sailed from Zeebrugge to Middelkerke Bank at 10h45. Following arrival at the ADCP deployment site at 12h45, the Benthos acoustic release was fired and the ADCP surfaced shortly afterwards at 13h00. The mooring and ballast frame were recovered using the 'Z' boat to attach the winch line. RV Belgica then proceeded to the waverider site at 14h20. The buoy was seen at 13h30 and recovered from its original deployment site at 13h45 in the same manner as the ADCP.

From 14h00 on 21 December, members of the Gent scientific party prepared equipment for side-scan sonar and bathemetric survey work of Middelkerke Bank. The survey proceeded until 19h00 on 22 December when RV Belgica returned to the blue fluorescent sand deployment site at Middelkerke bank. Thirty grab samples at both the blue and red fluorescent sand sites were obtained between 19h43 on 22 December and 01h00 On 23 December, (see Tables 1.4.4 & 1.4.5). Remaining side scan sonar work was then completed and RV Belgica returned to Zeebrugge at 07h00 on 23 December. All Belgian and UK scientific equipment was then off-loaded for shipment back to Gent and POL respectively.

1.3.0 DIARY

RRS CHALLENGER 98

23 NOVEMBER 1992	OSCR system shipped to Belgium by SUDO.
25 NOVEMBER 1992	POL equipment loaded for transport to Barry, UK.
26 NOVEMBER 1992	POL equipment loaded onto RRS Challenger.
27 NOVEMBER 1992	OSCR system running. Good data return.
29 NOVEMBER 1992	RRS Challenger sailing delayed due to bad weather.
30 NOVEMBER 1992	RRS Challenger sails from Barry at 10h00 GMT.
01 DECEMBER 1992	Passage to Middelkerke Bank field site. Weather bad.
02 DECEMBER 1992	Cruise abandoned at 11h30 GMT due to forthcoming adverse weather. RRS Challenger proceeding to Great Yarmouth, UK.
03 DECEMBER 1992	RRS Challenger docked in Yarmouth at 09h00.
04 DECEMBER 1992	All scientific equipment off loaded and transported back to POL. Scientific party sign off RRS Challenger at 12h00.

RV BELGICA 92/14

12 DECEMBER 1992	POL equipment loaded for forthcoming RV Belgica cruises.

14 DECEMBER 1992	POL equipment transshipped to Zeebrugge, Belgium via Hull, UK.
15 DECEMBER 1992	POL equipment loaded onto RV Belgica. Sailed to the Middelkerke Bank field site at 17h30. Arrived at 19h00. Fluorescent sand, ADCP and waverider buoy deployed successfully using the crane.
17 DECEMBER 1992	Commenced grab sampling at site B at 22h20 until 23h42.
18 DECEMBER 1992	Commenced grab sampling at site R at 00h32 until 01h24.
18 DECEMBER 1992	RV Belgica returned to Zeebrugge at 11h00. Remaining equipment off-loaded and scientific party disembarked at 14h00.
21 DECEMBER 1992	Personnel from the University of Gent and POL join RV Belgica at 07h30. Ship sails to Middelkerke Bank at 09h00 and arrives at 10h45. The ADCP and the waverider buoy are recovered successfully using the 'Z' boat to attach the winch line and the 'A' frame.
22 DECEMBER 1992	30 grab samples obtained between 19h43 and 20h40 at site B.
23 DECEMBER 1992	30 grab samples obtained between 23h51 and 00h54 at site R.
23 DECEMBER 1992	RV Belgica returns to Zeebrugge at 07h00. All equipment off-loaded. Scientific party sign off at 09h00.

1.4.0 TABLES

Deployment	Location	Depth	Time
BLUE sand (B) (1000 Kg)	051.19.00.25 N 002.44.33.88 E	10.2 m	21h00
ADCP	051.20.12.11 N 002.45.18.74 E	18.1 m	21h53
Waverider buoy	051.18.41.28 N 002.46.15.89 E	15.0 m	22h24
RED sand (R) (1000 Kg)	051.18.42.96 N 002.45.06.40 E	9.8 m	22h47

TABLE 1.4.1 LOCATION OF MOORINGS, DEPLOYMENT TIMES AND WATER DEPTH, 15 DECEMBER, 1992.

SAMPLE No.	POSITION		TIME (LOCAL)	DEPTH (m)
B1	51.18.52.78N	02.44.24.41E	23h20 34	14.1
B2	51.19.01.48N	02.44.13.86E	23h26 25	16.9
B3	51.19.05.58N	02.44.09.73E	23h29 58	17.1
B4	51.19.19.71N	02.44.50.96E	23h48 14	13.3
B5	51.19.21.76N	02.44.44.75E	23h51 41	15.6
B6	51.19.20.67N	02.44.42.81E	23h54 38	15.6
B7	51.19.18.72N	02.44.41.85E	23h57 23	15.6
B8	51.19.17.22N	02.44.42.98E	00h00 35	14.8
B9	51.19.14.64N	02.44.40.26	00h03 15	14.4
B10	51.19.11.06N	02.44.37.25E	00h06 02	14.3
B11	51.19.10.20N	02.44.33.18E	00h09 23	15.4
B12	51.19.09.01N	02.44.34 89E	00h12 18	12.5
B13	51.19.08.40N	02.44.39.19E	00h15 07	11.1
B14	51.19.08.81N	02.44.41.55E	00h17 33	9.3
B15	51.19.09.06N	02.44.42.98E	00h19 48	9.0
B16	51.19.08.19N	02.44.42.42E	00h21 57	9.1
B17	51.19.05.44N	02.44.39.22E	00h24 32	9.3
B18	51.19.04.54N	02.44.39.01E	00h25 44	8.8
B19	51.19.04.30N	02.44.39.57E	00h28 51	8.4
B20	51.19.03.88N	02.44.39.16E	00h30 58	8.6
B21	51.19.02.71N	02.44.36.34E	00h33 09	8.7
B22	51.19.02.07N	02.44.32.81E	00h35 16	11.3
B23	51.19.00.96N	02.44.32.13E	00h37 36	10.5
B24	51.18.58.99N	02.44.32.34E	00h40 20	8.6
B25	51.18.57.36N	02.44.31.96E	00h42 34	9.1

TABLE 1.4.2 GRAB SAMPLE POSITIONS, TIMES AND DEPTHS, SITE B, 17 DECEMBER, 1992.

SAMPLE No.	POSITION		TIME (LOCAL)	DEPTH (m)
R1	51.18.53.17N	02.45.26.37E	01h32 18	11.1
R2	51.18.52.40N	02.45.21.21E	01h34 35	11.2
R3	51.18.52.54N	02.45.15.61E	01h36 48	9.8
R4	51.18.52.61N	02.45.10.22E	01h38 51	9.1
R5	51.18.52.19N	02.45.04.53E	01h40 52	8.1
R6	51.18.50.78N	02.45.59.51E	01h42 46	5.4
R7	51.18.49.81N	02.44.57.59E	01h44 44	6.2
R8	51.18.49.10N	02.45.00.46E	01h46 42	7.6
R9	51.18.47.90N	02.45.03.53E	01h48 38	8.9
R10	51.18.43.97N	02.45.06.39E	01h50 37	9.6
R11	51.18.38.97N	02.45.09.03E	01h53 03	12.3
R12	51.18.35.44N	02.45.11.46E	01h55 26	12.7
R13	51.18.33.36N	02.45.11.67E	01h57 38	12.6
R14	51.18.31.40N	02.45.11.51E	01h59 53	12.5
R15	51.18.29.88N	02.45.10.67E	02h01 49	13.9
R16	51.18.27.86N	02.45.09.44E	02h04 00	13.4
R17	51.18.25.83N	02.45.08.05E	02h06 05	13.4
R18	51.18.24.93N	02.45.07.77E	02h08 22	13.6
R19	51.18.25.48N	02.45.08.25E	02h10 40	13.3
R20	51.18.26.51N	02.45.09.39E	02h12 50	13.3
R21	51.18.28.13N	02.45.09.32E	02h15 06	13.5
R22	51.18.30.31N	02.45.01.30E	02h18 13	10.8
R23	51.18.30.36N	02.44.56.45E	02h20 22	11.4
R24	51.18.30.34N	02.44.53.67E	02h22 32	10.4
R25	51.18.30.68N	02.44.50.08E	02h24 35	9.9

TABLE 1.4.3 GRAB SAMPLE POSITIONS, TIMES AND DEPTHS, SITE R, 17 DECEMBER, 1992.

SAMPLE No.	POSITION		TIME (LOCAL)	DEPTH (m)
B1	51.18.40.10N	02.44.03.22E	20h43 40	17.0
B2	51.18.40.50N	02.44.04.73E	20h46 04	16.4
B3	51.18.40.89N	02.44.05.85E	20h47 58	18.8
B4	51.18.41.09N	02.44.06.53E	20h49 55	16.0
B5	51.18.41.68N	02.44.07.43E	20h51 50	15.7
B6	51.18.42.74N	02.44.08.54E	20h53 55	15.6
B7	51.18.43 23N	02.44.09.80E	20h55 45	12.1
B8	51.18.44.03N	02.44.11.09E	20h57 45	10.9
B9	51.18.44.83N	02.44.12.38E	20h59 39	11.2
B10	51.18.45.26N	02.44.13.17E	20h01 37	11.3
B11	51.18.45.58N	02.44.14.19E	21h03 29	10.7
B12	51.18.46.19N	02.44.15.35E	21h05 23	11.1
B13	51.18.46.98N	02.44.16.80E	21h07 25	11.2
B14	51.18.47.97N	02.44.18.35E	21h09 25	10.2
B15	51.18.49.11N	02.44.20.02E	21h11 26	10.6
B16	51.18.50.15N	02.44.21.79E	21h13 21	9.8
B17	51.18.51.51N	02.44.23.76E	21h15 44	11.2
B18	51.18.52.65N	02.44.25.51E	21h17 43	10.3
B19	51.18.53.79N	02.44.27.13E	21h19 36	9.8
B20	51.18.54.80N	02.44.28.92E	21h21 31	10.2
B21	51.18.55.86N	02.44.30.56E	21h23 24	9.2
B22	51.18.57.28N	02.44.32.48E	21h25 39	9.2
B23	51.18.58.63N	02.44.34.20E	21h27 23	9.3
B24	51.18.59.86N	02.44.35.95E	21h29 01	9.1
B25	51.18.01.21N	02.44.37.64E	21h30 51	9.7
B26	51.18.02.34N	02.44.39.36E	21h32 38	9.0
B27	51.18.03.46N	02.44.40.77E	21h34 28	8.6
B28	51.19.04.50N	02.44.42.32E	21h36 21	9.4
B29	51.19.05.71N	02.44.44.11E	21h38 15	8.3
B30	51.19.07.25N	02.44.45.95E	21h40 33	9.7

TABLE 1.4.4 GRAB SAMPLE POSITIONS, TIMES AND DEPTHS, SITE B, 22 DECEMBER, 1992.

