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INTERNAL DOCUMENT 21

I.O.S.

Results of Data Validation procedures carried out at the Institute of Oceanographic Sciences on data from the United Kingdom Offshore Operators Association environmental data collection programme.

NATURAL ENVIRONMENT RESEARCH COUNCIL
INSTITUTE OF OCEANOGRAPHIC SCIENCES

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Results of Data Validation procedures carried out at the Institute of Oceanographic Sciences on data from the United Kingdom Offshore Operators Association environmental data collection programme.

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Results of Data Validation Procedures carried out at the Institute of Oceanographic Sciences on data from United Kingdom Offshore Operators Association Environmental Data Collection Programme

Current Meter data

Stations: Stevenson, Boyle and Fitzroy

Period: April 1975 to the termination of Stevenson and Fitzroy Stations.
April 1975 to April 1976 for Boyle.

No 4 in a series of reports to be submitted to the Department of Industry and the Department of Energy by the Natural Environment Research Council, Institute of Oceanographic Sciences, Taunton. One further report covering the final year's data collected at the Boyle station will complete the validation of the current meter data collected for this programme.

CURRENT METER DATA

CONTENTS

Methods of data validation:

(i) Editing of raw data
(ii) Checks of the five-minute edited data
(iii) Plots of the five-minute-checked data
(iv) Vector-averages of the acceptable five-minute-checked data
(v) Computation of the tidal and non-tidal components
(vi) Plots of the tidal and non-tidal components
(vii) Spectral analysis of selected data
(viii) Definition of 'acceptable' category
(ix) Confidence placed on validation by plotting due to characteristic patterns in the data
(x) Difficulties involved in validating bottom current data
(xi) Method of calculating the percentage of 'acceptable' data
(xii) Calibration of the current meters

Discussion of results:

(i) Stevenson station
(ii) Boyle station
(iii) Fitzroy station

Tables summarising the results:

(i) Stevenson
(ii) Boyle
(iii) Fitzroy
(iv) All three by depth

IV Report

METHODS OF CURRENT DATA VALIDATION

The current data are received punched on paper tapes in the form of an impeller count and a meter direction (in degrees magnetic) taken every five minutes. The tapes are copied onto magnetic tape and magnetic disk. The latter are edited to remove any obviously false data from the beginning or end of the records. At this stage the data value corresponding to the immersion of the meter is identified as accurately as possible.

A computer program then performs simple checks on the data, removes spurious spikes and applies compass direction corrections. The program includes checking:

(i) the format of the records

(ii) that no compass direction exceeds 360 degrees

(iii) that no impeller count exceeds 1024 (the maximum recorded by the instrument)

(iv) that the differences calculated between consecutive current speeds do not exceed a given value (usually 20 cm sec^{-1}). (Any isolated large or small value of current speed is assumed to be due to instrument malfunction and is replaced by the previous good value. On rare occasions this may cause a 'cascade' effect which results in the replacement of a series of good data values. If this happens on an isolated occasion then the faulty value is manually replaced by an interpolated value and the computer program is rerun. However, if a succession of replacements occurs then the program is rerun on the original data values using a higher difference value (up to 80 cm sec^{-1}) so that the data series can be inspected).

The program produces two files, one containing the five minute checked data and the other containing half-hourly vector averages computed from the five minute checked data.

The five-minute checked data are examined for faults. The individual data values in each record are plotted on a polar diagram and each of the vector points is joined to the next in sequence. This polar plot is viewable on a VDU, whilst a permanent copy is made on a 35mm aperture card using a Microplotter. Both pieces of equipment are peripherals of the computer system. Any gross errors can be confirmed and less obvious errors may be revealed by plotting the individual five minute directions as a time series, and by resolving the five minute vector values into north and east velocity components and plotting these as a time series. When the data are found to be faulty, the records are not processed any further, and are classed as 'unacceptable'.

