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Data Reduction Summary

EW9809 – Chesapeake Bay, Virginia

October 15 – 16, 1998

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Data Reduction Summary

Summary of Data Processing for
Chesapeake Bay Survey

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Cruise Notes

All times specified within this report are GMT.

After several startup problems, mostly due to using a new UTC clock for the cruise, the shooting began at 14:14:49, and was interrupted once on the turn between lines Bay2 and Bay3 due to a software problem that was quickly resolved.

However, this software problem had gone unnoticed for several hours. Although it didn't interrupt the shooting process, it did cause incorrect shot positions to be put on the tape. This problem was corrected in post-processing for shot positions, but the 3490 tapes have incorrect shotpoint positions.

After switching from shore to ship power, the Truetime clock had trouble starting up. Due to this, shooting was based on the the Datum clock. There were troubles using the Datum for synchronizing CPU time and shooting at the same time, so until the Truetime clock came back on October 15, 21:36:59.

Due to the extreme difference in gravity between Halifax and Norfolk, and the fact that the BGM gravity was extremely close to the reference gravity, I did not reprocess the gravity using the previous tie. However, I did reprocess by subtracting 0.34 from all gravity fixes.

Cruise Data

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

Data Type	File	Description	Log Interval	Days Collected
UTC time	tr2	Datum UTC time clock	60 seconds	288 – 289
UTC time	tr1	Truetime UTC time clock	60 seconds	288 – 289
Furuno	fu	Furuno speed and heading	3 second	288 - 289
Y Code GPS	gp1	Tasman Ycode receiver	10 second	288 - 289
Trimble GPS	gp2	Differential GPS	10 second	288 - 289
Magnavox GPS	gp3	Selective availability GPS	10 second	288 - 289
Gravity	vc	Bell gravimeter data	1 second	288 – 289
Sea Temp	ct		60 second	288 – 289
Meteorology	wx	Weather Station	60 second	288 – 289
Gun Depths	dg	Depths of each gun at shot	shot	288 – 289
Navblock	nb	Time/Position/Shotpoint	120	288 - 289

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 data.

Shot times are from the UTC synchronized time.

Data Instruments

The following times are specified in GMT time.

Datum UTC Time Clock

The Datum 9390-1000 Startime GPS clock is logged at 60 second intervals. CPU time is synchronized every 60 seconds to this clock.

Date	Comment
288:0000	Start UTC Sync
288:14:00	**Start shooting, end Datum Sync**

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
288:21:36:59	Start UTC Sync
289:13:53:00	**End EW9809**

Furuno Speed and Heading

The Furuno CI-30 2 axes doppler speed log and Sperry MK-27 gyro are logged at 3 second intervals.

Date	Comment
288:21:36:59	Truetime clock online
289:13:53:00	End Ew9809

GPS Receivers

- gp1 = Tasman Ycode
- gp2 = Trimble Differential
- gp3 = Magnavox 4200

are 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.

Date	Comment
288:15:24:36	YCode GPS GP1 online
288:11:10:34	Differential GP2 logging Ew9809
288:00:00:00	GP3 Logging on
289:13:53:01	End Ew9809

Bell Gravimeter

Date	Comment
288:00:00:00	Start Gravity logging
288:13:53:02	EW9809

Weather Station

R.M. Young Precision Meteorological Instruments 26700 Series is used to log a variety of meteorological events at 60 second intervals.

Date	Comment
288:00:00:00	Start weather logging
289:13:53:00	End EW9809

Omega DP-10 Sea Temperature

Date	Comment
288:00:00:00	Start sea temp logging
289:13:53:00	End EW9809

Line Information

Line Name	Julian Date	FSP	SOL Time	LSP	EOL Time
Bay1	288	1	14:14:49	919	17:22:59
Bay2	288/289	920	17:23:11	3761	02:51:23
Bay3	289	0	02:54:19	2956	12:45:32

Gravity Ties

EW 9809 Norfolk, Virginia

EW-9809 NORFOLK, VIRGINIA

Pier/Ship	Latitude	Longitude
	36 51.193 N	76 17.896W

NOAA Atlantic Marine Center
439 West York Street
Dock 3

Shipped docked directly at reference point!

Reference	Latitude	Longitude
	36 51.193 N	76 17.896W

NOAA Atlantic Marine Center
439 West York Street
Dock 3, 150' South of SW corner of Warehouse
Bollard 2, Brass Plate

	Id	Julian	Date	Mistie	Drift/Day	DC Shift
Pre Cruise	None	289	10/16/98	0.00	0.00	0.00
Post Cruise	EW 9809	289	10/16/98	-0.34	#DIV/0!	0.00
Total Days			0.00	-0.34		

Time	Entry	Value	
17:30	CDeck Level BELOW Pier	0.75	meters
17:30	Pier 1 L&R Value	3459.98	L&R
17:30	Reference L&R Value	3459.98	L&R
17:30	Pier 2 L&R Value	3459.98	L&R
7/1/73 0:00	Reference Gravity	979859.40	mGals
17:30	Gravity Meter Value (BGM Reading)	979874.60	mGals
	Potsdam Corrected	1	1 if corrected

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

Difference in meters between Gravity Meter and Pier: 6.25 meters

Height Cor = Pier Height* FAA Constant

6.25	0.31			1.94	mGals/min

Difference in mGals between Pier and Gravity Meter

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

3459.98	3459.98	1.06		0.00	mGals

Gravity in mGals at Pierside

Reference + Delta mGals [+ Potsdam] → Pier Gravity

979859.40	0.00	13.60		979873.00	mgals

Gravity in mGals at Meter

Pier Gravity+ Height Correction → Gravity@meter

979873.00	1.94			979874.94	mGals

Current Mistie

BGM Reading- Calculated Gravity → Current Mistie

979874.60	979874.94			-0.34	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.

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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

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))

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
```

File Formats

Raw File Formats

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**

gpx.c - raw MX4200 GPS Fix

98+157:00:03:00.159

$PMVXG,001,000300,4250.432,N,06118.781,W,00009.0,3*5D

time Latitude Longitude Alt *POS*

POS =

1. Not Navigating
2. Remote Position (from remote device)
3. 2D Solution
4. 3D Solution
5. 2D Differential
6. 3D Differential

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 -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
```