Geophysical Investigation of the Exmouth and Cuvier Margins: Examining Strain Partitioning and the Development of the Continent Ocean Boundary

Introduction & Rationale

Continental extension, breakup, and the formation of new oceanic spreading centers are fundamental, yet poorly understood, parts of the plate-tectonic cycle. When continents break apart to form new ocean basins, processes that govern margin formation generate a remarkable diversity in basin architecture and magmatic construction (e.g., England, 1983; Buck, 1991; White, 1993; Driscoll and Karner, 1998). Many of these structural variations have been explained in terms of lithospheric conditions prior to, or during extension, such as anomalous mantle temperatures (Buck, 1991; Keen et al., 1994; McKenzie and Bickle, 1988), proximity to a hotspot (White and McKenzie, 1989), crustal thickness variations (Buck, 1991), and the ratio between pure shear and simple shear extension (Lister et al., 1992). Theoretical and conceptual models have achieved some degree of success in accounting for observed variations. For instance, hot rifts are predicted to produce massive volcanism during breakup and increased thicknesses of oceanic crust (McKenzie and Bickle, 1988). During the active extensional phase, large portions of hot rifts are subaerially exposed and consequently have a small ratio of synrift to postrift sediment thickness. However, despite the success of these models, recent studies (Keen et al., 1994; Boutilier and Keen, 1997) question whether the large volume of igneous material observed along passive continental margins can be explained simply in terms of decompression melting and secondary convection of anomalously hot mantle during extension as proposed by Holbrook and Keleman (1993). In addition, while hotter lithosphere is predicted to form wide rifts and colder lithosphere to form narrow rifts (Steckler, 1990; Buck, 1991), volcanic margins are often narrow (e.g., Voring Escarpment, Cuvier Basin; Hopper et al., 1992) and broad margins are often relatively non-volcanic (e.g., Grand Banks, Iberia, and Exmouth Plateau; Driscoll and Karner, 1998). Thus, our understanding of how the thermal and mechanical evolution of rift systems (at crustal to lithospheric scales) controls the variability of continental margins in space and time remains incomplete (Raleigh et al., 1989).

The Exmouth and Cuvier margin system represents one of the best locales to study the differences between wide versus narrow rifts and to define the interplay between strain partitioning, volcanism, segmentation, and the continent-ocean transition. We propose to conduct a geophysical expedition across the Exmouth and Cuvier magins (Figure 1), collecting 240-channel deep-penetration MCS data, OBS and sonobuoy refraction velocities, swath bathymetry, magnetic and gravity data, in order to investigate the tectonic, stratigraphic, and magmatic development of the region. The results from numerous Ocean Drilling Sites and exploratory wells from the region, which are in the public domain (e.g., Driscoll and Karner, 1998), will allow us to establish a regional chronostratigraphic framework. We will determine the subsidence patterns (timing, style, magnitude, and distribution) from analysis of the pre-, syn, and post-rift stratal packages and lithofacies preserved along the Exmouth and cuvier passive margins. The refraction and potential field data will be used to determine crustal type and thickness variations across and along the margin. We will input these parameters into our thermal mechanical model of lithospheric deformation (Weissel and Karner, 1989; Karner et al., 1997; Driscoll and Karner, 1998), which will provide quantitative estimates of the strain partitioning (i.e., stretching factors □ and □) between the crust and mantle associated with the extensional deformation and margin formation.

Our geophysical investigation of the Exmouth and Cuvier margins will test alternate models for continental margin development, and when these results are integrated with those from other margin studies, will lead to a better overall understanding and appreciation of:

- the strain partitioning across margins between the brittle upper crust and the ductile lower crust and lithospheric mantle (e.g., the upper plate paradox)
- the interplay between extensional style (rift architecture), magmatism and detachments
- the continent-ocean transition, and the origin of magnetic anomalies observed off the Exmouth and Cuvier margin,
- the formation of seaward-dipping reflectors along the continent-ocean boundaries and the importance of faults in their formation.

The proposed work will also serve as a site survey for an ODP proposal to drill into the Exmouth and Cuvier margins. Drilling continental margins is in accord with ODP's Long Range Plan to understand early margin development and the continent-ocean transition.

Strain Partitioning

In addition we will also be able to test futher the "upper plate paradox (Driscoll and Karner, 1998). Geophysical data from many conjugate margins document the existence of large regional subsidence with only minor accompanying brittle deformation and erosional truncation (e.g., North and South Atlantic - Driscoll et al., 1995; Karner and Driscoll, in press; Western Australian margin - Driscoll and Karner, 1995; 1998, South China Sea - Nissan and Hayes, 1998). To explain the magnitude of the regional subsidence with little or no attendant brittle deformation requires significant lower crustal and mantle extension across these margins (Driscoll and Karner, 1998). Driscoll and Karner (1998) proposed a model in which a detachment and/or diffuse zone separates the brittle and ductile deformation in the crust and shoals in the region of maximum heat input. Therefore, depending on the location of asthenospheric upwelling (e.g., the future ocean/continent boundary), the detachment will dip towards both margins. The balancing brittle deformation is focused in a narrow region adjacent to the continent/ocean boundary and soles into the detachment. The deformed continental crust in this region is highly intruded and overprinted by volcanism associated with rift-induced decompression melting. (This may be the origin of the MQZ?). The depth of the detachment migrates throughout the history of the rifting in response to the input of heat. The lower crustal extension appears to be most dominant during the late stages of the rifting phase just prior to continental breakup when the upwelling of asthenospheric heat causes the lower crust to deform plastically. The terminology of upper and lower plate is applicable when describing the morphology of the brittle deformation observed on conjugate margins. However, in terms of describing the distribution and style of subsidence observed on conjugate margins, the use of upper and lower plate may be misleading when both margins display subsidence patterns that are characteristic of the upper plate (e.g., Driscoll and Karner, 1998; Karner and Driscoll, 1999).

We will determine from the stratigraphic record, as described above, whether strain partitioning involving significant lower crustal and mantle extension is required across the Cuvier margin and compare its evolution to the wider reift, the Exmouth margin. Knowing the timing, style, magnitude, and distribution of the synrift and postrift subsidence, together with the distribution of volcanism defined from seismic reflection and magnetic data as well as refraction inversions of crustal structure, we will reconstruct the evolution of the Exmouth and Cuvier margins.

