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Survey 47

RIG SEISMIC RESEARCH CRUISE 2,
KERGUELEN PLATEAU:
EXPLANATORY NOTES TO ACCOMPANY RELEASE OF
NON-SEISMIC DATA

by

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INTRODUCTION

The purpose of this report is to summarise the processing techniques applied to the non-seismic geophysical data on *Rig Seismic* Research Cruise 2 (Survey 47; Kerguelen Plateau). Given that Survey 47 was the first full-scale *Rig Seismic* cruise on which all the major geophysical systems were running, it was expected that teething problems would be encountered and that data quality would frequently be less than ideal. Equipment installation problems were exacerbated by the typical sea conditions encountered - Southern Ocean sea states are rarely low. These problems particularly afflicted the through-the-hull sonar dopplers and the bathymetric systems and in fact at no stage during the survey did we have a fully operational ship's velocity system.

GEOPHYSICAL SYSTEMS & PERFORMANCE

The following non-seismic geophysical systems were employed during Survey 47:

Navigation

Prime System: Magnavox MX1107RS dual-channel short-count TRANSIT satellite navigator; ship speed from Magnavox 610D dual-axis sonar doppler and heading from Arma-Brown SGB 1000 gyro-compass.
Secondary System: Magnavox MX1142 single-channel short-count TRANSIT satellite navigator; ship speed from Raytheon DSN-450 dual-axis sonar doppler and heading from a Robertson gyro-compass.

Performance Comments: Both satellite navigators generally performed reliably, although at times the MX1107RS inexplicably did not receive satellites that were acquired by the MX1142. The MX1107RS was interfaced to the Data Acquisition System (DAS) and latitude, longitude, course, speed (every 10 seconds) and all satellite fix details were transferred and recorded. No interface was available for the MX1142; consequently, the only information available from this system was the satellite fixes, which were logged manually.

Both sonar dopplers and both gyro-compasses were recorded by the DAS quite independently of the satellite navigators. As previously noted, neither sonar doppler gave satisfactory results at any time during the survey. The sonar doppler problem was thought to be primarily due to aeration problems beneath the hull; however, even in low sea states, speeds recorded were completely unreliable with no back-scatter return being visible on the CRO monitor. As the problem affected both sonar doppler systems equally (and they transmit on quite different frequencies), the problem is presumed to be at least partly due to a lack of particulate matter in the water to produce an acoustic return.

Both gyro-compasses performed satisfactorily for the entire survey.

Bathymetric Systems

Raytheon Deep-sea Bathymetric System, with a maximum power output of 2 kW at 12 kHz. This system, purchased in the early 1970's, was of very sophisticated design for its day, providing in addition to digital depths and various alarm flags, an automatic tracking facility that should theoretically provide usable bathymetric data even in marginal recording conditions.

Performance Comments: A combination of transducers mounted inside the hull, frequently inclement sea conditions, and aging equipment resulted in the quality of the recorded bathymetric data varying from good in low sea states and in water depths of less than 1000 m, to irretrievable in high sea states at any depth. The extensive processing required to retrieve acceptable bathymetric data is described fully later in this report.

Magnetics

Two Geometrics G801/803 proton precession magnetometers were installed in the instrument room; signals were acquired from both single and dual channel (horizontal gradient) sensors towed astern.

Performance Comments: The magnetometer systems generally performed reliably, although noise levels were somewhat high (typically +/-3 nT in good conditions). The noise problems were a combination of extreme sensor motion in heavy seas, old equipment, and an unsolved installation problem that appeared to be related to interference from the Magnavox 610D sonar doppler. Because of these high noise levels, and the current lack of any in-house gradient processing software, the final processed data is only equivalent to single-channel data.

Gravity

A Bodenseewerk KSS-31 marine gravity meter was installed on the *Rig Seismic* immediately prior to the cruise and successfully interfaced to the DAS. Gravity data were recorded for the entire survey.

Performance Comments: The KSS-31 is a highly sophisticated single-axis marine gravity meter with extensive microprocessor control. The KSS-31 is designed to be interfaced to an external navigation system that can provide speed and heading input at a rate of as fast as 1 second; the speed and heading are then used by the processor to provide gyro corrections to the gravity meter to improve performance in heavy seas or during turns. Extensive tests were performed in interfacing to the DAS during Survey 47; however, we were never able to achieve any noticeable improvement in the gravity data over that available when no navigation data were input to the KSS-31. The reasons for this lack of success are not clear; while the manufacturer has since acknowledged a software problem in the equipment as supplied, the revised software does not appear to have countered the problem in subsequent surveys. For Survey 47, satisfactory gravity data have been achieved with appropriate post-survey filtering.

DATA ACQUISITION SYSTEM (DAS)

The shipboard DAS is based on a Hewlett-Packard 1000 E-Series 16-bit minicomputer which during Survey 47 was fitted with 256 kW of memory. The DAS programs run under the HP Real Time Executive (RTE-6/VM) disc-based operating system, which allows a multiprogramming environment and a large number of interactive users. Data are acquired either directly from the appropriate device through an RS-232C interface (gravity, Magnavox MX1107RS), or through a BMR-designed 16-bit digital multiplexer (magnetics, bathymetry) and attached gyro-log interface (for both sonar dopplers and gyro-compasses). After preliminary processing, plotting on strip-chart recorders, and listing on a variety of printers, the data were recorded on 9-track, 1600 bpi, phase-encoded magnetic tape in HP's 32-bit floating-point format.

Data were acquired and saved at a 10-second rate, regardless of ship speed and independently of the seismic acquisition system. The data were written to tape in 2.5 minute (15 record) blocks with 80 channels of data being recorded. The channels that were recorded are listed in Table 1.

DATA PROCESSING

The data were processed on an in-house Hewlett-Packard 1000 F-Series minicomputer utilising similar hardware and the same operating system as the DAS. The processing was applied in two phases, as follows:

<u>Phase 1:</u> transcription of field tapes; correction of time errors; production of raw data plots; bulk editing (principally deletion of bad data segments); retrieval of water depth data; assessment and retrieval of velocities; median filtering of magnetics and gravity; manual editing of problem areas; computation of incremental latitudes and longitudes; anti-alias filtering (smoothing) of magnetics, gravity, incremental latitudes and longitudes; production of final check plots; final editing.

<u>Phase 2:</u> tying of the dead-reckoned (DR) track to the satellite fixes using a cubic spline fitting technique for ocean currents; assessment and deletion of poor quality satellite fixes; computation of final positions for each DR system; computation of final ship position from an appropriate mix of the available DR systems; computation of final Eotvos-corrected gravity, including a correction for gravity meter drift; final data editing (particularly gravity data during turns).

