CHALLENGER 44

✓ INDEXED

# CRUISE REPORT

CRUISE RVS Cruise 44/89. Sediment Resuspension Experiments - SERE. This is the first of a series of three cruises studying sediment resuspension process as part of the NERC North Sea Project.

VESSEL RRS *Challenger*

PERIOD 13-27 January 1989

SCIENTIFIC PERSONNEL

| | |
|---|---|
| A W Morris | PML - Principal Scientist |
| A J Bale | PML |
| R J M Howland | PML |
| D Flatt | POL |
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| R Palin | POL |
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| D Teare | RVS |

ACKNOWLEDGEMENT

The excellent services afforded by Capt. G Long and his officers and crew throughout this cruise are most gratefully acknowledged.

## SCIENTIFIC OBJECTIVES

(1) To evaluate the hydrodynamic processes controlling the resuspension of sediment and its seasonal variability at two contrasting sites in the North Sea.
(2) To evaluate the influence of sedimentological characteristics and geotechnical and geophysical properties of the bed on the resuspension of sediment at the two sites.
(3) To examine the role of benthic and pelagic organisms in sediment resuspension and deposition processes.
(4) To determine the impact of sediment resuspension on water quality through its influence on trace metal, nutrient and organic contaminant exchange processes.
(5) To develop a detailed model interrelating vertical current structure and suspended sediment concentration at a point site. To use this model as the basis for constructing a fine-grid, 3-dimensional model incorporating sediment transport to cover the observational areas.

SPECIFIC OBJECTIVES

To make time series observations of physical, sedimentological and biological properties of the sediment, suspended particulate material and water at two sites in the North Sea using a variety of moored instruments, CTD/water bottles casts, pumped sampling and sediment grabs and box cores.
The two sites (Figure 1): are (1) northern site, 54° 35'N 04° 50'E, 45m depth, muddy sand, seasonally stratified water column, and (2) southern site, 52° 40'N 3° 40'E, 27m depth, sand, permanently well-mixed water column.

