Data Synopsis for HLY0901

March 10 – March 31 2008

Kodiak to Dutch Harbor

Chief Scientist- Lee Cooper

Healy Captain- Captain Frederick Sommer

ST LAWRENCE ISLAND POLYNYA PROJECT

Version 3/31/09

Prepared by: Tom Bolmer, David Forcucci, David Hassilev, Steve Roberts, & Dale Chayes

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Project Summary

Benthic Ecosystem Response to Changing Ice Cover in the Bering Sea

(Funded by the National Science Foundation)

Patch Dynamics

(Funded by the North Pacific Research Board)

USCGC Healy (HLY0901)

March 10-March 31, 2009

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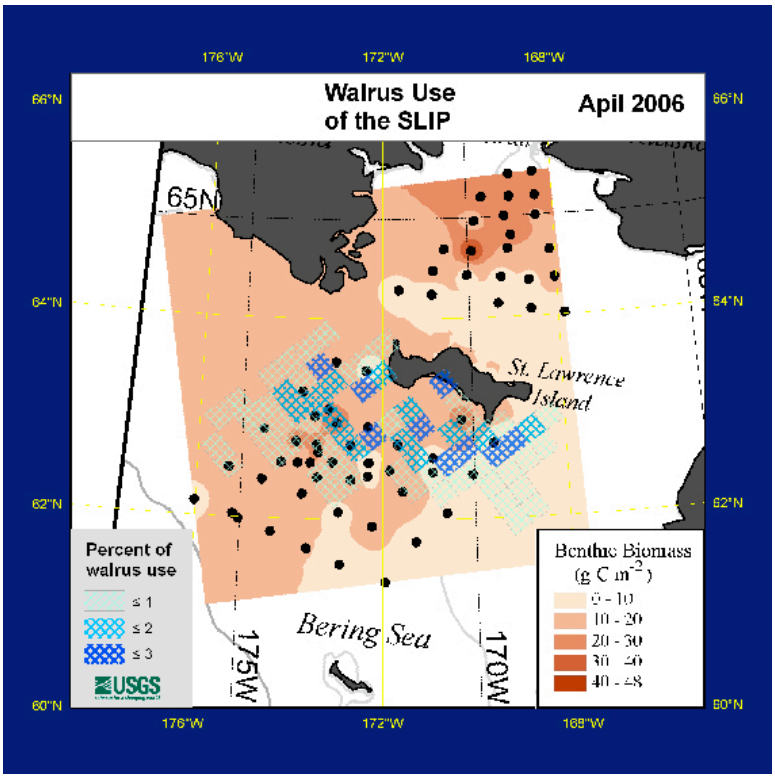
- Chad Jay, cjay@usgs.gov, phone: (907) 786-7414 (Biological Resources Division, US Geological Survey)

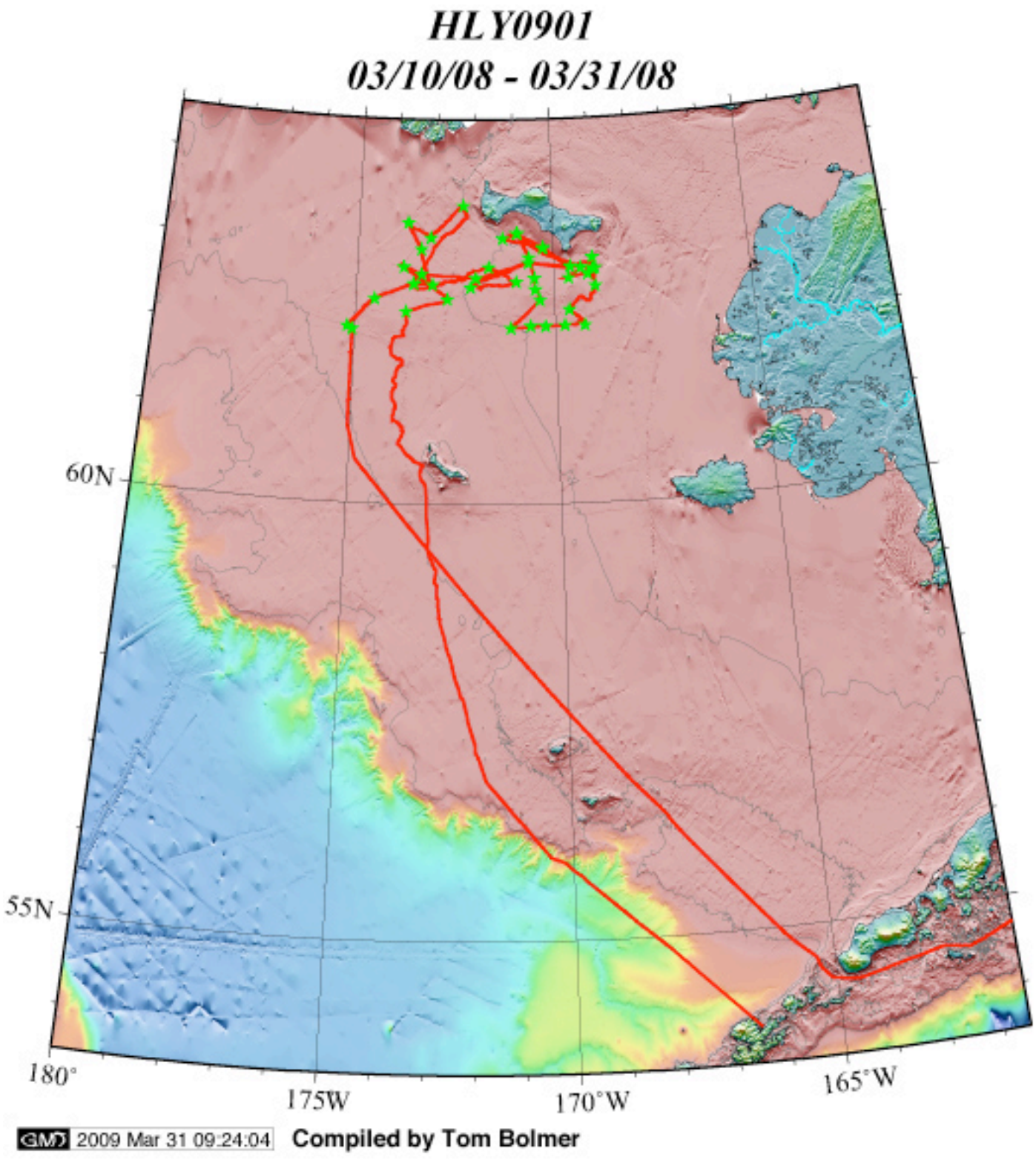
The first research cruise of the USCG Healy in 2009 (HLY09-01) was in waters near Saint Lawrence Island (north Bering Sea) in March. During this early season research cruise, we continued work on benthic (sediment-based) food webs, as well as documenting the distributions of walruses, other marine mammals and seabirds. Past scientific work in this area has shown that the number and weight of organisms present in the sediments is in decline and the species present have also changed. One of the main scientific questions is whether this change is due to the recent shifts in sea ice cover and associated apparent climate warming, and how these changes in food supply will affect animals that dive to the bottom to feed, including walrus, bearded seals, and eiders. Of concern also are whether fish are becoming more critical competitors in the food web as water temperatures warm and fish become present in greater numbers. Most of the work undertaken on this cruise related to these general questions using chemical and biological sampling approaches. Sampling of the sediments included shipboard oxygen respiration incubations and collection of benthic organisms for later laboratory identification. In addition, a research team studied the distributions of walrus in relation to the food resources on the sea floor. Tagging of walrus for tracking by GPS was accomplished by a helicopter based on the ship. Shipboard surveys were made of marine mammals and birds to better understand the distributions of the animals using the rich waters near Saint Lawrence Island. Additional efforts were made to incorporate educational and public outreach in the shipboard program. These efforts included the participation of a K-12 teacher at sea through the National Science Foundation's PolarTREC program, two ship-based International Polar Year office sponsored presentations to school audiences in three languages (for International Polar Oceans Day) and two web-based blogs. Public presentations on the planned research were provided to the Whaling Captain's Association of Savoonga during a visit by the cruise Chief Scientist, and to the IRA (tribal government) Council in Gambell on St. Lawrence Island (by email/mail and phone). Finally three media teams, from ABC News, National Public Radio, and the American Chemical Society journal Environmental Science and Technology were accommodated on the ship for a five day period to provide opportunities for science reporting from the ship.

Walrus tracks following tagging, 2008



Walrus use of habitat relative to benthic (seafloor) biomass (right), April 2006

Cruise Track



Personnel

HLY0901 Science Party Personnel

Name	*Institution*	*Position*	*Phone*	*Email*	*Date on*	*off*	*Nationality*
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Ship's Crew

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Appleberry, Jason LT
Ayers, Silas LT
Baldwin, Robin FS3
Bartlett, Charles MST1
Beasley, Corey HSCS
Beebe, Brandon FN
Bender, Zachary LTJG
Berringer, Mike ETC
Braddock, Amelia R. SN
Brogan, John MKC
Brown, Betty MK3
Buford, Aimee BM2
Chaidez, Marshal MST3
Coates, Brittney FN
Cooler, Jesse SA
Coombe, Jeffrey MK2
Dabe, Jeffrey IT1
Davis, Jonathon ET2
Dolton, Peter ENS
Dowd, Robert SN
Dull, Steven FS2
Dunning, Lara BM2
Fernandez, Chelsey SN
Ford, Angela SN
Galvez, Oscar R. LT
Glenzer, William BM1
Gray, Deidre SN
Griffin, Bobby SK2
Hamilton, H. Mark FS3
Harbinsky, Mark ET2
Harris, Daniel SK1
Howard, Daniel DC3
Huneycutt, Gaines BM1
Hurtado, Daniell EM1
Imgarten, Christopher DC1
Irwin, Paul EM2
Jacobs, Bryson LTJG
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Kruger, Thomas MST3
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Laisure, Jeremy SK2
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Merten, James BM3
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O'Sullivan, Brandon MK2
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Podhora, Curtis EMCM
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Shaffer, Hans EM1
Starling, Wendy MK2
Stein, Kelsey FN
Swanson, Shawn ET1
Thomas, Tasha LTJG
Von Kauffmann, Daniel IT1
Whiting, Allan, MK1
Williams, Tony FSCS
Wilson, Thomas BMCM
Yeckley, Andy BM2
Zitting, Arrene FS1

Science Components and their major sampling activities

Core Projects:

BEST Benthic Ecosystem Response to Changing Ice Cover in the Bering Sea (National Science Foundation ARC-0802290), Jackie Grebmeier and Lee Cooper, PIs

BSIERP: Patch Dynamics (North Pacific Research Board project O4.62), Andrew Trites and Chad Jay, lead shipboard PIs

Other Participating Projects:

BEST: Sea Ice Algae, a Major Food Source for Herbivorous Plankton and Benthos in the Eastern Bering Sea (NSF ARC-0732767)
PIs: Rolf Gradinger

Measuring and Modeling Habitat Use by Spectacled Eiders Wintering in the Bering Sea
PI: Jim Lovvorn, (NPRB Project 820)

North Pacific Pelagic Seabird Observer Program (NPRB BSIERP)
PIs: Kathy Kuletz

Optics under sea ice and heat absorption impacted by bioprocess (Chinese International Polar Year Program)
PI: Jinping Zhao, Ocean University of China

Thin Ice: An Exploration of the Bering Sea at the Dawn of Global Warming A public education project for the International Polar Year- 2007-2008 PI: Thomas Litwin

Intersection Between Science, Military and the Sea
PI: An-my Lê, Fine-Arts Photographer

Table of Projects and Team Members

Group	Position	Name
Chief Scientist	Chief Scientist	Lee W. Cooper
Benthos	Lead Scientist	Jackie Grebmeier

Group	Position	Name
		Marisa Guarinello, Linton Beaven, Regan Simpson, Krista Hoff, Maria Ceballos, Cynthia Yeung, Laura Gemery, & Nathalie Morata
Walrus	Lead Scientist	Chad Jay
		Anthony Fischbach
Marine Mammals	Senior Scientist	Andrew Trites
Spectacled Eiders	Lead Scientist	Jim Lovvorn
UV and dissolved organic carbon	Lead Scientist	Marjorie Brooks
Sea Ice	Lead Scientist	Rolf Gradinger
		Brenna McConnell & Jared Weems
Zooplankton	Lead Scientist	John Nelson
Optics and Physical Oceanography	Lead Scientist	Jiuxin Shi
		Hongli Fu
Seabirds	Lead Scientist	Kathy Kuletz
		Ivan Kuletz
PolarTREC teacher	PolarTREC teacher	Deanna Wheeler
LDEO Science Support	Data Support	Steve Roberts & Tom Bolmer
SIO CTD Support	Lead	Scott Hiller
		Matt Durham
Media and Outreach	Senior Scientist and NPRB representative	Tom van Pelt
	Senior Scientist and NPRB representative	Francis Wiese
	Board member, NPRB	Dorothy Childers
	Fine Arts Photographer	An-my Lë
	Science communication and outreach	Chris Conner
	News media representative	Elizabeth Arnold
	Science journalist	Erika Engelhaupt
	CBS News	Bill Blakemore & Clayton Sandell
Thin Ice	Lead	Thomas Litwin
		Tom Walker

Group	Position	Name
USCG Rep	USCG Science Liaison	Dave Forcucci

Distribution Contents

Introduction to Data

The Healy data acquisition systems continuously log data from the instruments used during the cruise. This document describes:

- The structure and organization of the data on the distribution media.
- The format and contents of the data strings.
- Formulas for calculating scaled, calibrated values from logged data.
- Information about the specific instruments in use during the cruise.
- A log of instrumentation issues, adjustments , acquisition problems, and events during the cruise that may affect the data.
- Calibration data for the instruments in use during the cruise.

The data is distributed on a small USB disk drive.

***IMPORTANT**: Read the section, "Acquisition Problems and Events," for important information that may affect the processing of this data.*

There are two logging system on the Healy. The US Coast Guard Seattle Electronic Support Unit (ESU) runs the NOAA/SCS logging system and the LDEO support group runs the Lamont Data System (LDS) logging system. Although this provides some redundancy in logging, LDS is is required to provide precision time-stamping, real-time reformatting, and logging of data that SCS was not designed to support including the sonar systems, web cameras, and gravity meters.

The NOAA-developed Scientific Computer System (SCS) (version 4.2) is a data acquisition, and display system designed for Oceanographic, Atmospheric, and Fisheries research applications and was originally intended to log data from supporting sensors (not the mapping sonar's) on survey launches. It acquires sensor data from shipboard oceanographic, atmospheric, and fisheries sensors and provides this information to scientists in real time via text and graphic displays, while simultaneously logging the data to disk for later analysis. SCS also performs quality checks by monitoring I/O, providing delta/range checks and plotting data after acquisition.

The LDEO Data System (LDS) is derived the logging code originally developed on the R/V Conrad in 1986 and has evolved through use on the Conrad, Ewing, Nathaniel B. Plamer, R/V Gould, six SCICEX submarine cruises and a number of smaller, short field programs since 1987. LDS is the result of significant restructuring of the code base in 2004 and has been data acquisition system on the R/V Langseth since she went into service.

SCS Data Overview

SCS receives all of its data through asynchronous serial (RS-232) connections. In SCS a time tag is added at the beginning of each line of data in the form,

mm/dd/yyyy,hh:mm:ss.sss,[data stream from instrument] where:

Format	Value used
mm	2 digit month of the year
dd	2 digit ay of the year
yyyy	4 digit year
hh	2 digit hour of the day
mm	2 digit minute
ss.sss	seconds

An example string from the Seabeam Centerbeam file is:

04/13/2007,06:49:20.920,$SBCTR,2007,4,13,06:49:09.437,57.158792,-165.664322 ,69.15,60*00

All times are reported in UTC. Each file type has it's own NEMA string name ($SBCTR as an example).

The delimiters that separate fields in the raw data files are commas. Care should be taken when reprocessing the data that the field's separations are clearly understood.

By design, SCS separates different data records from a single serial data stream into different directories. For instance, a GPS receiver may transmit $GPGGA, $GPHDT, and $GPGLL records. In the SCS data architecture, each of these messages will be logged in a different directory.

LDS Data Overview:

LDS receives most of its data through serial ports like SCS and like SCS, prepends a time stamp. Unlike SCS, LDS uses remote nodes to acquire and timestamp data and provide it to the central LDS logger. Data from the two ship's gyrocompasses is handled by a remote node installed on the bridge and data form the two gravity meters is handled by a node in IC/Gyro. Remote nodes are substantively different than terminal servers in that they timestamp the data locally which eliminates the network latency associated with acquiring data through a terminal server and then providing the timestamp later.

