Lamont-Doherty Earth Observatory
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R/V Maurice Ewing

Data Reduction Summary

EW9905 – Newport, Oregon

ORDGE

Origin and Tectonic Development of the Gorda Escarpment

May 3 - 20, 1998

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Data Reduction Summary

Summary of Data Processing for
Gorda Escarpment Survey

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Cruise Notes

All times specified within this report are GMT.

System Failures
There were three system failures during this cruise which caused loss of data: two which stopped shot logging for a short period; one which resulted in a turnaround to re-shoot a segment of the line.

At one point all logging was stopped during a turn for a period of approximately 15 minutes on day 135 between 04:32 and 04:47.

GPS/Navigation processing
All shots were processed using the Pcode GPS; which is the source for all the navigation processing. Although the Trimble was recording Differential most of the time, it was felt during the cruise that the Pcode GPS would be more reliable over time.

Tailbuoy Logging
Logging of the tailbuoy was intermittent due to unknown problems

Scripts
There is a directory of script files for performing scripts for plotting shot points over the track line (plotshots), and converting NMEA data to a format suitable for the gnav program from MBARI.

plotshots
This script will use the processed gps track files (n.*) and the processed shot files (ts.n*) to create a postscript plot of the shots overlaying the gps track.

convert_nmea_to_gnav
This script will convert a NMEA data file (in Ewing format) to a gnav data format suitable for importing into ARCview.

```
convert_nmea_to_gnav NMEAfilename > gnavfilename
```

Cruise Data

See *Data Instruments* for more precise definitions of these fields.

Data Type	File	Description	Log Interval	Days Collected
UTC time	tr1	Truetime UTC time clock	60 seconds	125-139
Furuno	fu	Furuno speed and heading	3 second	125-139
P Code GPS	gp01	Tasman Ycode receiver	10 second	125-139
Trimble GPS	gp02	Differential GPS	10 second	125-139
Tailbuoy GPS	tb01	Selective availability GPS	10 second	intermittent
Gravity	vc	Bell gravimeter data	1 second	125-139
Sea Temp	ct		60 second	125-139
Meteorology	wx	Weather Station	60 second	125-139
Gun Depths	dg	Depths of each gun at shot	shot	128-138
Navblock	nb	Time/Position/Shotpoint	50 meters	128-138
Magnetics	mg	Geometrics Magnetics	12	128-138
Hydrosweep CB	hb	Hydrosweep Centerbeam	12	12

Logging

All logged data (*except GPS and Shot data*) is synchronized to the CPU time of the logging computer, which in turn is synchronized to the UTC time.

GPS time is extracted from the GPS fix.

Shot times are the UTC time.

Data Instruments

The following times are specified in GMT time.

Truetime UTC Time Clock

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

Date	Comment
129:01:55:00	Start UTC Sync
135:04:33:59	**Interrupted**
135: 04:59:59	**resumed**
139	**End EW9905**

Furuno Speed and Heading

The Furuno CI-30 2 axes doppler speed log and Sperry MK-27 gyro are logged at 3 second intervals. Interruptions greater than 10 minutes are logged here.

Date	Comment
125:22:36:39	Furuno logging started
135:04:32:08	Furuno logging interruption
135:04:47:55	Furuno logging resumes
139:	End EW9905

Compass Block Data

Compass data is recorded after each shot for the streamer birds to give the orientation of each. Data gaps greater than 60 seconds are recorded here. Due to a compass malfunction, 2 compasses (#6 and #23) were not recording data until 136:04:29:58. Data gaps greater than 5 minutes are recorded here.

Date	Comment
128:00:31:07	Compass Block logging starts
128:03:44:37	interrupted
128:03:51:00	resumed
128:06:12:37	interrupted
128:06:35:26	resumed
131:19:28:32	interrupted
131:19:34:17	resumed
134:03:52:46	interrupted
134:04:35:29	resumed
135:04:29:34	interrupted
135:04:53:55	resumed
136:04:20:42	interrupted

136:04:29:38	resumed
138:04:19:25	End of shooting

Magnetics Data

The Geometrics G-886 Marine Magnetometer was logged at 12 second intervals. There were no logging interruptions.