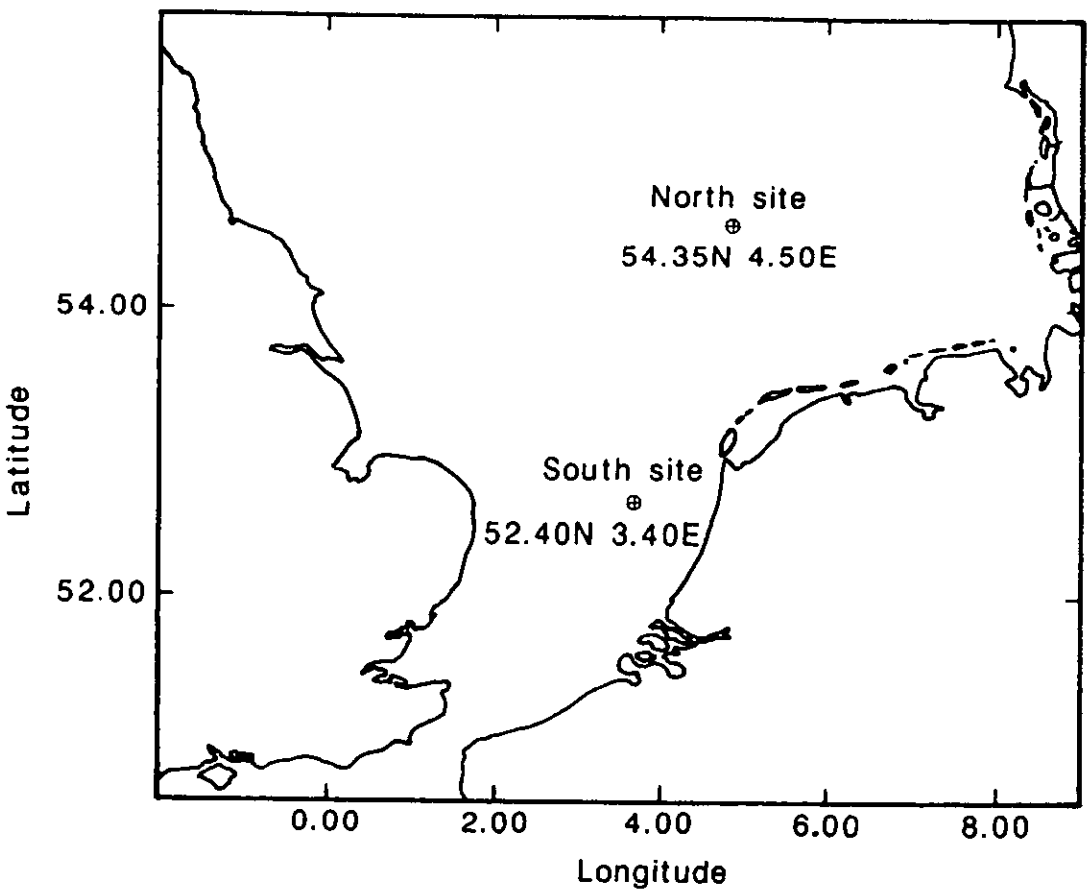


Figure 1. Location of the two experimental sites in the southern North Sea.

SUMMARY

The planned objectives for this cruise were mostly achieved despite the late replacement of John Howarth as Principal Scientist and the loss of two cruise days through initial engine problems. These necessitated: (1) abandoning the deployment of Argos tracking buoys at the two experimental sites, and (2) rearranging the timing of visits to the two experimental sites with reduced periods of deployment of moored rigs and reduced frequency and duration of serial observations at the two sites.

All the moored rigs (10 at the northern site; 3 at the southern site) were successfully deployed and recovered except for one transmissometer/current meter rig at the southern site which was snared and retained by a Dutch trawler. The instruments on this rig have since been retrieved. In addition, an acoustic Doppler rig left at Survey Station D during an earlier cruise was recovered.

Photographs of the sediment surface were taken at regular station intervals within a nautical square mile grid (5x5 = 25 stations) surrounding each of the experimental sites. Day grabs were also collected at these stations together with a smaller number of box cores (3x3 = 9 stations) for geotechnical measurements, grain size analysis, chemical measurements and faunal analysis.

Two sets of time-series observations (covering periods between 14 and 18h) of water column properties measured by the CTD system and of particle settling velocity were taken at each site. Samples were collected for analysis of nutrients, trace metals, chlorophyll, zooplankton, suspended particulate mass and composition.

NARRATIVE

| | |
|---|---|
| Thur 12 Jan | 1500 Scientific personnel embark at Great Yarmouth. Loading, servicing and commissioning of equipment. |
| Fri 13 Jan | 1400 Engine failure immediately on casting off at planned departure time. |
| Sat 14 Jan | Remain berthed at Great Yarmouth awaiting engine repairs. |
| Sun 15 Jan | Depart Great Yarmouth at 1430. Proceed directly to northern experimental site. Commissioning and testing of equipment en route. |
| Mon 16 Jan | Arrive at northern site ($54^{o}$ 35'N; $4^{o}$ 50'E) at 1100 and commence deployment of rigs starting with the met. buoy at 1130. A total of four rigs deployed (Met. buoy, waverider buoy, bottom mounted CM and tide guage) by 1700 when loss of daylight curtailed further rig operations. On-deck construction of STABLE started at 1800. From 1900, calibration and buoyancy tests for rigs carried out and then commenced collection of Day grab samples around the station grid. Grabbing continued until 2200 when called off by Master on safety grounds (swell). |

Tues 17 Jan — Calibrate transmissometers for STABLE at 0800. STABLE launched successfully at 0930. Then continue to deploy rigs interspersed with calibration operations and continuation of Day grabbing. All rig deployments and grabbing stations completed before darkness except for acoustic Doppler postponed till following morning. Commence tidal anchor station (14h) at 2000. Alternate CTD/water bottle profiling, large volume pump sampling and particle settling column deployments, each at approximately hourly intervals.