A brief summary of the processing steps follows, with some detail of the techniques applied.

PHASE 1

FCOPY: All field tapes were transcribed to processing tapes with several field tapes being combined into a single processing tape. Processing tapes were separated at obvious breaks (such as recording system crashes), or after about seven days recording. During the transcription, data were re-blocked to 2-minute blocks (12 records/block). Time jumps (positive or negative) were reported for processing in the next phase.

FIXTM: Time jumps reported in *FCOPY* were corrected, either automatically, or with a file of manual time corrections. Data channels were re-ordered (Table 2) to simplify further processing.

VARPL: All raw data channels requiring processing were plotted as strip records on a drum plotter. These plots were used to determine where editing was required and as a first guide for the setting of filter parameters.

FTAPE: This program was used for a variety of tasks as follows -

(1) Removal of hardware/software flags in the bathymetric data. The Raytheon echo-sounder system provides, in addition to digital bathymetry, 'flags' indicating that the echo-sounder has lost track or that the digitiser gate is searching for an echo. These flags were removed, as appropriate, and such values were replaced by the number 1.0E10 (10 raised to the power 10), to indicate absent data.

(2) 'Bulk' deletions were done of any large blocks of irretrievable data in particular channels.

(3) Automatic interpolations were done across data gaps of up to 120 seconds for selected data channels.

SALVG (Water depth recovery): Briefly stated, the problem of bathymetry recovery is to fill in all the gaps left after the Raytheon hardware/software flags were removed and to discriminate against the bad bathymetric values that still remain.

To accomplish this, a file was first created of manually digitised water depths at selected points; this file was then read in conjunction with the processing data file. SALVG then performs a straight line interpolation between adjacent tie points and compares the interpolated depth with the 10-second digital depth. If the difference is less than a user-specified threshold, then the digital depth is accepted and is used to replace the previous first tie point. If the difference is greater than the threshold, then the 10-second digital depth is replaced by the interpolated depth. In this way, the program tracks along the acceptable water depths, providing the threshold is small enough to reject bad data and large enough to accept the good data. In the case of the digital data being totally unacceptable, as during poor sea conditions, the threshold was set to a very small number (0.01 m) and the process became one of simple linear interpolation between adjacent tie points. In practice, the interval between manually digitised tie points varied from several hours in the case of good digital 10-second data, to several minutes in the case of poor 10-second data or a very rugged seabed.

The success of this process, which is routinely applied to all *Rig Seismic* bathymetric data, can be seen in the 'before' and 'after' plots of Figure 1.

TABLE 1: Field tape channel allocations

1 - Clock (survey & day number)
2 - GMT acquisition time from computer clock (hours, minutes, seconds)
3 - Master clock time at acquisition (hours, minutes, seconds)
4 - Latitude (radians)
5 - Longitude (radians)
6 - Speed (knots) - best estimate
7 - Heading (degrees) - best estimate
8 - Magnetometer No 1 (nT)
9 - Magnetometer No 2 (nT)
10 - Bathymetry No 1 (metres)
11 - Bathymetry No 2 (metres)
12 - Magnavox sonar doppler - fore/aft
13 - Magnavox sonar doppler - port/starboard
14 - Raytheon sonar doppler - fore/aft
15 - Raytheon sonar doppler - port/starboard
16 - Not used
17 - Not used
18 - Arma-Brown gyro-compass (degrees)
19 - Robertson gyro-compass (degrees)
20 - Not used
21 - Not used
22 - Not used
23 - Not used
24 - Not used
25 - Not used
26 - Not used
27 - Not used
28 - Not used
29 - Not used
30 - Not used
31 - Gravity (mgal x 100)
32 - Pitch acceleration (m/s**2)
33 - Roll acceleration (m/s**2)
34 - Sea state filter number
35 - Not used
36 - Not used
37 - Not used
38 - Magnetic gradient
39 - AGRF magnetic anomaly No 1
40 - AGRF magnetic anomaly No 2
41 - Latitude - Magnavox S/D + Arma-Brown gyro
42 - Longitude - Magnavox S/D + Arma-Brown gyro
43 - Latitude - Raytheon S/D + Robertson gyro
44 - Longitude - Raytheon S/D + Robertson gyro
45 - Not used
46 - Not used
47 - Not used
48 - Not used
49 - Not used
50 - GMT time from MX1107 satnav
51 - Dead-reckoning time from MX1107
52 - Latitude (radians) from MX1107
53 - Longitude (radians) from MX1107
54 - Speed (knots) from MX1107
55 - Heading (degrees) from MX1107
56 - Set (degrees) from MX1107
57 - Drift (knots) from MX1107

58 - Set/drift flag, 0 = manual, 1 = auto
59 - GMT from MX1142 satnav
60 - Dead-reckoning time from MX1142
61 - Latitude (radians) from MX1142
62 - Longitude (radians) from MX1142
63 - Speed (knots) from MX1142
64 - Heading (degrees) from MX1142
65 - Set (degrees) from MX1142
66 - Drift (knots) from MX1142
67 - Set/drift flag from MX1142, 0 = manual, 1 = auto
68 - Vector speed Magnavox sonar doppler
69 - Vector speed Raytheon sonar doppler
70 - Not used
71 - Vector heading Magnavox sonar doppler
72 - Vector heading Raytheon sonar doppler
73 - Not used
74 - Not used
75 - Not used
76 - Not used
77 - Not used
78 - Not used
79 - Not used
80 - Not used

