C2220/X/257 (Proj. 495)

INTERNAL DOCUMENT No. 257.
(495)

I.O.S.

# Wave Climate Studies in UK Waters

Department of Energy
Project 495

Final Report

E.G. Pitt

1986

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## History of the Work.

The origin of the work which was the subject of project 495 lies in pre-Rothschild days when The National Institute of Oceanography ran a programme of measurements using the Shipborne Wave Recorder fitted to station keeping ships of opportunity.
With the advent of the Rothschild arrangements the programme was continued with support from the Departments of Energy and Industry under a succession of agreements leading up to project 495, funded from April 1979 to March 1984 by the Department of Energy.
These arrangements permitted the scope of the programme to be extended to include work on the methodology of wave measurement and the analysis of wave data. During these projects IOS has obtained data from a number of positions around the coasts of the United Kingdom (shown on the map in figure 2 ) using standardised methods, for longer periods then was previously possible, while building the expertise necessary to carry out the work in a professional and economic manner.

## Description of the Work.

The wave climate programme included wave measurements, recording, preliminary analysis, further statistical treatments, routine reporting, data banking with the Marine Information and Advisory Service and reporting of results of scientific interest in the literature.
Supporting these activities was a programme of improvements in methods. These ranged from improvements in the wave measuring instruments themselves to methods of data recording, analysis and presentation.
The programme had close links with other Department of Energy projects, in particular the work on the statistics of waves and the Wave Energy Research and Development Programme.
When the latter programme came to an end, two of the sites were transferred to the wave climate programme. These were South Uist Deepwater and the Isles of Scilly, and they were supported under this project from April 1983.

## Instrumentation and recording.

Two instrument systems were used: the Tucker shipborne wave recorder (SBWR) and the Datawell Waverider buoy. A new electronics unit for the SBWR was introduced during the period of the project, but efforts to update the data recording were not entirely satisfactory and the primary recording medium remained pen and paper.
Latterly, however, progress has been made with the introduction of on-board microcomputers.
Digital recording was adopted as standard for the Waveriders throughout the programme with two generations of recorders being used. More recently, on-site microprocessors have been used to perform the analysis which was previously carried out using the laboratory computer.
Table 1 and its associated explanations summarise the history of the measurement programme and the introduction of new techniques.

Performance of the measuring programme.

The performance of the programme is quantified as the number of wave records which have passed the primary data validation process, expressed as a percentage of the possible number. These are shown in Tables 2a - 2i and figures 1A - 1E.

Presentation and Reporting of results:

During the project the suite of computer programs for the statistical analysis of the results and the presentation of these in graphical form was substantially completed and documented.
The report format was also standardised and extensive use was made of word processing techniques in the production of reports.
A list of IOS Reports dealing with wave climate results and related matters appears at Table 3a.
I.O.S. Internal Documents, which are limited distribution reports, were written on a number of topics during the project and these are listed in Table 3b.
Reports and papers which appeared in other publications, including conference proceedings and the open literature appear in Table 3c.

Table 1. Wave measuring sites with chronology of major events.

| SITE | | EVENT | DATE |
|---|---|---|---|
| OWS LIMA | | 1) Introduction of digital recording | November 1978 |
| | | 2) Introduction of Starella (based at Fleetwood) and Cumulus (based at Rotterdam) phasing out of Admiral Fitzroy and Admiral Beaufort (both based at Greenock). | 10 Jan 1982 |
| | | 3) Introduction of the HP9915 micro-computer. | 25 sept 1983 |
| SEVEN STONES LV | | 1) Light Vessel refitted | June/July 1981 |
| | A | 2) Introduction of MkII SBWR | 01 July 1981 |
| | E | 3) Introduction of the HP9915 Micro-computer. | 20 Dec 1984 |
| ST.GOWAN LV | | 1) Light Vessel refitted | 24 Oct 1979 |
| | A | 2) Introduction of MkII SBWR. | 09 Jan 1980 |
| CHANNEL LV | C | 1) Channel LV experiment conducted by G.N.Crisp. | 17 Oct 1980 - 10 Nov 1980 |
| | A | 2) Light vessel refitted. MkII SBWR. | 27 Oct 1982 |
| | B | 3) Trials of FM cassettes. | 27 Oct 1982 |
| DOWSING LV | A | 1) Light vessel refitted. MkII SBWR. | Jul - Dec 1981 |
| | B | 2) Trials of FM cassettes | December 1981 |
| SOUTH UIST | | 1) Introduction of Microdata logger | 28 Mar 1979 |
| | D | 2) Installation of HP9915 microcomputer | 21 Apr 1983 |
| ISLES OF SCILLY | | 1) Double length records | 06 Mar 1981 |
| | | 2) Modem, continuous logger and Micro-data. | 15 Sep 1981 - 02 Aug 1983 |
| | | 3) HP9915 microcomputer installed | 25 May 1983 |

| | | |
|---|---|---|
| | 4) Testing of the HP9915 | May 1983 - |
| D | 5) Regular use of the HP9915 | August 1983 |
| | 6) One and a half hourly records | August 1983 |
| D | 7) Use of the 'Digitalker'. | 02 Aug 1983 |

Development and introduction of new instrumentation and data processing techniques.

Table 1 lists the wave recording sites in the programme with a chronology of the major events which affected the data.
Several of the events listed in Table 1 require further explanation, these have been indicated with a letter which corresponds to the paragraph in which it is dicussed below.

A) Mark II Shipborne wave recorder.
The MKI shipborne wave recorder Tucker (1956) was replaced by an updated version using solid state electronics Haine (1980).

B) Frequency modulated cassettes.
A feasibility study was carried out using a waverider buoy prior to the trials on Channel LV and Dowsing LV. The results are given in Hardcastle (1981).
The trials on Channel and Dowsing LV gave unsatisfactory wave period comparisons, therefore the frequency modulated cassette system was not implemented.

C) The Channel LV experiment.
A comparison of a shipborne wave recorder and a waverider buoy was conducted at Channel LV. The results obtained are given Crisp (in press).

D) Introduction of HP9915 microcomputers on waverider sites.
The introduction of the HP9915 microcomputer system allowed the data collection and computing to be carried out on-site. Previously the data were recorded on-site and subsequently replayed and analysed in the laboratory. On-site analysis eventually enabled a 'Digitalker' to be installed at the Isles of Scilly. Anyone wishing to know Hs and Tz can telephone direct to the Isles of Scilly and obtain the information. Some house keeping information is also transmitted for use by the engineers.

E) Introduction of the HP9915 microcomputers on SBWR sites.
The introduction of the HP9915 microcomputer system at present installed on Seven Stones LV and soon to be installed on Dowsing LV has allowed data collection and computing to be carried out onboard the Light Vessels. After a satisfactory comparison has been done between the HP9915 system and the SBWR chart analysis process it is hoped that the HP9915 system will become the primary data source.

References

TUCKER, M.J. (1956) A shipborne wave recorder.
Trans. Instn. Nav. Archits. (London) Vol 98 p236.

HAINE, R.A. (1980) Second Generation shipborne wave recorder.
Transducer Technology Volume 2 Issue 2.