If no obvious errors have been seen in the plots of the five-minute checked data, then the corresponding half-hourly vector-averaged data are resolved into tidal and non-tidal (residual) components. The technique used is the response method, in which a computer program is used to correlate the vector-averaged data with a tidal height series at a nearby site, and so calculate the tidal and non-tidal components. (The non-tidal components form the basic data for many of the available techniques for estimating extreme currents). This method works best with data series lengths which are close to the lunar period of about 29 days, and therefore data of only a few days' duration are not processed in this way. The reference tidal series used in this validation work are those for Lerwick and Scilly. The method is fully described in a paper by Munk et al (1966) and more briefly in another by Cartwright et al (1969).

The next stage is an examination of these vector-averaged data and their components. Progressive vector plots are produced of both the vector-averaged currents and the non-tidal components; these show the virtual displacements at the meter locations, and also give an indication of how well the tidal components have been removed. If the plots show a large proportion of tidal energy remaining, this may be due either to incorrectly recorded velocities, in which case reference to the plots of the north and east components as time series may give some confirmation of this; or it may be due to an incorrect sampling interval, which may be detected by spectrally analysing the vector-averaged data and checking whether the peak lies at the tidal frequency as calculated from the stated sampling interval. (A further check on the sampling interval can be made by dividing the total time of deployment by the number of data points obtained; this may be less reliable in those cases when the deployment and retrieval times are not accurately identified).

If no outstanding error has been detected at this stage, the data is classed as 'acceptable'. It should be noted that no check is made on the magnitude alone of the currents before placing them in this category. It is possible to place reliance on the visual inspection of plots only because over a recording period of two or three weeks the current data show certain overall regularities and patterns which change very little from one month to another at each recording station. A typical pattern to emerge in the case of the polar plots is an elliptical distribution of currents, with the ellipse orientated in a specific way for each recording station (for example at Stevenson station good data almost always have the major axis of the ellipse aligned approximately NW-SE). Another prominent characteristic is the sense in which the current vector can be seen, on the VDU, to rotate during plotting, which is almost always clockwise for all stations. When data shows an orientation of ellipse which is a reflection in the north-south axis of that found for the majority of data at a specific

station, and when in addition the current vector has been observed to rotate in an anti-clockwise direction, it is usually assumed that the meter was placed on the mooring line upside-down. (The current meter design allows it to be moored upside down and still record data, which will then show both these characteristics). Further confirmation is provided by comparing the progressive vector diagram with those from meters moored at the same site for the same period but at different depths: if the virtual displacement is again a mirror image in the north-south axis of those for other meter positions then there is a high probability that the meter was moored upside-down. In these cases, if the record is otherwise acceptable it is classed as 'reprocessable' since the data that it would have recorded had the meter been properly moored can be salvaged by subtracting the original recorded directions from 360°.

Bottom current meter data does not appear to follow so closely the patterns described above (bottom currents are those recorded only 3 or 4 metres above the seabed). These data only rarely show the regular patterns that have been observed in the other data: the distribution of current vectors does not appear so obviously elliptical, the sense of rotation of the vectors is not always clockwise (at Fitzroy especially it is nearly always anti-clockwise) and the virtual displacement is usually much more complicated than the virtual displacements found in the top and middle waters. These irregularities may accurately describe the water movements at those depths, made complicated by the bottom topography; or they may be indicative of consistently malfunctioning current meters. This was difficult to ascertain in previous IOS validation reports when the same meter was deployed for consecutive months. The problem was highlighted on one occasion when a current meter was deployed for consecutive months producing very consistent, but very obviously faulty, data. However, with the more recent procedure introduced by Marex where a variety of meters is interchanged at various depths it would appear that some of the irregularities recur from month to month and meter to meter, suggesting that they reflect real phenomena at the sites. Many of the irregular bottom current meter records have been placed in the 'acceptable' category because only those records which have obvious and definite faults in them are placed in the 'unacceptable' category. This procedure is performed with more confidence in the light of the recent data returns for bottom meters covered by this report than has previously been the case.

Due to the complexities discussed above concerning current systems in confined waters, visual inspections of data plotted in a number of different ways have necessarily formed a large part of the quality control. The limitation of this approach is that only those errors which are evident from the plots are detected, although, as previously mentioned, spectral analysis is sometimes used to uncover less obvious errors.