TABLE 2: Processing channel allocations

1	-	Clock (survey & day number)
2	-	GMT acquisition time from computer clock (hours, minutes, seconds)
3	-	Master clock time at acquisition (hours, minutes, seconds)
4	-	Latitude (radians)
5	-	Longitude (radians)
6	-	Heading (degrees) - best estimate
7	-	Speed (knots) - best estimate
8	-	Bathymetry No 1 (metres)
9	-	Bathymetry No 2 (metres)
10	-	Magnetometer No 1 (nT)
11	-	Magnetometer No 2 (nT)
12	-	Magnetic gradient
13	-	Gravity (mgal x 100)
14	-	Pitch acceleration (m/s**2)
15	-	Roll acceleration (m/s**2)
16	-	Sea state filter number
17	-	Magnavox sonar doppler - fore/aft
18	-	Magnavox sonar doppler - port/starboard
19	-	Raytheon sonar doppler - fore/aft
20	-	Raytheon sonar doppler - port/starboard
21	-	Not used
22	-	Not used
23	-	Arma-Brown gyro-compass (degrees)
24	-	Robertson gyro-compass (degrees)
25	-	Not used
26	-	GMT time from MX1107 satnav
27	-	Dead-reckoning time from MX1107
28	-	Latitude (radians) from MX1107
29	-	Longitude (radians) from MX1107
30	-	Speed (knots) from MX1107
31	-	Heading (degrees) from MX1107
32	-	Latitude - Magnavox S/D + Arma-Brown gyro
33	-	Longitude - Magnavox S/D + Arma-Brown gyro
34	-	Latitude - Raytheon S/D + Robertson gyro
35	-	Longitude - Raytheon S/D + Robertson gyro
36	-	10-sec delta latitude - Magnavox S/D + Arma-Brown
37	-	10-sec delta longitude - Magnavox S/D + Arma-Brown
38	-	10-sec delta latitude - Raytheon S/D + Robertson
39	-	10-sec delta longitude - Raytheon S/D + Robertson
40-41	-	Not used
42	-	60-sec delta latitude - Magnavox S/D + Arma-Brown
43	-	60-sec delta longitude - Magnavox S/D + Arma-brown
44	-	60-sec delta latitude - Raytheon S/D + Robertson
45	-	60-sec delta longitude - Raytheon S/D + Robertson
46-64	-	Not used

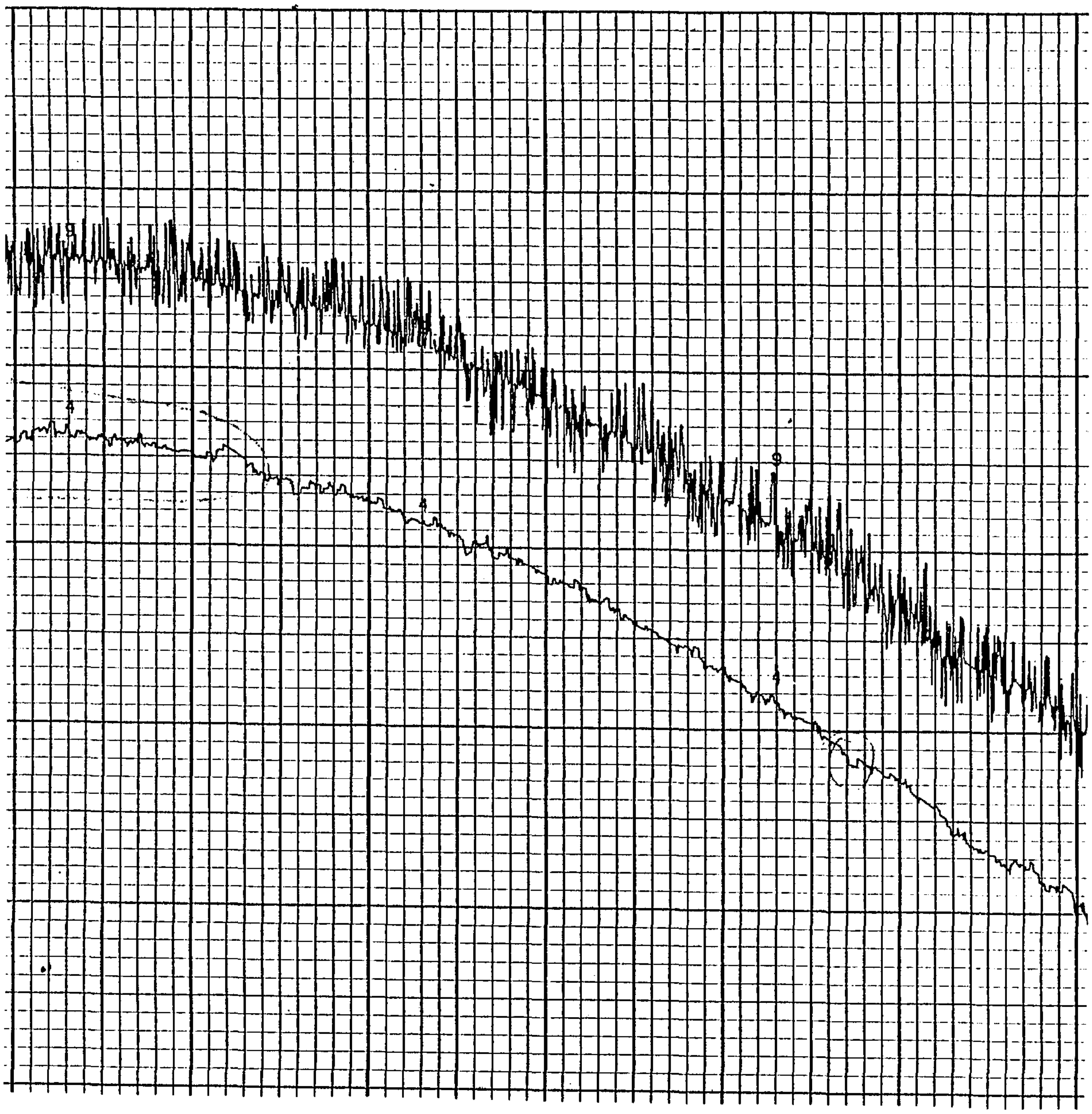

Figure 1: Bathymetry traces before (upper) and after processing by program SALVG. Vertical scale is 100 m/inch; horizontal scale is 30 minutes/inch. The input data are of fairly poor quality.

SALVG (Velocity recovery): As previously noted, at no time during Survey 47 were reliable velocities available from the Magnavox or Raytheon sonar dopplers. The only source of velocities available to us was those derived from the distance travelled between good quality satellite fixes. While this is a very rudimentary method of determining ship speed, the fact that most of the survey was completed along long lines of constant heading in deep water at either transit speed or seismic shooting speed (5.5-6.0 kn) has probably made the processing acceptable. Examination of all satellite fix intervals for Survey 47 showed that speed variations over periods of several hours were generally less than 0.5 kn. The approach adopted was to use the satellite fix computed speed at the mid-point of each satellite fix interval and to do a linear interpolation between successive values using program *SALVG*. Fluctuations of less than 0.5 kn were generally ignored as these were effectively incorporated in the Phase 2 processing (see below); velocities were only changed when there appeared to be a distinct change in the velocity level over several hours.

FDATA: The magnetic data were filtered using a sophisticated form of the median filter, a highly successful spike deletion tool. Such a filter is essential for magnetic data, which is susceptible to spikes arising from either poor tuning of the magnetometer or from electrical interference. A filter threshold of 7.0 nT was used with a filter window length of 13 samples.

