Lauwow – A Multichannel Seismic Investigation of the Lau Basin

Cruise Report for EW9914
R/V Maurice Ewing
Suva, Fiji to Christchurch, New Zealand
12th December – 29th December, 1999

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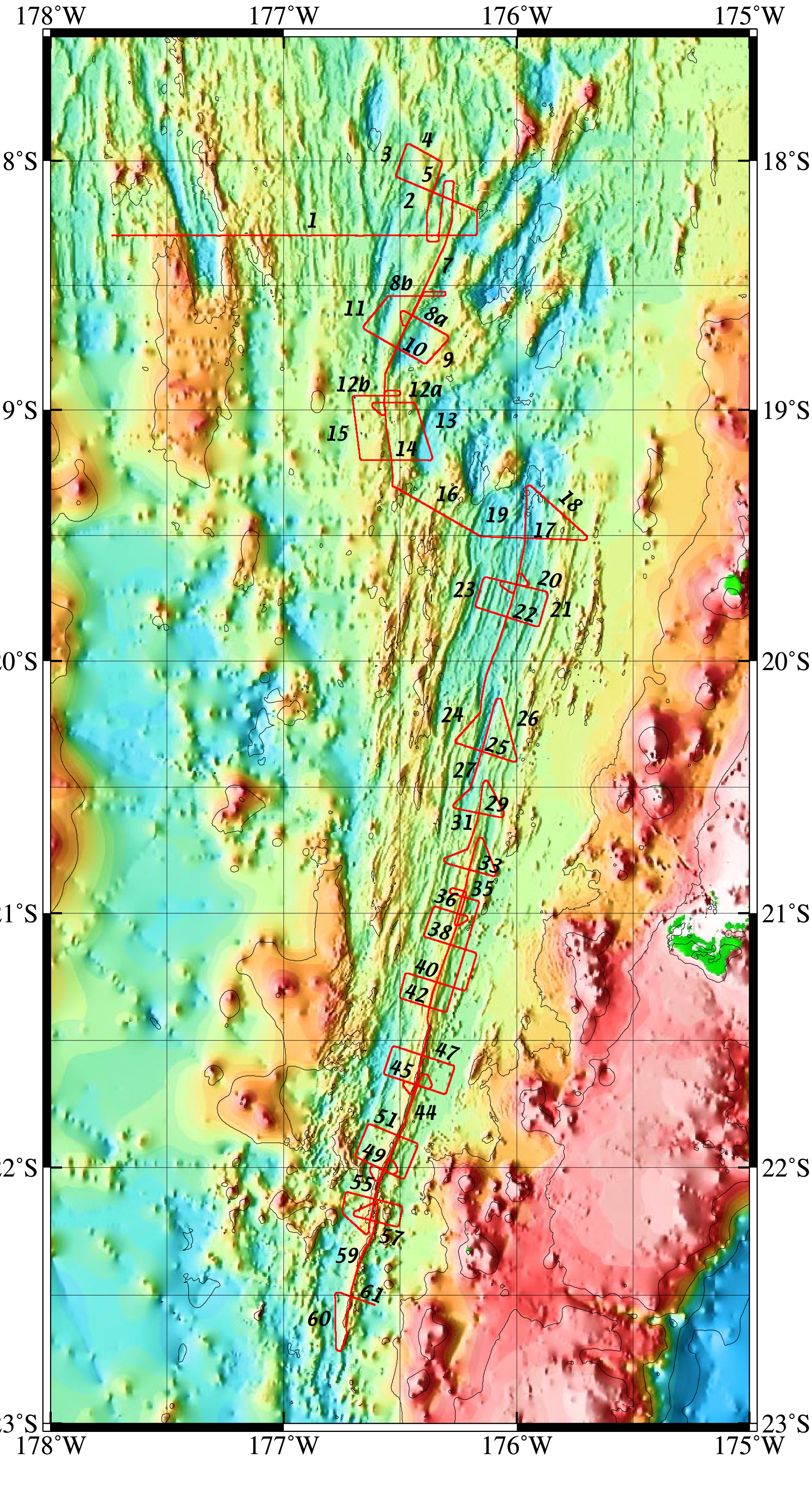
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Introduction

This experiment was a reconnaissance reflection survey that was the first to collect multichannel seismic data along and across all the major spreading centers in the Lau basin south of the Peggy Ridge – the Central Lau spreading center (CLSC), the Eastern Lau spreading center (ELSC), and the Valu Fa ridge (VFR). Until this survey, multichannel imaging within the Lau basin had been largely confined to the VFR (e.g. *Morton & Sleep*, 1985; *Collier & Sinha*, 1990,1992). Indeed, until the relatively recent compilation of bathymetric, magnetic and side-scan data (*Taylor et al*, 1996).the location of the ridge axis itself was poorly known along the northern part of the VFR and the ELSC. The primary aim of the seismic survey was to investigate how crustal accretion styles and parameters in a back arc setting differ from those found along mid-ocean ridges. Understanding, the correspondence between the two modes of crustal genesis bears directly on the reading of ophiolites suites as fossilized records of ridge processes, since many ophiolites are presumed to have originated in back arc environments. There are at least two significant controls on accretion within the basin – spreading rate and composition. Spreading rates within the basin cover the range from intermediate to fast, 65 – 100 mm/yr, and the composition of rocks ranges from N-MORB to more arc-like as the distance from the arc decreases.

The experiment was relatively short, a total of 11 acquisition days, but succeeded in its objective of collecting data along and across all the major spreading centers between 18° S and 22° 45'S. The final dataset consists of an axial profile along the entire length of the CLSC, ELSC, and VFR; 25 ridge crossing profiles,; a number of off-axis ridge parallel and ridge oblique connecting profiles; and an extended profile at 18° 18' S that started in the western extensional basin and crossed the western pseudofaults associated with the ridge propagation of the ELSC/VFR and the CLSC. The experiment collected all the originally planned lines except for an additional pair of crossings of the previously surveyed southern VFR, which were dropped because of time constraints.

The survey used the full length of the *R/V Ewing's* 6-km long, 480 channel streamer. The overall data quality is very good. Sea conditions were good throughout the experiment and after initial adjustments the streamer flew well. The Syntron acquisition system worked well, except for a couple of short duration system hangs,. The air gun array worked almost non-stop throughout the experiment, although there was the usual down time for individual guns. Near real-time processing of the seismic data was performed on board the *Ewing* during the cruise with brute stack plots of the data appearing only minutes after a tape was ejected from the acquisition system. This arrangement meant that are survey lines could be optimized based upon the incoming data.

The only serious problem occurred before the start of the cruise went it was discovered at almost the last possible moment that the necessary clearances had not been obtained. This problem was resolved and the cruise went ahead thanks to the good offices and swift responses of the Fijian and Tongan governments, and the U.S. State Department; the exceedingly generous and timely help of Russell Howorth and the South Pacific Applied Geoscience Commission (SOPAC); and the efforts of the Scripps Ship Operations office.

Data Overview

An axial magma chamber (AMC) reflection was not seen along the northernmost part CLSC nor on the along the last ridge of the Lau Extensional Transform Zone (LETZ), which is a series of left stepping en-echelon spreading segments that connect the CLSC to the Peggy ridge (*Taylor et al,* 1994). However, a characteristically bright axial magma chamber (AMC) reflector is seen along the CLSC starting at about 18° 21' S, just south of the initial line crossing, and extending to about 19° 05' S, just north of the neovolcanic tip identified by Wiedicke & Habler (1993) at 19° 07' S. The neovolcanic tip is the southern limit of the continuous axial volcanic ridge. The two-way travel time (TWTT) of the AMC reflection relative to the seafloor is unusually small, ~450 ms, near 18° 33' S, where the ridge is broadest and shallowest, but deepens to 740 ms before disappearing at 19° 05' S. No reflection was seen in the rift graben south of this point on either the along-axis or cross-axis line, line 14.

An AMC reflection is absent in the initially processed data for the northern ELSC, where the axis is deeper and is expressed as either a subdued ridge or rift. Near 20° 30' S, the AMC reflector reappears as an exceptionally bright event on a spur that marks the transition from rift to ridge. It is quasi-continuous all the way down to the southern end of the VFR. The TWTT of the AMC reflector is typically greater on the ELSC, reaching a maximum of 2.0 s near the southern end of the VFR. Over the last ~17 km of the survey at the very southern end of the Valu Fa ridge the TWTT of the AMC reflection increases by ~0.5 s from 1.5 to 2.0 s relative to the seafloor.

The MCS data corroborates the morphological and petrologic evidence that the CLSC has a fast spreading, "EPR-like" structure. In addition, to a relatively shallow axial magma chamber, the CLSC has a layer 2A that is thin on axis, ~0.1 s, but increases significantly off-axis to 0.3-0.4 s. On certain crossings, such as line 10, layer 2A appears to be a double step structure with a top layer that has a thin uniform thickness (c.f. CLSC figure). The ELSC in contrast has a relatively deep AMC reflector and, unusually, a thick layer 2A, ~0.6 s, that shows no thinning in the axial region (c. f. ELSC figure). The 6-km-long Ewing streamer allows layer 2A to be imaged, albeit weakly, along the VFR at ~1.0 s below the seafloor, a value consistent with previous OBS refraction work (*Turner et al*, 1999).

Acknowledgements

We would like to thank the captain and the crew of the R/V Ewing for their help and a great Christmas party. Russell Howorth and the South Pacific Applied Geoscience Commission (SOPAC), Bob Knox, Rose Dufour, John Orcutt, Carolyn Keen and Peter Lonsdale deserve thanks for their help in obtaining clearances at the eleventh hour. Brian Taylor & Kirsten Zellmer provided advanced copies of their bathymetry compilations and picks of the Lau spreading centers without which cruise planning would have been infinitely more complex and error prone. Much of the Underway Geophysics and File Formats sections of this report uses material from Jeff Turmelle. The real time processing sections are courtesy of Paul Henkart. Finally this cruise was made possible by the support of the National Science Foundation and Dave Epp.

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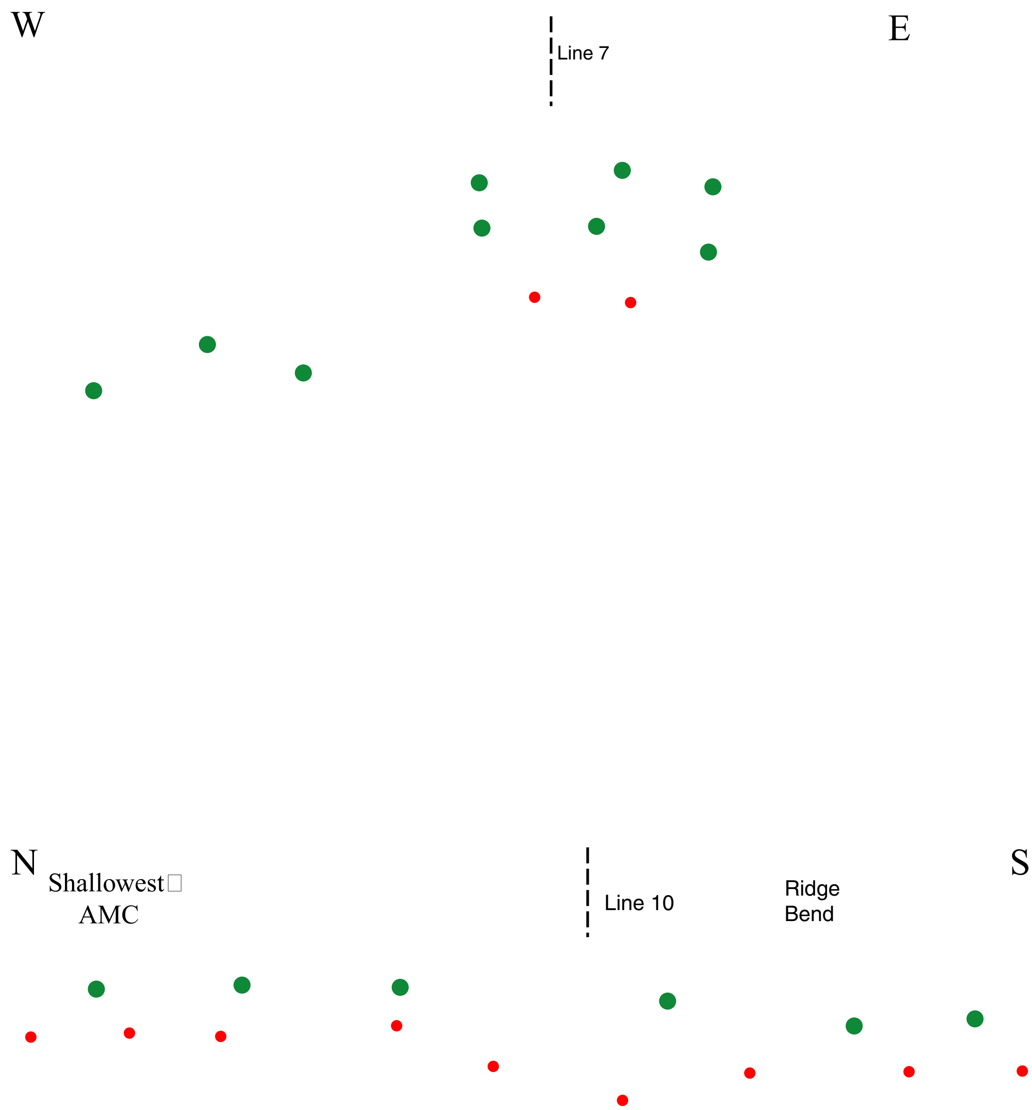
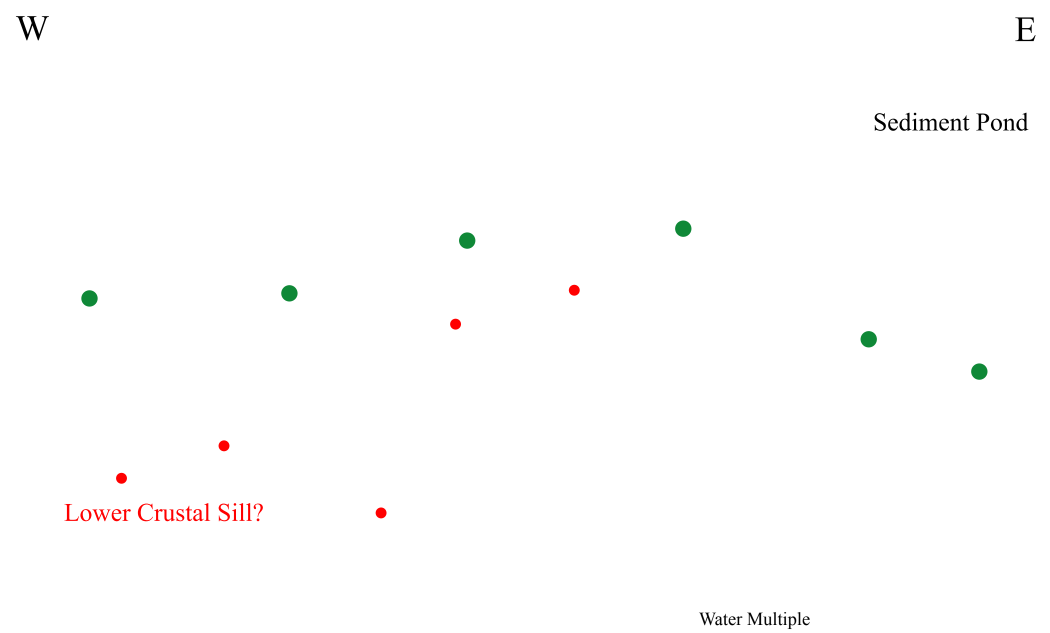
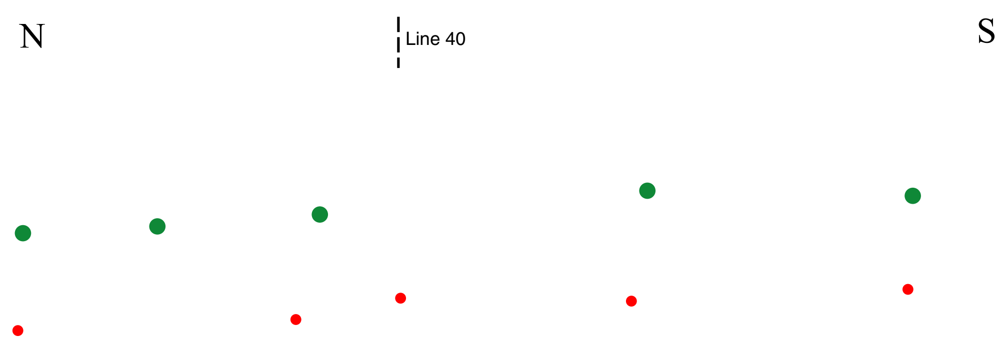