SAMPLE No.	POSITION		TIME (LOCAL)	DEPTH (m)
R1	51.18.53.81N	02.45.18.05E	00h49 39	14.5
R2	51.18.51.25N	02.45.15.83E	00h51 57	14.1
R3	51.18.49.45N	02.45.16.46E	00h54 12	14.0
R4	51.18.48.75N	02.45.15.48E	00h56 18	14.1
R5	51.18.47.76N	02.45.14.03E	00h58 27	13.9
R6	51.18.46.12N	02.45.12.69E	01h00 40	14.9
R7	51.18.46.90N	02.45.11.05E	01h02 49	12.6
R8	51.18.48.38N	02.45.10.35E	01h04 53	--
R9	51.18.47.82N	02.45.08.59E	01h08 39	--
R10	51.18.45.85N	02.45.07.22E	01h10 40	13.0
R11	51.18.43.81N	02.45.05.84E	01h12 52	13.5
R12	51.18.42.65N	02.45.05.41E	01h14 57	14.0
R13	51.18.43.01N	02.45.04.33E	01h17 03	13.6
R14	51.18.42.53N	02.45.02.59E	01h19 06	12.8
R15	51.18.39.95N	02.45.01.42E	01h21 19	12.9
R16	51.18.38.15N	02.44.59.94E	01h23 27	12.4
R17	51.18.36.50N	02.44.59.08E	01h25 38	14.2
R18	51.18.35.07N	02.44.58.54E	01h27 51	14.0
R19	51.18.32.97N	02.44.58.21E	01h30 13	15.1
R20	51.18.31.31N	02.44.57.12E	01h32 34	15.3
R21	51.18.31.15N	02.44.54.88E	01h35 01	15.4
R22	51.18.31.35N	02.44.53.00E	01h37 24	13.9
R23	51.18.31.69N	02.44.51.15E	01h39 34	--
R24	51.18.32.06N	02.44.49.19E	01h41 40	11.4
R25	51.18.30.62N	02.44.46.92E	01h44 08	13.3
R26	51.18.28.37N	02.44.44.16E	01h46 29	11.6
R27	51.18.26.85N	02.44.42.43E	01h48 37	13.2
R28	51.18.25.64N	02.44.42.09E	01h50 45	12.2
R29	51.18.24.55N	02.44.41.47E	01h52 53	--
R30	51.18.23.82N	02.44.40.72E	01h54 58	12.3

TABLE 1.4.5 GRAB SAMPLE POSITIONS, TIMES AND DEPTHS, SITE R, 22 DECEMBER, 1992.

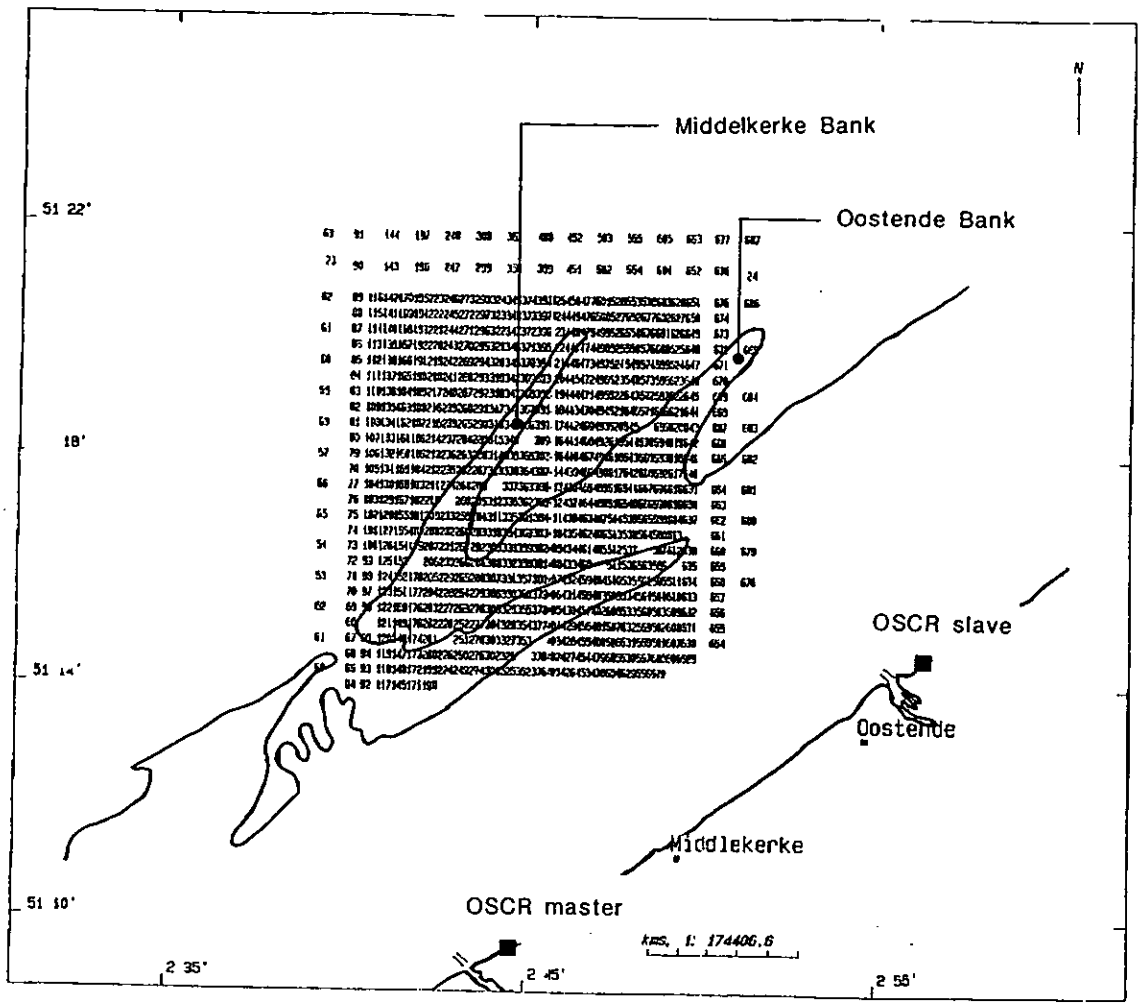


FIGURE 1.5.1 Location and processed area of OSCR.

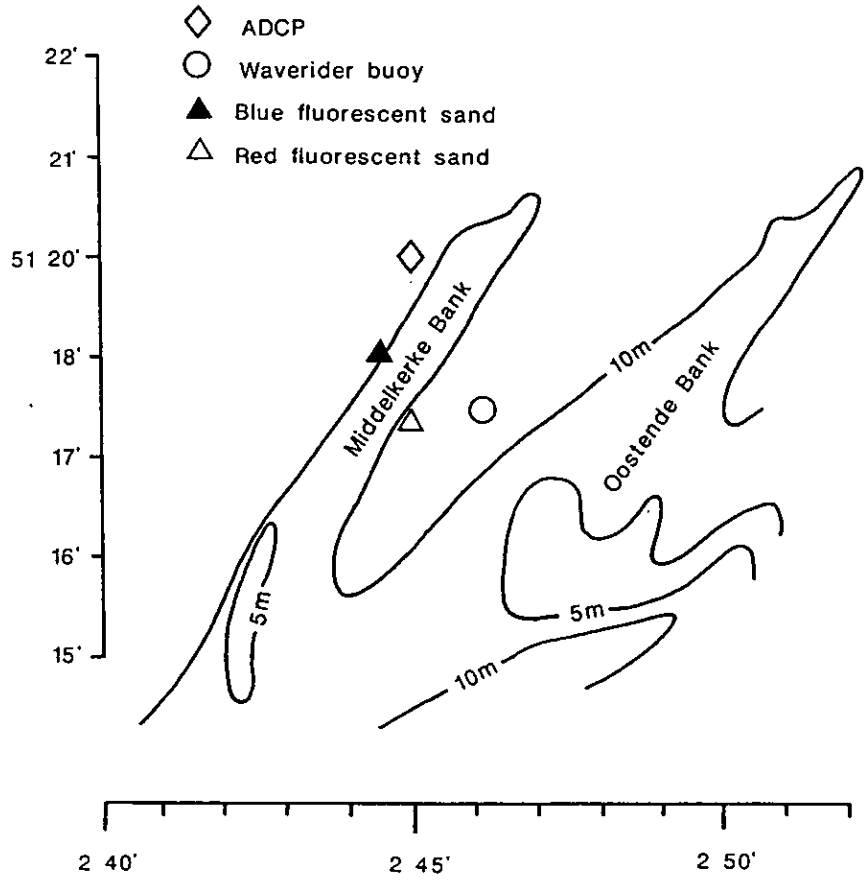


FIGURE 1.5.2 Location of moorings and fluorescent sand tracers.

PART TWO

RRS CHALLENGER 100

2.0.0 CRUISE OBJECTIVES

2.0.1 INTRODUCTION

Whilst some aspects of offshore sandbank origin and present day dynamics are well understood, the degree of coastal protection afforded by these features in storm conditions is uncertain. With current interest focused on various coastal defense strategies including artificial sandbanks and reefs, the need for improved understanding of natural sandbank systems is vital.