An example LDS data record is shown below. The first field is the instrument identifier, the second is a precioisn time stamp and the remainder is the raw data from the device, in this case, an LDEO iLab BGM-3 gravity meter interface:

```
bgm222  2008:264:00:00:26.9340  04:025508 00
```

Directories:

1_Minute_Averaged_Data: This directory contains one minute averages of many of the the under way data types.

data: This directory contains the data directories below.

SCS_Data*:* This directory contains serial data collected by the SCS version 4.2 data collection system in different directories. Directory names are labeled by the

	instrument name and string type of the data collected. A description of the data contained in this directory is below.
LDS_Data*:*	This directory contains data collected by the Lamont LDS data collection system in different directories. Directory names are labeled by the name of the instrument. A description of the data contained in this directory is below.
Raw:	This directory contains raw data as recorded by individual instruments and put into different directories. Directory names are labeled by the instrument name. A description of the data contained in this directory is below.
Meta_data:	This directory contains documents useful in the post analysis of the data on this DVD media set. The data types are separated into different directories. A description of these directories is below.
Plots:	This directory contain daily and hourly plots of underway data that were generated in LDS.
Ice_observations:	Directories of the Ice Observations taken for the cruise.

1_Minute_Averaged_Data:

HLY0901_distance.csv.gz	Distance along track from port.
HLY0901_Averaged.csv.gz	All the Under way data averaged for 1 minute.
Shapefile	All of the 1 minute under way data averaged at 1 minute spacing in shp, shx and dbf GIS files.

data

SCS_Data:

/aft_a_frame	Wire tension, wire out, and wire speed for the Aft A frame winches.
/air_temp_f	Temperature data from the ship temperature snsor on the bridge in Fahrenheit. Data is derived from data from files in the rmyoung_air directory.
/air_temp3a_f	Temperature data from the MET3A sensor on top of the HCO shack in Fahrenheit. Data is derived from data from files in the met3a_sen directory.
/air_temp_bow	Temperature data from the temperature sensor on the Jackstaff in Fahrenheit.
/ashtech_attitude	Attitude in NMEA format from the Ashtech ADU5 GPS receiver.
/ashtech_gga	Position data in NMEA GGA format from the Ashtech ADU5 GPS receiver.
/ashtech_gll	Position data in NMEA GLL format from the Ashtech ADU5 GPS receiver.
/ashtech_hdt	Heading data in NMEA HDT format from the Ashtech ADU5 GPS receiver.
/flomet	Flow meter data just upstream of the TSG and Fluorometer.
/flomet_b	Flow meter data just upstream of the B TSG and Fluorometer. (if this second sensor is installed)
/fluro	Flurometer for the TSG sensor.
/fluro_b	Flurometer for B TSG sensor. (if this second sensor is installed)
/glonass_gga	Position data in NMEA GGA format from the GLONASS GPS receiver.

/glonass_gll	Position data in NMEA GLL format from the GLONASS GPS receiver.
/gyro_mk27	Heading data in NMEA HDT format from the Sperry MK27 gyro compass.
/gyro_mk39	Heading data in NMEA HDT format from the Sperry MK39 gyro compass.
/ibs_waypoints	Waypoints from the Healy's Integrated Bridge Syste.m
/isus	ISUS Nitrate Sensor small file.
/isus3v	ISUS Nitrate Sensor 3V full file.
/knudsen	Depth data in a proprietary PKEL format received from Knudsen 320 B/R serial output.
/met3a_sen	Meterology data from the top of the Jackstaff.
/oxygen	Oxygen values from the TSG.
/oxygen_b	Oxygen values from B TSG. (if this second sensor is installed)
/pcode_aft_gga	Position data in NMEA GGA format from the Trimble Centurion receiver located in the Computer lab.<
/pcode_aft_gll	Position data in NMEA GLL format from the Trimble Centurion receiver located in the Computer lab.
/pcode_aft_vtg	Course and speed over ground in NMEA VTG format from the Trimble Centurion receiver located in the Computer lab.
/pcode_aft_zda	Time and date data in the NMEA ZDA format. Data retrieved from the Trimble Centurion receiver located in the Computer lab.
/pcode_bridge_gga	Position data in NMEA GGA format from the Trimble GPS receiver located on the bridge.
/pcode_bridge_gll	Position data in NMEA GLL format from the Trimble GPS receiver located on the bridge.
/pcode_bridge_vtg	Course and speed over ground data in NMEA VTG format from the Trimble GPS receiver located on the bridge.
/posmv_gga	Position data in NMEA GGA format from the POS/MV
/posmv_gst	Pseudorange error statistics in NMEA GST format from the POS/MV
/posmv_hdt	Heading data in NMEA HDT format from the POS/MV
/posmv_pashr	Roll, pitch and heave from POS MV inertial navigation system.
/posmv_vtg	Course and speed over ground in NMEA VTG format from the POS/MV
/posmv_zda	Time and date data in NMEA ZDA format from the POS/MV
/pressure_sen	Pressure sensor in the Uncontaminated Seawater System before the Bio Chem Lab which measures header pressure in PSI.
/rmyoung_air	Temperature, humidity, air pressure data in NMEA XDR format from the ship RM Young meteorological system near the bridge.
/rmyportwind	Wind speed and direction data in NMEA WMV format from the ship RM Young weather vane on the port side of the Healy Mast Yard.<
/rmystbdwind	Wind speed and direction data in NMEA WMV format from the ship RM Young weather vane on the starboard side of the Healy Mast Yard.
/samos_data	Meterology data for SAMOS.
/seabeam_center	Center depth data from the Seabeam 2112
/solar_radiometers	Solar Radiometer data for SW and IW.
/sperry_speedlog	Ground/water speed data from the Sperry Speed Log.
/stbd_a_frame	Wire tension, wire out, and wire speed for the starboard A frame winches.

/surface_par	Photosynthetic Active Radiation volts and Microeinstens/m2 se from the surface par sensor.
/sv2000	Sound Velocity data from the SV2000 sound velocimeter located in the ADCP BB150 sonar well.
/temp_incubat	Temperatures from the Incubators.
/true_wind_port	True wind speed data derived from gyro data and rmyportwind.
/true_wind_stbd	True wind speed data derived from gyro data and rmystbdwind.
/tsg	Thermosalinograph and fluorometer data from the TSG instruments in the Bio/Chem Lab.
/tsg_b	Thermosalinograph and fluorometer data from the B TSG instruments in the Bio/Chem Lab. (if this second sensor is installed)
/wind_aft	Wind data from the UltraSonic wind sensor on top of the HCO Shack.
/wind_bow	Wind data from the UltraSonic wind sensor on top of the Jack Staff.
/wind_mid	Wind data from the UltraSonic wind sensor on the Yard.

Extra files in the directory SCS_Data:

ACQLOG.LOG	Contains the data as to what occurred with SCS data. It shows when data collection was started and stopped. Includes startup and shutdown events.
Incidents_YYYYMMDD-TTTTTT.DTM	Contains any incident data, which were triggered in SCS. Refer to the SCS documentation for the definition of "incidents."
sensor_YYYYMMDD-TTTTTT.scf	Contains the configuration file for data collection as configured by SCS.

LDS_Data:

/AloftConCam	Contains picture files separated by folders named by Year and Day of the Year (YYYYJJJ). The picture files are in 5 minute JPEG format.
/FantailCam	Contains picture files separated by folders named by Year andDay of the Year (YYYYJJJ). The picture files are in 5 minute JPEG format.
/adcp_nav	Contains the navigation data sent to the ADCPs.
/adu5	Contains the data from the ADU5 GPS.
/aggps	Contains the data from the AG GPS.
/ais	Contains Automatic Identification System (AIS) messages as encapsulated VDM sentences.
/bgm221	Contains the data from the BGM221 Gravimeter.
/bgm222	Contains the data from the BGM222 Gravimeter.
/events	Contains the logs of event for different systems.
/hdgextract	Contains the extracted Heading data from the POSMV.
/mk27	Contains the data from the MK27 Gyro.
/mk30	Contains the data from the MK30 Gyro.

/posatt	Contains the attitude data from the POSMV GPS.
/posnav	Contains the navigation data from the POSMV GPS.
/posreform2sb	Contains the navigation data from the POSMV GPS reformatted for the SeaBeam.
/sbctr	Contains the center beam data from the SeaBeam.
/sbsv	Contains the surface sound velocity data for the SeaBeam.
/seabeam	Contains the data from the SeaBeam.
/tsg_met	Contains the all data from SIO TSG and Met sensors.
/SwapPingHLY	Contains ping results for Healy/Louis wireless network(swap) connection. Not currently active.
/SwapRoute	Contains routing table stats for Healy/Louis wireless network(swap) connection. Not currently active.
/SwapStatsHLY	Contains Healy wireless stats for Healy/Louis wireless network(swap) connection. Not currently active.
/SwapStatsLSL	Contains Louis wireless stats for Healy/Louis wireless network(swap) connection. Not currently active.
/winch_aft	Wire tension, wire out, and wire speed for the Aft A frame winches.
/winch_stbd	Wire tension, wire out, and wire speed for the Starboard A frame winches.

Raw:

/adcp150	150 Khz ADCP data.
/adcp75	75 KHz ADCP data.
/ctd	CTD data in directories by Cast number.
environmental_sensors	Temperature and Humidity Sensor data for the Climate control chambers
/knudsenraw	Knudsen 320B/R data.
/tsg_met	All the TSG and MET data.
/xbt	Expendable Bathythermograph data.

Images:

Contains satellite imagery in jpeg format

Satellite_Images

/dmsp	Data from the Defense Meteorology Satellite Program passes logged by the Healy's Terascan . Directories are identified by Year, Month, Day
/hrpt	Data from the NOAA weather satellite passes logged by the Healy's Terascan . Directories are identified by Year, Month, Day

Meta_Data:

/elog	Contains the technical support staff narrative of important events, which occurred both to the network and to individual sensors.
/Bridge_Logs	
DDMMMYY.doc	The "smooth log" containing events recorded by the bridge watch.
DDMMMYYWX.xls	Weather log recorded by the watch.
DDMMMYYNAV.xls	Navigation logs recorded by the watch.
/Sensor_Formats	Contains html and PDF files documenting the formats of all the files collected under way during the cruise.
./Systems_Calibrations	All of the calibrations sheets for the underway instruments are here.
./WHOisWHO	The directory has information about contacts for the Science personnel on this cruise.

Plots:

./knudsen_hourly_plots:	Directories of the SIOSEIS plots of the Knudsen 3.5 kHz data are in directories named by year, month, and day. These images are in the png format. There are two plots for each window in time. One is a large sized plot and one is a smaller plot. The files start 10 minutes before the file name and 10 minutes after the hour the file is named for.
./surface_daily_plots	Directories containing daily plots of under way data.

Ice_observations:

Directories of the Ice Observations taken for the cruise.

Contents by directory:

SCS_Data:

CallSign
NOAA_Data
aft_a_frame
air_temp3a_f
air_temp_f
airtemp_bow
ashtech_attitude
ashtech_gga
ashtech_gll
ashtech_hdt
flomet
flomet_b
fluro
glonass_gga
glonass_gll
gyro_mk27
gyro_mk39
ibs_waypoints
knudsen
met3a_sen
oxygen
pcode_aft_gga
pcode_aft_gll
pcode_aft_vtg
pcode_aft_zda
pcode_bridge_gga
pcode_bridge_gll
pcode_bridge_vtg
posmv_gga
posmv_gst
posmv_hdt
posmv_pashr
posmv_vtg
posmv_zda
pressure_sen
rmyoung_air
rmyportwind
rmystbdwind
samos_data
seabeam_center
sensor_2009*.scf
sensor_2009*.xml
solar_radiometers
sperry_speedlog
stbd_a_frame
surface_par
surface_temp
sv2000
temp_incubat
true_wind_port
true_wind_stbd
tsg
wind_aft
wind_bow
wind_mid

Raw:

adcp150
adcp75
ctd
environmental_sensors
knudsenraw
tsg
xbt

Images:

***Satellite*_Images:**

dmsp
hrpt

LDS_Data:

AloftConnCam
FantailCam
adcp_nav
adu5
aggps
ais
bgm221
bgm222
events
hdgextract
ibs_waypoints
mk27
mk39
posatt
posnav
posnavreform
posreform2sb
sbctr
sbsv
seabeam
tsg_met
winch_aft
winch_stbd
SwapPingHLY
SwapRoute
SwapStatsHLY
SwapStatsLSL

Meta_Data:

Bridge_Logs
Systems_Calibration_Data
Elog
WHOisWHO
Sensor_Formats

Plots:

Knudsen_hourly_plots

Surface_daily_plots

1_Minute_Averaged_Data:

Ice_observations:

Merged Data

LDEO Averaged One Minute Data File

The data are summarized into an averaged one (1) minute data file by the LDEO technician. This file takes the average value centered on the minute, (30 seconds either side of the whole minute). The averages are calculated from the raw values as they are logged. There has been no quality control done on these files prior to the averaging. Those wishing more accurate and quality controlled values should process the data in the directories described below in the document.

HLY0901_track.csv

10950,2009/03/18 02:28,63.2094507,-172.5289363,227.2,6.7,234.6,,-1.759,-1.279,26.1927,32.594,0.324,0.032,1.91,288.98,360.48,260.47,260.81,1421.95,-14.74,70.68,1035.20,104.69,7.43,0.35,9.29,101.71,6.28,1.04,8.09,7.519,-1.281,2,-80,-4,0,2,-80,-4,0,16.88,2.2,8.43,0.91
10951,2009/03/18 02:29,63.2081712,-172.5319592,227.1,6.7,234.2,,-1.758,-1.284,26.2043,32.615,0.352,0.035,1.91,286.02,361.14,260.52,260.80,1413.57,-14.80,70.25,1035.20,105.68,7.20,0.47,9.12,107.06,6.54,3.03,8.56,7.656,-1.286,2,-80,-4,0,2,-80,-4,0,17.28,3.2,8.43,0.77
10952,2009/03/18 02:30,63.2070295,-172.5346542,225.9,5.2,235.4,,-1.758,-1.287,26.2101,32.626,0.415,0.042,1.91,265.21,361.58,260.52,260.70,1391.30,-14.84,70.25,1035.23,107.69,7.36,0.30,9.13,107.76,6.24,2.74,8.08,7.661,-1.288,2,-80,-4,0,2,-80,-4,0,15.40,1.6,8.43,0.77

Field	Data	Example	Units
01	ID	10950	sample count
02	date	2009/03/18 02:28	date & time UTC (year/month/day hour:minute)
03	lat	63.2094507	$INGGA, POSMV Latitude (decimal degrees)
04	lon	-172.5289363	$INGGA, POSMV Longitude (decimal degrees)
05	cog	227.2	$INVTG, POSMV Course Over Ground (angular distance from 0 (North) clockwise through 360, 1 minute average)
06	sog	6.7	$INVTG, POSMV Speed Over Ground (Knots, 1 minute average
07	heading	234.6	$PASHR, POSMV ship heading(angular distance from 0 (North) clockwise through 360, 1 minute average)
08	depth		$SBCTR, Seabeam centerbeam depth(meters, 1 minute average)
09	SST	-1.759	$PSSTA, SBE3s RemoteTemperature, Sea Chest intake (Celsius, 1 minute average)
10	TSG_InTemp	-1.279	$PSTSA, SBE45 Water Temperature (Celsius, 1 minute average)
11	TSG_Cond	26.1927	$PSTSA, SBE45 Water Conductivity (millisiemens/centimeter, 1 minute average)
12	TSG_Sal	32.594	$PSTSA, SBE45 Water Salinity (PSU, 1 minute

Field	Data	Example	Units
			average)
13	SCF-FL	0.324	$PSFLA, Seapoint Fluorometer (Ug/l, 1 minute average)
14	SCF-FL-V	0.032	$PSFLA, Seapoint Fluorometer (Volts, 1 minute average)
15	tsg_flow_A	1.91	$PSFMA, Flowmeter in-line with PSTSGA, PSOXA, PSFLA (LitersPerMinute, minimum value in 1 minute interval)
16	SWR	288.98	$PSSRA, Short Wave Radiation (W/M^2, 1 minute average)
17	LWR	360.48	$PSSRA, Long Wave Radiation (W/M^2, 1 minute average)
18	LWR_Dome_T	260.47	$PSSRA, LWD Dome Temperature (Deg K, 1 minute average)
19	LWR_Body_T	260.81	$PSSRA, LWD Body Temperature (Deg K, 1 minute average)
20	PAR	1421.95	$PSSPA, Surface PAR (uE/Sec/M^2, 1 minute average)
21	JS_Air_Temp	-14.74	$PSATC, Bow Jackstaff Air Temperature (Deg C, 1 minute average)
22	Bridge_RH	70.68	$PSMEB, Bridge RM Young Relative Humidity (%, 1 minute average)
23	Bridge_Baro	1035.20	$PSMEB, Bridge RM Young Barometric Pressure (millibars, 1 minute average)
24	JS_WndDirR	104.69	$PSWDC, Jackstaff Relative wind direction (deg, 1 minute average)
25	JS_WndSpdR	7.43	$PSWDC, Jackstaff Relative wind speed (m/s, 1 minute average)
26	JS_WndDirT	0.35	$PSWDC, Jackstaff True wind direction (deg, 1 minute average)
27	JS_WndSpdT	9.29	$PSWDC, Jackstaff True wind speed (m/s, 1 minute average)
28	MM_WndDirR	101.71	$PSWDB, Main Mast Relative wind direction (deg, 1 minute average)
29	MM_WndSpdR	6.28	$PSWDB, Main Mast Relative wind speed (m/s, 1 minute average)
30	MM_WndDirT	1.04	$PSWDB, Main Mast True wind direction (deg, 1 minute average)
31	MM_WndSpdT	8.09	$PSWDB, Main Mast True wind speed (m/s, 1 minute average)
32	SBE_Oxy	7.519	$PSOXA, SBE-43 Oxygen(ml/l, 1 minute average)

