Field Measurements at the NOURTEC site, Terschelling, The Netherlands, October 1994

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Report SR 434
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Contract

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Summary

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This report describes the work carried out during a two-week field measurement campaign on the Dutch island of Terschelling in October 1994.

The site was being used by Dutch researchers to measure the movement of nourishment material placed offshore in water depths of 5-10m as part of an EC funded programme known as NOURTEC (Nourishment Techniques). The field measurement campaign described in this report was carried out jointly by HR Wallingford Ltd (HR) and the Department of Physical Geography at the University of Utrecht (UU), and was designed to supplement the NOURTEC campaign by measurements of waves, currents and bathymetry in the intertidal zone.

HR and UU each supplied three frames equipped with a variety of instruments. These frames were deployed along a cross-shore transect, close to the alignment of the NOURTEC instruments further offshore. Monitoring of the instruments was done continuously throughout the two-week period.

This report describes the frames, instruments and measurement campaign, together with the initial post-campaign analysis of the data. The report is unrestricted and contains the outcome of field measurements for subsequent use for validation of computer models. It is intended primarily for experimentalists and numerical modellers in civil engineering hydraulics. For further information regarding this study please contact Dr H N Southgate in the Marine Sediments Group.

Contents

1 Introduction

This report describes measurements made by HR Wallingford (HR) using a modified version of the PROTEUS long-term field measurement system and two further instrumentation packages each consisting of a pressure recorder and a recording current meter at the NOURTEC Field Site on the Island of Terschelling off the North East coast of Holland between 17 and 28 October 1994. NOURTEC (short for Nourishment Techniques) is an EC MAST project designed to evaluate the effects of nourishment material placed on the coastline shoreface in a natural bar system in depths of 5 to 10m. The University of Utrecht's Department of Physical Geography (UU), are carrying out much of the NOURTEC field measurements, and in addition, are monitoring hydrodynamic and morphological conditions in and close to the intertidal zone. The purpose of the HR measurements was to augment the latter measurements being made by UU during their autumn field measurement campaign.

The three HR frames were set up with three frames from UU along a shore-normal line in the intertidal zone. These frames were slightly offset from the alignment of the main NOURTEC instruments further offshore, but sufficiently close for the latter to provide input offshore conditions in subsequent modelling exercises.

It was agreed that UU would not only carry out the analysis of the high frequency data recorded from the modified PROTEUS instrumentation but would also provide all positional data of all instruments, as well as topographical and meterological data from the NOURTEC site.

The measurements carried out by HR were funded by the UK's Ministry of Agriculture, Fisheries and Food (MAFF).

2 Instrumentation

2.1 PROTEUS measurement system

PROTEUS is a measurement system developed at HR, and funded by the Department of the Environment, to make long-term unattended measurements of the hydrodynamics and suspended sediment concentrations close to a channel bed consisting of cohesive material. In addition the system includes a device to record bed elevation changes. The development of the system and its capabilities are fully described in Atkins and Ockenden 1993.

The PROTEUS measurement system consists of the following sensors:

- Two annular electromagnetic current meter heads.
- A pressure transducer.
- Three turbidity sensors.
- A bed elevation monitor.
- Integral data-logging facilities.
- Underwater electronic packages.
- Underwater power supply module.

The measurements described in this report were made in the inter-tidal zone of a beach which is predominately composed of sand with minimal silt and clay

content. The turbidity sensors fitted to PROTEUS operate on the principle of the photoextinction of infra-red light, meaning that the sensors respond well to fine particles in suspension but respond poorly to suspended sand. For this reason they were not deployed during this exercise. The bed elevation monitor is a commercially available sludge blanket detector designed for use in the water industry and is in essence a low-frequency echo sounder with integral signal processing and data logging. Although not specifically required it was deployed during this exercise to investigate the instrument's performance in operation over a sand bed. However, the instrument malfunctioned on deployment and no useable data was obtained from it.

Therefore, the sensors deployed during this exercise consisted of the following:

- Two electromagnetic current meter heads.
- Pressure transducer

The instruments were mounted on an open trapezoidal framework constructed from horizontal and vertical elements made of circular section tubing 0.045m diameter clamped together. The use of circular section material in the framework minimises both the drag forces on the frame and any local bed scour in the vicinity of the bed penetrating uprights.