Through an approach combining field measurements and modelling at a site off the Belgian coastline it is planned to assess protection through understanding the local hydrodynamics (including waves) and sediment sources, transport and accretion. The present study at Middelkerke Bank, Belgium builds on work undertaken by various European partners during EC MAST I projects (Linear sandbanks, LSB, and RESECUSED) and on preliminary MAST II CSTAB field deployments from R V Belgica during **CSTAB** fieldwork leg 2 in December 1992, (see Part 1).

CSTAB fieldwork leg 3 during Challenger cruise 100 follows an unsuccessful attempt to conduct similar work at Middelkerke Bank during **CSTAB** fieldwork leg 1, (Challenger cruise 98). Continual bad weather prevented any work on site and Challenger was forced to return to Great Yarmouth two days early, (see appendix 8.1).

Recovery of all moorings deployed in the vicinity of Middelkerke Bank during Challenger cruise 100 was successfully accomplished during **CSTAB** fieldwork leg 4 using RV Belgica on 18 March 1993, (see appendix 8.1).

2.0.2 SPECIFIC OBJECTIVES

(a) The measurement of currents and water depth at two sites at either end of Middelkerke Bank using RCM's, S4 current meters, and precision WLR's. These data will allow determination of form drag through a momentum balance approach.

(b) To measure vertical velocity structure using an ADCP and RCM's on the STABLE rig.

(c) The measurement of Reynolds stresses and wave induce currents at 40 cm and 80 cm above the bed using electromagnetic current meters (STABLE).

(d) To relate wave/current interactions and turbulent bursting phenomena to resuspension of bottom sediments using data from STABLE.

(e) The measurement of surface waves using a pressure transducer

(STABLE) and two waverider buoys moored on either flank of the bank.

(f) To measure suspended sediment concentration using an acoustic backscatter device on STABLE.

(g) To assess the net bedload transport rate and direction through deployment and subsequent sampling of fluorescent sand tracers on either flank of the bank.

2.1.0 NARRATIVE

The first scientific party and all equipment left POL at 09h30 on 22 February 1993. Loading commenced at 14h00 on 23 February. Remaining scientific personnel joined the ship by 16h00 on 24 February. RRS Challenger cleared the berth at Great Yarmouth, UK at 10h16 on 25 February and the ship got underway following departure of the Yarmouth pilot at 10h55. Weather conditions were favorable with a moderated sea and good visibility. Power failure early in the passage to Middelkerke Bank resulted in the loss of all power at 11h15. The fault was quickly rectified and following a second power loss the ship proceeded towards the Middelkerke Bank field site. During passage member of the scientific party were engaged in preparation of equipment for deployment.

Following an acoustics test with the ship stationary at 19h50, RRS Challenger reached the field site at 20h00. The first Argos buoy was released at 20h48 from the afterdeck followed by a second buoy at 20h48. The position of these buoys was monitored at 4 hourly intervals throughout the duration of the cruise. A second static acoustics wire test was conducted at 21h31 in order to assess correct functioning of the Benthos acoustic release system employed on the ADCP rigs.

With good weather conditions still prevailing, deployment of the new STABLE (Sediment Transport And Boundary Layer Equipment) rig commenced at 21h55 with positioning of the spar buoy. Deployment of STABLE, weighing approximately 3 tonnes, and associated ground line, anchor clump and spar buoy then proceeded smoothly and Challenger cleared the mooring at 22h12. Restrictions on crew working time for health and safety reasons prevented further mooring deployments.

Grab sample surveying in the vicinity of the blue fluorescent sand deployment site on the northern side of Middelkerke Bank, (RV Belgica, see Part 1), then proceeded at 00h20 on 26 February 1993. By 06h45, 80 samples had been obtained. Each was labeled and stored in sealed polythene bags for subsequent laboratory analysis.

Deployment of moorings proceeded at 07h00 on 26 February with two test ADCP rigs located at 51 19.87'N ,2 44.77'E (site C1) and at 51 19.72'N, 2 44.59'E (site C2). At 08h47, two observers, Mr Pollentier (Ministerie van Volksgezondheid en Leefmilieu, Oostende, Belgium) and Dr Stolk (University of Utrecht, Netherlands), joined Challenger from the tug "Zeehond" out of Oostende. Both work collaboratively with the present MAST II CSTAB group through the MAST II STARFISH project lead by Professor DeMoor at the University of Gent. In common with Professor Dias (IH, Lisboa), present as an observer on the cruise, their visit served two purposes: to observe mooring deployment operations aboard a

UK vessel; and to plan recovery of moorings deployed during the present Challenger cruise using RV Belgica in March 1993. In addition, agreements on working procedures and shiptime and on data exchange between the two MAST groups during the visit was especially welcome and acted to strengthened collaborative links with our European partners. Both visitors remained on board until collected by Zeehond at 17h20. During transfer between ships, a Argos buoy picked up by the tug due to a misunderstanding was returned and redeployed.

Deployment of remaining moorings proceeded at approximately 09h00 and was completed at 18h50. During this time, 8 further moorings consisting of S4 and rotary current meters, an acoustic doppler current profiler (ADCP), a precision water level recorder (WLR) and waverider buoys were deployed without incident (see figure 7.2 and appendix 8.2). Although northerly gales were forecast, weather conditions remained good for most of the day. With freshening winds and general fatigue amongst members of the scientific party and crew, watches were called off and Challenger remained hove to in the vicinity of the STABLE mooring. Previous fishing activity in the area became much less intense in the worsening sea and weather conditions.

Grab sampling in the vicinity of the blue fluorescent sand deployment site, (figure 7.2), was undertaken at approximately 09h30 on 27 February. Despite a 2-3 metre wind sea and squally hail and snow showers, Challenger was able to approach quite closely to Middelkerke Bank and 30 samples were obtained. Owing to weather and sea conditions and to uncertainty in depth measurements, it was not possible to cross the bank and Challenger headed around the northeastern end of Middelkerke Bank to reach the next grab survey site at approximately 13h00. Sampling for red fluorescent sand was then undertaken as close to the bank as conditions would allow. In total 30 samples were obtained from this site.

Following passage back to the northern side of the bank, both test ADCP rigs were recovered successfully by 17h30 in heavy snow and poor visibility. Preliminary inspection of the rigs showed that one had worked successfully and useful data had been obtained. Challenger proceeded to mooring sites F at 18h00 to assess the effectiveness of the radar enhancement devices installed on the toroid marker buoy. In common with site B, this device did little to improve the radar profile of the buoy. Malfunction is therefore suspected. With weather conditions still poor, Challenger remained hove to in the vicinity of the STABLE site until first light at approximately 06h40.

During the night of 27-28 February, weather conditions moderated slightly and the decision to attempt recovery of STABLE was made by POL staff on the advice of the bridge. This operation was started at approximately 07h00 and ended successfully at 07h50 with the STABLE frame in board. Despite failure of the acoustic system to release the heavy lead feet and three heavy collisions with the 'A' frame which shook the entire vessel (!), the rig suffered no detectable damage on recovery apart from a slight distortion of one leg.

The updated Argos position for the buoys was received at 08h15 and Challenger proceeded to rendezvous with buoy 1 just to the north west of

Kwinte Bank. On arrival, visual contact was established almost immediately and the buoy was recovered at 09h42. The remaining buoy, having drifted into shallow French waters, could not be recovered and the relevant authorities were notified. Given the rapid southerly drift, it was suspected that the drogue had become detached and the buoy had been blown by the strong northerly wind.

During 28 February - 2 March, Challenger proceeded towards Barry, UK to arrive at 09h00 in time to catch the midday high tide. During passage, Challenger stopped briefly to conduct an ADCP wire test at 09h00 on 1 March. Challenger docked at RVS Barry at approximately 11h35 on 2 March. Scientific equipment was off loaded on 3 March and the last remaining scientific personnel left the ship at approximately 12h00 to return to POL.

2.2.0 DIARY

FEBRUARY 22

09h30	First scientific party and equipment leave POL.
17h00	Arrival at Great Yarmouth.

FEBRUARY 23

14h00	Loading of equipment commenced.
18h30	Loading completed.
19h00	Preparation of equipment.

FEBRUARY 24

08h00	Preparation of equipment.
16h00	Remaining members of the scientific party join the ship.

FEBRUARY 25

10h16	RRS Challenger cleared berth.
10h55	Underway to Middelkerke Bank, Belgium.
11h15	Engine failure. Loss of all power.
11h30	Underway again.
11h40	Temporary loss of all power.
11h50	Underway again.
19h15	Acoustics wire test.
20h00	On site.
20h48	1st. Argos buoy released.
21h00	2nd. Argos buoy released.
21h31	Acoustics wire test.
21h55	Positioning spar buoy for STABLE mooring.
22h00	Commenced deployment of STABLE.
22h02	STABLE on bottom.
22h12	Mooring deployed and cleared.

FEBRUARY 26

00h20 Commenced grab sampling at blue fluorescent sand site, (west side of Middelkerke Bank).
06h45 Grab survey completed. Hove to till first light.
07h11 1st. test ADCP rig deployed.
07h18 2nd. test ADCP rig deployed.
08h45 Tug "Zeehond" transfers Dr Ad Stolk (University of Utrecht) & Mr Andre Pollentier (Oostende) to observe operations.
09h10 Commenced to deploy moored ADCP at site C.
09h20 ADCP deployed and mooring cleared.
10h30 Commenced laying WLR mooring at site G.
10h37 Mooring cleared.
13h08 Commenced laying RCM/S4 current meter mooring at site F.
16h16 Mooring cleared.
14h31 Commenced laying RCM/S4 current meter mooring at site B.
14h38 Mooring cleared.
16h10 Commenced laying RCM mooring at site E.
16h18 Mooring cleared.
16h55 Argos buoy picked up by "Zeehond".
17h27 "Zeehond" approaching.
17h32 "Zeehond" away with two observers.
17h55 Commenced deployment of RCM mooring at site H.
18h06 Mooring cleared.
18h21 Argos buoy deployed.
18h27 Waverider buoy deployed at site I.
18h50 Waverider buoy deployed at site D.
19h00 Hove to.