Field	Data	Example	Units
33	SBE_Oxy_T	-1.281	$PSOXA, SBE-43 Oxygen Temperature(Deg C, 1 minute average)
34	WinchAft	2	Aft A-Frame Winch number
35	TensionAft	-80	Aft A-Frame Winch Wire tension(Pounds, 1 minute average)
36	WireOutAft	-4	Aft A-Frame Winch Wire out (Meters, 1 minute average)
37	SpeedAft	0	Aft A-Frame Winch Wire speed(Meters/minute, 1 minute average)
38	WinchSbd	2	Starboard A-Frame Winch number
39	TensionSbd	-80	Starboard A-Frame Winch Wire tension(Pounds, 1 minute average)
40	WireOutSbd	-4	Starboard A-Frame Winch Wire out (Meters, 1 minute average)
41	SpeedSbd	0	Starboard A-Frame Winch Wire speed(Meters/minute, 1 minute average)
42	StbdWndSpdT	16.88	RMYoung True Wind Speed, starboard(Knots, 1 minute average)
43	StbdWndDirT	2.2	RMYoung True Wind Direction, starboard(angular distance from 0 (North) clockwise through 360, 1 minute average)
44	OxySat	8.43	Dissolved oxygen (DO) saturation as a funciton of T and S (Weiss)(ml/L, 1 minute average)
45	AOU	0.91	Apparent Oxygen Utilization (AOU)(ml/L,1 minute average)

File Formats of Data Collected Underway

The formats of the Under way data files that were collected on this cruise are in a separate document named HLY0901_Sensors. This is now a separate document due to its large size. The file HLY0901_Sensors.htm is found in the Meta_Data directory. A PDF version of this file should also be here. To use this html file you will need to have the directory HLY0901_Sensors_files in the same directory as the html file.

Also in the Meta_Data directory there may be some PDF files for data that was collected but not part of the normal science routine.

APPENDIX:

Acquisition Problems and Events

A electronic logbook (elog) is utilized on the ship for logging of science related problems and events as they happen. A dump of the logbook is done at the end of the cruise and saved in the Meta_Data directory under the "elog" subdirectory. Two logbooks are kept: one by the technical support personnel and one of entries by the science party watchstanders. Several dump formats are made available such as html, csv, xml and raw. These logs should be consulted to help identify instrument and system anomalies affecting data quality. Times are reported in GMT (UTC, Z).

Below here is a summary of technical logbook. For exact details you should check the files in elog. The science watchstanders log is not summarized here.

Date	*Time(UTC)*	*Comment*
03/09/09	21:48	Start LDS logging for HLY0901
03/10/09	23:12	Start SCS for HLY0901
03/10/09	23:46	HCO Met3A Sensor replaced with #1393
03/10/09	23:57	Seabeam to Survey mode
03/10/09	23:59	Knudsen started
03/11/09	00:28	Science Seawater started for HLY0901
03/11/09	01:00	Science Seawater amounts adjusted
03/11/09	07:43	Seabeam stopped about 10 minutes ago
03/11/09	07:56	Seabeam rebooted, Tape drive turned off
03/11/09	16:16	Seabeam stopped
03/11/09	16:28	Seabeam rebooted
03/11/09	18:20	Seabeam quality off due to IBS time not good
03/11/09	18:58	Seabeam IBS time good again 30 minutes ago
03/12/09	00:46	Seabeam IBS time good wondering alot
03/12/09	23:48	HCO MET3A sensor not working any more
03/13/09	03:20	New SVP for Seabeam for XBT and ARGO R4900844_051
03/13/09	05:18	Timeserver Antenna broken, no Timeservers
03/13/09	16:43	SCS shows no MK27 Gyro data
03/13/09	17:45	ADCP 75 shutdown for UPS work
03/13/09	18:53	SCS shows MK27 Gyro data again
03/13/09	17:49	ADCP 75 recording again
03/13/09	19:00	Map-2 was shutdown for UPS work and is back up again.
03/13/09	19:01	Map-3 was shutdown for UPS work and is back up again.
03/13/09	19:02	Map-4 was shutdown for UPS work and is back up again.
03/13/09	19:03	Map-5 was shutdown for UPS work and is back up again.
03/13/09	23:59	New Timeserver antenna, Timeservers running again
03/14/09	00:20	Science Seawater had ice blockage a bit ago
03/14/09	04:08	New SVP from CTD 1
03/15/09	04:08	Climate Control chamber plots started on MRTG
03/16/09	00:02	Up to now the Oxygen TSG sensor had wrong cal, right one now
03/16/09	06:04	ADU5 stop at 05:04Z
03/16/09	06:29	ADU5 reset and started at 06:18Z
03/16/09	19:12	QC plot for Climate Control chambers started and done for previous

Date	*Time(UTC)*	*Comment*
		times
03/20/09	04:38	LDS winch data adjusted. The whole cruise should be right now
03/22/09	20:33	ISUS added to seawater system, not logged yet
03/22/09	20:59	IBS will be down for several hours
03/23/09	00:28	IBS back up
03/25/09	02:45	Seabeam now getting ZDA from POSMV instead of IBS.
03/25/09	23:23	Start ADCP75 Vice versa syncing to SCS since it never was started
03/25/09	23:37	Note no POSMV data. Powered off by ETs at 22:55Z, restarted it.
03/26/09	18:14	Science Seawater down for ECC Maintenance at 16:38Z
03/27/09	16:08	ADCP 75 stopped and restarted. Stopped at about 07:50Z
03/29/09	07:13	Note Gravimeter 221 went bad 3/24/9 at 20:30
03/29/09	18:04	Stop SCS
03/29/09	18:05	Restart SCS, added ISUS logging
03/29/09	18:05	Note no heading data from MK27
03/29/09	20:45	Both Climate Control Chambers off for cleaning and work
03/30/09	06:34	ADU5 lost heading data about 0700Z 3/29
03/30/09	06:41	ADU5 heading reset and back
03/30/09	18:50	Precipitation Gauge stopped working at 1658Z, fix in port
03/30/09	21:28	Adjust seabeam surface and 100 depth sound velocity
03/30/09	21:56	Change seabeam SVP to ARGO float R4900855_018
03/31/09	14:10	Seabeam and Sub Bottom have lost bottom for a while
03/31/09	14:53	Seabeam shutdown
03/31/09	15:30	Lost some Sub Bottom due to shallow a bottom limit
03/31/09	15:52	Seabeam is back up but has been fairly flaky
03/31/09	15:52	Note that SCS data stopped copying in data. 03/27/2009 18:10:32. Data resumes 03/28/2009 00:00
03/31/09	19:38	Science Seawater secured for arrival in Dutch Harbor
03/31/09	19:41	ADCP 75 stopped for end of HLY0901
03/31/09	19:44	Seabeam to Idle for end of HLY0901
03/31/09	19:56	DS stopped, end of HLY0901

Comments that might help when using the data

The SCS system has to be stopped when fixing some kinds of issues. If this is the case, you should consult the elog entries for possible explanations. You can also look for the corresponding data in the LDS_Data directories. The data may have been recorded there.

The Knudsen data written into SCS_Data/Knudsen has an inconsistent time in the data. The time that the SCS writes to the start of the KEA file should be used. The Knudsen internal clock adds about 22.8 seconds to the internal clock each day near 00:00. But this is reset when the recording program is started up and when watchstanders manually synchronize the time. Use only the SCS time stamp for time in this data and it should be fine. The accuracy of the time in the SEG-Y files and KEB files should be inspected and compared to the time-stamped KEA records.

The SeaBeam data is raw and unedited. This data may need significant editing and care depending on the intended use. The SeaBeam 2112 has significant issues with the near-nadir beams: the bathymetry tends to be less repeatable in the near-nadir region compared to the middle of the swath. The outer beams are noisier in the icebreaker 2112 installations than those installed on non-icebreakers.. The acoustic noise plus bubble-sweep down and masking by ice under the hull all contribute to degrading the data quality while operating in ice.

The Knudsen subbottom data is not an accurate source of water depth for a number of reasons, including the fact that it is always recorded using a sound speed of 1500 meters/second., because the beam pattern Is large (3- to 60 degrees), because of it's bottom detection algorithm and because it penetrates the seafloor.

During the cruise at various times the re were people changing the water flow in the Science Sea Water system to test the system's response to various flow rates in the ice. This changes the amount of water going through the TSG and has discernable impact on the dissolved oxygen measurement among other things. You should closely follow the elog entries for the TSG to see when water flow rates were adjusted. These events were not always accurately entered into elog.

The ADCP file naming uses a series number after a base name. In starting up the ADCP 75 for this cruise the base name of the ADCP was misnamed to HLY09T01 instead of HLY0901. Details of events that affect the ADCP data recording were logged in both the Technicans' and the Watch Standers' electronic logs for the cruise.

The POSMV navigation system reports it's location as the master reference point and not at the antenna locations above the Helicopter Control Shack (HCO). The Location of the Master Reference Point (MRP) can be seen in the diagram at the end of this document showing instrument locations on the ship.

Earlier in the cruise it was noted that the TSG Oxygen sensor was using the incorrect Calibration values. This was corrected on 03/15/09 at 23:58:00 UTC. Prior to that time the data should be considered suspect.

The ADCP 75 has missing data for an unknown reason. There is a day and a half gap from about 07:50 UTC 3/26/9 to about 16:00 UTC 3/27/9. A listing of one file type in the adcp75 directory is:

10486665	Mar 25 11:17	data/Raw/adcp75/HLY09T01005_000028.ENS
10486665	Mar 25 21:00	data/Raw/adcp75/HLY09T01005_000029.ENS
10486665	Mar 26 06:42	data/Raw/adcp75/HLY09T01005_000030.ENS
1234440	Mar 26 07:50	data/Raw/adcp75/HLY09T01005_000031.ENS
1490805	Mar 27 17:29	data/Raw/adcp75/HLY09T01006_000000.ENS

Three Ultrasonic wind sensors were operated in addition to the ship's 2 existing sensors. These sensors operated satisfactorily for the leg. Care should be taken when using the HCO shack and Bow Jackstaff data since these data seem to be affected by the ship's deck house and the wind direction.

The Gravity Meter BGM-3 #221 started showing a platform DNV on Mar 24, 20:30:01 UTC 2009. Inspection of the system showed that the "system malf" and the "data not valid" lights are on. However plots of the data show no unusual offset. After this date the Gravity data for BGM-3 #221 should be considered suspect.

It was noted that SCS did not record data for the copy on Seaventure for all the loggers starting at 03/27/2009,18:10:32. Data resumes 03/28/2009,00:00. This should be fixed in the final distribution disk. But the user should be aware and check that the data is there.

Science Seawater sensor coefficient correction, March 15, 2009

Earlier in the cruise it was noted that the TSG Oxygen sensor was using the incorrect Calibration values. This was corrected on 03/15/09 at 23:58:00 UTC. Prior to that time the data should be considered suspect. (see the Note Below)

USCGC Healy
Science Seawater sensor coefficient correction
March 15, 2009

SBE-43 Oxygen sensor serial number and calibration coefficients used in the Science Seawater System on USCGC Healy (Mar 04 0000Z – 15 2358Z, 2009) were incorrect.

Oxygen sensor #1333 was in the system recording data during this time period, but sensor #1307's coefficients were being used. The oxygen data during this time period should be for qualitative use only, unless corrected with corresponding coefficients.

SAMOS parameter "OX"

		Soc	Voffset	Tau20	A	B	C	E
SBE-43	#1307	0.3828	-0.4782	1.83	-8.3074e-4	2.0208e-4	-3.7052e-6	0.036
SBE-43	#1333	0.4660	-0.4960	1.04	-1.3843e-3	1.2053e-4	-1.9443e-6	0.036

Oxygen (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * T2+ C * T3) * OxSol(T,S) * exp(E * P / K)

V = voltage output from SBE43

T = temperature [deg C]

S = salinity [PSU]

K = temperature [deg K]

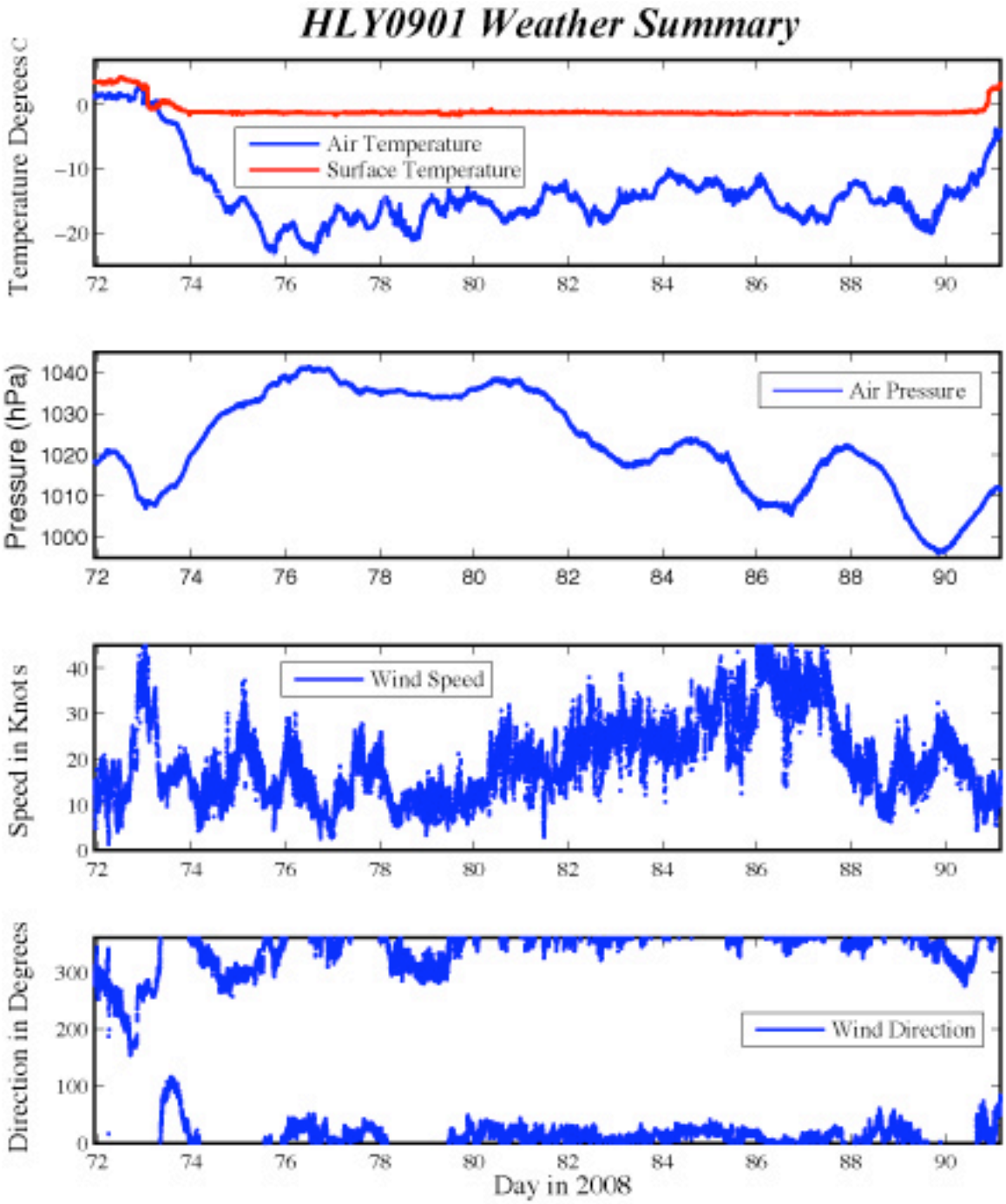
OxSol(T,S) = oxygen saturation [ml/l]

P = pressure [dbar]

Residual = instrument oxygen - bath oxygen

The temperature used in the above calculation comes from: "The SBE43 does not output a temperature value. However one is needed to calculate oxygen. The source of the oxygen temperature can be any device in the seawater line where the SBE43 is installed; such as a thermistor. In the case of the Healy the source of this temperature value is the SBE45 TSG. This device outputs temperature that is already calculated."

