Proudman Oceanographic Laboratory

The Holderness Coastal Experiment '93-'96

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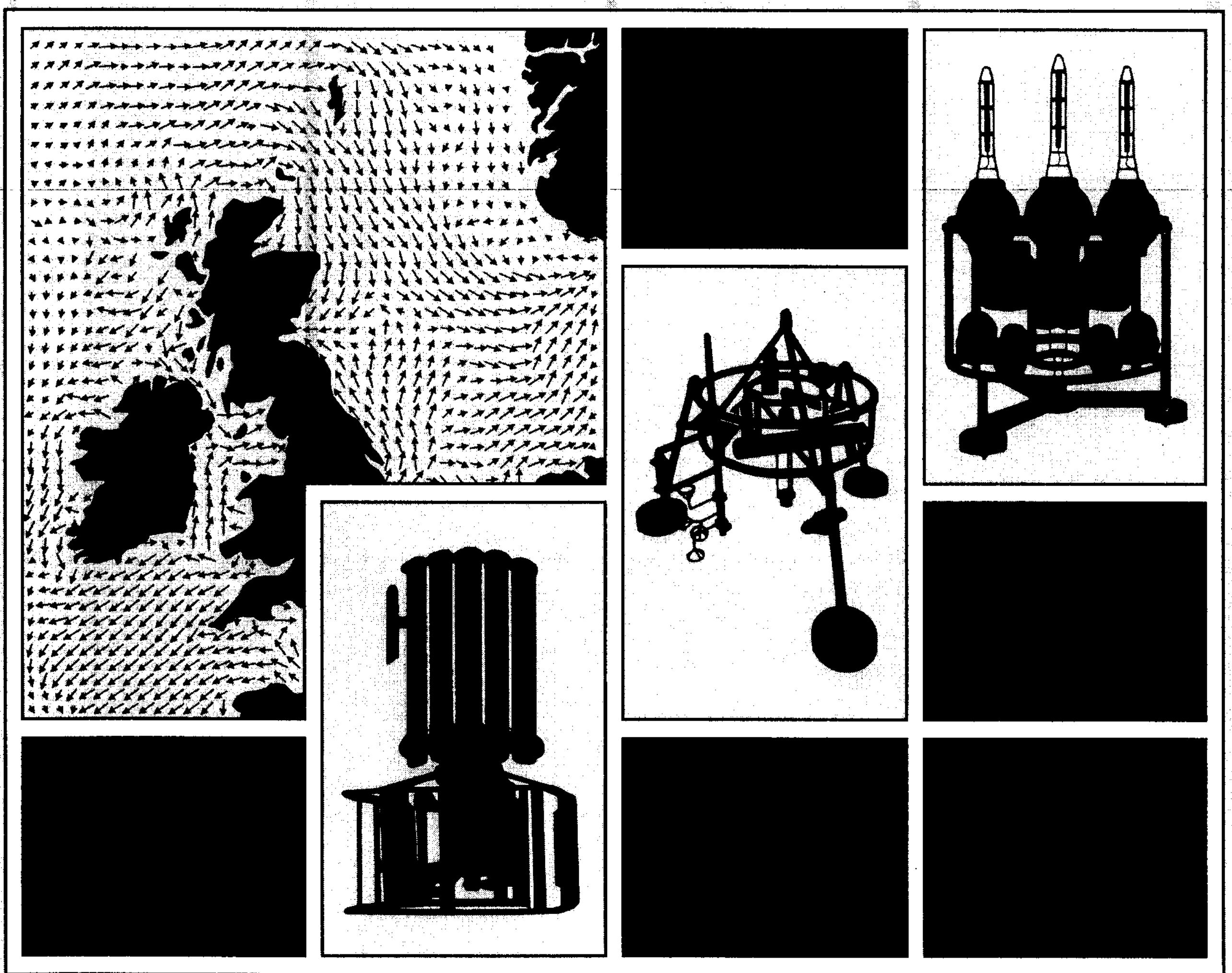

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ABSTRACT

The Holderness Coastal Experiment originated as a component of the UK LOIS programme, it is essentially the observational phase of a research programme aimed at understanding and ultimately predicting coastal erosion. The Holderness coast was chosen because of its rapid rate of erosion (20m glacial till cliffs eroding at an average rate of 1.7m /year) and its reasonable homogeneity over a 20km section. The perceived requirement was for continuous monitoring of representative conditions over a winter period providing data both for developing and verifying numerical models of the region and background descriptions for occasional more intensive localised process studies.

The core period chosen was from October '94 to March '95, pilot studies were made in November-December '93 with a follow-up phase between October '95 to January '96. A guiding principle was that all observed data be made available and readily accessible, initially to fellow researchers within the various collaborative programmes and ultimately to the community at large. (The data set contributes significantly to the CAMELOT, SCAWVEX and PROMISE research programmes described in Section 4). This report is essentially an inventory of the contributions of the POL. The aim is to provide sufficient background for researchers to appreciate the extent and nature of the data available.

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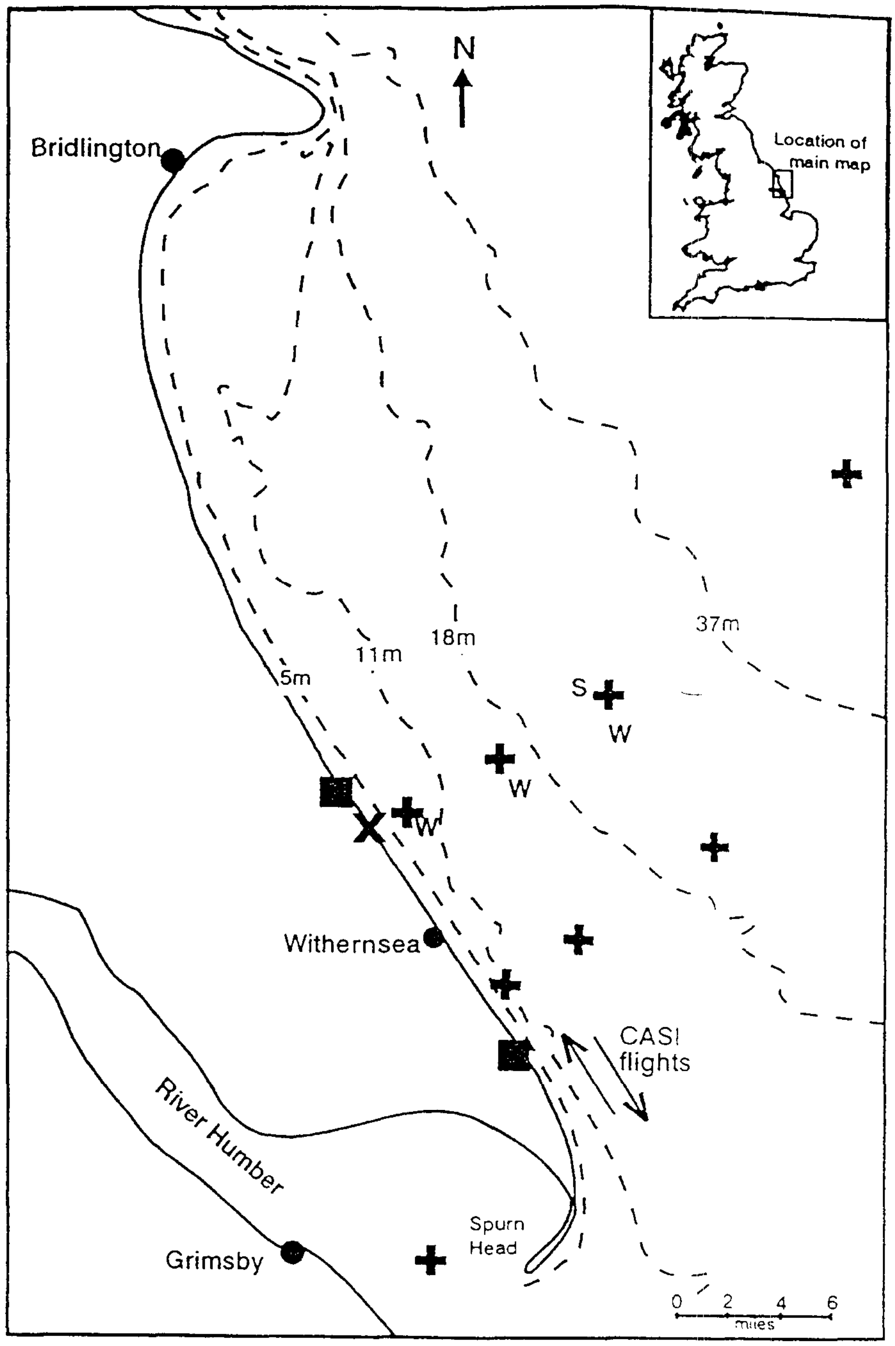
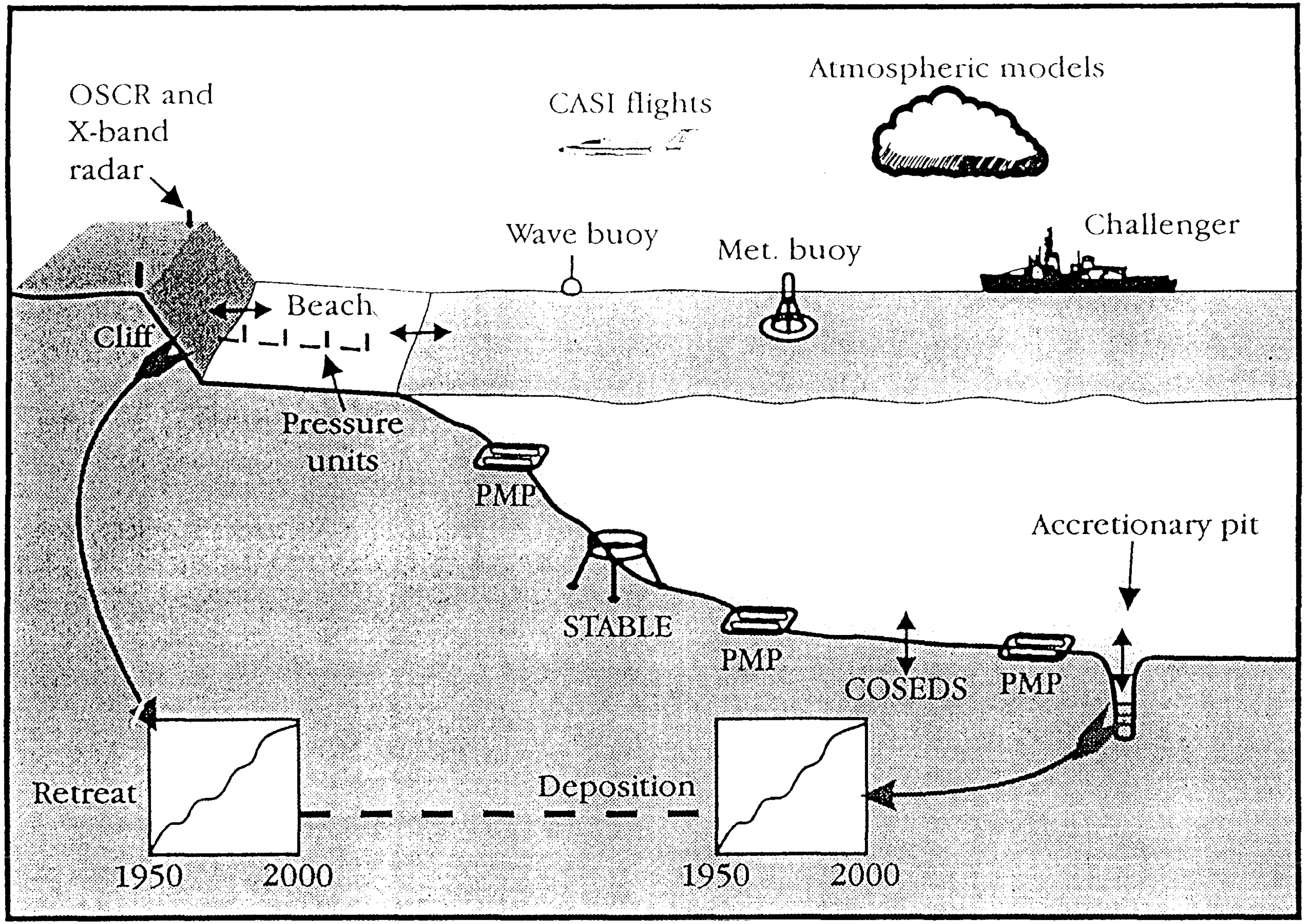