FEBRUARY 27

09h36 Commenced grab sampling in the vicinity of the blue fluorescent sand deployment site.
11h36 Grab sampling completed.
11h40 Proceed to next sampling station.
13h51 Hove to at grab station in the vicinity of the red fluorescent sand deployment site.
14h05 Commenced grab sample survey.
15h15 Grab survey complete.
15h20 Proceed to test ADCP deployments sites to the north of Middelkerke Bank.
16h30 ADCP test rig 1 on the surface.
16h38 Rig grappled.
16h43 Rig and ballast frame in board.
17h02 ADCP test rig 2 on the surface.
17h13 Rig grappled and lost.
17h26 Rig grappled again.
17h30 Rig and ballast frame in board.
18h20 Inspection of remaining moorings and assessment of radar enhancement equipment.
19h30 Hove to.

FEBRUARY 28

07h00 Recovery of STABLE begins.
07h25 Spar buoy grappled.
07h31 Spar buoy in board.

07h35 Anchor clump recovered.
07h46 STABLE on the surface.
07h50 STABLE on board undamaged.
08h24 Proceed to Argos buoy position.
09h30 Buoy sighted.
09h41 Buoy grappled.
09h42 All in board and clear.
09h48 Begin passage to Barry.

MARCH 1

09h00 Hove to for ADCP wire test.
09h00 ADCP over board.
09h24 ADCP in board. Resuming passage to Barry.

MARCH 2

Passage to Barry.
09h00 Hove to off Barry awaiting pilot.
11h35 Along side at RVS Barry.

MARCH 3

Equipment off loaded. Scientific party return to POL.

2.3.0 PROJECT REPORTS

2.3.1 MOORINGS

The location of all moorings deployed during Challenger 100 are given in table 2.5.1 and figure 2.6.2. Mooring diagrams are given in appendix 5.4.0. Each mooring included a surface marker buoy and the facility to recover the mooring anchor and so prevent fouling of the sea bed. This was achieved either by incorporating anchors with the mooring lines or through use of spooler lines. All mooring components were prepared prior to departure from POL and were arranged as a kit of parts.

At stations B and F each of the surface toroidal buoys was equipped with an Argos satellite beacon (MBM services), ID No. 1450 and 1451 respectively, together with a Radar Target Enhancer, type RTE 900, supplied by Electronica UK. Tests were carried out to evaluate the performance of these instruments at ranges of 1-5 miles using both radar sets on Challenger, (Decca Racal types 2690 BT and BT 502 operating at 9410 GHz nominally). Irrespective of range or buoy, no useful target enhancement was observed. It was concluded that either the system had failed to function correctly or that the system was incompatible in some way with the present radar. Further investigations are to be undertaken from RV Belgica during recovery operations at the end of March, 1993.

With RV Belgica available for mooring recovery during periods in March 1993, 8 of the moorings deployed during the cruise were left on site. This not only increased the duration of deployments to approximately 3 weeks but also ensured that instruments were running during some

exceptionally high spring tides during March. Although raising the risk of collision with local shipping and fishing activity in the area, it was considered that a reduced deployment time would compromise the principal objectives of the cruise.

Owing to high value and vulnerability, STABLE was deployed and recovered without incident during the cruise. The 58 hour deployment spanned a useful variety of current and wave conditions and included the build up to a moderate storm. This good fortune was better than had been anticipated and fulfills a major objective of the cruise. Failure of the acoustic system to jettison the heavy lead feet on the rig on recovery is currently the subject of further investigation. Rig performance could not be determined before returning to POL.

2.3.2 SEDIMENTS

Grab samples were obtained at two sites in the vicinity of past fluorescent sand deployments close to Middelkerke Bank using a Shipek grab. Sea conditions during latter operations were difficult and the grab failed to operate correctly on a number of occasions due to wire angle. Malfunction of the Challenger echo sounding equipment restricted operations in areas close to the bank considered to be the most likely places of tracer residence. Subsequent laboratory analysis will reveal whether or not the present sampling scheme was appropriate. All grab sample locations are given in tables 2.5.2 and 2.5.3.

2.3.3 DATA PROCESSING

The computer system on Challenger 100 consisted of the RVS "ABC" system. Data were logged from various instruments including: em log; gyro compass; Decca navigator; GPS; MX1107 satellite navigator; Simrad echo sounder; thermosalinograph; hull mounted ADCP; and grab sample positions. Plots of cruise track, mooring positions and grab sample locations were produced. With only two short periods of lost data, the system worked well for the duration of the cruise.

2.4.0 RECOMMENDATIONS

In general, equipment worked well and no difficulties were encountered. Poor functioning and failure of the echo sounding equipment, however, prevented necessary grab sampling work close to the sandbank and short passage across the bank between sites. This latter problem resulted in delay of some scientific operations which was rather disappointing given the short duration of this cruise on site.

2.5.0 TABLES

Name	Description	Position	Deployed	Recovered
A	STABLE	51 20.6'N 02 46.3'E	22h02 25/2/93	07h50 28/2/93
B	RCM/S4 "U" mooring.	51 20.9'N 02 45.9'E	14h33 26/2/93	-
C	Moored ADCP/WLR	51 20.5'N 02 45.9'E	09h18 26/2/93	-
C1	Pop-up ADCP	51 19.9'N 02 44.6'E	07h11 26/2/93	16h43 27/2/93
C2	Pop-up ADCP	51 19.7'N 02 44.6'E	07h18 26/2/93	17h30 27/2/93
D	Waverider	51 18.8'N 02 43.7'E	18h50 26/2/93	-
E	RCM single point mooring	51 18.3'N 02 43.4'E	16h12 26/2/93	-
F	RCM/S4 "U" mooring	51 16.2'N 02 41.1'E	13h09 26/2/93	-
G	WLR rig	51 15.9'N 02 41.2'E	10h37 26/2/93	-
H	RCM single point mooring	51 17.8'N 02 44.3'E	18h01 26/2/93	-
I	Waverider	51 18.2'N 02 44.7'E	18h31 26/2/93	-

TABLE 2.5.1 MOORING LOCATIONS, CHALLENGER 100.

Latitude	Longitude	Sample
51.328833	2.7476667	B1
51.327500	2.7480000	B2
51.327333	2.7478333	B3
51.327161	2.7478333	B4
51.326833	2.7476667	B5
51.326833	2.7480000	B6
51.326500	2.7478333	B7
51.326333	2.7476667	B8
51.325333	2.7485000	B9
51.325833	2.7478333	B10
51.325333	2.7475000	B11
51.325500	2.7471667	B12
51.325167	2.7471667	B13
51.324833	2.7471667	B14
51.324500	2.7470000	B15
51.324500	2.7465000	B16
51.324500	2.7463333	B17
51.323833	2.7461667	B18
51.323167	2.7455000	B19
51.322833	2.7456667	B20
51.322833	2.7448333	B21
51.322333	2.7450000	B22
51.322667	2.7445000	B23
51.322333	2.7446667	B24
51.322000	2.7450000	B25
51.319833	2.7425000	B26
51.319333	2.7406667	B27
51.319667	2.7413333	B28
51.319167	2.7401667	B29
51.318833	2.7400000	B30
51.318000	2.7386667	B31
51.317500	2.7380000	B32
51.317333	2.7378333	B33
51.317500	2.7375000	B34
51.317000	2.7373333	B35
51.316500	2.7361667	B36
51.316167	2.7355000	B37
51.315833	2.7356667	B38
51.315167	2.7348333	B39
51.314833	2.7338333	B40
51.313333	2.7325000	B41
51.312000	2.7316667	B42
51.311667	2.7301667	B43
51.310667	2.7291667	B44
51.309833	2.7291667	B45
51.309333	2.7271667	B46
51.307000	2.7255000	B47
51.306167	2.7250000	B48
51.304833	2.7243333	B49

TABLE 2.5.2 LOCATION OF GRAB SAMPLES, BLUE SAND SITE, (51 19.0'N, 2 44.3'E)

Latitude	Longitude	Sample
51.301500	2.7213333	B50
51.300333	2.7193333	B51
51.298500	2.7121667	B52
51.297833	2.7063333	B53
51.297667	2.7098333	B54
51.297167	2.7091667	B55
51.297000	2.7085000	B56
51.296333	2.7076667	B57
51.295333	2.7065000	B58
51.294833	2.7060000	B59
51.294167	2.7050000	B60
51.315167	2.7331667	B61
51.315000	2.7321667	B62
51.315333	2.7318333	B63
51.314833	2.7301667	B64
51.315833	2.7311667	B65
51.316000	2.7390000	B66
51.315167	2.7373333	B67
51.315500	2.7338333	B68
51.315833	2.7331667	B69
51.316833	2.7303333	B70
51.315833	2.7293333	B71
51.315667	2.7283333	B72
51.315667	2.7415000	B73
51.316667	2.7373333	B74
51.316000	2.7366667	B75
51.316167	2.7350000	B76
51.316333	2.7336667	B77
51.317000	2.7331667	B78
51.317000	2.7311667	B79
51.319333	2.7425000	B80
51.318667	2.7406667	B81
51.318667	2.7380000	B82
51.319167	2.7361667	B83
51.319333	2.7350000	B84
51.319500	2.7338333	B85
51.319500	2.7325000	B86
51.319500	2.7311667	B87
51.320000	2.7280000	B88
51.319667	2.7268333	B89
51.321000	2.7238333	B90

TABLE 2.5.2 *(cont.)* **LOCATION OF GRAB SAMPLES, BLUE SAND SITE, (51 19.0'N, 2 44.3'E)**

Latitude	Longitude	Sample
51.305167	2.7471667	R1
51.305667	2.7471667	R2
51.305333	2.7471667	R3
51.306167	2.7458333	R4
51.304833	2.7463333	R5
51.305500	2.7461667	R6
51.306000	2.7458333	R7
51.306000	2.7450000	R8
51.305833	2.7446667	R9
51.305000	2.7448333	R10
51.305833	2.7450000	R11
51.305000	2.7450000	R12
51.306500	2.7453333	R13
51.306500	2.7458333	R14
51.306333	2.7470000	R15
51.306333	2.7471667	R16
51.306833	2.7471667	R17
51.307333	2.7415000	R18
51.307333	2.7413333	R19
51.308167	2.7413333	R20
51.307667	2.7468333	R21
51.307833	2.7470000	R22
51.308500	2.7471667	R23
51.307500	2.7475000	R24
51.307167	2.7488333	R25
51.308167	2.7511667	R26
51.308000	2.7523333	R27
51.308333	2.7545000	R28
51.308667	2.7553333	R29