References

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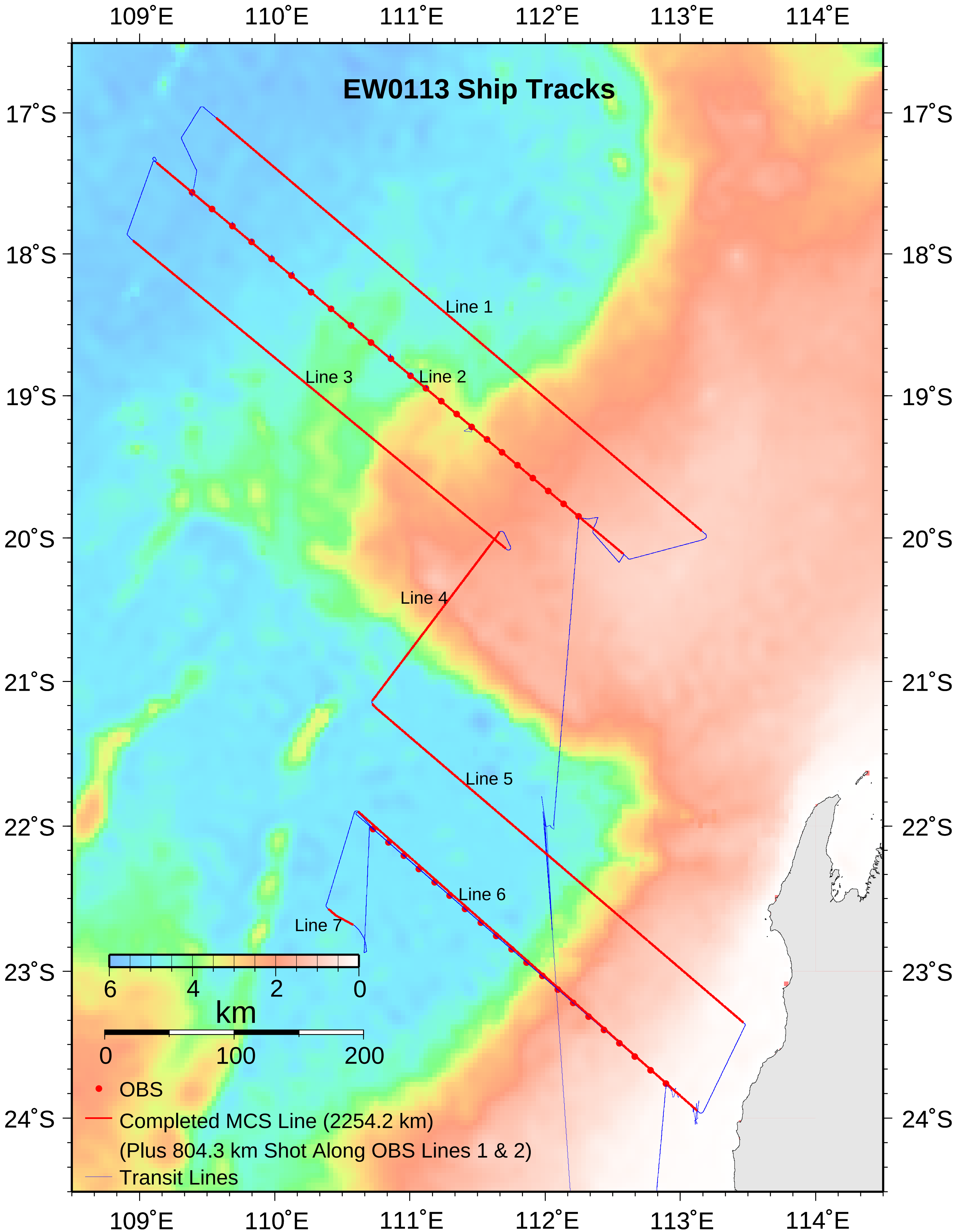

EW0113 Ship Tracks
109˚E
110˚E
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19˚S
20˚S
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Line 1
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km
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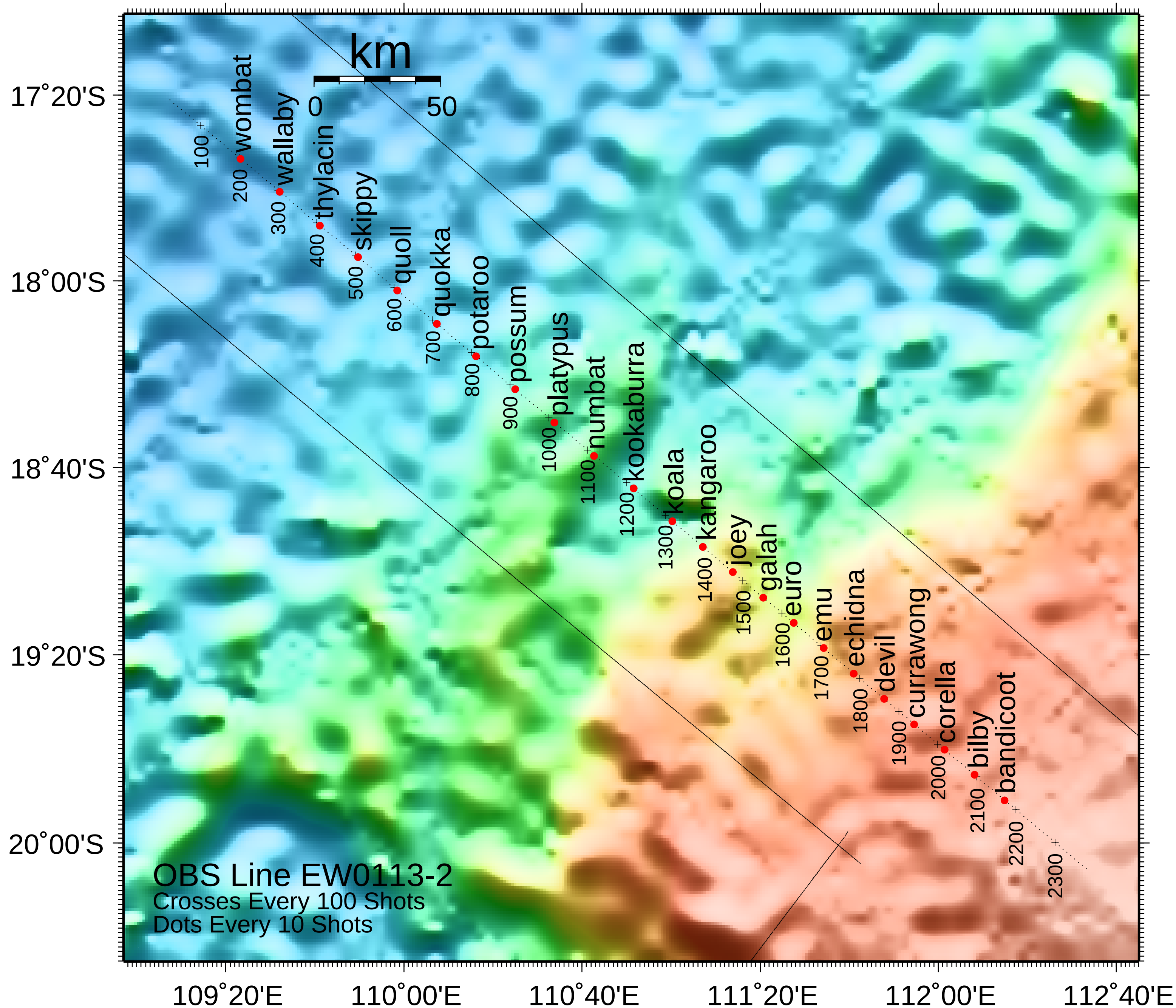
200
OBS
Completed MCS Line (2254.2 km)
(Plus 804.3 km Shot Along OBS Lines 1 & 2)
Transit Lines