HARDCASTLE, P.J. (1981) ANALYSIS OF SEA WAVES. A comparison of simple methods to obtain significant wave height.
Internal Document No. 143.

CRISP, G.N. (in press) An experimental comparison of a shipborne wave recorder and a waverider buoy conducted at the Channel LV.
IOS report No 141.

Percentage return of valid data.

For each site the following tables (2a-2i) show the percentage return of valid data arranged an financial years. The data contained in each table is also illustrated graphically in figures (1A - 1E)

O.W.S. LIMA Table 2a

Month

| YEAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 79/80 | 86 | 60 | 73 | 03 | 66 | 21 | 75 | 81 | 75 | 86 | 69 | 79 |
| 80/81 | 78 | 79 | 69 | 87 | 79 | 83 | 78 | 62 | 83 | 67 | 75 | 78 |
| 81/82 | 81 | 67 | 70 | 73 | 67 | 81 | 83 | 78 | 82 | 82 | 78 | 70 |
| 82/83 | 63 | 03 | 72 | 17 | 53 | 48 | 46 | 31 | 68 | 57 | 67 | 66 |
| 83/84 | 70 | 30 | 85 | 79 | 87 | 79 | 80 | 75 | 75 | 69 | 71 | 74 |

SEVEN STONES L.V. Table 2b

Month

| YEAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 79/80 | 98 | 99 | 100 | 99 | 100 | 58 | 94 | 98 | 100 | 100 | 100 | 99 |
| 80/81 | 100 | 99 | 100 | 99 | 99 | 100 | 99 | 98 | 97 | 99 | 100 | 98 |
| 81/82 | 100 | 98 | 14 | 00 | 75 | 65 | 53 | 92 | 98 | 99 | 98 | 98 |
| 82/83 | 99 | 99 | 99 | 97 | 100 | 98 | 99 | 99 | 94 | 93 | 100 | 100 |
| 83/84 | 100 | 99 | 99 | 94 | 98 | 98 | 100 | 99 | 99 | 98 | 99 | 94 |

ST GOWAN L.V. Table 2c

Month

| YEAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 79/80 | 97 | 98 | 96 | 99 | 87 | 98 | 57 | 00 | 00 | 00 | 00 | 00 |
| 80/81 | 88 | 99 | 100 | 13 | 00 | 88 | 100 | 20 | 39 | 100 | 100 | 69 |
| 81/82 | 93 | 71 | 97 | 100 | 95 | 100 | 96 | 100 | 89 | 65 | 00 | 00 |
| 82/83 | 00 | 36 | 99 | 82 | 98 | 98 | 97 | 99 | 36 | 69 | 97 | 99 |
| 83/84 | 95 | 99 | 100 | 98 | 98 | 99 | 97 | 99 | 100 | 67 | 64 | 10 |

DOWSING L.V. Table 2d

Month

| YEAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 79/80 | 88 | 90 | 100 | 100 | 90 | 100 | 98 | 100 | 100 | 100 | 100 | 97 |
| 80/81 | 98 | 96 | 100 | 100 | 98 | 99 | 98 | 100 | 100 | 98 | 100 | 100 |
| 81/82 | 95 | 98 | 44 | 00 | 00 | 00 | 00 | 00 | 00 | 49 | 100 | 56 |
| 82/83 | 100 | 100 | 98 | 98 | 99 | 100 | 100 | 99 | 97 | 56 | 00 | 00 |
| 83/84 | 42 | 99 | 100 | 98 | 98 | 99 | 100 | 99 | 100 | 99 | 82 | 91 |

CHANNEL L.V. Table 2e

Month

| YEAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 79/80 | -- | -- | -- | -- | -- | 97 | 89 | 100 | 97 | 99 | 99 | 100 |
| 80/81 | 100 | 98 | 99 | 84 | 98 | 99 | 36 | 13 | 100 | 100 | 100 | 100 |
| 81/82 | 98 | 99 | 99 | 100 | 98 | 77 | 56 | 100 | 100 | 99 | 42 | 00 |
| 82/83 | 32 | 100 | 100 | 98 | 91 | 00 | 00 | 00 | 51 | 98 | 91 | 99 |
| 83/84 | 97 | 100 | 100 | 98 | 98 | 98 | 100 | 100 | 98 | 100 | 89 | 69 |

SOUTH UIST (OFFSHORE) Table 2f

Month

| YEAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 79/80 | 75 | 71 | 91 | 57 | 58 | 25 | 54 | 45 | 40 | 67 | 90 | 64 |
| 80/81 | 94 | 97 | 94 | 92 | 77 | 90 | 00 | 00 | 00 | 21 | 08 | 00 |
| 81/82 | 05 | 96 | 98 | 99 | 90 | 98 | 95 | 88 | 97 | 99 | 94 | 94 |
| 82/83 | 78 | 86 | 71 | 95 | 98 | 98 | 90 | 57 | 00 | 00 | 32 | 00 |
| 83/84 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

SOUTH UIST (DEEPWATER) Table 2g

Month

| YEAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 79/80 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 80/81 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 81/82 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 82/83 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 83/84 | 21 | 81 | 29 | 86 | 78 | 64 | 49 | 78 | 44 | 00 | 20 | 39 |

ISLES OF SCILLY Table 2h

Month

| YEAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 79/80 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 80/81 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 81/82 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 82/83 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 83/84 | 99 | 99 | 98 | 88 | 86 | 52 | 83 | 94 | 93 | 00 | 47 | 82 |

EDDYSTONE Table 2i

Month

| YEAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 79/80 | 93 | 98 | 98 | 99 | 00 | 29 | 98 | 65 | 68 | 94 | 98 | 90 |
| 80/81 | 97 | 97 | 98 | 100 | 100 | 99 | 97 | 96 | 97 | 94 | 92 | 98 |
| 81/82 | 98 | 99 | 97 | 69 | 98 | 97 | 41 | 70 | 82 | 96 | 96 | 95 |
| 82/83 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 83/84 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

The percentage valid data returns for the Shipborne wave recorder (SBWR) sites were generally very good (shown in tables 2a - 2e), with the exception of Ocean Weather Station Lima (table 2a) which will be discussed later. The four light vessels operating with SBWR were brought into dock to be refitted during the five years considered, these were:

St Gowan L.V. October 1979 - March 1980
Seven stones L.V. June/July 1981
Dowsing L.V. July - December 1981
Channel L.V. September - December 1982

During these periods a relief vessel operated on each site, however it was not fitted with a wave recorder so no wave measurements were taken. The other occasions when the percentage valid data returns were low were caused by instrumentation faults.
Ocean Weather Station Lima has two ships which operate on the site. One ship attends the site for approximately one month and is then relieved by the other ship. The percentage valid data returns for this site were generally lower than for any other of the sites which are operating with the SBWR because the ship change overs did not always overlap; also as the ships which operate on this station are not permanently moored in position, they sometimes drift off station and have to steam back onto position. When the ships are steaming the wave data collected is not usuable because of disturbance caused to the wave measurements. In latter years data has been regularly lost because of interference to the wave recordings caused by the remote control of Telex transmissions of the Meteorological data. Action to solve this problem has not been successful as the control commands follow an irregular time pattern. Therefore the wave recording times cannot be easily altered so that they avoid the Telex transmission periods. In addition, there were several instances during the five financial years considered (shown in table 2a) when there were very low percentages of valid data return, in most cases these were caused by instrumentation faults, however in November 1982 one of the ships operating on the site did not sail so the wave data was not collected.

