

# R/V Maurice Ewing

## Data Reduction Summary

**EW9907 – Yokohama, Japan - Kochi,  
Japan**

**Nankai-I**

**3D Seismic Survey of the Nankai Trough**

June 18 – July 18, 1999

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# Data Reduction Summary

## Summary of Data Processing for 3D Nankai Survey

### Lamont-Doherty Science Crew List

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### Science Party List

**Chief Scientist:**            **Nathan Bangs**

**Party Members:**

- Tom Shipley
- Carmen Alex
- Barrie Taylor
- Denise Hills
- Amanda McCutcheon
- Zhao Zhiyong
- Greg Moore
- Sin'ichi Kuramoto
- Sumito Morita
- Hidenori Yagi
- Genshin Toyama
- Mimihiro Mochizuki
- Yasuyuki Nakimura
- Mark Wiederspahn
- Jim Dolan
- Sean Gulik

## Cruise Notes

All times specified within this report are GMT.

### **System Failures**

Minor failures on the part of the shot controlling (external, non-Lamont) computer occurred throughout the cruise which forced us to re-shoot few segments of the project. Diverse formats of the GPS strings from various units, associated with differential and non-differential modes of receivers cause a minor failures on the part of the program that provides navigation to the hydrosweep unit. This caused a crash of the acquisition routine and, consequently, loss of hydrosweep data for a 5 hour period during first day (JD 169) of the cruise. Major failure of the gravity meter caused by gyro damage had interrupted acquisition of the gravity data starting JD 179 at 0410 hours.

### **GPS/Navigation processing**

All shots were processed using the FUGURO differential GPS; which is the source for all the navigation processing. Pcode GPS was used to process data for the day JD 195.

### **Tailbuoy Logging**

Logging of the tailbuoy was intermittent due to a variety of problems. Poor sealing of the chamber with electronics, bad connection between modem and receiver.

## 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   | 169-200        |
| Furuno         | fu   | Furuno speed and heading   | 3 second     | 169-200        |
| Fuguro         | gp01 | Fuguro GPS receiver        | 10 second    | 169-200        |
| P Code GPS     | gp02 | Tasman Ycode receiver      | 10 second    | 169-200        |
| Trimble GPS    | gp03 | Differential GPS           | 10 second    | 169-200        |
| Tailbuoy GPS   | tb01 | Selective availability GPS | 10 second    | intermittent   |
| Gravity        | vc   | Bell gravimeter data       | 1 second     | 169-200        |
| Sea Temp       | ct   |                            | 60 second    | 169-200        |
| Meteorology    | wx   | Weather Station            | 60 second    | 169-200        |
| Gun Depths     | dg   | Depths of each gun at shot | shot         | 169-200        |
| Navblock       | nb   | Time/Position/Shotpoint    | 20 second    | 169-200        |
| Cable Geometry | cb1  | Time/Position/Compass data | 20 second    | 169-200        |
| Hydrosweep CB  | hb   | Hydrosweep Centerbeam      | 12           | 169-200        |
| Gun Status     | sh2  | Depth/Volume/Delta at shot | shot         | 177-199        |

### Logging

All logged data (*except GPS*) 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           |
|--------------|-------------------|
| 169:00:00:00 | Start UTC Sync    |
| 200:23:59:59 | <b>End EW9907</b> |

### 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                |
|--------------|------------------------|
| 169:00:00:00 | Furuno logging started |
| 200:23:59:59 | End EW9907             |

### Compass BlockData

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           |
|--------------|-------------------|
| 171:19:47:09 | Start of Shooting |
| 199:09:44:42 | 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                |
|--------------|------------------------|
| 169:00:00:00 | Weather logging online |
| 200:23:59:59 | End EW9907             |

## 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                                   |
|--------------|---|
| 169:01:20:28 | Hydrosweep logging begins                 |
| 169:14:26:39 | Logging interrupted, hs acquisition crash |
| 169:19:31:58 | Logging resumes                           |
| 169:20:55:37 | Logging interrupted                       |
| 169:21:08:09 | Logging resumes                           |
| 173:16:05:28 | Logging Interrupted                       |
| 173:16:30:03 | Logging resumes                           |
| 173:23:49:52 | Logging interrupted, hs acquisition crash |
| 174:00:40:15 | resumed                                   |
| 200          | End EW9907                                |

## GPS Receivers

- gp1 = Fuguro Differential
- 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                |
|--------------|------------------------|
| 169:00:00:00 | Fuguro GP1 online      |
| 169:03:49:41 | Fuguro interrupted     |
| 169:03:53:38 | Fuguro resumes         |
| 171:10:11:10 | Fuguro interrupted     |
| 171:10:26:11 | Furugo resumes         |
| 175:00:05:19 | Furugo interrupted     |
| 175:00:11:07 | Fuguro resumes         |
| 184:04:43:09 | Fuguro interrupted     |
| 184:04:50:33 | Fuguro resumes         |
| 191:20:02:13 | Fuguro interruped      |
| 191:20:05:22 | Fuguro resumes         |
| 169:21:04:23 | Pcode GPS GP2 online   |
| 200:         | End EW9907             |
| 125:22:35:36 | Trimble GPS GP3 online |

---

|      |            |
|------|------------|
| 139: | End EW9907 |
|------|------------|

---

### Bell Gravimeter

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

---

| Date         | Comment   |
|--------------|---|
| 169:00:00:00 | Start Gravity logging                               |
| 179:04:47:35 | Gravity logging interrupted caused by BGM-3 failure |

---

### Omega DP-10 Sea Temperature

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

---

| Date         | Comment                |
|--------------|------------------------|
| 169:00:00:03 | Start sea temp logging |
| 200          | End of EW9907          |

---

### 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 provided that data to the logger and gun box. Due to the arrangement data was not analyzed for consistency.

---

| Date             | Shot Point | Comment          |
|------------------|------------|------------------|
| 171:19:46:49     | 4          | Shooting begins! |
| 199:09:44:42.588 | 000855     | 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                  |
|------------------|-------------|--------------------------|
| 177:07:51:40:249 | 138         | Shooting begins!         |
| 178:20:45:07.835 | 158         | Shot logging interrupted |
| 190:13:43:38.597 | 162         | Shot logging resumes     |
| 199:09:44:42.588 | 114A        | 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<sup>1</sup>
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.

---

<sup>1</sup> **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

|   |                     |
|---|---------------------|
| $bias = 852645.3;$                            | <i>Dec 5, 1997</i>  |
| $scale = 5.0940744$                           | <i>July 9, 1992</i> |
| $mGals = raw\_gravity\_count * scale + bias;$ |                     |

### 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

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