The results of the quality control are presented in three sections, one for each location. At the end of each section the total durations are given in hours for each of the following:

(i) the data it was attempted to collect

(ii) the data found to be 'acceptable'

(iii) the data found to be 'unacceptable'

These figures have been calculated by multiplying the number of data points on each record (as notified by Marex) by the sampling interval in hours. In cases where a meter has been lost, the record length which might have been obtained has been taken as equal to the record lengths obtained by other meters deployed at the same time. In cases where all meters have been lost an average record length for that particular station has been substituted.

REFERENCES

1. Munk, W.H. and Cartwright, D.E. 1966. Tidal spectroscopy and prediction. Phil. Trans., A259, 533-581.

2. Cartwright, D.E., Munk, W. and Zetler, B. 1969. Pelagic tidal measurement. Transactions of the American Geophysical Union, 50, 472-477.

DISCUSSION OF THE RESULTS

Stevenson

The data considered in this part of the report cover deployments at the Stevenson Station for the period 4 April 1975 to 18 February 1976 when the station was closed down. During this time thirty-nine deployments of current meters took place. Nine of these occasions refer to three successive deployments of three meters during one cruise June - July 1975. Of the total number of attempts to collect data nine deployments were unsuccessful. These events usually have no record number so the deployment periods and meter numbers are listed:

20.6.75 to 27. 6.75	meter no 330	Successive deployments (during one cruise) of a flooded meter
4.7.75 to 14. 7.75	" " "	
16.7.75 to 28. 7.75	" " "	
8.10.75 to 26.10.75	" " 142	constant direction (acknowledged by Marex)
1.11.75 to 25.11.75	" " 333	no translation of the tape possible due to inter-message pulses (acknowledged by Marex)
1.11.75 to 25.11.75	" " 393	blank tape (acknowledged by Marex)
30.11.75, not recovered	" " "	meter lost
30.11.75, " "	" " 415	" "
1.1.76 to 21.1.76	" " 388	impeller damaged (acknowledged by Marex)

This last deployment is incorrectly reported in the Marex Stevenson Report Winter 75/76. The details of this and those for the following top deployment AM110 (meter no 416) have been interchanged. This error is corrected in the erratum to the Marex Stevenson Report March 1975/February 1976.

Of the remaining thirty records all were examined by IOS and five were found to contain faulty data and were placed in the unacceptable category. These were:

AM 83: 5.4.75 to 5.5.75: meter no 330

AM 84: 12.5.75 to 12.6.75: meter no 330

These two successive deployments of meter 330 both had very small velocity readings which suggest rotor or electronic malfunction of the meter. Marex did not use this data as they had also recognised the fault.

AM 97: 8.10.75 to 26.10.75: meter no 388

Marex reported that this record showed a compass fault from 16 October, however the IOS analysis showed that the compass was sticking for the whole record. IOS have classified all of the data as unacceptable.

AM 99: 1.11.75 to 25.11.75: meter no 388.

This data was recorded in the Marex monthly sea report as having erratic velocities, IOS confirmed this and found that the directions were also suspect (see comments under AM97, previous deployment of this meter). These data flaws were so bad that even though this record was from a bottom meter with all of the problems of validation referred to in the introduction, it was placed in the unacceptable category. Marex, however, have included the data in their analysis.

AM 96: 8.10.75 to 26.10.75: meter no 393.

Marex have used this data in their reports and have noted the sampling interval is 3m 15sec. IOS validation procedures confirmed this as being the average sampling period by dividing the total time deployed by the number of valid observations. The record is classed as unacceptable. However, if Marex can confirm that the instrument had been wrongly set to record at 3m 15sec, this data is probably retrievable. A DNC-2 current meter uses a set of miniature plugs and sockets to set its sampling period from 15sec, to 31min 45sec in 15 second increments. It is clear that it is possible to set the meter to record at 3m 15sec.

The reservations concerning data collected by bottom meters and the difficulties of confidently accepting or rejecting such data have been referred to in the introduction. Data which are borderline cases are given the benefit of the doubt, and are placed in the acceptable category; one such record is:

AM 90: 4.8.75 to 2.9.75: meter no 142.

