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Data Reduction Summary

EW9912 – Townsville, Broome, Darwin, Townsville Australia

October 28, 1999 - November 29, 1999

Port Dates

Date	Julian	Time	Port
10/28	300	1000	Leave Townsville
11/10	314	1000 - 2000	Broome Stop
11/14	318	2320	Arrive Darwin
11/16	320	0900	Depart Darwin
11/29	333	0600	Arrive Townsville

Table of Contents

Project Summary

N_2 Fixation as a Source of New N in the Oligotrophic Tropical Oceans

Research will largely focus on N and C cycling in the upper water column, particularly on the role of N2 fixing organisms such as the planktonic cyanobacterium *Trichodesmium*, in providing new N to these systems. Routine analyses include CTD/inorganic nutrient characterization from 0 to 500m, phytoplankton and *Trichodesmium* specific biomass and abundance, primary productivity, inorganic N uptake, natural abundance analysis of PON and inorganic pools, and N2 fixation rates.

Specific experimental and analytical tasks will include:

1. Assessment of *Trichodesmium* population abundance by direct counts and chl a
2. Total phytoplankton population abundance by direct counts and chl a
3. N2 fixation by Trichodesmium by C2H2 reduction and 15N2 uptake
4. Phytoplanktonic N assimilation (new and regenerated) by 15N
5. 14C productivity for both Trichodesmium and nanoplankton
6. Inorganic nutrient profiles
7. Profiles of particulate C & N mass and natural abundance (d 15N, d 13C)
8. size fractionated zooplankton
9. Measurements of normalized water leaving radiance, remote sensing reflectance, down welling irradiance, upwelling radiance, particulate and dissolved fraction absorption

Station Plan

In the proposed operating area, our primary objectives will be to assess nutrient cycling processes in the upper (< 500 m) water column. We are planning on one station per day, lasting from about 0600 to 1800 local time, and involving several (3-4) CTD casts, surface plankton tows, and ocean optical measurements.

Cruise Members

Lamont-Doherty Science List

Name	Position	Email Address
Mark Landow	Captain	captain@ewing.ldeo.columbia.edu
Steve Pica	Chief Engineer	engine@ewing.ldeo.columbia.edu
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Science Party List

Chief Scientists	Doug Capone	Ed Carpenter	Joseph Montoya
Party Members	Janet Barnes	Kay Bateman	Ilana Berman-Frank
	Jay Burns	Ron Dotson	Cecile Dupouyd-Doucheme
	Rachel Foster	Jed Fuhrman	Miles Furnas
	Troy Gunderson	Cindy Heil	Pilar Heredia
	Ian Hewson	James King	Jamie Krauk
	Adam Kustka	Pernilla Lundgren	James McClellan
	Margie Mulholland	Diann Neenan	Jacques Neveux
	Karen Orcutt	Chris Payne	Ulla Rasmussen
	Laura Sprague	Daryl Swensen	Ajit Subramanian
	Marcelo Tenorio	Tracy Villareal	

Data Reduction

Cruise Notes

All times specified within this report are GMT and are synchronized to UTC time, with the exception of the GPS times which are taken directly from the GPS fix.

GPS/Navigation processing
The source of all the navigation processing is the Pcode GPS. The Pcode GPS has an inherent error of approximately 15 meters.

PAR Sensor
The PAR sensor was configured differently for the first few days to get the optimum settings. Therefore the readings vary in intensities until XXXXX when we settled on 0 - 5000 as the proper range.

ThermoSalinograph
The TSG was inadvertently turned off several times during the cruise, and those times will be reflected in the logs. Usually, a low conductivity (below 5) will mean that the pump had failed and no water was getting to the TSG sensor. These times are also reflected in the data.

Meteorology
There are several days of bad meteorological readings due to faulty sensors. These days/times are accounted for in this report.

Data Instruments

Truetime UTC Time Clock

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

Date	Comment
299: 00:00	Start Logging
332:23:59	End Logging

Fluorometer

Turner Designs Model 10-AU-005-CE Fluorometer was logged at 1 second intervals.