The percentage valid data returns for the waverider sites are also good (shown in tables 2f - 2i). The periods when there were low percentages of valid data return were when the buoys were lost from station.

I.O.S. WAVE DATA REPORTS PUBLISHED SINCE 1979. Table 3a.

Waves at Ocean Weather Station 'Alpha'.
CARTER, D.J.T. and DRAPER, L.
IOS Report No 69 1979.
Composite data from period 1959 - 1971.

Contoured wave data off South Uist.
FORTNUM, B.C.H., HUMPHERY, J.D. and PITT, E.G.
IOS Report No 71 1979
Data from 1976 - 1977.

Waves recorded at Aldeburgh, Dunwich and Southwold on the East Coast of England.
FORTNUM, B.C.H and HARDCASTLE, P.J.
IOS Report No 65 1979.
Data from 1975 - 1977.

Waves recorded at Port Talbot on the South Wales Coast.
FORTNUM, B.C.H. and HARDCASTLE, P.J.
IOS Report No 78 1979.
Data from 1975 -1976, 1977.

Waves recorded at Scarweather Bank in the Bristol Channel.
FORTNUM, B.C.H. and HARDCASTLE, P.J.
IOS Report No 79 1979.
Data from 1976 - 1977.

Waves recorded off South Uist in the Hebrides.
FORTNUM, B.C.H.
IOS Report No 115 1981
Data from 1976 - 1978.

Waves recorded at St Gowan Light Vessel.
FORTNUM, B.C.H.
IOS Report No 125 1981.
Data from 1975 - 1976, 1977 - 1978.

Waves recorded at Dowsing Light Vessel.
FORTNUM, B.C.H.
IOS Report No 126 1981
Data from 1970 - 1971, 1975 - 1976, 1977 - 1979.

Waves recorded off Eddystone Lighthouse.
FORTNUM, B.C.H.
IOS Report No 132 1982
Data from 1978 - 1981.

Waves recorded at Ocean Weather Station ' Lima '.
GLEASON, R.
HMSO Department of Energy report
Data from 1975 - 1981.

Return wave heights off South Uist - estimates from seven years of data.
STANTON, B.R.
IOS Report No 164 1984.

INTERNAL DOCUMENTS PRODUCED SINCE 1979. Table 3b.

The Hebrides waverider installments.
HUMPHERY, J.D.
Internal Document No 113 1981.

Spectral analysis of wave data.
PITT, E.G.
Internal Document No 120 1981.

A user guide to IOS digital wave data time series.
GLEASON, R.
Internal Document No 154 1982.

Predictability of surface wave spectra from a parametric spectral model.
ARANUVCHUPUN, S.
Internal Document No 219 1984.

ANALYSIS OF SEA WAVES. A comparison of simple methods to obtain significant wave heights.
HARDCASTLE, P.J.
Internal Document No 143 1981.

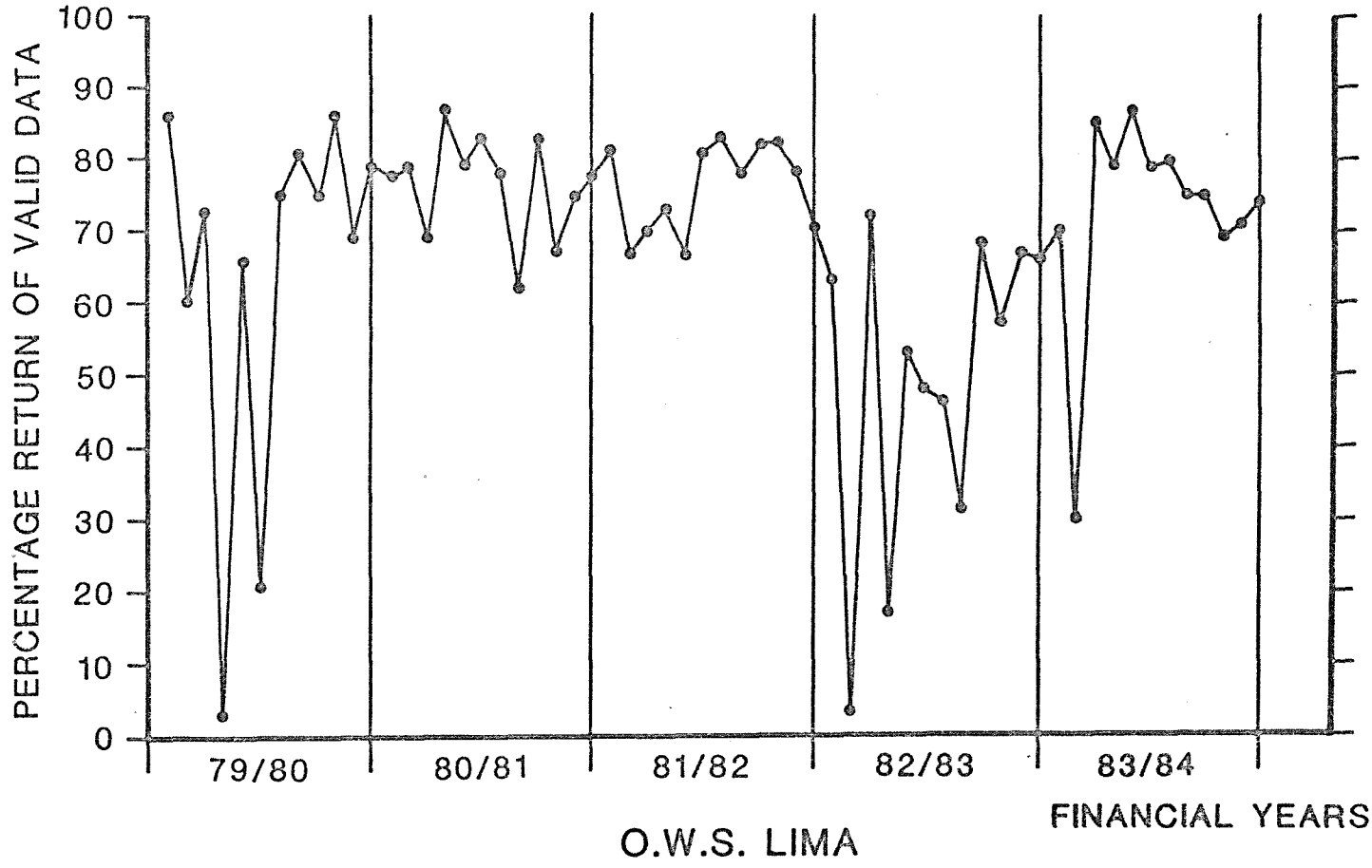
PUBLICATIONS. Table 3c.

Estimating return values of environmental parameters.
CARTER, D.J.T. and CHALLENOR, P.G. (1981)
Quarterly Journal Royal Meteorological Society. Vol 107 No 451.