TABLE 2.5.3 LOCATION OF GRAB SAMPLES, RED SAND SITE, (51 18.4'N, 02 45.1'E)

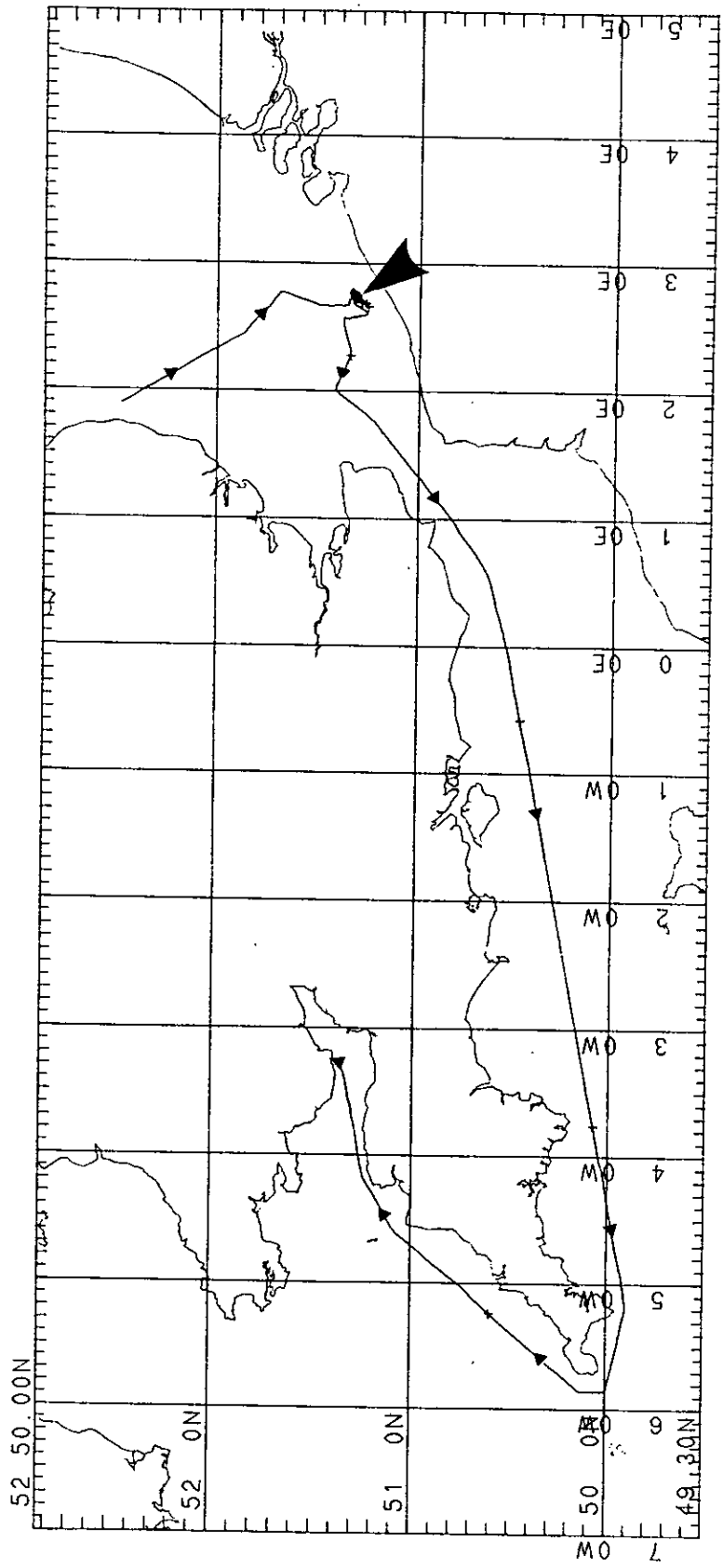


FIGURE 2.6.1 Ships track and location of field site.

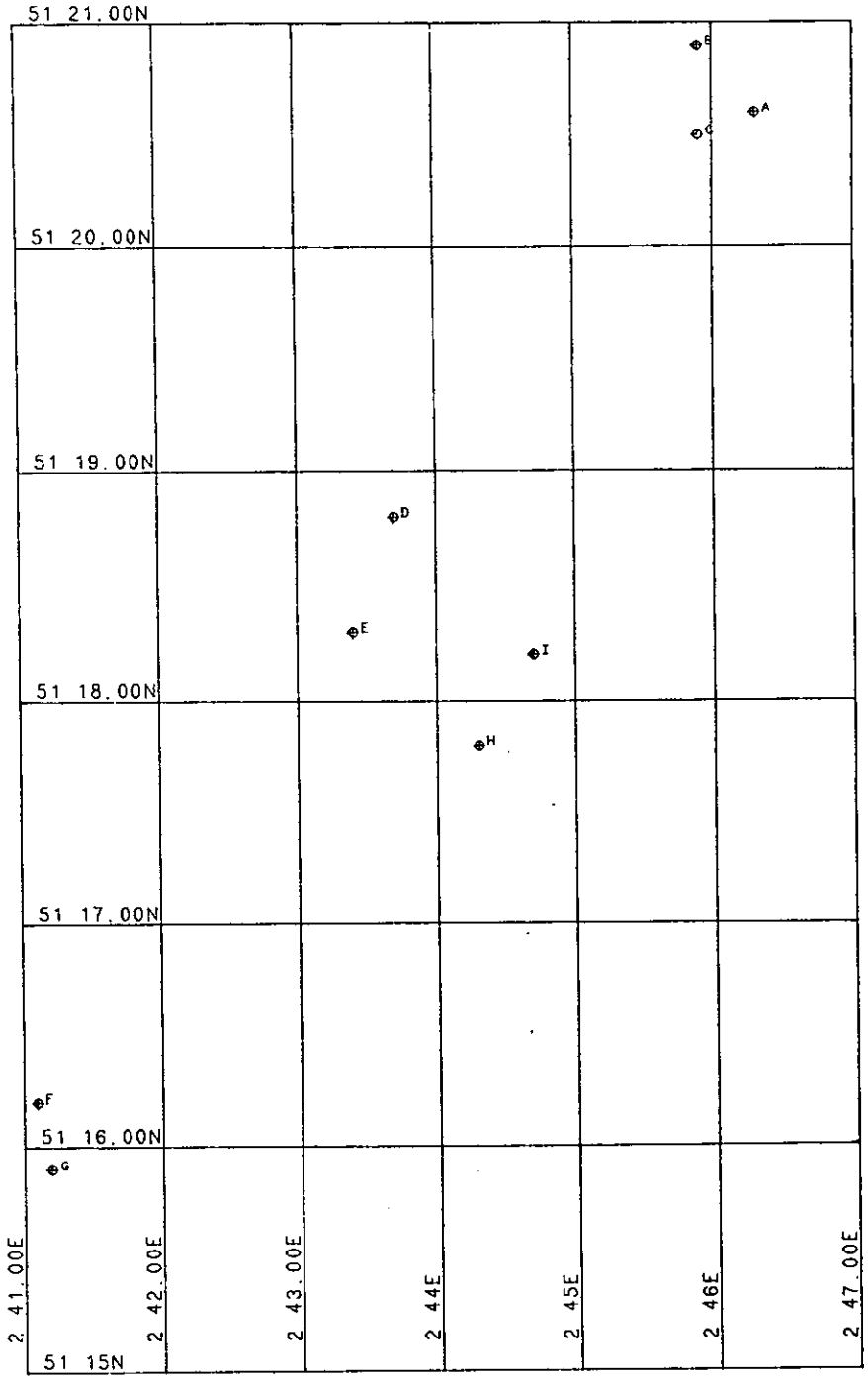


FIGURE 2.6.2 Location of moorings.