EDATA: This is a utility program used for the manual editing of problem areas that are not amenable to filtering or automatic editing.

DELTA: Incremental (delta) latitude/longitudes were produced every 10 seconds by combining the ship speed with the headings from the Arma-Brown and Robertson gyro-compasses. This effectively gave two distinct dead-reckoning (DR) systems.

MUFF: This program was used to anti-alias filter certain data channels prior to resampling to 60-seconds for Phase 2 processing. The channels filtered were magnetics, gravity, and incremental latitude/longitudes. The filter used was a SINC function with a filter period of 180 seconds extended to the third zero crossing of the abscissa each side of the filtered point. The filter coefficients and the approximate response of the filter to a sine wave input are given in Table 3.

INTEG: The filtered incremental latitude/longitudes were re-integrated over running 60-second intervals. These 60-second incremental distances were then used in the Phase 2 processing to compute the DR vector over each satellite fix interval.

VARPL/EDATA: As the final stage of the Phase 1 processing, all processed channels were plotted again as 'strip' plots with program VARPL. Program EDATA was then used to correct any minor residual data problems.

SMOOTH FILTER 1 PUTS CHANNEL 11 INTO 11

FILTER CUT-OFF AT 3.TH ZERO

SAMPLING INTERVAL IN SECONDS 10.0

PERIOD OF FILTER IN SECONDS 180.0

APPROXIMATE RESPONSE OF FILTER TO SINE WAVE

NUMBER OF POINTS IN FILTER 53

FILTER COEFFICIENTS AS FOLLOWS

.000	.001	.002	.003	.004	.004	.004	.003	-.000	-.004
-.008	-.012	-.015	-.018	-.018	-.015	-.009	.000	.012	.027
.043	.060	.076	.091	.102	.109	.111	.109	.102	.091
.076	.060	.043	.027	.012	.000	-.009	-.015	-.018	-.018
-.015	-.012	-.008	-.004	-.000	.003	.004	.004	.004	.003
.002	.001	.000							

FRACTION	PERIOD	RESPONSE	db
.500	90.0	.00108	-59.3
.518	93.2	.00442	-47.1
.536	96.5	.00672	-43.5
.555	99.9	.00672	-43.5
.574	103.4	.00380	-48.4
.595	107.0	-.00178	-55.0
.616	110.8	-.00884	-41.1
.637	114.7	-.01548	-36.2
.660	118.8	-.01934	-34.3
.683	122.9	-.01804	-34.9
.707	127.3	-.00946	-40.5
.732	131.8	.00793	-42.0
.758	136.4	.03500	-29.1
.785	141.2	.07183	-22.9
.812	146.2	.11784	-18.6
.841	151.4	.17184	-15.3
.871	156.7	.23226	-12.7
.901	162.2	.29728	-10.5
.933	167.9	.36499	-8.8
.966	173.9	.43355	-7.3
1.000	180.0	.50127	-6.0
1.035	186.3	.56672	-4.9
1.072	192.9	.62872	-4.0
1.110	199.7	.68641	-3.3
1.149	206.8	.73918	-2.6
1.189	214.1	.78669	-2.1
1.231	221.6	.82882	-1.6
1.275	229.4	.86564	-1.3
1.320	237.5	.89735	-.9
1.366	245.9	.92426	-.7
1.414	254.6	.94676	-.5
1.464	263.5	.96527	-.3
1.516	272.8	.98024	-.2
1.569	282.5	.99210	-.1
1.625	292.4	1.00129	.0
1.682	302.7	1.00821	.1
1.741	313.4	1.01322	.1
1.803	324.5	1.01665	.1
1.866	335.9	1.01881	.2
1.932	347.7	1.01994	.2
2.000	360.0	1.02028	.2

TABLE 3: Filter coefficients and approximate response of filter to sine wave for magnetics smoothing filter.

PHASE 2

Phase 2 processing encompasses the following tasks -

1. Re-formatting and production of assessment listings of satellite fixes;

2. Resampling Phase 1 data;

3. Assessment of satellite fixes and deletion of those considered dubious or unacceptable;

4. Constrainment of DR track to remaining satellite fixes and computation of 1-minute positions for each DR system;

5. Selection of a suitable mix of navigation systems to produce final positions;

6. Application of Eotvos and drift corrections to gravity data and conversion to absolute values;

7. Final plots and editing as necessary.

In rather more detail, the programs applied were as follows -

RESAF: Re-format the ASCII parameter file of satellite fixes and adjust each fix to the nearest whole minute of survey time using the ship speed and heading applying at that time in the Phase 1 data file.

FIXES: Produce a listing of the satellite fixes for assessment purposes (Table 4).

RESAM: Concatenate the Phase 1 data files, as appropriate, and resample to produce 1-minute data.

SAT12: Two passes of this program are required for each round of satellite fix assessment. During each pass, a number of options are called, as follows:

Pass 1

a. SATEL - reads in the file of satellite fixes and stores them in memory. Any fix intervals with dubious speeds (too low or too high) or any intervals that are very short (<15 minutes) or very long (>120 minutes) are flagged in the output listing.

b. DRNAV - uses the incremental latitude/longitudes stored on the Phase 1 file and the satellite fix information to compute the DR path (or DR vector) for each satellite fix interval. This is saved as an ASCII parameter file.

c. CALNV - reads the DR file created by DRNAV and computes the ratio of the average DR velocity to the velocity computed from successive satellite fixes. This is done for each DR system used, and the results are listed.

