Lamont-Doherty Earth Observatory
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EW-0004 Data Reduction Summary

EW0004 - Puntarenas, Costa Rica - Santa Cruz, Galapagos, Ecuador
Santa Cruz, Galapagos - Puerto Caldera, Costa Rica

April 1, 2000 - May 20, 2000

Port Dates

Date	Julian	Time	Port
4/1/2000	092	1600	Depart Puntarenas
5/1/2000	122	0630	Arrive Puerto Ayora, Santa Cruz
5/2/2000	123	1042	Depart Puerto Ayora
5/20/2000	141	1419	Arrive Puerto Caldera

Contents

Project Summary

*G': Galapagos **P**lume **R**idge **I**nteraction **M**ulti-discplinary **E**xperiment*

The Galápagos region, in the eastern equatorial Pacific, provides an ideal natural laboratory in which to address two fundamental problems: (1) mantle flow and melting at a mid-ocean ridge interacting with an off-axis plume including the origin of hotspot swells, and (2) the effect of variations in magma supply on axial topography, basalt chemistry, and crustal magmatic processes. These are long standing and first order problems of mid-ocean ridge and hotspot processes, but they are complex. They require an understanding of mantle flow, source heterogeneity, and variations in mantle melting/magma supply. To address these problems adequately, integrated geophysical and geochemical field measurements are needed and they must be analyzed jointly with geodynamical models. We propose an ambitious field and laboratory program that involves coordinated seismic, petrologic and modeling studies along an ~700-km-long section of the Galápagos Spreading Center (GSC), west of the 91°W transform.

This study has four main objectives:

1. determine how the compensation of the Galápagos swell is partitioned between variations in crustal thickness and mantle density by measuring crustal thickness variation along the swell and the degree of melting inferred from the chemistry of GSC basalts.
2. find an explanation for the chemical paradox at the Galápagos plume-ridge system; i.e. the apparently contradictory observation that variations in basalt geochemistry along the GSC suggest lower extents of melting nearer the hotspot, while bathymetric and gravity data imply thickened crust and/or hotter mantle near the hotspot.
3. determine if there is a threshold factor such as crustal thickness or depth, size, or disappearance of a crustal melt lens that controls the transition from an axial high to a rift valley morphology
4. determine how the extent of crystal fractionation of ridge basalts relates to the presence or absence of a melt lens and proximity to propagating rifts.

The seismic program will utilize wide-angle refraction and multichannel reflection techniques to measure crustal thickness and velocity structure at three locations along the western GSC (91.5°W, 94°10'W and 97°W), and map crustal structure, including the existence of a crustal melt lens, along the axis of the GSC from 95.5°W to 91°W. The rock sampling program will provide new samples along the western GSC between 91°W and 98°W which, together with existing sample coverage, will be sufficient to evaluate the pattern of geochemical gradients away from the Galápagos hotspot, and determine the effect of magma supply on crustal magmatic processes. We will use these seismic and geochemical results to test and refine existing models, as well as develop new models, of plume-ridge interaction, crustal magma chamber processes, and ridge topography. We believe an integrated approach, combining seismic, petrologic, geochemical and modeling into a single, coordinated effort is essential to advance our understanding of plume-ridge systems.

Hydrosweep

Several problems relating to Y2K were found in the software:

- Navigation problems found in early hydrosweep data. Bad course and heading were being generated. HS navigation source was rewritten. Data before 095 has this bad data, and it is unknown whether the HS data is valid due to this.
- CKeel inputs were consistently displaying bad sound velocities causing HS dropouts of 20%. This was also restored on day 95.

Day 112: 0608 - 0636, 1354 - 1425; HS lost its position causing it to report incorrect bottom times. The data has been cut from the processed hydrosweep, but remains in the raw.

Day 134-135: Hydrosweep lost its realtime navigation input causing incorrect navigation info t obe sent to the HS system. Although this was processed out, there is a 10 minute gap between 02:55 and 0305 on day 135.

Hydrosweep processing was performed by the science party: Buffy Cushman, Tanya Blacic, Sylvana Hildago, Cheney Millholland, Cesar Witt, Iris Van der Zander.

Magnetics

Hardware problems with the magnetometer resulted in good magnetics not being acquired until after day 095. Any raw data that may exist before that time should be ignored.

UTC Times

UTC clock failed several times starting at ~1600 on day 105. Particularly for lines **gsc-s2**, **gsc-RF6**, **gsc-X6** , **gsc-AA3**.

The clock was restored at ~2040 on day 106.

Therefore, the UTC times on this line may be slightly out of line with reality. For those two days, there are alternate processing files: ts1.n105, and ts1.n106 that use the datum clock to determine the shot time. These shot times should be about 40 milliseconds later than the actual shot time, but are based on true UTC time.

Due to constant clock problems, CPU clock synchronization was abandoned on day 133.

Cruise Members

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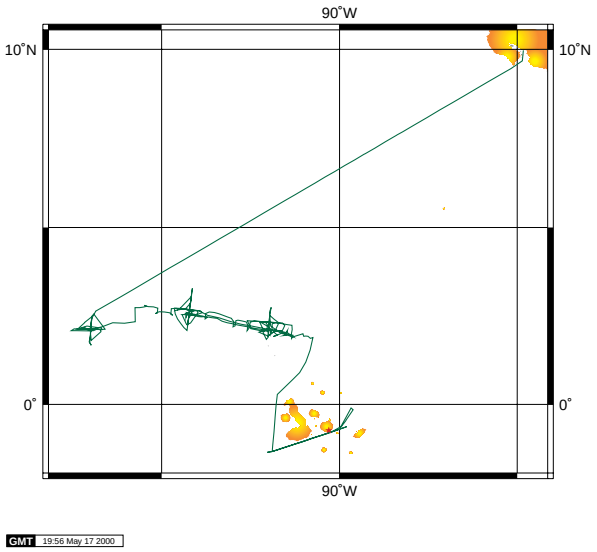
Track Maps