km
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111°20'E
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112°40'E
wombat
wallaby
thylacin
skippy
quoll
quokka
potaroo
possum
platypus
numbat
kookaburra
koala
kangaroo
joey
galah
euro
emu
echidna
devil
currawong
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bandicoot
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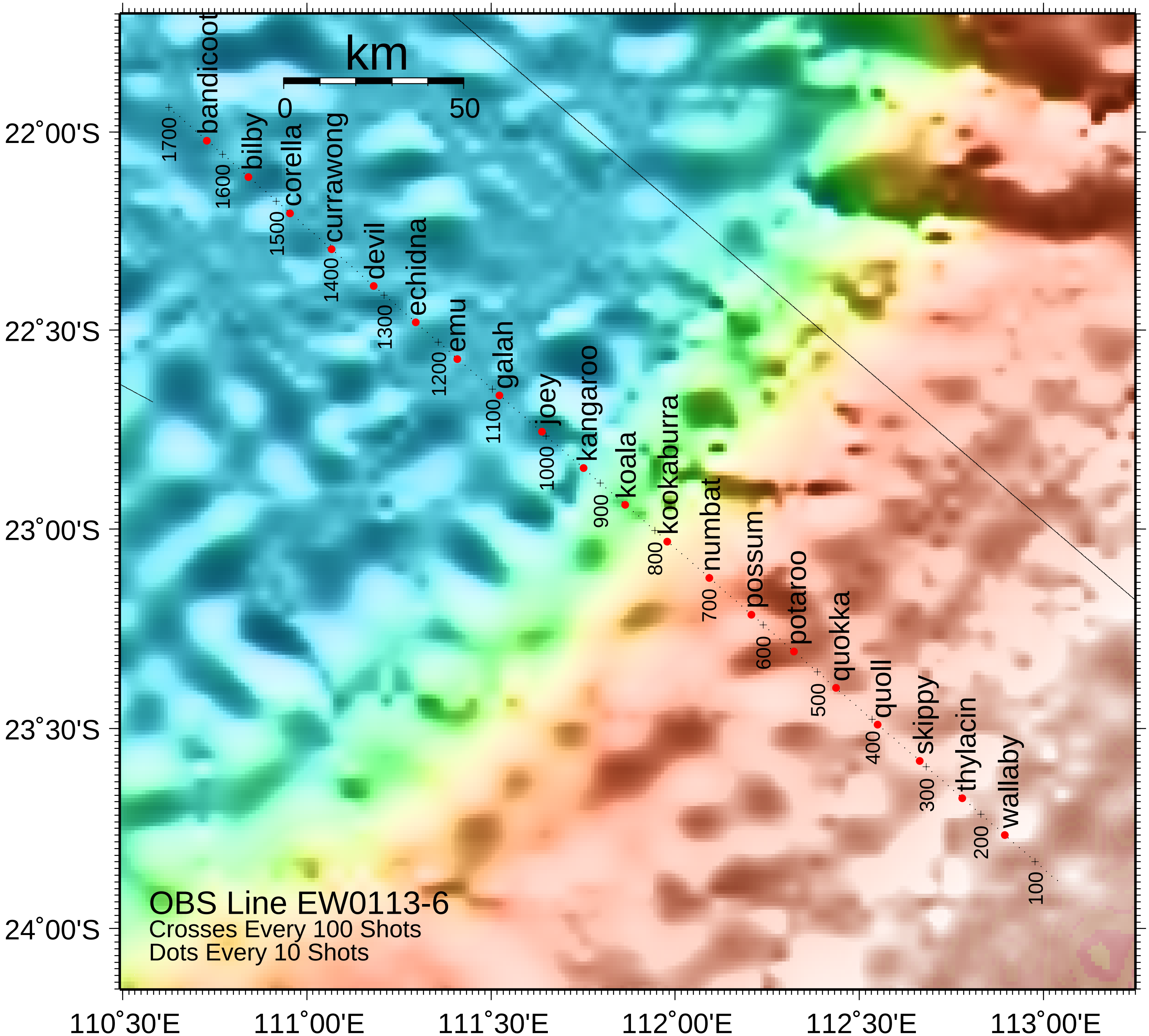
OBS Line EW0113-2
Crosses Every 100 Shots
Dots Every 10 Shots


km
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possum
potaroo
quokka
quoll
skippy
thylacin
wallaby
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22°00'S
22°30'S
23°00'S
23°30'S
24°00'S
110°30'E
111°00'E
111°30'E
112°00'E
112°30'E
113°00'E
OBS Line EW0113-6
Crosses Every 100 Shots
Dots Every 10 Shots

Location of OBS/H Used During EW0113

Deployment 1 (Line 2)

	Name	Latitude (S)	Longitude (E)	Depth (m)	Comments
1	bandicoot	19.848502	112.24802	1437.7	
2	bilby	19.759037	112.135465	1729.2	
3	corella	19.669637	112.022912	1886.6	
4	currawong	19.58033	111.91034	1970.4	
5	devil	19.489692	111.796507	2190.0	
6	echidna	19.399312	111.682527	2526.7	
7	emu	19.309248	111.57081	2850.1	
8	euro	19.22011	111.458325	3468.3	Did Not Respond
9	galah	19.129608	111.344638	3913.5	
10	joey	19.03936	111.230795	3314.2	
11	kangaroo	18.949323	111.119295	3794.7	
12	koala	18.859058	111.00556	4510.9	
13	kookaburra	18.74108	110.859368	4561.2	
14	numbat	18.625	110.7116	4010.9	
15	platypus	18.505948	110.56407	3866.2	Did Not Record
16	possum	18.38778	110.41587	4585.2	
17	potaroo	18.269907	110.26996	4943.7	
18	quokka	18.153123	110.12322	5122.6	
19	quoll	18.034358	109.975838	5203.7	
20	skippy	17.915535	109.8286	5205.0	
21	thylacin	17.802388	109.68635	5421.0	
22	wallaby	17.681302	109.536348	5542.6	
23	wombat	17.562703	109.389213	5665.1	Did Not Respond

Deployment 2 (Line 6)

	Name	Latitude (S)	Longitude (E)	Depth (m)	Comments
1	bandicoot	22.02141667	110.7278	5135	
2	bilby	22.11303333	110.8418333	5139	
3	corella	22.2049	110.9548667	5131	
4	currawong	22.29581667	111.0673833	5156	
5	devil	22.38903333	111.18205	5151	
6	echidna	22.48025	111.2953833	5146	
7	emu	22.57243333	111.4086	5119	
8	galah	22.6641	111.5232167	5119	
9	joey	22.75536667	111.63855	5070	
10	kangaroo	22.84753333	111.7512667	4814	
11	koala	22.9394	111.86445	4116	
12	kookaburra	23.03141667	111.9792333	3555	
13	numbat	23.12333333	112.0931333	2312	
14	possum	23.21548333	112.2076667	1495	

15	potaroo	23.3079	112.32215	1259
16	quokka	23.39893333	112.4367333	1110
17	quoll	23.49051667	112.55015	911
18	skippy	23.58186667	112.6643167	647
19	thylacin	23.67486667	112.7802333	389
20	wallaby	23.76616667	112.8948	210

	Longitude	Latitude	Meters	JD	HHMMSS	Shot	Z (m)	Line
EW0113-2								
Start:	109.123078	-17.349823	0.0	307	111352	19	5612.2	2
End:	112.561445	-20.096838	-473135.7	309	205339	2385	964.9	2
EW0113-6								
Start:	113.051000	-23.891100	0.0	329	013622	51	119.2	6
End:	110.614000	-21.928900	-331207.0	330	134437	1707	5067.4	6