Wed 18 Jan — Anchor station operations completed by 1100. Deploy Doppler rig. Attempt to recover large volume sediment trap unsuccessful; only separated mooring buoy hauled in; postpone recovery of trap until later in cruise. Depart for southern experimental area at 1400.

Thur 19 Jan — Reach southern site ($52^{o}$ 39'N; $3^{o}$ 40'E) at 0330 and prepare rigs for deployment. Large volume sediment trap and transmissometer/CM string deployed by 0730; sequential sediment traps at 0830. Day grabbing and box coring around grid until 1700. Commence 18h time series observations at anchor station at 2000 (alternate CTD/water bottles, large volume pumped water samples and particle settling column deployments, each at hourly intervals).

Fri 20 Jan — Complete anchor station 1500. Retrieve large volume sediment trap successfully by 1630. Complete the grid of Day grabs/box cores by 2400 and then depart on transit to the northern site.

Sat 21 Jan — Arrive at northern site 1030. Check presence of rig markers, - all sighted. Weather too rough for planned box coring so substituted by sea bed photography around grid until 1900. Anchor station (14h) comenced (procedures as previously).

Sun 22 Jan — Anchor station operation completed by 1030. Commence recoveries of rigs earlier than intended (threatening weather forecast; Master advised retaining flexible recovery time). Three rigs recovered before dark.

Mon 23 Jan — 0700 continue rig recoveries. All except damaged sediment trap rig safely on board by 1700.

Tues 24 Jan — Box coring around grid from 0700. Break for grappling attempts for sediment trap at midday. Successful recovery achieved. Complete box coring by 1900 and depart for southern site detouring via Survey Station D to attempt recovery of two acoustic Doppler rigs.

Wed 25 Jan — 0700 recover first acoustic Doppler rig at Station D. Grapple for second rig not responding to acoustic release signal. Abandon unsuccessful search at 1200 and proceed to southen site, arriving ca. 1800. Check presence of rigs visually - sediment trap OK; CM/transmissometer string not in position, surface toroid buoy located by radar about two miles away. Recover bouy with severed ground line. Commence anchor station operations at 2100.

Thur 26 Jan — Anchor station completed by 1030. Recover sediment trap at 1130. Carry out camera survey of sediment surface till 1900. Experimental CTD profiling to investigate fine structure close to sea bed. Depart southern site en route for Great Yarmouth at 2200. Decommissioning and packing of equipment.

Fri 27 Jan — Hove to off Great Yarmouth awaiting midday high water. Tie up at Great Yarmouth and disembark.

## RESULTS

### Moored rigs.

Details of moored rigs and their deployment, recovery and performance are listed in Table 1.

Table 1. Rig deployments and recoveries.

| Rig (Position) | Deployed date | Deployed time | Recovered date | Recovered time | Comment |
|---|---|---|---|---|---|
| **Northern site.** | | | | | |
| Met. buoy (54°36.0'N 04°51.9'E) | 16/1/89 | 1130 | 23/1/89 | 1337 | good data |
| Waverider (54°35.9'N 04°51.5'E) | 16/1/89 | 1200 | | | data recorded but not yet checked |
| Bottom CM/ tide guage (54°34.6'N 04°51.5'E) | 16/1/89 | 1400 | 23/1/89 | 1046 | difficult tape; probably OK |
| Rig 1, U-shaped two bottom RCMs transmissometers 5, 10 and 30m above bed (54°35.5'N 04°51.8'E) | 16/1/89 | 1643 | 22/1/89 | 1153 | CM data OK, 5m transmissometer damaged - no data, other two OK |
| STABLE EM flowmeters, rotor, optical backscatter probes, transmissometers (54°35.0'N 04°48.2'E) | 17/1/89 | 0920 | 22/1/89 | 1545 | ca. 9h complete data (4 bursts); otherwise one tape only; all 1min values OK and burst samples of horizontal current velocity; |