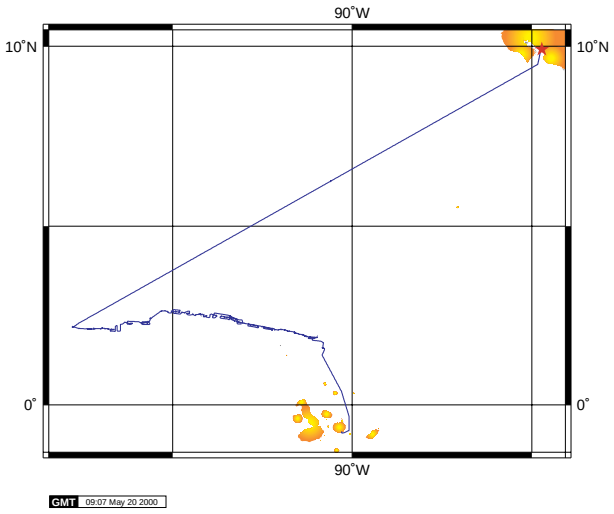
Leg 1 - Puntarenas, CR - Puerto Ayora, Santa Cruz Ecuador

EW-0004 Leg 1



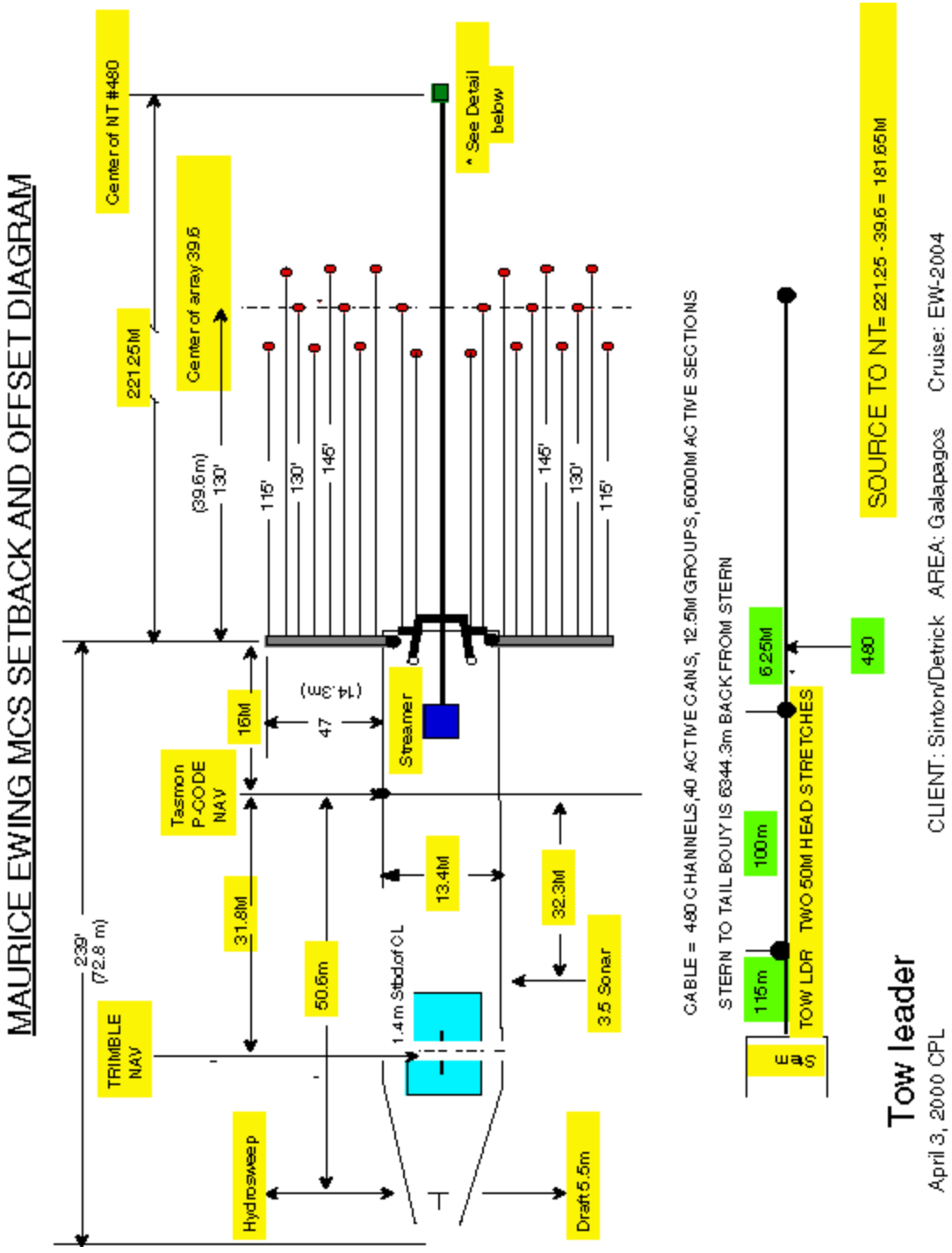
Leg 2 - Puerto Ayora, Santa Cruz Ecuador - Puerto Caldera, CR