CRUISE EW-0111 **6KM CONFIG** **5/22/02 Seychelles**

MOD	SERIAL #	CAN#	SHIP OFFSET	CHANNELS	BIRD	COMMENTS
TB			6314M			TAIL BUOY AT 6314M
STIC	CABLE 26M		6288M TO 6314M			NEW STICK CABLE
1		2151				
HS	30120-HS	50M	6238M TO 6288M			
TS	0697-30284TS	50M	6188M TO 6238M			
					1	BIRD AT 6198M
AT	0498-30025	4M	6184M TO 6188M			new
	31374	RED	6109M TO 6184M	1 TO 3		
2		3538			2C	BIRD AT 6103M
	0298-31388	ORNG	6034M TO 6109M	4 TO 6		
	0996-30299	RED	5959M TO 6034M	7 TO 9		new
3		2734			3	Bird at 5953M
	1296-30808	ORNG	5884M TO 5959M	10 TO 12		new
	1096-30330	RED	5809M TO 5884M	13 TO 15		new
4		2731			4C	BIRD AT 5803M
	30301	ORNG	5734M TO 5809M	16 TO 18		NEW
	31407	RED	5659M TO 5734M	19 TO 21		NEW
5		2754			5	BIRD AT 5653M
	31408	ORNG	5584M TO 5659M	22 TO 24		
	0298 31361	RED	5509M TO 5584M	25 TO 27		
6		3607			6C	BIRD AT 5503M
	0298-31402	ORNG	5434M TO 5509M	28 TO 30		
	0298-31337	RED	5359M TO 5434M	31 TO 33		
7		3189				
	1096-30337	ORNG	5284M TO 5359M	34 TO 36		new
	0298-31390	RED	5209M TO 5284M	37 TO 39		
8		3606			7	BIRD AT 5203M
	0298-31346	ORNG	5134M TO 5209M	40 TO 42		
	0298-31381	RED	5059M TO 5134M	43 TO 45		
9		3107				
	0298-31391	ORNG	4984M TO 5059M	46 TO 48		
	0298-31406	RED	4909M TO 4984M	49 TO 51		new
10		3395			8C	Bird at 4903M
	0298-31384	ORNG	4834M TO 4909M	52 TO 54		
	0198-31341	RED	4759M TO 4834M	55 TO 57		
11		3599				
	0198-31398	ORNG	4684M TO 4759M	58 TO 60		
	0298-31387	RED	4609M TO 4684M	61 TO 63		
12		3597			9	Bird at 4603M
	31333	ORNG	4534M TO 4609M	64 TO 66		
	0298-31369	RED	4459M TO 4534M	67 TO 69		
13		3604				
	0298-31396	ORNG	4384M TO 4459M	70 TO 72		
	0198-31335	RED	4309M TO 4384M	73 TO 75		
14		2965			10	BIRD at 4303M
	0198-31362	ORNG	4234M TO 4309M	76 TO 78		
MOD	SERIAL #	CAN#	SHIP OFFSET	CHANNELS	BIRD	COMMENTS
	0298-31373	RED	4159M TO 4234M	79 TO 81		
15		5993-R				
	0198-31334	ORNG	4084M TO 4159M	82 TO 84		
	0298-31405	RED	4009M TO 4084M	85 TO 87		
16		2740			11	BIRD AT 4003M
	0298-31386	ORNG	3934M TO 4009M	88 TO 90		new
	0397-31119	RED	3859M TO 3934M	91 TO 93		
17		3031				

	0198-31318	**ORNG**	3784M TO 3859M	**94 TO 96**		
	0198-31343	**RED**	3709M TO 3784M	**97 TO 99**		
18		**3602**			**12C**	**BIRD at 3703M**
	1296-30312	**ORNG**	3634M TO 3709M	**100 TO 102**		
	0996-30302	**RED**	3559M TO 3634M	**103 TO 105**		
19		**2940**				
	30804	**ORNG**	3484M TO 3559M	**106 TO 108**		
	0996-30327	**RED**	3409M TO 3484M	**109 TO 111**		
20		**1036R**			**13**	**Bird at 3403M**
	0197-31058	**ORNG**	3334M TO 3409M	**112 TO 114**		
	0298-31389	**RED**	3259M TO 3334M	**115 TO 117**		
21		**3184**				
	31329	**ORNG**	3184M TO 3259M	**118 TO 120**		_
	0996-30279	**RED**	3109M TO 3184M	**121 TO 123**		
22		**2563**			**14C**	**BIRD AT 3103M**
	0996-30291	**ORNG**	3034M TO 3109M	**124 TO 126**		**new**
	31371	**RED**	2959M TO 3034M	**127 TO 129**		
23		**2507**				
	31350	**ORNG**	2884M TO 2959M	**130 TO 132**		
	31363	**RED**	2809M TO 2884M	**133 TO 135**		
24		**2567**			**15**	**BIRD at 2803M**
	0996-30300	**ORNG**	2734M TO 2809M	**136 TO 138**		
	0696-31347	**RED**	2659M TO 2734M	**139 TO 141**		
25		**2717**				
	31327	**ORNG**	2584M TO 2659M	**142 TO 144**		
	31383	**RED**	2509M TO 2584M	**145 TO 147**		
26		**2523**			**16C**	**BIRD AT 2503M**
	0996-30304	**ORNG**	2434M TO 2509M	**148 TO 150**		_
	0696-0138	**RED**	2359M TO 2434M	**151 TO 153**		**new**
27		**1910R**				
	298 31372	**ORNG**	2284M TO 2359M	**154 TO 156**		
	0298-31365	**RED**	2209M TO 2284M	**157 TO 159**		**new**
28		**2511**			**17**	**BIRD AT 2203M**
	31326	**ORNG**	2134M TO 2209M	**160 TO 162**		
	30251	**RED**	2059M TO 2134M	**163 TO 165**		
29		**2570**				
	0298-31321	**ORNG**	1984M TO 2059M	**166 TO 168**		**new**
	31433	**RED**	1909M TO 1984M	**169 TO 171**		**new**
30		**3172**			**18C**	**BIIRD AT 1903M**
MOD	**SERIAL #**	**CAN#**	**SHIP OFFSET**	**CHANNELS**	**BIRD**	**COMMENTS**
	0597-31268	**ORNG**	1834M TO 1909M	**172 TO 174**		
	0996-30281	**RED**	1759M TO 1834M	**175 TO 177**		
31		**2505**				
	0696-10406	**ORNG**	1684M TO 1759M	**178 TO 180**		
	0996-30303	**RED**	1609M TO 1684M	**181 TO 183**		
32		**2554**			**19**	**BIRD AT 1603M**
	1096-30346	**ORNG**	1534M TO 1609M	**184 TO 186**		
	30313	**RED**	1459M TO 1534M	**187 TO 189**		
33		**3182**				
	31319	**ORNG**	1384M TO 1459M	**190 TO 192**		**new**
	30326	**RED**	1309M TO 1384M	**193 TO 195**		_
34		**5943R**			**20C**	**BIRD AT 1303M**
	0198-31350	**ORNG**	1234M TO 1309M	**196 TO 198**		**new**
	0696-10057	**RED**	1159M TO 1234M	**199 TO 201**		
35		**2462**				
	1096-30320	**ORNG**	1084M TO 1159M	**202 TO 204**		**BLKHDS THIN SECTION**
	0996-31349	**RED**	1009M TO 1084M	**205 TO 207**		