This record contains blocks of samples which have some very small velocities and whose direction can jump by 180° or more from one five minute reading to the next. This may indicate that the meter is fouling the sea bed or some obstacle at various times. It may also reflect a real phenomenon related to unusual current effects on Neap tides. The data should be used with caution.

The total durationsof the various categories are:

Attempted collection	- 17940 hours
Acceptable data	- 11605 "
Unacceptable data	- 2775 "

Expressing the durations of the data in the validation categories as a percentage of the time covered by the meter deployments (attempted collection):

Analysed by IOS	= 80.2%
Acceptable data	= 64.7%

For a comprehensive summary of the results see tables 1 and 4.

BOYLE

The forty-one deployments of current meters considered here cover the period 20 April 1975 to 6 April 1976 at the Boyle location. The following ten deployments with no record number failed to return data:

20. 4.75 to 18. 5.75:	meter no 155:	broken tape (acknowledged by Marex)
20. 4.75 to 18. 5.75:	" " 195:	direction constant (acknowledged by Marex)
20. 5.75 to 15. 6.75:	" " 195:	clamp nut missing from takeup spool (acknowledged by Marex)
20. 5.75 to 15. 6.75:	" " 154:	velocities zero (acknowledged by Marex)
19. 9.75 not recovered:	" " 195)	Meters all lost. Probably run down by shipping or trawled (reported by Marex)
19. 9.75 "	" " 154)	
19. 9.75 "	" " 155)	
19.11.75 "	" " 418:	meter lost (acknowledged by Marex)
19.12.75 to 13. 1.76:	" " 416:	tape blank (acknowledged by Marex)
14. 2.76 to 8. 3.76:	" " 355:	tape blank (acknowledged by Marex)

Only three records of the remaining thirty one were found to be unacceptable when analysed and validated by IOS. These were:

AS43: 16. 7.75 to 13. 8.75: meter no 195

AS44: 16. 8.75 to 14. 9.75: meter no 195

These were successive deployments of meter 195. Halfway through the first record a malfunction occurred in the direction readings. This appeared to be a fault in the compass electronic circuit as the resolution was no longer 3° but closer to 9°. This fault is apparent on the whole of the second record. Although this data is classed as unacceptable it may be of limited use where the directional resolution is not important. Marex have only rejected data for AS44.

AS45: 16. 8.75 to 14. 9.75: meter no 154.

IOS found that this meter had a sticking compass. All directions were limited to the south-east quadrant. Marex also recognised this malfunction and did not use the data.

The total durations of the various categories are:

Attempted collection	- 21954 hours
Acceptable data	- 13604 "
Unacceptable data	- 2071 "

Expressing the durations of the data in the validation categories as a percentage of the time covered by the meter deployments (attempted collection):

Analysed by IOS	= 71.4%
Acceptable data	= 62.0%

For a comprehensive summary of the results see tables 2 and 4.

FITZROY

The data collected at the Fitzroy location for this report cover the period 6 April 1975 to 30 May 1976 when the ship was withdrawn from this location. During the period under consideration there were fifty three deployments of current meters of which ten failed to collect data. These deployments which have not been numbered were:

12. 6.75 to 11. 7.75: meter no 193: after recovery meter found faulty on test (acknowledged by Marex)
19. 7.75 to 13. 8.75: " " 173: faulty battery connection (acknowledged by Marex)
17. 8.75 not recovered: meter no 312: meter lost, cause unknown (acknowledged by Marex)
23. 9.75 to 7. 10.75: meter no 331) successive deployments of meter with tape wound
7.10.75 to 18.10.75: " " 331) around drive wheel (acknowledged by Marex)
23.10.75 to 22.11.75: " " 331: tape around capstan (acknowledged by Marex)
27.11.75: not recovered: meter no 419)
27.11.75: " " " " 384) meter lost, cause unknown, (acknowledged by
27.11.75: " " " " 448) Marex)
27.11.75 to 27. 1.76: meter no 420: meter faulty (acknowledged by Marex)

On the basis of the IOS data validation programme fourteen of the remaining records were placed in the unacceptable category. These were:

AJ35: 6. 4.75 to 3. 5.75: meter no 312

Although the data collected by this meter came from a bottom deployment with all of the reservations related to that type of record the data were classed as unacceptable. The velocity and direction time series show unusual restrictions in their values which could be interpreted as the meter fouling the seabed.