Cruise Weather Summary



Underway Sensors and Calibrations

Sensors and Calibrations

HLY0901 Shipboard Sensors

Sensor	Description	Serial #	Last Calibration Date	Status
Meteorology & Radiometers				
Port Yard Arm Anemometer	RM Young 09101	L001	12/01/08	Collected
Stbd Yard Arm Anemometer	RM Young 09101	L003	03/07/07	Collected
Barometer	RM Young 612011	BP01643	02/22/08	Collected
Air Temp/Rel. Hum.	RM Young 41382V	13352	02/22/08	Collected
Helo shack PAR	BSI QSR-2200	20270	01/09/07	Collected
Shortwave Radiation	Eppley labs - PSP	35032F3	11/11/08	Collected
Longwave Radiation	Eppley labs - PIR	34955F3	11/13/08	Collected
Helo shack MET3A Barometer, Relative Humidity, Temperature	Paroscientific MET3A	103943	06/27/07	Collected
HCO Precipitation	RM Young 50202	1567	1/19/09	Collected
Jack Staff Temperature	41342LC	15166	12/17/08	Collected
Jack Staff Ultrasonic Anemometer	RM Young 85004	00894	09/20/07	Collected
Yard Arm Stbd Ultrasonic Anemometer	RM Young 85004	00704	09/20/07	Collected
Helo shack Ultrasonic Anemometer	RM Young 85004	00703	09/20/07	Collected
Underway Ocean				
TSG	SeaBird SBE45	0215	01/09/09	Collected
Remote Sea Temp	SeaBird SBE3S	4063	12/13/08	Collected
Fluorometer	Seapoint SCF	SCF2957	12/15/07	Collected
Oxygen Sensor	SeaBird SBE-43	1333	01/20/09	Collected
Wet lab Flowmeter	Flocat C-ES45-B003	09061005	01/07/08	Collected
Wet lab Pressure	Hiller1	001P	12/15/07	Collected
Bow Flowmeter	Signet P51530-PO	60012089621	01/07/08	NOT Collected

Sensor	Description	Serial #	Last Calibration Date	Status
Ultraviolet Spectrophotometer	Satlantic MBARI-ISUS V3	0141	01/15/09	Collected
Sonars				
Knudsen- subbottom	320 B/R	K2K-00-0013	N/A	Collected
ADCP 150 kHz	Broad Band (BB150)	80	N/A	Collected
ADCP 75 kHz	Ocean Surveyor	172	N/A	Collected
Multibeam	Seabeam 2112	?	N/A	Collected
Speed log	Sperry SRD500	?	N/A	Collected
Navigation				
P-Code GPS (aft)	Trimble Centurion	0220035469	N/A	Collected
Attitude GPS	Ashtech ADU5	AD520033513	N/A	Collected
DGPS	Trimble AGGPS-AG132	0224016199	N/A	Collected
POSMV	Model- MV V4	2306	N/A	Collected
P-Code GPS (fwd)	Rockwell Collins	?	N/A	Collected
Glonass GPS	?	?	N/A	Collected
GYRO 1	Sperry MK39 Mod 3A PN 03956-1982416-2	340	?	Collected
GYRO 2	Sperry MK27A 4800880-1	025	N/A	Collected

HLY0901- CTD Sensors

Sensor	Comments	Serial #	Last service/ Calibration Date	Status
CTD sensor	SBE 911plus	639	01/14/09	
Pressure Sensor #1	Digiquartz with TC	83012	01/14/09	Collected
Temperature #1	SBE3- Primary	2841	12/18/08	Collected
Temperature #2	SBE3- Secondary	2824	12/18/08	Collected
Conductivity #1 *	SBE4- Primary	2545	12/18/08	Collected
Conductivity #1 *	SBE4- Primary	2575	01/08/09	Collected
Conductivity #2	SBE4- Secondary	2619	12/18/08	Collected
Pump	SBE5 Primary	3115	01/08	NA
Pump	SBE5 Secondary	3112	01/08	NA
Deck Unit	SBE 11-Plus V2	0417	12/07	NA
Altimeter	PSA916	843	01/08	Collected
Oxygen *	SBE43	456	12/17/08	Collected
Oxygen *	SBE43	458	12/17/08	Collected
Fluorometer	Chelsea-Aquatrack3	088234	03/06/07	Collected
Transmisometer	Wetlabs	CST-390DR	02/27/07	Collected
PAR	Bioshperical QSP2300	70115	12/01/08	Collected
Carousel	SBE32- 12 place	347	01/08	NA

* indicates used for part of HLY0901.

Sensor Serial Numbers used for HLY0901 CTD Casts

CTD Cast Numbers	1-4	5-18	19-end
Temperature #1	2841	2841	2841
Temperature #2	2824	2824	2824
Conductivity #1	2545	2575	2575
Conductivity #2	2619	2619	2619
Oxygen	456	456	458

Software Versions of some Recording programs

System	Program	Version number
CTD	Seabird SeaSave	7.18c
XBT	Turo XBT software	3.03.01
XBT	Sippican (Old system)	2.1.2

HLY0901 Sensor Calculations

The coefficients for temperature, conductivity, fluorometer and turbidity sensors can be found in the calibrations sheets below in the Appendix.

Calculating PAR for surface PAR

raw data = mV
calibration scale = 6.08 V/(μEinstiens/cm ^{2}sec)
offset (V_{dark}) = 0.3 mV
(*raw* mV - V_{dark})/scale x 10^4 cm^2/m^2 x 10^{-3} V/mV= μEinstiens/m^2sec
or
(*data* mV – 0.3 mV) x 1.65 (μEinstiens/m^2sec)/mV = μEinstiens/m^2sec

Calculating Pyrgeometer Values

V = Eppley PIR Thermopile voltage

S = Sensitivity (Calibration factor from Eppley Cal sheet)

S = 3.32

J = Stefan-Boltzmann Constant

J = 5.6697e-8

B = [absorption constant (for Eppley Black paint formula) 0.985 / dome glass IR transmission 0.5]

B= 3.5 for Stock Eppley PIR

Tb = Eppley Body Temperature in degrees Kelvin

Td = Eppley Dome Temperature in degrees Kelvin

Tb and Td calculated as follows:

T = 1/ (a + ln(Vo/Irt)*(b + c*(ln(Vo/Irt)**2)));

Irt = (Vref-Vin)/R1

On Healy R1 = 82500 Vref = 5.0

a= 0.0010295 b= 0.0002391 c = 1.568e-7

W/M2 = V/S + (J * Tb^4) + (B*J*(Tb^4 - Td^4))

Calibrations

The following pages are replicas of current calibration sheets for the sensors used during this cruise.

Meteorology & Radiometers

Yard Arm R.M. Young Wind Bird, Starboard

Serial # L001

R. M. Young Wind bird Calibration Results
Model # 09101, S/N L003 (Starboard Windbird)
As per Young Meteorological Instruments
Wind System Calibration Manual

Date: 07 Mar 07 Technician: ET1 Berringer / ETC Rodda

Wind speed torque: Passed

Maximum toque = 2.4 gm/cm
Test results:
CW 0.7
CCW 0.7

Wind direction torque: Passed

Maximum toque = 30 gm/cm

Test results:
CW 20 gm/cm
CCW 22 gm/cm

Wind speed signal:

Maximum % error = 1%

Test results: Passed

Actual RPM	Actual Wind Speed	Measured	% Error
200	1.90	1.9	0.21
500	4.76	4.8	0.84
1200	11.42	11.4	0.21
3600	34.27	34.3	0.08
5000	47.60	47.6	0.00

Note; Wind speed in knots = 0.00952 * shaft RPM

Wind direction signal:

Maximum error = +/- 2 degrees

Test results: Failed – off by 1 degree

Actual	Meaured	Error
0	358	-2
30	27	3
60	58	2
90	88	2
120	118	2
150	149	1
180	178	2
210	207	3
240	238	2
270	268	2
300	297	3
330	327	3

Yard Arm R.M. Young Wind Bird Port

Serial # L001

R. M. Young Wind bird Calibration Results
Model # 09101, S/N L001

As per Young Meteorological Instruments
Wind System Calibration Manual

Date: 01 DEC 08 Technician: ET3 Adams

` **Wind speed torque:** Passed

Maximum toque =2.40 gm/cm

Test results:

CW: .2 gm/cm
CCW: .2gm/cm

Wind direction torque: Passed

Maximum toque = 30 gm/cm

Test results:

CW 15gm/cm
CCW 15gm/cm

Wind speed signal: Passed

Maximum % error = 1%

Test results:

Actual RPM	Actual Wind Speed	Measured	% Error
200	1.90	1.9	0.00
500	4.80	4.8	0.00
1200	11.40	11.4	0.00
3600	34.30	34.2	0.29
5000	47.60	47.6	0.00

Note; Wind speed in knots = 0.00952 * shaft RPM

Wind direction signal: Passed

Maximum error = +/- 2 degrees

Test results:

Actual	Meaured	Error
0	0	-1
30	31	-1
60	62	-2
90	92	-2
120	121	-1
150	150	0
180	179	1
210	210	0
240	240	0
270	268	2
300	300	0
330	331	-1

Bridge Barometer

Serial # BP01643

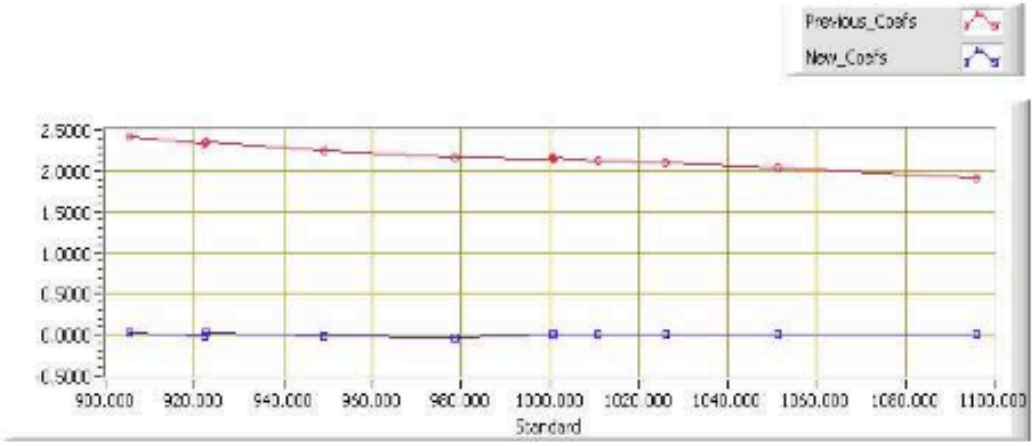
Baro Pres Calibration Report
STS/ODF Calibration Facility

SENSOR SERIAL NUMBER: BP01643
CALIBRATION DATE: 22-Feb-08
SENSOR ID: BPR80
Mfg: RM Young Model: 612011
Previous Cal Date: 01-Jan-00
Calibration Tech: CM
CALIBRATION AT 25.0 DegC

A= 5.98528E+1
B= 8.02635E+2

Calibration Standard: Mfg: Paroscientific Model: 765-16B s/n: 101778
Polynomial Order = 1
Xcalc = A*X+B

SENSOR VOLTS	STANDARD DATA	SENSOR New_Coefs	SPRT-INST Prev_Coefs	SPRT-INST New_Coefs
4.901	1095.960	1095.953	1.920	0.007
4.151	1051.090	1051.086	2.028	0.004
3.731	1025.970	1025.963	2.092	0.007
3.475	1010.640	1010.645	2.118	-0.005
3.306	1000.490	1000.479	2.159	0.011
3.314	1000.990	1000.986	2.151	0.004
2.939	978.480	978.517	2.165	-0.037
2.445	948.980	949.001	2.254	-0.021
2.004	922.570	922.555	2.355	0.015
1.998	922.190	922.205	2.326	-0.015
1.713	905.210	905.180	2.413	0.030



Bridge Air Temperture / Relative Humidity

Serial # 13352

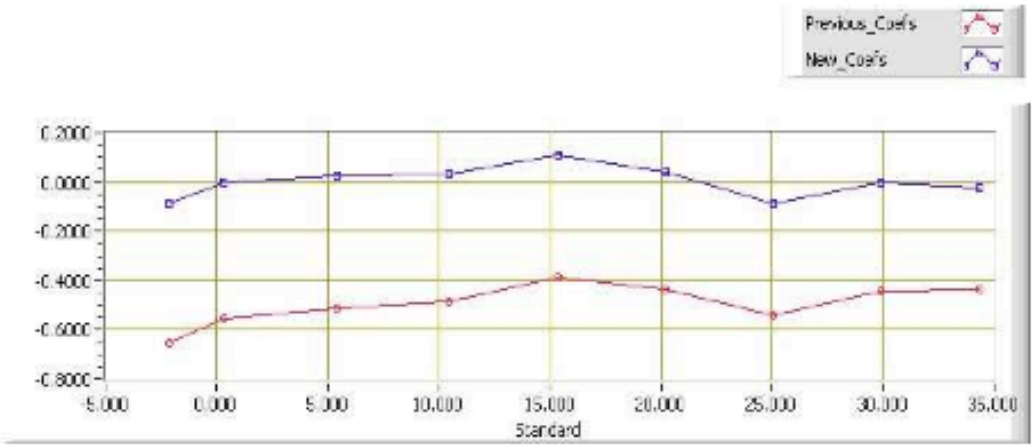
Air Temperature Calibration Report
STS/ODF Calibration Facility

SENSOR SERIAL NUMBER: 13352
CALIBRATION DATE: 22-Feb-08
SENSOR ID: HRH17
Mfg: RM Young Model: 41382V
Previous Cal Date: 01-Jan-2000
Calibration Tech: CM

A= 1.01413E+2
B= -5.07642E+1

Calibration Standard: Mfg: Seabird Model: SBE35 s/n: 0006
Polynomial Order = 1
Xcalc = A*X+B

SENSOR	STANDARD DATA	SENSOR New_Coefs	SPRT-INST Prev_Coefs	SPRT-INST New_Coefs
0.480	-2.122	-2.035	-0.652	-0.087
0.504	0.337	0.338	-0.557	-0.001
0.554	5.421	5.398	-0.513	0.023
0.603	10.448	10.418	-0.485	0.030
0.651	15.345	15.235	-0.386	0.110
0.699	20.190	20.154	-0.439	0.036
0.748	25.029	25.113	-0.539	-0.084
0.796	29.914	29.920	-0.442	-0.006
0.840	34.361	34.382	-0.439	-0.021



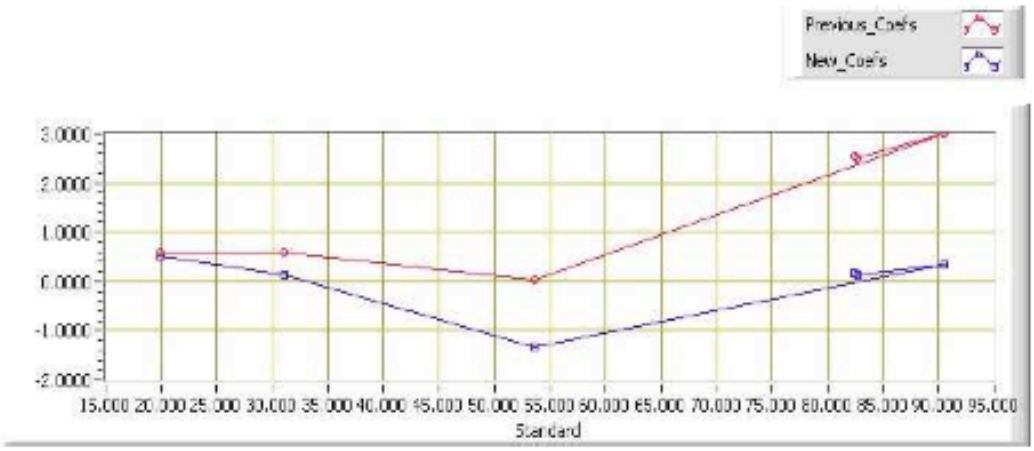
HUMIDITY Calibration Report
STS/ODF Calibration Facility

SENSOR SERIAL NUMBER: 13352
CALIBRATION DATE: 24-Feb-08
SENSOR ID: HRH17
Mfg: RM Young Model: 41382V
Previous Cal Date: 01-Jan-2000
Calibration Tech: CM

A= 1.04836E+2
B= -6.79727E-1

Calibration Standard: Mfg: GE Sensing Model: Humilab s/n: 0240507
Polynomial Order = 1
Xcalc = A*X+B

SENSOR	STANDARD DATA	SENSOR New_Coefs	SPRT-INST Prev_Coefs	SPRT-INST New_Coefs
0.791	82.450	82.266	2.539	0.184
0.794	82.710	82.560	2.516	0.150
0.866	90.460	90.108	2.994	0.352
0.530	53.570	54.904	0.020	-1.334
0.301	31.000	30.876	0.599	0.124
0.192	19.920	19.396	0.579	0.524



PAR

Serial # 20270

Biospherical Instruments Inc.