Crossing MCS profiles from the Central Lau Spreading Center
The axial profile, line 7 and cross-axis profile, line 10 cross at 18° 45'S, 176° 31'W. ●- axial magma chamber reflector, ●- layer 2A. The subseafoor depth of the AMC depth averages ~ 1.3 km but reaches a minimum of ~1.1 km near RP 9500. Profile 10 is unusual in having two recognizable near-surface reflectors, indicating a double-step structure for layer 2A.





Crossing MCS profiles from the Eastern Lau Spreading Center

The axial profile, line 35 and cross-axis profile, line 40 cross at 21° 16S, 176° 21'W. ● - axial magma chamber reflector, ● - layer 2A. Along the ELSC, Layer 2A is much thicker, typically appearing 0.6s after the seafloor reflection, and in contrast to the CLSC shows no thinning at the axis. As a result, the AMC is deeper, initial estimates yield average AMC depth along the ELSC of ~2.2 km

Seismic Lines

The location of the seismic lines is shown in the accompanying figures, which for convenience are split the Lau basin into the three tectonic regions of operation, the Central Lau Spreading center, the Eastern Lau Spreading center, and the Valu Fa Ridge. Line are indexed by a primary line number and often a secondary section letter, e.g. line 7a, 7b, & 7c. The line subsections were not shot consecutively, but in most cases, combine to make a single logical line, for example, 7a,b, & c combine to form line 7, the axial line for the Central Lau, while 20a & 20b combine to form a single eastern Lau cross-axis line, line 20.The exception to this is some of the cross-axis lines, notably 8a,b & c; 10a &b and 36a,b & c. In these cases the location of part of the cross-lines was changed on board the Ewing in response to the real-time stack of the along-axis profile, but the original numbering was kept. In addition line 11, a ridge parallel line from the Central Lau, is sometimes referred to as 11a & b. This is because there was a gap in acquisition during the shooting of this line.

The track lines on the CLSC were originally laid out, so that cross-axis lines were shot ahead of, rather than behind the southward advancing axial profile. This was to guard againts the possibility that the planned axial profile might be mispositioned relative to the narrow axial magma chamber (AMC) reflector. However, in the end a greater problem along the CLSC was the intermittancy of the AMC reflector rather than its lateral displacement, and the better strategy would have been to shoot the cross-axis lines across an already completed axial profile. Along the southern part of the ELSC, where there were multiple parallel ridges that were potentially the current axis, the cross lines were collected ahead of the axial profile to confirm the pick of the axis. Conversely along the northern VFR, where the axis is well defined and blade like, the cross-axis lines were shot behind the advancing axial profile.

RP gathers

The data was gathered into RPs assuming strictly linear profiles with the streamer directly behind the ship. As such start and end shot numbers for a line were chosen so as to avoid any data from the turn. Data was gathered into RPs using a 6.25 m bin spacing. Linear distance, x, along an individual profile was found by accumulating the shot-to-shot distances calculated from the processed shot files, the ts.n<jday> files and adding it to an initial offset, i.e. $x = \Sigma\Delta s + offset$. The offset has a minimum value 5000 m, ensuring that all RPs, calculated as $round(x_m/6.25)$ where x_m is the midpoint location, are positive. The initial offsets were adjusted so that combined lines, e.g 7a &b, have, as far as possible, the same RPs in their overlap region. In addition offsets for cross-axis lines were adjusted so that the RP at the crossing point with the axial line was close to 5000. In most instances, the RPs listed as the end points of lines in the following tables are at, or are close to, full 80-fold gathers. In some cases particularly for shorter lines the limits include the roll-off at the end of the line.

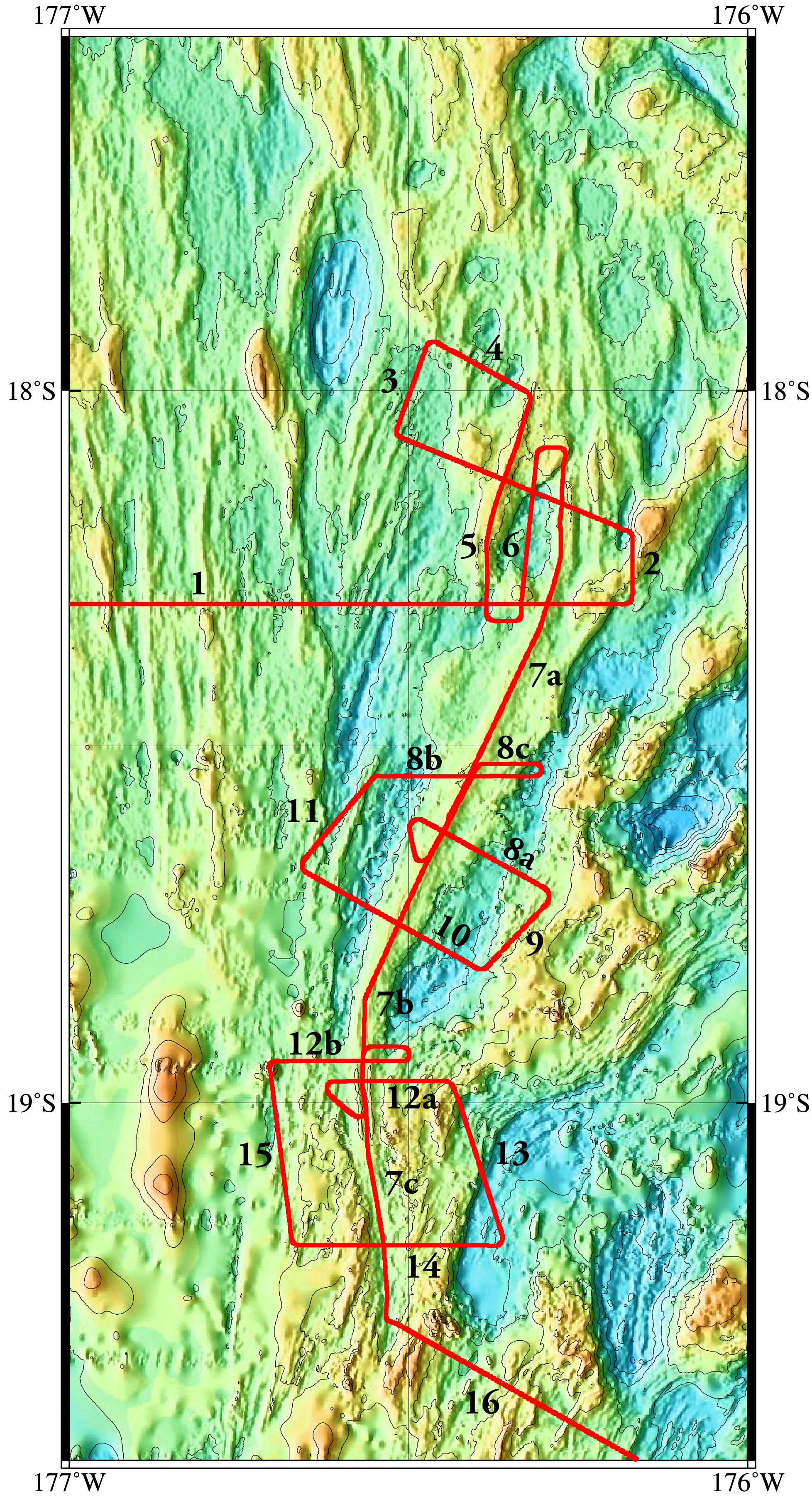
Line ends for Central Lau Spreading Center

	RP		Start		Finish	
Line	**Start**	**End**	**Latitude**	**Longitude**	**Latitude**	**Longitude**
1	1460	27245	18° 18.005' S	177° 43.985' W	18° 18.004' S	176° 12.539' W
2	3383	8863	18° 11.681' S	176° 11.154' W	18° 04.576' S	176° 29.092' W
3	770	2490	18° 03.323' S	176° 31.069' W	17° 57.844' S	176° 28.999' W
4	775	2720	17° 56.109' S	176° 27.189' W	17° 59.246' S	176° 21.134' W
5	770	5735	18° 00.832' S	176° 19.211' W	18° 17.068' S	176° 23.091' W
6	770	4170	18° 18.473' S	176° 20.038' W	18° 07.017' S	176° 18.825' W
7a	770	11020	18° 05.466' S	176° 16.099' W	18° 37.905' S	176° 27.348' W
7b	8466	18101	18° 30.265' S	176° 23.076' W	19° 00.483' S	176° 33.782' W
7c	16704	22918	18° 55.779' S	176° 34.006' W	19° 16.678' S	176° 31.911' W
8a	4360	7371	18° 36.168' S	176° 28.928' W	18° 41.100' S	176° 19.561' W
8b	2720	6150	18° 32.510' S	176° 32.704' W	18° 32.522' S	176° 20.524' W
8c	3717	4800	18° 31.495' S	176° 18.900' W	18° 31.506' S	176° 22.746' W
9	770	2465	18° 43.252' S	176° 17.767' W	18° 47.422' S	176° 21.909' W
10	2792	7172	18° 48.677' S	176° 24.044' W	18° 41.396' S	176° 37.614' W
11a*	770	1300	18° 39.718' S	176° 39.336' W	18° 38.333' S	176° 38.136' W
11b	2430	3030	18° 35.406' S	176° 35.552' W	18° 33.854' S	176° 34.174' W
12a	4268	6529	18° 58.219' S	176° 36.720' W	18° 58.181' S	176° 28.671' W
12b	2925	5503	18° 56.513' S	176° 41.403' W	18° 56.495' S	176° 32.224' W
13	770	4105	18° 58.805' S	176° 25.956' W	19° 09.539' S	176° 22.254' W
14	2185	6590	19° 12.038' S	176° 22.162' W	19° 11.998' S	176° 37.866' W
15	770	4520	19° 11.413' S	176° 40.360' W	18° 58.810' S	176° 42.030' W
16	770	7425	19° 18.350' S	176° 31.681' W	19° 29.330' S	176° 10.941' W

* Line 11 is split into 11a & b because of a 49 minute gap in data acquisition.