Threshold methods for sample extremes
SMITH, R.L. (1984)
Ed. J. Tiago de Oliveira. Statistical extremes and applications.
Dordrecht: Reidel pp 621 - 638.

The measurement of Ocean waves and currents.
PITT, E.G. (1980)
Journal of the Society for Underwater Technology 6 No. 4 pp 4 - 12.

Progress in Wave Climate Studies at I.O.S.
PITT, E.G. and FORTNUM, B.C.H. (1980)
Sea Climatology, proc of international conference, Paris 1979.
Editions Technip, Paris pp 191 - 205.



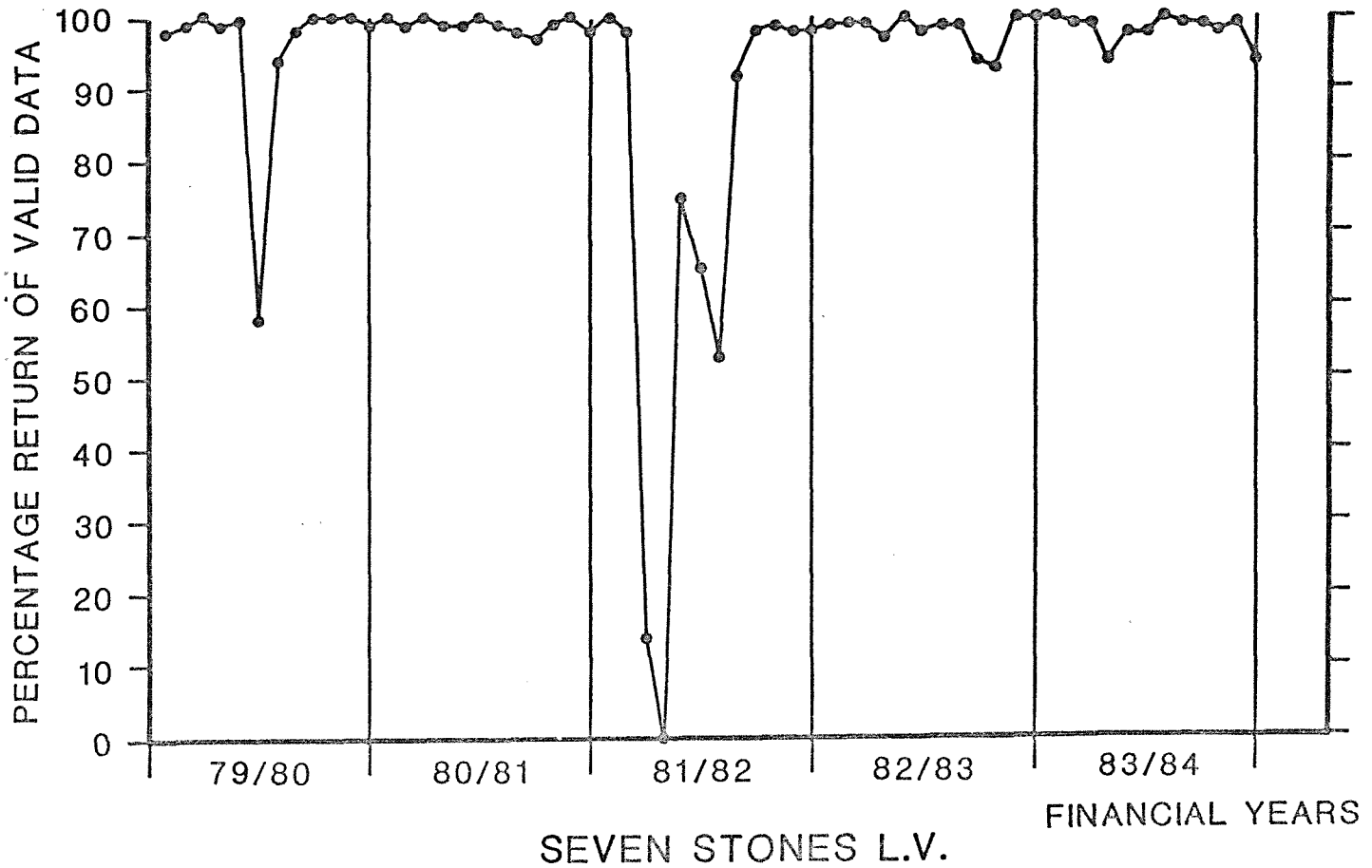
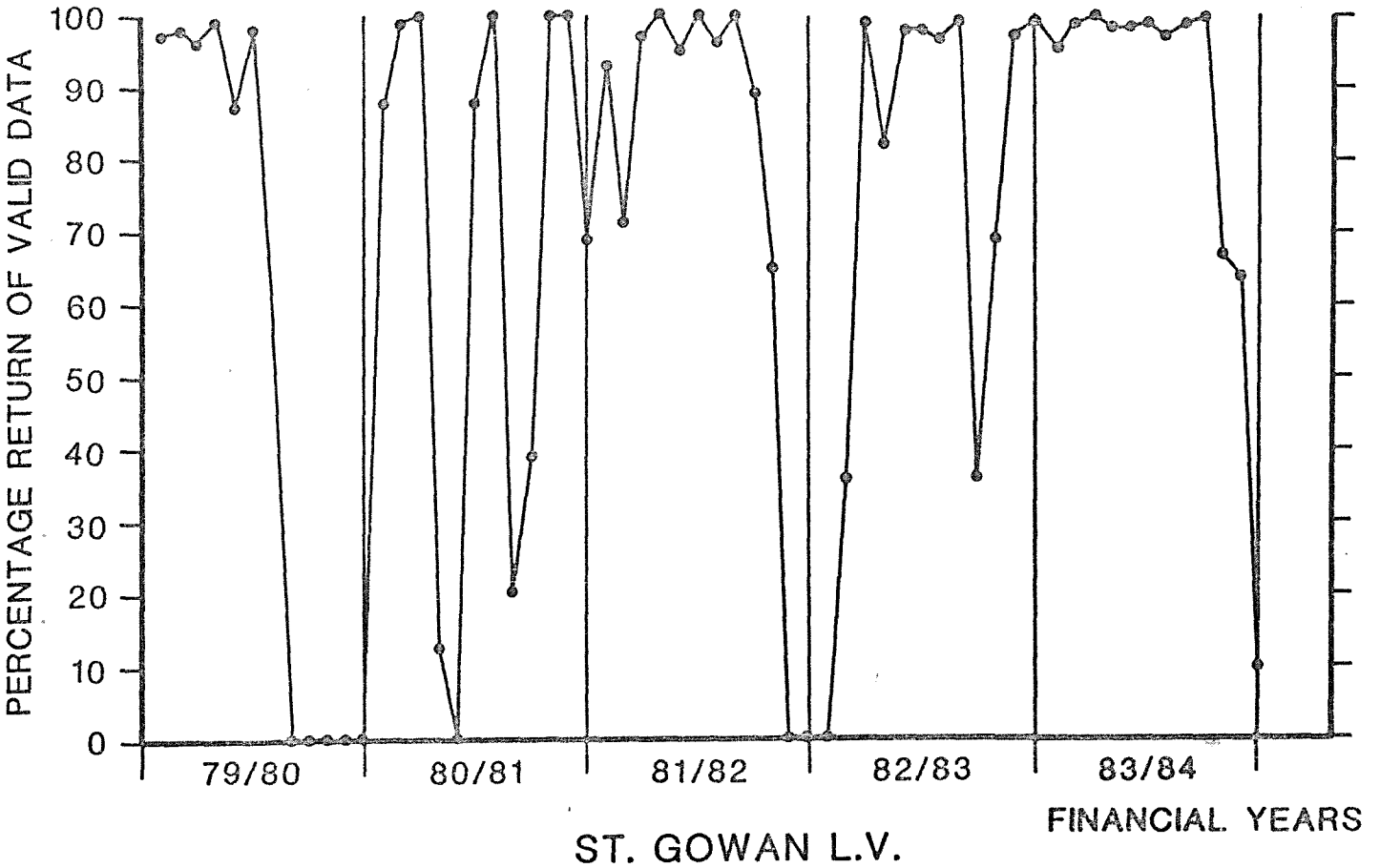