EW-0004 Puntarenas - Puerto Caldera, Costa Rica

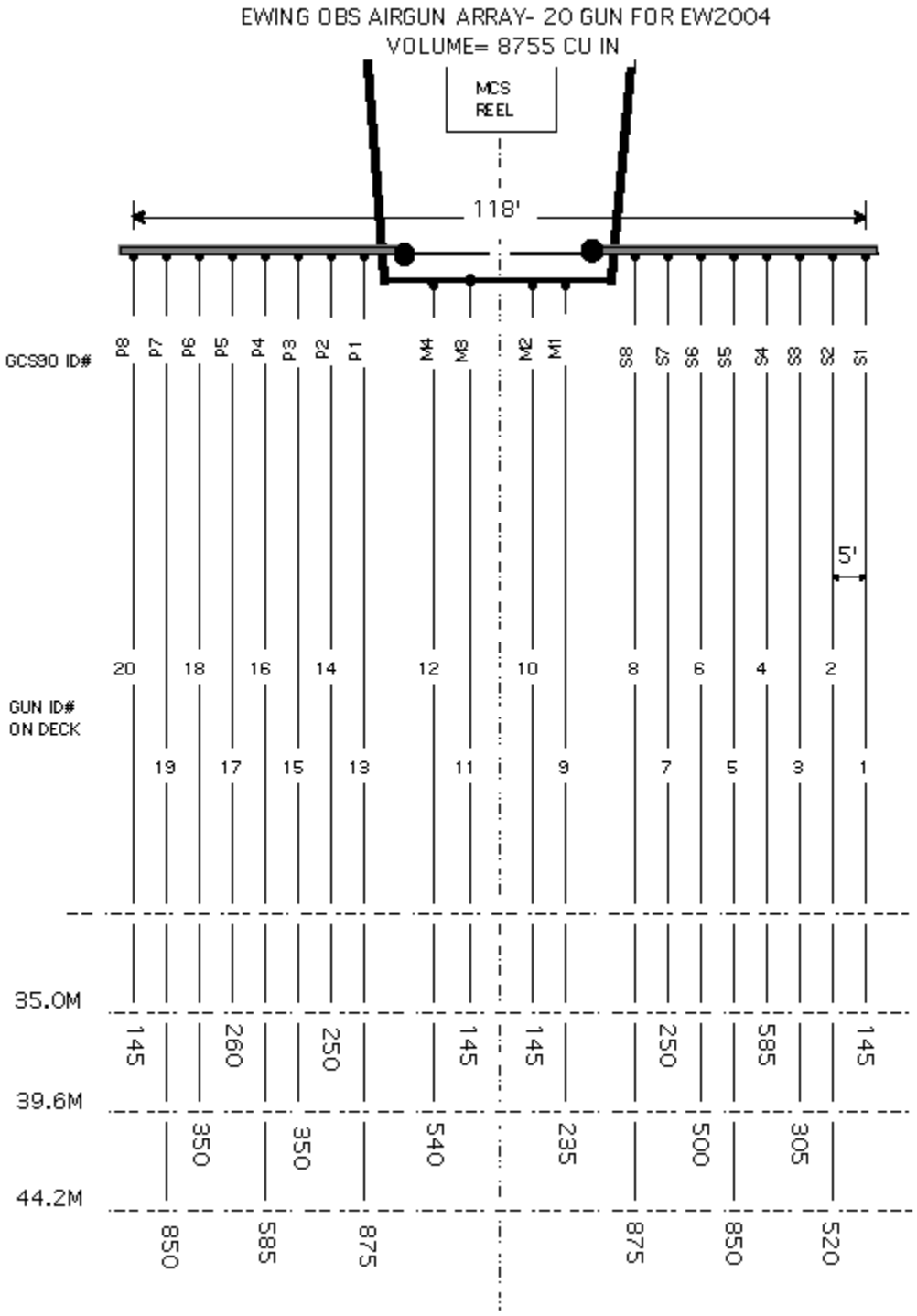


Shooting Configurations

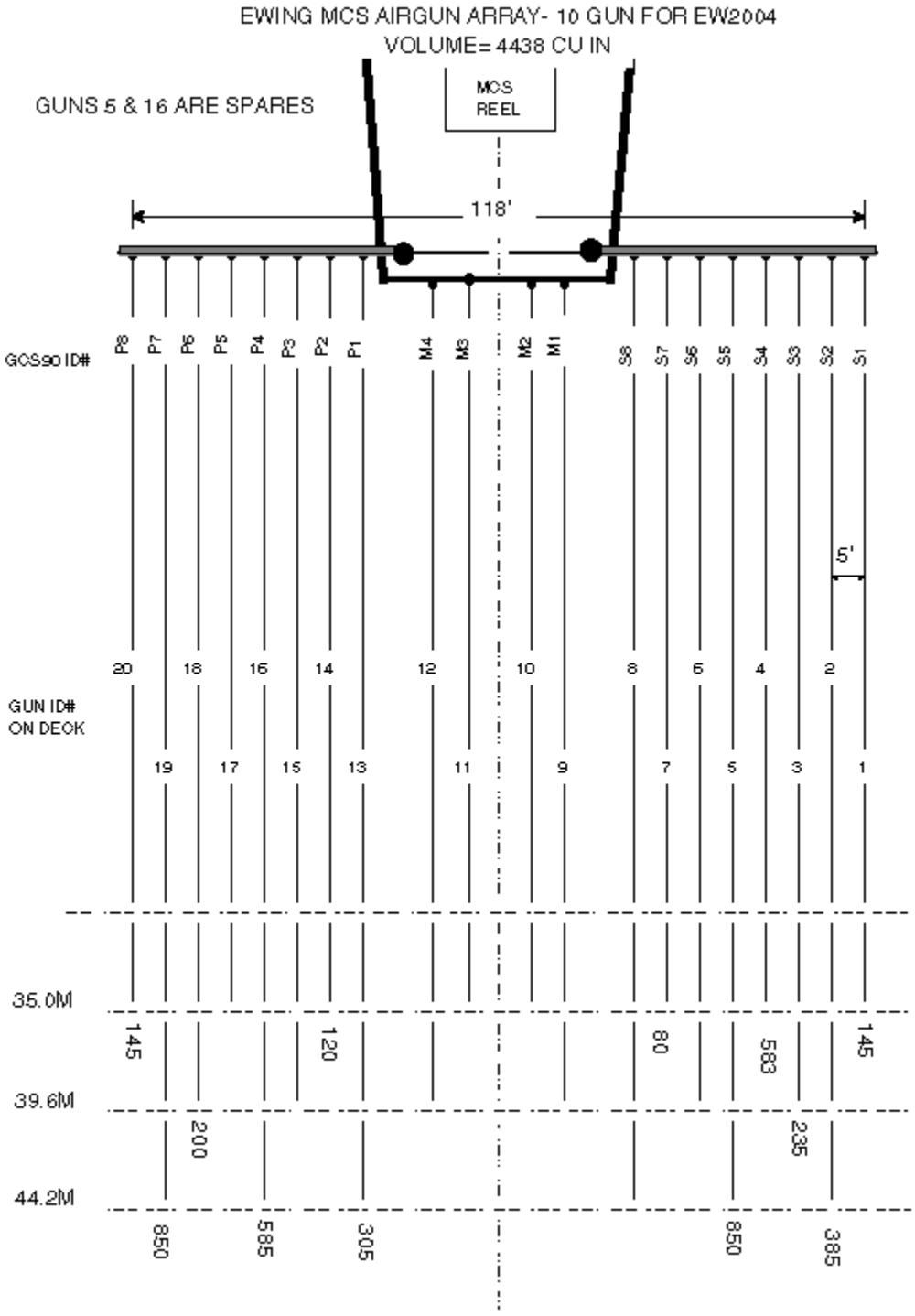
MCS Setback and Offset Diagram



20 Airgun Array



10 Gun Array


EWING MCS AIRGUN ARRAY- 10 GUN FOR EW2004
VOLUME= 4438 CU IN
GUNS 5 & 16 ARE SPARES
MCS REEL
118'
GCS90 ID#
P8 P7 P6 P5 P4 P3 P2 P1 M4 M3 M2 M1 S8 S7 S6 S5 S4 S3 S2 S1
5'
20 18 16 14 12 10 8 6 4 2
GUN ID# ON DECK
19 17 15 13 11 9 7 5 3 1
35.0M
145 120 80 583 145
39.6M
200 235
44.2M
850 585 305 850 385

Streamer Configuration

Mod	Serial #	Can #	Ship Offset	Channels	Bird	Comments
TB			6344.3M			Tailbuoy at 6345M
STIC	Cable 25.3M		6319M - 6344M			
1		2151				Power Module 12151
HS	30120-HS	50M	6269M - 6319M			
TS	0697-30284TS	50M	6219M - 6269M		#1C	Compass at 6264M
AT	0498-30024	4M	6215M - 6219M			
2	0398-31433	3538	6140M - 6215M	1 to 6	#2	Bird at 6210M
	0298-31388		6065M - 6140M	7 to 12		
3	0298-31407	2734	5990M - 6065M	13 to 18	#3C	SRD1,Compass at 6060M
	0198-31319		5915M - 5990M	19 - 24		AT
4	0198-31333	2731	5840M - 5915M	25 to 30	#4	Bird AT 5910M
	0298-31385		5765M - 5840M	31 to 36		AT
5	0298-31399	2759	5690M - 5765M	37 to 42	#5C	Compass Bird at 5760M
	0298-31386		5615M - 5690M	43 to 48		AT
6	0996-30314	3607	5540M - 5615M	49 to 54	#6	Bird AT 5610M
	0298-31402		5465M - 5540M	55 to 60		AT
7	0298-31337	3189	5390M - 5465M	61 to 66	#7C	Compass at 5460M
	0298-31382		5315M - 5390M	67 to 72		AT
8	0298-31390	3606	5240M - 5315M	73 to 78		AH
	0298-31346		5165M - 5240M	79 to 84		AT
9	0298-31381	3107	5090M - 5165M	85 to 90	#8	Bird at 5160M
	0298-31391		5015M - 5090M	91 to 96		AT
10	0298-31336	3395	4940M - 5015M	97 to 102		AH
	0298-31384		4865M - 4940M	103 to 108		AT
11	0198-31341	3599	4790M - 4865M	109 to 114	#9C	SRD2 Compass at 4860M
	0198-31398		4715M - 4790M	115 to 120		