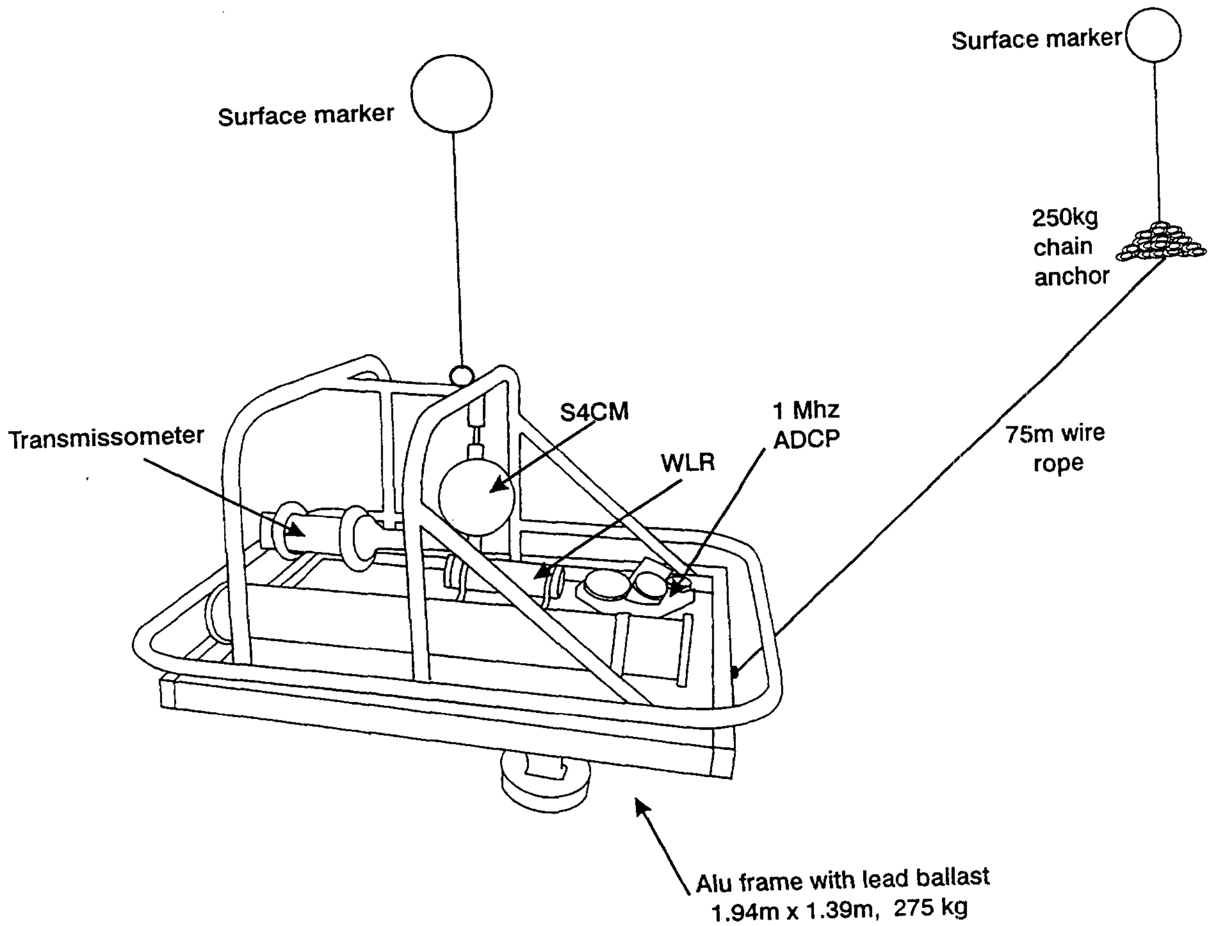
+ = PMP mooring
W = Waverider buoy
S = STABLE
X = X-band radar
■ = OSCR HF Radar site

CASI: Compact Airborne Spectral Imager
COSEDS: Cohesive Sediment Dynamic Study
OSCR: Ocean Surface Current Radar
PMP: POL Monitoring Platform
STABLE: Sediment Transport and Boundary Layer Equipment

