I.O.S.

4/e

# SIZEWELL-DUNWICH BANKS FIELD STUDY

by

B J LEES

PROGRESS REPORT FOR THE PERIOD
January 1977 to December 1978

Report No 72
1978

This project is supported financially by the
Department of the Enviroment

NATURAL ENVIRONMENT RESEARCH COUNCIL
INSTITUTE OF
OCEANOGRAPHIC
SCIENCES

## INSTITUTE OF OCEANOGRAPHIC SCIENCES

Wormley, Godalming,
Surrey, GU8 5UB.
(0428 - 79 - 4141)

(Director: Dr. A.S. Laughton)

Bidston Observatory,
Birkenhead,
Merseyside, L43 7RA.
(051 - 653 - 8633)

(Assistant Director: Dr. D.E. Cartwright)

Crossway,
Taunton,
Somerset, TA1 2DW.
(0823 - 86211)

(Assistant Director: M.J. Tucker)


---

# SIZEWELL-DUNWICH BANKS FIELD STUDY

by

B J LEES

PROGRESS REPORT FOR THE PERIOD
January 1977 to December 1978

Report No 72

1978

This project is supported financially by the
Department of the Environment

Institute of Oceanographic Sciences
Crossway
Taunton
Somerset

CONTENTS

LIST OF FIGURES

SIZEWELL - DUNWICH BANKS FIELD STUDY : SECOND PROGRESS REPORT

## 1. INTRODUCTION

The first two years' work on the Sizewell-Dunwich Banks Project (Location Map Fig 1) has been described in IOS Report No 38, 1977. The present report covers the following two years until 31 December 1978.

The study is still at a stage where field data is being obtained and this is likely to continue until about the end of the 1978-79 financial year. Thus the analysis undertaken so far has employed routine methods and has been restricted to specific aspects of the field data. For example, grain size analyses of both selected pumped samples and the top few centimetres of certain box cores were carried out to help determine the tracer particle size to be used in the fluorescent tracer experiment described below.

Synthesis of the Sizewell-Dunwich data and comparison of the ensuing results with those from Swansea Bay (Project No S31) will follow in the financial year 1979-80.

It is worth reiterating briefly the objectives of this study. They fall naturally into three groups:

(a) Objectives involved with understanding the sediment transport system of an offshore bank.

These include mapping the sediment distribution, both laterally and with depth; identifying sediment transport paths; defining the relationship between the banks and the adjacent coastline; and if possible suggesting reasons for the presence and relative stability of the banks.

(b) Objectives concerned with the study of large scale sediment transport processes under waves and tidal currents.

An essential part of the research under this heading is the comparison with the results from Swansea Bay. The study includes comparing measured and predicted rates of sediment transport; establishing how meteorological forcing affects mean water circulation and therefore sediment transport; relating wave climate to sediment transport; and providing reference concentrations for suspended sediment in offshore tidal waters. Additionally it will be possible to make a relative assessment of radioactive and fluorescent tracer methods, and results.

(c) Objectives associated with providing useful data for input to, and validation of, the mathematical model (Project No S33).

These include, for example, obtaining synoptic current meter data, and tidal elevation information over a period of at least two months as well as the benefits of a complete bathymetric survey.

During the period in which the project has been in existence two factors have had a strong influence on its development. Firstly there was the curtailment of the time allowed for completion by one year, and secondly a change of emphasis towards the study of sediment transport processes. This has meant that some objectives in the first group have been less fully studied than others. For example, when considering the relationship of the banks to the adjacent coastline, the role of longshore transport and the solid geology of this coastline have not been investigated in detail. Field work in 1978 in particular has concentrated on obtaining sediment transport measurements for the comparison of measured and predicted rates both of suspended sediment and bedload, a major objective in the second group.

## 2. PROGRESS FROM 1 JANUARY 1977 TO 31 DECEMBER 1978

### 2.1 Geology

2.1.1 Geological sampling. Since the original grab sample survey in February 1975 (Fig 2) a second has been made over a limited area (Fig 3). This was an inherent part of the background survey carried out immediately prior to the injection stage of the August 1978 fluorescent tracer experiment. Certain differences in the sediment distribution may be noted.

In the Dunwich Bank area the sand became less extensive to both the west and east and thereby uncovered the blue-grey clay (see key in Fig 2). This confirms the indications of the 1975 geophysical survey that the clay underlay the sand in this region. More of this clay became exposed along what was the western edge of the sand almost as far south as Thorpeness. To the east of this strip, where in the winter of 1975 there was a sandy col between the banks, in August 1978 there was an area of intercalated sands, silts and clays. These were very soft in texture when first brought up from the seabed and contained large numbers of the tube worm Owenia fusiformis. In the south, offshore from Thorpeness, the sand extended further eastwards. The boundary between the sand and the intercalated sands, silts and clays was somewhat irregular. It is considered that these may well be seasonal variations.

2.1.2 Box cores. Box core surveys have been undertaken in 1977 and 1978, the latter primarily for measuring the depth of burial of the fluorescent tracer. Thirty-two cores were obtained in July 1977 mainly in the 1975 area of intercalated sands, silts and clays, using the IOS Reineck-type corer. A further eight samples were cored in August 1978, with a MAFF designed corer, similar in principle to the Reineck, but less bulky to handle. Fig 4 shows the coring stations.

2.1.3 Vibrocores. Fig 4 also shows the location of seven successful vibrocore stations which were drilled in March 1978. At a depth of 2.7m Core 1 penetrated a bright yellow shelly rock not exposed at the surface, and this has been identified as Crag, probably Coralline Crag. The surface of this bed can also be recognised on the geophysical records and appears on the isopachyte map (IOS Report No 38, 1977) to the east of Thorpeness, as a horizon deeper than the sand/blue-grey clay interface. Cores 5, 6 and 8 also penetrated yellowish medium to very fine sands, but these are likely to be younger than the Crag sediments.

The intercalation of the sand, silt and clay sediments is very apparent in vibrocores 5 and 7, and schematic drawings of the core sections are shown in Fig 5. This structure tends to be obscured in grab samples because of the soft nature of the sediment. Depth of burial measurements using the box cores taken during the fluorescent tracer experiment will be useful in giving an indication of the depositional time scale of these structures.

2.2 Hydrodynamics

2.2.1 Midwater current meter data. The long term current meter mooring, first deployed in August 1976 at Station 22 (Fig 1) has been changed at two monthly intervals and this will be continued until March 1979. Although the rig stayed intact through January and February 1977, the Plessey M021 meter developed a fault and only six days' data were recovered. For the corresponding period in 1978 the meter was lost from the rig, but it is hoped to cover this gap during January and February 1979. The May/June 1977 block was reduced to 27 days' data, but all other tapes so far analysed have given satisfactory data.

Six current meters were deployed for the maximum two month period (ie when sampling is at ten minute intervals) from mid-July to mid-September 1977. One of these was lost from the shallow mooring on the Dunwich Bank, and two developed faults, leaving three sets of good continuous data.

In addition to the long term mooring, two further meters were deployed in the north and south of the area in August 1978 to give current vectors synchronous with the initial phases of the fluorescent tracer experiment (see 2.3.2 and Fig 1, Stations 32 and 33). The meters were retrieved the following October.

The coverage of current meter data is now such that synoptic tidal component current vectors can be provided for the validation of the mathematical model.

Standard processing has been carried out for the greater part of the data. Figure 6 is a preliminary sketch of the residual flow pattern of the area derived from progressive vector plots. The pattern is not altogether clear at this early stage of the analysis. However, it can be seen from this diagram that the residual flows measured over spring tides are greater than those measured over neaps as would be expected. There appears to be an overall pattern of residual flow towards the crests of the banks, but this is deduced from midwater measurements only, and there is likely to be some balancing flow at other levels. There also appears to be a consistent flow to the southeast at both ends of the channel between the Sizewell Bank and Thorpeness.

2.2.2 Velocity profiles. Velocity profiles were measured in the southern part of the area using a fixed array of flowmeters suspended from a ship's davit. Figure 1 shows the three stations where 25 hour series of readings were made. Station VP1 is on the Sizewell Bank, Station VP3 away from the bank in a SE direction, and Station VP2 is located half way between them. Because the distance from the seabed is not fixed with this array, but varies with the tide and roll of the ship, the results have been less satisfactory than those from the Marconi Buoyed System, deployed in 1976 (Report No 38, 1977).