AJ38: 6. 4.75 to 3. 5.75: meter no 331
AJ51/54: 17. 8.75 to 15. 9.75: meter no 331

These two records show a restriction of the compass readings between 300° and 30°, the first for all of the record and the second for the first half of the data. They are both also rejected by Marex.

Although there is nothing obviously wrong with the two intervening deployments of this meter (AJ45 and AJ46) certain irregularities in the time series plots suggest that the data should be treated with caution.

AJ 34: 6. 4.75 to 3. 5.75: meter no 355
AJ 40: 7. 5.75 to 6. 6.75: " " "
AJ 55A: 23. 9.75 to 7.10.75: " " "
AJ 55B: 9.10.75 to 18.10.75: " " "
AJ 62: 23.10.75 to 22.11.75: " " "
AJ 68: 6. 1.76 to 23. 1.76: " " "

All six of these successive deployments of meter 355 have been classed as unacceptable as they all show an error in the direction plots. Regular gaps appear in the direction time series typically of the order of 9^{o} separated by a correct difference of 3^{o} (minimum compass resolution). These gaps suggest that there was a fault in the compass direction electronic circuitry. As the velocity readings seem to be acceptable and the basic elliptical nature of the vector plots is maintained these records may be of use where good directional resolution is not required.

AJ 56A: 29. 9.75 to 7.10.75: meter no 173
AJ 56B: 9.10.75 to 18.10.75: " " "
AJ 60: 24.10.75 to 20.11.75: " " "
AJ 67: 6. 1.76 to 27.1.76: " " "
AJ 77: 28.2.76 to 19.3.76: " " "

These five deployments of meter 173 show the progressive breakdown of the compass readings culminating in the last record with the directions restricted to the NE quadrant. During the deployment prior to these records the meter was lost and later recovered by grappling. It may be speculated that some damage occurred to the meter during this process of loss and recovery. As with the previous meter the velocity values seem acceptable.

The fact that the velocity readings were correct for the last three meter groups (ie meter 331, meter 355 and meter 172) is also indicated by the calibrations carried out on these and four other meters by the then British Hovercraft Corporation Limited, Experimental and Electronic Laboratories, in December 1975 (Report No X/0/2126). Unfortunately these calibrations only related to the velocity recordings of the meters and no compass calibrations appear to have been carried out.

Some comments and cautionary remarks are needed concerning four deployments of meters for the first sea period of this report, even though two of the records have been rejected.

AJ 34:	6. 4.75 to 3. 5.75:	Top meter no 355	}	System 1
AJ 35:	" "	Bottom meter no 312	}	
AJ 36:	" "	Upper meter no 193	}	System 2
AJ 37:	" "	Lower meter no 331	}	

The meters were deployed in two systems as shown above. All four meter records suggest that both systems were drifting for about four days. Indeed Marex reported that the Waverider was moved after this period of time as it was believed that the current meters were becoming entangled with it. The system 1 current meters both have a clear spike in the data about this time; also shortly afterwards meter 193 ceased to operate. The data for AJ 34 and AJ 35 have already been rejected. However the records numbers AJ 36 and AJ 37 although having no obvious cause to reject them contain data for the first four days when it is believed they were drifting. They should be treated with caution.

The total durationsof the various categories is:

Attempted collection	- 26818 hours
Acceptable data	- 14814 "
Unacceptable data	- 6937 "

Expressing the durations of the data in the validation categories as a percentage of the time covered by the meter deployments (attempted collection):

Analysed by IOS	= 81.1%
Acceptable data	= 55.2%

For a comprehensive summary of the results see tables 3 and 4.