FIGURE 1A - MONTHLY DATA RETURNS



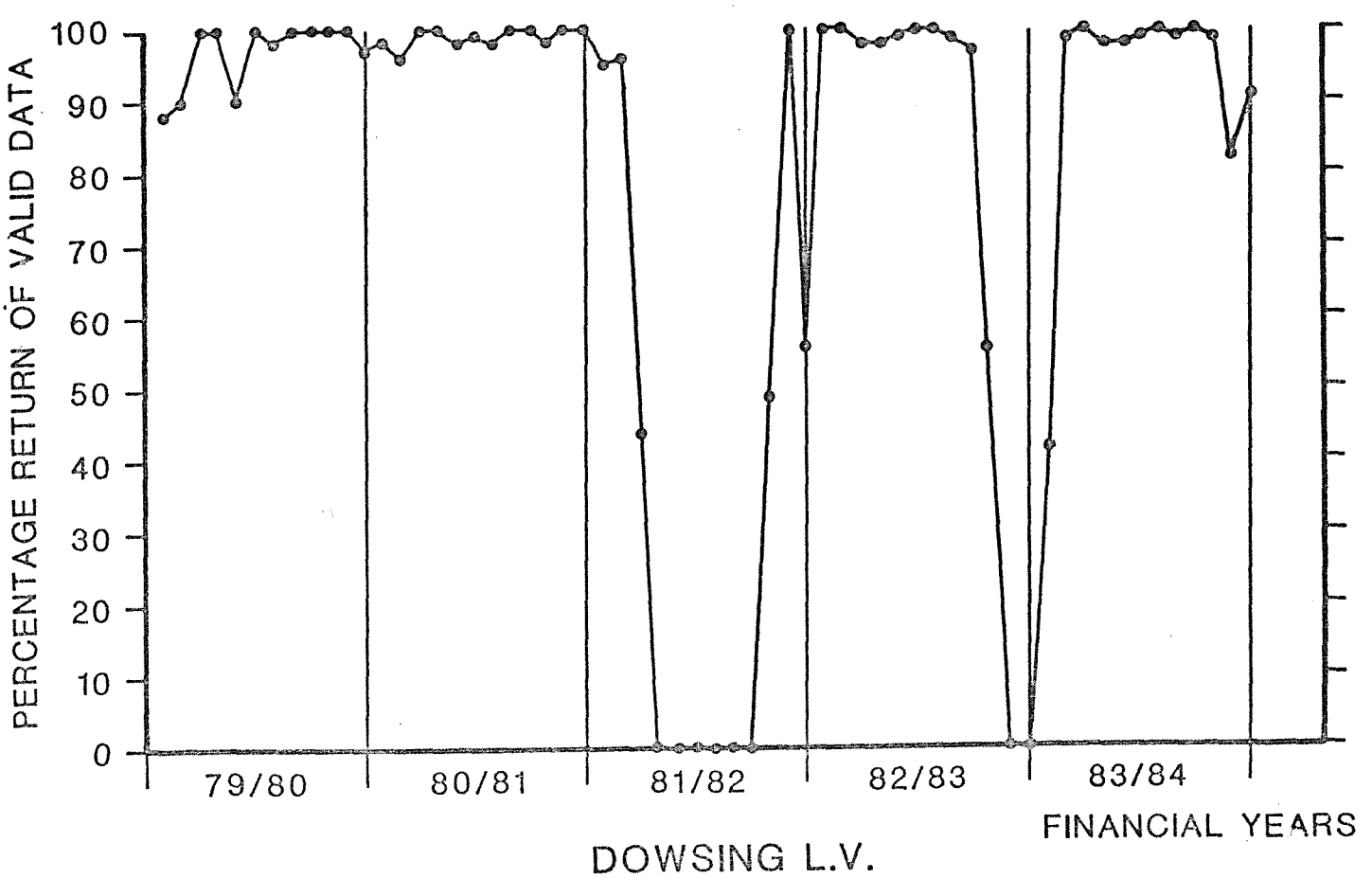
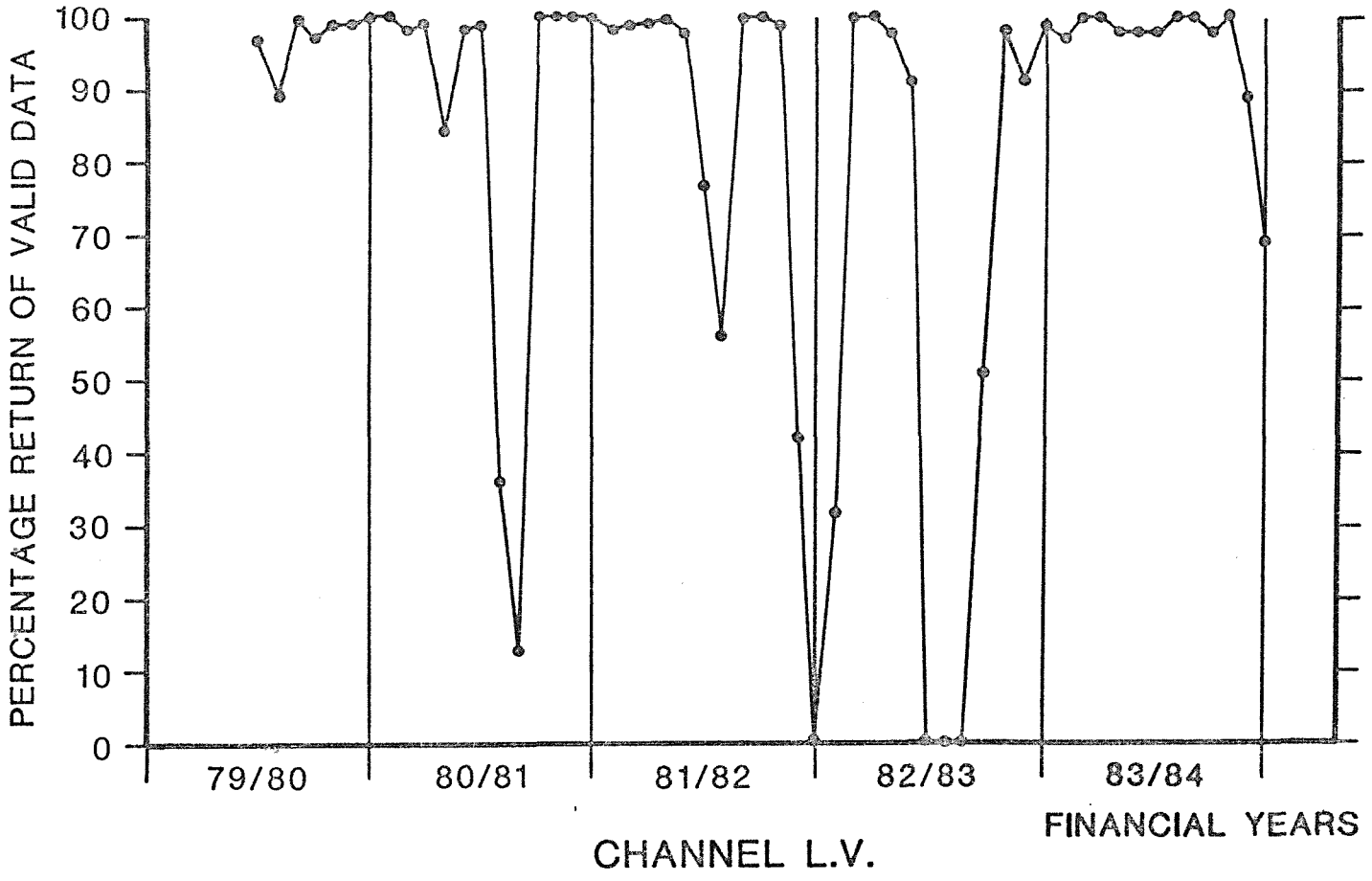