2.2.3 Wave climate. The three FM pressure transducers mentioned in the Progress Report No 38, 1977, have been providing and continue to provide useful data.

In order to examine the effect of the banks on the wave climate certain wave data comparisons have been made. Wind directions at the Aldeburgh coastguard station were assumed to be the same as the wave approach directions seaward of the banks. With the relatively short fetch for this area of the east coast this is a reasonable assumption. Wave data appropriate to directions in twenty degree segments from $85^{\circ}$ to $185^{\circ}$ were examined and Hs (Southwold) plotted against Hs (Dunwich), Hs being the significant wave height. This was repeated for Tz (zero crossing period). The same analyses were also undertaken for Aldeburgh against Dunwich data. In each instance a threshold of Hs = 0.20m was used and linear regressions were carried out on both Hs and Tz plots for the pairs of stations. In all cases the correlation coefficients indicated that there was no significant difference between the Hs and Tz measured behind the Dunwich Bank and those measured on the open coast at either Southwold or Aldeburgh. In order to get a more direct measure of the wave climate on the seaward side of the banks a Waverider buoy was deployed in August 1977 and a second one inshore of the bank in October 1978 (Fig 1). Spectral analysis of the data obtained over the coming winter should help identify and quantify the effect that the bank may have on the wave regime.

2.3 Sediment Transport

2.3.1 Measurement of suspended sediment transport rates. The Pumped Sampling apparatus shown schematically in Fig 7 was used to make measurements, firstly to determine the concentrations and grain size distributions of suspended sediment, secondly to estimate sediment flux rates, and thirdly to estimate bed shear stresses. Measurements were taken at five stations, for twenty-five hours at each, and were carried out during spring tides in March 1978. Two sites were located in the south and three in the north (Fig 8) along lines normal to the shore. Measurements were made close to the boundaries of the research area in order to assess the flow of sediment through the area, tidal flow being parallel to the shoreline.

2.3.2 Measurement of bedload sediment transport. Two preliminary experiments were undertaken using fluorescent tracer in 1976 and 1977 with less than satisfactory results. After the more precise results achieved by the radioactive work in Swansea Bay it was felt that this method of labelling was preferable and a suitable experiment was planned for the East Coast. When preparations were well under way it became apparent that IOS's use of radioactive tracer might produce major monitoring problems for the Central Electricity Generating Board's nuclear power station at Sizewell,and a change back to inert fluorescent material became necessary.

It was intended that as far as possible bedload only should be measured. To determine the appropriate particle size for the experiment grain size analyses were performed on some of the pumped samples, in particular those obtained at times of maximum tidal current flow, to discover the size of the coarsest material which goes into suspension in the area. The profiles of these sediments sampled during an ebb tide at Station PS2 are shown in Fig 9. This figure also shows the cumulative grain size distribution curve for the seabed surface sample from Box Core 37, near the tracer injection site and the three curves differ very little from one another. In other words, particles of the same grain size distributions as those on the seabed can also be found in suspension at times of maximum flow. Therefore a slightly coarser sand (Fig 9) was chosen for fluorescent coating in a deliberate attempt to keep as much of the tracer as possible on the seabed.

A new injection technique was designed to overcome the problem of getting a large quantity, ie 0.75 tonne, of wetted sand quickly onto the seabed over a slack water period. The injection needs to prevent any tracer escaping into the water column, and preferably without the use of divers. The area invariably has nil visibility below the sea surface. A slurry was made on deck in a water butt, the water supply coming simultaneously from two sources in order to provide sufficient volume, while the sand was added manually. In the butt was a 'Flygt' centrifugal pump, which was able to pump out the slurry at a rate of 500 $1\ min^{-1}$ down a 10cm diameter vertical pipe lashed to the ship's rail, terminating 40cms above the seabed. The tracer was released at a night time high water slack in a calm sea, two days after maximum spring tides. The whole operation only took eight minutes, thus leaving some slack water time during which the material could settle. The water speed normally falls below $12cms^{-1}$ for about twenty minutes at slack water in the area.

After the injection the ship steamed due east for one hour. The deck area and anything which may have been in contact with the tracer were then thoroughly hosed down and the ultra-violet lamp used to check that all fluorescent tracer had been removed. After this decontamination procedure, the ship returned to the study area, and the first post-injection survey began.

Another problem with fluorescent tracer is locating its presence and quantity in the field, and thus ensuring that the whole amount can be accounted for during each survey. A Shipek grab was used for all the sampling. This is a simple, reliable grab which cuts a semi-cylindrical sample from the seabed with a maximum depth of 15 cms. This ensured that buried tracer as well as that on the surface would be retrieved. As each sample was brought inboard a sub-sample was bagged and labelled for subsequent precise analysis in the laboratory. The remainder was spread out thinly and examined under ultraviolet light and notes made of the type of sediment and number of grains seen, estimated to the nearest five when quantities were small, and to the nearest fifty when they were larger. These samples examined on board were of roughly equal size so that direct comparisons could be made. After practice, a rate of sixteen samples per hour was achieved. Position fixing was by Trisponder and this enabled sampling stations to be located within 10 to 20 m of one another where necessary. At the time of writing, laboratory analysis is under way to find the exact concentrations of coated sand in each sample, prior to calculations being made of centroid positions and sediment transport rates.

Figure 8 shows the extent of the tracer clouds determined by the field data. After 5 days the bulk of the tracer was located in an area 450m long and 30m wide. This became extended to an area 1050m by 60m after seven weeks. During this time there was one NE gale. The tracer clouds' long axes remained parallel to the bank and aligned with the directions of tidal flow.

2.4 Topography

2.4.1 Bathymetry. In July 1977 virtually all of the study area, except for areas less than 5m deep along the shoreline, was covered by an echosounding survey. Most of the lines were run normal to the shore and had a mean interval of 153m. Additionally several tie lines were followed parallel to the shore. Tidal height data were provided by the three nearshore pressure transducers which had been modified to give continuous readings instead of the usual three hour sample intervals. Additional tidal height data were provided by pressure sensors on the two current meters moored in the NE and SE extremes of the area. This comprehensive set of tidal height readings is also required for boundary elevation input to the mathematical model.

2.4.2 Beach profiles. Profiling along ten beach sections was begun in March 1978. The levelling is carried out at low water springs, but this still leaves a gap between the lower limits of the profiles and the inshore limit of the echosounding survey.

Twelve sections were planned initially, but the two in the Walberswick area (Fig 10) were discarded as the Coast Protection Authority frequently modifies the shingle banks with bulldozers, particularly after storms. The most interesting section so far has been the one at Thorpeness and profiles for the months of April, May and October 1978 showing the range of variation are displayed in Fig 11. This is in marked contrast to the profiled beach in Swansea Bay which is far nearer an equilibrium state, (Swansea Bay Project, Topic Report 2). Changes in the surface distribution of sediments alongshore are also apparent with mean grain sizes ranging from pebbles to very fine sand.

3. SUMMARY

1977 and 1978 have been years of increasing field activity, with four cruises in 1978. Foreshore profiling began in March 1978.

The current meter coverage of the area is reasonably complete, and by March 1979 there should be a continuous series of data throughout the year from the long term mooring. Useful velocity profiling data is also available.

There is an excellent run of over 90% good data from the three pressure wave recorders, and by March 1979 this will be of four years' duration. There should be several winter months of Waverider buoy data from two locations inshore and seawards of the Dunwich Bank to supplement the seawards Waverider and the earlier nearshore data.

The geological programme should have been completed with the vibrocore survey in March 1978, but in the event only half of the proposed sites were cored. A comprehensive box core survey has been carried out, mainly in areas of intercalated sands, silts and clays.

Sediment transport measurements have been made of suspended sediment at five stations, with 25 hours of data at each, obtained during a spring tide.

After initial setbacks, and in particular the cancelling of the radioactive tracer experiment, useful bedload sediment transport measurements have been made, from which bedload transport rates will be calculated.

Bathymetric and foreshore topographic surveys have also been undertaken, although there is a gap between the two where the water is too shallow for the ship, and too deep for the foreshore surveyors.

During the past three and a half years the emphasis has been on acquiring the necessary field data. The coming year is a critical one, when the data will be further analysed and synthesised. It is important that the maximum effort be put into this part of the work to realise the full potential of the observations and measurements. In this context comparative work with the Swansea Bay results is crucial.