12	0298-31387	3597	4640M - 4715M	121 to 126		AH
	0298-31378		4565M - 4640M	127 to 132		AT
13	0298-31369	3604	4490M - 4565M	133 to 138	#10	Bird at 4560M
	0298-31396		4415M - 4490M	139 to 144		
14	0198-31335	2965	4340M - 4415M	145 to 150		AH

	0198-31362		4265M - 4340M	151 to 156		AT
15	0298-31373	2714	4190M - 4265M	157 to 162	#11C	Compass at 4260M
	0198-31334		4115M - 4190M	163 to 168		AT
16	0298-31405	2757	4040M - 4115M	169 TO 174		AH
	0198-31348		3965M - 4040M	174 TO 180		AT
17	0397-31119	3031	3890M - 3965M	181 TO 186	#12	Bird at 3960M
	0198-31318		3815M - 3890M	187 TO 192		AT
18	0198-31343	3602	3740M - 3815M	193 TO 198		AH
	1296-30808		3665M - 3740M	199 TO 204		AT
19	0996-30302	2940	3590M - 3665M	205 TO 210	#13C	SRD3 Compass at 3660M
	30804		3515M - 3590M	211 TO 216		AT
20	0996-30327	2935	3440M - 3515M	217 TO 222		AH
	0197-31058		3365M - 3440M	223 TO 228		AT
21	0298-31375	2704	3290M - 3365M	229 TO 234	#14	Bird at 3360M
	31329		3215M - 3290M	235 TO 240		
22	0996-30279	2563	3140M - 3215M	241 TO 246		AH
	0297-31082		3065M - 3140M	247 TO 252		AT
23	1096-30330	2507	2990M - 3065M	253 TO 258	#15C	Compass at 3060M
	31350		2915M - 2990M	259 TO 264		AT
24	31363	2567	2840M - 2915M	264 TO 270		AH
	0996-30300		2765M - 2840M	271 TO 276		AT
25	0696-31347	2717	2690M - 2765M	277 TO 282	#16	Bird at 2760M
	0697-31351		2615M - 2690M	283 TO 288		
26	31383	2523	2540M - 2615M	289 TO 294		AH
	0996-30304		2465M - 2540M	295 TO 300		AT
27	0996-30283	3163	2390M - 2465M	301 TO 306	#17C	SRD5
	298 31372		2315M - 2390M	307 TO 312		
28	0996-30301	2511	2240M - 2315M	313 TO 318		AH
	1096-30332		2165M - 2240M	319 TO 324		AT
29	30311	2570	2090M - 2165M	325 TO 330	#18	Bird at 2160M
	0597-31248		2015M - 2090M	331 TO 336		
30	0597-31269	3172	1940M - 2015M	337 TO 342		AH
	0597-31268		1865M - 1940M	343 TO 348		AT