FIGURE 1B - MONTHLY DATA RETURNS



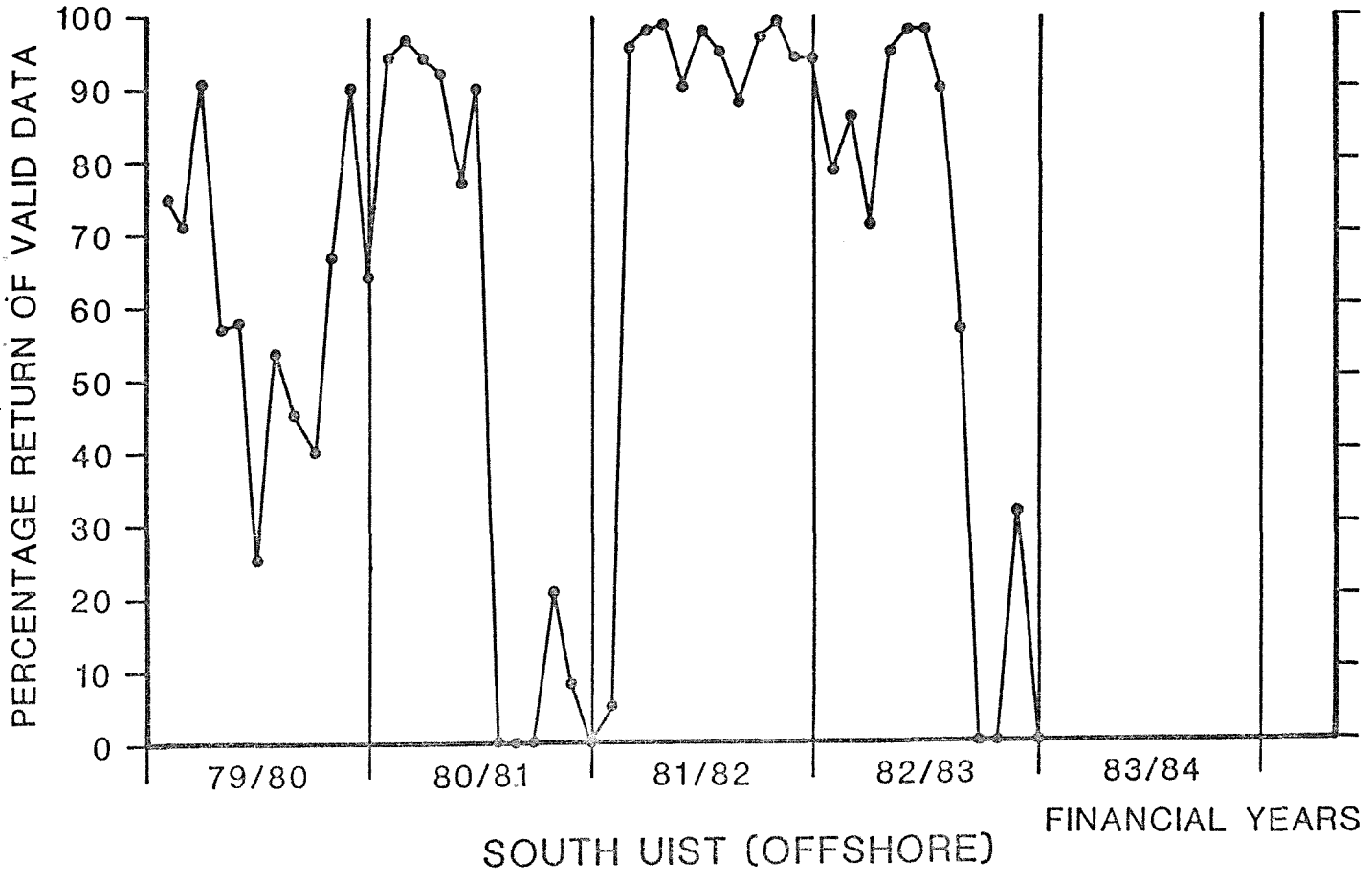
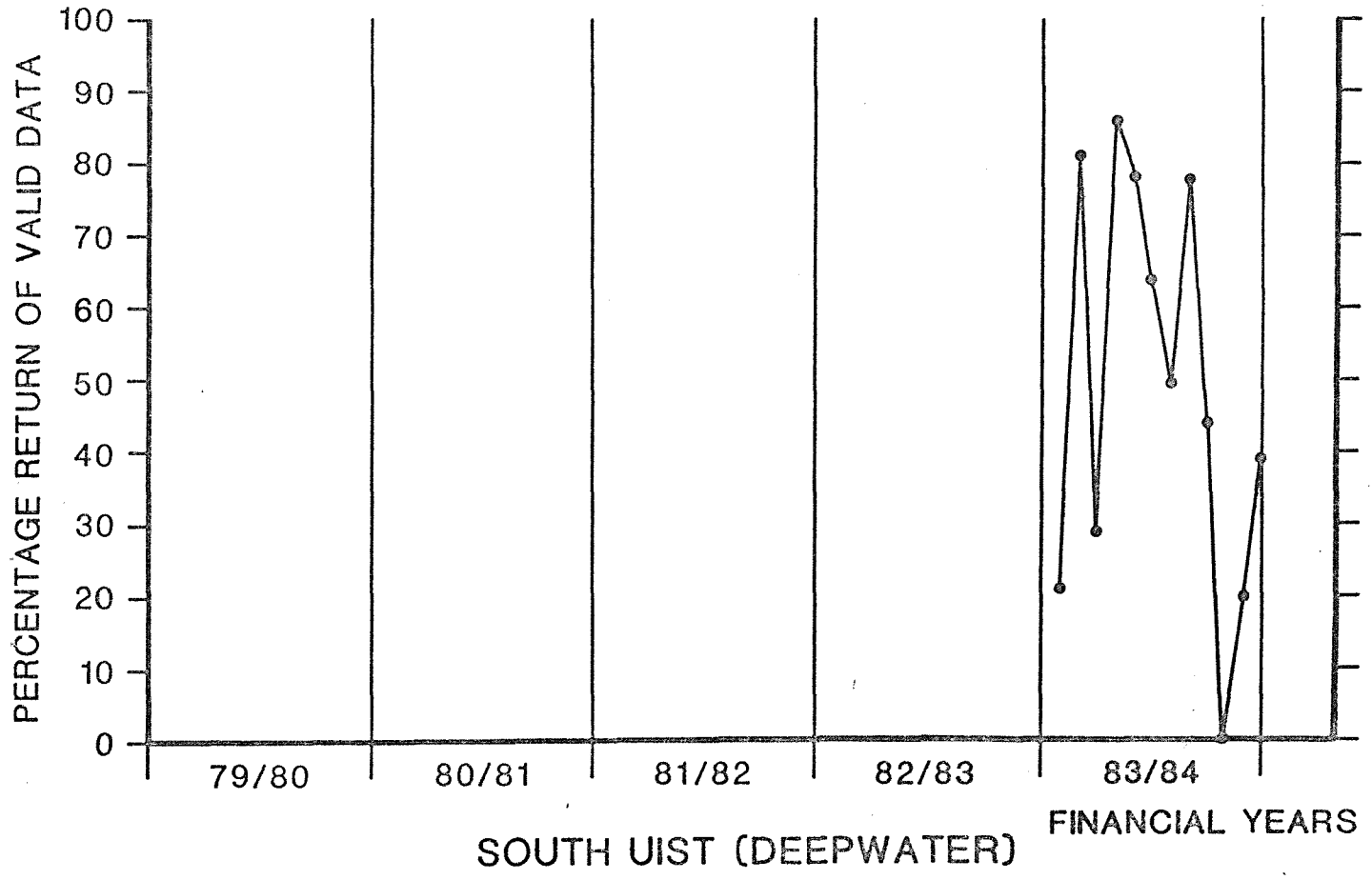