## 4. FUTURE WORK

### 4.1 Until the end of March 1979

New work will be limited to sediment sampling linked to the beach profiling and to one further survey of the fluorescent tracer injected in August. Depending on weather conditions during the winter this last survey will probably be in February. Ongoing measurements include those of wave parameters and beach topography. The long term mooring will be changed at two monthly intervals. Data processing and analysis will continue.

### 4.2 April 1979 to March 1980

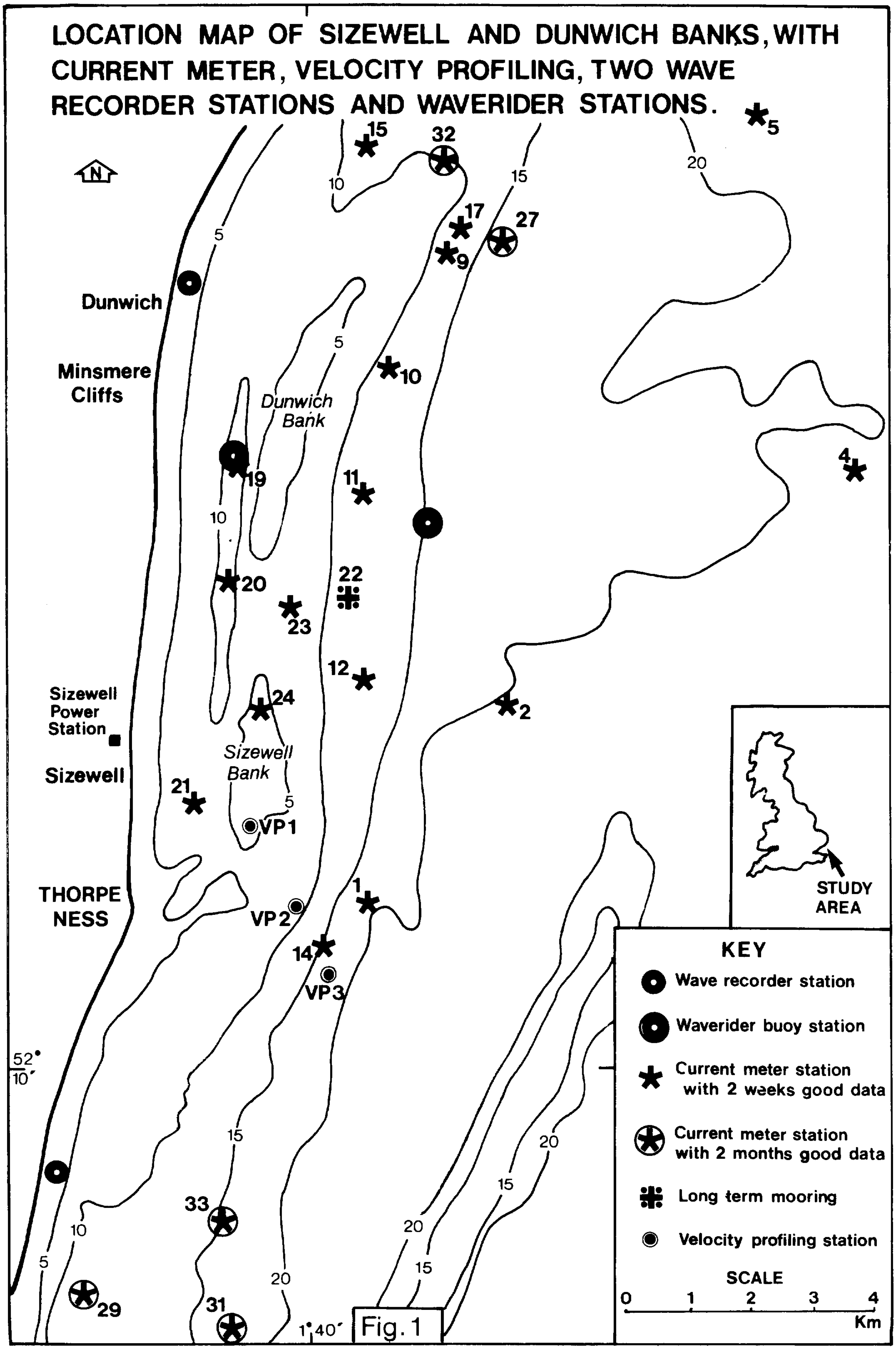
It is anticipated that the vibrocoring programme will be completed in April when a suitable ship is next available.

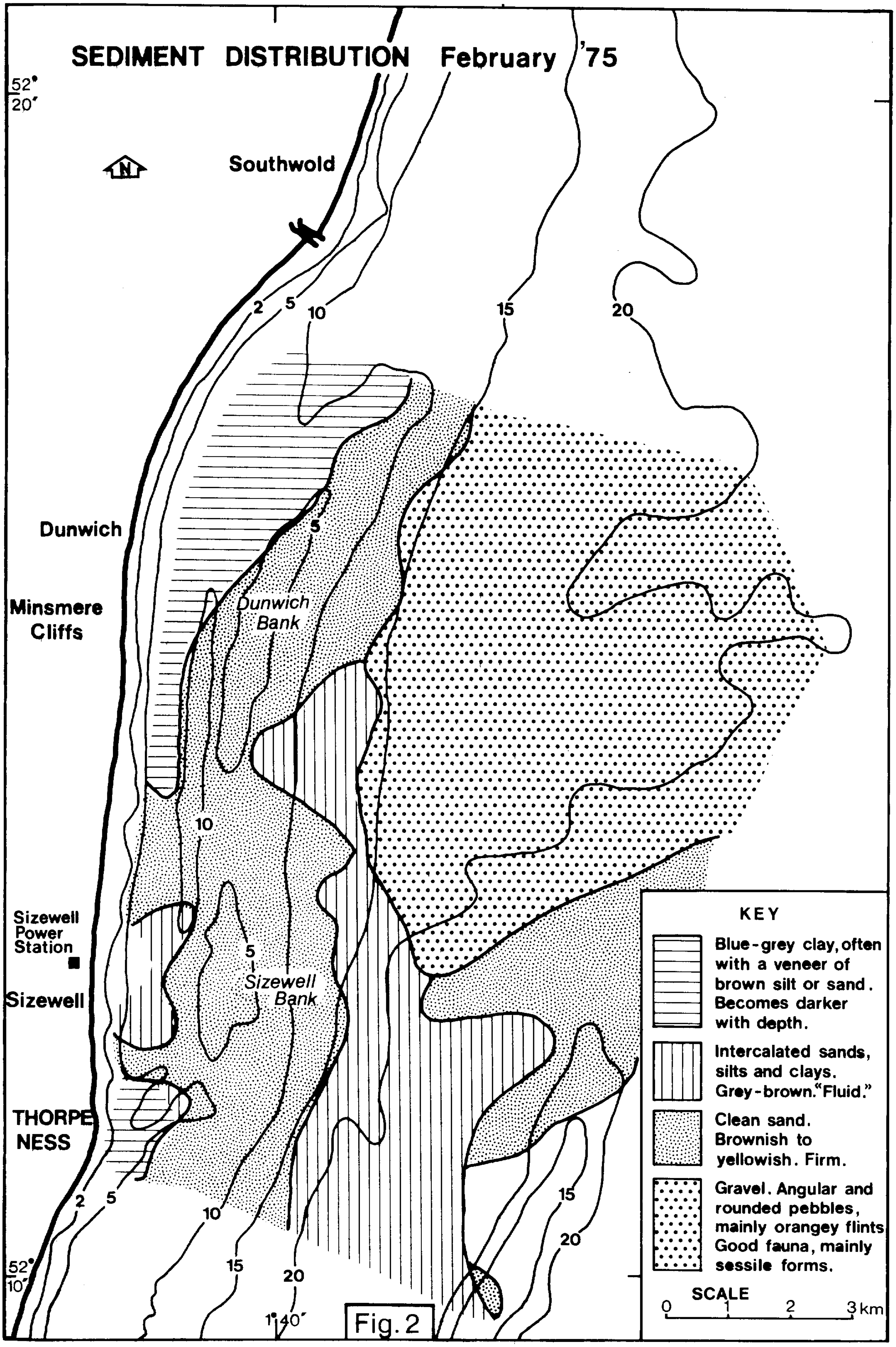
During the financial year 1979/80 a major effort will be put into data synthesis. Tidal component harmonic analysis will be carried out on current meter data to identify that part of the current caused by meteorological factors. Wind data from the Aldeburgh coastguard station will be used to look at meteorological forcing of the currents. Sediment transport rates will be calculated from these data and compared with the direct measurements made during the fluorescent tracer experiment. Pumped sampling concentrations will be considered in the light of theoretical expectations of behaviour. The total available current meter data will be used to give a synoptic view of the residual flow in the study area. It is hoped that a relationship can be shown to exist between the resulting pattern,and the sediment distribution and bathymetry changes in the area.