83	47.075.082700	47 30.239	96 7.945	1107	130	Y	22	19	4	SW	.72	271	50	38		259.5	9.6
84	47.075.102000	47 32.620	95 41.813	1142	480	Y	7	20	2		1.50	320	0	0		254.4	9.7
85	47.075.111400	47 34.536	95 28.[illegible]	1107	500	Y	16	27	4	NE	.75	284	102	66		256.0	9.9
86	47.075.130400	47 37.846	95 1.887	1107	500	N	79	30	2	NE	1.89	265	18	95	1	258.2	10.3
87	47.075.133000	47 38.941	94 55.351	1107	200	N	7	20	7	NE	2.48	258	138	69	2	256.1	10.4
88	47.075.151800	47 42.346	94 27.680	1107	200	Y	48	32	2	NE	4.35	260	16	25		255.4	10.7
89	47.075.163700	47 45.483	94 6.911	1107	110	Y	34	32	2	NW	1.12	234	28	32		257.0	10.3
90	47.075.170200	47 46.486	94 .815	1107	200	Y	32	29	3	NW	.22	151	21	23		256.1	9.8
91	47.075.174600	47 48.528	93 50.973	1107	130	Y	31	32	3	NE	.76	113	29	29		257.5	9.4
92	47.075.190300	47 52.447	93 33.729	1107	480	Y	54	38	3	SE	1.42	123	22	42		251.5	9.4
93	47.075.193300	47 53.881	93 27.298	1107	130	Y	54	35	3	NW	.70	107	22	43		256.2	9.4
94	47.075.205200	47 56.966	93 10.466	1107	480	Y	34	35	3	SW	1.83	84	31	32		252.5	9.4
95	47.075.211800	47 57.982	93 4.558	1107	130	Y	11	23	3	NW	.35	252	104	72		256.0	9.2
96	47.075.233400	48 2.156	92 36.212	1107	500	Y	20	25	5	SE	.86	52	76	60		254.1	8.3
97	47.076.011000	48 4.684	92 17.834	1142	110	Y	9	25	2		1.40	50	0	0		253.1	8.0
98	47.076.025500	48 7.384	91 56.832	1107	110	Y	47	34	3	SE	2.27	47	30	47		255.0	8.0
99	47.076.031200	48 12.234	92 5.508	1107	200	N	37	13	3	SE	9.21	118	999	999	5	256.3	4.8
100	47.076.044200	48 8.525	91 43.761	1107	110	Y	36	33	3	SW	.57	1	20	23		256.4	8.6

FIX	FIX TIME	LAT	LONG	SYSTEM	SAT	OK	ELEV	COUNT	ITER	GEOM	ERROR	DIR	SLT	SLN	CODE	COURSE	SPEED
101	47.076.045700	48 8.966	91 40.663	1107	200	Y	37	27	3	SW	.12	266	39	47		256.1	8.6
102	47.076.055000	48 10.952	91 29.503	1107	130	Y	29	27	4	SE	.67	244	37	34		257.2	8.8
103	47.076.062200	48 12.135	91 23.134	1107	480	Y	28	33	3	NE	.21	211	54	48		256.1	8.9
104	47.076.073600	48 14.655	91 6.864	1107	130	Y	60	35	3	SW	1.31	260	13	29		258.5	9.0
105	47.076.081100	48 15.717	90 59.137	1107	480	Y	67	38	3	NW	.62	272	20	63		253.4	9.0
106	47.076.092500	48 18.070	90 42.670	1107	130	Y	11	23	4	SW	1.40	269	132	90		254.9	8.4
107	47.076.095800	48 18.860	90 37.815	1107	480	Y	15	26	5	NW	.07	263	71	56		259.6	7.7
108	47.076.105100	48 19.592	90 29.650	1142	500	Y	8	26	2		.60	353	0	0		257.6	7.8
109	47.076.124200	48 22.223	90 6.877	1107	500	Y	46	36	3	NE	2.03	305	29	42		254.8	8.3
110	47.076.140100	48 24.348	89 50.258	1107	110	Y	20	25	3	NE	1.52	280	57	45		257.9	8.5
111	47.076.143000	48 24.879	89 44.139	1107	500	Y	40	35	2	NW	.40	316	31	41		257.6	8.5
112	47.076.155400	48 27.258	89 28.089	1107	200	Y	67	30	4	NE	.98	96	17	55		258.6	7.6
113	47.076.161700	48 28.107	89 23.858	1107	500	N	7	21	6	NW	.43	122	248	197	1	258.6	7.4
114	47.076.165400	48 28.365	89 17.012	1107	130	N	11	14	0	NE	1.08	63	186	144	5	263.4	7.2
115	47.076.173400	48 29.366	89 10.102	1142	110	Y	19	15	2		.90	77	0	0		262.1	7.3
116	47.076.173800	48 29.644	89 9.521	1107	200	Y	24	26	3	NW	1.97	81	45	37		260.6	7.3
117	47.076.184100	48 31.138	88 58.269	1107	480	Y	33	33	3	SE	.76	88	35	37		260.8	7.4
118	47.076.202900	48 33.883	88 38.258	1107	130	Y	30	20	3	NW	.85	98	61	46		260.3	7.6
119	47.076.221900	48 36.284	88 17.311	1107	480	Y	12	27	5	SW	.25	26	117	78		262.3	7.7
120	47.076.231200	48 36.975	88 7.505	1107	500	Y	11	24	3	SE	.52	0	140	103		256.9	7.7
121	47.077.010000	48 38.899	87 46.490	1107	500	Y	54	37	3	SE	.86	309	25	47		261.4	8.9
122	47.077.020600	48 40.079	87 30.693	1107	110	Y	19	24	3	SE	1.96	284	81	59		255.9	9.8
123	47.077.024900	48 41.048	87 19.983	1107	500	Y	34	35	3	SW	.81	291	35	37		256.9	10.2
124	47.077.034800	48 42.217	87 4.337	1107	200	Y	53	28	3	SE	1.72	278	24	45		257.6	10.6
125	47.077.050200	48 45.656	86 44.528	1107	130	N	10	21	4	SE	1.34	238	85	70	2	259.3	10.6
126	47.077.053400	48 47.377	86 36.955	1107	200	Y	27	27	3	SW	1.47	207	30	28	-	257.1	10.7
127	47.077.055800	48 48.587	86 30.780	1107	480	Y	16	28	2	NE	.38	175	65	46	-	260.1	10.7
128	47.077.064700	48 50.594	86 17.461	1107	130	Y	53	34	3	SE	.53	227	12	22		255.5	10.7
129	47.077.074800	48 53.136	86 1.460	1107	480	Y	73	38	3	NE	.49	192	18	68	1	263.0	11.3
130	47.077.083400	48 55.330	85 48.079	1107	130	Y	33	32	3	SW	1.13	234	26	28		259.3	11.1

Table 4: Sample satellite fix listing from Survey 47. Headings are as follows:-
FIX - fix number within file; FIXTIME - time of fix to nearest minute;
LAT, LONG - fix position adjusted to nearest minute;
SYSTEM - indicates MX1107 or MX1142 fix; SAT - satellite ID code;
OK - Y or N indicates fix accepted or rejected;
ELEV - maximum elevation of satellite during fix, in degrees;
COUNT - number of doppler counts received during pass;
ITER - number of iterations required for fix to compute;
GEOM - geometry of pass;
ERROR, DIR - distance (nautical miles) and bearing (degrees) of fix update (based on shipboard DR data);
SLT, SLN - standard deviation of latitude and longitude (metres);
CODE - error code, blank if fix accepted by MX1107 or MX1142;
COURSE, SPEED - course (degrees) and speed (knots) of ship at time of fix.

d. CALPL - produces a line printer plot of the velocity ratios for each satellite fix interval.