FIGURE 1C - MONTHLY DATA RETURNS



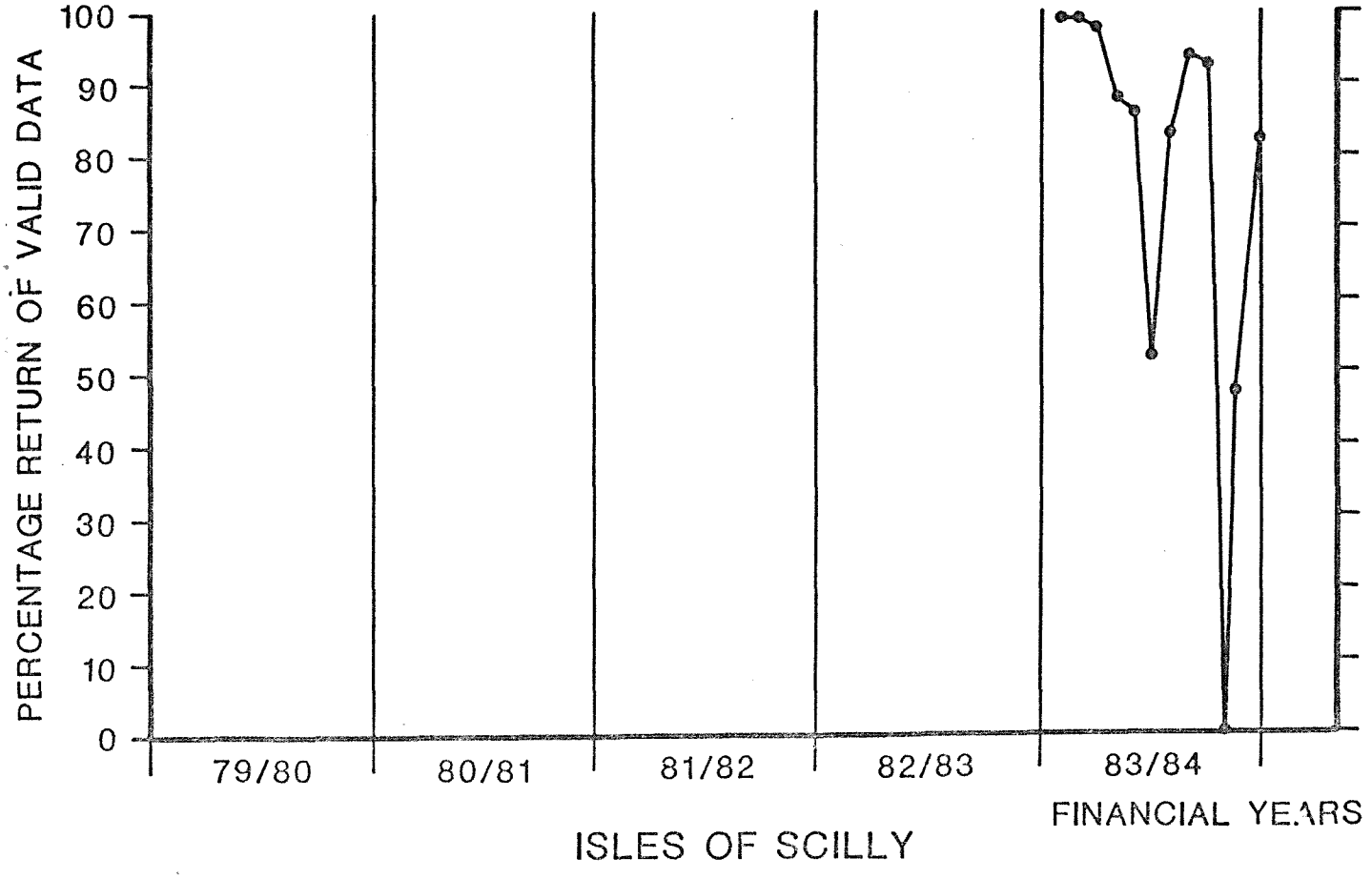




FIGURE 1D - MONTHLY DATA RETURNS

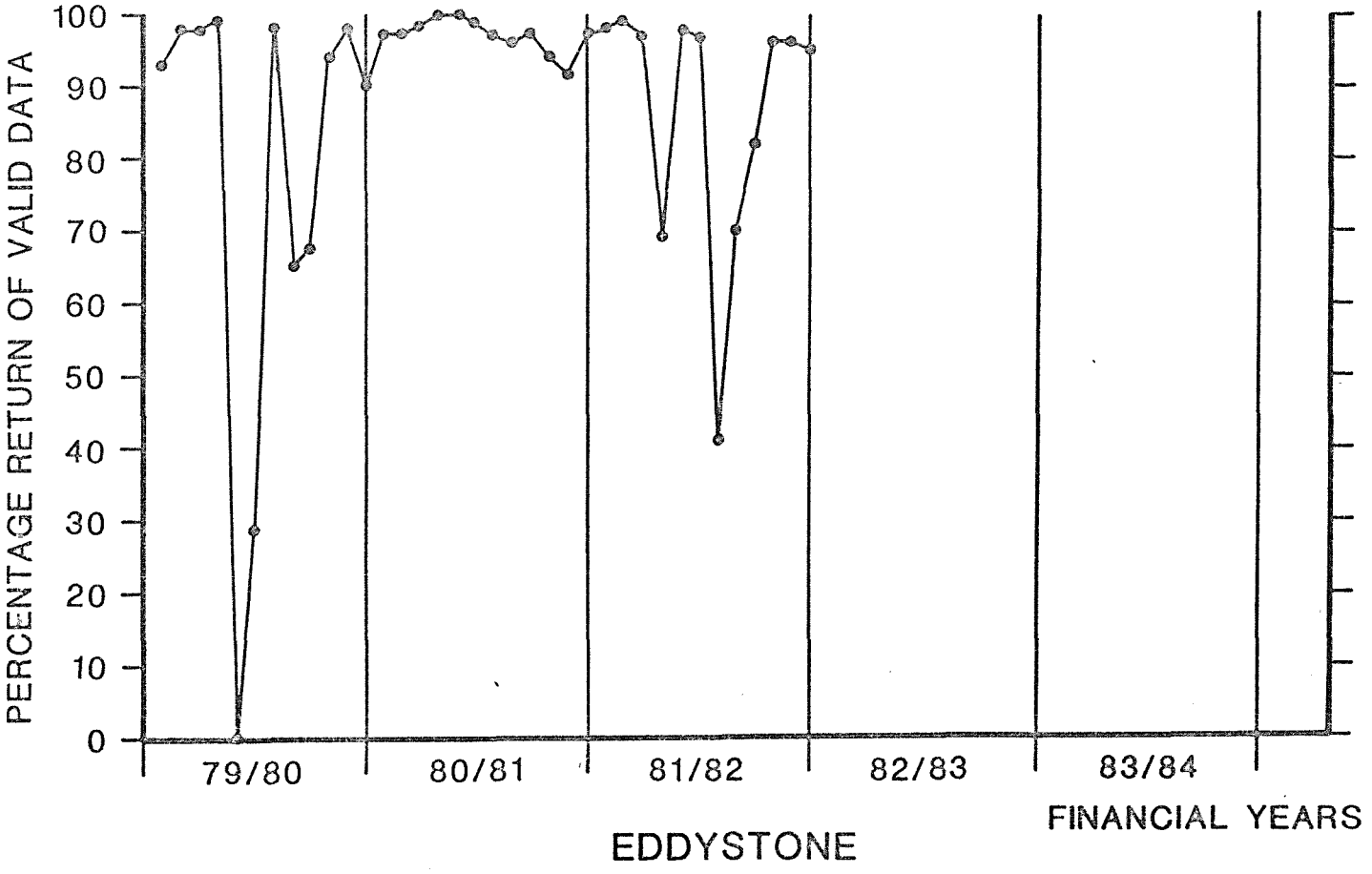