Probably most important of all, these results will be compared with similar ones from Swansea Bay. The two areas offer important contrasts which make such a study worthwhile and to clarify this they will be tabulated.

| Swansea Bay | Sizewell-Dunwich Banks |
|---|---|
| 1. Zeta-shaped bay | 1. Open coastline |
| 2. Coastline fairly stable | 2. Coastline easily eroded, giving large sediment supply to area. |
| 3. Tidal range 4.1m Neaps<br>8.6m Springs | 3. Tidal range 1.1m Neaps<br>1.9m Springs |
| 4. Maximum fetch WSW across Atlantic giving long period waves. | 4. Maximum fetch across North Sea only, giving shorter period waves. |
| 5. Suspended sediment $< 4.00\ \phi$ | 5. Suspended sediment $> 4.00\ \phi$ |
| 6. Dredging and engineering works influencing natural processes. | 6. No major engineering or dredging, although there are some minor works. |

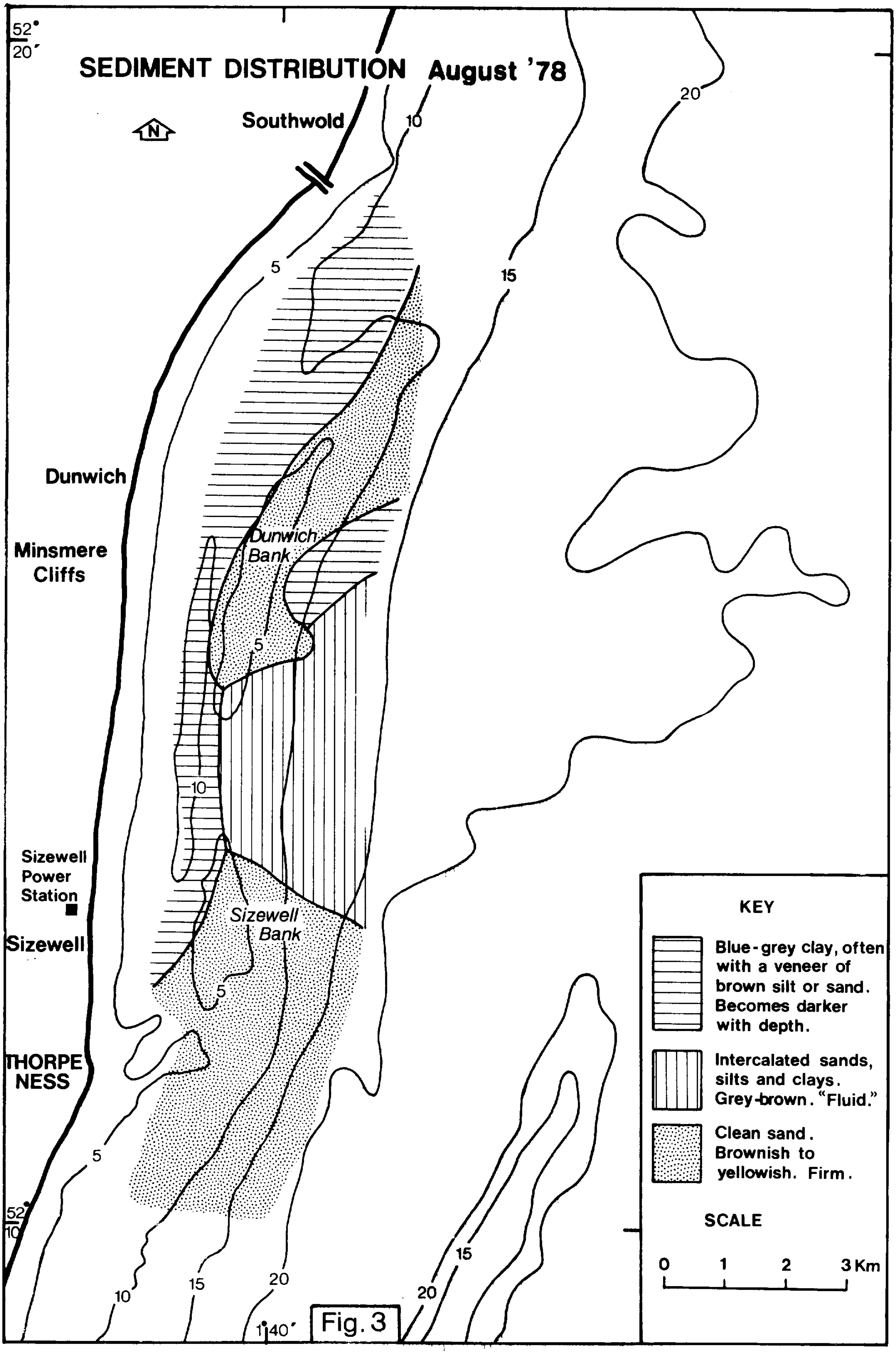
From this comparison it is hoped to deduce which common factors control large scale sediment transport processes. It may then be possible to apply the knowledge elsewhere around the coasts of Britain. In particular it should become clearer which of the many available sediment transport formulae are applicable in a given set of circumstances.


LOCATION MAP OF SIZEWELL AND DUNWICH BANKS, WITH CURRENT METER, VELOCITY PROFILING, TWO WAVE RECORDER STATIONS AND WAVERIDER STATIONS.
N
Dunwich
Minsmere Cliffs
Dunwich Bank
Sizewell Power Station
Sizewell
Sizewell Bank
THORPE NESS
VP1
VP2
VP3
52° 10'
1° 40'
STUDY AREA
KEY
Wave recorder station
Waverider buoy station
Current meter station with 2 weeks good data
Current meter station with 2 months good data
Long term mooring
Velocity profiling station
SCALE
0 1 2 3 4
Km
Fig. 1