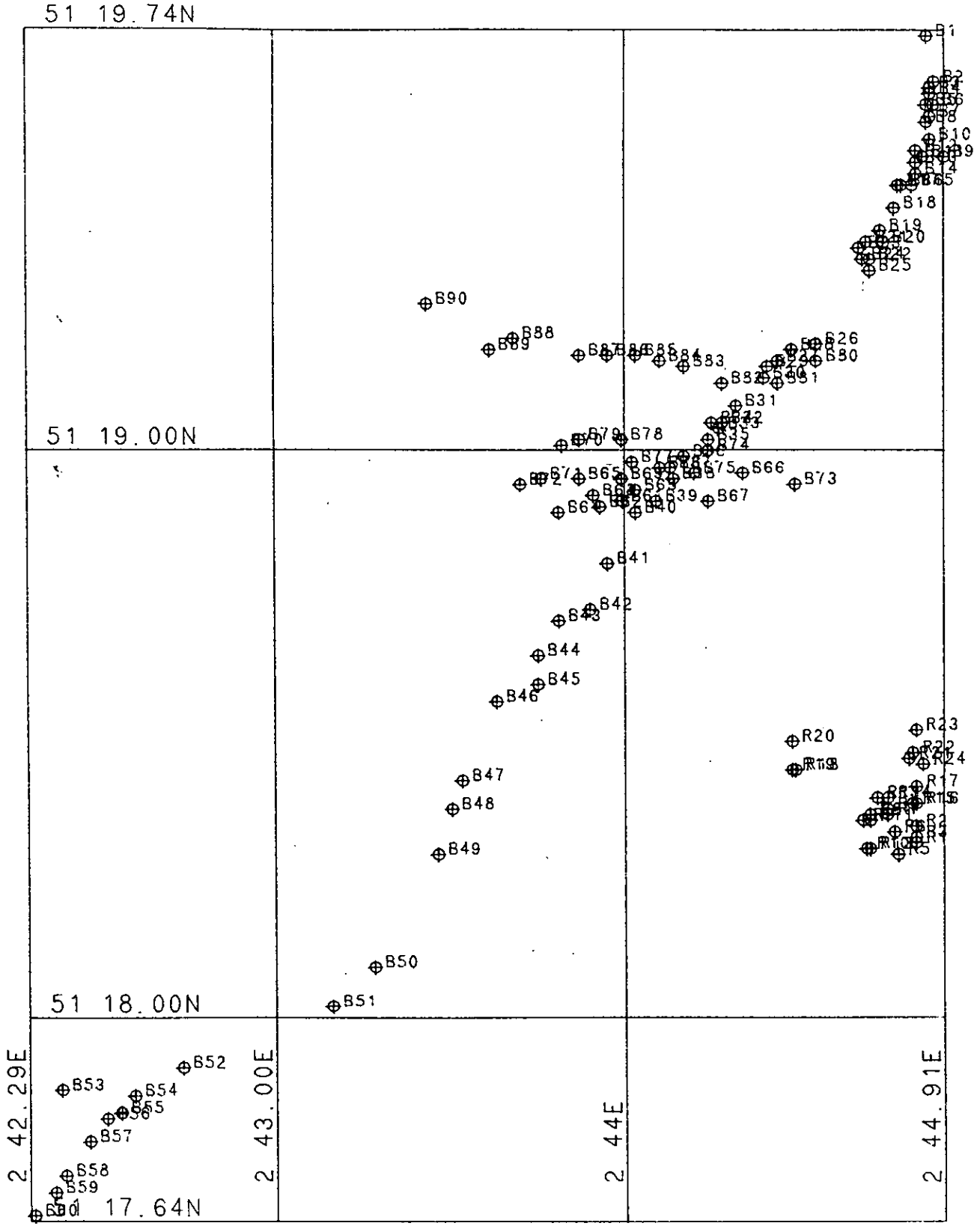


FIGURE 2.6.3 Location of grab sample sites.

PART THREE

RV BELGICA 93/6

3.0.0 BACKGROUND

Following the successful deployment of 8 mooring by 19h00 on 26 February 1993 during **CSTAB** fieldwork on Challenger 100, RV Belgica was made available for recovery operations on 18 March 1993. During the 20 day deployment, fishing and other shipping activities in the vicinity of Middelkerke Bank had been intense and despite frequent navigation hazard warnings being transmitted, the likelihood of mooring damage was considered to be high.

3.1.0 NARRATIVE

A scientific party and necessary mooring recovery equipment left POL on 16 March 1993 to join RV Belgica at 07h00 on 18 March 1993. With wind speed at force 4 to 5 and a moderate sea RV Belgica sailed from Zeebrugge, Belgium to the Middelkerke Bank field site at 08h45 with little optimism in recovering all the moorings.

Moorings at site I and H (figure 2.6.2) were sighted at 10h40 and the "Z" boat was launched to help in recovery operations. Following an aborted recovery attempt and several incidents when the "Z" boat nearly capsized, the waverider buoy at site I was recovered successfully. Parting of the stray line against the ship during an initial recovery attempt for current meter mooring H resulted from ship movement in a difficult wind against tide situation and further slowed recovery operations. With discarded fishing net wrapped around the lower aanderra current meter, mooring H was finally in board by 13h00.

RV Belgica then proceeded to the northeastern end of Middelkerke Bank to recover moorings at sites B and C, (figure 2.6.2). With deck working procedure now fully established, and with wind and sea conditions now moderating, mooring recovery proceeded smoothly and sites B and C were cleared by 14h45. The moored ADCP at site C failed to surface following acoustic "firing" and was recovered subsequently using the ground line. Reasons for failure were not determined during the cruise. During passage to sites F and G at the southwestern end of Middelkerke Bank, it was noted that the toroid marker buoy on current meter mooring E was missing. Moorings at sites F and G were recovered rapidly and without incident by 16h34.

Recovery of the final two mooring at sites D and E was completed by 17h48. In common with mooring H, the lower aanderra current meter was fouled by stray fishing net but was otherwise undamaged. Loss of the toroid buoy from this mooring was thought to result though abrasion between the sea bed and the mooring line as the water depth at this site was shallower than had been anticipated.

With light failing rapidly, RV Belgica set sail for Zeebrugge to arrive

at 20h00. In recovering all the moorings so quickly and proficiently,the hard work and professionalism of the Belgian officers and crew was very much appreciated by the UK scientific party.

3.2.0 DIARY

16 MARCH 1993	Scientific party leave POL
18 MARCH 1993	
07h00	Scientific equipment offloaded onto RV Belgica.
08h45	RV Belgica departs Zeebrugge for Middelkerke Bank.
09h00	Discussion with RV Belgica officers and crew on mooring recovery procedure and sequence.
10h40	Moorings sighted at sites I and H.
10h48	"Z" boat launched with two crew members.
11h04	Line attached to waverider buoy.
11h10	Waverider inboard.
11h18	Anchor inboard.
12h25	"U" mooring grappled.
12h30	Stray line parted against the ship.
12h32	Line re-attached successfully.
12h47	Anchor clump 1 inboard.
12h52	Toroid marker buoy inboard.
12h57	Current meters, anchor clump 2 and sub-surface buoy inboard.
13h00	Recovery complete. "Z" boat recovered.
13h35	Arrival at site B, "Z" boat launched.
13h46	Line attached.
13h52	Toroid inboard.
13h54	Anchor clump 1 inboard.
13h56	Current meters, anchor clump 2 and sub-surface buoy inboard.
13h58	Recovery complete.
14h15	ADCP acoustic release fired at site C. Failed to surface.
14h30	Winching in mooring C.
14h36	Spar buoy inboard.
14h38	Anchor clump inboard.
14h43	ADCP inboard, apparently undamaged despite failure to surface.
14h45	ADCP ballast frame in board. Recovery completed.
14h55	"Z" boat recovered.
15h30	"Z" boat launched.
16h33	Mooring F grappled.
15h36	Toroid onboard.
15h40	Anchor clump 1 onboard.
15h44	Current meters, anchor clump 2 and sub-surface buoy inboard.
15h45	Recovery completed.
15h55	WLR acoustic release fired.
15h56	Mooring on surface.
16h10	Mooring grappled.
16h20	Spar buoy inboard.
16h28	Anchor clump inboard.

16h32	WLR ballast frame inboard.
16h34	WLR inboard.
16h57	Arrival at sites D and E. "Z" boat following RV Belgica.
17h01	Mooring E grappled. Toroid missing.
17h15	Anchor clump 1 inboard.
17h18	Current meters, anchor clump 2 and sub-surface buoy inboard.
17h19	Mooring recovery completed.
17h22	Waverider buoy sighted by the bridge, (mooring D).
17h35	Mooring grappled.
17h37	Waverider buoy inboard.
17h48	Anchor inboard. recovery completed.
18h00	Depart Middelkerke Bank for Zeebrugge.
19h45	Arrive Zeebrugge.
19 MARCH 1993	Offload all scientific equipment for transportation back to POL, UK.
21 MARCH 1993	Scientific party arrive back at POL.

PART FOUR

NERC aircraft aerial photography survey of Middelkerke Bank

4.0.0 INTRODUCTION AND OBJECTIVES

Whilst instrumented moorings generally provide excellent measurements of local hydrodynamic conditions in a given study area, obtaining field information which reflects large scale processes presents more difficulty. During preliminary fieldwork discussions, it was speculated whether or not it might be possible to infer any large scale hydrodynamic and sediment transport/resuspension processes utilizing a combination of aerial photographs and satellite imagery. In order to investigate this further, it was considered that aerial photographic reconnaissance of the present field site at Middelkerke Bank would aid assessment of the potential of remote sensing data and provide useful additional information on the field site.

4.1.0 SURVEY INFORMATION

The aircraft used in the present study for aerial survey work is a Navajo Chieftain (BA31) owned by NERC and operated by Air Atlantic from Coventry airport, UK. The Wild RC8 camera mounted in the aircraft is equipped with a 15.2 cm lens and produces 24 cm X 24 cm square format images. During two complete surveys over Middelkerke Bank, Agfa 200 ASA colour aerofilm was used and photographs were taken with a shutter speed setting of 1/250 second at f5.6. With good visibility permitting relatively high altitude photography, the aircraft flew at 1670 metres at a ground speed of approximately 220 Km/hr. Using Decca navigation equipment, five lines were flown during both a morning and afternoon survey .Photographs were taken at 30 second intervals to give ground coverage of approximately 2500 m^2 with approximately 20% and 25% forward and lateral overlap respectively. A Decca navigation position was noted for the centre of each photograph. In total, 80 photographs were taken during the aerial survey of Middelkerke Bank along the survey reference lines. The surveys conducted in the morning and afternoon of 13 March were approximately coincident with times of low and high water respectively.

4.2.0 DIARY

13 March 1993

07h00	Aircraft pre-flight checks.
08h30	Take-off from Coventry airport, UK.
09h40	Begin aerial survey 1 of Middelkerke Bank, line 1.
09h55	End line 1.
09h59	Start line 2.
10h10	End line 2.
10h16	Start line 3.
10h27	End line 3.
10h29	Start line 4.

10h41	End line 4.
10h56	Start line 5.
11h07	End line 5. End of aerial survey 1.
11h23	Land at Oostende airport to refuel.
14h56	Take-off from Oostende airport.
15h10	Begin aerial survey 2 of Middelkerke Bank, line 5.
15h21	End line 5.
15h25	Start line 4.
15h32	End line 4.
15h47	Start line 3.
15h57	End line 3.
16h14	Start line 2.
16h25	End line 2.
16h37	Start line 1.
16h48	End line 1. End of aerial survey 2.
18h15	Land at Coventry airport.

4.3.0 PRELIMINARY SURVEY OBSERVATIONS

During aerial survey work over Middelkerke Bank, differences in surface waves in areas adjacent to and over Middelkerke Bank could be discerned. In addition, and much to our surprise, the bank and associated large bedforms (sandwaves) could be seen through the water at both states of the tide and the western limit of the bank was picked out by a foam line. Variations in suspended sediment concentration in the surface waters in the vicinity of Middelkerke bank was also evident during overpasses with significantly darker water associated with the muddy swale regions between the sandbanks. Marker buoys deployed during RRS Challenger cruise 100 were visible using the aircraft sight and in conjunction with large Belgian navigation buoys, provide an accurate ground position for later photographic analysis.