R GLEASON

3 February 1978

TABLE 1

STEVENSON

Summary of the Results

			Record Sub-total	Record Totals
Acceptable		AM: 81,82,85,86,87a,b + c,88a, 88b + c,90*,91,92,93,94, 100,104,105,107,108,109, 110*,111,112,113.	25	25
Unacceptable	Constant Compass Direction	AM: 97	1	5
	Constant or Erratic Velocity	AM: 83,84,99	3	
	Sampling Interval error	AM: 96*	1	
Deployed but no data return	Meter lost		2	9
	Mechanical failure or flooding. Meter malfunction		7	
		Total		39

The following records, classed as unacceptable by IOS, appear in Marex reports.

Report	Figure No	Record No	Dates
Stevenson Autumn 1974	19	AM96	8.10.75 to 26.10.75
Stevenson Autumn 1975	21	AM99	1.11.75 to 18.11.75
Stevenson March 1975	22	AM96	8.10.75 to 26.10.75
February 1976	24	AM99	1.11.75 to 18.11.75

*See comments on these records in the main text

TABLE 2

BOYLE

Summary of the Results

			Record Sub-total	Record Totals
Acceptable		AS: 33,37,38,39,40,41,42,46, 50,51,52,53,54,56a,56b, 57a,57b,59a,59b,60a, 60b,61a,61b,68,70,62, 63,64	28	28
Unacceptable	Constant Compass Direction	AS: 45	1	3
	Timing Irregularity	AS: 43,44	2	
Deployed, but no data return	Trawled, meters lost		4	10
	Meter Malfunction, mechanical failure		6	
		Total		41

The following record, classed as unacceptable by IOS, appears in Marex reports.

Report	Figure No	Record No	Dates
Boyle Summer 1975 June 75 - May 76	13 20	AS43	16.6.75 to 13.8.75

TABLE 3

FITZROY

Summary of the Results

			Record Sub-total	Record totals
Acceptable		AJ: 36*,37*,39,41,42, 43,45,46,48,49/52, 57a,57b,59,69,70, 71,72,73,74,75, 76,78,79,80,81,82, 83,84,85	29	29
Unacceptable	Constant Compass Direction	AJ: 38,51/54	2	14
	Unusual Distribution	AJ: 35	1	
	Electronic Compass Fault	AJ: 34,40,55a,55b,56a, 56b,60,62,67,68,77	11	
Deployed but no data return	Assumed trawled or meters lost		4	10
	Meter malfunction, mechanical failure		6	
		Total		53

The following records, classed as unacceptable by IOS, appear in a Marex quarterly report:

Report	Figure No	Record No	Dates
Fitzroy Spring 1975	18	AJ 34	6.4.75 to 3.5.75
"	21	AJ 35	6.4.75 to 3.5.75
"	18	AJ 40	7.5.75 to 3.6.75
Fitzroy Autumn 1975	18	AJ 55^{a}_{b}	23.9.75 to 7.10.75 9.10.75 to 18.10.75
"	21	AJ 56^{a}_{b}	23.9.75 to 7.10.75 9.10.75 to 18.10.75
"	20	AJ 60	24.10.75 to20.11.75
"	21	AJ 62	23.10.75 to22.11.75
Fitzroy Winter 1975/76	19	AJ 68	6.1.76 to23.1.76

*See comments on these records in the main text

TABLE 4

SUMMARY OF RETURNS BY DEPTH

Measuring Site	Acceptable data(in hours and as a percentage of the time covered by this report)				Total time covered by this report (ii)
	Top	Upper	Lower	Bottom	
Stevenson(i)	4167	1739	2257	3442	7674
(iii)	54%	23%	29%	45%	100%
Fitzroy (i)	2919	3948	4186	3760	10080
(iii)	29%	39%	42%	37%	100%
Boyle (i)	3002	-	4577	6025	8448
(iii)	36%	-	54%	71%	100%

This table shows:

(i) the number of hours of acceptable data returned for each meter depth;

(ii) the total time covered by this report, ie the maximum time over which data could have been continuously collected;

(iii) the acceptable data from (i) expressed as a percentage of the total time covered by (ii).