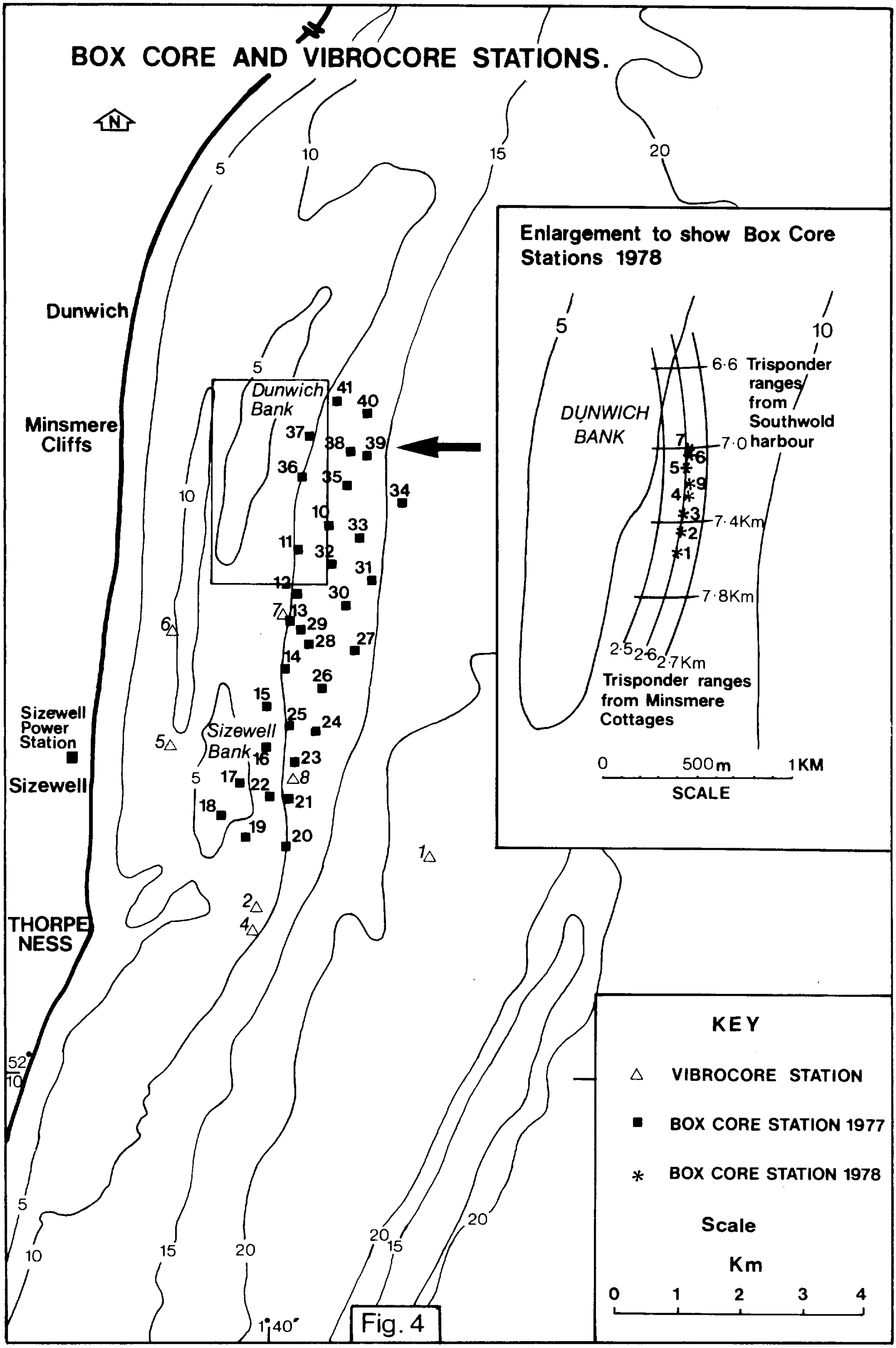
SEDIMENT DISTRIBUTION February '75
52° 20'
N
Southwold
Dunwich
Minsmere Cliffs
Sizewell Power Station
Sizewell
THORPE NESS
52° 10'
1° 40'
Dunwich Bank
Sizewell Bank
2
5
10
15
20
KEY
Blue-grey clay, often with a veneer of brown silt or sand. Becomes darker with depth.
Intercalated sands, silts and clays. Grey-brown."Fluid."
Clean sand. Brownish to yellowish. Firm.
Gravel. Angular and rounded pebbles, mainly orangey flints Good fauna, mainly sessile forms.
SCALE
0 1 2 3 km

Fig. 2



SEDIMENT DISTRIBUTION August '78
52° 20'
N
Southwold
Dunwich
Minsmere Cliffs
Sizewell Power Station
Sizewell
THORPE NESS
52° 10'
1°40'
Dunwich Bank
Sizewell Bank
5
10
15
20
KEY
Blue-grey clay, often with a veneer of brown silt or sand. Becomes darker with depth.
Intercalated sands, silts and clays. Grey-brown. "Fluid."
Clean sand. Brownish to yellowish. Firm.
SCALE
0 1 2 3 Km


Fig. 3



BOX CORE AND VIBROCORE STATIONS.
N
Dunwich
Minsmere Cliffs
Sizewell Power Station
Sizewell
THORPE NESS
Dunwich Bank
Sizewell Bank
Enlargement to show Box Core Stations 1978
DUNWICH BANK
6·6
7·0
7·4Km
7·8Km
Trisponder ranges from Southwold harbour
2·5
2·6
2·7Km
Trisponder ranges from Minsmere Cottages
0
500m
1KM
SCALE
KEY
VIBROCORE STATION
BOX CORE STATION 1977
BOX CORE STATION 1978
Scale
Km
0
1
2
3
4
52° 10'
1° 40'