CALIBRATION CERTIFICATE

Calibration Date	12/1/2008
Model Number	QSR-2200
Serial Number	20270
Operator	TPC
Standard Lamp	91537(10/25/2006)
Probe Excitation Voltage Range:	6 to 18 VDC(+)
Output Polarity:	Positive

Probe Conditions at Calibration(in air):

Calibration Voltage:	6 VDC(+)
Probe Current:	4.0 mA

Probe Output Voltage:

Probe Illuminated	88.3 mV
Probe Dark	1.3 mV
Probe Net Response	86.9 mV
RG780	1.8 mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

8.83E+15	quanta/cm²sec
0.01467	uE/cm²sec

Calibration Scale Factor:

(To calculate irradiance, divide the net voltage reading in Volts by this value.)

Dry:	9.8382E-18	V/(quanta/cm²sec)
	5.9246E+00	V/(uE/cm²sec)

Notes:

1. Annual calibration is recommended.
2. Calibration is performed using a Standard of Spectral Irradiance traceable to the National Institute of Standards and Technology (NIST).
3. The collector should be cleaned frequently with alcohol.
4. Calibration was performed with customer cable, when available.

QSR240R 05/24/95

Shortwave Radiation Pyranometer

Serial # 35032F3

THE EPPLEY LABORATORY, INC.
12 Sheffield Ave., P.O. Box 419, Newport, RI 02840 USA
Telephone: 401-847-1020 Fax: 401-847-1031
Email: info@eppleylab.com Internet: www.eppleylab.com

EPLAB
Scientific Instruments
for Precision Measurements
Since 1917

STANDARDIZATION OF EPPLEY PRECISION SPECTRAL PYRANOMETER Model PSP

Serial Number: 35032F3

Resistance: 724 Ω at 23 °C
Temperature Compensation Range: -20° to +40 °C

This radiometer has been compared with Standard Precision Spectral Pyranometer, Serial Number 21231F3 in Eppley's Integrating Hemisphere under radiation intensities of approximately 700 watts meter^{-2} (roughly one half a solar conatant).

As a result of a series of comparisons, it has been found to have a sensitivity of:

8.20 x 10^{-6} volts/watts meter^{-2}

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 1400 watts meter^{-2}. This radiometer is linear to within ± 0.5% up to this intensity.

The calibration of this instrument is traceable to standard self-calibrating cavity pyrheliometers in terms of the Systems Internationale des Unites (SI units), which participated in the Tenth International Pyrheliometric Comparisons (IPC X) at Davos, Switzerland in September-October 2005.

Eppley recommends a minimum calibration cycle of five (5) years but encourages annual calibrations for highest measurement accuracy. Unless otherwise stated in the remarks section below or on the Sales Order, the results are "AS FOUND / AS LEFT".

Useful conversion facts: 1 cal cm^{-2} min^{-1} = 697.3 watts meter^{-2}
1 BTU/ft^2-hr^{-1} = 3.153 watts meter^{-2}

Shipped to:
University of California
La Jolla, CA
S.O. Number: 61853
Date: Nov. 14, 2008

Date of Test: Nov. 11, 2008
In Charge of Test: R.T. Eppley
Reviewed by: Thomas D. Kuhn

Remarks:

Longwave Radiation Pyrgeometer

Serial # 34955F3

THE EPPLEY LABORATORY, INC.
12 Sheffield Ave., P.O. Box 419, Newport, RI 02840 USA
Telephone: 401-847-1020 Fax: 401-847-1031
Email: info@eppleylab.com Internet: www.eppleylab.com

EPLAB
Scientific Instruments
for Precision Measurements
Since 1917

STANDARDIZATION OF EPPLEY PRECISION INFRARED RADIOMETER Model PIR

Serial Number: 34955F3

Resistance: 686 Ω at 23 °C
Temperature Compensation Range: -20° to +40 °C

This pyrgeometer has been compared against Eppley's Blackbody Calibration System under radiation intensities of approximately 200 watts meter^{-2} and an average ambient temperature of 25 °C as measured by Standard Omega Temperature Probe, RTD#1.

As a result of a series of comparisons, it has been found to have a sensitivity of:

3.28 x 10^{-6} volts/watts meter^{-2}

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 700 watts meter^{-2}. This radiometer is linear to within ±1.0% up to this intensity.

The calibration of this instrument is traceable to the International Practical Temperature Scale (IPTS) through a precision low-temperature blackbody.

Eppley recommends a minimum calibration cycle of five (5) years but encourages annual calibrations for highest measurement accuracy. Unless otherwise stated in the remarks section below or on the Sales Order, the results are "AS FOUND / AS LEFT".

Shipped to:
University of California
La Jolla, CA.
S.O. Number: 61853
Date: Nov. 14, 2008

Date of Test: Nov. 13, 2008

In Charge of Test: R. T. Eppley

Reviewed by: Thomas J. Kuhn

Remarks:

Helo shack MET3A Station

Serial # 101757

Paroscientific, Inc.
Pressure Instrument Configuration

SN: 101757 Part Number: 1539-004 Model: MET3A Port:

Calibration Date: 27-Jun-07 Report No: 7238 Technician: WMR

Pressure Range: 500 to 1100 hPa Temperature Range: -50 to -60

Customer: Scripps Inst. of Oceanography Report Date: 27-Jun-07

Address : 8825 Biological Grade Sales Order: 24387

La Jolla, CA 92037 USA S/R Number :

Configuration

BL: 0	PT: N
BR: 9600	QD: -
DD: -	QO: -
DL: -	SL: -
DM: -	SN: 101757
DO: -	ST: -
DP: -	SU: -
ID: 01	TI: -
IM: -	TR: 00952
LL: -	TU: -
LH: -	UF: 1.000000
MC: Y	UL: -
MD: 0	UM: -
MN: -	UN: 3
OP: -	US: -
PF: -	VR: M1.02
PI: -	ZI: -
PL: -	ZS: -
PO: -	ZL: -
PR: 00238	ZV: -
PS: -	

Calibration Coefficients

U0:	5.766908	µsec
Y1:	-4015.975	deg C / µsec
Y2:	-17065.37	deg C / µsec²
Y3:	-140256.4	deg C / µsec³
C1:	94.87589	psi
C2:	3.545282	psi / µsec
C3:	-114.9551	psi / µsec²
D1:	0.0345157	
D2:	0.0000000	
T1:	28.00064	µsec
T2:	0.837535	µsec / µsec
T3:	16.78157	µsec / µsec²
T4:	-150.7085	µsec / µsec³
T5:	-129.729	µsec / µsec⁴
TC:	0.6782145	
PA:	0.0000000	
PM:	1.0000000	

Met3/3A Coefficients

R1:	-0.551136	E2:	0.84
F1:	-264.3591	F2:	3.152
G1:	12.56743	G2:	0.00216
H1:	RHT894	H2:	0.0036
K1:	01842	K2:	0.00511
M1:	1	M2:	1
Z1:	0	Z2:	0

Paroscientific, Inc.
4500 148th Ave. N.E. Redmond, WA 98052
Phone: (425)883-8700 Fax: (425)867-5407
Web:http://www.paroscientific.com
Email: support@paroscientific.com

Prepared by

PARO TEST 17

Digiquartz® Technology

Page 1 of 1

Paroscientific, Inc.
4500 148th Avenue N. E. Facsimile: (425) 867-5407
Redmond, WA 98052-5194 Email:salessupport@paroscientific.com
Telephone: (425) 883-8700 Internet:http://www.paroscientific.com

CERTIFICATE OF CALIBRATION

TRANSDUCER MODEL: MET3A

SERIAL NUMBER: 101757

The Paroscientific transducer(s) identified above has been calibrated and tested with one or more of the following primary pressure and temperature standards. All have traceability to the National Institute of Standards and Technology.

Bell and Howell Primary Pressure Standard

Pneumatic Absolute or Gauge Dead Weight Tester Part Number: 6-201-0001, S/N 4034 and S/N 1014

___ Piston/Cylinder: 6-001-0002, P2-919/C2-1523,
Weight Set 1: 6-002-0002
Range: 1.5 to 50 psi [10 to 345 kPa]
Accuracy: 0.010 percent of reading

✓ Piston/Cylinder: 6-001-0002, P2-652/C2-1378,
Weight Set 2: 6-002-0002
Range: 1.5 to 50 psi [10 to 345 kPa]
Accuracy: 0.010 percent of reading

___ Piston/Cylinder: 6-001-0001, P1-949/C1-922 ,
Weight Set 2: 6-002-0002
Range: 0.3 to 5 psi [2 to 34 kPa]
Accuracy: 0.015 percent of reading

DH Primary Pressure Standard

Pneumatic Absolute or Gauge Dead Weight Tester Part Number: PG7601 S/N 161

___ Piston/Cylinder: S/N 305, Mass Set: S/N 2052
Range: 0.7 to 50 psi [5 to 345 kPa] absolute mode, 0.29 to 50 psi [2 to 345 kPa] gauge mode
Accuracy: 0.002 percent of reading

DH Primary Pressure Standard

Pneumatic Gauge Dead Weight Tester, Model 5203, S/N 5557

___ Piston/Cylinder: S/N 4845, Mass Sets: S/N 2032, S/N 3293
Range: 20 to 1,600 psi [0.14 to 11 MPa]
Accuracy: 0.005 percent of reading

DH Primary Pressure Standard

Oil Operated Gauge Dead Weight Tester, Model 5306, S/N 3505

___ Piston/Cylinder: S/N 3375, Mass Set: S/N 2032
Range: 40 to 20,000 psi [0.3 to 138 MPa]
Accuracy: 0.01 percent of reading above 200 psi [1.4 MPa]
or 0.02 psi [0.14 kPa] at lower pressure

___ Piston/Cylinder: S/N 3511, Mass Set: S/N 2032
Range: 145 to 72,500 psi [1 to 500 MPa]
Accuracy: 0.02 percent of reading above 725 psi [5 MPa]
or 0.145 psi [1 kPa] at lower pressure

Hart Scientific Precision Thermometer (MET3A only)

✓ Black Stack model 1560 S/N 97568, PRT Scanner model 2562 S/N A34523, Temperature Probe Model A1959: S/Ns 4424A-02, 4424A-04, 4424A-05, 4424A-06 and 5177C-02.
Range: -50° to 60° C.
Accuracy: .015°C.

PARO TEST 17

Tested By: _____ DATE 6-27-07

Underway Ocean Flow through Sensors

Seabird ThermoSalinograph

Serial # 0215

Temperature

SEA-BIRD ELECTRONICS, INC.
1808 136th Place N.E., Bellevue, Washington, 98005 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0215
CALIBRATION DATE: 31-Dec-08

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

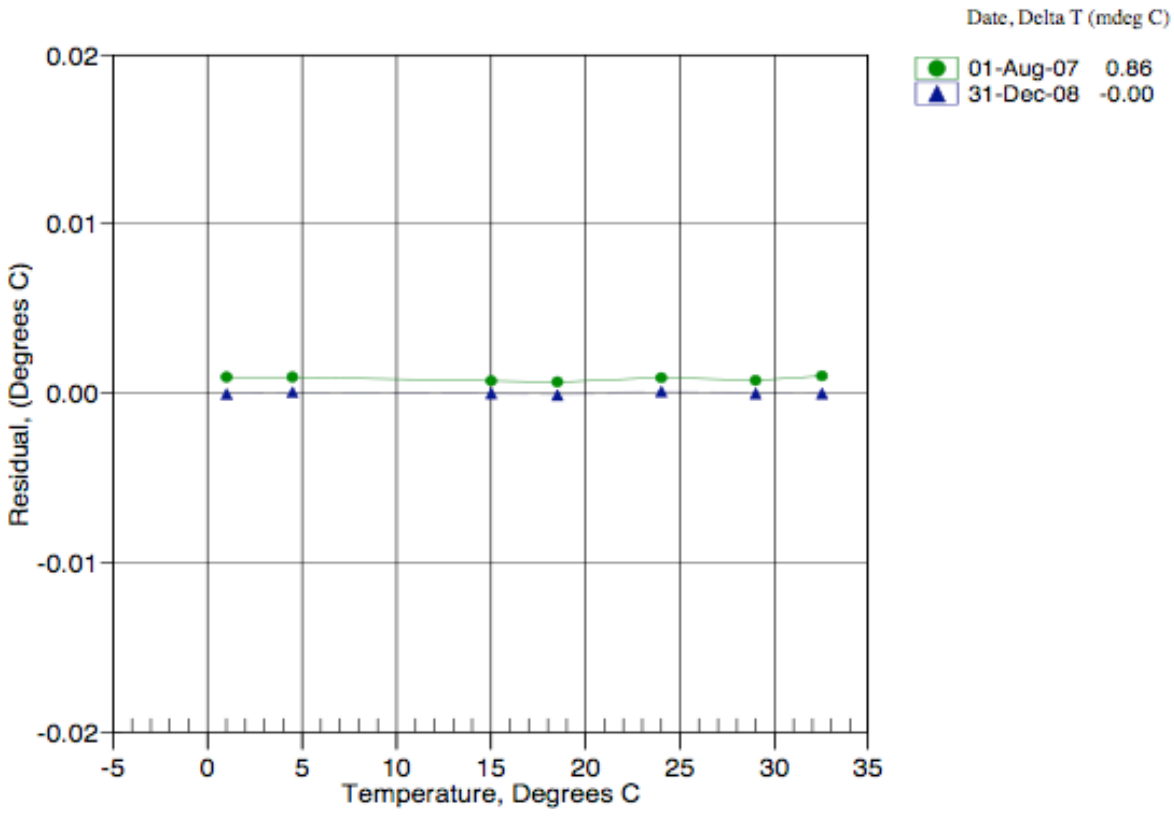
ITS-90 COEFFICIENTS

a0 = -8.503332e-006
a1 = 2.817172e-004
a2 = -2.887758e-006
a3 = 1.665030e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	657839.3	1.0000	-0.0000
4.5000	562413.4	4.5001	0.0001
15.0000	358344.4	15.0000	-0.0000
18.5000	310261.9	18.4999	-0.0001
23.9999	248863.7	24.0000	0.0001
29.0000	204891.6	29.0000	-0.0000
32.5000	179410.7	32.5000	-0.0000

Temperature ITS-90 = $1/\{a0 + a1[ln(n)] + a2[ln^2(n)] + a3[ln^3(n)]\} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



Conductivity

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0215
CALIBRATION DATE: 31-Dec-08

SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g = -9.822539e-001
h =  1.407806e-001
i = -1.197370e-004
j =  3.169131e-005