36		**2747**			**21**	**Bird at 1003M**
	0697-31282	**ORNG**	934M TO 1009M	**208 TO 210**		
	31413	**RED**	859M TO 934M	**211 TO 213**		
37		**3192**			**22C**	**Bird at 853M**
	SS1-0696-0140	**ORNG**	784M TO 859M	**214 TO 216**		
	31400	**RED**	709M TO 784M	**217 TO 219**		
38		**3543**			**23**	**Bird at 703M**
	0298-31410	**ORNG**	634M TO 709M	**220 TO 222**		
	31284	**RED**	559M TO 634M	**223 TO 225**		
39		**3605**			**24C**	**BIRD AT 553M**
	30360	**ORNG**	484M TO 559M	**226 TO 228**		
	31375	**RED**	409M TO 484M	**229 TO 231**		**new**
40		**2485**			**25**	**BIRD AT 403M**
	30314	**ORNG**	334M TO 409M	**232 TO 234**		
	31357	**RED**	259M TO 334M	**235 TO 237**		
41		**2970**			**26C**	**BIRD AT 253M**
	30332	**ORNG**	184M TO 259M	**238 TO 240**		
	30128HS		134M TO 184M	STRETCH		
42		**10284**	**PASSIVE CAN**			
	30137HS		84M TO 134M	STRETCH		replaced 30134
LDR	0298-30127		STERN TO 84M	LEADER		replaced bad 0498-30025

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EW−0113 Freemantle, W. Australia − Freemantle, W. Australia

Date	Julian Date	Time	Port
October 29, 2001	302	02:00:00	Freemantle, W.A.
December 2, 2001	336	06:30:00	Freemantle, W.A

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Justin Walsh	Gunner	cabinboy@ldeo.columbia.edu

Ship Crew

James O'Loughlin	Captain	captain@ewing.ldeo.columbia.edu
Karlyn, Albert	Chief Engineer	engine@ewing.ldeo.columbia.edu
Gilbert Thurston	1st Mate	
Bob Beauregard	2nd Mate	
Meredith Mecketsy	3rd Mate	
Matthew Tucke	1st A/Engineer	
Miguel Flores	2nd A/Engineer	
Chris Rooney	3rd A/Engineer	
Jack Schwartz	Electrician	
John Smith	Steward	
David Philbrick	Bosun	
Bachelor, John	Cook	
Ewing, Robert	A/B	
Lee, Daniel	Oiler	
McNeal, Fred	O/S	
Moqo, Luke	Utility	
Noonan, Meg	A/B	
Scanlan, Elizabeth	A/B	
Strickland, Gordon	Oiler	
Uribe, Fernando	Oiler	

All data in this report is logged using GMT time and Julian days in order to avoid confusion with local time changes.

Spectra

Spectra logs data to files in UKOOA[1] P1/90 format and P2/94 Format. The file formats are included in separate PDF documents on the tape. The contents of these files contain all the parameters used during shooting each of the lines, as well as the positions of all the sensors. I have included perl scripts for extracting shot times and positions from the P1 and P2 files on the tape.

Positioning of Sensors

The Spectra system defines a reference point which is used as a reference to all points which need an offset (range and bearing to TB, for example). This reference point has been defined as the center of the ship's mast, at sealevel.

Any documentation included herein that refers to the vessel reference or reference or master will be referring to this reference point.

However, daily navigation files that are not related to spectra (ie. n., hb.n, mg.n, files) are referenced to the Tasmon P−Code GPS filtered positions.

Offset information can be found under the **Ship Diagrams** section of this document.

Data Reduction

Since spectra positions its shots precisely based on a Kalman filtering algorithm, we will assume that it has the correct shot location. However, as a fallback measure, I have also processed the shots using our normal navigation filtering.

Therefore you will find the following shotlog files:

- nb0.r — Contains shot times and positions based on Spectra positioning.
- nb2.r — Contains shot times and positions based on Spectra navigation
- ts.n — Contains shot times and positions based on Ewing navigation
- shots.p1 — Contains shot times and positions based on Spectra P1 files
- shots.p2 — Contains shot times and positions based on Spectra P2 files

Please see the File Formats section for more information on these files.

Hydrosweep

There were several chronic problems with hydrosweep data acquisition.

1. Examination of raw multi−beam data revealed a 0.5 degree roll bias error.
2. The system intermittently went into a "narrow" swath mode, losing several beams.

---

1 United Kingdom Offshore Operators Association

Gravity

There were no gravity data interruptions.

Seismic Acquisition

Streamer configuration files are included on the tape in Excel 97 format.

Data Logging

The R/V Maurice Ewing data logging system is run on a Sparc Ultra Enterprise Server. Attached are 48 serial ports via 3 16−port Digi International SCSI Terminal Servers. Generally, all data logged by the Ewing Data Acquisition System (DAS) is time stamped with the CPU time of the server, and broadcast to the Ewing network using UDP packet broadcasts. The CPU time of the server is synchronized once every half hour to a Datum UTC gps time clock.

GPS times are also time−tagged with cpu time, although the time of the GPS position is from the GPS fix itself.

The following tables describe the data instruments which performed logging during this cruise. The tables associated with the instruments describe logging periods and data losses for that instrument.

Time Reference

JoeTime 9390−1000

logging interval: 30 minutes
file id: tr3

Used as the CPU synchronization clock. This clock is polled once every half hour to synchronize the CPU clock of the data logger to UTC time. The logger (octopus) is responsible for updating the times of the other CPUs.

Note that the Spectra system uses its own Trimble gps receiver for synchronizing its hardware to UTC time. This is the time the shot points are referenced to; not the CPU time.

Interruption s greater than 30 minutes are displayed in the following table

Log Date	LogDate	Comment
2001+302:00:10:29.724		Logging officially started
2001+106:23:45:29.725	2001+113:15:40:30.083	Data interruption
		Logging officially ends

Spectra

Spectra uses its own Trimble gps receiver for synchronizing its hardware to UTC time. This is the time the shot points are referenced to; not the CPU time.

Spectra P1 and P2 files were logged for each

GPS Receivers

GPS data is usually logged at 10 second intervals. The NMEA strings GPGGA and GPVTG are logged for position, speed, and heading fixes. This data was logged constantly throughout the cruise.

The Tasmon GPS was the primary GPS for this cruise.

Trimble Tasmon P/Y Code Receiver

logging interval: 10 seconds
file id: gp1

The Tasmon is the primary GPS receiver for the Ewing Logging system and the primary GPS for Spectra fixes. The accuracy is around 15 meters. There were no interruptions during this cruise.

Interruptions greater than 10 minutes are displayed in the following table

Log Date	LogDate	Comment
2001+302:01:18:00.205		Logging officially starts
2001+303:14:36:30.632	2001+303:14:59:01.708	Data interruption
2001+303:15:19:56.594	2001+303:15:32:36.367	Data interruption
2001+303:15:33:38.547	2001+303:15:51:54.035	Data interruption
2001+303:15:52:24.521	2001+303:16:04:14.460	Data interruption
2001+305:11:11:48.897	2001+305:11:56:57.604	Data interruption
2001+335:23:59:55.226		Logging officially ends

Trimble NT200D

logging interval: 10 seconds
file id: gp2

The Trimble is the secondary receiver for GPS data. Data is logged at 10 second intervals and is also used as an input to Spectra, although it is weighed at a lower value than the Tasmon receiver. During this cruise, there were several Trimble outages.