Line crossings for Central Lau Spreading Center

Along Axis		Cross-axis		Crossing Point	
Line	**RP**	**Line**	**RP**	**Latitude**	**Longitude**
5	6009	1	24261	18° 17.998' S	176° 23.120' W
6	909	1	25131	18° 18.005' S	176° 20.037' W
7a2	4532	1	25783	18° 17.999' S	176° 17.725' W
7a3	9243	8b	4999	18° 32.521' S	176° 24.614' W
7b1	9224	8b	5076	18° 32.524' S	176° 24.340' W
7a3	10779	8a	4999	18° 37.194' S	176° 26.927' W
7b1	10782	8a	5002	18° 37.198' S	176° 26.918' W
7b1	13338	10	5002	18° 44.983' S	176° 30.881' W
7b2	16919	12b	4998	18° 56.505' S	176° 34.023' W
7c	16918	12b	4994	18° 56.505' S	176° 34.035' W
7b2	17418	12a	5000	18° 58.195' S	176° 34.115' W
7c	17417	12a	5005	18° 58.196' S	176° 34.099' W
7c	21535	14	5002	19° 12.005' S	176° 32.203' W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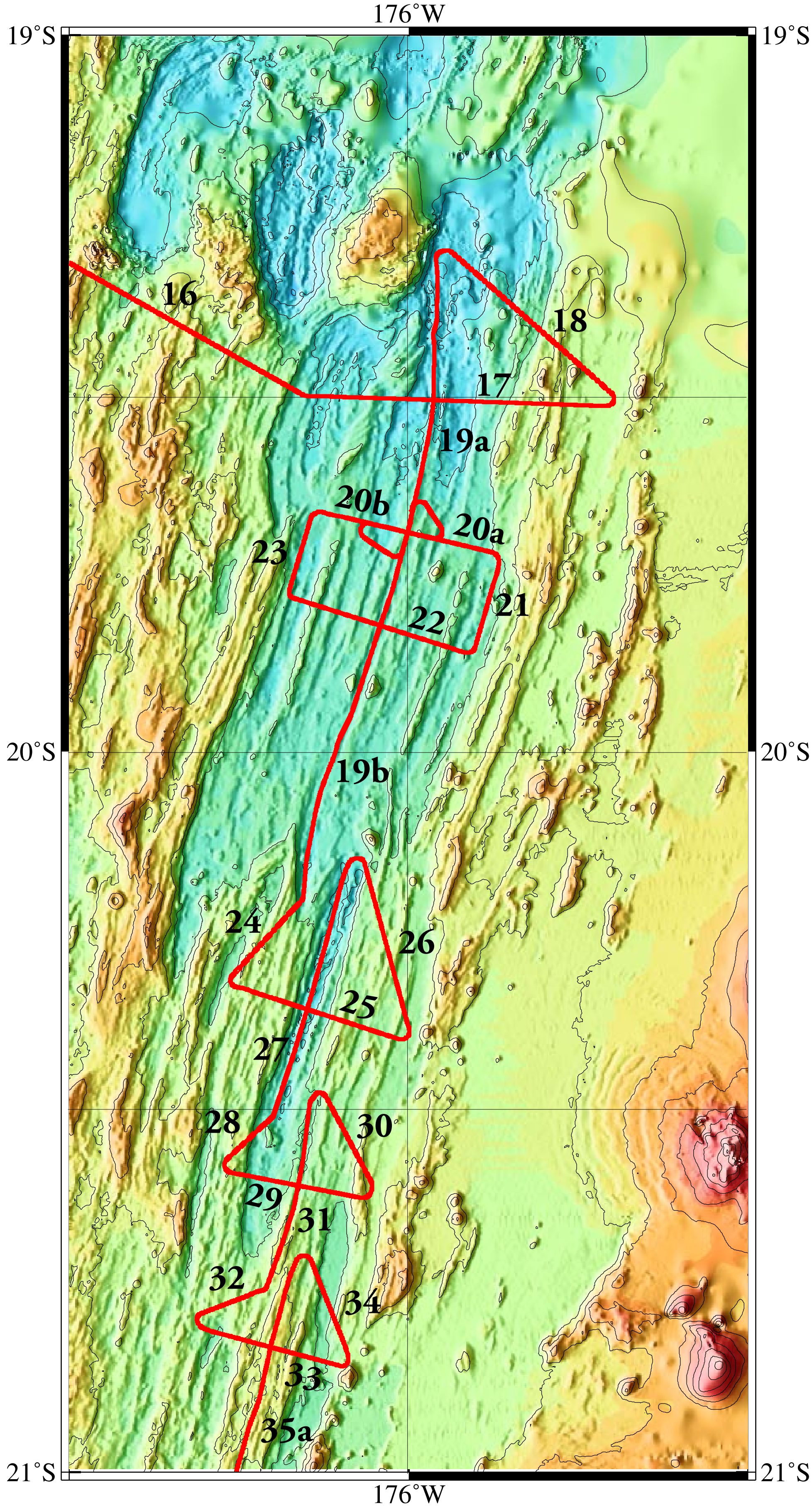
Line ends for Eastern Lau Spreading Center

	RP		Start		Finish	
Line	**Start**	**End**	**Latitude**	**Longitude**	**Latitude**	**Longitude**
17	1970	8790	19° 30.324' S	176° 08.605' W	19° 31.077' S	175° 44.256' W
18	770	5595	19° 30.131' S	175° 41.942' W	19° 19.326' S	175° 54.867' W
19a	801	7629	19° 18.813' S	175° 57.578' W	19° 41.666' S	176° 00.067' W
19b	7287	16533	19° 40.547' S	175° 59.755' W	20° 10.472' S	176° 09.145' W
20a	4000	6657	19° 40.933' S	176° 03.549' W	19° 42.991' S	175° 54.301' W
20b	2978	5139	19° 40.172' S	176° 07.116' W	19° 41.831' S	175° 59.591' W
21	770	2260	19° 44.847' S	175° 52.101' W	19° 49.688' S	175° 53.614' W
22	2756	6764	19° 51.785' S	175° 54.842' W	19° 47.695' S	176° 08.520' W
23	770	2230	19° 46.766' S	176° 10.599' W	19° 42.027' S	176° 09.108' W
24	770	2860	20° 12.395' S	176° 09.382' W	20° 17.591' S	176° 14.472' W
25	3267	6878	20° 19.712' S	176° 14.870' W	20° 23.497' S	176° 02.541' W
26	770	4525	20° 23.208' S	175° 59.921' W	20° 10.933' S	176° 03.444' W
27	777	6335	20° 10.637' S	176° 05.820' W	20° 28.714' S	176° 11.365' W
28	770	1805	20° 30.491' S	176° 12.022' W	20° 32.865' S	176° 14.759' W
29	3351	6105	20° 35.146' S	176° 15.589' W	20° 36.909' S	176° 05.864' W
30	770	2710	20° 35.959' S	176° 03.239' W	20° 30.167' S	176° 06.533' W
31	777	5003	20° 29.277' S	176° 08.716' W	20° 43.194' S	176° 11.998' W
32	770	1890	20° 44.885' S	176° 12.827' W	20° 46.210' S	176° 16.599' W
33	3548	6279	20° 48.355' S	176° 17.263' W	20° 50.742' S	176° 07.761' W
34	770	2810	20° 50.398' S	176° 05.321' W	20° 43.957' S	176° 07.969' W
35a	777	6343	20° 42.433' S	176° 09.919' W	21° 00.532' S	176° 15.385' W

Line crossings for northern Eastern Lau Spreading Center

Along Axis		Cross-axis		Crossing Point	
Line	**RP**	**Line**	**RP**	**Latitude**	**Longitude**
19a	4306	17	4997	19° 30.629' S	175° 57.797' W
19a	7643	20a	4998	19° 41.711' S	176° 00.078' W
19b	7643	20a	4997	19° 41.710' S	176° 00.083' W
19a	7643	20b	4998	19° 41.713' S	176° 00.079' W
19b	7643	20b	4997	19° 41.711' S	176° 00.083' W
19b	10040	22	5000	19° 49.497' S	176° 02.498' W
27	4111	25	4999	20° 21.532' S	176° 08.962' W
31	2843	29	5002	20° 36.205' S	176° 09.759' W
35a	2998	33	4999	20° 49.624' S	176° 12.212' W



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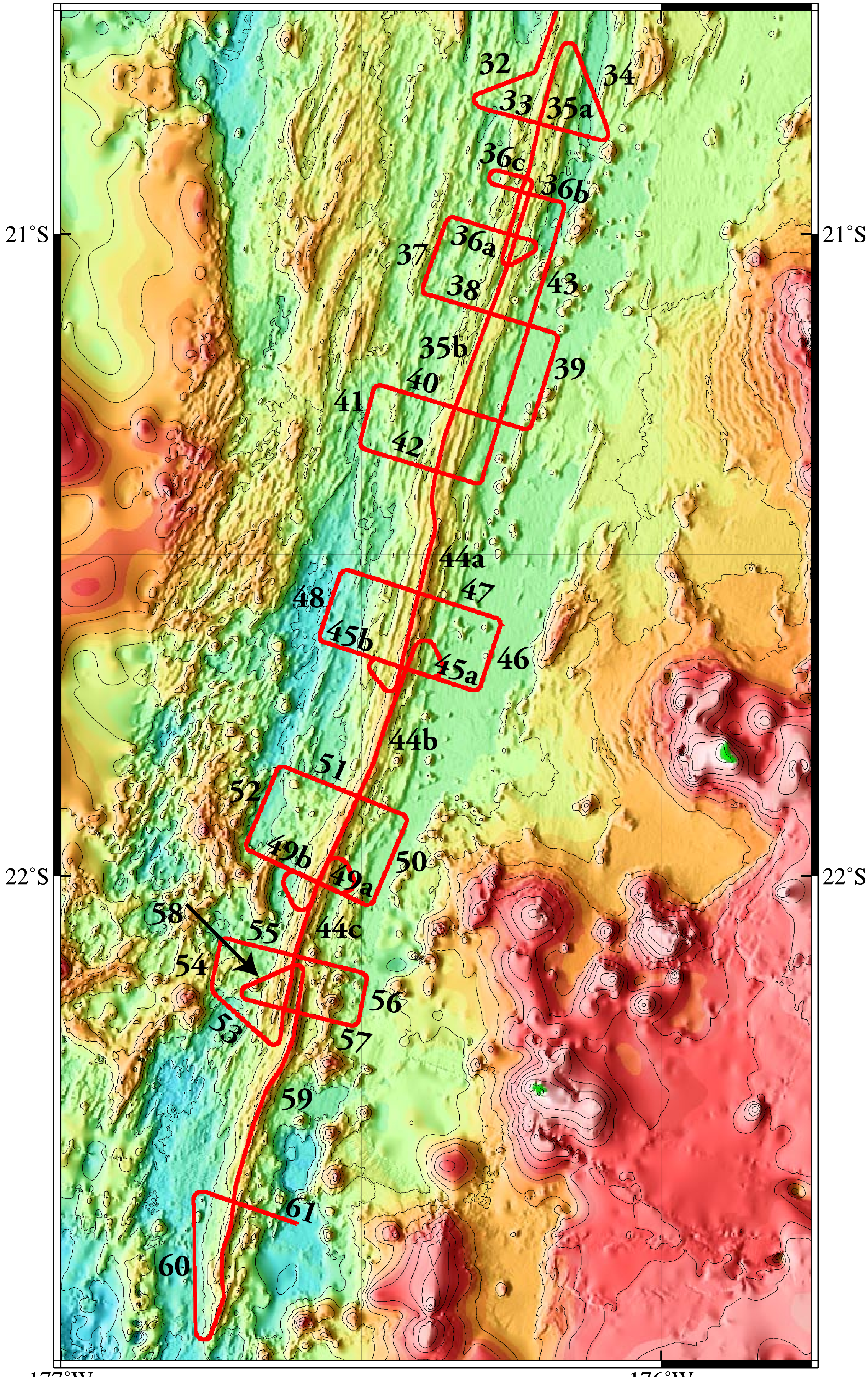
Line ends for southern Eastern Lau Spreading Center and Valu Fa Ridge

	RP		Start		Finish	
Line	**Start**	**End**	**Latitude**	**Longitude**	**Latitude**	**Longitude**
32	770	1890	20° 44.885’ S	176° 12.827’ W	20° 46.210’ S	176° 16.599’ W
33	3548	6279	20° 48.355’ S	176° 17.263’ W	20° 50.742’ S	176° 07.761’ W
34	770	2810	20° 50.398’ S	176° 05.321’ W	20° 43.957’ S	176° 07.969’ W
35a	777	6343	20° 42.433’ S	176° 09.919’ W	21° 00.532’ S	176° 15.385’ W
35b*	4742	10503	20° 55.535’ S	176° 12.967’ W	21° 13.980’ S	176° 19.708’ W
36a	4393	6113	21° 00.523’ S	176° 13.129’ W	20° 58.902’ S	176° 19.086’ W
36b	3973	5303	20° 56.914’ S	176° 10.433’ W	20° 55.743’ S	176° 15.062’ W
36c	4200	5000	20° 54.031’ S	176° 16.283’ W	20° 54.739’ S	176° 13.497’ W
37	770	2120	20° 59.053’ S	176° 21.593’ W	21° 03.359’ S	176° 23.223’ W
38	3159	6316	21° 05.655’ S	176° 23.472’ W	21° 08.727’ S	176° 12.563’ W
39	770	2715	21° 09.901’ S	176° 10.358’ W	21° 16.197’ S	176° 12.426’ W
40	3024	7106	21° 18.238’ S	176° 13.769’ W	21° 14.195’ S	176° 27.870’ W
41	770	1770	21° 14.555’ S	176° 28.749’ W	21° 17.834’ S	176° 29.654’ W
42	2983	5603	21° 20.199’ S	176° 29.442’ W	21° 22.807’ S	176° 20.387’ W
43	775	8115	21° 23.079’ S	176° 17.907’ W	20° 59.282’ S	176° 10.252’ W
44a	777	5123	21° 26.442’ S	176° 22.697’ W	21° 40.745’ S	176° 26.093’ W
44b	4383	11603	21° 38.546’ S	176° 24.633’ W	22° 01.157’ S	176° 34.518’ W
44c	10703	15203	21° 58.385’ S	176° 33.193’ W	22° 12.933’ S	176° 37.831’ W
45a	4253	6603	21° 39.681’ S	176° 28.573’ W	21° 42.177’ S	176° 20.490’ W
45b	2703	5403	21° 38.119’ S	176° 33.919’ W	21° 40.939’ S	176° 24.619’ W
46	775	2010	21° 42.274’ S	176° 18.050’ W	21° 38.300’ S	176° 16.660’ W
47	2863	6518	21° 35.836’ S	176° 16.871’ W	21° 32.002’ S	176° 29.453’ W
48	770	1985	21° 31.914’ S	176° 32.108’ W	21° 35.810’ S	176° 33.519’ W
49a	4303	6003	21° 59.594’ S	176° 36.585’ W	22° 02.036’ S	176° 30.995’ W
49b	2946	5121	21° 57.584’ S	176° 41.209’ W	22° 00.704’ S	176° 34.056’ W
50	770	2605	22° 02.264’ S	176° 28.730’ W	21° 56.527’ S	176° 26.167’ W
51	3656	6699	21° 54.268’ S	176° 25.751’ W	21° 50.427’ S	176° 35.995’ W
52	770	2425	21° 50.234’ S	176° 38.470’ W	21° 55.413’ S	176° 40.761’ W
53	770	2165	22° 15.382’ S	176° 39.304’ W	22° 12.256’ S	176° 43.105’ W
54	770	1340	22° 09.877’ S	176° 44.854’ W	22° 07.984’ S	176° 44.448’ W
55	3036	6388	22° 05.765’ S	176° 43.534’ W	22° 08.543’ S	176° 31.728’ W
56	770	1435	22° 09.639’ S	176° 29.425’ W	22° 11.845’ S	176° 29.908’ W
57	3151	5551	22° 13.868’ S	176° 31.177’ W	22° 11.917’ S	176° 39.653’ W
58	770	1720	22° 10.219’ S	176° 41.430’ W	22° 08.937’ S	176° 38.262’ W
59	13912	23853	22° 08.937’ S	176° 35.758’ W	22° 41.149’ S	176° 44.459’ W
60	770	3880	22° 42.251’ S	176° 46.525’ W	22° 31.721’ S	176° 46.697’ W
61	3615	6829	22° 28.828’ S	176° 47.526’ W	22° 32.304’ S	176° 36.437’ W