Fig. 4

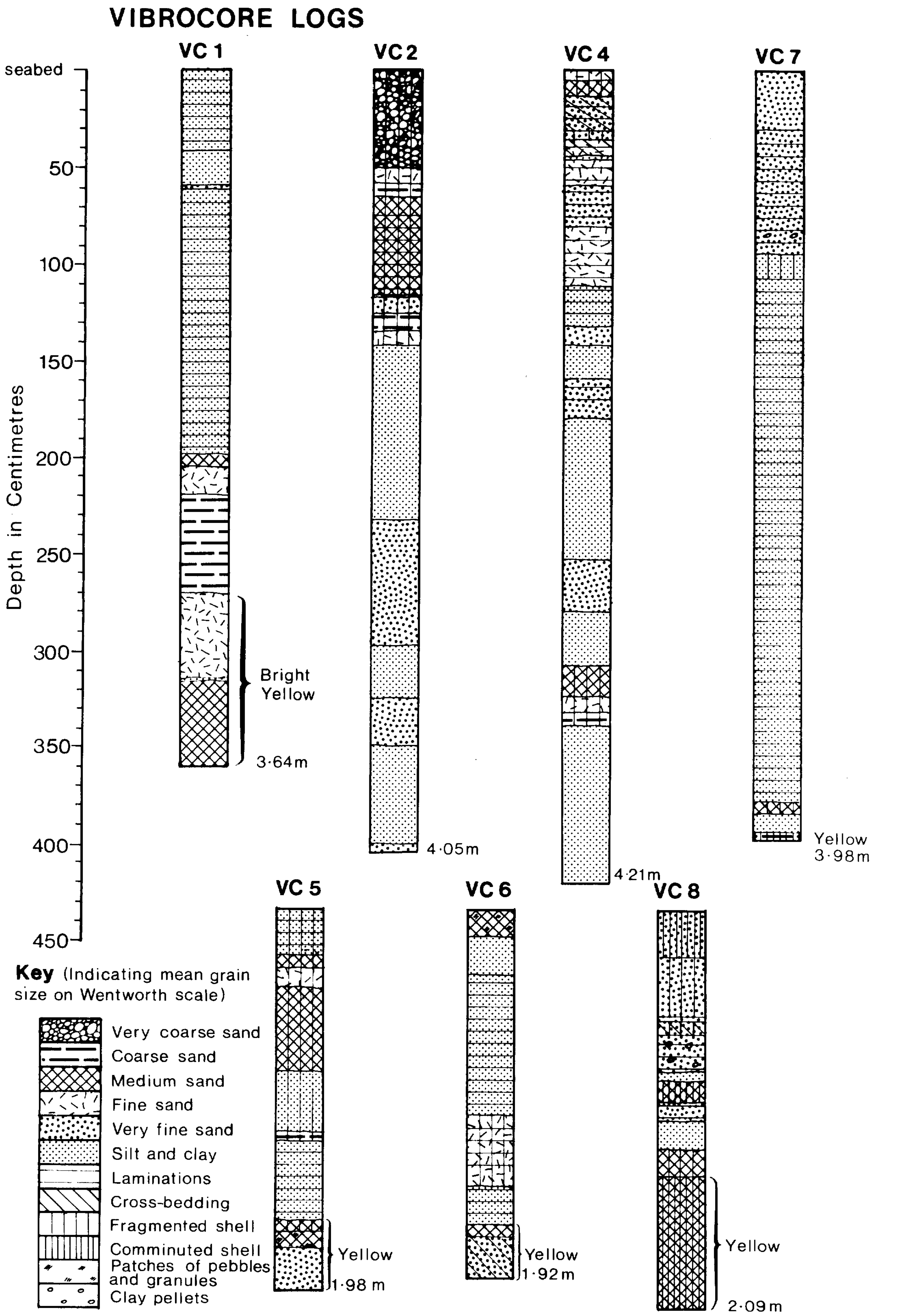
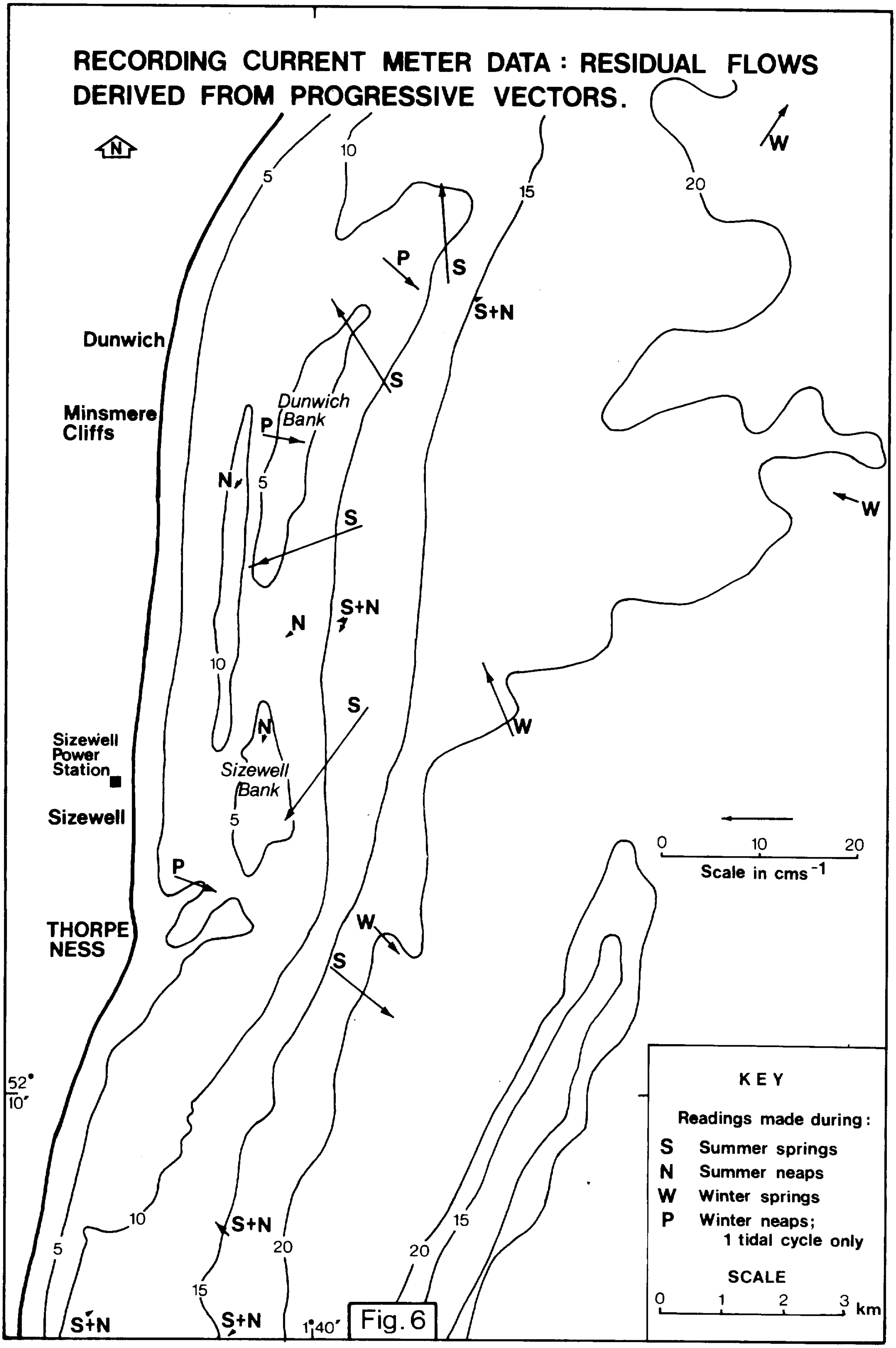
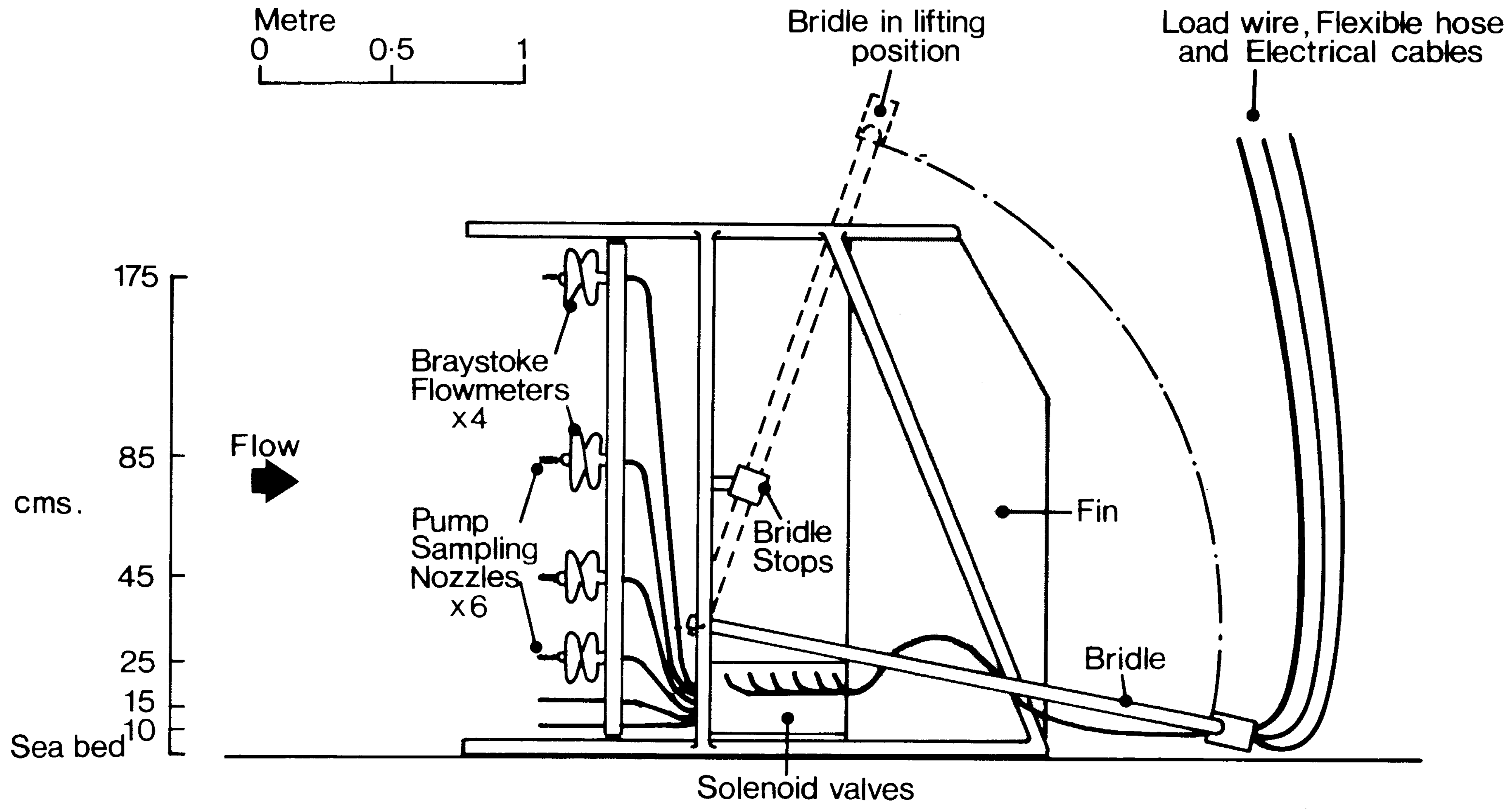

VIBROCORE LOGS
VC 1
VC 2
VC 4
VC 7
seabed
50
100
150
200
250
300
350
400
450
Depth in Centimetres
Bright Yellow
3·64m
4·05m
4·21m
Yellow
3·98m
VC 5
VC 6
VC 8
Yellow
1·98 m
Yellow
1·92m
Yellow
2·09m
Key (Indicating mean grain size on Wentworth scale)
Very coarse sand
Coarse sand
Medium sand
Fine sand
Very fine sand
Silt and clay
Laminations
Cross-bedding
Fragmented shell
Comminuted shell
Patches of pebbles and granules
Clay pellets