1. The Holderness Coast and instrument deployments

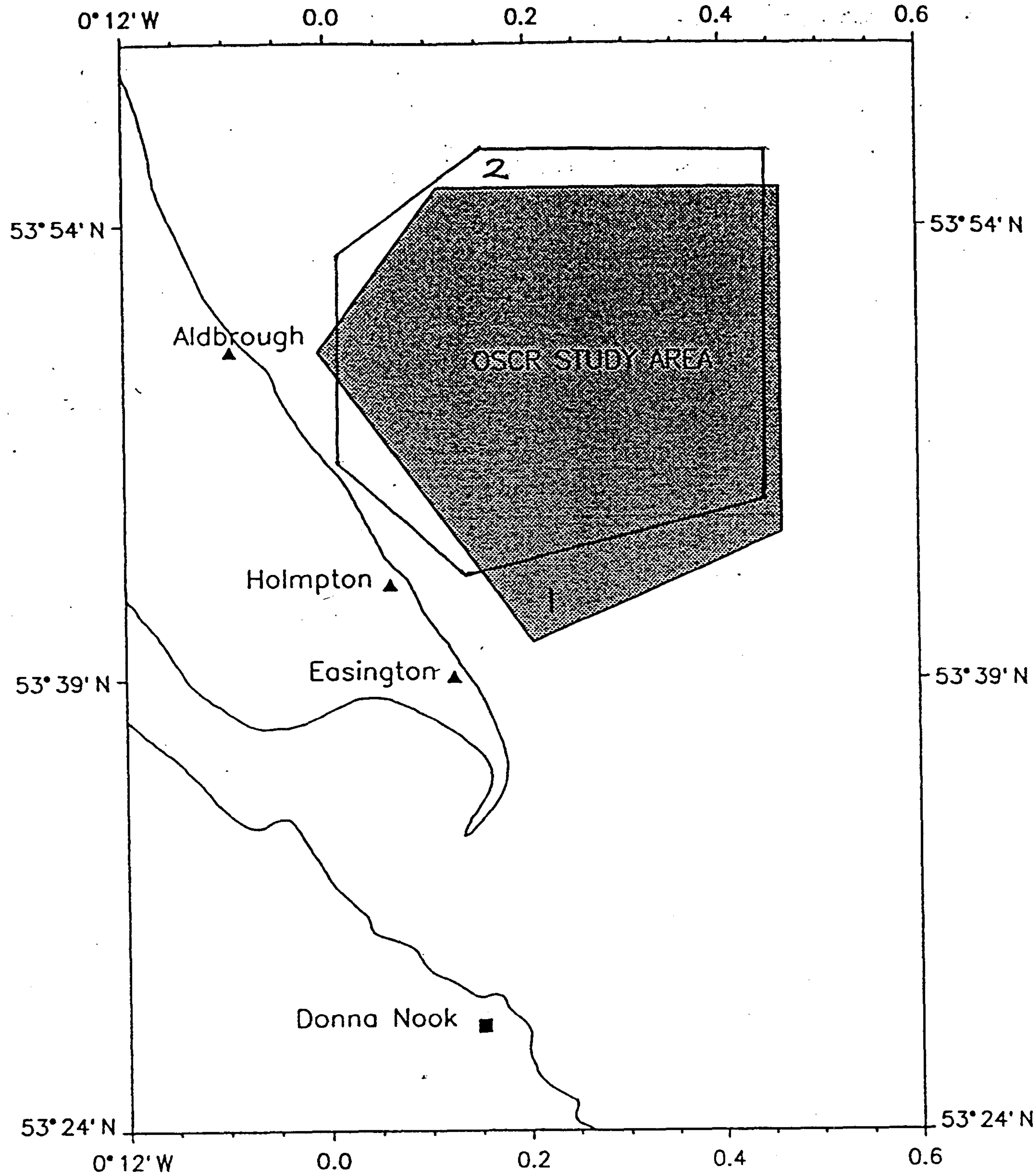


2. Conceptual description of the Holderness Study



PMP Bed-frame and mooring

3. The POL Monitoring Platform



4. OSCR H.F. Radar sites and coverage

1. OBJECTIVES

Within the overall UK LOIS programme objective of determining land-ocean contaminant fluxes, the specific objectives of the Holderness Project were:

- To quantify contemporary fluxes from a rapidly eroding coast to the adjacent sea and relate these fluxes to separate causative mechanisms via model simulations.
- To extend these simulations to predict wider scale, longer-term sediment motions and test against historical records of erosion and accretion.
- To examine the associated impact of future and historical scenarios of climate change.

The observational phase described here included components aimed at: (i) understanding specific processes and thereby providing algorithms for modelling and (ii) wider-scale monitoring to evaluate subsequent model calculations.

Recognising the expense of this observational phase and the diversity of contributions necessary to achieve the above objectives, a policy of free and ready-access to synthesised data sets was adopted. While 'Principal Investigators' must enjoy early opportunities to address their specific goals, subsequent transfer of data to the wider community is itself a goal of the project.

2. INTRODUCTION

Objectives

In the early '90s, the UK's Natural Environment Research Council established a 6-year research project LOIS (Land-Ocean Interaction Study) to parallel international initiatives of the IGBP. The overall objective of LOIS is to quantify rates of material exchange between the land and ocean. The Holderness experiment was formulated to address one component of this exchange involving transports between an eroding coastline and the adjacent sea region. From this perspective, Holderness (Figure 1) was selected as constituting: (i) the largest single UK coastal sediment 'source' with 20m high boulder clay cliffs eroding at an average rate of 1.7m per year, (ii) a 20km section of sensibly uniform long-shore conditions largely unaffected by any adjacent estuarine influences, (iii) primarily inorganic sediments, (iv) a hydrodynamic regime comprising strong tidal currents with occasional large storm surges and broad exposure to wind waves.

Understanding of the mechanisms of sediment transport is the essence of long term prediction of coastal evolution. With the policy of soft coastal defence there is a need to assess coastal development over decades, this requires the synthesis of both detailed observations and longer term monitoring with modelling. New instrument developments are revealing fine details of variability leading to a more fundamental understanding of sediment processes. Small scale high frequency mechanisms need to be better represented in larger scale models, linking nearshore sediment dynamics with offshore movement. This outlook provided the basis of the Holderness study and should lead to significant advances in our understanding of sediment processes and budgets. It is likely that the coastal morphology of Holderness is controlled by a combination of incident wave energy and storm/tidal dynamics and importantly dynamical interactions between these.

The observational phase of the Holderness experiment aimed to monitor this transport of some one million cubic metres of sediment (annually) over the period of October '94 to March '95. Aspects of the observations focused on: (i) continuous single-point observations linked with synoptic spatial surveys to develop/validate models, (ii) shorter intensive deployments both to develop instrumentation and to study specific processes.

Following the validation of predictive models, the intention is to run long-term hindcast simulations and compare the calculated larger scale patterns of erosion and deposition with observational data from: bathymetric surveys, cliff erosion and siltation rates inferred from sediment cores (figure 2). The success of these comparisons will determine our capability to predict future trends as functions of various climate scenarios.

Implementation

As preparation for the main phase of the experiment in '94 - '95, pilot deployments were made in the autumn of '93 to test (and set parameter ranges for) instrumentation, platforms, hired vessels etc. Furthermore, a second phase of this main '94 - '95 experiment was carried out from October '95 to Jan '96 to extend the range of observations and cover gaps remaining from the earlier phase.

In addition to the measurements taken by the POL described here, important parallel deployments were made by groups from MAFF Lowestoft, Universities of Bangor, Hull, Plymouth, Southampton and PML. These other measurements will be reported elsewhere.

3. OBSERVATIONAL PROGRAMME

Figure 1 shows the geographical deployment of instruments for the 'core' monitoring programme carried out by POL for the Holderness experiment. This involved 8 PMPs (POL Monitoring Platforms, figure 3) located on the seabed, each measuring vertical profiles of current and suspended sediment using an ADCP (Acoustic Doppler Current Profiler) together with near-bed monitoring of: (i) turbulence and surface wave currents by an S4 electromagnetic current meter, (ii) suspended sediment concentration by an optical transmissometer (UCNW) and (iii) pressure, Pressure Wave Recorder measuring: tide, surge and surface wave components. The transmissometers also recorded temperature and conductivity. These platforms were designed to house a variety of autonomous instruments within a protective, stable and recoverable housing (a 100% recovery record was achieved in 12 monthly deployments in the Dover Strait in 1990). The suitability of their design for Holderness was tested to the limit within a day of first deployment in November '93 when winds up to 80 knots occurred.

The two lines of 3 PMPs off the Holderness coast (figure 1) measured long-shore and cross-shore gradients out from the wave-dominated near-shore region to the deeper tidal current dominated offshore region. An offshore site to the north-east provides boundary condition data on open-sea conditions. A PMP moored on a sandbank at the mouth of the Humber estuary provides both a link between erosion from Holderness and conditions in the estuary and serves directly as a boundary condition for estuary models. This was the only site where siltation problems occurred, requiring divers to recover the PMP on one occasion.

The POL also co-ordinated the deployment of: (i) the OSCR H.F. Radar system measuring surface currents up to 20kms offshore, (ii) an X-band radar measuring directional wave spectra up to 2kms offshore, (iii) directional wave buoys, (iv) the STABLE instrument system for measuring near-bed hydrodynamics and suspended sediment dynamics and (v) a cross-shore array of bottom-mounted pressure sensors measuring surface waves and 'medium-frequency' waves. Additional wave data were obtained from analysis of the H.F. Radar back-scattered spectra (University of Sheffield). This unique concentration of surface wave measurements from a range of instruments has been made available (on CD ROM) as a discrete data set for development of wave-propagation models worldwide. (Production of fine-scale bathymetric data of the associated region has been specially commissioned to maximise the usefulness of this data set.)

More specialised instrumentation (BLISS) for measuring near-bed dynamical and sedimentary processes were deployed by UCNW and University of Plymouth at 4 near-shore locations alongside one of the PMP sections. Similar equipment (Minipods) were deployed alongside the other PMP section by MAFF (Lowestoft) as part of their involvement in the COSEDS programme. This COSEDS group also deployed the specialist multi-instrument platforms Quadrapod & Tetrapod at the deeper water end of a PMP section. In the deeper water of the other PMP section, POL deployed the STABLE rig to make similar recordings of the near-bed wave-current interactions and sedimentary regime. A programme to monitor the cliff, beach and nearshore bathymetry was carried out by the Institute of Estuarine and Coastal Studies of Hull University.

This array of moorings was supplemented by CTD profiles and water bottle samples taken from RRS Challenger during the October '94 and January '95 cruises. Calibration exercises (Lowry '95) extended over tidal periods close to both spring and neap tides at each PMP site. Challenger also completed wider-area quasi-synoptic surveys at the beginning and end of each cruise to provide 'initial conditions and validation data' for model simulations. The moorings closest to the beach were deployed by a trawler - allowing only cursory calibrations.

Related LOIS research components

While the experiment as outlined concentrates on physical and sedimentological components, the transport models developed will be of direct use in simulating the mixing of both biological and chemical tracers in this area. Moreover these models will need to incorporate contributions from organic material in suspension and the effects of biological agents in bio-turbation/binding of bed sediments.

Related components of the LOIS programme include: (i) chemical analyses of both suspended and bed sediments to provide essential evidence on provenance and pathways, (ii) radio-nuclide analyses of recent bed sediments to construct chronologies of sedimentation rates against which to compare the hindcast model simulations. To link the rates of erosion inferred by the model simulations to contemporary changes in both cliff retreat and beach conditions, new techniques in the interpretation of (aircraft) remote sensing images are being developed alongside conventional surveying techniques.