Interruptions greater than 10 minutes are displayed in the following table

Log Date	LogDate	Comment
2001+302:01:24:19.777		Logging officially started
2001+303:14:32:54.132	2001+303:14:59:09.902	Data Interruption
2001+303:15:19:55.919	2001+303:15:51:59.616	Data Interruption
2001+303:15:52:23.601	2001+303:16:04:27.617	Data Interruption
2001+305:11:12:13.943	2001+305:12:00:47.707	Data Interruption
2001+306:16:32:49.901	2001+306:16:48:41.718	Data Interruption
2001+309:01:41:37.948	2001+309:03:05:15.659	Data Interruption
2001+309:03:15:35.836	2001+310:03:27:13.634	

Log Date	LogDate	Comment
2001+313:11:44:21.803	2001+313:11:59:11.604	
2001+314:00:08:01.860	2001+316:06:35:17.623	
2001+319:04:53:39.818	2001+319:11:15:07.612	
2001+326:07:44:15.825	2001+326:08:12:49.617	
2001+327:15:46:27.582	2001+327:19:12:47.604	
2001+328:07:21:27.829	2001+328:23:44:14.160	
2001+331:05:01:19.822	2001+332:05:29:45.621	
2001+333:16:22:31.819	2001+334:00:16:57.637	
2001+335:23:59:54.152		Logging officially ends

Tailbuoy Garmin GP8

logging interval: 10 seconds
file id: tb1

The tailbuoy receiver was working during all lines with the exception of minor blackouts during deployment and turns.

Interruptions greater than 30 minutes are displayed in the following table

Log Date	Log Date	Comment
2001+312:22:49:00.314		Tailbouy logging starts
2001+320:16:21:47.635	2001+320:17:16:27.532	Data Interruption
2001+325:22:59:05.583		Tailbuoy logging officially ends

Speed and Heading

Furuno CI−30 Dual Axis Speed Log
Sperry MK−27 Gyro

logging interval: 6 seconds
file id: fu

The Furuno and Gyro are combined to output speed, heading and course information to a raw Furuno file, as well as an NMEA VDVHW signal used as an input to various systems including steering and Spectra.

Interruptions greater than 30 minutes are displayed in the following table

Log Date	Log Date	Comment
2001+302:01:19:07.159		Logging officially starts
2001+305:11:09:41.607	2001+305:11:57:23.523	Data Interruption
2001+335:23:59:58.206		Logging officially ends

Gravity

Bell Aerospace BGM−3 Marine Gravity Meter System

logging interval: 1 second
file id: vc. (raw), vt. (processed)
drift per day:

The BGM consists of a forced feedback accelerometer mounted on a gyro stabilized platform. The gravity meter outputs raw counts approximately once per second which are logged and processed to provide real−time gravity displays during the course of the cruise as well as adjusted gravity data at the end of the cruise.

Interruptions greater than 10 minutes are displayed in the following table

Log Date	Log Date	Comment
2001+302:01:19:52.788		Official start date
2001+303:15:35:26.788	2001+303:16:05:16.761	Lost BGM output
2001+305:11:08:14.925	2001+305:11:57:40.863	Lost BGM output
2001+335:23:59:59.826		Logging officially ends

Bathymetry

Krupp Atlas Hydrosweep−DS

logging interval: variable based on water depth
file id: hb (centerbeam), hs (swath)

The hydrosweep full swath data is continuously logged for every cruise, and centerbeam data is extracted and processed separately. The centerbeam operates at a logging frequency dependent on the water depth.

The full swath data is not routinely processed, but can be processed with the MB−System software which can be downloaded for free. For instructions, use the website: http://www.ldeo.columbia.edu/MB−System.

MBSystem, version 4.6.10 is necessary to process data after Jan 1, 2000.

Note: During OBS deployment and recovery, the hydrosweep was routinely suspended to avoid interference with the standard wide beam profilers. Those interruptions should not be listed.

Interruptions greater than 10 minutes are displayed in the following table

Log Date	LogDate	Comment
2001+302:18:27:11.000		Logging officially starts
2001+303:15:13:14.000	2001+303:16:07:59.000	HS Interruption
2001+303:16:07:59.000	2001+303:16:34:51.000	HS Interruption
2001+314:05:22:08.000	2001+314:05:51:57.000	HS Interruption
2001+334:22:42:49.000		Logging officially ends

Weather Station

RM Young Precision Meteorological Instruments, 26700 series

logging interval: 1 minute
file id: wx

The weather station is used to log wind speed, direction, air temperature, and barometric pressure. We log this information at 1−minute intervals.

Log Date	LogDate	Comment
2001+302:01:21:01.016		Logging officially starts
2001+302:01:21:01.016	2001+302:18:28:43.574	Data Interruption
2001+303:15:36:00.199	2001+304:02:12:00.084	Data Interruption
2001+305:11:09:00.082	2001+305:11:58:23.098	Data Interruption
2001+335:23:59:00.868		Official end logging

Magnetics

Varian Magnetometer

logging interval: 12 seconds
file id: mg

Interruptions greater than 10 minutes are displayed in the following table

Start Log Date	End LogDate	Comment
2001+303:08:44:28.457		Official start logging
2001+303:15:34:48.808	2001+303:16:05:54.601	Data Interruption
2001+305:03:00:41.531	2001+305:12:02:25.935	Data Interruption
2001+306:01:41:54.369	2001+307:08:20:18.800	Data Interruption
2001+309:20:58:03.877	2001+313:03:24:46.205	Data Interruption
2001+314:02:57:41.605	2001+314:03:18:09.486	Data Interruption
2001+314:03:18:20.883	2001+314:04:08:36.312	Data Interruption
2001+314:04:22:30.460	2001+314:04:50:03.944	Data Interruption
2001+314:05:09:58.349	2001+314:10:46:37.695	Data Interruption
2001+325:21:09:35.346	2001+328:23:43:24.850	Data Interruption
2001+328:23:52:27.952	2001+329:01:21:45.205	Data Interruption
001+329:05:29:25.924		Official end logging

As this was the second cruise using the Spectra system to fire the guns and log the shot times, we are still in the process of integrating the Spectra system into the Ewing system. this has resulted in some compromises in shot logging.

The following items were of concern during this cruise:

- The P2 and P1 formats do not store the shot time in millisecond range
- SIOSEIS cannot handle the Spectra output header for SEG−D

Due to these facts, a system has been created where the Spectra header, data from the Digicourse cable output, data from the gun depths, and real−time data from the Ewing logging system are all used to create a Ewing standard SEG−D header readable by SIOSEIS to place on the 3490 tape for each shot.

There are several files for each line reflecting the line status:

File	Description
ts.n	Shot time is merged with Ewing navigation to determine shot location
nb2.r	Navigation is from Spectra, and includes tailbuoy, tailbuoy range and bearing
shotlog.p1	Shots are from the p1 file. (should be identical to nb2.r), includes source position
shotlog.p2	Shots are from the p2 file (should be identical to tss.n), includes source position

Shot Files Table

Line Name	Times ()	Ewing(ts.n, nb2.r)		Spectra (shots.p1, shotlog.p2)		
		Shots	Missing	P1 Shots	P2 Shots	Missing
Ex_OBS_ Line1	307:11:13:52 20:53:39.464	0019−2385	0006−0018	0006−2385	0001−2385	
Ex_MCS_ Line1	313:05:53:02 314:05:04:14	0004−3866		0004−3862 (last shots misnumbered)	0004−3862 (last shots misnumbered)	
Ex_MCS_ Line1B	314:05:50:36 315:15:49:15	3998−9961		3998−9961	3998−9961	
Ex_MCS_ Line2	315:23:13:25 318:09:05:06	0001−9509	2979,2980	0001−9509	0001−9509	
Ex_MCS_ Line3	318:17:19:24 320:16:11:07	0002−7533	0001,4643, and 4644	0001−7533	0001−7533	
Ex_MCS_ Line4	320:18:36:06 321:13:27:11	0023−3283		0023−3283	0023−3283	
Ex_MCS_ Line5	321:13:44:22 323:09:41:20	0033−7489	4159	0033−7489	0033−7489	

Line Name	Times ()	Ewing(ts.n, nb2.r)		Spectra (shots.p1, shotlog.p2)		
		Shots	Missing	P1 Shots	P2 Shots	Missing
Ex_MCS_Line6	323:18:46:05 325:09:50:20	0001−6863	2334, 5451, 6405	0001−6863	0001−6863	
Ex_MCS_Line7	325:18:27:38 325:21:12:41	0019−0466		0019−0466	0019−0466	
Ex_OBS_Line2	329:01:36:22 330:13:44:37	0051−1707		0051−1707	0051−1707	

Freemantle, W.A.