31	0996-30281	2505	1790M - 1865M	349 TO 354	#19C	Compass at 1860M
	SS1-0696-0138		1715M - 1790M	355 TO 360		AT
32	0996-30303	2554	1640M - 1715M	361 TO 366		AH
	1096-30346		1565M - 1640M	367 TO 372		AT
33	30313	3182	1490M - 1565M	373 TO 378	#20	Bird at 1560M
	0696-10388		1415M - 1490M	379 TO 384		AT
34	0697-31277	2506	1340M - 1415M	385 TO 390		AH
	0696-31280		1265M - 1340M	391 TO 396		AT
35	SS1-0696-10057	2462	1190M - 1265M	397 - 402	#21C	SRD5,Compass at 1260M
	1096-30320		1115M - 1190M	403 TO 408		AT
36	0996-31349	2747	1040M - 1115M	409 TO 414		AH
	0697-31282		965M - 1040M	415 TO 420		AT
37	1096-30337	3192	890M - 965M	421 TO 426	#22	Bird at 960M
	SS1-0696-0140		815M - 890M	427 TO 432		
38	31400	3162	740M - 815M	433 TO 438	AH	
	0298-31410		665M - 740M	439 TO 444	AT	
39	0298-31365	2728	590M - 665M	445 TO 450	#23C	Compass Bird at 660M
	31346		515M - 590M	451 TO 456		AT
40	0298-31377	2485	440M - 515M	457 TO 462		AH
	0198-31321		365M - 440M	463 TO 468		AT
41	0298-31403	3084	290M - 365M	469 TO 474	#24	Bird at 469M
	0298-31406		215M - 290M	475 TO 480		AT
42	30128HS	284	165M - 215M	Stretch		Passive can 10284
	30134HS		115M - 165M	Stretch		
LDR	0498-30025		Stern - 115M	Tow Leader		Fiber optics

Data Instruments

The following tables describe the times data was logged for all instruments. Unless otherwise noted, the tables will show the start of logging through the end of logging, with only the data interruptions described in the tables.

Time References

Droputs of greater than 1 hour are shown below. For dropouts for less than 1 hour, we can assume that the CPU clock managed to stay within several hundred milliseconds of UTC time.

Kinemetrics TrueTime Clock
The TrueTime clock is used to keep theCPU times of the servers in synch with UTC time. It is also used to tag the shot time via an IRIG signal. Due to many clock logging problems, time synchronization was abandoned entirely on day 133.

Date	Comment
092/0000	Started Synching the CPU times
105/16:15 - 106/20:47	Lost Lock on clock, clock not logged
108/0405 - 112/0800	Lost lock; clock not logged; datum intermittently logged
113/2011 - 114/1607	Lost lock, clock not logged
115/1557 - 115/1618	stopped logging
117/1652	Switched entirely to Datum for CPU synchronization
131/0137	Datum problems, trying again
133/1547	Stopped clock synchronization

Datum StarTime 9390-1000
Alternate UTC clock.

Date	Comment
108/1918	Started use of Datum to synchronize clocks
109/0335 - 111/1555	Datum clock stalled, no clocks logged
111/1952 - 112/0130	Datum clock stalled, no clocks logged
112/0730 - 117/2030	Datum clock not logged, used TrueTime
117/2030	Datum clock used exclusively now for CPU time synch
132:0155	Stopped Datum clock logging

Speed and Heading

The Furuno CI-30 dual axis speed log and Sperry MK-27 are logged at 3 second intervals.

Date	Comment
092/0000	Furuno logging started
141/1419	Furuno logging ends

GPS Receivers

gp1 = Trimble Tasman Y-Code**gp2** = Trimble NT200D

Both GPS receivers were logged at 10 second intervals. Navigation is processed and reduced to 60 second intervals which is then applied to the magnetics, gravity, bathymetry, and shot data. All data for this cruise was processed with the Tasman (gp1). Only outages > 10 minutes are accounted for here. Frequent interruptions for GP2 are due to EMail connects.

Date	Comment
092/0000	GPS Logging starts
092/2049 - 2105	GP2 interruption
094/2325 - 2346	GP2 interruption
096/1300 - 1313	GP2 interruption
108/0511 - 0522	GP2 interruption
131/0118 - 0129	Interruptions due to errors with CPU clock synchronization
131/0119 - 0136	and the TrueTime clocks
141/1419	GPS Logging ends

Gravimeter

The Bell BGM-3 Gravimeter is logged at 1-second intervals. There were no data interruptions.
`DC Shift: 4.16  Drift per Day: 0.01  Gravity Tie Date:May 20,23:06`

Date	Comment
092/0000	Gravity logging begins
141/1419	Gravity logging ends

Magnetometer

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

Date	Comment
095/0000	Maggie logging started
095/2344 - 096/1739	Logging interrupted
096/2207 - 097/0240	Logging interrupted
097/1111 - 097/1353	Bad maggie data
098/0429 - 100/1859	No logging
100/2333 - 101/0513	no logging
108/0409 - 109/1608	no logging
111/1415 - 114/1508	no logging
116/0925 - 118/0047	no logging
119/0309	Magnetics Logging ends for first leg
123/2240	Magnetics logging for leg 2 starts
124/0631	Megnetics logging for leg2 ends

Hydrosweep Bathymetry

The Krupp Atlas Hydrosweep-DS full swath data is logged for each ping, and the centerbeam data is extracted and processed separately. The hydrosweep operates at varying intervals based on water depth.

The full swath data can be read and processed using the MB-System software which can be downloaded from the web site: **http://www.ldeo.columbia.edu/MB-System**
MB-System 4.6.10 is necessary to process data after Jan 1, 2000.