The electronics associated with the instruments and power supply for the system are housed in underwater modules which were located approximately 5m landward of the framework and buried in the beach. To prevent the modules moving freely whilst underwater they are normally held in position using an upright driven into the bed with a clamped cross-piece passing through the tops of the modules. In practice this arrangement needed modification for the NOURTEC location due to scour around the modules caused by the wave conditions and longshore current. To ensure that the modules remained in position a heavy length of scrap anchor chain was buried beneath the modules which were then lashed to the chain.

The framework carrying the PROTEUS instrumentation initially formed the inner-most measurement point, position 6, on the cross-beach measurement transect and can be seen in Plates 1 and 2.

2.1.1 Electromagnetic Current Meters

The annular electromagnetic current meter (ECM) heads have a diameter of 0.17m with a measurement diameter of 0.1m. The electrodes in each ECM head are set at 90° intervals around the inner circumference of the annulus. Voltages are induced between diametrically opposed pairs of electrodes on the annulus by water flowing through the magnetic field set up by the ECM. The induced voltages are linearly related to the speed of the water passing through the magnetic field and the system output from each ECM head is nominally 1V per ms^{-1}, bi-directional on each velocity component. Both ECM heads, and their associated electronics have been rigorously calibrated in HR's Current Meter Rating Tank facility and have linear calibrations, relating output voltage to water flow speed, in the range $\pm 1.5 ms^{-1}$ on both axes.

The output from each of the four velocity components is filtered within the underwater ECM electronics package using factory fitted filters each with a -3dB cut-off point at 10Hz allowing frequency measurements of up to 10Hz if required. In this application the ECM output signals were further filtered for anti-aliasing purposes at 2Hz within the data recorder (see later). Factory

inter-wiring between the electronics for both of the ECM heads, to synchronise the two clocks, ensured that both heads can be used in close proximity to each other without electronic or electromagnetic interference.

Both ECM heads were mounted to measure turbulent velocities in the horizontal and vertical planes. One head was aligned with its horizontal axis directed parallel to the beach, the other with its horizontal axis directed normal to the beach.

2.1.2 Pressure Transducer

The pressure transducer is used to make measurements from which the water depth and wave characteristics can be determined. The pressure transducer incorporated in PROTEUS has an operating range of 0 - 1 bar gauge pressure ($0\text{-}10^5 Nm^{-2}$) with a corresponding 0 - 1V output. The calibration of this sensor is linear. The actual measurement range of the pressure transducer depends upon the density of the water in which it is being used and the ambient atmospheric pressure but is approximately 0 - 10m water depth. The transducer is mounted in a purpose-designed rigid PVC housing to protect the sensor during deployment whilst allowing the water access to the sensor.

2.1.3 Power Supply

Power for the instruments mounted on the framework and the digital data recorder was supplied from 12V unregulated DC sources. The power supply for the instruments was contained within the power supply module adjacent to the instrumentation module, and power supplies for the data recorder were located within the aluminium case in which the recorder was housed during the measurement exercise.

2.1.4 Data Recording

An integral data logger is normally used with the PROTEUS system. However, problems had been experienced with the integral data logger prior to this exercise requiring replacement parts which failed to arrive from the manufacturers in time. The PROTEUS system is equipped to allow alternative data logging methods to be used and as the integral data logger was not available an alternative system using an Earth Data Recorder 8000 digital instrumentation recorder was employed. The EDR 8000 digital recorder can be used to record data from up to eight analogue inputs and has integral anti-alias filters on each input channel the band-width of which can be selected to suit requirements. The sampling frequency of the data recorded is determined by the band-width selected for the anti-alias filters. For this application the filter band-width was set to 2Hz which will adequately record greater than 90% of the hydrodynamic events likely to be encountered during this exercise. The EDR 8000 recorder only allows selection of a number of analogue input channels to be a power of two. The recorder was therefore set to record eight data channels, although there were only five useable channels employed during this exercise. The digital recording tapes used by this recorder had sufficient storage for about seven days with the recorder set up for this field exercise, but tapes were changed daily to prevent data loss. The power supply for the recorder was provided by a 12V DC unregulated source. This recording technique uses a 200m cable, connected to the sensor outputs, to conduct the analogue output voltages to the data recorder positions at a site remote from the sensors. The 200m cable was buried in the sand to protect it from the wave conditions likely to be experienced at the site. The EDR 8000 recorder was positioned on top of a mobile tower used for other experiments

being conducted simultaneously on the NOURTEC site, and was installed in a sealed aluminium case to protect it against the weather and vandalism.