* Fold drops between RPs 8501–9122, reaching a minimum of 53-54 for RPs 8645–8978, because of an aquisition failur



21°S
21°S
22°S
22°S
177°W
176°W
32
33
34
35a
36c
36b
36a
37
38
43
35b
39
40
41
42
44a
47
48
45b
45a
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44b
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52
49b
49a
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58
55
44c
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57
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61
60

Line crossings for southern Eastern Lau Spreading Center and Valu Fa Ridge

Along Axis		Cross-axis		Crossing Point	
Line	**RP**	**Line**	**RP**	**Latitude**	**Longitude**
35a	2998	33	4999	20° 49.624' S	176° 12.212' W
35a	4552	36c	5000	20° 54.739' S	176° 13.497' W
35a	4954	36b	5000	20° 56.011' S	176° 14.009' W
35a	6180	36a	4998	20° 59.999' S	176° 15.238' W
35b	4953	36b	4777	20° 56.204' S	176° 13.230' W
35b	6184	36a	4785	21° 00.200' S	176° 14.496' W
35b	8437	38	4997	21° 07.419' S	176° 17.113' W
35b	11226	40	5002	21° 16.279' S	176° 20.605' W
35b	13056	42	5002	21° 22.216' S	176° 22.465' W
44a	2945	47	5002	21° 33.578' S	176° 24.234' W
44a	5048	45a	5000	21° 40.504' S	176° 26.014' W
44a	5048	45b	4997	21° 40.505' S	176° 26.014' W
44b	5052	45a	5157	21° 40.668' S	176° 25.475' W
44b	5055	45b	5153	21° 40.679' S	176° 25.479' W
44b	8817	51	4998	21° 52.590' S	176° 30.276' W
44b	11430	49a	5003	22° 00.611' S	176° 34.288' W
44b	11428	49b	5003	22° 00.605' S	176° 34.286' W
44c	11426	49a	4999	22° 00.606' S	176° 34.299' W
44c	11424	49b	5000	22° 00.600' S	176° 34.296' W
44c	13536	55	4998	22° 07.411' S	176° 36.630' W
44c	15032	57	5000	22° 12.366' S	176° 37.706' W
59	15031	57	4622	22° 12.682' S	176° 36.376' W
59	20563	61	5002	22° 30.283' S	176° 42.729' W

Shot table for Central Lau Spreading Center

Line		JD	GMT	Latitude	Longitude	Shot	Comments
1	Start	346	01:56	18° 18.005	177° 43.826	1	Long initial line with ridge crossing
	End	346	21:03	18° 17.993	176° 10.765	4367	
2	Start	346	22:59	18° 11.633	176° 11.260	4725	Cross-axis Line
	End	347	03:51	18° 03.931	176° 30.722	5716	
3	Start	347	04:04	18° 03.224	176° 31.031	5758	Ridge parallel
	End	347	05:47	17° 56.258	176° 28.414	6122	
4	Start	347	06:06	17° 56.151	176° 27.108	6195	
	End	347	07:47	18° 00.080	176° 19.571	6599	
5	Start	347	07:59	18° 00.931	176° 19.248	6647	Axial line on last ridge of LETZ
	End	347	11:51	18° 18.752	176° 23.147	7552	
6	Start	347	12:43	18° 18.368	176° 20.031	7758	Overlap basin line
	End	347	15:33	18° 05.339	176° 18.645	8402	
7A	Start	347	16:00	18° 04.796	176° 16.647	8557	Start of CLSC along-axis line
	CC	347	18:01	18° 13.972	176° 16.546	8973	At End of overlap basin
	CC	347	19:21	18° 20.018	176° 18.389	9283	Onto long-linear segment of CLSC
	End	347	23:54	18° 39.357	176° 28.187	10342	
8A	Start	348	01:04	18° 36.207	176° 28.850	10603	Ridge x-line
	End	348	03:36	18° 41.933	176° 18.002	11185	
9	Start	348	03:56	18° 43.328	176° 17.842	11264	Ridge parallel
	End	348	05:27	18° 48.650	176° 23.136	11625	
10	Start	348	05:41	18° 48.633	176° 24.119	11675	Ridge x-line
	End	348	09:34	18° 40.519	176° 39.223	12485	
11	Start	348	09:49	18° 39.636	176° 39.266	12535	System hung at shot 12627 for 46 min
	End	348	11:54	18° 32.641	176° 33.077	12797	
8B	Start	348	12:00	18° 32.512	176° 32.576	12822	Ridge x-line
	End	348	14:47	18° 32.515	176° 18.795	13469	
8C	Start	348	15:11	18° 31.496	176° 18.985	13558	Ridge x-line
	End	348	16:08	18° 31.494	176° 23.456	13768	
7B	Start	348	16:15	18° 31.770	176° 23.913	13794	Along-axis line
	CC	348	20:53	18° 51.349	176° 33.853	14865	turn at End of axial high
	End	348	22:50	19° 00.563	176° 33.774	15320	
12A	Start	349	00:06	18° 58.218	176° 36.635	15595	Ridge x-line
	End	349	02:05	18° 58.185	176° 26.880	16052	
13	Start	349	02:21	18° 58.904	176° 25.918	16113	Ridge parallel
	End	349	05:04	19° 11.150	176° 21.703	16747	
14	Start	349	05:19	19° 12.034	176° 22.269	16804	Ridge x-line
	End	349	08:46	19° 12.003	176° 39.641	17616	
15	Start	349	09:00	19° 11.308	176° 40.370	17669	Ridge parallel
	End	349	12:04	18° 57.134	176° 42.265	18372	
12B	Start	349	12:21	18° 56.512	176° 41.317	18435	Ridge x-line
	End	349	14:36	18° 56.492	176° 30.468	18943	
7C	Start	349	15:44	18° 55.939	176° 34.012	19208	Along-axis line
	End	349	20:29	19° 18.302	176° 31.776	20320	End of CLSC survey

Shot lines for northern Eastern Lau Spreading Center

Line		JD	GMT	Latitude	Longitude	Shot	Comments
16	Start	349	20:32	19° 18.391	176° 31.579	20330	Transit line from CLSC to ELSC
	End	350	01:35	19° 30.168	176° 09.395	21517	
17	Start	350	01:46	19° 30.323	176° 08.498	21560	1st ELSC crossing line
	End	350	07:02	19° 31.123	175° 42.475	22775	starts at course change from line 16
18	Start	350	07:22	19° 30.062	175° 42.026	22847	Oblique
	End	350	11:29	19° 18.215	175° 56.204	23729	
19a	Start	350	11:50	19° 18.813	175° 57.578	23814	ELSC along-axis line
	End	350	17:08	19° 43.308	176° 00.548	25036	
20A	Start	350	18:29	19° 40.953	176° 03.462	25314	Cross-axis Line
	End	350	20:41	19° 43.391	175° 52.549	25837	
21	Start	350	21:03	19° 44.947	175° 52.134	25925	Ridge parallel
	End	350	22:30	19° 51.323	175° 54.107	26252	
22	Start	350	22:43	19° 51.762	175° 54.928	26300	Cross-axis Line
	End	351	02:14	19° 47.178	176° 10.237	27048	
23	Start	351	02:24	19° 46.666	176° 10.569	27080	Ridge parallel
	End	351	03:55	19° 40.399	176° 08.586	27402	
20B	Start	351	04:16	19° 40.187	176° 07.031	27483	Cross-axis Line
	End	351	06:08	19° 42.201	175° 57.836	27923	
19B	Start	351	07:34	19° 40.626	175° 59.777	28231	ELSC along-axis line
	End	351	14:41	20° 12.168	176° 09.303	29852	
24	Start	351	14:46	20° 12.470	176° 09.460	29869	Oblique
	End	351	16:50	20° 18.840	176° 15.675	30295	
25	Start	351	17:09	20° 19.738	176° 14.788	30368	Cross-axis Line
	End	351	20:03	20° 24.014	176° 00.817	31050	
26	Start	351	20:22	20° 23.107	175° 59.953	31124	Oblique
	End	351	23:36	20° 09.295	176° 03.900	31828	
27	Start	352	00:16	20° 10.716	176° 05.843	31980	Along-axis line
	End	352	04:45	20° 30.333	176° 11.932	32986	
28	Start	352	04:49	20° 30.561	176° 12.105	33000	Oblique
	End	352	05:59	20° 34.026	176° 16.079	33251	
29	Start	352	06:19	20° 35.160	176° 15.504	33329	Cross-axis Line
	End	352	08:37	20° 37.225	176° 04.085	33868	
30	Start	352	09:00	20° 35.867	176° 03.293	33958	Oblique
	End	352	10:48	20° 28.680	176° 07.401	34360	
31	Start	352	11:13	20° 29.358	176° 08.727	34448	Along-axis line, rift to ridge transition
	End	352	14:54	20° 44.637	176° 12.553	35224	
32	Start	352	15:00	20° 44.918	176° 12.932	35247	Oblique
	End	352	16:10	20° 46.814	176° 18.284	35512	

Shot table for southern Eastern Lau Spreading Center

Line		JD	GMT	Latitude	Longitude	Shot	Comments
33	Start	352	16:46	20° 48.376	176° 17.179	35640	Cross-axis line
	End	352	19:22	20° 51.195	176° 06.011	36175	
34	Start	352	19:39	20° 50.298	176° 05.356	36240	Oblique
	End	352	21:27	20° 42.384	176° 08.626	36658	
35A	Start	352	21:47	20° 42.508	176° 09.952	36737	Along-axis line
	End	353	02:10	21° 02.157	176° 15.890	37744	
36A	Start	353	03:17	21° 00.503	176° 13.220	38007	Cross-axis line
	End	353	04:50	20° 58.409	176° 20.791	38372	
37	Start	353	05:05	20° 59.151	176° 21.633	38430	Ridge parallel
	End	353	06:24	21° 04.957	176° 23.818	38733	
38	Start	353	06:36	21° 05.674	176° 23.388	38779	Cross-axis line
	End	353	09:20	21° 09.223	176° 10.826	39385	
39	Start	353	09:33	21° 10.001	176° 10.390	39433	Ridge parallel
	End	353	11:22	21° 17.811	176° 12.947	39835	
40	Start	353	11:34	21° 18.241	176° 13.759	39883	Cross-axis line
	End	353	14:45	21° 14.172	176° 27.958	40568	
41	Start	353	14:58	21° 14.657	176° 28.777	40618	Ridge parallel
	End	353	16:02	21° 19.482	176° 30.078	40863	
42	Start	353	16:16	21° 20.226	176° 29.352	40917	Cross-axis line
	End	353	18:26	21° 23.310	176° 18.658	41433	
43	Start	353	18:38	21° 22.994	176° 17.884	41476	Extended ridge parallel line
	End	354	00:17	20° 57.669	176° 09.728	42778	
36B	Start	354	00:33	20° 56.892	176° 10.521	42840	Cross-axis line
	End	354	01:47	20° 55.384	176° 16.539	43128	
36C	Start	354	02:18	20° 54.066	176° 16.147	43246	Cross-axis Line
	End	354	02:54	20° 54.788	176° 13.332	43381	
35B	Start	354	03:07	20° 55.612	176° 12.995	43430	Along-axis Line
	End	354	10:08	21° 26.503	176° 22.691	45000	System down for 7 mins at shot 44137

Line		JD	GMT	Latitude	Longitude	Shot	Comments
44A	Start	354	10:08	21° 26.523	176° 22.688	45001	Along-axis line northernVFR
	End	354	13:42	21° 42.347	176° 26.472	45802	Continuous with 35b
45A	Start	354	14:49	21° 39.776	176° 28.293	46056	Cross-axis Line
	End	354	16:46	21° 42.665	176° 18.879	46512	
46	Start	354	16:58	21° 42.190	176° 18.023	46563	Ridge parallel
	End	354	18:13	21° 36.695	176° 16.089	46848	
47	Start	354	18:33	21° 35.808	176° 16.957	46918	Cross-axis Line
	End	354	21:48	21° 31.471	176° 31.186	47607	
48	Start	354	22:04	21° 32.014	176° 32.144	47664	Ridge parallel
	End	354	23:25	21° 37.411	176° 34.100	47945	
45B	Start	354	23:39	21° 38.182	176° 33.700	47992	Cross-axis Line
	End	355	01:56	21° 41.413	176° 23.031	48508	
44B	Start	355	03:19	21° 38.814	176° 24.733	48816	Along-axis line
	End	355	08:54	22° 02.556	176° 35.000	50078	
49A	Start	355	10:14	21° 59.685	176° 36.382	50386	Cross-axis Line
	End	355	11:46	22° 02.618	176° 29.650	50727	
50	Start	355	12:00	22° 02.166	176° 28.688	50782	Ridge parallel
	End	355	13:38	21° 54.975	176° 25.464	51166	
51	Start	355	13:49	21° 54.239	176° 25.833	51209	Cross-axis Line
	End	355	16:22	21° 49.798	176° 37.691	51796	
52	Start	355	16:37	21° 50.331	176° 38.511	51847	Ridge parallel
	End	355	18:21	21° 56.973	176° 41.465	52201	
49B	Start	355	18:35	21° 57.678	176° 40.963	52248	Cross-axis Line
	End	355	20:35	22° 01.501	176° 32.243	52690	
44C	Start	355	21:47	21° 58.767	176° 33.380	52988	Along-axis line northernVFR
	End	356	01:58	22° 14.446	176° 37.954	53792	
53	Start	356	02:31	22° 15.313	176° 39.388	53907	Start of Paper Clip Turn at OSC
	End	356	03:50	22° 11.122	176° 44.455	54218	
54	Start	356	04:08	22° 09.774	176° 44.833	54290	Ridge parallel
	End	356	04:52	22° 06.328	176° 44.107	54463	
55	Start	356	05:04	22° 05.787	176° 43.450	54508	Cross-axis Line northernVFR
	End	356	08:08	22° 08.970	176° 29.956	55146	
56	Start	356	08:22	22° 09.742	176° 29.448	55195	Ridge parallel
	End	356	09:17	22° 13.508	176° 30.261	55384	
57	Start	356	09:32	22° 13.849	176° 31.266	55438	Cross-axis line at OSC
	End	356	11:42	22° 11.492	176° 41.423	55918	
58	Start	356	12:04	22° 10.179	176° 41.325	56007	
	End	356	13:05	22° 08.276	176° 36.659	56241	
59	Start	356	13:22	22° 09.017	176° 35.771	56306	Along-axis line, central & southern VFR
	End	356	21:58	22° 42.692	176° 45.066	58040	
60	Start	356	22:23	22° 42.146	176° 46.528	58140	Oblique
	End	357	00:33	22° 30.026	176° 46.739	58737	
61	Start	357	00:57	22° 29.476	176° 45.142	58830	Cross-axis Line
	End	357	02:60	22° 32.334	176° 36.355	59256	End of Experiment

Seismic Acquisition Parameters

Streamer Configuration

The Lau basin experiment was shot using the Ewing's 480 channel, 6-km-long streamer. Two slightly different streamer configurations with different tow leader lengths of were used on the cruise. The first configuration was used only for shooting line 1, the initial east-west line into the CLSC. The tow leader, connecting the streamer to the ship, was shortened by 31.9 m during the turn at the end of line 1. Other than this, the streamer configuration was not altered during acquisition.