4. APPLICATIONS AND FUTURE DEVELOPMENTS

Although the Holderness experiment originated as part of the NERC's LOIS project, the concept of a comprehensive data set measuring synoptically sea levels, currents, waves, suspended sediments etc. has since led to these data underpinning a number of related studies. With the experimental component of Holderness essentially completed by January 1996, several links to European-wide research initiatives have been established reflecting the initial concept of LOIS as part of LOICZ. The following projects involve the POL:

CAMELOT: MAFF POL Co-ordinator: P. Thorne
(Contract FD311 of MAFF's Flood Defence Commission with NERC)

Coastal Area Modelling for Engineering in the Long-Term (Soulsby, Southgate, Thorne and Flather, 1994) integrates the near-shore modelling programme of POL with the beach models of HR Wallingford and process studies of UCNW, Bangor. The Institute for Estuarine and Coastal Studies at Hull University also carried out a series of near-shore bathymetric surveys.

SCAWVEX - Surface Current and Wave Variability Experiment MAST II
Co-ordinator: L. Wyatt, U. Sheffield
(MAS2 CT940103)

Measures and examines spatial and temporal variability in waves and currents (including their interaction) in the coastal zone. Includes development/assessment of new technology for wave measurements, especially H.F. Radar.

PROMISE - Pre-operational Modelling in the Seas of Europe. MAST III.
Co-ordinator: D. Prandle, POL
(MAS3 CT950025)

Preparatory stage in the implementation of operational oceanography on a European scale. Develops modelling components, specifications for monitoring arrays and communications networks and inter-relationships with remote sensing.

5. ACKNOWLEDGEMENTS

The observational programme has received formal support from

The NERC LOIS programme

The MAFF Flood and Coastal Defence division's CAMELOT study.

6. DATA INVENTORY

Tables 1 to 3 indicate instrument deployments and associated data returns.

More detailed descriptions follow in Appendices.

	Instrumentation Deployed	November 1993	December 1993	January 1994	February 1994
	HM1 (13m) 53 47.70N 0 00.16E	█	█		
	ADCP				
	WLR	█			
	S4	█	█		
	TRANS	█	█		
	EMP	█			
	HM2 (16m) 53 46.50N 0 02.80E	█	█		
	ADCP				
	WLR	█	█		
	S4	█			
	TRANS	█	█		
	EMP	█			
	ABS		█		
	HM3 (27m) 53 50.60N 0 09.00E	█	█		
	ADCP	█	█		
	WLR	█	█		
	S4 53 50.70N 0 09.20E	█	█		
	TRANS	█	█		
	BFM (10m) 53 33.57N 0 03.34E	█	█		
	WLR	█			
	S4	█	█		
	TRANS	█	█		
	EMP	█			
	HMD (14m) 53 43.98N 0 07.60E		█		
	ADCP		█		
	S4		█		
	TRANS		█		
	EMP				
	HMB (15m) 53 48.05N 0 03.04E		█		
	S4		█		
	TRANS		█		