Pass 2

a. CFACT - uses the DR file and a user-created file of calibration factor intervals to compute velocity calibration factors for each DR system.

b. APROX - uses the calibration factors computed in CFACT and the DR file to produce an approximately calibrated DR file.

c. ASSES - uses the approximately calibrated DR file created by APROX to produce a line printer plot of the current and summed error vectors at and between satellite fixes. The plot is produced at a 10-minute sample interval.

The basis of the processing is that option 'ASSES' takes the summed latitude and longitude error vectors at each fix (*ie* a running sum of the DR position to satellite fix position vectors at the time of each fix) and uses a piece-wise cubic polynomial curve-fitting function (the Akima spline) to compute error vectors at all times between satellite fixes. It is assumed that the ensuing smooth variation of the error vector is due to ocean currents, winds, etc. Poor quality fixes will produce unrealistic or large and variable ocean currents. At each round of assessment (and usually at least three rounds are required for each file), the satellite fixes are checked wherever the summed error and current vectors suggest a problem, and those fixes of poor quality are deleted for the next program run. The effect of this process can be seen in the example in Figures 2 and 3.

SAT3: uses the final file of satellite fixes and the DR data to produce final positions for each DR system. This program again uses the Akima spline to compute the assumed currents acting at all times between satellite fixes and applies those currents to the DR data to compute positions.

FINAV: performs the following functions -

a. Computes final 1-minute positions based on a 'mix' of DR systems (and radio-navigation or GPS, if available) according to a file specified by the user. In the case of the Kerguelen Plateau data, a constant 1:1 mix was used of the two systems available (*ie* manual velocity + Arma-Brown gyro-compass and manual velocity + Robertson gyro-compass).

b. The gravity data (which was in mgals relative to an arbitrary datum) was converted to absolute values corrected for meter drift and with Eotvos corrections applied. Gravity ties were performed in Devonport, Tasmania prior to the cruise, and at Melbourne after the cruise.

VARPL/EDATA: As a final check, the Phase 2 positions, water depths,

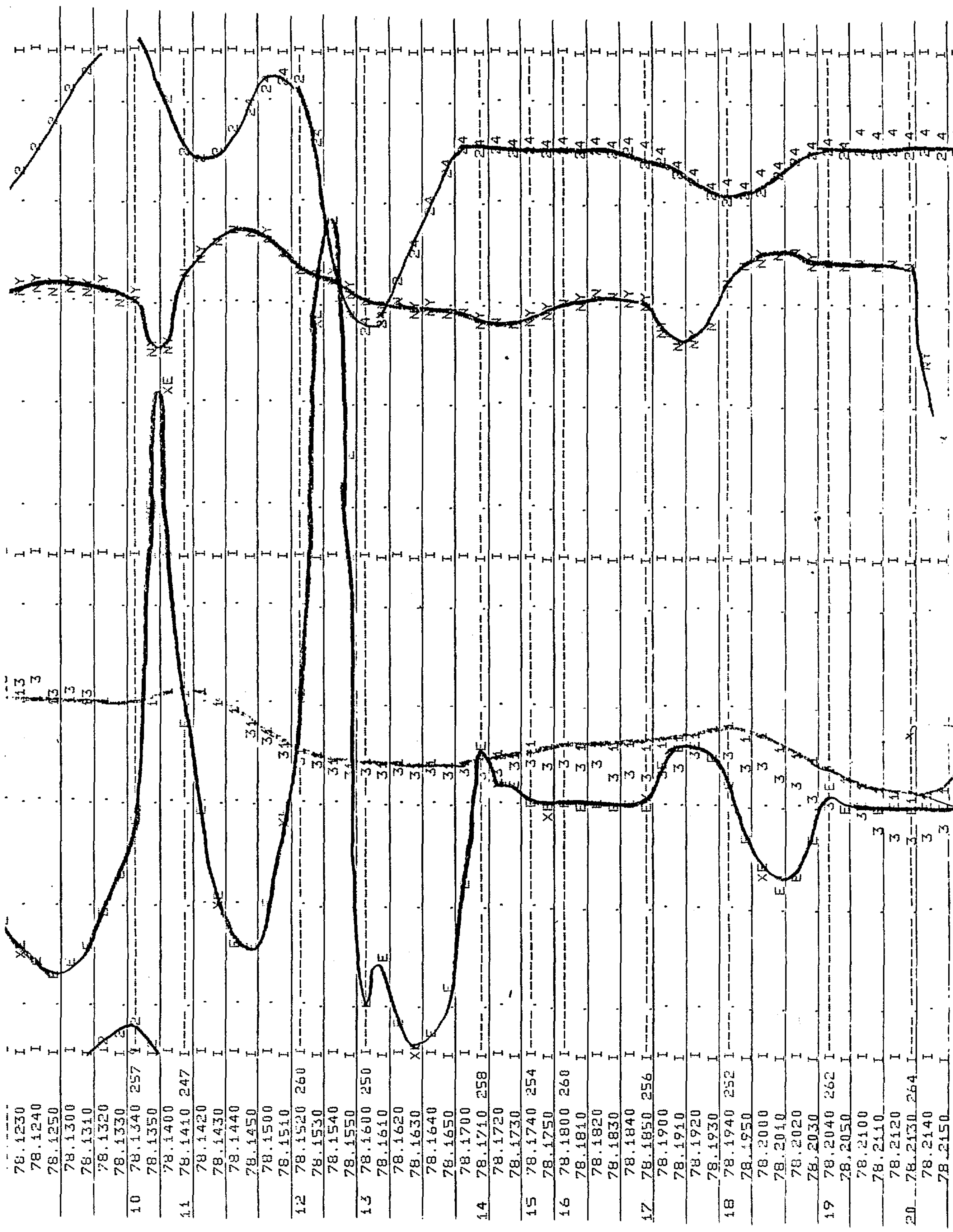

Figure 2: Satellite fix assessment plot. 10-minute time (DD.HHMM) along bottom of plot; satellite fixes indicated by row of dashes (*eg* at 78.1520); traces on the plot are as follows:-

N & E - north and east currents for DR system 1;

1 & 2 - north & east summed error vectors for DR system 1; Y & X - north & east currents for DR System 2; 3 & 4 - north & east summed error vectors for DR system 2.