Date	Comment
304:05:08	Logging Started
304:06:41 - 304:12:06	No logging
304:20:05 - 305:03:25	No Logging
305:04:51 - 305:06:22	interrupted
305:08:12 - 305:20:24	
316:19:39 - 317:06:46	Broome Port Stop
317:06:47	continue logging
318:22:09 - 321:02:08	Darwin Port Stop
321:02:08	continue logging
325:01:10 - 325:01:52	interrupted
332:08:32	End of logging

Furuno Speed and Heading

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

Date	Comment
299: 00:00	Start Logging
332:23:59	End Logging

GPS Receivers

gp1 = Tasman Y/Pcode
gp2 = Trimble Selective Availability

were logged at 10 second intervals. Navigation is processed and reduced to 1 minute intervals, which is later applied to hydrosweep bathymetry, magnetics, gravity, PAR, fluorometer, and TSG data. All data has been processed using gp1: Pcode navigation. This GPS has an error factor of up to 15 meters. **gp2** data is occasionally lost during email connects, but all processing was performed with gp1, which experienced no losses during the cruise.

Date	Comment
299: 00:00	Start Logging
332:23:59	End Logging

Bell Gravimeter

The gravity meter is logged at one second intervals. There were no gaps in the gravimeter record for this cruise.

Date	Comment
299: 00:00	Start Logging
332:23:59	End Logging

Hydrosweep Centerbeam and Swath Data

Krupp Atlas Hydrosweep Centerbeam. Each Hydrosweep ping is logged, and center beam data is extracted and logged separately. Hydrosweep was logged during the entire cruise. Hydrosweep swath data is available from the *Lamont-Doherty Earth Observatory Marine Office*.

HS swath data can be read and processed using MB-System software which can be found at the website of Dale Chayes: http://www.ldeo.columbia.edu/~dale.

Date	Comment
300: 00:00	Start Logging
300:18:28 - 300:19:43	interruption
307:16:48 - 307:20:21	interruption
314:00:12 - 314:10:26	Broome Port Stop
318:23:49 - 320:11:23	Darwin Port Stop
	End Logging

PAR Sensor

A *LI-COR* **LI-190SA Quantum** sensor was used, S/N Q26562. Calibration Multiplier: -152.44 and was calibrated 23-March 1999.

Date	Comment
305:08:12	Start Logging
306:08:15 - 306:19:59	interrupted
308:02:43 - 308:03:24	interrupted
308:12:38 - 308:20:57	interrupted
310:06:47 - 310:08:54	interrupted
312 - 317	Many interruptions as the voltage is adjusted to calibrate properly
317:11:41	Logging continues
332:08:48	End Logging

Seacat ThermoSalinograph

The Seacat ThermoSalinograph, Model SBE21 was logged at 30 second intervals. The sensors were recalibrated on October 4, 1999. Calibration records are attached separately.

Date	Comment
301:13:38	Start Logging
310:13:19 - 312:03:34	Logging interrupted, fire at transformer!
313:11:21 - 313:16:12	TSG inadvertently shut off
313:21:58 - 314:10:55	Broome port stop
319	Darwin Port stop, TSG running, but values should be static
332: 10:02	end logging

Omega DP-10 Sea Temperature

Sea temperature is logged at 60 second intervals; there were no gaps in the data for the cruise.

Date	Comment
299: 00:00	Start Logging
332:23:59	End Logging

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
305 04:33 - 05:51	Interruption
316 10:56 - 11:34	Interruption, working on sensor
316 23:29 - 317 00:06	Interruption, work on sensor completed
332:08:30 - 332:23:59	End Logging

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 DOP1
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.

[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.

Hydrosweep Processing

Centerbeam Processing steps

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.

