Lamont-Doherty Earth Observatory
Marine Office
61 Route 9W
Palisades, NY 10964

R/V Maurice Ewing

Data Reduction Summary

EW9908 – Kochi, Japan - Yokohama, Japan

Nankai-II

3D Seismic Survey of the Nankai Trough

July 22 – August 18, 1999

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Data Reduction Summary

Summary of Data Processing for 3D Nankai Trough Survey

Lamont-Doherty Science Crew List

Name	Position	Email Address
Joe Stennett	Science Officer	stennett@ldeo.columbia.edu
Gregory Vsevolozhsky	Data Reduction	gregv@ldeo.columbia.edu
John DiBernardo	Gunner	Honey@ldeo.columbia.edu
John Byrne	Gunner	
Dan Doughton	Gunner	
Grant Rawson	Gunner	

Science Party List

Chief Scientist:	**Nathan Bangs**
Party Members:	Tom Shipley
	Carmen Alex
	Stephen Leslie
	Denise Hills
	Amanda McCutcheon
	Zhao Zhiyong
	Greg Moore
	Asahiko Taira
	Toshihiro Ike
	Shinobu Ito
	Jin-Oh Park
	Mimihiro Mochizuki
	Yasuyuki Nakimura
	Mark Wiederspahn
	Jim Dolan
	Sean Gulik

Cruise Notes

All times specified within this report are GMT.

System Failures
There was a major power failure during this cruise (JD 217 that caused interruption of data acquisition. Due to a failure of the BGM-3 unit gravity data was not acquired during this cruise. Also, a major failure of the Furuno course and speed unit prevented us from acquiring Furuno data starting JD 219 as of 00:51:59.402. A fake Furuno was used to provide gyro information for cb1, nb, and other files. There were multiple incidents of redoing lines and it's segments.

GPS/Navigation processing
All shots were processed using the Fugro GPS; which is the source for the most of the navigation processing. Due to significan interruption with Fugro receiver, during days 210, 217, 218, 219 Ycode Tasmon was used to calculate navigation file.

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

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	202-230
Furuno	fu	Furuno speed and heading	3 second	202-219
Fugro	gp01	Fugro GPS receiver	10 second	202-230
P Code GPS	gp02	Tasman Ycode receiver	10 second	202-230
Trimble GPS	gp03	Differential Trimble GPS	10 second	202-230
Tailbuoy GPS	tb01	Selective availability GPS	10 second	intermittent
Sea Temp	ct		60 second	202-230
Meteorology	wx	Weather Station	60 second	202-230
Gun Depths	dg	Depths of each gun at shot	shot	202-230
Navblock	nb	Time/Position/Shotpoint	20 second	202-230
Cable Geometry	cb1	Time/Position/Compass data	20 second	202-230
Hydrosweep CB	hb	Hydrosweep Centerbeam	12	202-230
Gun Status	sh2	Depth/Volume/Delta at shot	shot	203-228

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
202:00:00:00	Start UTC Sync
217:09:02:00	**Interrupted**
219:09:39:58	**Resumed**
230	**End EW9908**

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
202:00:23:46	Furuno logging started
217:00:29:11	Furuno logging interruption due to power failure
217:09:04:02	Furuno logging resumes
219:00:51:59	Furuno logging interrupted due to Furuno unit failure
230	End EW9908

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, compass (#2) was not providing perfect data. Data gaps greater than 5 minutes are recorded here.

Date	Comment
203:01:11:13	Compass Block logging starts
207:00:23:01:091	Interrupted
207:20:01:33.083	Resumed
207:20:05:58.946	Interrupted due to problems with cable
208:18:18:20.745	Resumed
216:23:28:47.324	Interrupted
217:00:13:08.465	Resumed
217:00:28:56.473	Interrupted due to power failure
219:09:31:20.875	Resumed
221:23:46:42.970	Interrupted
222:00:07:20.772	Resumed

228:10:02:21.986	End of shooting

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
202:00:00:00	Weather logging online
230	End EW9908