TABLE 1. Holderness Data Inventory '93 - '94

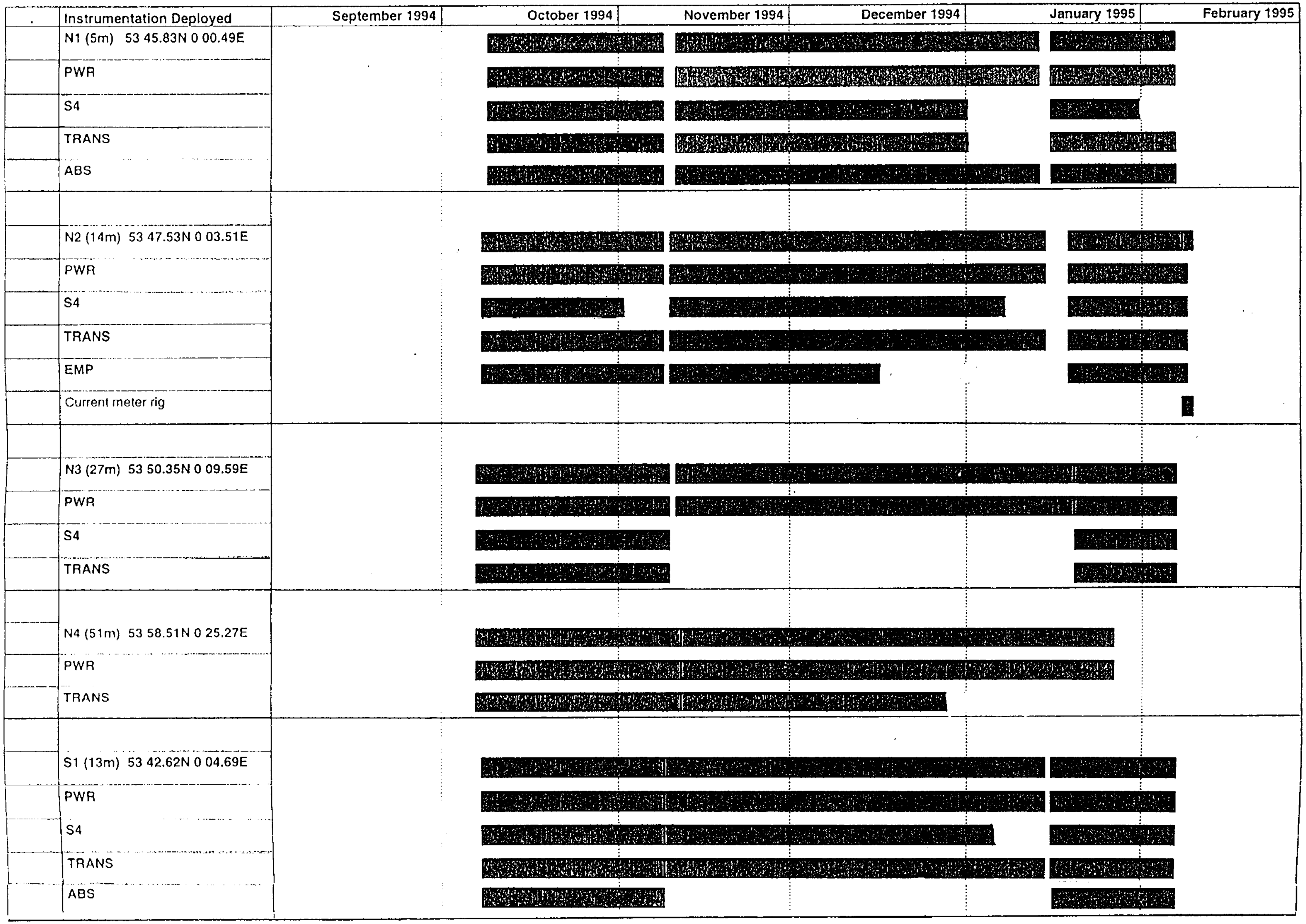


TABLE 2. Holderness Data Inventory '94 - '95

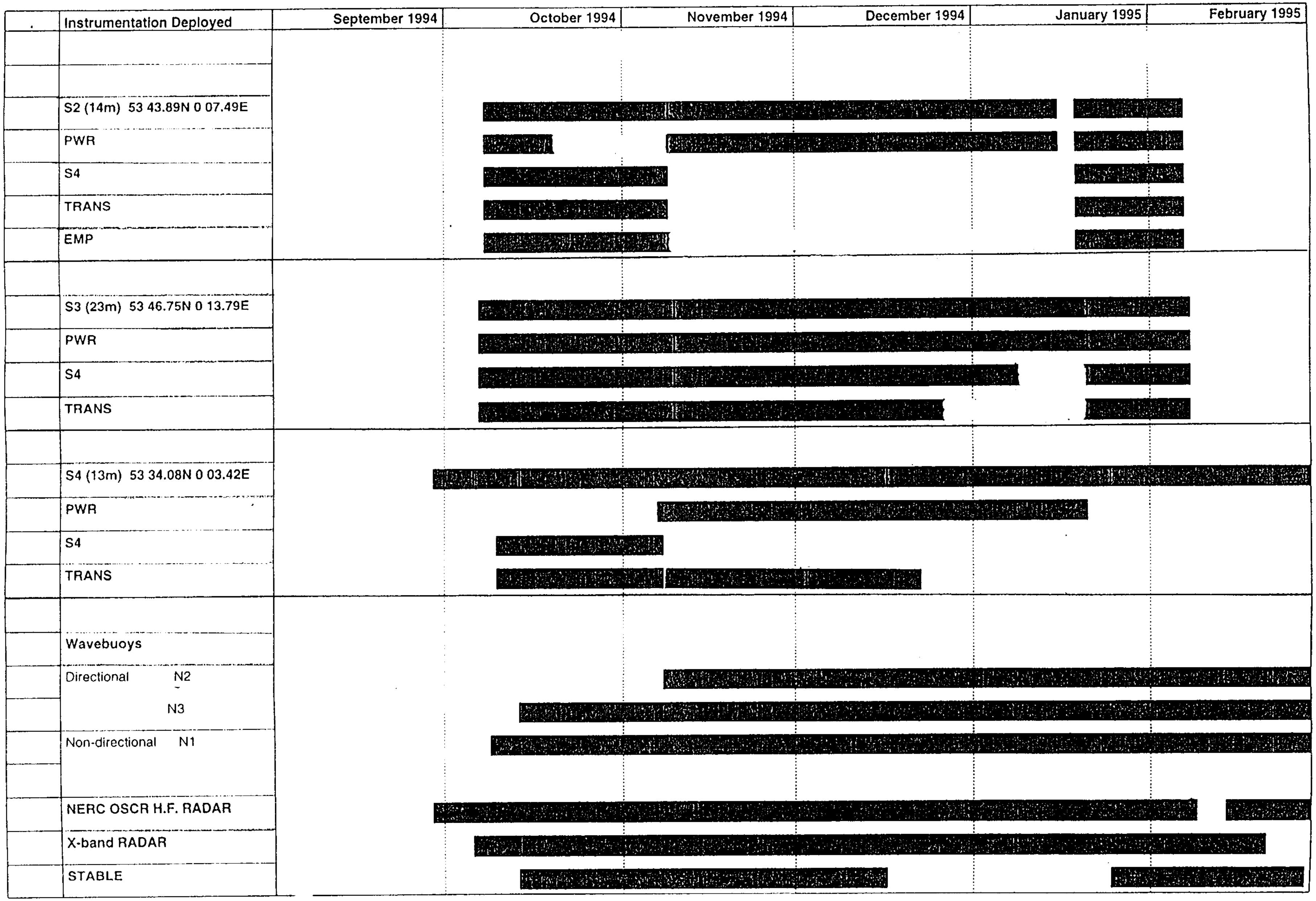


TABLE 2 (cont) Holderness Data Inventory '94 - '95

TABLE 3. Holderness Data Inventory '95 - '96

- 22 -

.	Instrumentation Deployed	September 1995	October 1995	November 1995	December 1995	January 1996	February 1996
	N2A (18m) 53 47.62N 0 03.50E						
	ADCP						
	PWR						
	S4						
	TRANS						
	ABS						
	N2B (19m) 53 47.50N 0 03.50E						
	ADCP						
	S4						
	S1 (15m) 53 42.76N 0 04.59E						
	ADCP						
	PWR						
	S4						
	TRANS						
	EMP						
	S2 (18m) 53 43.90N 0 07.56E						
	ADCP						
	PWR						
	S4						
	TRANS						
	EMP						

TABLE 3 (cont) Holderness Data Inventory '95 - '96

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APPENDIX A

PMP - POL Monitoring Platform (Figure 2)

The PMP was developed as a multi-purpose structure to house an array of instruments close to the seabed with emphasis on stability, security and a proven strategy for recovery.

Development of the POL Monitoring Platform (PMP), and the associated instrumentation modules progressed in preparation for the Holderness experiment. Eight PMPs were prepared, comprising the following instruments:-

- A 1MHz, 2 beam ADCP to measure vertical profiles of currents and suspended sediments from backscattered signals
- An S4 electromagnetic current meter to measure turbulent current flow from surface waves
- An optical transmissometer to measure suspended sediment concentrations, together with temperature and conductivity.
- A pressure and wave recorder to measure waves by burst sampling and tides/surges by continuous integration of the pressure signal.

Other self-contained instruments such as optical and acoustic backscatter probes were accommodated as required. The study required some equipment to be deployed in shallow water at depths of about ten metres, close to the shore (see Figure 1). This made navigation for *RRS Challenger* hazardous in all but ideal conditions and for this reason a small 55 foot fishing vessel based at Bridlington the *MFV Janet M*, was chartered.

Mooring and platform designs were developed to allow shallow water mooring operations from either vessel, as necessary. In total 46 mooring operations took place between November '94 and February '95 at the eight sites. There were no major problems, one mooring was damaged by shipping and only one instrument, an S4, was lost. One mooring in the mouth of the River Humber, had to be recovered by divers when it became embedded in the sandy sea bed due to scouring by the strong tidal currents. All the platforms and associated moorings withstood the winter storms and remained on position collecting data.

APPENDIX A(i) ADCP

Data return Holderness October '93 - January '96

Two types of ADCP were deployed, both built and developed at POL.

Type I had previously been deployed in experiments at Dover and in the River Mersey but was not fully suited to the conditions at Holderness, (shallow depths). Only one instrument of this type was deployed (station numbers 612,613 & 638) during November - December 93 and gave good current and backscatter data.

Type II instruments were more suited to the expected conditions and gave encouraging results during the pilot study in 93 with data from dp000x(608). However unexpected problems with building new instruments were not overcome until Oct 95.

ADCP current data returns. Oct 95 - Jan 96

To quantify the ADCP data return for currents is not straightforward since some near bins are contaminated with modulation, some far bins with tidal depth. Further problems are transmitter batteries running down at the end of some deployments and to complicate matters a frequency offset needs to be calibrated out. Rig movement is known to have occurred during some deployments but as yet no corrections have been applied for tilt. Some records will be affected by this.

To assess the data set, time series for bin 10 have been plotted and data return tabulated below. This bin was chosen to avoid modulation and tidal interference effects. This gives currents 7.5 meters above the sea-bed. The column 'T days' gives the number of days of data at 7.5m. The last column is percentage of 'T days' to total deployment period.

Sites	Data Return			Currents at		7.5m	T-days	%
N1	1 p8	10 p8	10 p5	? p2(1)	17 p5	37 p4	75	78 (4)
N2	1 p2		10 p3(5)	33 p1(2)		14 p7(3)	58	70(4)
S1				35		31	66	89
S2				34		26	60	81
Total Days							259	79(4)

Notes:-

The px refers to poldopx, the data set to be used when more than one instrument was deployed at a site. Bracketed numbers refer to the following notes.

(1) The instrument Poldop2 had a faulty connector and only recorded on one beam, however this beam pointed in the major axis of flow and gave a good indication of current speed.

(2) Poldop8 was also deployed at this site but had a missing blanking plug which caused the instrument to reset after each recorded scan. Hourly values of current will be available after editing.

(3) A further 20 days of data is available from poldop6 at this site but requires tilt correction and may suffer from signal amplitude loss.

(4) Data rate higher if (1) and (3) are usable.

(5) A third beam fitted in the vertical direction.

ADCP Backscatter return

Type I & II backscatter data has to be treated in a different way to get the relative values of signal strength. Type I recorded only beam1 whilst type II records both beams, except poldop3 (713) which only recorded beam 1. This data will need calibration files.

The data needs to be checked for modulation effects on the first few bins, though this is not thought to be a problem on beam 2.

ADCP Standard deviation return

Standard deviation in current speed was recorded for both beams. The data looks to be of good quality and the return is expected to be the same as the Backscatter.

ADCP Processing, 1995-96 (A. Lane)

(1) Software PV-Wave programs have been developed to translate the new POL ADCP's ASCII raw data into engineering units. Graphical output is available in different formats: time series, scatter plots, progressive vector plots.

(2) Hardware problems. High initial transmitter battery power output occasionally affected some instruments. At high power output during the start of a deployment, modulations in the bins closest to the instrument can be serious. This decays as the battery voltage reduces. However, as the power level continues to reduce (when the battery becomes exhausted), the signal returns (especially from the more distant bins) are weak and prone to being swamped by noise. The effects of battery power output are being dealt with on the hardware by isolating sensitive circuitry, and by rationing the number of pings per ensemble.

(3) Data processing problems. Offsets were identified from the data plots (evident in scatter and progressive vector plots). These were attributed to differences in the expected and actual frequencies of the transmitted and return signals. Corrections, once determined, can be applied since the frequency shifts for each beam are recorded together with compass directions for each sample. (The method for obtaining corrections is empirical). Although not a major undertaking here, it is potentially difficult to incorporate post-calibrations (particularly where instruments record data only after pre-processing). The large data volumes make re-processing of data a long and arduous task: each of the present 18 files takes at least half an hour to convert from raw to

calibrated data when there are no associated processing problems. Ideally, instruments should be calibrated and offsets removed before deployment.

(4) Data return. For sites N2 and S2 of the 1995-6 surveys, the data return is 76% of the deployment time. Since not all bins can be used, the average 'usable data' return for currents reduces to 56%. However the backscatter return is close to 76%. For N1 and S1 data return (deployment time) is 78% reducing to 64% usable.

Appendix A(ii)

Pressure Wave Recorders

Holderness Pilot Project November/December 1993

Sea Level Measurements

These were made using Aanderaa Pressure/Temperature Recorders incorporating either 27Bar or 7Bar Absolute Digiquartz pressure sensors manufactured by Paroscientific. The instruments were calibrated prior to deployment and have a calibration uncertainty of 0.01%. The accuracy to which sea level measurements can be made is however 1cm. For all deployments the sampling interval has been set at 10 minutes with an integration period of 40 seconds for the pressure sensors.

Nine deployments were made with instruments WLR500, 915, 1038, 1042, 1357 and produced 8 drift free pressure/elevation records and 6 temperature records. The WLR1357 instrument, deployed at HM3/1, flooded and only produced data for three days whilst the lack of a full temperature data set can be attributed to the fact that WLR500 did not have a temperature sensor fitted. Data from the inshore stations showed some spikes in the record during a period of surge activity around Julian days 318-319 suggesting small platform movements of the order of a few cms confirmed by the tilt sensors on the ADCPs. Such movements probably reflect the mobility of the sea-bed during high wave activity causing settlement of the platform.

HOLDERNESS EXPERIMENT October 94/March 95

Eight prototype PWRs (Wave/Tide pressure recorders) were constructed at POL and incorporated either 27BAR or 7BAR Absolute Digiquartz pressure transducers and thermistor temperature sensors. With the 7BAR instruments used at the offshore sites the resolution for waves was 0.07mb and with the 27Bar deployed at the nearshore site the resolution for waves was 0.34mbs. As with the WLRs, the tidal elevations can be considered accurate to 1cm. Silicone oil filled tubes approximately 50cm in length, were fitted to the pressure ports and attached proud of the PMP frame in order to reduce the Benoulli effect associated with flow around the instrument case.