Table 1 contd.

| | | | | | |
|---|---|---|---|---|---|
| | | | | | no burst samples of vertical velocity, backscatter or pressure after 9h. |
| ETA rig. two RCMs Toroid fitted with Argos transmitter ($54^{o}34.9'N$ $04^{o}51.3'E$) | 17/1/89 | 1140 | 22/1/89 | 1114 | 1xS4 OK |
| Rig 2, near-surface RCMs ($54^{o}35.4'N$ $04^{o}48.1'E$) | 17/1/89 | 1519 | 22/1/89 | 0942 | 2xS4, 1xAanderaa OK |
| Sediment trap sequential ($54^{o}34.5'N$ $04^{o}48.1'E$) | 17/1/89 | 1634 | 23/1/89 | 0928 | S4 not working, trap OK |
| Sediment trap large volume ($54^{o}34.8'N$ $04^{o}50.0'E$) | 17/1/89 | 1817 | 24/1/89 | 1230 | recovered by grappling sample intact |
| Acoustic Doppler Current profiler ($54^{o}35.9'N$ $04^{o}48.3'E$) | 18/1/89 | 1129 | 23/1/89 | 1118 | data OK |
| Southern site. | | | | | |
| Sediment trap large volume | 19/1/89 | 0630 | 20/1/89 | 1630 | good sample |
| Transmissometer/ CM | 19/1/89 | 0730 | - | - | rig snared by trawler |
| Sediment trap sequential | 19/1/89 | 0830 | 26/1/89 | 1100 | operated successfully |

Sequential sediment traps.

A new design of pre-programmable sequential sediment trap was developed specifically for this study. The traps operated successfully and provided a composite sample and a series of semi-diurnal settling sediment samples over 6 days for the northern site and 7 days at the southern site. Settling fluxes determined from the sequential trap collections (aperture diameter, 15cm) were in good agreement with those determined from the large volume traps (aperture diameter, 60cm). The trapped volumes covaried with tidal range at the shallower southern site, but not at the northern site.