Hydrosweep data was logged continuously throughout the cruise with varying degrees of success. Initially there were some problems with the navigation, then sound velocities, and later corrupted data. We try and keep track of these anomalies here. 112: 0608 - 0636, 1354 - 1425

Date	Comment
092/1513	HS logging starts
093/1541 - 093 1838	HS interruption
092 - 096/2359	HS Navigation data incorrect. Unknown consequences to the data
098/1135 - 1149	HS Interruptions due to OBH ? pickups (only those > 15 minutes)
1720 - 1804	
1852 - 2007	
099/0120 - 0626	
0914 - 1116	

Date	Comment
1217 - 1340	
1733 - 2001	
102/0146 - 0215	HS logging stopped?
108/1020 - 1100	
1122 - 1218	
2314 - 2346	
111/1635 - 1738	
1934 - 2051	
2123 - 2236	
112/0126 - 0242	
0350 - 0454	
0608-0636	BAD HS DATA, incorrect depths. cut from processed, still in raw
0731 - 0838	
0938 - 1040	
112/1212 - 1354	
1354 - 1425	BAD HS DATA, cut from processed, still in raw
1505 - 1626	
116/1901 - 2002	OBS pickups
2053 - 2217	
2244 - 2345	
117/0139 - 0224	
121/0731 - 0929	OBS pickups
2157 - 2218	
122:1300	Arrived Santa Cruz
Leg 2	*Due to the number of dredges and cores, (92) and the constant stopping and starting of the hydrosweep, the hydrosweep dropouts are not logged for this leg.*
131:1300 - 1500	Hydrosweep depth problems
133:1400 - 1500	Hydrosweep depth problems
141/0613	Hydrosweep logging ends due to malfunction.

Sea Temperature

Date	Comment
092 /1745	Start Logging at 1 minute intervals
141/1419	Sea Temperature logging ends

Weather Station

The R.M. Young Precision Meteorological Instruments; 26700 series is used to log a variety of weather conditions at 1-minute intervals.

Date	Comment
092/1745	Logging starts
141/1419	Logging ends

Winch Logs

These logs represent the times and position of the ship when the dredge entered the water, and not necessarily where the ship was when the dredge was on the bottom.

A Booth Winch (dredges)

Day:Time	Lat	Lon	CBD	Comment
122:0336	00 06.119S	089 40.640W	1487	Test
124:0714	01 35.503N	090 48.653W	3322	
124:1800	01 53.770N	091 03.578W	1973	
124:2346	01 54.211N	091 11.030W	1812	
125:0310	01 55.405N	091 16.752W	1658	
125:0950	01 56.173N	091 19.510W	1589	New Rollers
125:1303	01 57.718N	091 21.812W	1616	
125:1545	01 58.428N	091 24.276W	1659	
125:1929	01 59.099N	091 29.103W	1697	
125:2231	02 00.421N	091 33.610W	1767	
126:0342	02 02.813N	091 36.424W	1822	
126:0711	02 03.744N	091 44.823W	1867	
126:1001	02 04.287N	091 48.169W	1798	
126:1248	02 06.175N	091 52.865W	1727	
126:1521	02 06.759N	091 57.417W	1659	
126:1808	02 07.042N	092 00.713W	1808	
126:2105	02 06.328N	092 03.039W	1737	
126:2357	02 06.578N	092 09.416W	1793	
127:0545	02 06.794N	092 13.179W	1843	
127:0835	02 07.636N	092 14.640W	1857	
127:1119	02 08.826N	092 19.201W	1820	
127:1555	02 10.413N	092 25.528W	1838	
127:1907	02 11.397N	092 31.090W	1868	
128:0234	02 12.290N	092 36.984W	1890	
128:0545	02 13.556N	092 41.650W	2019	
128:0919	02 14.949N	092 49.185W	2144	
128:1224	02 15.844N	092 52.754W	2129	
128:1507	02 16.713N	092 58.168W	2199	
128:1741	02 17.181N	093 00.592W	1740	
128:2017	02 17.814N	093 02.790W	2192	
129:0225	02 26.410N	093 25.847W	2316	

Day:Time	Lat	Lon	CBD	Comment
129:0600	02 23.367N	093 21.215W	2162	
129:0902	02 21.097N	093 16.124W	2328	
129:1208	02 20.162N	093 13.074W	2371	
129:1503	02 19.274N	093 09.501W	2251	
129:1757	02 18.512N	093 05.509W	2232	
129:2203	02 23.326N	093 12.168	2227	
130:0101	02 24.855N	093 15.451W	2256	
130:0400	02 25.328N	093 17.775S	2387	
130:0710	02 26.347N	093 21.140W	2368	
130:1034	02 27.224N	093 29.646W	2347	
130:1350	02 28.009N	093 33.996W	2320	
130:1637	02 29.412N	093 39.509W	2218	
131:0045	02 30.107N	093 52.236W	2240	
131:0438	02 30.177N	093 46.734W	2324	
131:0845	02 30.766N	093 57.864W	2324	
131:1232	02 30.336N	094 03.808W	2485	hydrosweep lost depth: 1346
131:1550	02 30.809N	094 07.782W	2525	
131:2135	02 32.126N	094 13.222W	2507	
132:0050	02 33.373N	094 14.396W	2514	
132:0347	02 32.401N	094 16.525W	2322	
132:0705	02 32.725N	094 21.013W	2441	
132:1025	02 36.668N	094 26.083W	2611	
132:1409	02 24.475N	094 36.018W	2635	
132:1704	02 34.016N	094 32.350W	2621	
132:2050	02 34.983N	094 39.787W	2719	
133:0005	02 35.718N	094 44.698W	2661	
133:0629	02 36.154N	094 49.404W	2784	
133:1009	02 36.780N	094 54.530W	2732	
133:1323	02 37.067N	094 58.702W	2808	
133:1625	02 37.767N	095 02.008W	2751	
133:2008	02 37.150N	095 08.602W	2838	
133:2315	02 38.319N	095 12.734W	3083	
134:0301	02 37.979N	095 19.019W	3222	
134:0801	02 25.539N	095 36.162W	2861	
134:1656	02 18.091N	095 42.115W	2985	
134:2010	02 18.252N	095 47.542W	2775	
134:2314	02 17.874N	095 52.559W	3000	
135:0549	02 17.546N	096 07.587W	2924	
135:0901	02 16.904N	096 11.465W	2894	