The PWR instrument utilised a GCAT processor along with removable 2Mb solid state flash memory cards. Wave burst data was sampled at 2Hz for 20 minutes every three hours whilst tidal pressure data was obtained by 10 minute integration with almost continuous sampling. During the period when wave measurements were made the tidal data needs to be reconstructed from averaged wave data. The large amounts of wave data is logged in binary form whereas the tidal data is recorded in ASCII format.

PWR-01(27Bar) was used for three deployments: N2/1, N2/2 and N2/3

PWR-02(27Bar) was used for three deployments: N1/1, N1/2 and N1/3

PWR-03(27Bar) was used for three deployments: S1/1, S1/2 and S1/3

PWR-04(27Bar) was used for three deployments: S2/1, S2/2 and S2/3

PWR-05(27Bar) was used for two deployments: S4/1 and S4/2 but did not produce any usable data from the first deployment

PWR-06(7Bar) was used for three deployments: N3/1, N3/2 and S3/3

PWR-07(7Bar) was used for two deployments: N4/1 and N4/2

PWR-08(7Bar) was used for three deployments: S3/1, S3/2 and N3/3

Comments

(1) A full calibration of the PWRs was not undertaken until October 95 so reliance had to be made on the single (10C) pre-deployment calibration. This was acceptable as the temperature effects on these transducers is negligible i.e. <1mb/°C.

(2) Timing problems were encountered with data from N1 and N2. This was finally tracked down to a "rogue" line left in the start up Autoexec.bat file which caused the instrument to

override the menu setup start time.

(3) During the deployment N1/1 and all of the N2 deployments very low wave heights were obtained. After checking the calibration data no explanation for this was found although sediment was found in the oil filled tubes notably S1/2, N1/2 and N2/2 which may have degraded the high frequency response of the instruments. No reduction in tidal amplitude was observed. It should be noted that PWR-01 which was deployed on the N2 stations was subsequently deployed on the SCAWVEX experiment January 96 and recorded lower wave amplitudes than expected. One is lead to the conclusion that the poor frequency response in this instrument could be caused either by an air bubble trapped in the internal oil filled pipe to the transducer or attributed to the mechanism within the transducer itself.

(4) Occasional step changes in the mean level of the wave burst data were observed. These can be attributed to the wave counter (8 bit resolution) overflowing at times of high signal range. This is most often encountered under high wave conditions but also appears when longer period oscillations are present (of the order of 2-3 minute).

Appendix A(iii)

Transmissometers

Holderness Pilot Project November/December 1993

The UCNW self recording transmissometer logs the average of 200 instantaneous values sampled at 400Hz and spaced 1 minute apart. The optical path length chosen for these deployments were 10cm for the inshore site, 25cm offshore and 5cm for the estuarine environment.

Calibrations were undertaken in situ by noting blanked path readings (V0) and then strapping the instrument onto the CTD frame which uses a 25cm pathlength Sea Tech transmissometer. The CTD attenuance value is then used to calculate the full scale reading (V_{100}) using

$$V_{100} = ((V_T - V_0)/\exp(-1.0*\text{path}*\text{atten})) + V_0$$

where path = UCNW transmissometer path length in metres

atten = CTD attenuance (per metre)

V_T = selfrecording transmissometer reading during calibration

Attenuance data during deployment is then derived from the V_0 and V_T values from

$$\text{Attenuance} = -1.0/\text{path}*\ln((V_T - V_0)/(V_{100} - V_0))$$

In theory V_0 and V_{100} are determined pre and post deployment so that a correction term for instrument drift and optical fouling can be derived.

During the pilot study cruises CH108A,B,C the conversion of beam attenuance to sediment concentration was done by the gravimetric determination of samples taken during CTD calibration casts.

During the pilot study 4 transmissometers were deployed and produced 10 records, calibrations were attempted for nine of these. The main problems encountered were poor stability in the blanked path readings from all of the instruments and insufficient CTD calibration dips.

The poor performance of the temperature and conductivity sensors meant that only a limited amount of data is available from deployments.

HOLDERNESS October 94 - March 95

Three UCNW TRB1 transmissometers were deployed. On this occasion with the temperature and conductivity sensors disabled, because longer deployments were needed and also because they did not function well during the pilot phase.

TRB-001 was deployed twice at N4/1 and N4/2 but there is some doubt as to whether it was fitted with 10cm or 25cm pathlength optics. TRB1-002 was deployed twice at S4 (Bull Fort mooring in the Humber). The second deployment could not be recovered by conventional means as the platform stuck in the soft mud and had to be retrieved by divers. TRB1-003 was used for three deployments S3/1, S3/2 and S3/3.

There were 7 transmissometer records obtained from the UCNW instruments and although the blanked path readings were more stable than during the 93 deployments, significant drift was still present. Again there were insufficient calibration points - only 7 out of a theoretical 14. The lack of calibration data could be attributed to (a) 1 CTD calibration lost due to water being too turbid (b) loss of 3 calibrations due to instrument running out of memory and (c) a possible 3 calibrations not done for operational reasons i.e. having to use the Janet M for deployment/recoveries and Challenger being drydocked during CH117.

Five WS Ocean TRB2 transmissometers S/N1683, 1686, 1760, 1761, 1762, based on the UCNW designed TRB1 transmissometer but utilising a GCAT PC with data storage on 2Mb SRAM PCMIA cards, were purchased for the experiment. These were the first instruments of this type to be commercially available and as a result a few teething problems were experienced.

The calibration procedure adopted by WSO differs from the UCNW empirical approach.

The equation given by WSO for transmittance T is

$$T = (C_W - C_B)/(C_A - C_B)$$

where C_W = logged Counts in water

C_A = Counts in air

C_B = Counts with the light patch blocked

Beam attenuance is computed from attenuance using the equation

$$Atten = -1.0/\text{path length}*\ln(T)$$

Sediment concentration is derived in the same way as for the UCNW instruments. With the absolute approach for the TRB2s reliance is made on the counts in air with clean optics whilst with the empirical approach reliance is made on good calibration dips.

Five TRB2 transmissometer instruments were deployed with temperature and conductivity sensors fitted. A common timing fault was encountered with all of the instruments. Although the correct time was entered in the set up menu the logged time was invariably one month out.

TRB2-1683 was used for three deployments: S1/1, S1/2, S1/3

TRB2-1686 was used for three deployments: N1/1, N1/2, N1/3

TRB2-1760 was used for three deployments: S2/1, S2/2 and S3/3 but failed to produce data during the second deployment

TRB2-1761 was used for three deployments: N2/1, N2/2 and N2/3

TRB2-1762 was used for three deployments: N3/1, N3/2 and N3/3 but failed to produce data during the second deployment.

In general the quality of the calibration data left a lot to be desired. Although the blanked readings for all of the instruments were extremely stable, problems arose during CTD calibration dips. On several occasions the instruments' output saturated to the 4095 value during critical calibrations and on other occasions the water was too turbid for the CTD transmissometer. In addition one must take into account the operational problems encountered with the UCNW instruments mentioned earlier. The WSO instruments appear to be stable and it looks as if attenuance, for this exercise, can best be determined from the air and blanked readings (i.e. without calibration dips).

Appendix A(iv)

S4 Currents, depth and Obs measurements

The S4 were all set to record in burst mode of either 1,2,5 or 20 minutes every one or two hours depending on memory size. Only 2005 & 2006 recorded 20 minute bursts, they also recorded depth (waves) and OBS at 1 second intervals.

Zero offset calibrations have been carried out on the instruments but interactions with the PMP frame will seriously effect residual current calculations.

Records missing or suspect:-

November - December 1993

S4 1832 (611) no data returned.

October - March 1995

S4 1112 (654) flooded.

S4 1113 (649) lost.

S4 1664 (652) failed to record.

October - January 1996

S4 2005 (724) Wave data from the last N2 deployment looks suspect, only the last part of each 20 minute burst may be of use.

S4 2005 (724)

S4 2006 (726)

The short records at N1/N2 is due to an unexpected deterioration of the instruments with time.

S4 1265 (725) Failed soon after deployment.

S4 1832 (729) Faults on eastings for 1st nine days.

APPENDIX A(v) ABS

Holderness: ABS Winter 95/96

Acoustic Backscatter Systems were deployed as follows:

System B: Deployed on PMP at Site N1.

Boards 3FR2, logging program 3FRSampl

Transducers: Transonic Deep Sea

Start Date/Time: 1/11/95 0600 GMT

Last data Date/Time: 26/11/95 0900 GMT

Data return 98.67%. Loss due to files not recording on hard disc drive.

System A: Deployed on PMP at Site N2

Boards 3FR3, logging program 3FRSampl

Transducers: Transonic Plastic Ser No 001

Start Date/Time: 1/11/95 0600 GMT

Last data Date/Time: 10/12/95 1000 GMT

Data return 100%

System C: Deployed on PMP at Site N1

Boards 3FR4, logging program 3FRSampl

Transducers: Transonic Deep Sea

Start Date/Time: 10/12/95 1300 GMT

Last data Date/Time: 16/1/96 1100 GMT

Data return: 4MHz transducer inoperative due to cable fault caused by excessive bending. All other data gave 94% return. Loss due to files not recording on hard disc drive.