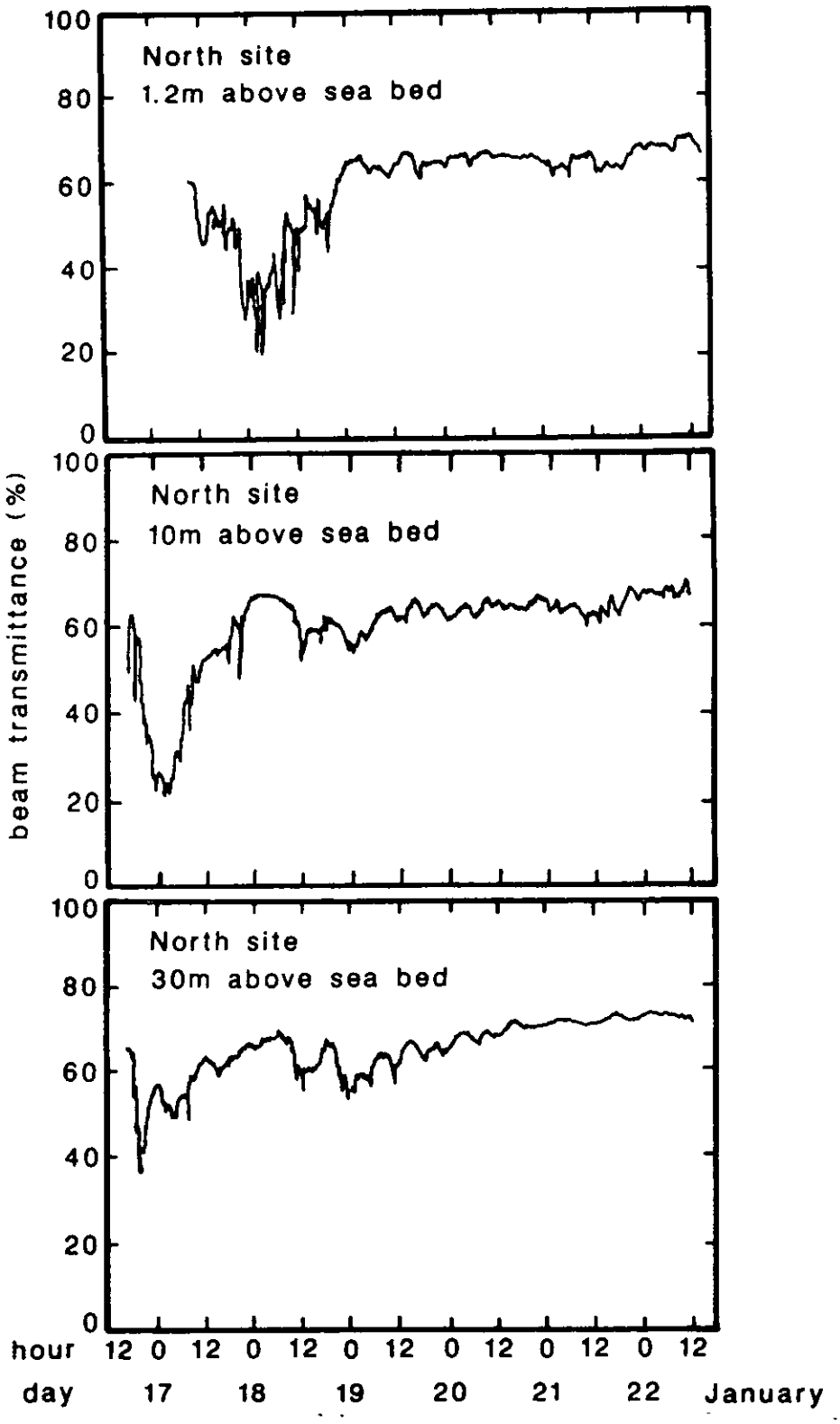


Figure 2. Tramsmissometer outputs at 1.2, 10 and 30m above the sea bed at the Northern experimental site.

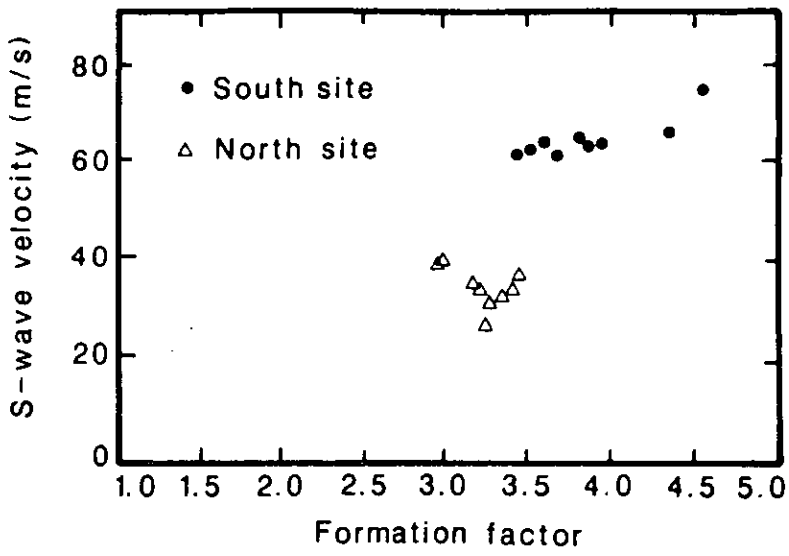


Figure 3. S-wave velocity compared with formation factor within the grids of stations at the northern (open triangles) and southern (closed circles) experimental sites.

Suspended sediment.