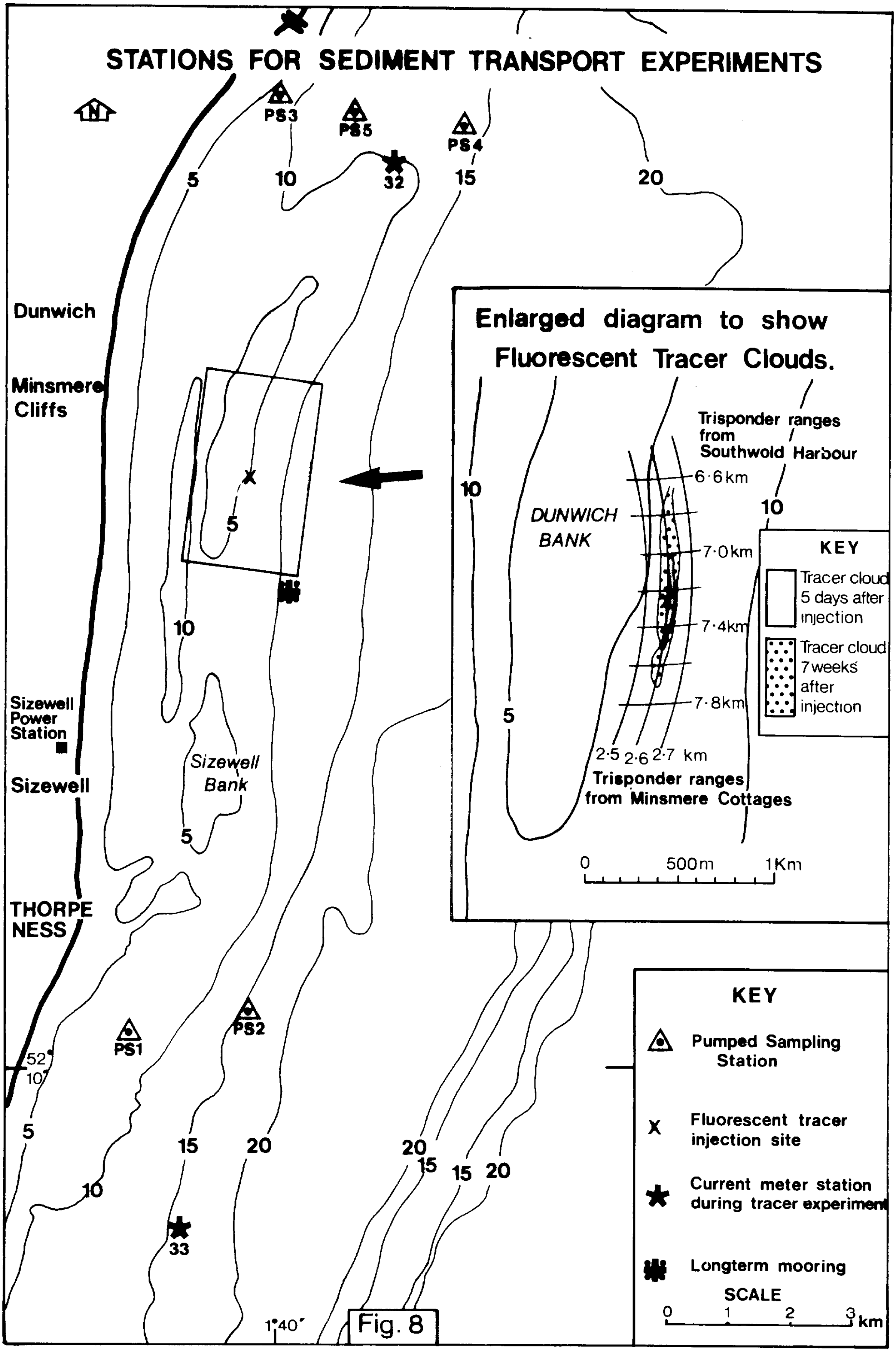
Fig. 5


RECORDING CURRENT METER DATA : RESIDUAL FLOWS DERIVED FROM PROGRESSIVE VECTORS.
N
Dunwich
Minsmere Cliffs
Dunwich Bank
Sizewell Power Station
Sizewell
Sizewell Bank
THORPE NESS
52° 10′
1°40′
Scale in cms⁻¹
0
10
20
KEY
Readings made during:
S Summer springs
N Summer neaps
W Winter springs
P Winter neaps; 1 tidal cycle only
SCALE
0 1 2 3 km
Fig. 6




SCHEMATIC DIAGRAM OF PUMPED SAMPLING APPARATUS

Fig. 7


STATIONS FOR SEDIMENT TRANSPORT EXPERIMENTS
N
PS3
PS5
PS4
32
5
10
15
20
Dunwich
Minsmere
Cliffs
Sizewell
Power
Station
Sizewell
Sizewell
Bank
THORPE
NESS
PS1
PS2
52°
10'
33
1°40'
Enlarged diagram to show
Fluorescent Tracer Clouds.
Trisponder ranges
from
Southwold Harbour
6·6km
7·0km
7·4km
7·8km
DUNWICH
BANK
2·5 2·6 2·7 km
Trisponder ranges
from Minsmere Cottages
KEY
Tracer cloud
5 days after
injection
Tracer cloud
7 weeks
after
injection
0 500m 1Km
KEY
Pumped Sampling
Station
Fluorescent tracer
injection site
Current meter station
during tracer experiment
Longterm mooring
SCALE
0 1 2 3 km
Fig. 8