In general the survey was instructive and should provide useful additional data for **CSTAB**. It is considered that such surveys, if conducted in the future, should attempt to obtain a synoptic view of Middelkerke Bank in a range of different wave and current conditions. In pursuit of this aim, inquiries into the availability of satellite data are currently being undertaken by our Belgian colleges.

PART FIVE

APPENDICES

APPENDIX 5.0.0 Staff lists, Challenger 98 and 100

CHALLENGER 98

SCIENTISTS		SHIPS OFFICERS	
N C G Ballard	POL	P H P Maw	(Master)
P Bell	POL	G M Long	(Ch.Off)
A J Harrison	POL	P T Oldfield	(2nd Off)
N J MacDonald	Univ. Liverpool	J C Holmes	(3rd Off)
A Cormack	RVS		
J McKeown	POL	Ships Engineers	
A R Rimmer	POL		
J A Smith	POL	D C Rowlands	(Ch. Eng)
M Wilkin	Univ. Southampton	A Greenhorn	(2nd Eng)
J J Williams	POL (PSO)	S F Dean	(3rd Eng)
		Boatswain	
		R MacDonald	

CHALLENGER 100

SCIENTISTS		SHIPS OFFICERS	
H C Anderson	RVS	P H P Maw	(Master)
N C G Ballard	POL	G M Long	(Ch.Off)
J M A Dias	IH, Lisboa*	P T Oldfield	(2nd Off)
D Flatt	POL	J C Holmes	(3rd Off)
A J Harrison	POL		
D S Jones	POL	Ships Engineers	
R I Palin	POL		
A I R Pollentier	MVL, Oostende*	D C Rowlands	(Ch. Eng)
J D Humphery	POL	A Greenhorn	(2nd Eng)
R W Powell	RVS	S F Dean	(3rd Eng)
J D Richards	POL		
A R Rimmer	POL	Boatswain	
A Stolk	University of Utrecht*		
J J Williams	POL (PSO)	R MacDonald	

* EC MAST II observers.

APPENDIX 5.1.0 Notice to mariners and major equipment lists.

Notice to Mariners

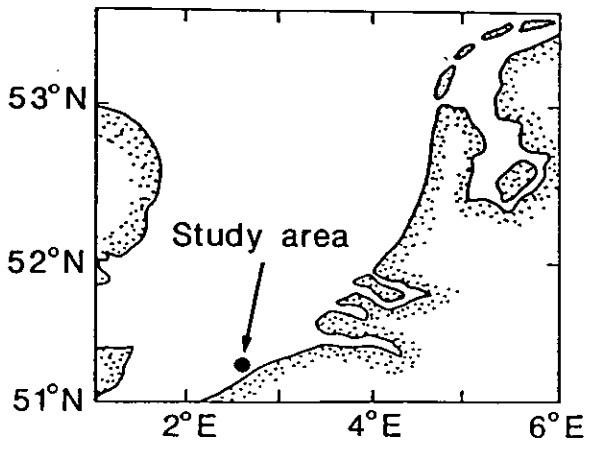
Southern North Sea

25 February - 31 March 1993

A hazard to shipping and fishing will be presented by an array of moorings at a study site in the vicinity of 51°18′N 2°43′E (the approaches to Oostende).

Sea bed frame, sub-surface buoyed and surface buoyed moorings will be deployed. The yellow surface buoys (either 2m diameter toroids or 5m spar buoys) conform to IMCO recommendations and contain a radar reflector and a yellow light which flashes rapidly for 5 seconds every 20 seconds. The Laboratory's name is painted on the buoys. In addition, ARGOS/DECCA drifting buoys will be deployed and tracked in the vicinity of the study area.

To avoid fouling the moorings the Laboratory would be grateful if ships and fishing boats would keep at least 5 cables clear of the moorings.



Site position			
Lat	Long	Decca (OE)	
(N)	(E)	Green	Purple
51°18′	2°43′	G30	H0

Proudman Oceanographic Laboratory,
Bidston Observatory,
Birkenhead L43 7RA, United Kingdom

Tel 051-653 8633 / Telex 628591 OCEANB G / Fax 051-653 6269

CHALLENGER 98: List of Equipment for Customs: Moorings, Frames (but NOT all instruments).

	Total Est. Weight	Replacement Cost
BED-HOPPING CAMERA + FRAME	200Kg	£25K
EG + G SIDESCAN FISH	40Kg	£15K
10 x ½T CLUMPS	5 Tonnes	£2.1K
2 x 6m SPAR BUOYS	0.5 Tonnes	£8K
4 x TOROIDS + FRAMES	1 Tonne	£6K
2 x 200Kg SPAR BALLAST	400Kg	£650
4 x 40" SSF + FRAMES	1 Tonne	£10K
WAVERIDER BUOY x 2	100Kg	£8K
1 x DOPPLER FRAME (WLR)	250Kg	£750
2 x LOW PROFILE DOPPLERS	500Kg	£2K
ROPES, WIRES, SHACKLES, HOOKS, LINKS FOR 13 x MOORINGS	1 Tonne	£15K
TOOL BOXES, SPARES BOXES + KITS	500Kg est.	£10K
COMPUTER + PRINTER	10Kg	£1.5K
MISCELLANEOUS ITEMS	200Kg	£5K

CHALLENGER 98: List of Instruments

	Weight	Value
S4 CURRENT METERS x 2	30Kg	£60K
RCM CURRENT METERS x 8	280Kg	£40K
1MHz DOPPLER CURRENT PROFILER x 2	50Kg	£30K
BENTHOS ACOUSTIC RELEASE x T600 x 3	15Kg	£12K
ARGOS BEACONS x 2	10Kg	£4K
RELEASE SPOOLER x 2	25Kg	£2K
BENTHOS DECK EQUIPMENT x 2	20Kg	£10K
DECCA/ARGOS DRIFTING BUOYS x 5	20Kg	£50K

SIDESCAN TOWFISH

SIDESCAN RECEIVER + PAPER + PSU?

CAMERA FRAME

2 x CAMERA BOXES + AL. BOX + WEIGHTS

WAVERIDER x 2

TOROIDS + LIGHTS x 4

40" SSF x 4

SPAR BUOYS + LIGHTS x 2

LOW PROFILE DOPPLER BALLAST FRAMES x 3

ANCHOR CLUMPS x ½T x 10

200Kg SPAR BALLAST x 2

SINGLE STUD LINKS x 2

LOW PROFILE DOPPLERS x 2

DOPPLER FRAME (WLR) x 1

CHALLENGER 100: List of Equipment for Customs: Moorings, Frames (but NOT all instruments).

	Total Est. Weight	Replacement Cost
BED-HOPPING CAMERA + FRAME	200Kg	£25K
EG + G SIDESCAN FISH	40Kg	£15K
12 x ½T CLUMPS	6 Tonnes	£2.1K
2 x 6m SPAR BUOYS	0.5 Tonnes	£8K
4 x TOROIDS + FRAMES	1 Tonne	£6K
3 x 200Kg SPAR BALLAST	600Kg	£975
4 x 40" SSF + FRAMES	1 Tonne	£10K
WAVERIDER BUOY x 2	100Kg	£8K
1 x DOPPLER FRAME (WLR)	250Kg	£750
3 x LOW PROFILE DOPPLERS	750Kg	£6K
ROPES, WIRES, SHACKLES, HOOKS, LINKS FOR 11 x MOORINGS	1 Tonne	£15K
TOOL BOXES, SPARES BOXES + KITS	500Kg est.	£10K
COMPUTER + PRINTER	10Kg	£1.5K
MISCELLANEOUS ITEMS	200Kg	£5K
1 x STABLE II SYSTEM	2000Kg	£10K
S4 CURRENT METERS x 2	30Kg	£60K
RCM CURRENT METERS x 8	280Kg	£40K
1MHz DOPPLER CURRENT PROFILER x 3	60Kg	£60K
BENTHOS ACOUSTIC RELEASE x T600 x 4	20Kg	£16K
ARGOS BEACONS x 2	10Kg	£4K
RELEASE SPOOLER x 4	50Kg	£4K
BENTHOS DECK EQUIPMENT x 2	20Kg	£10K

CHALLENGER 100: List of Instruments

	Weight	Value
DECCA/ARGOS DRIFTING BUOYS x 5	20Kg	£50K
STABLE II INST. + SENSORS	500Kg	£100K

CHALLENGER 100:

SIDESCAN TOWFISH

SIDESCAN RECEIVER + PAPER + PSU?