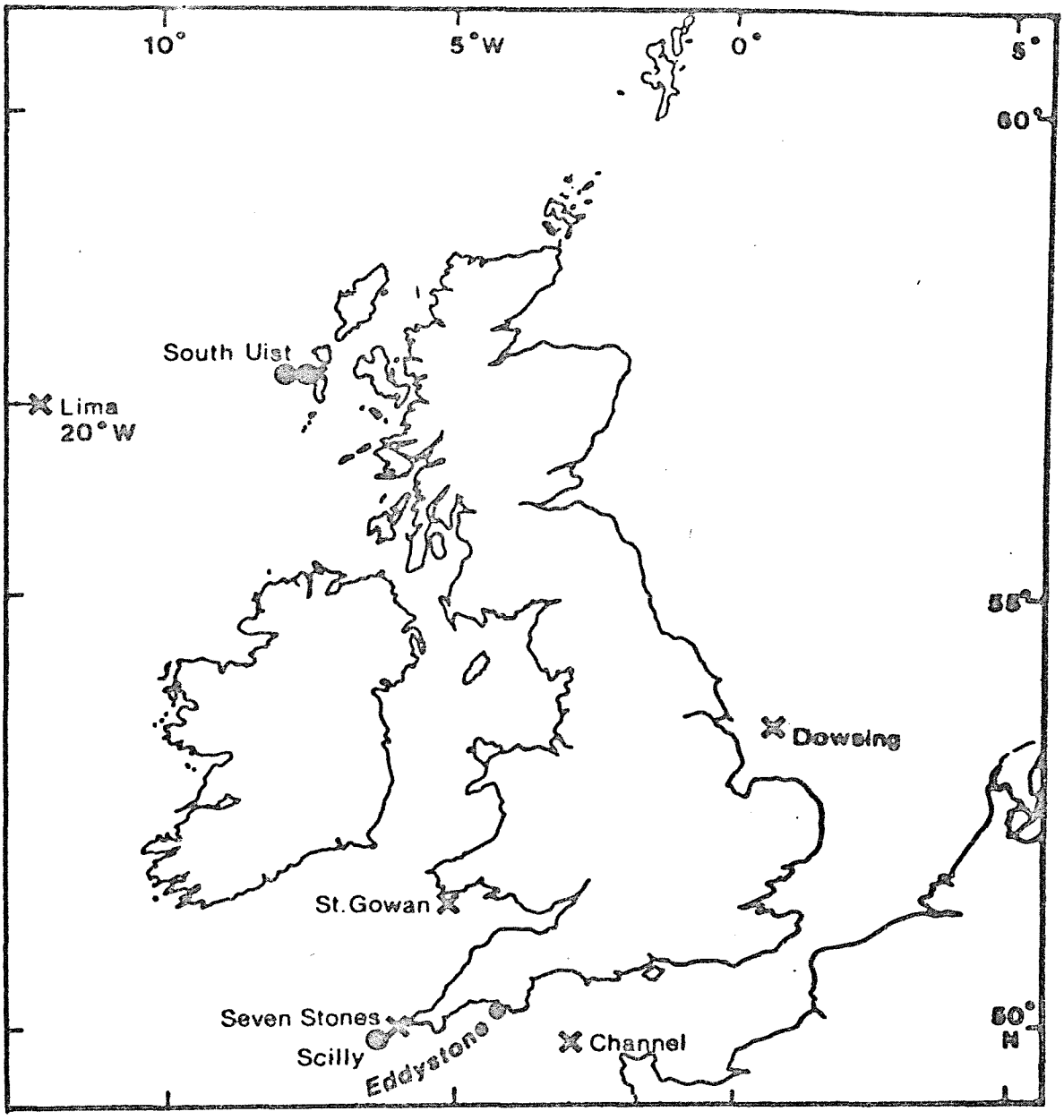



FIGURE 1E - MONTHLY DATA RETURNS




● Waverider

✕ S.B.W.R.

Principal stations in the I.O.S. Wave Climate Study.

Fig. 2