CPcor = -9.5700e-008
CTcor =  3.2500e-006
WBOTC =  2.4202e-005
```

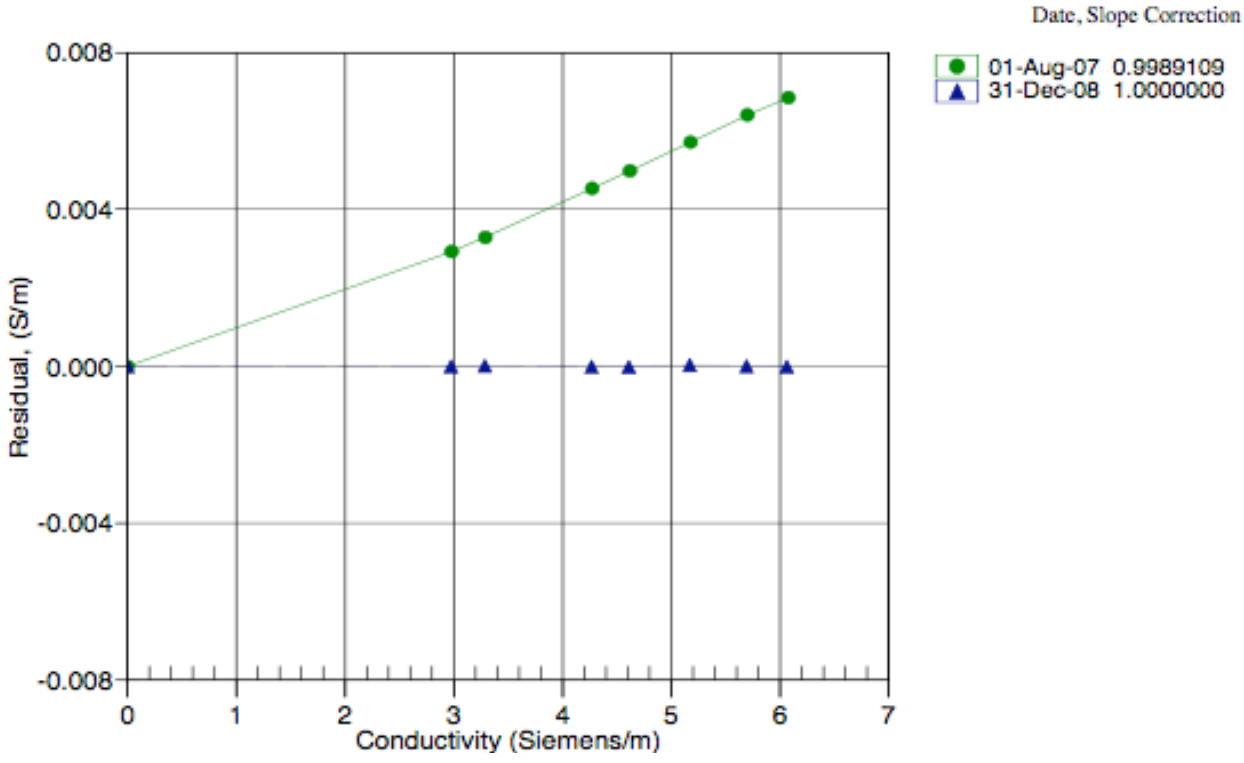
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2641.63	0.00000	0.00000
1.0000	34.8102	2.97549	5297.30	2.97549	-0.00000
4.5000	34.7900	3.28249	5497.85	3.28250	0.00001
15.0000	34.7467	4.26398	6093.86	4.26397	-0.00001
18.5000	34.7376	4.60905	6289.66	4.60904	-0.00002
23.9999	34.7273	5.16684	6593.51	5.16686	0.00002
29.0000	34.7206	5.68841	6865.05	5.68841	0.00000
32.5000	34.7171	6.06065	7052.22	6.06064	-0.00001

f = INST FREQ * sqrt(1.0 + WBOTC * t) / 1000.0

Conductivity = $(g + hf^2 + if^3 + jf^4) / (1 + \delta t + \varepsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = instrument conductivity - bath conductivity



Remote Sea Temperature (Sea Chest)

Serial # 4063

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4063
CALIBRATION DATE: 17-Dec-08

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.29954091e-003
h = 6.37146260e-004
i = 2.12509560e-005
j = 1.65873526e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS

a = 3.68121775e-003
b = 5.99724022e-004
c = 1.62957593e-005
d = 1.66021597e-006
f0 = 2721.793

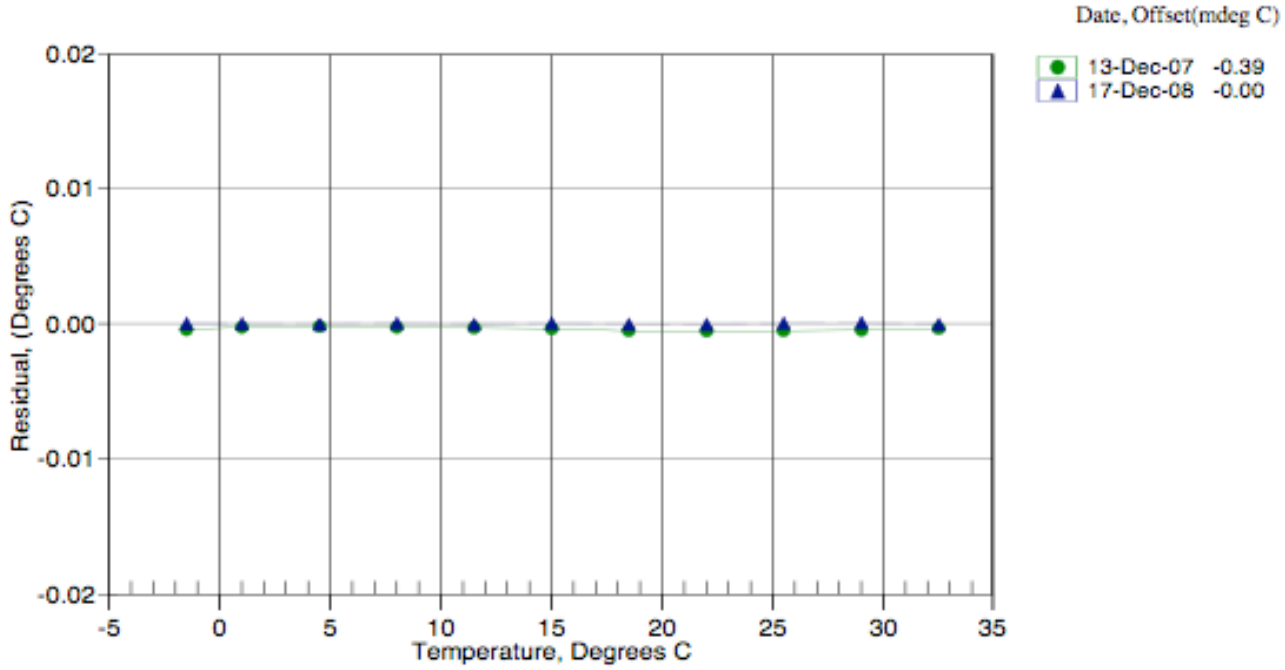
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5004	2721.793	-1.5004	-0.00000
0.9997	2878.779	0.9997	0.00000
4.4997	3109.448	4.4997	-0.00002
7.9996	3353.169	7.9996	0.00004
11.4996	3610.308	11.4996	-0.00003
14.9996	3881.237	14.9996	0.00004
18.4997	4166.295	18.4997	-0.00003
21.9997	4465.819	21.9996	-0.00006
25.4997	4780.158	25.4997	0.00003
28.9997	5109.619	28.9998	0.00007
32.4997	5454.503	32.4997	-0.00004

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



Oxygen Sensor

Serial # 1307

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 1333
CALIBRATION DATE: 05-Jan-09p

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS

Soc = 0.4660
Voffset = -0.4960
Tau20 = 1.04

A = -1.3842e-003
B = 1.2053e-004
C = -1.9443e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS

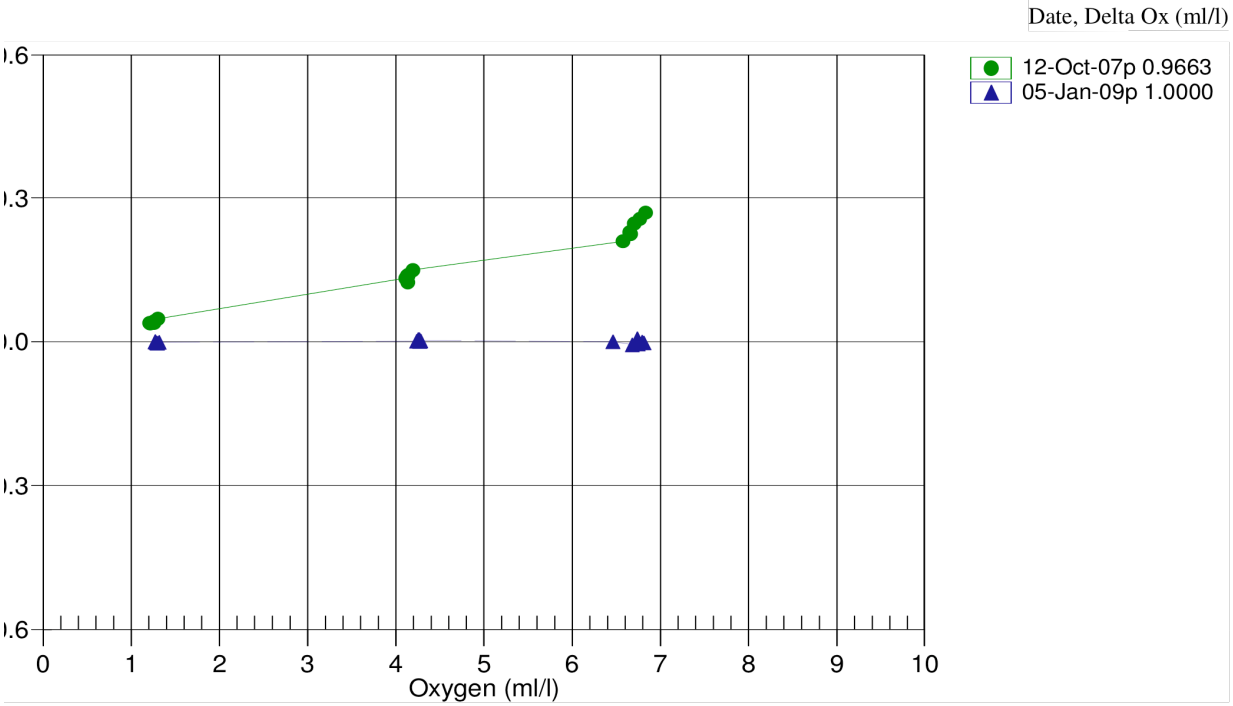
D1 = 1.92634e-4
D2 = -4.64803e-2
H1 = -3.30000e-2
H2 = 5.00000e+3
H3 = 1.45000e+3

BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(VOLTS)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
1.27	12.00	0.01	0.858	1.27	-0.00
1.27	6.00	0.01	0.811	1.27	-0.00
1.27	2.00	0.00	0.779	1.27	0.00
1.28	20.00	0.01	0.926	1.28	-0.00
1.30	26.00	0.01	0.980	1.29	-0.00
1.31	30.00	0.02	1.021	1.31	-0.00
4.24	20.00	0.01	1.919	4.24	0.00
4.25	12.00	0.01	1.709	4.25	0.00
4.25	30.00	0.02	2.198	4.25	0.00
4.27	6.00	0.01	1.553	4.27	0.00
4.27	26.00	0.01	2.092	4.27	0.00
4.28	2.00	0.00	1.448	4.28	0.00
6.46	30.00	0.02	3.081	6.46	-0.00
6.68	26.00	0.01	2.990	6.67	-0.01
6.74	20.00	0.01	2.759	6.74	0.01
6.75	12.00	0.01	2.420	6.74	-0.01
6.79	6.00	0.01	2.176	6.79	-0.00
6.81	2.00	0.00	2.010	6.81	-0.00

$Oxygen\ (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * T^2 + C * T^3) * OxSol(T,S) * \exp(E * P / K)$

V = voltage output from SBE43, T = temperature [deg C], S = salinity [PSU] K = temperature [deg K]

OxSol(T,S) = oxygen saturation [ml/l], P = pressure [dbar], Residual = instrument oxygen - bath oxygen



CTD Sensors

CTD Sensor – Presure Sensor

Serial # 639 and 83012

SEA-BIRD ELECTRONICS, INC.
1808 136th Place N.E., Bellevue, Washington, 98005 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0639
CALIBRATION DATE: 14-Jan-09

SBE9plus PRESSURE CALIBRATION DATA
10000 psia S/N 83012

DIGIQUARTZ COEFFICIENTS:

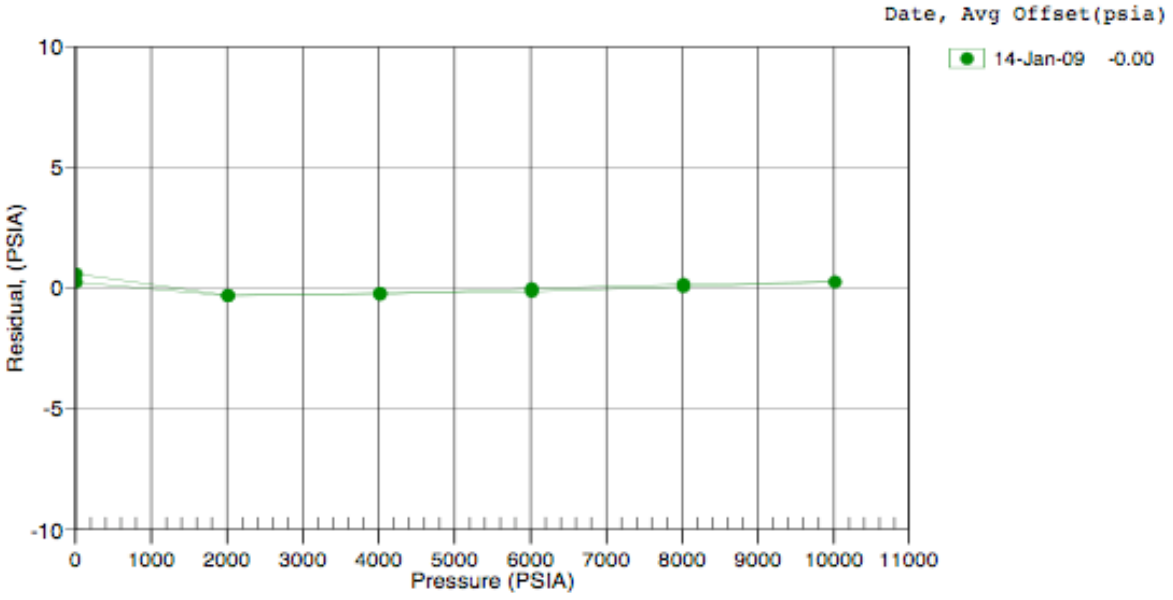
C1 =	-3.840384e+004
C2 =	-2.736111e-001
C3 =	1.081720e-002
D1 =	3.215400e-002
D2 =	0.000000e+000
T1 =	3.019013e+001
T2 =	-1.599643e-004
T3 =	3.601120e-006
T4 =	4.889920e-009
T5 =	0.000000e+000

AD590M, AD590B, SLOPE AND OFFSET:

AD590M =	1.27551e-002
AD590B =	-9.09133e+000
Slope =	0.99960
Offset =	-0.1134 (dbars)

PRESSURE (PSIA)	INST OUTPUT(Hz)	INST TEMP(C)	INST OUTPUT (PSIA)	CORRECTED INST OUTPUT (PSIA)	RESIDUAL (PSIA)
14.827	33132.00	19.6	15.571	15.406	0.579
2015.272	33982.14	19.7	2015.928	2014.963	-0.309
4015.525	34809.10	19.7	4017.027	4015.262	-0.263
6015.448	35614.18	19.7	6017.987	6015.421	-0.027
8015.592	36398.96	19.7	8019.117	8015.751	0.158
10015.843	37164.71	19.8	10020.259	10016.092	0.249
8015.528	36398.90	19.8	8018.953	8015.587	0.059
6015.415	35614.11	19.8	6017.827	6015.261	-0.154
4015.370	34809.06	19.8	4016.926	4015.161	-0.209
2015.280	33982.14	19.8	2015.922	2014.957	-0.322
14.825	33131.86	19.9	15.227	15.062	0.237

Residual = corrected instrument pressure - reference pressure



Temperature #1

Serial # 2841

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 2841
CALIBRATION DATE: 18-Dec-08

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.36183818e-003
h = 6.43754556e-004
i = 2.29302915e-005
j = 2.15053894e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS

a = 3.68121696e-003
b = 6.01398414e-004
c = 1.58890815e-005
d = 2.15206038e-006
f0 = 2991.099

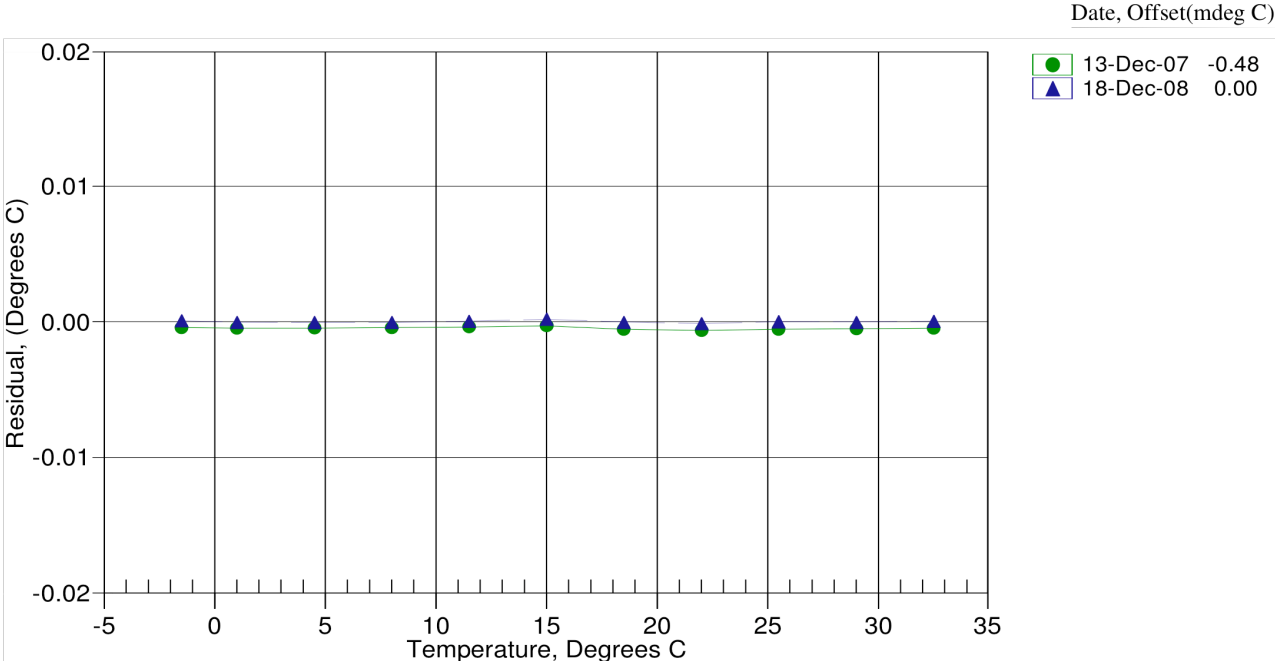
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5004	2991.099	-1.5003	0.00006
0.9996	3163.101	0.9996	-0.00004
4.4996	3415.772	4.4995	-0.00006
7.9996	3682.634	7.9995	-0.00005
11.4996	3964.074	11.4997	0.00005
14.9996	4260.456	14.9998	0.00018
18.4997	4572.116	18.4997	-0.00003
21.9997	4899.419	21.9996	-0.00013
25.4996	5242.714	25.4996	0.00001
28.9997	5602.312	28.9997	-0.00002
32.4996	5978.504	32.4996	0.00004

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



Temperature #2

Serial # 2824

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 2824
CALIBRATION DATE: 18-Dec-08

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.32230352e-003
h = 6.37267548e-004
i = 2.21261090e-005
j = 2.10917721e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS

a = 3.68121746e-003
b = 5.98239841e-004
c = 1.55737429e-005
d = 2.11066204e-006
f0 = 2828.705

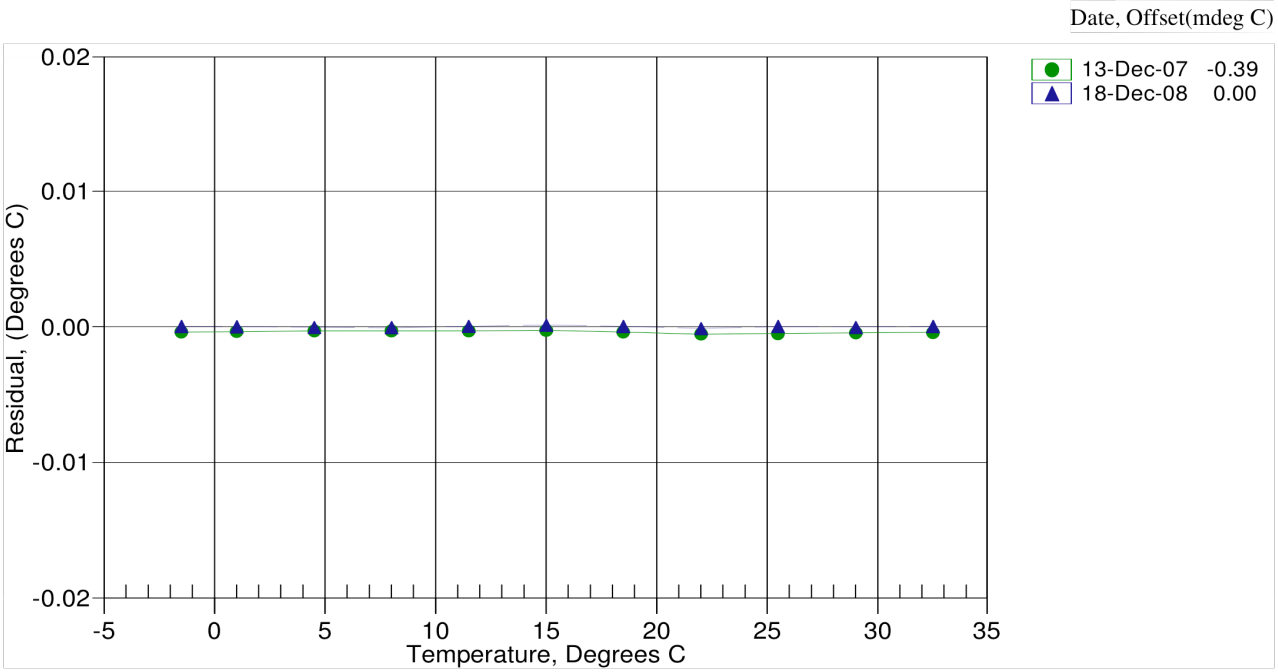
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5004	2828.705	-1.5004	0.00002
0.9996	2992.255	0.9996	0.00000
4.4996	3232.577	4.4996	-0.00003
7.9996	3486.485	7.9995	-0.00007
11.4996	3754.360	11.4996	0.00003
14.9996	4036.550	14.9997	0.00013
18.4997	4333.395	18.4997	0.00003
21.9997	4645.226	21.9996	-0.00013
25.4996	4972.399	25.4996	0.00001
28.9997	5315.213	28.9997	-0.00001
32.4996	5673.950	32.4996	0.00003

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



Conductivity #1

Serial # 2545

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 2545
CALIBRATION DATE: 18-Dec-08

SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS

```
g = -1.06738325e+001
h =  1.64053986e+000
i = -6.82435086e-004
j =  1.65012708e-004
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  4.26643454e-005
b =  1.63913611e+000
c = -1.06716709e+001
d = -8.42014066e-005
m =  4.4
CPcor = -9.5700e-008 (nominal)
```

BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREO (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.55126	0.00000	0.00000
-1.0000	34.6427	2.79189	4.84935	2.79189	-0.00000
0.9999	34.6431	2.96256	4.95528	2.96256	0.00000
15.0000	34.6425	4.25254	5.69213	4.25256	0.00001
18.4999	34.6416	4.59768	5.87348	4.59765	-0.00003
29.0000	34.6376	5.67633	6.40704	5.67637	0.00004
32.5000	34.6312	6.04735	6.58042	6.04733	-0.00002

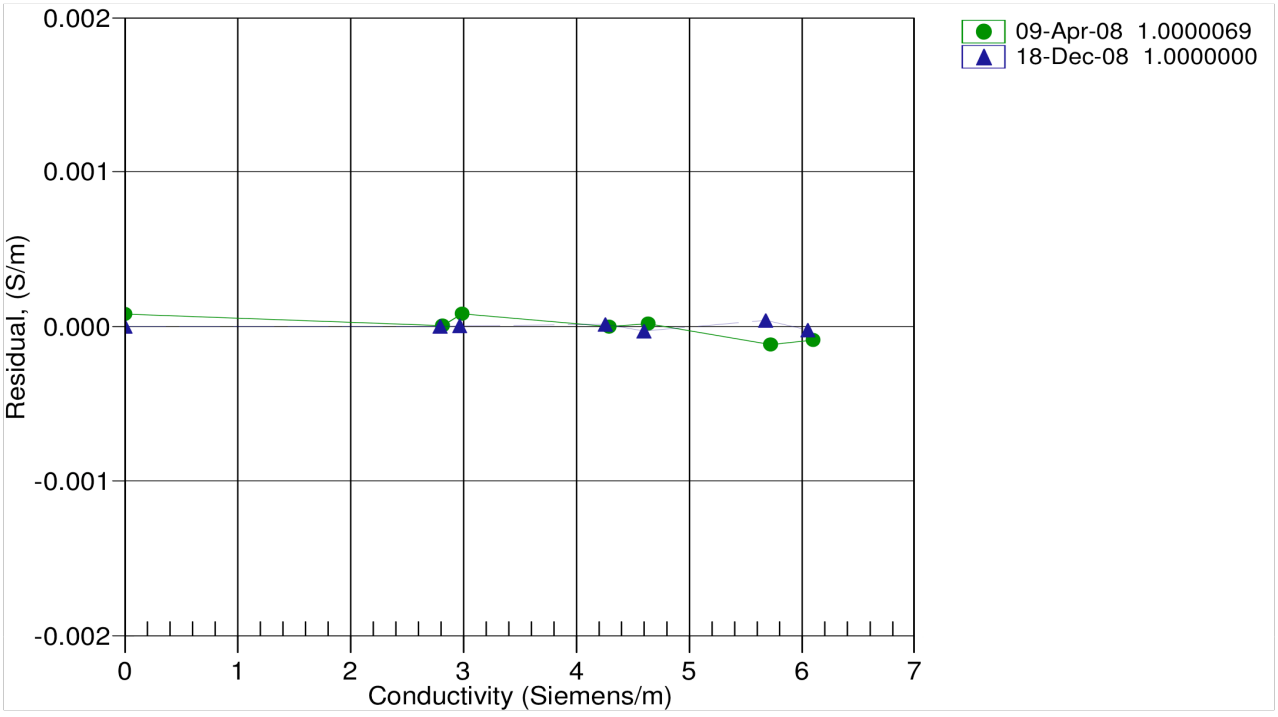
Conductivity = $(g + hf^2 + if^3 + jf^4) / 10(1 + \delta t + \varepsilon p)$ Siemens/meter

Conductivity = $(af^m + bf^2 + c + dt) / [10 (1 + \varepsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients

Date, Slope Correction



Conductivity # 1 - replacement

Serial # 2575

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 2575
CALIBRATION DATE: 08-Jan-09

SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS

```
g = -1.03094334e+001
h =  1.52988341e+000
i =  1.32524434e-004
j =  7.77398933e-005
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  1.71280982e-004
b =  1.52983504e+000
c = -1.03090766e+001
d = -8.29105473e-005
m =  3.7
CPcor = -9.5700e-008 (nominal)
```

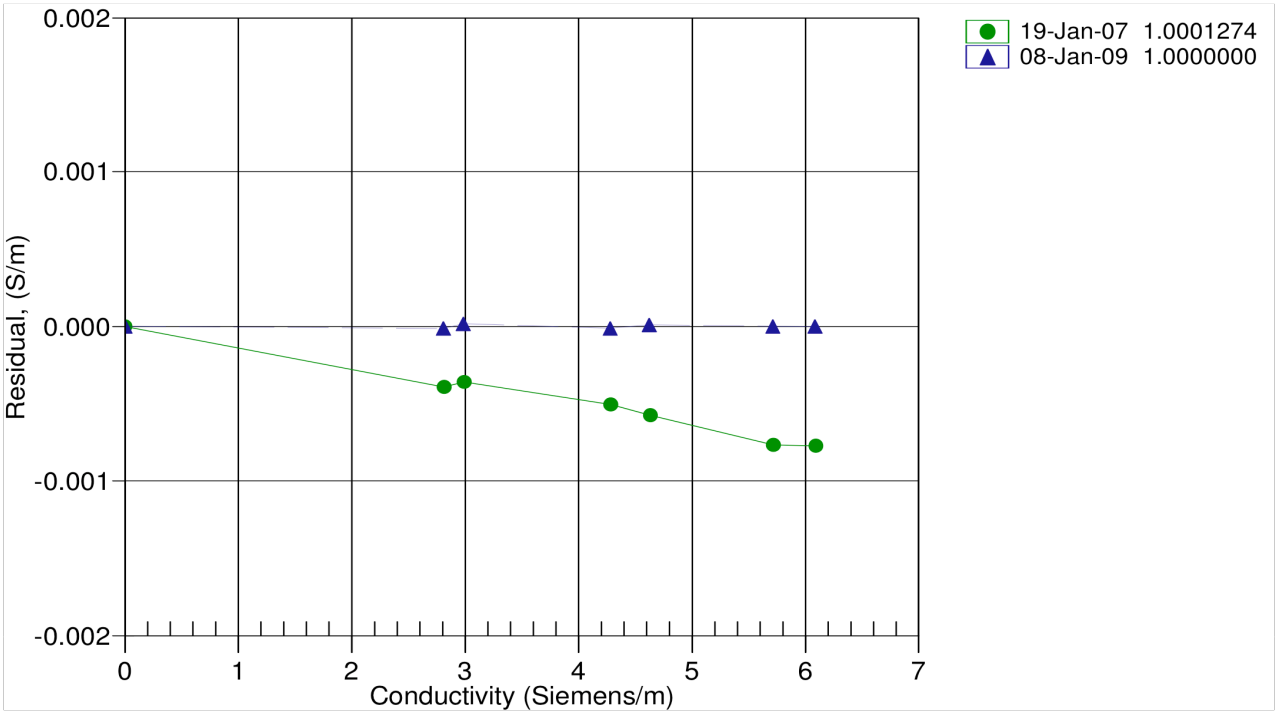
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREO (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.59517	0.00000	0.00000
-1.0000	34.8546	2.80737	5.00460	2.80736	-0.00001
1.0453	34.8551	2.98289	5.11761	2.98291	0.00002
14.9999	34.8565	4.27601	5.88315	4.27600	-0.00001
18.5000	34.8563	4.62310	6.07213	4.62311	0.00001
29.0000	34.8545	5.70787	6.62783	5.70787	0.00000
32.5000	34.8485	6.08097	6.80840	6.08097	-0.00000

Conductivity = $(g + hf^2 + if^3 + jf^4) / 10(1 + \delta t + \varepsilon p)$ Siemens/meter

Conductivity = $(af^m + bf^2 + c + dt) / [10 (1 + \varepsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



Conductivity # 2

Serial # 2619

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 2619
CALIBRATION DATE: 18-Dec-08

GHIJ COEFFICIENTS

```
g = -1.00814744e+001
h =  1.38129883e+000
i = -5.00015206e-004
j =  1.21456280e-004
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

ABCDM COEFFICIENTS

```
a =  3.17140662e-005
b =  1.38027318e+000
c = -1.00799542e+001
d = -8.60839141e-005
m =  4.4
CPcor = -9.5700e-008 (nominal)
```

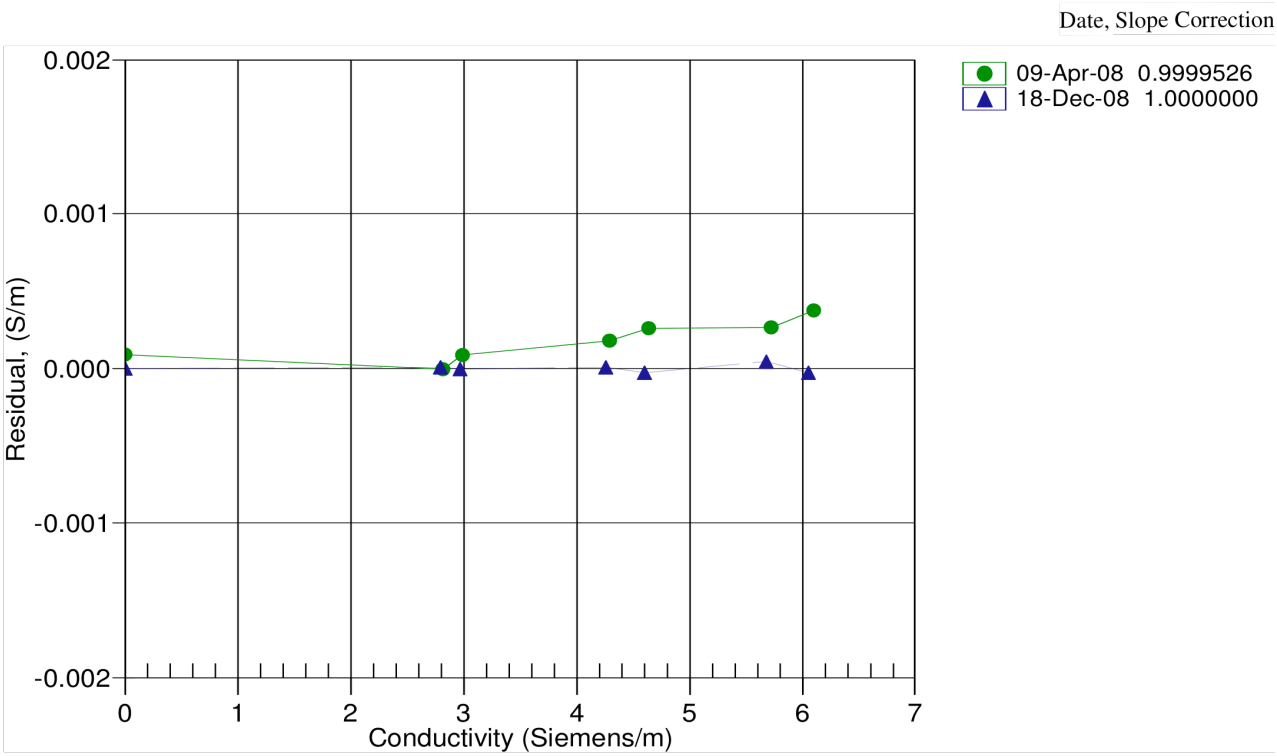
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.70204	0.00000	0.00000
-1.0000	34.6427	2.79189	5.24369	2.79190	0.00001
0.9999	34.6431	2.96256	5.35998	2.96255	-0.00000
15.0000	34.6425	4.25254	6.16801	4.25255	0.00001
18.4999	34.6416	4.59768	6.36667	4.59765	-0.00003
29.0000	34.6376	5.67633	6.95077	5.67638	0.00004
32.5000	34.6312	6.04735	7.14047	6.04732	-0.00003