The heart of the Ewing streamer is 40 active sections each 150 m long giving a total length of 6 km. At the front of the streamer there is a passive stretch section and an armored tow leader connecting the streamer to the ship. At the back of the streamer there is a small 4m active section, which completes the last hydrophone group, a passive stretch section and a tailbuoy section. Each active section of the streamer consists of 2 joined 75 m cable sections terminated by cans. An active section has 11 complete 12.5 m receiver groups plus 2 half groups at either end. The half groups are completed by the adjoining active section. Consequences of this arrangement are that the center of the first group is 12.5 m from the start of the first active section; groups are centered on the cans joining active sections; and the 4 m active section is required to complete the last group.

Compass Birds and Streamer Navigation

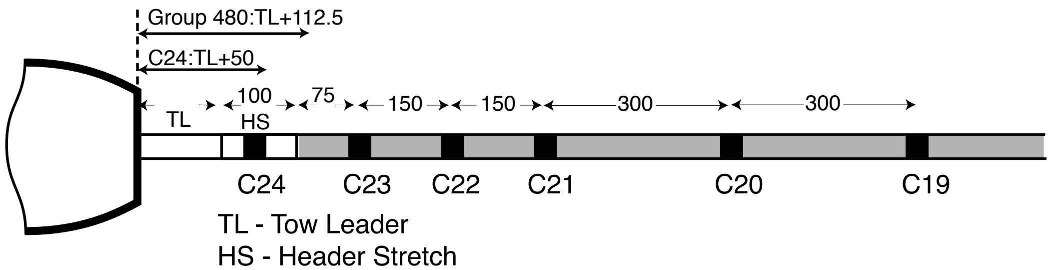
The streamer was instrumented with 24 depth control birds of which 12 odd numbered ones were compass birds. The 4 birds at the front of the streamer, 24-21, and the 3 at the end, 3-1, were more closely spaced. In the main part of the streamer, 21-3, the spacing of birds was 300 m (compass birds 600 m). The tail buoy was attached to the active part of the streamer by 150 m of stretch section and 25.3 m stick. There was a functioning CA code GPS receiver on the tail buoy during acquisition. Locations from this receiver, a CA code receiver on the *Ewing*, and the Y-code receiver were recorded in the compass bird data files, cb1.d<julian_day>, along with the compass bird headings.

Lau Streamer Configurations

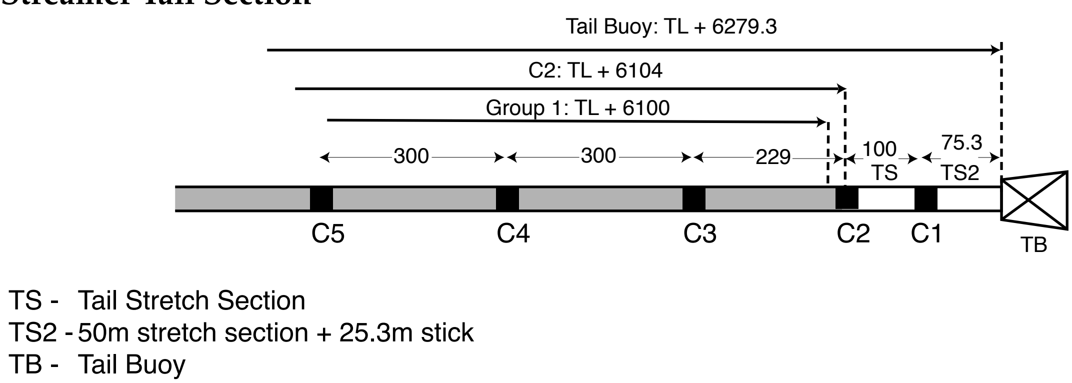
Offset(m)		Line 1	Others
GPS antenna to stern	18.5		
Group spacing	12.5		
Stern to source array center	37.5		
Tow Leader		147.5	115.6
Stern to group 480	TL+112.5	260.0	228.1
Stern to group 1	TL+6100	6247.5	6216.4
Source to group 480	TL+75	222.5	190.6
Source to group 1	TL+6062.5	6210.0	6178.1
Depth bird 24	TL+50	197.5	165.6
Compass bird 23	TL+175	322.5	290.6
Depth bird 22	TL+325	472.5	440.6
Compass bird 21	TL+475	622.5	590.6
Depth bird spacing 21 to 3	300		
Compass bird 3	TL+5875	6022.5	5990.6
Depth bird 2	TL+6104	6251.5	6219.6
Compass bird 1	TL+6204	6351.5	6319.6
Tail Buoy	TL+6279.3	6426.8	6394.9

* TL - Tow Leader

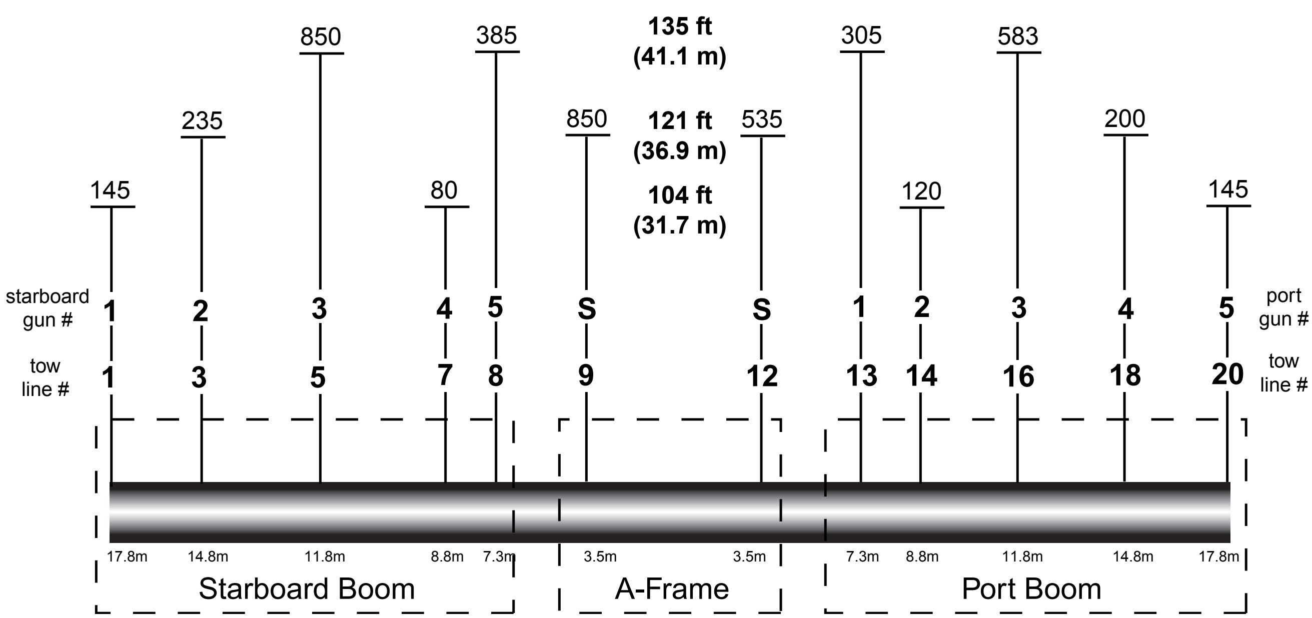
Streamer Head Section



Streamer Tail Section



R/V Ewing streamer geometry for Lau experiment



R/V Ewing gun array showing gun numbers and chamber sizes. The two guns on the A-frame, marked S, were spare guns used to replace the 850 cu. in. & 583 cu. in. guns when they went down

Air Gun Array

A 10 air gun, 3048 cu. in. (50L) array was used during the entire experiment. Two additional air guns with chambers sizes comparable to the largest guns in the array, 850 & 535 cu. in., were kept on ready deck to be substituted for the largest guns in the event of a gun blow out or other problems. Since the largest chambers have the biggest effect on the source signature, the aim was to minimize the duration of any large changes. The acquisition schedule was tight enough that there was no possibility of reshooting lines in the event of system failures.

Gun numbers are reported in the seismic log is as starboard gun #x or port gun #y. Guns are numbered starting from the starboard side, thus starboard gun 1 is the gun furthest out on the boom, but port gun #1 is nearest to the A-frame, see figure of gun configuration.

Acquisition

Data was acquired using "shoot-on-distance" plus randomization to reduce the coherence of water multiples. The mean shot spacing was set at 37.5 m, and the randomization produced shot spacings with a standard deviation of 0.38 m, corresponding to a time deviation of 0.17 s. The shot spacing exceeded 39 m or was less than 36 m, 0.2% of the time. These values were computed for line 7a but should be representative of all the lines. The 37.5 m shot spacing means that full-fold RP gathers are 80-fold. At the nominal shooting speed of 4.5 kts, the mean shot interval was 16.2 s.

For each shot, 10 s of data was recorded for all 480 channels at 4 ms sample interval. Each 3490E tape was set to record 145 shots, which corresponds ~40 minutes of data. The original SEG-D format data was converted to SEG-Y for archiving and subsequent processing. The size of each SEG-Y formatted file of 145 shots is 681 Mb. The SEG-Y formatted shot gathers include a trace "0", with trace ID =28, that holds the auxillary data for the shot, such centerbeam depth, from the SEG-D extended general header (see Reat Time Processing section for more details). The naming convention for SEG-Y files is `day<jday>.shot<shot>`, where `<jday>` is the julian day of the data and `<shot>` is the first shot in the file, e.g. day356.shot56538. There is a total of 411 shot files/tapes for the experiment. The following tapes depart from the standard of length 145 shots, 714192400 bytes, or have some other problem. In a few instances near the beginning of the cruise, the shot data was recorded to tape but the time was not recorded to the shot time, ts, file. Also up to shot 758, incorrect times were recorded in the SEG-Y header, and were off, early by about 10 minutes.

Line	Tape	Name	Apparent # shots	Comment
1	4	day346.shot00436	145	Shot 406 @ 03:35:45 OK but 1:06 after shot 405 and not in TS file
1	5	day346.shot00591	145	Shot 616 not in TS file but recorded to tape.
1	6	day346.shot00726	146	Shot 759 not recorded. From shot 760 @ 5:19:39 onwards times in SEG-Y header agree with TS file
3	41	day347.shot05802	145	Shots 5810,11,13 not in TS file but recorded to tape.
10	82	day348.shot11747	101	Has 101 shots, all OK, none missed.
11	88	day348.shot12573	54	Record up to shot12627 at 10:14:05 before system hung
11	89	day348.shot12627	144	System restarted at 11:03 with shot 12627
17	152	day350.shot21761	145	Shot 21903 bad from trace 297 on. No shots 21904,5
17	153	day350.shot21906	145	Last shot, shot 22050 @ 03:52 not recorded
24	209	day351.shot30026	25	Has 25 shots, all OK, none missed.
35a	256	day352.shot36721	145	Shots 36864,5 missing or bad
35a	257	day352.shot36866	145	Shots 37008,9,10 missing or bad
35a	258	day352.shot37011	145	Shots 370153,4,5 missing or bad
35a	259	day352.shot37156	145	Shots 37299,300 missing or bad
35b	307	day354.shot44116	146	No shot 44136. Shot 44135 @ 06:09:38, shot 44137 @ 06:16:45
45b	337	day355.shot48467	95	Has 95 shots, all OK, none missed.
45b	338	day355.shot48562	146	On turn 45b->44b. Shot 48566 @ 2:10:26 not recorded.
61	411	day357.shot59148	99	Last tape of cruise

Seismic Cruise Log

Note, line start and end times are logged here only if something of note happened during the line. Times are in UTC, during the cruise, the ships clock was exactly 12 hours ahead of UTC.

Day 346 (12th December)

01:56 Beginning of Lau line 1
02:56 Slowing down to add a bird (~shot 236)
03:30 Came back up to speed (~shot 344)
03:46 Missed shot 406; 162 m between shots
04:02 Port gun #4, 200 cu. in. misfiring.
04:41 Missed shot 616; 200 m between shots
05:08 Shot 759 not recorded. Shot 758 @ 5:08:07, shot 760 @ 5:19:39
07:00 Port Gun #4, 200 cu. in. misfiring
18:38 Lost starboard gun #2, 120 cu. in. briefly. Timing glitch on port gun #2, 235 cu. in.
21:03 End of line 1
21:08 Stopped shooting, although acquisition system still running. Reduced length of tow leader by 31.9 m to raise front part of streamer.
21:16 Finished turn, starting connecting line.
21:40 Port Gun #2, 235 cu. in. shut down
22:08 Port gun #2 back on.
22:52 Coming on to line #2

Day 347 (13th December)

03:54 Finished line 2
04:04 Start line #3
04:18 Shots 5810, 5811 & 5813
05:47 End of line #3
16:00 Starting Line 7
16:30 Streamer droop, ratty data for 5 minutes.