2.2 Auxiliary Bed Frames

The two auxiliary bed frames were positioned initially at positions 2 and 3 on the cross-shore transect. Both of these frames are also constructed from circular section material. The frames were positioned on the transect and held in position by clamping the frames to uprights driven as far as possible into the bed. In addition, for added security, the frames were chained to a screw anchor driven into the sand close to each frame. Each frame carried an S4 spherical electromagnetic current meter and a DNW-5 wave and tide recorder. Both instruments have internal solid-state data recording facilities and require no external power supply. The spherical S4 current meter has a diameter of 250mm and is a two-component device which includes a Flux-Gate compass. In this exercise the current meter was configured to record a mean velocity vector, resolved from the two measured components of flow, and the direction of the vector at 10 minute intervals. The current meter was configured at HR to make these measurements starting at a preset time on the first day of the measurements (17 October). This meant that it was not necessary to communicate with the current meter in the field. The DNW-5 wave and tide recorder consists of a cylindrical case (160mm diameter by 530mm long) with the tapping for the internal pressure transducer at one end of the case. The recorder was mounted as close to the bed as possible, in a vertical position, with the tapping uppermost. These recorders were initiated on site and set to record at 1Hz for 10 minutes every 30 minutes. Plate 3 shows these two frames and the instruments prior to their positioning on the measurement transect.

3 Measurements

Appendix 1 is a complete diary of events during the period of the field measurements on Terschelling. However, a brief summary of the main events will be given in this section. Recording of data from the S4 current meters and DNW-5 pressure recorders was started on 17 October and continued uninterrupted until the end of the exercise and the instruments and their bed-frames recovered on 28 October.

The instruments from the modified PROTEUS system were deployed on 18 October. Recordings were made from these instruments continuously over approximately 24h periods, the site being visited daily for servicing the equipment. The servicing regime meant that recordings were made over two complete tidal cycles. Servicing entailed changing the power supply batteries on either the instruments or the data recorder, and measurement of the ECM output voltages in flow shielded conditions (offsets). The tapes in the data recorder were changed during each service visit. There was a break in measurements during the tides overnight on 22-23 October as UU were not making any simultaneous instrument deployments.

4 Turbulent Data Handling

4.1 Data Retrieval

The data recorded on tape during the field measurements was transferred to a PC using proprietary software supplied with the data recorder. Setting the band-width of the EDR 8000 data recorder at 2Hz automatically selects a 10Hz sampling rate for the data on retrieval to the PC hard disk. The digital data is retrieved and stored in binary form, each data point being held in offset binary form as a two byte number. An ASCII header of 512 bytes on each file contains information as to the start time and date of the data record and relevant recorder settings. These data files are interrogated by a purpose-written program which summarises the required information.

4.2 Data Reduction

As the retrieved digital binary data had a sampling rate which was twice that determined by the anti-alias filters, the first stage of the data reduction process was to use a purpose-written computer program which reduced the sampling rate to 5Hz by simply reading through each digital data file writing every other data scan to a second output file. The computer program used for this process only wrote the data from the five input channels on the data recorder which contained useable data. The ASCII file header on each of the original data files was not written to the output file.

From the reduced data, 30s mean values of the signal levels were computed during the first stage of the data reduction process and plotted as time-series. The times during which the instruments were under water were estimated from the results of the analysed data from the DNW-5 pressure recorders. The time-series plots when the instruments were under water were visually examined by an experienced operator looking for obvious signs of instrument malfunction. This is usually seen on the ECM outputs as irregular or "spiked" signals. After examination of the data it was considered that twelve tidal cycles (flood and ebb tide), or that major portions of some of the tidal cycles, were suitable for final analysis (see Appendix 2).