EW0113 Fremantle, Australia

Pier/Ship	Latitude	Longitude
	32 03.156S	115 44.251E

The pier tie was taken at Bollard "E", which is the 6th Bollard from the end of the pie

Reference	Latitude	Longitude
	31 58.900S	115 48.800E

The reference tie was made to ACIC 3651-1. This in the basement of the Geology Building at the University of Western Australia.

	Id	Julian	Date	Mistie	Drift/Day	Prev Mistie
Pre Cruise	EW0112	296	10/23/2001	34.68	0.22	27.73
Post Cruise	EW0112	299	10/26/2001	8.94	-8.580	34.68
Total Days			3.00	-25.74		

Time	Entry	Value	
15:00	CDeck Level BELOW Pier	2.00	
13:30	Pier 1 L&R Value	3028.48	L&R
14:00	Reference L&R Value	3006.91	L&R
14:40	Pier 2 L&R Value	3028.48	L&R
	Reference Gravity	979394.47	mGals
	Gravity Meter Value (BGM Reading)	979428.60	mGals
	Potsdam Corrected	0	1 if corrected

*Gravity meter is **5.5** meters 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	
3028.48	3006.91	1.06		22.86	mGals

Gravity in mGals at Pierside

Reference +	Delta mGals [+ Potsdam]			Pier Gravity	
979394.47	22.86	0.00		979417.33	mgals

Gravity in mGals at Meter

Pier Gravity+	Height Correction			Gravity@meter	
979417.33	2.33			979419.66	mGals

Current Mistie

BGM Reading	Calculated Gravity			Current Mistie	
979428.60	979419.66			8.94	mGals

Freemantle, W.A.

EW0113 Fremantle, Australia

Pier/Ship	Latitude	Longitude
	32 02.960S	115 44.720E

The pier tie was taken at Bollard 57, which is near Shed D at

Reference	Latitude	Longitude
	32 03.156S	115 48.800E

The reference tie was made to Bollard "E" which is the 6th Bollard from the end of th

	Id	Julian	Date	Mistie	Drift/Day	Prev Mistie
Pre Cruise	EW0112	299	10/26/2001	8.94	−8.58	34.68
Post Cruise	EW0113	338	12/03/2001	9.22	0.007	8.94
Total Days			38.00	0.28		

Time	Entry	Value	
10:30	CDeck Level BELOW Pier	2.00	
10:00	Pier 1 L&R Value	3025.70	L&R
14:00	Reference L&R Value	3028.20	L&R
10:05	Pier 2 L&R Value	3025.70	L&R
	Reference Gravity	979417.30	mGals
	Gravity Meter Value (BGM Reading)	979426.20	mGals
	Potsdam Corrected	0	1 if corrected

*Gravity meter is **5.5** meters below CDeck*

Difference in meters between Gravity Meter and Pier: 7.50 meters

Height Cor = Pier Height* FAA Constant

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
3025.70	3028.20	1.06		−2.65 mGals

Gravity in mGals at Pierside

Reference + Delta mGals [+ Potsdam]				Pier Gravity
979417.30	−2.65	0.00		979414.65 mgals

Gravity in mGals at Meter

Pier Gravity+	Height Correction			Gravity@meter
979414.65	2.33			979416.98 mGals

Current Mistie

BGM Reading	Calculated Gravity			Current Mistie
979426.20	979416.98			9.22 mGals

For all formats, a **–** in the time field means an invalid value for some reason.

Streamer Compass/Bird Data — cb.r

This data is not processed, but can still be found in the "processed" data directory.

```
Shot Time              Line    Shot    Latitude     Longitude
2000+079:00:08:40.085  strike1 000296  N 15 49.6217 W 060 19.8019

2nd GPS Position                      Tailbuoy Position
Latitude     Longitude                Latitude     Longitude
N 15 49.6189 W 060 19.8101    N 15 47.1234 W 060 20.1901

Furuno  Streamer
Gyro    Compasses & Heading
344.1       C01 2.3 C02 1.7  ...
```

Gun Depths — dg

Gun depths in tenths of meters. There will always be 20 gundepths even if only one gun was configured and shooting.

```
                      Gun Depths
Shot Time             1   2   3  4    5   6   7   8   9  ...  20
2001+089:06:47:05.909 189 068 005 005 096 005 060 054 005 ... 6
```

Raw Furuno Log — fu.s

This data has been smoothed and output 1 fix per minute.

```
CPU Time Stamp        Track Speed Hdg   Gyro
2000+166:00:01:53.091 –      4.4   140.5 148.3
```

Hydrosweep Centerbeam — hb.n

Hydrosweep data merged with navigation

```
                               Centerbeam
CPU Time Stamp       Latitude  Longitude         Depth
2000+074:09:55:00.000  N 13 6.6206    W 59 39.3908   134.9
```

Merged Data — m

```
                                                     GPS
CPU Time Stamp        Latitude     Longitude         Used  Set  Drift Depth
2000+200:12:25:00.000 N 45 54.1583 W 42 47.1770      gp1   0.0  0.0

Magnetic                       Gravity
Total Intensity   Anomaly      FAA  GRV        EOTVOS   Drift   Shift
49464.7           55.5         22.2 980735.0   -8.4     -0.1     2.8

Temperature Salinity Conductivity
0.0         0.0      0.0
```

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

Temperature,Salinity and Conductivity will only be valid while logging a Thermosalinograph, which is not usually the case.

Magnetics Data — mg.n

- A minus sign in the time stamp is flagged as a spike point, probably noise...
- Anomaly is based on the International Geomagnetic Reference Field revision 2000

CPU Time Stamp	Latitude	Longitude	Raw Value	Anomaly
200+077:00:23:00.000	N 16 11.2918	W 59 47.8258	36752.2	−166.8

Navigation File — n

CPU Time Stamp	Latitude	Longitude	Used	Set	Drift
2000+074:00:03:00.000	N 13 6.2214	W 59 37.9399	gp1	0.0	0.0

Navigation Block — nb0

Navigation is a compendium of Ewing logged data at shot time. The shot position here is the shot position from the Spectra system.