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

1. Raw gravity is logged to disk (roughly 1 sample/second) and broadcast to the network.
2. 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

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;
   ```

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

   ```
   filter1D -G480 -R -E
   ```

5. 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
   ```

6. 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*

7. 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

Gravity Ties

EW-9912 Townsville, Australia

Pier/Ship	Latitude	Longitude
	19 15.067 S	146 49.8395E

Berth 10, Townsville Port

End of pier (near bollard 10)

C Deck is 1 meter below Pier

Reference	Latitude	Longitude
	19 15.70S	146 46.80 E

Townsville City College Campus; Corner of Stanley and Walker. I took the reading near the bike rack outside the back door of C Block building as the original reading was carpeted over

	Id	Julian	Date	Mistie	Drift/Day	DC Shift
Pre Cruise	EW9911	295	10/22/99	2.28	0.02	1.55
Post Cruise	EW9912	336	12/2/99	3.87	0.04	2.28
Total Days			41.00	1.59		

Time	Entry	Value	
12/2/99 00:00	CDeck Level BELOW Pier	2.00	meters
	Pier 1 L&R Value	2286.01	L&R
	Reference L&R Value	2281.58	L&R
	Pier 2 L&R Value	2286.03	L&R
	Reference Gravity	978623.30	mGals
	Gravity Meter Value (BGM Reading)	978634.20	mGals
	Potsdam Corrected	0	1 if corrected

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

Difference in meters between Gravity Meter and Pier: 7.50 meters

Height Cor = Pier Height* FAA Constant

7.50	0.31			2.33 mGals/min

Difference in mGals between Pier and Gravity Meter

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

2286.02	2281.58	1.06		4.71 mGals

Gravity in mGals at Pierside

Reference + Delta mGals [+ Potsdam] = Pier Gravity

978623.30	4.71	0.00		978628.01 mgals

Gravity in mGals at Meter

Pier Gravity+ Height Correction = Gravity@meter

978628.01	2.33			978630.33 mGals

Current Mistie

BGM Reading- Calculated Gravity = Current Mistie

978634.20	978630.33			3.87 mGals

fl.n Fluorometer

```
   CPU Time Stamp      Latitude     Longitude    Fluorometer Count
   ------------------- ------------ -------------    -----
   99+330:00:03:00.000  S 13 52.1213 E 146 14.5633  7.1050
```

The Fluorometer is median filtered at 5 second intervals and then interpolated to get the value at the Lat/Lon position at the even minute.

fu.r Raw Furuno Log

```
   CPU Time Stamp      Track Speed Hdg   Gyro
        ------------------- ---   ----- ----- -----
   98+166:00:01:53.091 -     4.4   140.5 148.3
```

hb.n Hydrosweep Centerbeam

```
                       Centerbeam
   CPU Time Stamp      Latitude     Longitude    Depth
   ------------------- ------------ -------------    -----
   98+074:09:55:00.000 N 13  6.6206 W  59 39.3908   134.9
```

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

m Merged Data

```
                       GPS
CPU Time Stamp      Latitude     Longitude         Used  Set  Drift Depth
------------------- ------------ -------------  ----  ---  ----- -----
98+074:14:08:00.000 N 13 54.3859 W  59 43.5175  gp1   0.0  0.0   732.9

Magnetic       Gravity
Total Intensity   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.

n Navigation File

```
CPU Time Stamp      Latitude     Longitude       Used  Set  Drift
------------------- ------------ -------------   ----  ---  -----
98+074:00:03:00.000 N 13  6.2214 W  59 37.9399   gp1   0.0   0.0
```

The raw navigation (PCode) is interpolated to 30 second intervals.
Then smoothed with a 9 point windowing average. The smoothed
GPS points are them Fixed at 1 minute intervals. Dead reckoning
is then performed across the gaps to insure proper GPS positioning.

pr.n PAR Sensor File

```
CPU Time Stamp      Latitude     Longitude       Median PAR value
------------------- ------------ -------------   --------
99+330:00:00:00.000  S 13 52.1278 E 146 14.5715  535.9909
```

The PAR sensor is median filtered at 15 second intervals and
then interpolated to get the value at the Lat/Lon position at
the even minute.

sg.n ThermoSalinograph Data

```
CPU Time Stamp      Latitude     Longitude
------------------- ------------ -------------
99+330:00:00:00.000 S 13 52.1278 E 146 14.5715

ipts68 ipts68 ipts68
local  remote local
temp.  temp.  conductivity   salinity
------ ------ -----          --------
27.027 26.970 5.537          35.122
```

ThermoSalinograph data is computed based on the calibration records

Frequency (Hz) is then determined with the following calculations:

```
              Temp Freq. = Value/19 + 2100
      Conductivity Freq. = sqrt( (Value*2100) + 6250000)
```

Voltages can be calculated by Value/819

From there the actual temperature and conductivity are calculated using
the Seabird calibration values.

If you need these you can get them from the science officer.

The salinity is then calculated using the formulas from:

```
   IEEE, Journal of Oceanic Engineering
   Vol. OE-5, No. 1, January 1980, page 14
```

We use a nominal pressure of 10 mBars for the pressure.

To get the ITS90 Temperatures, use the following formula:
      T90 = T68/1.00024

Data is median filtered at 3 minute intervals, and then interpolated
to 1 minute navigation.

---

vc.r Raw Gravity Counts

---

sample BGM-3 gravity count record (without time tag):

```
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
```

The input of data can be at 1 or 10 seconds.

---

vt.n Gravity Data   -- see README.gravity

```
_  ** A minus sign in the time stamp is flagged as a spike point,
      probably noise, or change in course
   *2 m_grv calculates the Eotvos correction as:
      eotvos_corr = 7.5038 * vel_east * cos(lat) + .004154 * vel*vel
   *3 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
   *4 The FAA is computed as:
            faa = corrected_grv - theoretical_grv
   * Velocity smoothing is performed w/ a 5 point window

   CPU Time Stamp      Latitude     Longitude     Model FAA     RAW
   ------------------- ------------ ------------- ----- ------  -----
   98+077:00:15:00.000 N 16 11.8600 W  59 48.0157 1980  -175.9
978253.6

   Eotvos  Drift DC     Raw  Velocity    Smooth Velocity
   Smooth  Total Shift  North    East    North   East
   ------  ----- -----  --------------   ---------------
   9.7     0.0   4.5    -4.350   1.282   -4.333   1.329
```

wx Raw Weather File Format

```
94+022:00:00:00.244   9.3  15.4  13.2  21.1 271 261
date    time         wsi1  wss1  wsm1  wsx1 wdc1 wds1

6    12.6  15.9  15.6  20.7 261 253  6    66.7 66.7
wdm1 wsi2  wss2  wsm2 wsx2 wdc2 wds2 wdm2 tcur tavg

66.5  67.0 66 58  68  1016.8
tmin  tmax rh rhn rhx baro
```

1 wsi1 = wind speed, instantaneous, bird #1
2 wss1 = wind speed, 60 second average, bird #1
3 wsm1 = wind speed, 60 minute average, bird #1
4 wsx2 = wind speed, current 60 minute maximum, bird #1
5 wdc1 = wind direction, current, bird #1
6 wds1 = wind direction, 60 second average, bird #1
7 wdm1 = wind direction, 60 second st deviation, bird #1

8 wsi2 = wind speed, instantaneous, bird #2
9 wss2 = wind speed, 60 second average, bird #2
10 wsm2 = wind speed, 60 minute average, bird #2
11 wsx2 = wind speed, current 60 minute maximum, bird #2
12 wdc2 = wind direction, current, bird #2

13 tcur = temperature, current
14 tavg = temperature, current 60 minute average
15 tmin = temperature, current 60 minute minimum
16 tmax = temperature, current 60 minute maximum

17 rh = relative humidity
18 rhn = relative humidity, current 60 minute minimum
19 rhx = relative humidity, current 60 minute maximum

20 baro = barometric pressure

Data output is raw data for the given time.

Tape Contents

The tape contains the following items:

- DOCS
  Cruise Summary, Readme files for file formats, processing; gravity tie information.
- EW9912.cdf, EW9912.cdf_nav
- clean
  intermediate processed data
- ctd
  CTD logs
- mocness
  MocNess data
- nutrients
- nutrients_rchive (nutrients in archive format)
- processed
  Final processed data collected during the cruise and tied to navigation.
  Also includes trackplots, and some GMT plots and scripts of the cruise.
- raw
  All data logged during this cruise from octopus
- sources
  source code to custom routines for this cruise
- trichototo
- xbt
  XBT data taken at various times during the cruise