CAMERA FRAME

2 x CAMERA BOXES + AL. BOX + WEIGHTS

WAVERIDER x 2

TOROIDS + LIGHTS x 4

40" SSF x 4

SPAR BUOYS + LIGHTS x 3

LOW PROFILE DOPPLER BALLAST FRAMES x 3

ANCHOR CLUMPS x ½T x 12

200Kg SPAR BALLAST x 3

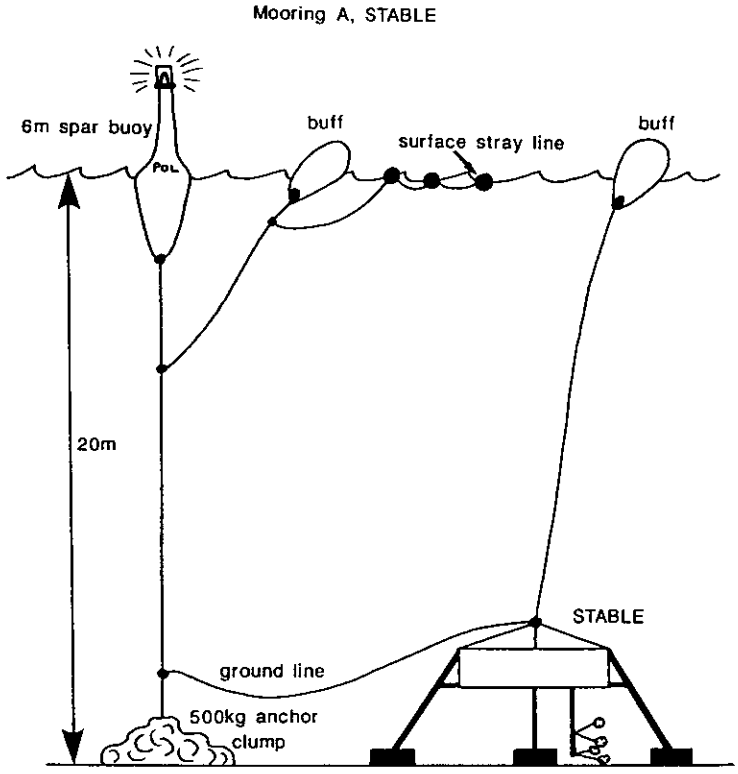
SINGLE STUD LINKS x 3

LOW PROFILE DOPPLERS x 3

DOPPLER FRAME (WLR) x 1

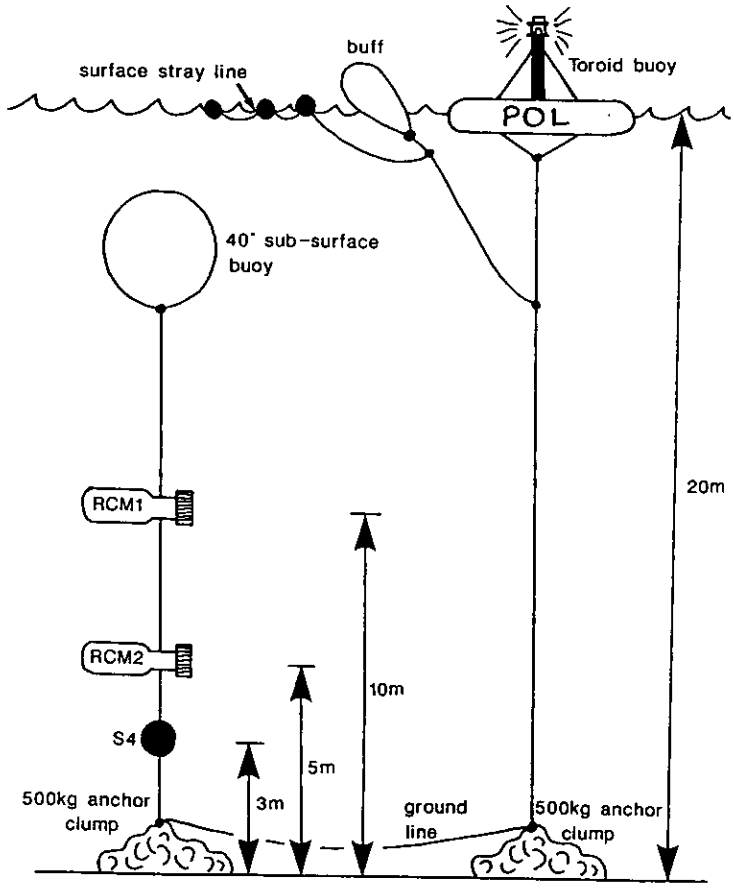
STABLE II FRAME

APPENDIX 5.2.0 Mooring diagrams, Challenger 100.

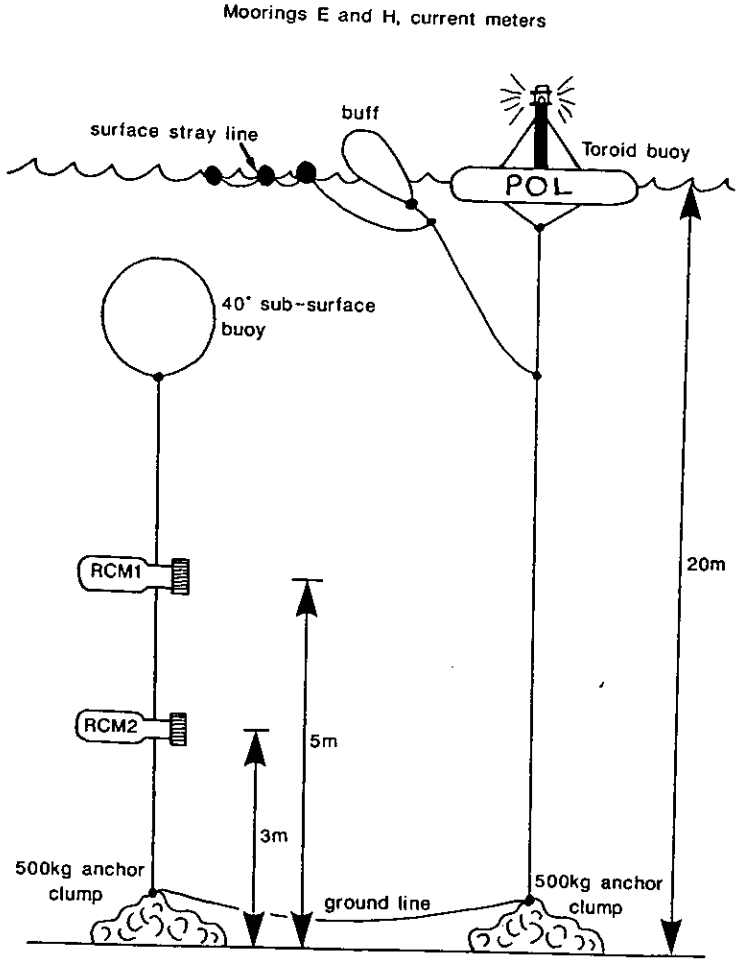


5.2.1 STABLE (Sediment Transport And Boundary Layer Equipment) mooring (schematic).

Moorings B and F, current meters

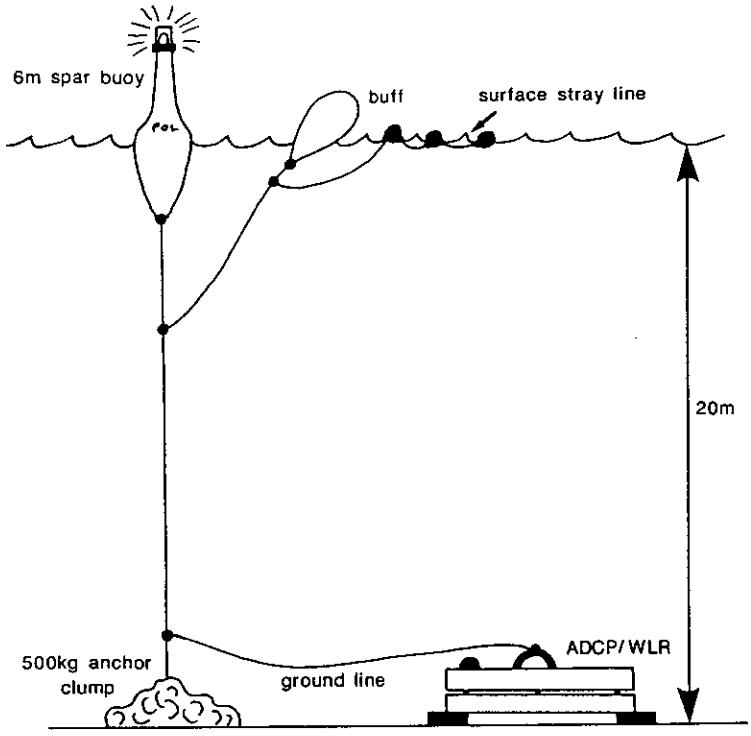


5.2.2 Rotary current meter (RCM) and electromagnetic S4 current meter "U"-shape mooring.

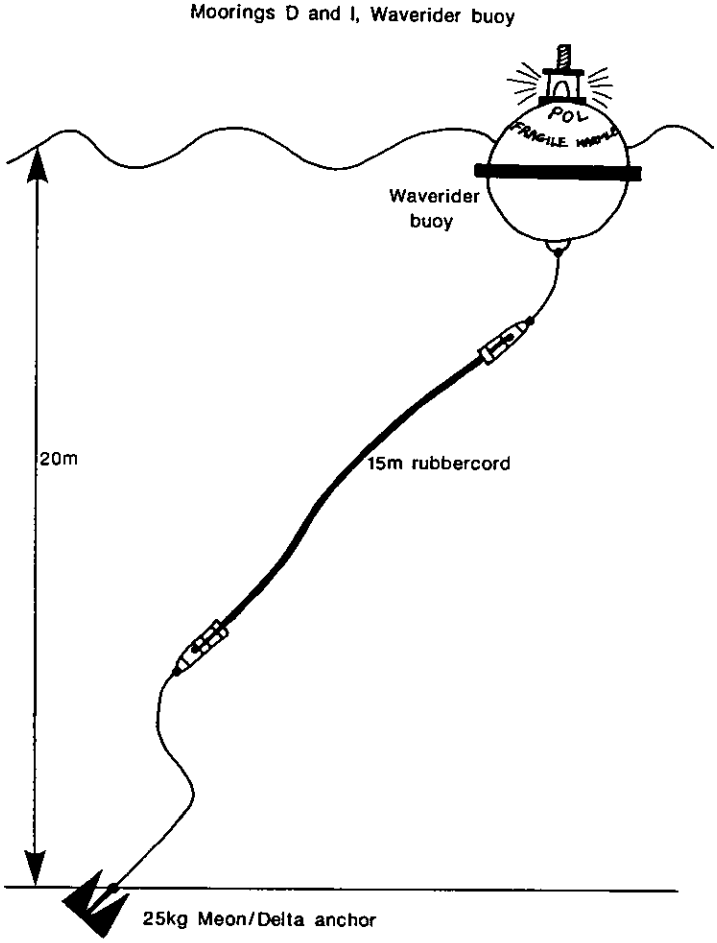


5.2.3 Rotary current meter (RCM) "U"-shape mooring.

Moorings C and G, ADCP/WLR



5.2.4 Acoustic Doppler Current Profiler (ADCP) and marker buoy mooring. (Note: as the ADCP is "pop-up", such moorings are not used in normal circumstances. The hazard presented by local fishing activity, however, necessitated the use of a navigation buoy.)



5.2.5 Mooring for the waverider buoys. Movement of the anchor at locations with sandy substrate noted on previous deployments of this mooring was not detected in the present study.