Date	Comment
128:01:49:30	Magnetics logging started
135:04:32:15	Logging interrupted
135:04:47:57	Logging resumes
138:03:18:22	End Magnetics logging

Weather Station

R.M. Young Precision Meteorological Instruments 26700 Series is used to log a variety of meteorological events at 60 second intervals. Gaps in recording greater than 600 seconds are accounted for here.

Date	Comment
125:22:35:36	Weather logging online
135:04:32:15	Logging interrupted
135:04:47:57	Logging resumes
139:	End EW9905

Hydrosweep Centerbeam and Swath Data

Krupp Atlas Hydrosweep Centerbeam. Each Hydrosweep ping is logged, and center beam data is extracted and logged separately.

Date	Comment
127:04:25:23	Hydrosweep logging begins
134:03:51:24	Logging interrupted, system crash
134:04:49:03	Logging resumes
135:04:30:31	Logging interrupted, system reboot
135:04:56:06	resumed
139	End EW9905

GPS Receivers

- gp1 = Tasman Ycode
- gp2 = Trimble Differential
- tb1 = Garmin Tailbuoy GPS

were logged at 10 second intervals. Navigation is processed and reduced to 1 minute intervals, which is later applied to hydrosweep bathymetry and gravity. All data has been processed using gp4: differential navigation. When differential navigation is not available, Ycode is used. Interruptions greater than 60 seconds are logged here

Date	Comment
125:22:35:35	Pcode GPS GP1 online
126:18:43:44	Pcode interrupted
126:18:45:38	Pcode resumes
135:04:32:10	Pcode Interrupted
135:04:47:55	Pcode Resumes
139:	End EW9809
125:22:35:36	Trimble GPS GP2 online
126:18:43:39	Trimble interrupted
126:18:45:39	Trimble resumes
127:04:09:44	Trimble interrupted
127:04:23:12	Trimble resumes
135:04:32:10	Trimble interrupted
135:04:47:55	Trimble resumes
139:	End EW9809

Bell Gravimeter

The gravity meter is logged at one second intervals. . Gaps in recording greater than 60 seconds are accounted for here.

Date	Comment
125:22:35:36	Start Gravity logging
135:04:32:10	Gravity logging interrupted
135:04:47:55	Gravity logging resumed
139:	End EW9809

Omega DP-10 Sea Temperature

Sea temperature is logged at 60 second intervals. Gaps larger than 600 seconds are accounted for here. Although the sea temperature was logged consistently through the cruise and fed to the hydrosweep as CKEEL data, a bug in the logging program caused a loss of data for day 125 and most of days 126 and127. Since sea temperature was being fed to the bridge and to the hydrosweep and the fact that sea temperature data is not processed, the loss was not noted until day 127.

Date	Comment
126:19:25:05	Start sea temp logging
126:23:59:03	logging loss of data
127:20:29:16	resumed
135:04:32:02	Logging interrupted
135:04:47:57	resumed
139:	End of EW9905

Shot Data

Shot Data was shot based on distance intervals of 50 meters. The shot interval was determined by our speed and course over a 2 minute filter, which was used to determine the time it would take to arrive at the next shot interval. The following table shows gaps in shots > 40 seconds. (the average shot period should be between 20 and 25 seconds)

Date	Shot Point	Comment
128:00:29:04	1	Shooting begins!
128:03:44:37 -128:03:51:00	593 - 595	Shooting interrupted for 383 seconds
134:03:52:46 -134:04:35:29	24941- 25029	system crash
135:04:29:34 - 135:04:53:55	29035 - 29072	System restart during turn
138:04:19:25.044	41198	End Shooting!

Gravity Ties

EW 9905 Newport, Oregon Pre-Cruise Tie

EW-9905 NEWPORT, OR

Pier/Ship	Latitude	Longitude
	44 37.542 N	124 02.695 W

Bollard in the middle of the Taquina Bat "T" pier on the south shore of the Yaquina Bay.

Reference	Latitude	Longitude
	44 37.542 N	124 02.695 W

Referenced Gravity tie at the foot of the west "T" pier on the south shore of Yaquina Bay at the OSU Marine Facility.