APPENDIX A(vi)

Summary of EMP 2000 deployments

PMP Site	S/No	Deployed	Recovered	Comments
1993/1994				
N1 (HM1)	1055	12-11-93	23-11-93	Good Data
N2 (HM2)	1059	12-11-93	23-11-93	Good Data
S4 (BFM)	1056	13-11-93	22-11-93	OBS off range (sat)
N1 (HM1)	1055	26-11-93	17-12-93	No data recorded
S4 (BFM)	1059	27-11-93	08-12-93	logging file not specified
S2(D) (HMD)	1056	13-12-93	17-12-93	Good Data
1994/1995				
N2	1065	08-10-94	08-11-94	Faulty Temp Chl
S2	1066	08-10-94	08-11-94	Good Data
N2	1065	09-11-94	15-01-95	Faulty Temp Chl
S2	1066	09-11-94	15-01-95	Good Data
S2	1065	19-01-95	07-02-95	Faulty Temp Chl
N2	1066	19-01-95	09-02-95	Good Data
1995/1996				
S1	1057	09-12-95	17-01-96	Battery voltage Chl incorrect values logged
S2	1059	09-12-95	17-01-96	Faulty end cap connector

APPENDIX B

Wavebouy measurements at Holderness

Winter of 94/5

Two Directional Wavebuoys were hired from Wimpey Environmental and deployed at Sites N2 and N3 from October 1994 to February 1995. The buoy radio transmissions were received at Tunstall. On examination of the received data, it was found that one of the buoys had been supplied with a defective accelerometer. The buoy was replaced as soon as possible.

Data is available as follows:

Site N3: 14th October 1994 to 28th February 1995.

Site N2: 8th November 1994 to 28th February 1995.

Data from these buoys are recorded as Directional Wave Spectra, computed from records of 1600 seconds length, at 30 minute intervals. It follows that there are 48 records per day. Data recovery rates exceeds 99% at both sites.

A Waverider buoy owned by POL was deployed at Site N1 from October 1994 to February 1995. The buoy radio transmissions were received at Tunstall.

Data is available as follows:

Site N1: 9th October 1994 to 28th February 1995.

Data from this buoy was computed to give Wave Spectra from records of 1024 seconds length, at 90 minute intervals, giving 16 records per day. Data recovery rate exceeds 99%.

The data from these buoys has all been checked, translated into ASCII files, recorded on Optical Disc and passed to David Neave at BODC. Floppy Disc Versions have been written and passed to Lucy Wyatt, M J Tucker and Judith Wolf.

Winter of 95/6

Two Directional Wavebuoys were hired from HR Wallingford and deployed at Offshore and Nearshore sites from October 1995 to January 1996. The buoy radio transmissions were received at Tunstall.

Data is available as follows:

Offshore Site: 31st October 1995 to 17th January 1996

Nearshore Site: 31st October 1995 to 17th January 1996

Data from these buoys are recorded as Directional Wave Spectra, computed from records of 1600 seconds length, at 30 minute intervals, giving 48 records per day. Data recovery rate from the nearshore buoy exceeds 99%, while that of the offshore buoy exceeds 97%. Problems were caused by radio interference on the channels used by these buoys, which were different to those used previously.

The data from these buoys has not yet been fully checked for transmission errors.

APPENDIX C

Holderness - H.F. Radar Deployments

Deployment 1: 29th September 1994 - 8th February 1995 and 14th February - 16th March 1995

This used the NERC H.F. Radar (OSCR) operated by Southampton University. Major data loss occurred for several reasons:-

(1) Software problem occurred 29/09 - 07/12/94 (master site) and 29/09 - 14/12/94 (slave site) resulting in loss of all data for cells 1-129 inclusive, cells 130- not affected.

(2) Consistently poor raw data quality at Easington (master site) eventually led to resiting of master to Holmpton 08/02/95.

(3) Poor performance of power amplifier and transmit antennae at Aldbrough slave site led to loss of return signal, resulting in a significant fall off of good data with range.

(4) Intermittent hardware failures at both sites.

Data were provided in 5 thirty day data sets, and apart from cells 1-129 for the first half of the deployment, all cells provided enough data for analysis, and comparison with wind data. The master radar site was moved 08/02/95 to try and improve data capture, resulting in a different configuration for the data 14/02 - 16/03/95. See POL Internal Document No. 92, for more details.

Of the 161 days the radar was deployed, 100 days of data were recorded intermittently, although for about 40 of these, cells 1-129 were missing.

Deployment 2: 3rd November 1995 - 15th January 1996

This used the Wimpey Environmental H.F. Radar (OSCR) system, operated by them but with day to day 'troubleshooting' carried out by a member of Sheffield University staff. Major data loss occurred for two reasons:-

(1) The hardware was newly refurbished, a consequence of which was that the component parts were not all operating to the same frequency, and this took some time to identify and resolve.

(2) Hardware faults in some of the boards occurred, with no adequate replacement available in the correct frequency. This resulted in the system then having to be reconfigured to another frequency.

All cells provided enough data for analysis. When the system was up and working correctly, the data quality was very good. See POL Internal Document No. 93, for more details.

Of the 73 days the radar was deployed, the frequency problem (see (1) above) was resolved for the latter 29 days, of which 27 days recorded good data.

APPENDIX D

Holderness : X Band Radar Data

The X Band Radar was used at Holderness during the Winter of 94/95 in conjunction with a pressure transducer in the beach at the Spring Tide low water mark to obtain experimental data to confirm if such a system could produce reliable measurements of Directional Wave Energy Spectra. The Radar would also have the capability of providing experimental data on Wave Velocities near the beach.

It was not intended that the system would be used to provide routine wave data, and indeed data from the combined pressure transducer/ X Band Radar is only available at High Water.

The data has been analysed and will be described in a report to MAFF. Data recovery rates are of the order of 40% for October, November and December 1994.

The pressure transducers were removed from the beach in February 1995.

The Radar was re-installed for the winter of 95/96 to develop the operational system and provide longer time series data of wave advance towards the beach.

Directional Wave Spectral data are available from the Radar whenever it was operational, but there will be no corresponding Wave Spectral Energy estimates when the pressure transducer data are not available. Data from the Radar alone does not give confidence in its ability to measure wave energy with the present hardware\software configuration.

APPENDIX E

STABLE - Sediment Transport and Boundary layer Equipment:

Holderness Deployments

Introduction

STABLE was deployed on two occasions at approximately 53° 49.5'N, 00° 6.8'E off the Holderness coast during October - December 1994 and January - February, 1995. Data obtained during both deployments has now been analysed, (Williams et al, 1996a, 1996b).

During these deployments, the STABLE rig measured turbulence, surface waves and the concentration of suspended particulate matter (optical backscatter) in *burst* data acquisition mode at 8 Hz at heights (z) above the sea bed for 20 minutes every hour of rig deployment using electromagnetic current meters (ECM) (at z = 30.5cm and 60.3cm, deployment 1; and z = 44cm, deployment 2), a sensitive pressure sensor at z = 172.5cm and optical backscatter (OBS) instruments at z = 30.5cm and 60.3cm, respectively. In addition, the vertical concentration profile of suspended particulate matter (SPM) has been measured at 4 Hz in *burst* mode using a triple frequency (700 kHz, 2.0 MHz and 4.0 MHz) acoustic backscatter system (ABS) at z = 126.5cm. These data were logged independently and were synchronised precisely with *burst* ECM and pressure sensor data.

Measurements of average current flow speed at four heights above the sea bed (z = 39.0cm, 57.0 cm, 75.0 cm and 93.0 cm), average current direction (z = 107.5 cm), water depth (z = 174.5 cm) and rig orientation were recorded in *mean* mode at intervals of one minute. In addition, STABLE acted as a platform to support sediment traps at z = 184.5 cm and 95.0 cm. A detailed description of the STABLE rig and data acquisition and storage and of the ABS system is given by *Thorne et al., (1993)* and *Humphery & Moores (1994)*.

STABLE was deployed from the MAFF research trawlers *Corystes* and *Cirolana*, midway between the N2 and N3 sites in about 25m of water mid-tide. The seabed in the area was of stones, gravel and coarse sand; it was not possible to characterise the bed under the rig exactly.

Deployment 1, 14th October, 1994 to 15th December, 1994

Depth 23m, 53° 49.45'N 0° 6.96'N

Measurements of average current speed, current direction and water depth (tides) were obtained for the period 15th October, 1994 to 15th December, 1994. Whilst time series plots indicate all sensors operated correctly during this period, a full evaluation of this data awaits completion.

Detailed analysis of the STABLE burst data set has been undertaken. Corrosion caused failure of the electromagnetic current meters (ECM's) approximately 2 weeks after deployment. As a consequence, the resulting data set derived from the burst measurements of flow turbulence, pressure and suspended sediment concentration only spans the period 02h 00 GMT on 15th October, 1994 to 12h 00 on 27th October 1994. During this time however, all STABLE instrumentation functioned well and a high quality data set was obtained. These data are described in detail by *(Williams et al., 1996a).*

Deployment 2, 25th January, 1995 to 27th February, 1995

Depth 27m, 53° 49.59'N 0° 6.72'E

STABLE was equipped with only one ECM pair at z = 44cm during this deployment. The value of this data set is therefore reduced slightly. All instruments functioned well during an interesting and contrasting range of hydrodynamic conditions. All data are described in detail by Williams et al (1996b).