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
202:02:43:34	Hydrosweep logging begins
207:21:28:00	Logging interrupted, logging routine crash
208:00:00:33	Logging resumed
217:00:28:43	Logging interrupted, power failure
217:01:17:21	Logging resumes
217:09:01:47	Logging interrupted, system reboot
217:14:17:54	Logging resumed
230	End EW9908

GPS Receivers

- gp1 = Fugro differential GPS
- gp2 = Tasman Ycode
- gp3 = 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 gp1: differential navigation. When differential navigation is not available, Ycode is used. Interruptions greater than 60 seconds are logged here

Date	Comment
202:00:23:44	Fugro GPS GP1 online
207:22:51:37	Fugro interrupted
207:22:56:10	Fugro resumes
207:23:07:21	Fugro interrupted
207:23:39:57	Fugro resumes
207:23:49:35	Fugro interrupted
207:23:57:47	Fugro resumes

209:05:15:25	Fugro interrupted
209:05:20:42	Fugro resumes
213:00:46:07	Fugro interrupted
213:02:15:19	Fugro resumed
214:04:11:54	Fugro interrupted
214:04:15:18	Fugro resumed
217:00:29:01	Fugro interrupted power failure
217:00:58:50	Fugro resumes
217:14:09:42	Fugro interrupted
218:08:57:36	Fugro resumes
228:10:10:35	End EW9908
202:00:23:44	Pcode GPS GP2 online
207:21:28:14	Pcode interrupted
207:23:57:47	Pcode resumes
213:00:45:58	Pcode interrupted
213:02:15:20	Pcode resumes
217:00:42:30	Pcode Interrupted
217:00:47:20	Pcode Resumes
230	End EW9908
202:05:31:39	Trimble GPS GP3 online
230:	End EW9809

Bell Gravimeter

The gravity meter was not providing meaningful data, therefore, was logged only to provide time string for displays on the bridge.

Omega DP-10 Sea Temperature

Sea temperature is logged at 60 second intervals. Gaps larger than 600 seconds are accounted for here.

Date	Comment
126:19:25:05	Start sea temp logging
207:21:29:00	logging loss of data
208:00:06:25	Logging resumed
213:00:46:02	Logging interrupted
213:02:15:21	Resumed
230:	End of EW9908

Shot Data

Shot Data was based on ship's position with respect to the nodes of the predetermined grid. The shot interval was set by an external controlling computer (the average shot period should be between 20 and 25 seconds) that determined a current shot number from the ship's coordinates, and it was provided to the logger and gun box. Due to the arrangement data was not analyzed for consistency.

Date	Shot Point	Comment
203:01:11:13	000201	Shooting begins!
228:10:02:21	000301	End Shooting!

Gun Data

Gun Data was put together to provide adequate information about gun array performance and to correlate this data with the ship's position. A lack of reliable time on the computer running GCS90 software prompted collection of this data.

Date	Line Number	Comment
203:06:43:05.617	169	Shooting begins!
207:20:05:59.276	161	Shot logging interrupted
209:00:38:07.360	135	Shot logging resumes
216:21:59:56.284	134b	Shot logging interrupted
217:10:01:15.020	126b	Shot logging resumes
217:12:01:01.749	126b	Shot logging interrupted
219:09:32:00.686	34	Shot logging resumes
221:23:45:25.601	143a	Shot logging interrupted
222:00:18:13.442	143a	Shot logging resumes
288:10:00:30.872	121a	End Shooting!

Gravity Ties

There was no gravity tie done in Yokohama due to lack of information on a tie point. Observed BGM-3 value and corresponding information was collected and is available. During the cruise BGM-3 failed due to mechanical problems with gyro. The post cruise tie could not be performed.

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.

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[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

sh2.d Gun Array Data
This data is not processed, and is linked by time, line number and the shot points.

CPU Time Stamp Program ver. Line # Shot # GSC time stamp Gun Array data
98+079:00:08:40. GCS900544 163
1293.00005085E99/07/17:18:09:00132014...

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 hydrosweep data

- LOGGED
  All data logged during the cruise in raw format

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