The final stage of the data reduction process was to edit the periods containing the useable data, identified in the second stage, from the reduced data sets. This resulted in twelve separate digital data files for final analysis. It should be noted at this stage that no editing of the data for spikes had been carried out at HR, although some of the identified useable data sets contained minimal "spiking".

4.3 Data Analysis

As part of the development of the PROTEUS measurement system a complete suite of computer programs were produced for efficiently processing the data collected. However, it was agreed between HR's project manager and UU personnel involved in the overall project that the analysis of the turbulent data from the modified PROTEUS system would be undertaken by UU using their software package developed specifically for editing and processing data of this nature.

The twelve data sets identified above, along with the relevant calibration data, were sent to UU for analysis after final editing to remove any "spikes".

5 Analysis of S4 and DNW-5 data

The data from the two S4 current meters and two DNW-5 pressure recorders were analysed by standard software packages developed and operated by HR's Field Studies section. The results of these analyses and the raw data were also sent to UU.

6 Acknowledgements

The assistance of students and staff of the Department of Physical Geography of the University of Utrecht during the field measurement programme is gratefully acknowledged. We would like to thank Dr Piet Hoekstra, Gerben Ruessink and Klaas Houwman in particular.

7 References

Atkins R and Ockenden M C (1993). Near-bed Cohesive Sediment Processes. Development of a Self-Contained system for Long-Term Field Measurements. HR Report SR 341.