Day 348 (14th December)

09:53 Starting line 11
10:14 Problems with acquisition system. Hung at shot 12627 (10:14:05) for 49 min. Tape 88 (day348.shot12753 on archive) recorded only shots 12573-12627.
10:58 Shots times (but no data) were recorded up to shot 12786
11:03 Recording system restarted. Shot number set back to 12627
11:07 Shots fired regularly starting at shot 12629. Missed ~7.1 km of data ~190 shots.
11:54 End of line 11

Day 349 (15th December)

02:21 Finished turn onto line 13
02:30 Starboard guns, #3, #4 & #5, 850, 80, & 385 cu, in. were turned off.
02:45 Starboard guns #3 & #4 back on.
03:17 All guns on.
05:00 End of line 13
08:57 Start of line 15
09:23 Not logging Hydrosweep. Hydrosweep navigation crashed.
09:31 Hydrosweep back on
12:19 End of line 15

Day 350 (16th December)
01:46 Start of line 17 - first ridge crossing line of ELSC
03:14 Trace 297 of shot 21903 is misrecorded with NaN plus very large & small numbers
03:52 Shot 22050 is not recorded to tape
07:02 End of line 17

Day 351 (17th December)
20:22 Start of line 26
22:30 Port gun #1 out, 305 cu. in.
22:45 Stopped shooting, gun leak.
22:55 Guns back on line
23:30 End of line 26

Day 352 (18th December)
14:58 Start of line 32
16:05 Starboard guns #4 & #5, 80 cu. in. and 385 cu. in., out
16:22 End of line 32
16:41 Starboard guns #4 & #5 back on
17:04 Start of line 33

Day 353 (19th December)
18:26 End of line 42
18:39 GPS tail buoy glitch
18:47 Start of line 43

Day 354 (20th December)
03:05 Start of line 35b
06:09 Guns stopped firing for 7 minutes because of bad GPS record. Missed a shot in sequence at restart
10:04 End of line 35b
18:34 Start of line 47
20:30 Starboard gun #1, 145 cu. in., leaking
21:48 End of line 47
22:05 Start of line 48
22:27 Starboard gun #1, 145 cu. in.
23:39 End of line 48

Day 355 (21st December)
03:19 Start of line 44b
06:14 Starboard gun #3, 850 cu. in., shut off.
06:27 850 cu. in. on A-frame turned on.
07:42 Changed back to 850 cu. in. on starboard gun boom (gun #5).
08:54 End of line 44b

Day 356 (22nd December)
11:42 End of line 57
12:00 GPS tail buoy out for last 6 minutes. Reset successfully.
12:04 Start of line 58
13:22 Start of line 59
18:02 Small leak port gun #3, 583 cu. in.
20:30 Port gun #3, gun off, switched to 535 cu. in. gun on A-frame.
21:58 End of line 59

Day 357 (23rd December)

03:00 Last Shot, shot 59256. End of line 61

Real Time Processing

There were 3 on board processing objectives for the Lau cruise -

1. Near real-time brute stack.
2. Tape copy and reformat.
3. Quality control.

These objectives are similar to those on previous Ewing cruises and as before were achieved by using Sioseis and sister processes running on the *Ewing* workstations. The biggest advance made in the processing stream during EW9914 was that brute stack data from Sioseis was plotted on the large format Atlantek plotter as the stacked traces were generated, rather than having to wait until after the end of the line. Thus on board processing moves ever closer to being a true real time system. This rapid processing was a boon to the scientific decision making as it allowed modifications the cruise plan to be made as early as possible.

Overview of the processing sequence

Immediately after ejection from the Syntron acquisition system, each 3490E tape was taken (sneakernet) to "heezen", the Sun SparcStation 10 with the 3490E tape drive. Each tape was read twice; once for the brute stack and once for reformatting to SEG-Y and copying to DLT tape. Doing the tape copy and stack as separate processes allows greater flexibility in changing stack parameters and restarting the stack process. The stack script generated a plotfile that was plotted on the Atlantek plotter while the stack process was still running. Thus, there was no waiting until the end of the line, the seismic line could be viewed while it was being collected. As a quality control check, the stack script also wrote every 50th shot, every 50th CMP gather, and every 50th moved-out/muted gather to circular disk files, were they could be viewed by independent processes.

The tape copy and reformat took 13 minutes and the brute stack took 22 minutes. The Syntron recording system filled an IBM 3490E tape with 145 shots in 40 minutes, meaning that the processing was completed with 5 minutes to spare. However, the brute stack script only used 240 traces because the SparcStation 10 was not fast enough to perform both tasks (reformat and stack) on all 480 traces before the next tape arrived. Initially we used alternate traces from each shot as if the hydrophone spacing was 25 m rather than 12.5m. While all 6km of the streamer was used, the far range traces contributed to excessive "stretch" due to incorrect velocities. As a result, we decided to use every trace of the near 3km of the streamer in the stack (traces 241-480 - remember 480 is closest to the ship).

Program atlantek was run on"grampus", the Sun Enterprise Server that has the Atlantek thermal printer attached as: /dev/ihcp0. It continuously checked the sioseis plot file being generated by the stack script and plotted any new information as soon as it was appended to the file. The stack script was run "heezen", but the plot file was written to a disk that was NFS mounted by "grampus". Program atlantek doesn't know when the plotfile is really complete, so it must be terminated with a control-c. The program needs to be restarted every time a new line is started by the stack script because the plot filename changes.

Using the Sun CDE environment on "heezen" simplified switching between processing tasks. One CDE screen was set up for the tape copy/reformat, one for the stack, one for the QC plots. The reformat screen had two windows; one running the script and one for controlling the tape ready file "in". Both windows belonged to "heezen" and were in directory /ldata/realtime/reformat. The stack screen had three windows; one running the script, one for controlling the tape ready file "in", and one for running the Atlantek plotter program..The following entries added the following lines to Henkart's .cshrc to simplify processing:

```
set path=($path /export/sioseis/bin )
alias xl “xloadimage -r 90 sunfil &”
alias sd “/export/sioseis/doc/siodoc”
alias s “suntops  psfil”
```

Brute Stack Script

One of the keys to doing “real-time” stacks is having a velocity function ahead of time. This is accomplished in Sioseis by using the parameter “vtrkwb” in process nmo. This allows the velocity function to vary based on the water depth supplied to the SEG-D header by the Hydrosweep system. Without it the velocity function is spatially varied according to the SEG-Y shot/rp number; with it “fno” is interpreted as the water bottom depth. The post-nmo mute is also based off of the Hydrosweep water depth.

The very low filter passband of 5-40 Hz caused some wrap around artefacts in the plot, so the fft length was increased by increasing the length of the processed data from 4 s to 5 s. This changed the filter fft from 1024 points with only a 24 points pad to 2048 points with a 778 point pad.

The brute stack script has several features:

- The script is executed with the line name on it so the output and plot filenames are unique.
- SEGDIN: reads SEG-D tapes, discarding traces 1-240 as mentioned above. The data were processed from 1 to 6 seconds (1251 samples). Each 3490E tape is ejected after all shots have been read. It also uses the Syntron shot number as the SEG-Y shot number (the SEG-D file number is a count of files written to tape). SEGDIN converts the SEG-D extended trace header into a SEG-Y trace 0 with trace id 28.The streamer depths were not placed into the SEG-Y headers during the reformat step because the streamer was towed at a very uniform depth.
- PROUT: prints a line to the screen once every 10 shots so that the user knows the job is running.
- GEOM: assigns the streamer and subsurface geometry. A missing shot number indicates the shot is missing (parameter type 2).
- HEADER: converts the Hydrosweep depth in word 54 to a water bottom time.
- DISKOB: writes every 50th shot to a “circular” file for QC (quality control).
- GATHER: gathers traces according to common midpoint.
- NMO: applies normal moveout with the velocity varying according to the water bottom time.
- MUTE: Mute the early part of the traces with nmo stretch, starting from the water bottom time.
- STACK: Sum the traces in a CMP gather.
- DISKOE: saves the unfiltered stack to a disk file.
- FILTER: applies a zero phase, 5-40 Hz frequency domain bandpass filter.
- DISKOA: saves the filtered stack to a disk file.
- AGC: uses a 0.5 second agc with the multiplier applied at 0.1 s rather than 0.25 - a look-ahead window
- PLOT: generates a raster plot for the Atlantek plotter (nibs 7224).

Copy Script

The copy script reformatted the SEG-D 3490E tapes onto SEG-Y DLT tapes. Each 3490E tape is written as an SEG-Y file (process output parameter newfile), even though the SEG-Y standard does not allow multiple files on a tape. The output tape further violates the SEG-Y standard by writing in IEEE format.

Both the brute stack and copy scripts utilize segdin parameter *offline*, which rewinds and ejects the input SEG-D tape after it has been read. This signals the “operator” that a new tape should be “mounted”. After a new tape is inserted, a file named “in” must be created with the tape unit number in it. SEGDIN waits for the creation of this file before reading the new tape. SEGDIN deletes the file “in” so that it enters another wait state at the end of tape. Two files “go” and “stop” were added to the reformat directory to control the input tape file “in”. File “go” had the input tape unit “43” in it. File “stop” had a “-1” in it. When a new tape was ready the watch standers did not need to use an editor but could copy “go” to “in”. The “in” file with a -1 is the normal sioseis termination flag signaling processes gather and stack to flush all buffers.The reformat script was not terminated with the “-1”, rather it was control-c ed when sioseis asked for a new output tape.

```
#! /bin/csh
# run on “heezen” in directory:    /ldata/realtime/brute_stack
if ( $#argv < 1 ) then
    echo “Usage: stack line-number”
    exit 1
endif
set LINENO = $1

sioseis << eof
procs segdin prout geom header diskob gather nmo mute diskod stack diskoe filter diskoa
agc plot end
segdin
   iunit 43  ffilen 99999   # take all shots
   ftr 241 ltr 480 fcset 1 lcset 1
   stime 1 secs 5.0
   offline yes end    # at EOT rewind and eject
end
prout
 fno 0 lno 99999 ftr 479 ltr 479 noinc 10 end
end

geom
  type 2           # increment the shot location based on the shot number
  fs 1 ls 999999   # all shot have the same parameters (preset)
  gxp 480 -196.6    # RESET the closest group only.
  ggx -12.5         # Used to extrapolate gxp!
  dfls 37.5 dbrps 6.25 smear 6.25
  rpadd 1000 end
end

header
   fno 0 lno 9999999 ftr 1 ltr 9999
   r50 r54 / 750.  # convert water depth to water time
   end
end
diskob     # write every 50th shot to a “circular” file
    fno 1 lno 999999 noinc 50 rewind 1
    opath /ldata/realtime/shots/latest.shot end
end
gather
   maxtrs 50 maxrps 250 end
end

nmo   # real time nmo, replace interpolation by RP to WB depth in Meters.
# If water depth changes by > 500 m, use previous value.
# Water-depth velocity functions derived from ESP5, interpolation by iso-velocity layering
 vtrkwb 500 stretc 0.50
 vtp 1500 2.0
     1539 2.081
     1574 2.110
     1705 2.159
     2137 2.312
     2379 2.413
     2603 2.513
     2665 2.539
     2827 2.650
     2834 2.769
     2967 3.029
     3939 4.409
     4053 4.559
     4596 5.060 end
```

Sioseis Brute stack script

```
fno 2000 lno 2000
vtp 1500 2.667
     1529 2.748
     1557 2.777
     1659 2.826
     2012 2.979
     2218 3.080
     2414 3.180
     2468 3.206
     2614 3.317
     2629 3.436
     2761 3.696
     3711 5.076
     3823 5.226
     4351 5.727 end
 fno 2500 lno 2500
 vtp 1500 3.333
     1524 3.414
     1546 3.443
     1629 3.492
     1928 3.645
     2108 3.746
     2282 3.846
     2330 3.872
     2463 3.983
     2481 4.102
     2608 4.362
     3526 5.742
     3636 5.892
     4146 6.393 end
 # etc for other depths
end

mute
   fno 1 lno 999999 addwb yes xtp 200 -.1 1500 -.1 3000 1 6200 2 end
end

diskod
    fno 1 lno 999999 noinc 50 rewind 1 opath /ldata/realtime/shots/latest.mute end
end

diskoe   # Write out disk file
  opath stack.$LINENO end
end
filter
    pass 5 40 ftype 0 dbdrop 48 end
end

diskoa   # Write out disk file
  opath LAUBASIN.$LINENO end
end
agc
   winlen .5 center .1 end
end
 plot
  scalar 1.e-07 tlines 0.5 1 nibs 7224 ann gmtint anninc 30
  def 0.01 trpin 80 wiggle 0
  stime 2 nsecs 4 vscale 5
  opath siopltfil.$LINENO end
end
end
eof
```

Sioseis brute stack script continued

```
#  EW9914 SIOSEIS tape copy/reformat script
#  Reads 3490E tape and outputs SEG-Y files to DLT tape
#  run on "grampus" in directory:    /net/heezen/ldata/realtime/reformat

sioseis << eof
procs segdin output end
segdin
   iunit 43
   ffilen 99999   # take all shots (this is the preset!)
   ftr 1 ltr 480  # skip the auxiliary channels - 161-172 and 161-180
   fcset 1 lcset 1
   secs 10
   offline yes   # eject after rewinding at EOT
   newfile yes   # start a new SEG-Y file for every SEG-D tape
    end
end

output
   ounit 66
   ontrcs 480
   rewind 0   # leave the tape alone!
    end
end

eof
```

Tape copy script for EW9914

```
# EW9914 Script for screen display of the "latest" shot
# run on "grampus" in directory:   /net/heezen/ldata/realtime/plots

sioseis << eof
procs diskin agc plot end
diskin
   ipath /net/heezen/ldata/realtime/shots/latest.shot end
end

agc
    winlen .1 end
end

plot
  wiggle 0 tlines .5 1.
  stime 2 nsecs 4
   nibs 7224 vscale 1.25 trpin 40 ann sh&tr
   def .03 clip .03
   opath siofil
   srpath sunfil end
end

end
eof
xloadimage -r 90 sunfil &
```

Screen plot script for EW9914 displays the "latest" shot from the circular shot file written by the stack script.

Ewing SEG-D Tape Format

The Ewing Syntron seismic system may record in any SEG-D demultiplexed format – 20bit binary, IBM floating point, or IEEE floating point), however IEEE is preferable. The SEG-D format specifies that the first tape record of each shot contain the SEG-D headers, the demultiplex traces follow and are terminated by a file mark.

SEG-D allows the seismic channels be grouped into channel sets. The Syntron system on the Ewing normally has the streamer data in channel set 1 and the 12 channel auxiliary box in channel set 2. If the aux box is not used, channel set 2 need not be recorded. In contrast, the old Digicon system had the first channel set as the non-seismic “trace 0” and the second channel set had the seismic data.

LDEO uses the SEG-D extended general header to record many other recording variables much as it used “trace 0” on the old Digicon recording systems. For instance, the Hydrosweep center beam depth and streamer depth and streamer compasses are in the LDEO SEG-D extended trace header. Sioseis process *segdin* retains the extended general header, and extracts the Hydrosweep depth, compasses, shot number, and True Time clock for the trace header. Sioseis process *output* automatically writes the SEG-D extended general header as “trace 0” in the SEG-Y format.