	Id	Date	Mistie	Drift/Day	DC Shift
Pre Cruise	EW9903	4/12/99	-0.85	-0.02	-0.39
Post Cruise	EW9904	5/3/99	-0.39	0.02	-0.85
Total Days		21.00	0.46		

Time	Entry	Value	
4/12/99 22:50	CDeck Level BELOW Pier	1.00	meters
4/12/99 22:50	Pier 1 L&R Value	4153.05	L&R
4/12/99:23:00	Reference L&R Value	4153.66	L&R
4/12/99 23:10	Pier 2 L&R Value	4153.80	L&R
	Reference Gravity	980610.42	mGals
	Gravity Meter Value (BGM Reading)	980611.80	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

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

4153.43	4153.66	1.06		-0.25	mGals

Gravity in mGals at Pierside

Reference + Delta mGals [+ Potsdam] = Pier Gravity

980610.42	-0.25	0.00		980610.17	mgals

Gravity in mGals at Meter

Pier Gravity + Height Correction = Gravity@meter

980610.17	2.02			980612.19	mGals

Current Mistie

BGM Reading - Calculated Gravity = Current Mistie

980611.80	980612.19			-0.39	mGals

EW 9905 Newport, Oregon Post-Cruise Tie

EW-9905 NEWPORT, OR

Pier/Ship	Latitude	Longitude
	44 37.542 N	124 02.695 W

Bollard in the middle of the Taquina Bat "T" pier on the south shore of the Yaquina Bay.

Reference	Latitude	Longitude
	44 37.542 N	124 02.695 W

Referenced Gravity tie at the foot of the west "T" pier on the south shore of Yaquina Bay at the OSU Marine Facility.

	Id	Date	Mistie	Drift/Day	DC Shift
Pre Cruise	EW9904	5/3/99	-0.39	0.02	-0.85
Post Cruise	EW9905	5/19/99	-1.26	-0.05	-0.39
Total Days		16.00	-0.87		

Time	Entry	Value	
	CDeck Level BELOW Pier	3.50	meters
	Pier 1 L&R Value	4153.05	L&R
	Reference L&R Value	4153.66	L&R
	Pier 2 L&R Value	4153.80	L&R
	Reference Gravity	980610.42	mGals
	Gravity Meter Value (BGM Reading)	980611.70	mGals
	Potsdam Corrected	0	1 if corrected

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

Difference in meters between Gravity Meter and Pier: 9.00 meters

Height Cor = Pier Height* FAA Constant

9.00	0.31			2.79	mGals/min

Difference in mGals between Pier and Gravity Meter

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

4153.43	4153.66	1.06		-0.25	mGals

Gravity in mGals at Pierside

Reference + Delta mGals [+ Potsdam] — Pier Gravity

980610.42	-0.25	0.00		980610.17	mgals

Gravity in mGals at Meter

Pier Gravity+ Height Correction — Gravity@meter

980610.17	2.79			980612.96	mGals

Current Mistie

BGM Reading- Calculated Gravity — Current Mistie

980611.70	980612.96			-1.26	mGals

Data Processing

GPS Data Reduction/Processing

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

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 Processing

Furuno speed and heading is processed by smoothing the data using a vector summing algorithm. Data is 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.

Hydrosweep Processing

Centerbeam Processing steps

1. Remove all survey and calibration records from the raw data and all *0* level depths.

---

[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.

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 is processed using a package from Lamont-Doherty Earth Observatory called **MB-System**.