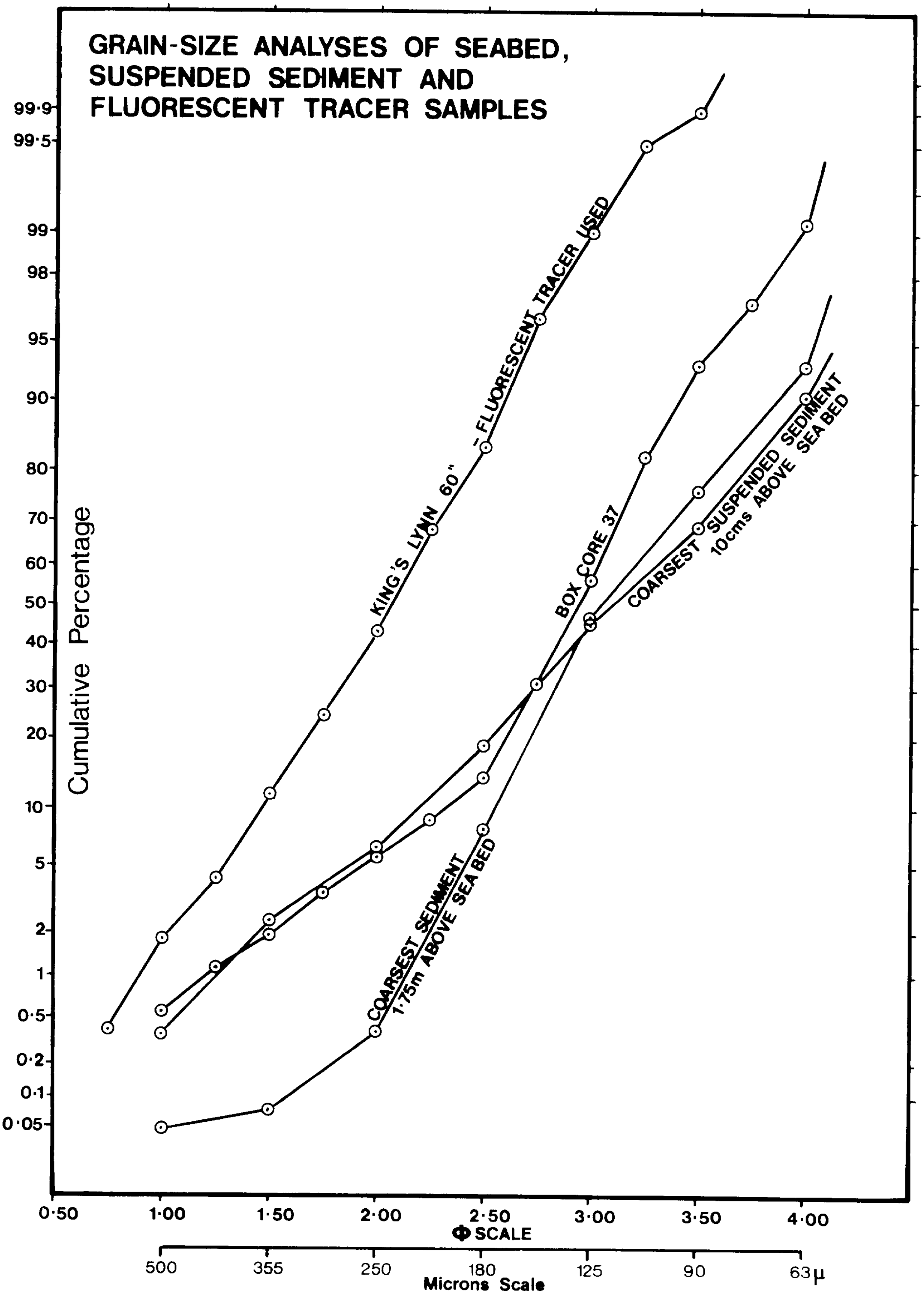
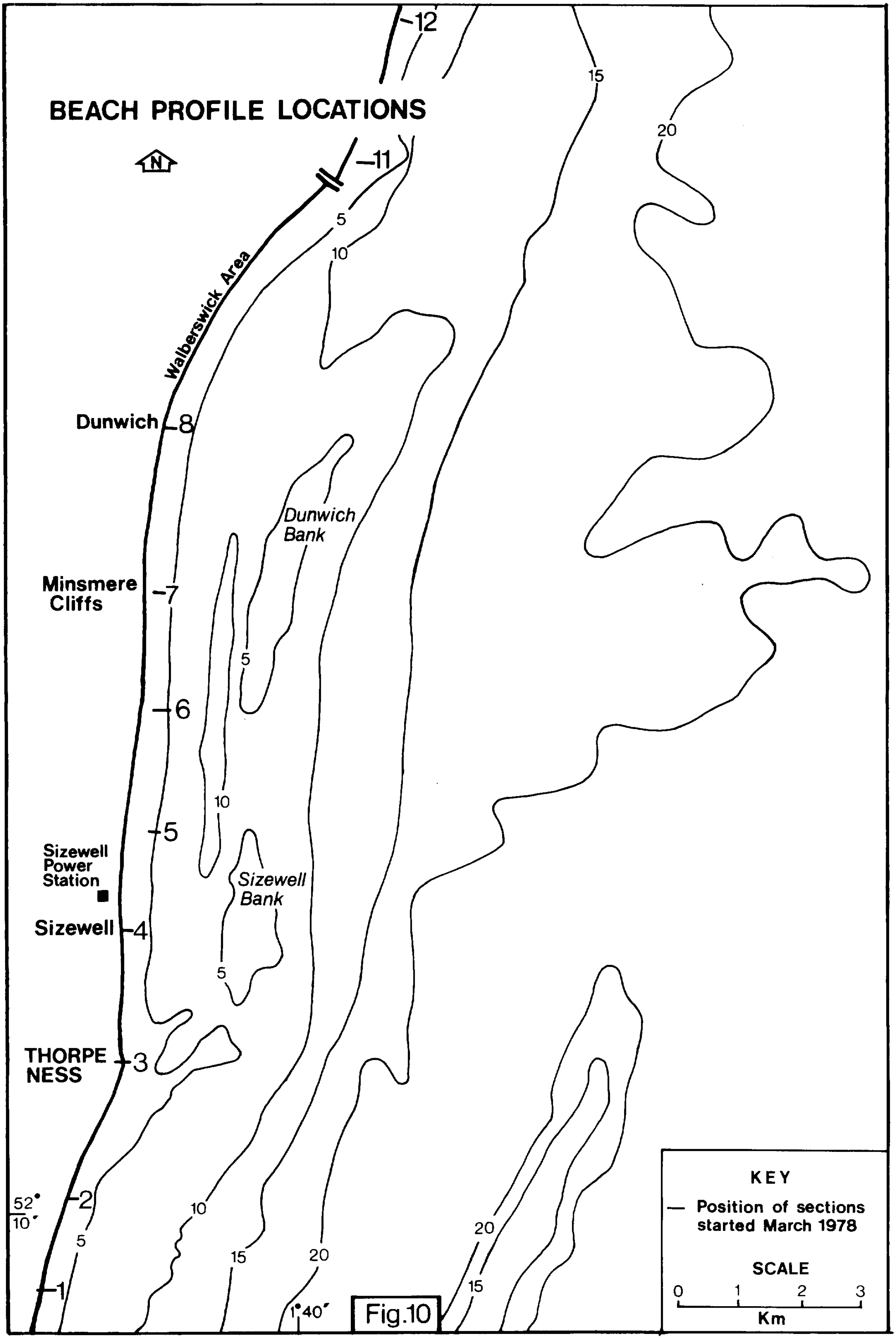
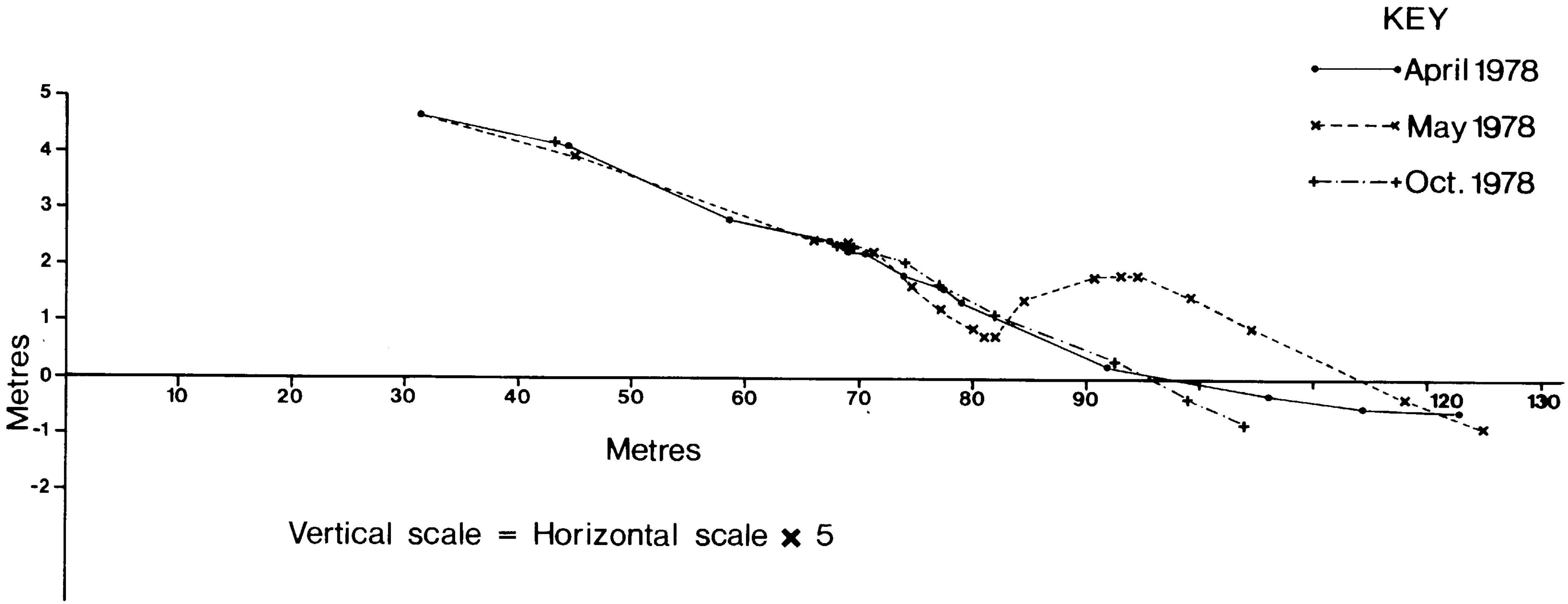

GRAIN-SIZE ANALYSES OF SEABED, SUSPENDED SEDIMENT AND FLUORESCENT TRACER SAMPLES
Cumulative Percentage
99·9
99·5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0·5
0·2
0·1
0·05
KING'S LYNN 60" - FLUORESCENT TRACER USED
BOX CORE 37
COARSEST SUSPENDED SEDIMENT 10cms ABOVE SEA BED
COARSEST SEDIMENT 1·75m ABOVE SEA BED
0·50
1·00
1·50
2·00
2·50
3·00
3·50
4·00
Φ SCALE
500
355
250
180
125
90
63μ
Microns Scale

Fig. 9


BEACH PROFILE LOCATIONS
N
Walberswick Area
Dunwich
Minsmere Cliffs
Sizewell Power Station
Sizewell
THORPE NESS
Dunwich Bank
Sizewell Bank
1
2
3
4
5
6
7
8
11
12
5
10
15
20
52°
10'
1°40'
KEY
— Position of sections started March 1978
SCALE
0
1
2
3
Km
Fig.10




Vertical scale = Horizontal scale × 5

**SECTION 3. THORPENESS, showing maximum variation measured between March and October 1978**

Fig. 11