Note in particular the large fluctuations in the east current and the east summed error vector on the left-hand half of the plot.

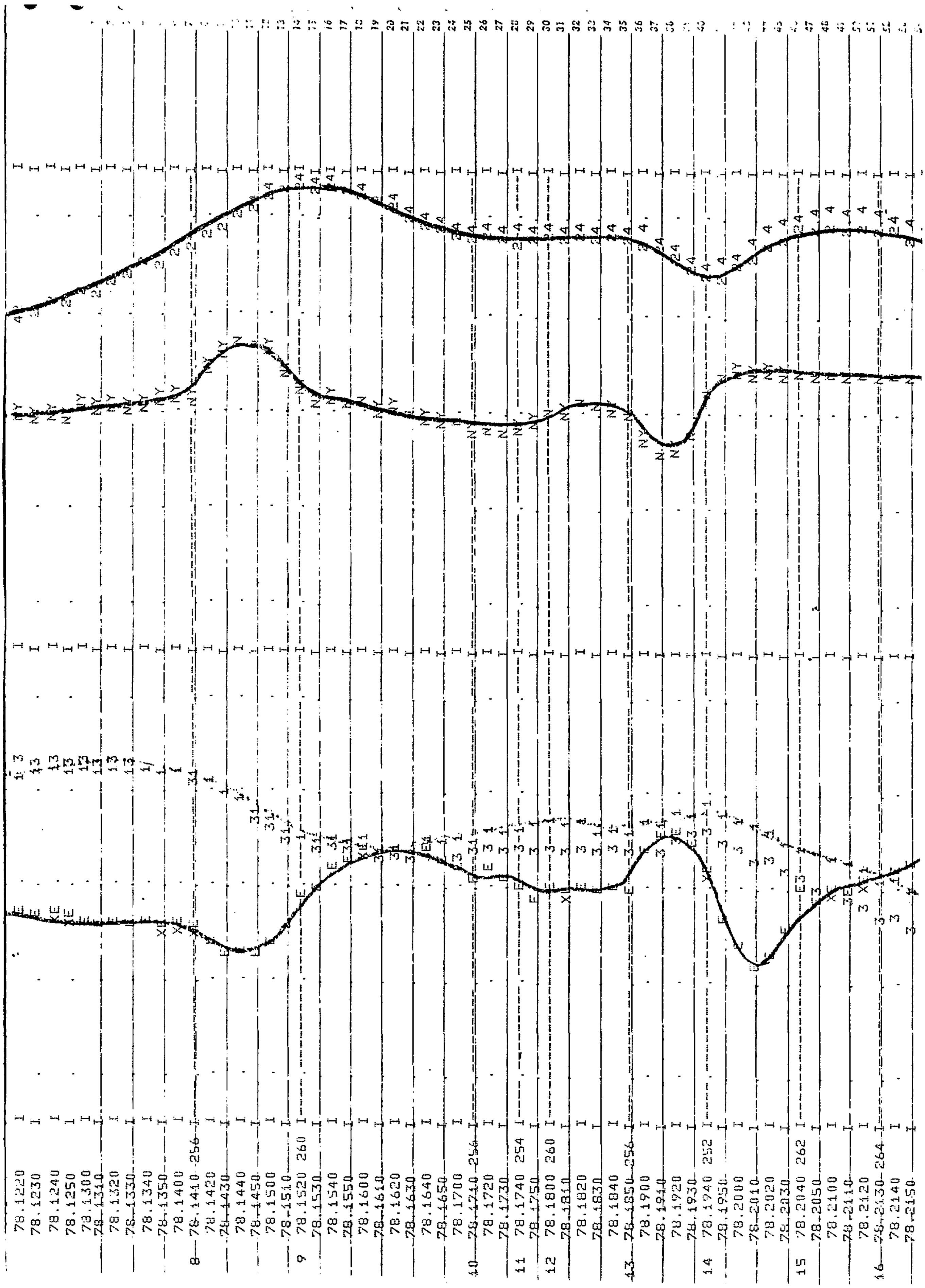

Figure 3: Same plot as for Figure 3, but after removal of satellite fixes at 78.1340 and 78.1600. Note that the large fluctuations in the east currents and summed error vectors have been smoothed out

magnetic, and gravity data were plotted and editing applied as necessary.

DATA AVAILABILITY

The Kerguelen Plateau non-seismic data are available in two forms:

a. Magnetic Tape - 9-track, 1600 bpi, phase-encoded, as either
- ASCII records, 80 characters per record, 10x1-minute records per block; or
- Hewlett-Packard 32-bit floating point, 8 channels, 60x1-minute records per block.

Enquiries concerning these data should be addressed to -

Chief Scientist,
Division of Marine Geosciences & Petroleum Geology,
Bureau of Mineral Resources,
GPO Box 378
Canberra, ACT 2601, Australia

b. Track Maps - corresponding to the GEBCO sounding sheets 494, 495, 518, and 519 and available from -

Copy Service,
Assistant Government Printer (Production)
PO Box 84,
Canberra, ACT 2600, Australia