The processing includes hand-editing the beam data to insure an accurate hydrosweep survey. This process is too involved to document here; but the source code and documentation may be found at the website:
http://www.ldeo.columbia.edu/~dale

Gravity Processing

bias = 852645.3; *Dec 5, 1997*
scale = 5.0940744 *July 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))

Gravity Post Processing

- Raw gravity is filtered using a 6 minute gaussian filter and mGals are output. The raw mGals are represented by

  *mGals = gravitycount * scale + bias;*

- A second filter is then applied; an 8 minute Gaussian filter using the GMT system:

  filter1D -G480 -R -E

- 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
```

- 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*

- 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 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 File Formats

fu.r Raw Furuno Log
CPU Time Stamp Track Speed Hdg Gyro
98+166:00:01:53.091 - 4.4 140.5 148.3

gp*x*.c - raw NMEA GPS
98+157:00:03:10.951 N 42 50.4311 W 061 18.8016 P-trimble

- **P-trimble Pcode Fix**
- **D-trimble Differential Fix**
- **trimble S/A fix**

cb1.d Streamer Compass Bird Block Data
This data is not processed, and is linked only by the shot points!

CPU Time Stamp Line Shot Latitude Longitude
98+079:00:08:40.085 strike1 000296 N 15 49.6217 W 060 19.8019

Furuno Streamer
Heading Compasses & Heading
341.2 C01 2.3 C02 1 .7 ...

vc.r - raw gravity counts
98+144:00:00:16.219 **01:022466 00**
CPU Time 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

Processed File Formats

n. - final navigation at even minute intervals

```
98+074:00:03:00.000 N 13  6.2214 W  59 37.9399   gp1   0.0   0.0
yr +day   time          Latitude        Longitude        gps   set   drift
```

hb.n - interpolated center beam merged with navigation

```
yy+ddd:hh:mm:ss:mmm N 12 12.1234 E 123.1234  2222.0
yr    day  time          lat             lon          depth (meters)
```

m. - merged bathymetry, magnetics, gravity with final navigation.

```
98+123:04:36:03.895  N 14  9.0555 W  67  2.3969   gp3 276.9  0.2
yr  day time          lat             lon             id  set   drift
5034.9    37401.8    17.2          -1.6     978349.0   13.1      9.1   13.2
depth     mag tot    mag          grv.   raw_grv     eotvos  tot   dc
          intensity  anomaly      faa                      drift  shift
```

vt.n - merged BGM-3 gravity with final nav.

```
yy+ddd:hh:mm:ss.mmm N 16  0.4273 W  73 20.3055  1980   -4.1
yr  day  time          lat             lon             theog   FAA
978416.9   27.6   9.9   13.2   -2.7   3.9      -2.8   3.8
raw_grav   eotvos drift  dc     raw_vel     smooth_vel
                                 shift      N        E         N      E
```

ts.n - Shot Data

A - sign in the time stamp is flagged as a missing shot that has been interpolated. The shot was not present in the file, but the shot has been calculated using a very simple interpolation.

CPU Time Stamp	Shot #	Latitude	Longitude	Line Name
98+079:00:08:01.507	000295	N 15 49.5703	W 060 19.7843	strike1

ts.n.status or nb, -Shot Data Status

Occasionally the MCS system will miss a shot. In these cases it is nice to know what is going on. The ts.n.status files will report the lines that were shot for the day, the time the line started and if any shots are missing from that line:

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

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).

On line strike one, shots 347, 410, 1727 were missing from the log. This doesn't necessarily mean the shots weren't fired. These shots were interpolated between the previous and following shots:

Original ts.n file:

98+079:00:40:49.662 000346 N 15 52.1994 W 060 20.6578 strike1
98+079:00:42:05.212 000348 N 15 52.3044 W 060 20.6907 strike1

Fixed ts.n file

98+079:00:40:49.662 000346 N 15 52.1994 W 060 20.6578 strike1
=>98-079:00:41:27.437 000347 N 15 52.2519 W 060 20.6742 strike1
98+079:00:42:05.212 000348 N 15 52.3044 W 060 20.6907 strike1

Science Tape Contents

The tape contains the following items:

- DOCS
  Readme files for file formats, processing, etc.

- HS
  RAW and processed hydrosweep data

- LOGGED
  All data logged during the cruise in raw format

- karen
  Karen Salamy's home directory containing some useful scripts for hydrosweep processing?

- processed
  Processed data collected during the cruise and tied to navigation

- raw
  Semi-formatted versions of the raw data; most notably the GPS data is converted from NMEA into a readable format

- scripts
  Some scripts for playing with Ewing data: plots, conversions, extracting points for gmt