APPENDIX F

LOIS RACS DEPLOYMENT SUMMARY

1993

Station	Position	Dep	Deployed	Recovered	ADCP	WLR/PWR	S4	TRANS	EMP2000	Notes
HM1/609	53 47.70N 0 00.16E	13m	12/11/93 14:35 CH108A	23/11/93 13:47 CH108A	[dp0001]	wr0500	s41644	tr0001	em1055	
608			26/11/93 14:11 CH108B	17/12/93 08:25 CH108C	[dp000x]	~~wr0500~~	s41644	tr0001	~~em1055~~	
HM2/610	53 46.50N 0 02.80E	16m	12/11/93 11:30 CH108A	23/11/93 09:45 CH108A	~~dp000x~~	wr1042	s41832	tr0002	em1059	
611			26/11/93 10:48 CH108B	12/12/93 10:45 CH108C	[dp0001]	wr1042	~~s41832~~	tr0002	-	
HM3/612	53 50.60N 0 09.00E	27m	12/11/93 09:40 CH108A	22/11/93 16:00 CH108A	dp0010	wr1357	-	-	-	
613			26/11/93 09:07 CH108B	08/12/93 15:00 CH108B	dp0010	wr1038	-	-	-	
614	53 50.70N 0 09.20E	27m	12/11/93 09:30 CH108A	22/11/93 14:48 CH108A	-	-	s41119	tr0004	-	
615			26/11/93 09:23 CH108B	08/12/93 15:23 CH108B	-	-	s41119	tr0004	-	
BFM/617	53 33.57N 0 03.34E	10m	13/11/93 15:33 CH108A	22/11/93 11:45 CH108A	~~dp0002~~	wr1038	s41112	tr0003	em1056	
618			27/11/93 15:09 CH108B	08/12/93 11:44 CH108B	-	-	s41112	tr0003	~~em1059~~	
HMB/637	53 48.05N 0 03.04E	15m	12/12/93 10:00 CH108C	17/12/93 13:45 CH108C	-	~~wr0915~~	s41119	tr0004	-	
HMD/638	53 43.98N 0 07.60E	14m	13/12/93 08:45 CH108C	17/12/93 10:45 CH108C	dp0010	~~wr1038~~	s41112	tr0003	~~em1056~~	

1994-95

Station	Position	Dep	Deployed	Recovered	ADCP	WLR/PWR	S4	TRANS	EMP2000	Notes
N1/639	53 45.83N 0 00.49E	12m	09/10/94 08:57 FV JnM	08/11/94 15:20 FV JnM	~~dp0004~~	pr0002	s42006	tr1686	-	
647			10/11/94 11:05 CH115C	14/01/95 10:19 FV JnM	~~dp0010~~	pr0002	s42006	tr1686	-	
655			16/01/95 13:48 FV JnM	07/02/95 10:00 FV JnM	~~dp0004~~	pr0002	s42006	tr1686	-	
N2/640	53 47.53N 0 03.51E	18m	08/10/94 13:25 CH115A	08/11/94 14:20 FV JnM	[dp0001]	pr0001	s41644	tr1761	em1065	
648			09/11/94 17:18 CH115C	15/01/95 09:45 FV JnM	~~dp0001~~	pr0001	s41832	tr1761	em1065	
656			19/01/95 09:34 CH117A	09/02/95 08:30 CH117B	~~dp0010~~	pr0001	s41832	tr1761	em1066	
656A			08/02/95 08:31 CH117B	09/02/95 09:27 CH117B	-	s42006, s41119, s41196, s41265, s42005			-	Crrnt mtr rig
N3/641	53 50.35N 0 09.59E	29m	07/10/94 08:08 CH115A	09/11/94 16:24 CH115C	~~dp0003~~	pr0006	s41113	tr1762	-	
649			11/11/94 12:58 CH115C	20/01/95 10:15 CH117A	~~dp0003~~	pr0006	~~s41113~~	~~tr1762~~	-	
657			20/01/95 16:35 CH117A	07/02/95 14:10 CH117B	[dp0002]	pr0008	s41265	tr1762	-	
N4/642	53 58.51N 0 25.27E	54m	07/10/94 19:08 CH115A	11/11/94 07:06 CH115C	~~dp0006~~	pr0007	-	tr0001	-	
650			12/11/94 13:50 CH115C	27/01/95 09:00	~~dp0006~~	pr0007	-	tr0001	-	
S1/643	53 42.62N 0 04.69E	14m	08/10/94 08:23 CH115A	08/11/94 11:00 FV JnM	[dp0008]	pr0003	s42005	tr1683	-	
651			09/11/94 09:53 CH115C	14/01/95 09:40 FV JnM	~~dp0008~~	pr0003	s42005	tr1683	-	
658			16/01/95 12:30 FV JnM	07/02/95 09:30 FV JnM	[dp0009]	pr0003	s42005	tr1683	-	
S2/644	53 43.89N 0 07.49E	18m	08/10/94 07:40 CH115A	08/11/94 10:00 FV JnM	[dp0002]	pr0004	s41832	tr1760	em1066	
652			09/11/94 09:14 CH115C	15/01/95 10:40 FV JnM	~~dp0002~~	pr0004	~~s41644~~	~~tr1760~~	~~em1066~~	
659			19/01/95 08:36 CH117A	07/02/95 10:04 CH117B	~~dp0001~~	pr0004	s41119	tr1760	em1065	
S3/645	53 46.75N 0 13.79E	25m	07/10/94 12:25 CH115A	09/11/94 11:08 CH115C	[dp0007]	pr0008	s41265	tr0003	-	
653			10/11/94 17:40 CH115C	20/01/95 08:50 CH117A	~~dp0007~~	pr0008	s41265	tr0003	-	
660			21/01/95 09:20 CH117A	07/02/95 11:45 CH117B	[dp0007]	pr0006	s41196	tr0003	-	
S4/646	53 34.08N 0 03.42E	12m	10/10/94 09:24 CH115A	07/11/94 09:30 CH115C	[dp0005]	~~pr0005~~	s41112	tr0002	-	
654			07/11/94 14:55 CH115C	Unknown	~~dp0005~~	pr0005	~~s41112~~	tr0002	-	

1995-96

Station	Position	Dep	Deployed	Recovered	ADCP	WLR/PWR	S4	TRANS	EMP2000	Notes
N1A/712	53 46.06N 0 00.47E	12m	10/10/95 12:32 FV JnM	21/10/95 10:55 FV JnM	dp0008/1	~~pr0003/6~~	-	~~tr1762~~	-	Test deplyment
714	53 46.04N 0 00.50E	14m	21/10/95 11:55 FV JnM	31/10/95 17:45 FV JnM	dp0005	-	-	-	-	
718	53 45.93N 0 00.75E	14m	31/10/95 17:42 FV JnM	20/11/95 13:15 FV JnM	dp0002	pr0001	s42006	tr1762	-	
723			20/11/95 14:07 FV JnM	08/12/95 11:50 FV JnM	dp0005	pr0001	s42006	tr1762	-	
726	53 45.89N 0 00.78E	13m	10/12/95 12:20 FV JnM	16/01/96 12:05 FV JnM	dp0005	pr0003	s42006	tr1762	-	
N1B/715	53 45.94N 0 00.73E	14m	21/10/95 10:49 FV JnM	31/10/95 17:00 FV JnM	dp0006	-	-	-	-	
730	53 46.05N 0 00.59E	14m	31/10/95 16:16 FV JnM	08/12/95 11:33 FV JnM	-	-	s41196	-	-	
727	53 45.94N 0 00.75E	13m	10/12/95 12:10 FV JnM	16/01/96 12:40 FV JnM	dp0004	-	s41119	-	-	
N2/713	53 47.59N 0 03.53E	18m	21/10/95 12:52 FV JnM	31/10/95 15:27 FV JnM	dp0003	-	-	-	-	
N2A/711	53 47.64N 0 03.53E	17m	10/10/95 11:46 FV JnM	11/10/95 11:28 FV JnM	dp0002/4	-	-	-	-	Test deplyment
716	53 47.60N 0 03.49E	19m	31/10/95 15:27 FV JnM	20/11/95 15:30 FV JnM	dp0001	pr0008	s42005	tr0001	-	
721			20/11/95 15:45 FV JnM	08/12/95 10:35 FV JnM	dp0001	pr0008	s42005	tr0001	-	
724	53 47.64N 0 03.50E	18m	10/12/95 13:55 FV JnM	16/01/96 13:20 FV JnM	dp0006	pr0007	s42005	tr0001	-	
N2B/717	53 47.48N 0 03.59E	19m	31/10/95 14:05 FV JnM	20/11/95 14:40 FV JnM	dp0008	-	s41119	-	-	
722			20/11/95 15:08 FV JnM	08/12/95 10:00 FV JnM	dp0006	-	s41119	-	-	
725	53 47.52N 0 03.51E	18m	10/12/95 13:15 FV JnM	17/01/96 11:20 FV JnM	dp0007	-	[s41265]	-	-	
S1/720	53 42.71N 0 04.55E	15m	01/11/95 14:53 FV JnM	08/12/95 12:45 FV JnM	dp0004	pr0004	s41644	tr1683	-	
729	53 42.82N 0 04.63E	14m	09/12/95 12:50 FV JnM	17/01/96 12:45 FV JnM	dp0002	pr0002	s41832	tr1683	em1057	
S2/719	53 43.92N 0 07.47E	18m	01/11/95 16:25 FV JnM	08/12/95 13:20 FV JnM	dp0007	pr0007	s41832	-	-	
728	53 43.87N 0 07.66E	18m	09/12/95 12:25 FV JnM	17/01/96 12:10 FV JnM	dp0008	pr0006	s41196	tr1686	em1059	

AL, 14/08/96.

[ ] data corrupted

~~no data returned~~