Shot Time	Shot #	CPU Time	Shot Position
2001+088:00:00:00.606	016967	2001+088:00:00:03.031	N 30 11.8324 W 042 10.8162

Water Depth	Sea Temp	Wind Spd	Wind Dir	Tailbuoy Latitude	Tailbuoy Longitude	Tailbuoy Range	Tailbuoy Bearg	Line Name	Speed	Heading
2565.1	20.7	16.4	164	N 30 12.0427	W 042 14.7319	6296.3	93.5	MEG−10	4.2	101.1

Tailbuoy Navigation — tb1.c

Raw tailbuoy fixes

CPU Time Stamp	Latitude	Longitude	GPS Precision
2001+088:00:00:02.000	N 30 12.0424	W 042 14.7309	SA

GPS Precision is either SA, DIFF or PCODE

Ewing Processed Shot Times — ts.n

Shot times and positions based on the Ewing navigation data processing

CPU Time Stamp	Shot #	Latitude	Longitude	Line Name
2000+079:00:08:01.507	000295	N 15 49.5703	W 060 19.7843	strike1

Shot Data Status — ts.n.status

The ts.nxxx.status file describes the line information for that day, giving some basic statistics about the line: start, end times; missing shots; start and end shots.

```
LINE   strike1: 98+079:00:00:15.568 : 000283 .. 002286
        MISSING: 347, 410, 1727
LINE   dip2: 98+079:23:05:22.899 : 000002 .. 000151
```

This example says that on Julian Day 079 of 1998, two lines (strike1 and dip2) were run: the end of strike 1 (shots 000283 to 002286) and the start of dip2 (shots 000002 to 000151).

Line strike1 had some missing shots in the data file (probably missing on the SEG−d header as well).

Spectra Shot Times

nb2.r

The shot times and positions based on the Spectra positioning; with raw tailbuoy range and bearing.

```
CPU Time Stamp          Shot # Latitude      Longitude      Line Name

2001+084:00:00:05.924 009245 N 23 31.2410 W 045 25.0894

                              Tailbuoy
Latitude     Longitude      Range  Bearing  Line Name

N 23 30.4540 W 045 21.4338 6389.8 283.2    KANE-4
```

Raw Gravity Counts

vc.r

```
sample BGM-3 gravity count record (without time tag):

pp:dddddd ss

|    |    |___________ status: 00 = No DNV error; 01 = Platform DNV
|    |                         02 = Sensor DNV;   03 = Both DNV's
|    |________________ count typically 025000 or 250000
|_____________________ counting interval, 01 or 10
                       The input of data can be at 1 or 10 seconds.
```

Gravity Data

vt.n

```
* A minus sign in the time stamp is flagged as a spike point
* m_grv3 calculates the Eotvos correction as:
  eotvos_corr = 7.5038 * vel_east * cos(lat) + .004154 * vel*vel
* The theoretical gravity value is based upon different models for the earth's shape.
      1930 = 1930 International Gravity Formula
      1967 = 1967 Geodetic Reference System Formula
      1980 = 1980 Gravity Formula
* The FAA is computed as:
  faa = corrected_grv - theoretical_grv
* Velocity smoothing is performed w/ a 5 point window

CPU Time Stamp          Latitude     Longitude     Model FAA     RAW

2000+148:00:10:00.000 N 09 34.7255 W 085 38.5826 1980  9.48    978264.16

Eotvos  Drift DC     Raw  Velocity    Smooth Velocity
Smooth  Total Shift  North    East    North   East

-74.78  0.06  4.16   1.875 -10.373    1.927 \10.166
```

Joe Time

ts3.r

```
CPU Time              Datum Time       Time Reference

2001+069:00:15:29.727 069 00 15 29.378 datum
```

Raw GPS

gp(12).d, tb1.d

Raw GPS is in NMEA Format.

Meteorological Data

wx

	True
CPU Time Stamp	Spd Dir
2001+045:00:00:00.967	7.8 22

Bird1: Speed Inst	60sA	60mA	60sM	Direction Inst	60sA	60mA	Bird 2 Speed Inst	60sA	60mA	60sM	Direction Inst	60sA	60mA
7.8	6.6	8.5	16.8	277	291	5	0.0	0.0	0.0	0.0	0	0	0

Temperature Inst	60mA	60mm	60mM	Humidity Inst	60mm	60mM	Barometer
15.0	14.2	14.3	15.1	92	90	93	1027.5

Inst: Current

60sA: 60 second average

60mA: 60 minute average

60sM: 60 second maximum

60mm: 60 minute minimum

60mM: 60 minute maximum

Shot Times from Spectra P1 Files shots.p1

These files were created with the script: *extract_shots_from_p1* ***-a 1***

Epoch Time	Shot#	Source Lat/Lon		TB Lat	TB Lon
985788741.000	015570	30.283881	-41.854536	30.320144	-41.886642

Vessel Ref Lat/Lon		Antenna GPS Lat/Lon		Water Depth
30.283478	-41.854117	30.283531	-41.854078	2894.2

- Source is the Center of the Guns
- TB is the Tailbuoy, according to Spectra
- Vessel Ref is the location of the center of the Mast
- Antenna GPS is the location of Antenna 1 (-a 1 flag); in this case is the Tasmon GPS
- Water Depth is the HS Centerbeam depth

Shot Times from Spectra P2 Files shots.p2

These files were created with the script: *extract_shots_from_p2 -o "V1 G1"*

Epoch Time	Shot#	Vessel Ref Lat/Lon		Source Lat/Lon	
985716772.4	00015572	30.282803	-41.866136	30.283207	\41.866540

- Vessel Ref is the location of the center of the Mast
- Source is the Center of the Guns

I have included some scripts for extracting information out of the P1 and P2 formatted files. In order to use these scripts you will also need to install the Ewing Perl libraries I have included in the scripts directory, or at least include that directory in your PERL5LIB environment. It is not my intention to describe how to use perl in this document though.

extract_shots_from_p1 [−a antenna] [−h] filename

Given an input P1 File, create a shotpoint file with the times, and the positions of the given antenna [1 = tasmon, 2 = Trimble] and optionally the header records at the beginning of the file.

The output will be:

```
epochtime shotnumber sourcePos tbPos vesselPos antennaPos depth
```

- **epochtime** is the # of seconds since Jan 1, 1970
- **shotnumber** is the shot number
- **sourcePos** is the center position of the sound source [lat lon]
- **tbPos** is the position of the tailbuoy [lat lon]
- **vesselPos** is the position of the vessel reference (center of mast) [lat lon]
- **antennaPos** is the position of the specified antenna [lat lon]
  1 = tasmon, 2 = trimble
- **depth** is the water depth in meters

extract_shots_from_p2 [−s shotnumber] [−o "output values"]

−s define if you only want the statistics for a single shot

−o "*outputs*" defines the outputs you want from the P2 file.

This routine will output by default the shotpoint, the line name and the shot time. Optionally, you can output position (Lat Lon) info for a number of items:

Outputs can be one or more of the following:

- V1 Vessel 1 Reference
- V1G1 Tasmon GPS Receiver
- V1G2 Trimble GPS Receiver
- V1E1 Hydrosweep Transducer
- TB1 Tailbuoy 1
- S1 Streamer 1
- V1SC Streamer Compasses
- G1 Gun Array 1

All the formats output a Lat Lon pair in decimal degrees. (*West and South being negative*)

Output will be: `epochtime   shotnumber   [output lat/lon pairs]`

Tape Contents

EW0113/

EW0113.pdf	this document
ew0113.cdf	NetCDF database file of this cruise
ew0113.cdf_nav	NetCDF database file of this cruise' navigation
docs/	File Formats, Spectra manuals
processed/	Processed datafiles merged with navigation
shotlogs/	processed Shot Files
trackplots/	daily cruise track plots (*postscript*)
raw/	Raw data directly from logger
reduction/	Reduced data files
clean/	daily processing directory, includes daily postscript plots of the data.
fixes/	fixes for the RTNu HS loss of d088
scripts/	Perl scripts and their friends
spectra/	P1/90 and P2/94 files from MCS lines
streamer/	Excel spreadsheets of streamer configuration