Day:Time	Lat	Lon	CBD	Comment
135:1235	02 19.057N	096 19.932W	3031	
135:2048	02 06.036N	096 43.527W	3200	
136:0028	02 06.955N	096 37.883W	3162	
136:0352	02 07.280N	096 41.817W	3140	
136:0724	02 07.346N	096 46.558W	3064	
136:1025	02 08.293N	096 49.101W	3090	
136:1329	02 08.393N	096 52.644W	3111	
136:1647	02 09.419N	096 57.748W	3219	
136:1941	02 08.243N	096 59.734W	3334	
136:2304	02 08.378N	097 06.048W	3293	
137:0243	02 08.569N	097 11.532W	3314	
137:1247	02 08.154N	097 21.495W	3260	
137:1936	02 08.697N	097 36.243W	3455	
137:2328	02 11.630N	097 47.000W	3367	

B Booth Winch (wax cores)

Day/Time	Lat	Lon	Depth	Comment
124:1544	01 53.353N	090 59.199W	1997	
124:2129	01 53.594N	091 04.631W	2000	
125:0726	01 57.379N	091 21.456W	1378	Bottom hit: 08:38
126:0120	02 00.750N	091 36.616W	1936	Bottom hit: 02:12
126:1804	02 09.467N	092 22.412W	1804	Bottom hit: 14:41
131:1925	02 32.241N	094 10.365W	2458	Bottom hit: 20:03
134:1100	02 25.258N	095 37.258W	2800	Bottom hit: 11:55, bad wire wraps@2700m
136:1610	02 07.771N	097 15.080W	3284	Bottom hit: 16:53

Pre-Cruise Gravity Tie

EW -2003

Pier/Ship	Latitude	Longitude
	9 58.4N	84 49.9W

Tied at dock in Puntarenas, about 100 meters from the base station

Reference	Latitude	Longitude
	9 58.4N	84 49.9W

At the end of the dock by the 4 canons is a tiny gravity marker in the corner closes to the water.

ACIC 4551-1

	Id	Julian	Date	Mistie	Drift/Day	DC Shift
Pre Cruise	EW9914	363	12/29/99	4.16	0.01	3.87
Post Cruise	EW2003	88	3/28/00	4.21	0.001	4.16
Total Days			90.00	0.05		

Time	Entry	Value	
03:20 CST	CDeck Level BELOW Pier	1.00	meters
	Pier 1 L&R Value	1912.30	L&R
	Reference L&R Value	1912.30	L&R
	Pier 2 L&R Value	1912.30	L&R
	Reference Gravity	978230.87	mGals
	Gravity Meter Value (BGM Reading)	978237.10	mGals
	Potsdam Corrected	0	1 if corrected

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

Difference in meters between Gravity Meter and Pier: 6.50 meters

Height Cor = Pier Height* × FAA Constant

Pier Height*	FAA Constant				
6.50	0.31			2.02	mGals/min

Difference in mGals between Pier and Gravity Meter

Pier (avg) - Reference * 1.06 L&R/mGal = Delta L&R

Pier (avg)	Reference	1.06 L&R/mGal		Delta L&R	
1912.30	1912.30	1.06		0.00	mGals

Gravity in mGals at Pierside

Reference + Delta mGals [+ Potsdam] = Pier Gravity

Reference	Delta mGals	[+ Potsdam]		Pier Gravity	
978230.87	0.00	0.00		978230.87	mgals

Gravity in mGals at Meter

Pier Gravity+ Height Correction = Gravity@meter

Pier Gravity	Height Correction			Gravity@meter	
978230.87	2.02			978232.89	mGals

Current Mistie

BGM Reading- Calculated Gravity = Current Mistie

BGM Reading	Calculated Gravity			Current Mistie	
978237.10	978232.89			4.21	mGals

Post-Cruise Gravity Tie

EW -2004 Puntarenas,CR

Pier/Ship	Latitude	Longitude
	9 58.4N	84 49.9W

Tied at dock in Puntarenas, about 100 meters from the base station

Reference	Latitude	Longitude
	9 58.4N	84 49.9W

At the end of the dock by the 4 canons is a tiny gravity marker in the corner closes to the water.

ACIC 4551-1

	Id	Julian	Date	Mistie	Drift/Day	DC Shift
Pre Cruise	EW2003	88	3/28/00	4.21	0.01	4.16
Post Cruise	EW2004	141	5/20/00	**4.73**	**0.010**	**4.21**
Total Days			**53.00**	**0.52**		

Time	Entry	Value	
5/20/00 22:30	**CDeck Level BELOW Pier**	0.00	
	Pier 1 L&R Value	1912.30	**L&R**
	Reference L&R Value	1912.30	**L&R**
	Pier 2 L&R Value	1912.30	**L&R**
	Reference Gravity	978230.87	**mGals**
	Gravity Meter Value (BGM Reading)	978237.30	**mGals**
	Potsdam Corrected	0	**1 if corrected**

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

Difference in meters between Gravity Meter and Pier: **5.50** meters

Height Cor = Pier Height* × FAA Constant

Pier Height*	FAA Constant				
5.50	**0.31**			**1.71**	mGals/min

Difference in mGals between Pier and Gravity Meter

Pier (avg) - Reference * 1.06 L&R/mGal = **Delta L&R**

Pier (avg)	Reference	1.06 L&R/mGal		Delta L&R	
1912.30	**1912.30**	**1.06**		**0.00**	mGals

Gravity in mGals at Pierside

Reference + Delta mGals [+ Potsdam] = **Pier Gravity**

Reference	Delta mGals	[+ Potsdam]		Pier Gravity	
978230.87	**0.00**	**0.00**		**978230.87**	mgals

Gravity in mGals at Meter

Pier Gravity+ Height Correction = **Gravity@meter**

Pier Gravity	Height Correction			Gravity@meter	
978230.87	**1.71**			**978232.58**	mGals

Current Mistie

BGM Reading- Calculated Gravity = **Current Mistie**

BGM Reading	Calculated Gravity			Current Mistie	
978237.30	**978232.58**			**4.73**	mGals

Data Processing

GPS Processing

Navigation data is post-processed in order to accurately determine the position and remove GPS accuracy errors. We perform slightly different processing depending on the type of receiver.