The shot time in the regular SEG-D location is the PC clock within the Syntron system. The LDEO true time (GPS) clock that all Ewing real-time systems reference is extracted by Sioseis process *segdin* and is used in its SEG-Y headers. The true time clock, also known as Joe’s clock, is the time base used in the LDEO ts shot files.

The LDEO R/V Ewing gun firing system generates a shot number every time the guns are fired. Thus, the shot number is a count of shot triggers sent to the guns. The SEG-D file number is a count of files written to tape. If the system triggers but the guns do not fire, the shot is not recorded. As a result the shot number increments but the file number does not. Experience shows that files may be lost by the recording system, but triggers (and shot numbers) are rarely dropped and one can assume a constant distance between shot numbers when “shooting by distance”. Sioseis puts the shot number in SEG-Y trace header “shot number” position (the third 32 bit integer) and the file number in the “energy source number” (the fifth 32 bit integer).

Each 3490E tape can hold 810MB, but Syntron does not use the entire tape. Theoretically, 69 shots of 480 traces at 2 mils and 12 seconds can be held on a 3490E tape, but Syntron only records 60 shots. Likewise, only 145 shots are recorded per 3490E tape with 480 channels at 4 mils for 10 secs. Also note that a 3490E is not the same as 3490, 3590, or 3480.

Program list_ewing

Program *list_ewing* can be used to list the 3490E tapes produced by the Ewing’s Syntron system. Sioseis can be used to reformat the SEG-D data into SEG-Y (see Real Time Processing). Parameters to *list_ewing* follow the format of sioseis: a parameter name followed by a value, with the complete parameter set terminated by the word end.

Parameters

iunit - The tape drive unit number. As of April 1999, the 3490E tape drive was unit 11 on computer heezen aboard the Ewing. The program uses the unit number as: /dev/nrstIUNIT. Preset = 1

inc - The increment between traces to print. E.G. A data set with 172 channels written on the tape label, and increment of 173 will get trace 0 of every shot. Preset = 1 e.g. inc 173

nshots - The number of shots to print. Preset = all shots on tape e.g. nshots 1

print - A bitwise switch indicating the print option selection. Bit 0 is the least significant bit. E.G. bit 0 is 2**0, bit 1 is 2**1. In order to set multiple bits, turn the bit on (or add the numbers up). E.G. bit 0 and bit 1 becomes 1+2 or 3.
bit 0, Prints the FIRST SEG-D general header. (print 1)
bit 1, Prints the SEG-D channel set header. (print 2)

bit 2, Prints the SEG-D demux trace header. (print 4)
bit 3, Dumps the entire General header in hex. (print 8)
bit 4, Print ALL SEG-D general headers. (print 16)
bit 5, Print the Extended General Header. (print 32)
bit 6, Dumps the trace header in hex (packed BCD). (e.g. print 64)
bit 7, Dumps the LDGO/Digicon trace 0 sections. (e.g. print 128)
= 256 (1+2+4+8+16+32+64+128), ALL prints are printed.

end - Terminates parameter reading.

Examples 1. List all traces on a tape:

```
list_ewing
iunit 11 end
```

Resulted in the following output:

```
Shot on 13 Mar. 1999 (day  72) at  214z
The tape format is demultiplexed IEEE f.p.
     File   Shot   Tr   si  delay day hr min  sec mils nbytes
     1    333    1 2000  0.000  72  2  15    3  148 24628
     1    333    2 2000  0.000  72  2  15    3  148 24628
     1    333    3 2000  0.000  72  2  15    3  148 24628
     1    333    4 2000  0.000  72  2  15    3  148 24628
     1    333    5 2000  0.000  72  2  15    3  148 24628
     1    333    6 2000  0.000  72  2  15    3  148 24628
     1    333    7 2000  0.000  72  2  15    3  148 24628
     1    333    8 2000  0.000  72  2  15    3  148 24628
```

Example 2. List the first trace of the first 10 shots, where each shot has 480 channels:

```
list_ewing
iunit 11 nshots 5   inc 480 end
```

Resulted in the following:

```
Shot on 13 Mar. 1999 (day  72) at  214z
The tape format is demultiplexed IEEE f.p.
     File   Shot   Tr   si  delay day hr min  sec mils nbytes
     1    333    1 2000  0.000  72  2  15    3  148 24628
     2    334    1 2000  0.000  72  2  15   18  908 24628
     3    335    1 2000  0.000  72  2  15   34  709 24628
     4    336    1 2000  0.000  72  2  15   50  454 24628
     5    337    1 2000  0.000  72  2  16    6  254 24628
```

Example 3. Print all possible information on the first trace:

list_ewing

iunit 11 nshots 1 inc 480 lprint 255 end

Resulted in:

```
SEG-D General Header in packed BCD:
0001805812345678901299207202144834000400000002010008120010100FF97
00000000000084000000010000000000000000200000000000000000000000001
00000000000000000001 4D0000000000000000301000000000000000000000000
SEG-D Channel Set Headers in packed BCD:
010100001800008C04801009020602760003000600000000000000000000010101
  Shot on 13 Mar. 1999 (day  72) at  214z
The tape format is demultiplexed IEEE f.p.
manufacturer =   34 serial No.  4 format   8058
bytes per scan =  0, polarity =  1, scan per block =  0, type =   8
scan types per record =  1, channel sets per scan =  1, skew sets=  0
number of additional general header blocks   2
extended header=  132, external header =  97
scan type   1   Channel set   1 has   480 channels, start time =  0. end
time = 12.2880
chan type=  10 subscans=  1, gain control=  9 notch=  0.
alias filter =  206 with slope   276, low cut filter =  3 with slope   6
```

```
Shot number:   333 Hydrosweep depth=    3393.10
Joe date:   99  72  2  15  3
ship pos:     8.26365   -90.1671   tail pos:   0.  0.
tail dist and bearing:   0.  0.
  File   Shot   Tr   si  delay day hr min  sec mils nbytes
SEG-D Trace Header in packed BCD:
 0001010100010000000100000000000000000000
  1    333    1 2000  0.000  72  2  15    3  148 24628
iscant=  1 ichnsn=  1 skew=  0. tbreak=  0.
```

RP Gathering

The near real-time brute stack data created were gathered assuming a constant shot spacing of 37.5 m. The post-cruise gathering of the data used positions from the processed shot time files, ts.n<jday>, which contain ship positions as measured at the antenna of the Ewing's Y-code GPS receiver. As noted previously, the data were gathered into RPs assuming strictly 1-D linear profiles, and thus that the acquisition geometry was fixed relative to the ship position/GPS antenna: source and receiver positions are found as offsets from the GPS locations. Linear distance along a profile was found by accumulating the shot-to-shot distances calculated from the shot files and adding it to an initial offset, i.e. $x = \Sigma\Delta s + offset$. The offset has a minimum value 5000 m, ensuring that all RPs, calculated as $round(x_m/6.25)$ where x_m is the midpoint location and 6.25 m is the bin spacing, are positive. For the minimum offset, the initial RP number at the GPS antenna is 801, the RP corresponding to trace 480 is 777, and that furthest from the ship is 298.

Example Gather Script

```
sioseis << eof
procs diskin geom gather prout diskoa end

diskin
  ipath day356.shot56248 set 2.0 7.0 fno 56306 lno 56392 end
  ipath day356.shot56393 set 2.0 7.0 fno 56393 lno 56537 end
  ipath day356.shot56538 set 2.0 7.0 fno 56538 lno 56568 end
end

geom
    gxp 480 191    # offset of nearest group (480) from source array
    ggx 12.5       # group spacing
    dbrps 6.25     # RP spacing
    ntrcs 480      # number of traces in shot gather
    offset 56      # distance from GPS antenna to center of source array
    type 3 navfil Lau.line59.nav  # binary LDEO format nav file.
    end
end

gather
    maxtrs 90 maxrps 490 end
end

prout
    fno 1 lno 99999 noinc 100 ftr 1 ltr 1 end
end

diskoa
    opath lau.59.g.13430.15000 fno 13909 lno 15000 end
end

end
eof
```

The streamer geometry is specified in process `geom`. The offset from the GPS antenna to source array is specified by parameter `offset`, and the offset from the source array to the nearest group in the streamer by ggx. The navigation is supplied via a binary, LDEO format nav-file, which was created from original ts-file, via program navcmp. This binary formatting is unnecessary as Sioseis will use an ASCII file based directly on the ts-file, see http://sioseis.ucsd.edu for details. A side benefit of the navcmp program is that it produces an ASCII file listing the RP numbers at the antenna, and at the ends of the streamer for each shot. This file is used by a Perl script to automatically generate the gather scripts for a given line and RP range. It finds the shot files and the shot numbers to produce full fold output gathers. The navcmp ASCII files are also used to find profile crossing points.

Example: Start of navcmp ASCII file for line 59

```
#                                                          RP numbers
# shot     Δs      x        Latitude  Longitude   gps    grp 1 & 480
56306  0  0.000 87094.453 -22150288 -176596185  13936  13433 13912
56307  0 37.269 87131.719 -22150621 -176596235  13942  13439 13918
56308  0 37.269 87168.984 -22150955 -176596285  13948  13445 13924
56309  0 37.501 87206.484 -22151290 -176596338  13954  13451 13930
56310  0 38.100 87244.586 -22151630 -176596395  13960  13457 13936
56311  0 37.945 87282.531 -22151968 -176596453  13966  13463 13942
56312  0 38.100 87320.633 -22152308 -176596510  13972  13469 13948
56313  0 36.563 87357.195 -22152635 -176596561  13978  13475 13954
```

In this case the initial offset for shot 56306 is large to ensure that lines 44a, and 59 have the nearly the same RPs in their overlap region at the OSC. In general initial offsets were adjusted so that combined lines, e.g 7a &b, have, as far as possible the same RPs in their overlap region. In addition offsets for cross-axis lines were adjusted so that the RP at the crossing point with the axial line was close to 5000. The following table is the offset table for all profiles. The navcmp program automatically adds 5000 m to all offsets listed. The "Alt" column is simply a numerical version of the alphanumeric line name with "a" mapped to "1", and is required by navcmp.

Offset table for RP gathering

Line	Alt	1st Shot	Last Shot	Offset
1	1	1	4367	4315
2	2	4725	5716	16345
3	3	5758	6122	0
4	4	6195	6598	0
5	5	6647	7552	0
6	6	7758	8402	0
7a	71	8557	10342	0
7b	72	13794	15320	51036
7c	73	19208	20320	99691
8a	81	10603	11185	22390
8b	82	12822	13469	12221
8c	83	13558	13768	18375
9	9	11264	11625	0
10	10	11675	12485	12600
11a	111	12535	12830	0
11b	112	12629	12797	10587
12a	121	15595	16052	21822
12b	122	18435	18943	13425

Line	Alt	1st Shot	Last Shot	Offset
13	13	16113	16747	0
14	14	16804	17616	8840
15	15	17669	18372	0
16	16	20330	21517	0
17	17	21560	22775	7494
18	18	22847	23729	0
19a	191	23814	25036	0
19b	192	28231	29852	40687
20a	201	25314	25837	20144
20b	202	27483	27923	13756
21	21	25925	26252	0
22	22	26300	27048	12375
23	23	27080	27402	0
24	24	29869	30295	0
25	25	30368	31050	15562
26	26	31124	31828	0
27	27	31980	32986	0
28	28	33000	33251	0
29	29	33329	33868	16087
30	30	33958	34360	0
31	31	34448	35224	0
32	32	35247	35512	0
33	33	35640	36175	17318
34	34	36240	36658	0
35a	351	36737	37744	0
35b	352	43430	45000	24782
36a	361	38007	38372	22615
36b	362	42840	43128	19985
36c	363	43246	43381	21480
37	37	38430	38733	0
38	38	38779	39385	14887
39	39	39433	39835	0
40	40	39883	40568	13880
41	41	40618	40863	0
42	42	40917	41433	13794
43	43	41476	42778	0
44a	441	45001	45802	0
44b	442	48816	50078	22910

Line	Alt	1st Shot	Last Shot	Offset
44c	443	52988	53792	62644
45a	451	46056	46512	22082
45b	452	47992	48508	12281
46	46	46563	46848	0
47	47	46918	47607	13044
48	48	47664	47945	0
49a	491	50386	50727	22265
49b	492	52248	52690	13556
50	50	50782	51166	0
51	51	51209	51796	18000
52	52	51847	52201	0
53	53	53907	54218	0
54	54	54290	54463	0
55	55	54508	55146	14118
56	56	55195	55384	0
57	57	55438	55918	14844
58	58	56007	56241	0
59	59	56306	58040	82093
60	60	58140	58737	0
61	61	58800	59256	20725

Underway Geophysics

Navigation

GPS Receivers

There were 3 GPS receivers on board

gp1 – Tasman Y/Pcode
gp2 – Trimble Selective Availability
tb1 – Ashtec G8 Selective Availability

Each was logged at 10 second intervals. Navigation was post-processed and reduced to 1 minute intervals. Post-processing is performed in order to identify GPS errors and produce accurate positions. Slightly different processing is performed depending of the type of receiver. The processed gp1/P-code navigation is later applied to hydrosweep bathymetry, magnetics, gravity, and shot data.

GPS Processing Steps

1. Check data for mutant records and non-sequential times.
2. If we have speed and/or DOP information, remove records that have excessive speed or too high of a DOP[1]
3. Convert from NMEA or proprietary format to a standard format – 98+240:00:28:50.091 N 42 14.1536 W 063 25.5897 P-trimble
4. If we are processing known differential data, remove non-differential fixes from the file.
5. Interpolate and reduce data. Fixes are reduced to 30 second fixes and any minor gaps (< 3 minutes) are linearly interpolated.
6. Smooth data using a 9 point running average algorithm and further reduce data to 60 second fixes.
7. Perform dead reckoning using the smoothed Furuno speed and heading to fill in major gaps (> 3 minutes) and to insure the accuracy of the GPS data. By performing dead reckoning, we can determine the drift of the GPS vs. the speed and heading. Any huge distances will alert us to a problem.