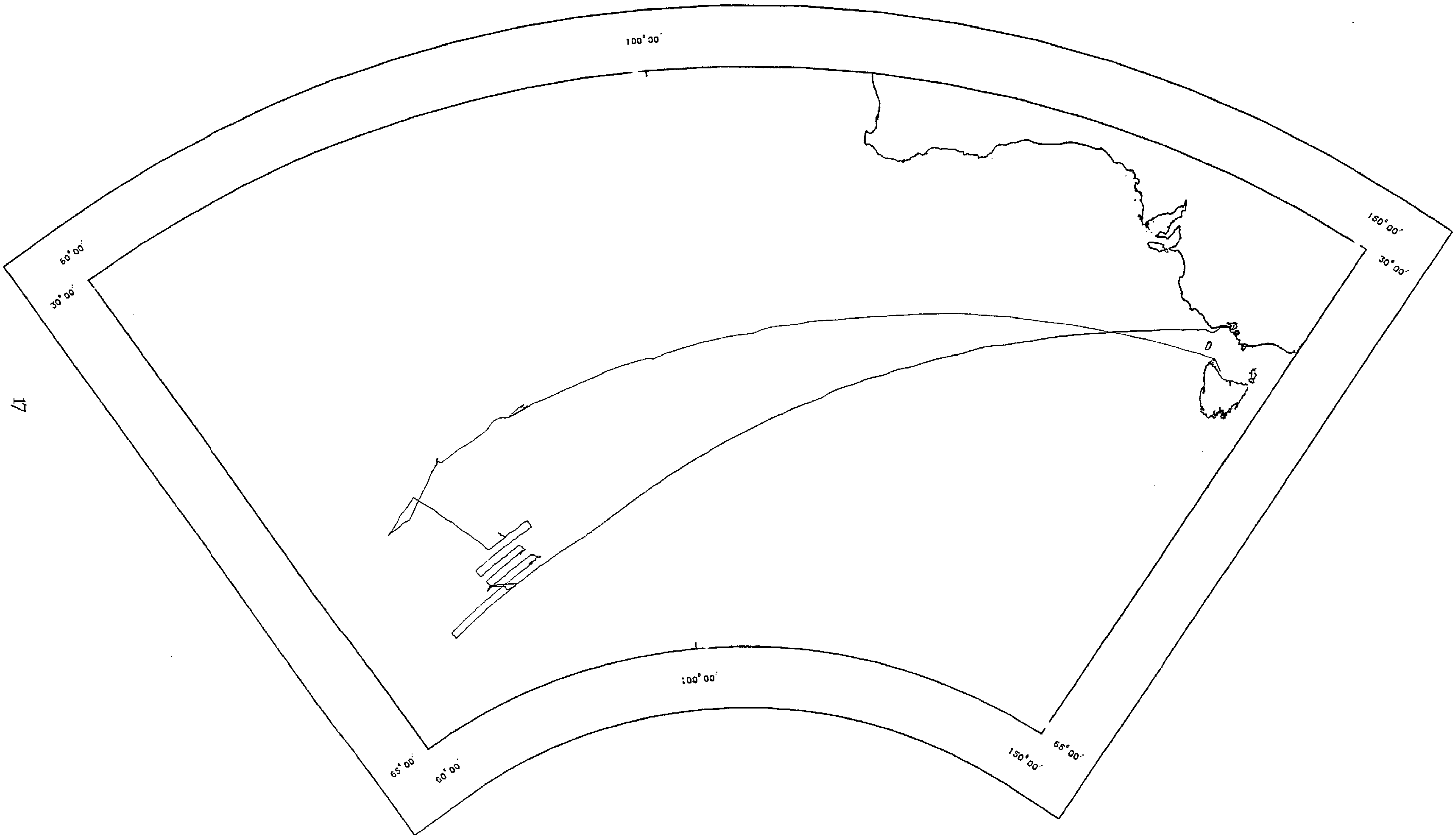

Figure 4: Tracks of *Rig Seismic* Survey 47 in the Southern Ocean.

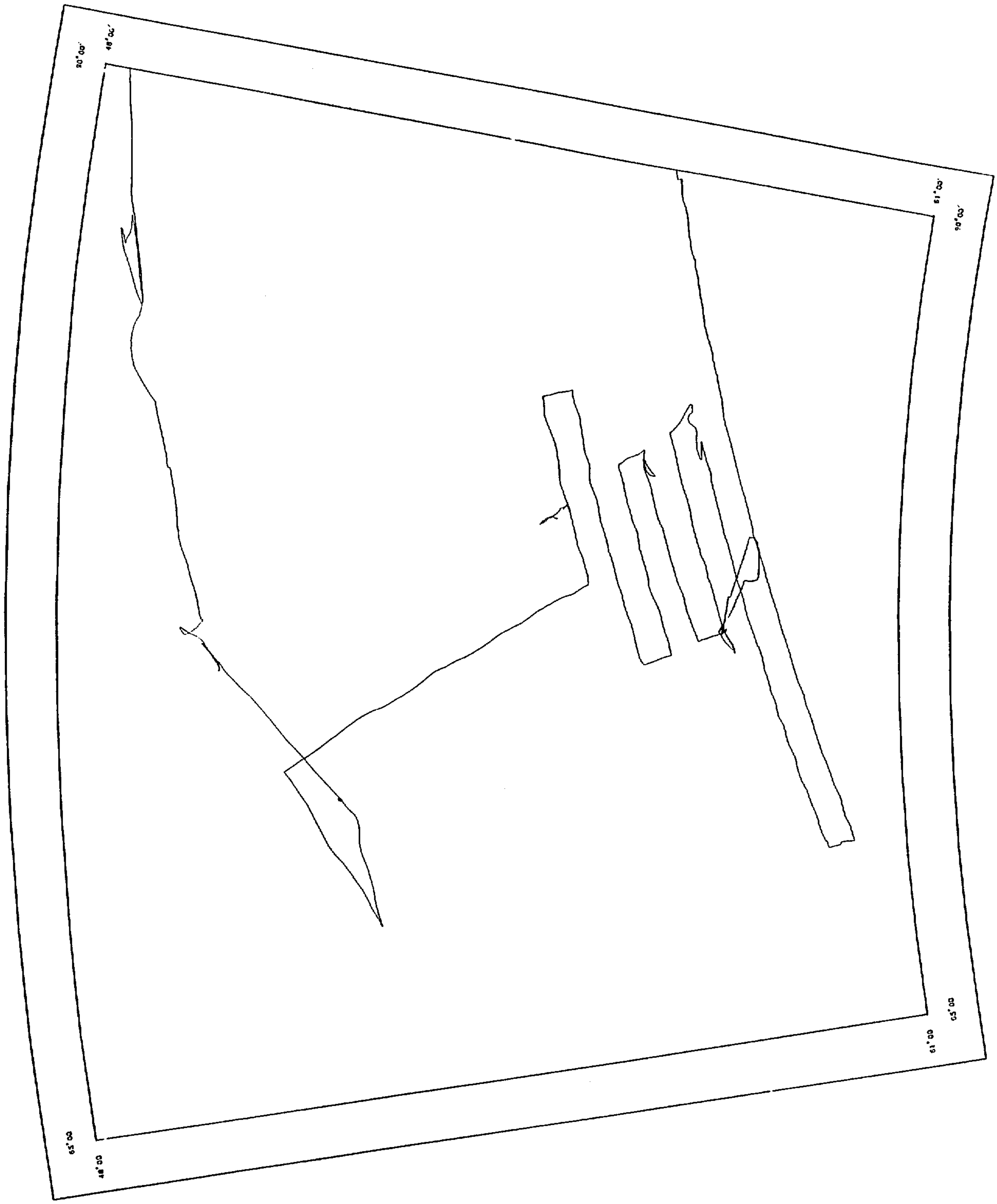

Figure 5: Tracks of *Rig Seismic* Survey 47 on the Kerguelen Plateau.