Plates

Plate 1 **Modified PROTEUS system**

Plate 2 **Modified PROTEUS system with power and instrument modules**

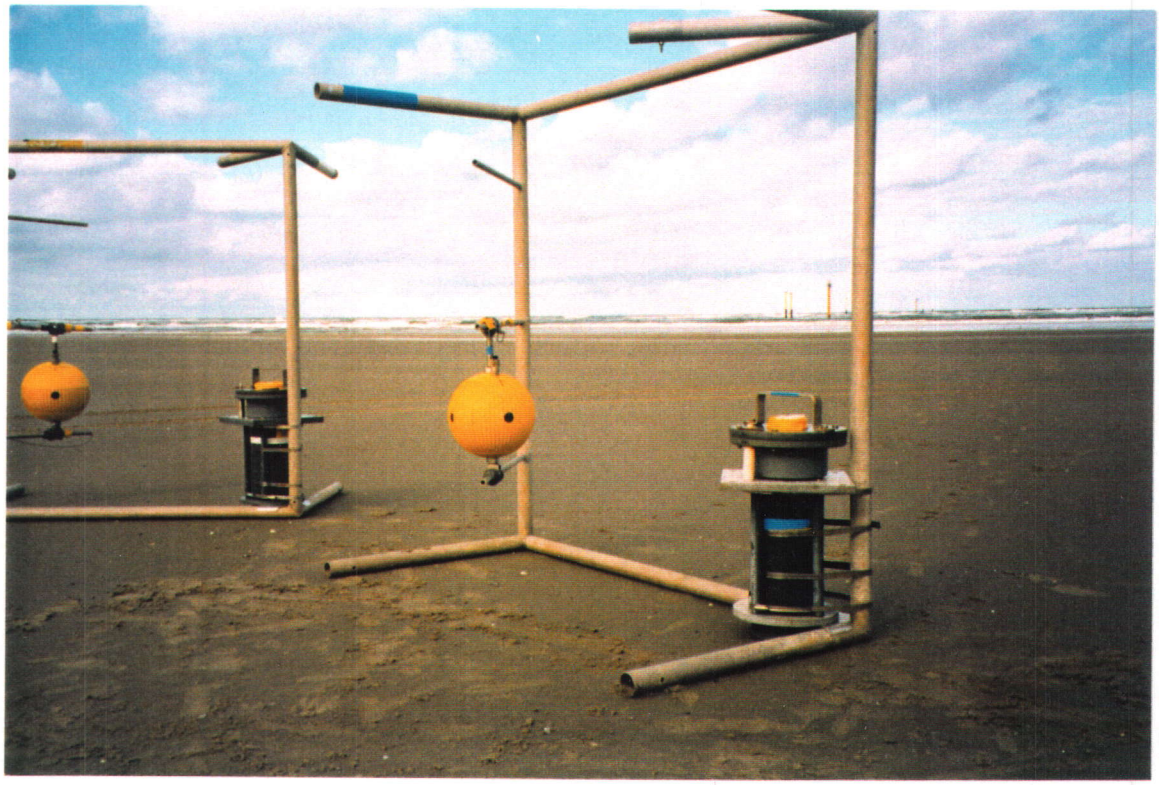

Plate 3 Auxiliary bed frames

Appendices

Appendix 1

Diary of Events

Appendix 1 Diary of Events

15 October 1994	HR personnel (RA and HNS) with all equipment depart Wallingford and travel to Harwich by van, catching the overnight ferry to the Hook of Holland.
16 October 1994	Depart from the Hook of Holland and travel to Harlingen catching the ferry from Harlingen to Terschelling. Visit to NOURTEC site on arrival, discussions as to the positioning of the HR instrument packages in relation to the UU packages and the beach formation. Decided that measurements would be made to investigate long-beach conditions.
17 October 1994	Arrived on site to find that the beach formation had changed considerably from that previously discussed and the position of the instrument packages had to be changed to investigate cross-beach conditions. Installation of the two S4/DNW-5 instruments and frames, construction of the framework for the modified PROTEUS instrumentation.
18 October 1994	Installed the modified PROTEUS system sensors as per UU requirements. Laid out and buried 200m cable between these sensors and recording position. Failed to get ECM offsets due to incoming tide. Set up recording site and started recording high frequency data from the sensors. Attempted to set up and start recording from the ARX bed-elevation monitor without success.
19 October 1994	HNS departs Terschelling for Harlingen. Reinstalled outer S4/DNW-5 frame after it had been twisted in position by waves. Changed batteries on PROTEUS system and modified retainment method as the battery module had been moved significantly by the waves. Attempted to start ARX bed elevation monitor, again without success. No ECM offsets due to incoming tide. Changed the data recording tape.
20 October 1994	Changed the batteries on the data recorder. Improved the retainment of the PROTEUS modules by lashing them to approximately 50kg of scrap anchor chain buried beneath the modules. Changed the data recording tape. Obtained ECM offsets.
21 October 1994	Changed batteries on the PROTEUS system. Checked the instrument module and found that a small amount of water inside but had caused no damage. Changed the tape on the data recorder.
22 October 1994	No deployment today. Attempted to retrieve some of the data recorded so far.

23 October 1994	New batteries on both the data recorder and the instrumentation. Obtained ECM offsets.
24 October 1994	Problems found with the data recorder. Restarted the recorder after changing the batteries. Obtained ECM offsets.
25 October 1994	Changed the data recorder batteries and tape. Obtained ECM offsets.
26 October 1994	Changed the data recorder batteries and the recorder tape. Tidal ranges are such that it is not possible to change the instrument battery or get ECM offsets.
27 October 1994	Could not get to the instruments on the PROTEUS frame at low water because of the neap tide conditions. Changed batteries and tape on the data recorder. Large visiting party to the site.
28 October 1994	Stopped the high frequency data collection. Cleared all the instruments and frames from the site. Transported all equipment from the beach and repacked into the van.
29 October 1994	Ferry from Terschelling to Harlingen and travel to Breda for overnight stop.
30 October 1994	RA travels from Breda to the Hook of Holland to catch the overnight ferry to Harwich.
1 November 1994	Travel from Harwich to Wallingford.

Appendix 2

Summary of useable data periods

Appendix 2 Summary of useable data periods

Examination of the data, as outlined in 4.2, above, identified the following periods of data to be worthy of complete turbulent analysis.

18 October 1994	1740h to 2100h		
19 October 1994	0540h to 1000h		
19 October 1994	1900h to 2200h		
20 October 1994	0620h to 1100h		
20 October 1994	1800h to 0020h	21 October 1994	
21 October 1994	0620h to 1040h		
24 October 1994	1940h to 0100h	25 October 1994	
25 October 1994	0800h to 1220h		
25 October 1994	1900h to 0200h	26 October 1994	
26 October 1994	0820h to 1500h		
26 October 1994	2000h to 0340h	27 October 1994	
27 October 1994	1100h to 1520h		

The times quoted are to local Dutch time, ie. 1 hour in advance of GMT.