Furuno Speed and Heading

The Furuno CI-30 2 axes doppler speed log and Sperry MK-27 gyro was logged at 3 second intervals. Furuno was logged during the entire cruise.Furuno speed and heading was processed by smoothing the data using a vector summing algorithm. Data was reduced and output at 1 minute intervals by taking the smoothed values and calculating the mean value for the 30 seconds before and after the whole minute

Truetime UTC Time Clock

The Kinemetrics Truetime UTC clock is logged at 60 second intervals. CPU time is synchronized every 60 seconds to this clock

Hydrosweep Centerbeam and Swath Data

Krupp Atlas Hydrosweep Centerbeam. Each Hydrosweep ping was logged, and center beam data was extracted and logged separately. Hydrosweep was logged during the entire cruise. HS swath data can be read and processed using MB-System software which can be found at the web site of Dale Chayes: http://www.ldeo.columbia.edu/~dale.

Centerbeam Processing steps

1. Remove all survey and calibration records from the raw data and all 0 level depths.
2. Reduce data to one minute intervals on 00 seconds of the minute by computing the median values from the raw values that lie between +-30 seconds of 00 seconds of the minute.
3. Merge the data with the processed navigation to end up with one minute hydrosweep centerbeam fixes with navigation.

Swath Processing

Hydrosweep swath data was processed using the MB-System package from Lamont-Doherty Earth Observatory. The processing included hand-editing the beam data to insure an accurate hydrosweep survey.

Magnetometer

Geometrics G-886 Marine Magnetometer was logged at 12 second intervals.

Magnetic Log

Date	Comment
346:04:09	Logging resumes
351:15:40	Magnetometer gets progressively noisier from this day forward
357:01:56	End of logging

Gravity

The Bell BGM-3 gravimeter was logged at one second intervals. There were no gaps in the gravimeter record for this cruise.

Logging

- Raw gravity is logged to disk (roughly 1 sample/second) and broadcast to the network.
- A real-time gravity process reads the sampled data and applies a 6 minute gaussian filter to the raw sample to provide a running display of the current gravity. This value is used in the gravity ties to determine the local gravity. (Gravity Meter Value (BGM Reading))

Gravity Post Processing

1. Raw gravity is filtered using a 6 minute gaussian filter and mGals are output. The raw mGals are represented by `mGals = gravity_count * scale + bias;`
   bias = 852645.3 (Dec 5, 1997). scale = 5.0940744 (July 9, 1992)
2. A second filter is then applied; an 8 minute Gaussian filter using the GMT system:
   `filter1D -G480 -R -E`
3. The filtered output is then reduced to 1 minute intervals by using the mean values of all data +/- 30 seconds from the 00 second mark of the minute to output:
   98+254:00:07:00.000 980422.37
   98+254:00:08:00.000 980422.38
4. The data is merged with the navigation. See Processed File Formats. At this point eotvos corrections are determined by merging the daily navigation and raw gravity files and calculating the Eotvos correction as:
   `Eotvos correction = 7.5038*vel_east*cos(lat) + .004154*vel*vel`
5. The velocities used in the Eotvos calculation are smoothed to reduce the jitter in the corrected gravity and FAA values. The smoothing is done using a 9 point running average.

Gravity Ties

It is usual practice to have a gravity "tie" to a gravity reference base station during the port stay. A portable gravity meter, e.g. the Lacoste Model G #70, is used to make 1) a pier-side reading; 2) a reading at the base station; 3) an additional pier-side reading. The pier-side gravity value, adjusted in value to correspond to the height of the BGM gravity meter, is compared to the real-time BGM Gravity Reading discussed previously.

The practice is not to adjust the BGM-3 so that its reading agrees with the pier-side gravity value, but to establish a "dc shift", which represents a constant correction to be applied to all gravity values on the next cruise.

For example, suppose the pier-side value equaled 980274.7 mGal and the BGM reading was 980279.9, the dc shift would be 5.2 mGal. In other words, the BGM is 5.2 mGal high. This value is subtracted from observed values of gravity following the cruise as a constant correction. The “drift” of the Bell gravity meter is determined from the two in-port gravity station ties. In the pre-cruise tie the BGM might have been found to be 5.3 mGal high and during the post-cruise tie it is 8.4 mGal high. The drift during the cruise is therefore equal to 3.2 mGal (8.4 - 5.2). The amount of drift per day is then calculated and gravity data is processed with the drift values corrected for the length of the cruise.

Thus, for daily reduction at sea the drift correction option cannot be used. However, the drift rate of the Bell gravimeter is very low, usually much less than 0.1 mGals/day; thus useful analysis of the FAA values while at sea is possible

A corrected gravity value is computed as:

```
corrected_grv = raw_grv + eotvos_corr - drift - dc_shift
```

The FAA is computed as:

```
faa = corrected_grv - theoretical_grv
```

The theoretical gravity value is based upon different models for the earth’s shape.

Pier/Ship	Latitude	Longitude
	19 15.067 S	146 49.8395E

Berth 10, Townsville Port

End of pier (near bollard 10)

C Deck is 1 meter below Pier

Reference	Latitude	Longitude
	19 15.70S	146 46.80 E

Townsville City College Campus; Corner of Stanley and Walker. I took the reading near the bike rack outside the back door of C Block building as the original reading was carpeted over

	Id	Julian	Date	Mistie	Drift/Day	DC Shift
Pre Cruise	EW9911	295	10/22/99	2.28	0.02	1.55
Post Cruise	EW9912	336	12/2/99	3.87	0.04	2.28
Total Days			41.00	1.59		

Time	Entry	Value	
12/2/99 0:00	CDeck Level BELOW Pier	2.00	meters
	Pier 1 L&R Value	2286.01	L&R
	Reference L&R Value	2281.58	L&R
	Pier 2 L&R Value	2286.03	L&R
	Reference Gravity	978623.30	mGals
	Gravity Meter Value (BGM Reading)	978634.20	mGals
	Potsdam Corrected	0	1 if corrected

Gravity meter5.5ismeters below CDeck

Difference in meters between Gravity Meter and Pier — 7.50 meters

Height Cor =

Pier Height*	FAA Constant				
7.50	0.31			2.33	mGals/min

Difference in mGals between Pier and Gravity Meter

Pier (avg) -	Reference *	1.06 L&R/mGal		Delta L&R	
2286.02	2281.58	1.06		4.71	mGals

Gravity in mGals at Pierside

Reference +	Delta mGals	[+ Potsdam]		Pier Gravity	
978623.30	4.71	0.00		978628.01	mgals

Gravity in mGals at Meter

Pier Gravity+	Height Correction			Gravity@meter	
978628.01	2.33			978630.33	mGals

Current Mistie

BGM Reading-	Calculated Gravity			Current Mistie	
978634.20	978630.33			3.87	mGals

Gravity Tie: Christchurch, New Zealand

Pier/Ship	Latitude	Longitude
	43 36.4S	172 43.2 E

Reference	Latitude	Longitude
	43 31.77 S	172 37.18 E

Using Reference point from March 1992, and again in February 1996:

Marker 1962 on walkway across from RR tracks.

	Id	Julian	Date	Mistie	Drift/Day	DC Shift
Pre Cruise	EW9912	336	12/2/99	3.87	0.04	2.28
Post Cruise	EW9914	363	12/29/99	4.16	0.011	3.87
Total Days			27.00	0.29		

Time	Entry	Value	
	CDeck Level BELOW Pier	1.50	meters
	Pier 1 L&R Value	4095.00	L&R
	Reference L&R Value	4064.90	L&R
	Pier 2 L&R Value	4095.00	L&R
7/1/70 0:00	Reference Gravity	980508.06	mGals
	Gravity Meter Value (BGM Reading)	980546.30	mGals
	Potsdam Corrected	0	1 if corrected

Gravity meter5.5smeters below CDeck

	Difference in meters between Gravity Meter and Pier				7.00	meters
Height Cor =	Pier Height*	FAA Constant				
	7.00	0.31			2.17	mGals/min

Difference in mGals between Pier and Gravity Meter

Pier (avg) -	Reference *	1.06 L&R/mGal		Delta L&R	
4095.00	4064.90	1.06		31.91	mGals

Gravity in mGals at Pierside

Reference +	Delta mGals	[+ Potsdam]		Pier Gravity	
980508.06	31.91	0.00		980539.97	mgals

Gravity in mGals at Meter

Pier Gravity+	Height Correction			Gravity@meter	
980539.97	2.17			980542.14	mGals

Current Mistie

BGM Reading-	Calculated Gravity			Current Mistie	
980546.30	980542.14			4.16	mGals

Weather Data

Omega DP-10 Sea Temperature

Sea temperature was logged at 60 second intervals; there were no gaps in the data for the cruise.

Weather Station

R.M. Young Precision Meteorological Instruments 26700 Series was used to log a variety of meteorological events at 60 second intervals.

File Formats

Processed Data Formats

Data processing has been performed on this data set as outlined and merged with corrected navigation. The merged file, m.<jday>, contain the essential data from the n.<jday>, hb.<jday>, vt.<jday>

Merged Data m.

CPU Time Stamp	Latitude	Longitude	GPS	Set	Drift	Depth
98+074:14:08:00.000	N 13 54.3859	W 59 43.5175	gp1	0.0	0.0	732.9

Magnetic Total Intensity	Gravity Anomaly	FAA	GRV	Eotvos	Drift	Shift
0.0	0.0	31.3	978370.7	-3.9	0.0	4.5

Navigation File n.

CPU Time Stamp	Latitude	Longitude	Used	Set	Drift
98+074:00:03:00.000	N 13 6.2214	W 59 37.9399	gp1	0.0	0.0

The raw navigation is interpolated to 30 second intervals. Then smoothed with a 9 point windowing average. The smoothed GPS points are them Fixed at 1 minute intervals. Dead reckoning is then performed across the gaps to insure proper GPS positioning.

Shot Time File ts.n

CPU Time Stamp	Shot #	Latitude	Longitude	Line Name
98+077:00:15:00.000	00295	N 16 11.8600	W 59 48.0157	strike1

Hydrosweep Centerbeam merged with navigation hb.n

CPU Time Stamp	Latitude	Longitude	Depth
98+074:09:55:00.000	N 13 6.6206	W 59 39.3908	134.9

Hydrosweep is median filtered at 1 minute intervals, then merged with navigation at 1 minute intervals.

Gravity File merged with navigation vt.n

CPU Time Stamp	Latitude	Longitude	Model	FAA	RAW
98+077:00:15:00.000	N 16 11.8600	W 59 48.0157	1980	-175.9	978253.6

Eotvos Smooth	Drift Total	DC Shift	Raw Velocity North	Raw Velocity East	Smooth Velocity North	Smooth Velocity East
9.7	0.0	4.5	-4.350	1.282	-4.333	1.329

The gravity drift and shift are values that have been added to the raw gravity logged to make up for drift in the meter that has been lost in accordance with a gravity check at each port stop. The 1980 model is the 1980 gravity formulat.

- `eotvos_corr = 7.5038 * vel_east * cos(lat) + .004154 * vel*vel`
- `faa = corrected_grv - theoretical_grv`

Magnetics File merged with navigation mg.n

Time	Latitude	Longitude	Magnetic Intensity	Anomaly
99+348:00:17:00.000	S 18 38.9426	W 176 29.4934	42394.2	121.1

Raw Data Formats

Seismics

Raw Compass Block 9914cb1.d

CPU Time Stamp	Line	Shot	GPS 1 Position
99+350:00:01:29.572	LAU1	021144	S 19 26.4331 W 176 16.3491

GPS2 Position	Tailbuoy Position	Ship Heading	Compass Heading	etc...
S 19 26.4393 W 176 16.3198	S 19 25.2864 W 176 19.7897	107.0	C01 97.8	C03...

No processing is performed on compass block data since the compasses are directly related to the GPS position at the given time.

Raw Gun Depths 9914dg.d

CPU Time Stamp	Depths of guns in order
99+348:00:00:12.042	62 5 78 10 78 5 78 89 5 0 5 0 82 58 0 79 5 58 5 60

Gun positions are read from starboard to port (see figure of gun array). In general guns that are not working or not available give spuriously high readings. While guns that are available but not deployed give spuriously high readings.

Tail Buoy Distance and Heading 9914nb2.d

CPU Time Stamp	Track	Speed	Heading	Gyro
98+166:00:01:53.091	4.4	140.5	148.3	

Navigation

Raw Furuno Log 9914fu.d

CPU Time Stamp	Track	Speed	Heading	Gyro
98+166:00:01:53.091	-	4.4	140.5	148.3

Raw GPS from Tasman Y-code 9914gp1.d

Time Stamp	Lat	Lon

99+348:00:00:06.519 $GPGGA,000005.636,1839.6459,S,17628.5845,W,3,06,1.1,016.7,M,

This is standard (NMEA?) raw GPS ascii stream which includes the position data as part of the stream

Geophysics

There are raw ascii data files for gravity, magnetics and hydrosweep centerbeam with file name roots *9914vc.d, 9914mg.d*, and *9914hb.d* respectively. These files form the raw input for the processed files listed above. In addition the underway geophysics data include the full hydrosweep swath bathymetry.

Binary Hydrosweep Data 9914hs.d

The full binary data for each day is stored in these files. The files may be read by the MB System suit of programs for swath bathymetry manipulation

Weather

Raw Sea Surface Temperature 9914ct.d

CPU TIme Stamp	Temperature
99+348:00:17:01.400	0027.800

Raw Weather File Format 9914wx.d

CPU Time Stamp	wsi1	wss1	wsm1	wsx1	wdc1	wds1	wdm1	wsi2	wss2
94+022:00:00:00.244	9.3	5.4	13.2	21.1	27.1	26.1	6	0	0
wsm2	wsx2	wdc2	wds2	wdm2	tcur	tavg	tmin	tmax	
0	0	0	0	0	26.7	26.7	26.5	27.0	
rh	rhn	rhx	baro						
66	58	68	10	16.8					

- wsi1 = wind speed, instantaneous, bird #1
- wss1 = wind speed, 60 second average, bird #1
- wsm1 = wind speed, 60 minute average, bird #1
- wsx2 = wind speed, current 60 minute maximum, bird #1
- wdc1 = wind direction, current, bird #1
- wds1 = wind direction, 60 second average, bird #1
- wdm1 = wind direction, 60 second st deviation, bird #1
- wsi2, wss2,wsm2,wsx2,wdc2 Corresponding entries for bird #2 which was deactivated so items are invalid
- tcur = temperature, current
- tavg = temperature, current 60 minute average
- tmin = temperature, current 60 minute minimum
- tmax = temperature, current 60 minute maximum
- rh = relative humidity
- rhn = relative humidity, current 60 minute minimum
- rhx = relative humidity, current 60 minute maximum
- baro = barometric pressure