Transmissometer data from three depths at the northern site are shown in Figure 2. The data cover a period of increasing tidal range, but the time-series was clearly dominated by high turbidity during the first two days attributable to a period of enhanced wave activity just prior to deployment. Peak turbidities occur later in time with increasing depth of measurement as the material suspended by the wave stress settles out of suspension. Despite this interference, a tidal signal is also evident in the time-series, even at 30m above the bed.

Suspended particle settling velocities were measured *in situ* at a height of 1m above the sea bed at hourly intervals throughout the anchor station operations whilst samples for mineralogical analysis were collected at various heights above the sea bed. These measurements designed to augment the transmissomenter results have not yet been fully analysed.

Sediment observations.

The sediment surface photography and the grab and core samples confirmed the contrasting sediment characteristics between the two sites but also showed the relative uniformity of sediment within the sampled grid at each site. This is illustrated, for example, by the plots of S-wave velocity against formation

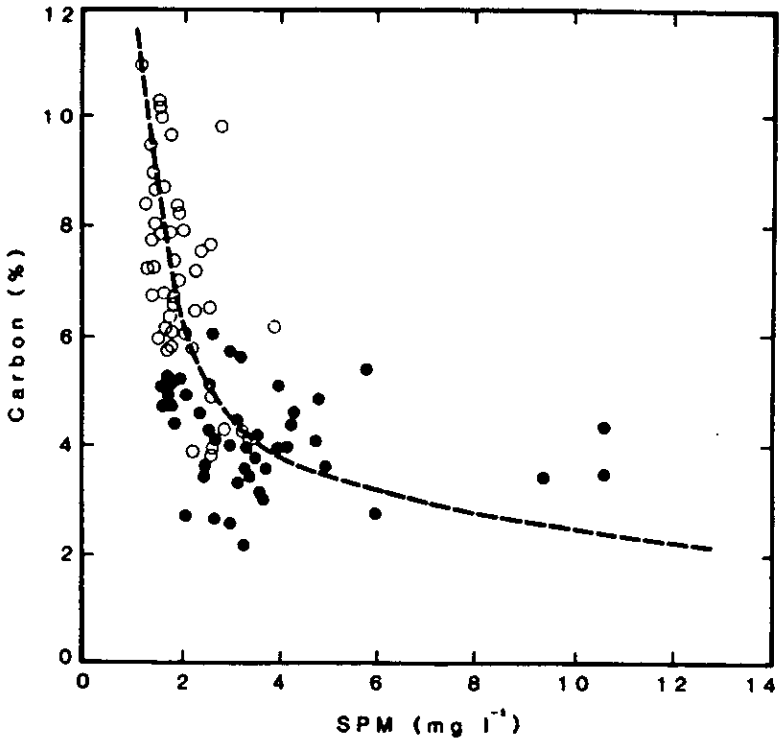


Figure 4. Variations in the carbon content of the suspended particulate load at the northern (closed circles) and southern (open circles) experimental sites with changes in the total suspended particulate load.

factor shown in Figure 3.
A preliminary interpretation of the benthic data indicates populations of organisms which were quite uniformly distributed within the experimental grids and were typical for the observed sediment types in the North Sea although somewhat sparse at the southern site and with unusually large numbers of the suspension feeding brittlestar, *Amphiura filiformis*.

Water column observations.

Observed variations in the suspended particulate load of the water column clearly showed the influence of semi-diurnal and spring-neap tidal oscillations as well as wave activity, in keeping with the transmissometer results. Under quiescent conditions, suspended loads at both site were around 1.5 mg/l, rising to maximum values at the muddier northern site of about 10 mg/l. Resuspension effects at the southern site were much less pronounced.
Systematic variations in the organic carbon and nitrogen content of the suspended material occurred in response to changes in the particulate load at both sites (Figure 4). The data are consistent with the dilution of a more permanently suspended particulate load which is organic rich (C/N ratio = 8 - 12; organic carbon content >10%) with organically depleted resuspended particles (C/N ratio = 17 - 20; carbon content <2%).

Report prepared by: A W Morris, 19 June 1989

Report authorised by: B L Bayne, 19 June 1989

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