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
4. 2000+009:00:28:50.091 N 42 14.1536 W 063 25.5897 P-trimble
5. If we are processing known differential data, remove non-differential fixes from the file.
6. Interpolate and reduce data. Fixes are reduced to 30 second fixes and any minor gaps (< 3 minutes) are linearly interpolated.
7. Smooth data using a 9 point running average algorithm and further reduce data to 60 second fixes.
8. 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

Furuno Processing

Furuno speed and heading is processed by smoothing the data using a vector summing algorithm. Data is reduced and output at 60 second intervals by taking the smoothed values and calculating the mean value for the 30 seconds before and after the whole minute.

Hydrosweep Processing

Center Beam Processing

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.

Full Swath Processing

Hydrosweep swath data is processed using the MB-System software, and consists primarily of hand-editing the beam data. Source code and documentation for MB-System may be found at the Web site: **http://www.ldeo.columbia.edu/MB-System**.

1. Dilution of Precision, a term used to measure the accuracy of the fix based on the number of Satellites the GPS receiver is tracking, and the position of the satellites.

bias = 852645.3;Dec 5, 1997
scale = 5.0940744July 9, 1992
*mGals = raw_gravity_count * scale + bias;*

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))

Reduction

1. Raw gravity is filtered using a 6 minute gaussian filter and mGals are output. The raw mGals are represented by
   `mGals = gravitycount * scale + bias;`
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 Tie

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 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
```

Raw Compass Block — cb1.d*jjj*

Official Shot Time	Line	Shot	GPS1 Position *P-Code*
2000+009:00:01:29.572	LAU1	021144	S 19 26.4331 W 176 16.3491

GPS2 Position *Trimble*	Tailbuoy Position	Gyro	Compass# Position
S 19 26.4393 W 176 16.3198	S 19 25.2864 W 176 19.7897	107.0	C01 97.8...

No processing is performed on compass block data.

Raw Furuno Log — fu.d*jjj*

CPU Time Stamp	Track	Speed	Heading	Gyro
2000+009:00:01:53.091	-	4.4	140.5	148.3

Hydrosweep Center Beam merged w/ Navigation — hb.n*jjj*

CPU Time Stamp	Latitude	Longitude	Depth
2000+009:09:55:00.000	N 13 6.6206	W 59 39.3908	3409.1

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

Merged Data — m.*jjj*

CPU Time Stamp	Latitude	Longitude	GPS	Set	Drift	Depth
2000+009:14:08:00.000	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

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.

Navigation File — n.*jjj*

CPU Time Stamp	Latitude	Longitude	Used	Set	Drift
2000+009:00:03:00.000	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 window average. The smoothed GPS points are then fixed at 1 minute intervals. Dead reckoning is performed across the gaps to insure proper GPS positioning.

Time Shot File — ts.n*jjj*

Official Shot Time	Shot #	Shot Position		Line Name
2000+009:00:15:00.000	00295	N 16 11.8600	W 59 48.0157	strike1

Navblock File (processing file) — nb.r*jjj*

Official Shot Time	Shot Number	CPU Time Stamp	Shot Position
2000+103:00:00:05.150	12016	2000+103:00:00:05.138	N 02 33.4911 W 094 16.3357

Depth	Sea Temp	Wind speed	Wind direction	Offical Tailbuoy Position
2444.2	27.7	2.5	52	N 02 33.8605W 094 19.7385

Distance to tailbuoy (meters)	Bearing to Tailbuoy	Line Name	Speed over Water	Gyro
6338.9	96.2	gsc-AA2	4.9	100.0

Gravity File merged with navigation — vt.n*jjj*

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

CPU Time Stamp	Latitude	Longitude	Model[1]	FAA	Raw
2000+009:00:15:00.000	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

Raw Weather File Format — wx.d*jjj*

CPU Time Stamp	tws	twd	wsi1	wss1	wsm1	wsx1	wdc1	wds1
2000+009:00:00:00.244	9.3	5.4	13.2	21.1	27.1	26.1		

wdm1	wsi2	wss2	wsm2	wsx2	wdc2	wds2	wdm2	tcur	tavg
6	0	0	0	0	0	0	0	26.7	26.7

min	tmax	rh	rhn	rhx	baro
26.5	27.0	66	58	68	10

tws = true wind speed *** calculated from ship speed/heading vs. wind speed.*
twd = true wind direction *** calculated from ship heading vs. wind direction*
wsi1 = wind speed, instantaneous, bird #1
wss1 = wind speed, 60 second average, bird #1
wsm1 = wind speed, 60 minute average, bird #1

1. The theoretical gravity value is based upon different models for the earth's shape: 1930 is the 1930 Intl. Gravity Gormula; 1967 is the 1967 Geodetic Referency System Formula, and 1980 is the 1980 Intl. Gravity Formula.

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 = wind speed, instantaneous, bird #2~~
~~wss2 = wind speed, 60 second average, bird #2~~
~~wsm2 = wind speed, 60 minute average, bird #2~~
~~wsx2 = wind speed, current 60 minute maximum, bird #2~~
~~wdc2 = wind direction, current, bird #2~~
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

Bird2 is deactivated.

Tape Contents

Tape 1

- *EW0004.pdf*
  this cruise report (Adobe Acrobat PDF file)
- *ew0004.cdf*
  final one-minute processed data tied to navigation (NetCDF files) for LDEO MG&G database
- *ew0004.cdf_nav*
  final one-minute processed navigation (NetCDF files) for LDEO MG&G database
- *docs/*
  FileFormats for all the files included on tape, hydrosweep info, etc.
- *processed/*
  final processed data tied to navigation (daily files) plus trackplots, scripts, summary files
- *raw/*
  original logged data (daily files)
- *reduction/*
  intermediate processed data (daily files)
- *hydrosweep/*
  raw/
  processed/
  xbt/