Conductivity = $(g + hf^2 + if^3 + jf^4) / 10(1 + \delta t + \varepsilon p)$ Siemens/meter

Conductivity = $(af^m + bf^2 + c + dt) / [10 (1 + \varepsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



Oxygen

Serial # 0456

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0456
CALIBRATION DATE: 17-Dec-08p

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS

Soc = 0.3799
Voffset = -0.5143
Tau20 = 1.77

A = -2.2029e-004
B = 1.0644e-004
C = -2.1444e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS

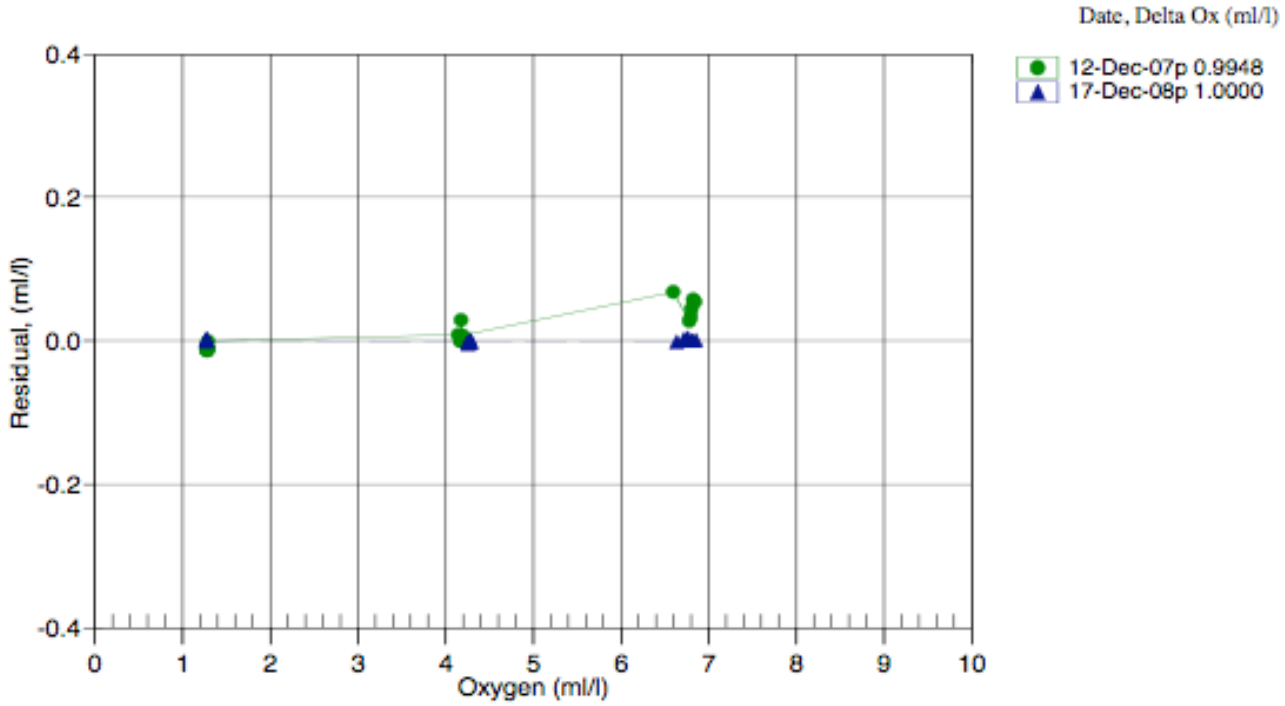
D1 = 1.92634e-4 H1 = -3.30000e-2
D2 = -4.64803e-2 H2 = 5.00000e+3
H3 = 1.45000e+3

BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(VOLTS)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
1.27	12.00	0.01	0.954	1.27	0.00
1.27	6.00	0.01	0.899	1.27	0.00
1.27	2.00	0.00	0.861	1.27	0.00
1.27	20.00	0.01	1.031	1.27	-0.00
1.28	26.00	0.01	1.091	1.28	0.00
1.29	30.00	0.02	1.136	1.29	0.00
4.25	20.00	0.01	2.234	4.24	-0.00
4.25	26.00	0.01	2.429	4.25	-0.00
4.26	12.00	0.01	1.986	4.26	-0.00
4.28	30.00	0.02	2.580	4.28	0.00
4.28	6.00	0.01	1.805	4.28	-0.00
4.29	2.00	0.00	1.681	4.29	-0.00
6.63	30.00	0.02	3.715	6.63	-0.00
6.72	26.00	0.01	3.544	6.72	0.00
6.75	20.00	0.01	3.249	6.75	0.00
6.76	12.00	0.01	2.855	6.77	0.00
6.82	6.00	0.01	2.570	6.82	0.00
6.85	2.00	0.00	2.378	6.85	0.00

Oxygen (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * T^2 + C * T^3) * OxSol(T,S) * exp(E * P / K)

V = voltage output from SBE43, T = temperature [deg C], S = salinity [PSU] K = temperature [deg K]

OxSol(T,S) = oxygen saturation [ml/l], P = pressure [dbar], Residual = instrument oxygen - bath oxygen



Oxygen replacement

Serial # 0458

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0458
CALIBRATION DATE: 17-Dec-08p

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS

Soc = 0.4307
Voffset = -0.4913
Tau20 = 1.07

A = -1.4735e-003
B = 1.2172e-004
C = -2.5852e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS

D1 = 1.92634e-4
D2 = -4.64803e-2

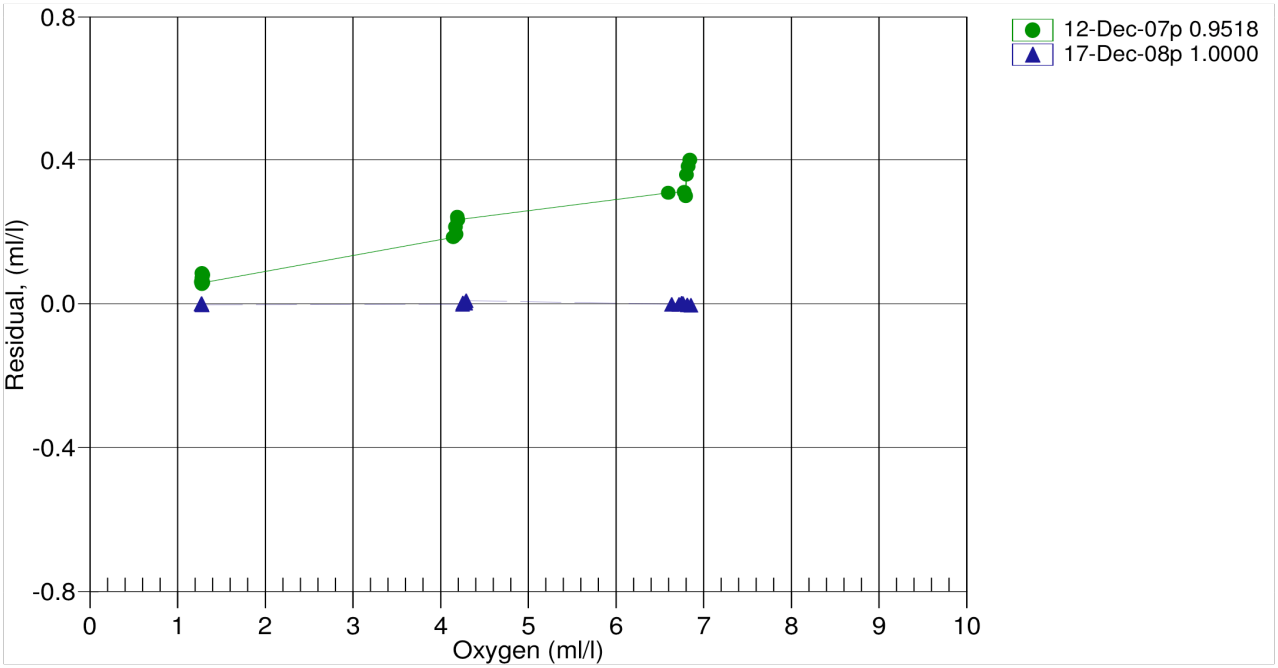
H1 = -3.30000e-2
H2 = 5.00000e+3
H3 = 1.45000e+3

BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(VOLTS)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
1.27	12.00	0.01	0.883	1.27	-0.00
1.27	6.00	0.01	0.832	1.27	0.00
1.27	2.00	0.00	0.797	1.27	-0.00
1.27	20.00	0.01	0.957	1.27	-0.00
1.28	26.00	0.01	1.014	1.28	-0.00
1.29	30.00	0.02	1.058	1.28	-0.00
4.25	20.00	0.01	2.043	4.24	-0.00
4.25	26.00	0.01	2.233	4.25	0.00
4.26	12.00	0.01	1.809	4.26	0.00
4.28	30.00	0.02	2.380	4.28	0.00
4.28	6.00	0.01	1.638	4.28	0.00
4.29	2.00	0.00	1.525	4.30	0.01
6.63	30.00	0.02	3.416	6.63	-0.00
6.72	26.00	0.01	3.242	6.72	-0.00
6.75	20.00	0.01	2.958	6.75	0.00
6.76	12.00	0.01	2.583	6.76	0.00
6.82	6.00	0.01	2.317	6.81	-0.00
6.85	2.00	0.00	2.138	6.85	-0.00

$$\text{Oxygen (ml/l)} = Soc * (V + Voffset) * (1.0 + A * T + B * T^2 + C * T^3) * OxSol(T,S) * \exp(E * P / K)$$

V = voltage output from SBE43, T = temperature [deg C], S = salinity [PSU] K = temperature [deg K]
OxSol(T,S) = oxygen saturation [ml/l], P = pressure [dbar], Residual = instrument oxygen - bath oxygen

Date, Delta Ox (ml/l)



Fluorometer

Serial # 088234

CERTIFICATE OF CALIBRATION

All test equipment and standards used are of known accuracy and are traceable to national standards. Details of test equipment and standards relevant to this certificate are available upon request.

Chelsea Technologies Group

55 Central Avenue
West Molesey
Surrey KT8 2QZ
United Kingdom
Tel: +44 (0)20 8481 9000
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sales@chelsea.co.uk
www.chelsea.co.uk

Date of issue	06 March 2007
Description	Mk III Aquatracka (Chlorophyll-a)
Serial Number	088234
Part No	3598C

REPORT

The fluorimeter was exposed to various concentrations of Chlorophyll-a dissolved in acetone in addition to pure water and pure acetone. The following formula was derived from the readings to relate instrument output to chlorophyll-a concentration.

$$\text{Conc.} = (0.00779 \times 10^{\text{Output}}) - 0.0211$$

Where -

Conc. = fluorophor concentration in µg/l
Output = Aquatracka output in volts

The above formula can be used in the range 0 - 100 microgrammes per litre to an uncertainty of 0.02 microgrammes per litre plus 5% of value.

Notes

The above formula has been derived using Chlorophyll-a dissolved in acetone. No guarantee is given as to the performance of the instrument to biologically active chlorophyll in sea-water.

The zero offset has been determined in the laboratory using purified water from a reverse osmosis/ion exchange column. It is possible that purer water may be found in clean deep ocean conditions. Under these conditions, the offset shown in the above formula should be replaced by the antilogarithm of the Aquatracka output in the purest water found, multiplied by the scale factor.

Transmisometer

Serial # CST-390DR

PO Box 518
620 Applegate St.
Philomath, OR 97370

(541) 929-565
Fax (541) 929-527
www.wetlabs.co

WET Labs

C-Star Calibration

Date February 27, 2007 Customer US Coast Guard Work order 004

Job # 0012004 S/N# CST-390DR Pathlength 25 cm

	Analog meter
V_d	0.058 V
V_{air}	4.788 V
V_{ref}	4.707 V

Temperature of calibration water	18.8 °C
Ambient temperature during calibration	23.4 °C

Relationship of transmittance (Tr) to beam attenuation coefficient (c), and pathlength (x): $Tr = e^{-cx}$

To determine beam transmittance: $Tr = (V_{sig} - V_{dark}) / (V_{ref} - V_{dark})$

To determine beam attenuation coefficient: $c = -1/x * \ln(Tr)$

V_d Meter output with the beam blocked. This is the offset.
V_{air} Meter output in air with a clear beam path.
V_{ref} Meter output with clean water in the path.
Temperature of calibration water: temperature of clean water used to obtain V_{ref}.
Ambient temperature: meter temperature in air during the calibration.
V_{sig} Measured signal output of meter.

PAR

Serial # 70115

Calibration Date:	12/01/08			**Job No.:**	R10081
Model Number:	QSP2300				
Serial Number:	70115				
Operator:	TPC				
Standard Lamp:	91537(10/25/2006)				
Operating Voltage Range:	6	to	15	VDC (+)	

Note: The QSP2300 output is a voltage that is proportional to the log of the incident irradiance.
To calculate irradiance, use this formula:
Irradiance = Calibration factor * (10^Light Signal Voltage - 10^Dark Voltage)

Dry Calibration Factor:	**3.47E+12**	**quanta/cm²·sec per volt**	**5.76E-06**	**µEinsteins/cm²·sec per volt**
Wet Calibration Factor:	**5.84E+12**	**quanta/cm²·sec per volt**	**9.69E-06**	**µEinsteins/cm²·sec per volt**

Sensor Test Data and Results[2)]

Sensor Supply Current (Dark):	3.7	mA	
Supply Voltage:	6	Volts	
Lamp Integrated PAR Irradiance:	8.83E+15	quanta/cm²·sec	0.01467 µEinsteins/cm²sec
Immersion Coefficient:	0.594		

Nominal Filter OD	Expected Transmission	Calibrated Trans.	Sensor Voltage	Expected Voltage	Voltage % Error	Measured Trans.	Transmission Error (%)	Test Irrad. (quanta/ cm²·sec)
No Filter	100%	100.00%	3.407	3.407	0%	100.00%	0.0	8.83E+15
0.3	50%	36.10%	2.967	2.964	0%	36.32%	-0.6	3.21E+15
0.5	32%	27.60%	2.853	2.847	0%	27.92%	-1.1	2.47E+15
1	10%	9.27%	2.387	2.374	1%	9.52%	-2.6	8.41E+14
2	1%	1.11%	1.478	1.452	2%	1.14%	-2.6	1.01E+14
3	0.10%	0.05%	0.332	0.134	60%	0.04%	19.2	3.98E+12
RG780	0.00%	0.00%	0.538	0.003	100%	0.10%	-100.0	8.50E+12

Dark Before:	0.003	Volts
Light - No Filter Hldr.:	3.407	Volts
Dark After - NFH:	0.003	Volts
Average Dark	0.0026	Volts

Notes:
1. Annual calibration is recommended.
2) This section is for internal use and for more advanced analysis.

Gravity Meters

Serial # 221

BGM-3 PLATFORM TESTS

Sensor Subsys.	S/N 221
C.P.S.	S/N 324
Platform	S/N 324

ZERO DAMP period (SPEC: 533 SEC +/- 5)

		ROLL (R49)	PITCH (R65)	
11 FEB08	2157Z	531 sec.	530 sec.	2208Z
		sec.	sec.	
		sec.	sec.	

TILT TEST (SPEC: +/- 0.7 MRAD)

		ROLL (R41)		PITCH (R56)	
2343Z	NOMINAL	979 318.03			12 FEB08
	POS	316.95 mgal.		317.16 mgal.	0001
	NEG	317.00 mgal.		316.62 mgal.	
	.36 (POS - NEG) -.05	-0.018 **mrad**	.54	0.194 **mrad**	
	Adjustments	NONE		NONE	
12 FEB08 0114	NOMINAL	979 317.94			
	POS	mgal.		mgal.	
	NEG	mgal.		mgal.	
	.36 (POS - NEG)	**mrad**		**mrad**	
	Adjustments				
	NOMINAL				
	POS	mgal.		mgal.	
	NEG	mgal.		mgal.	
	.36 (POS - NEG)	**mrad**		**mrad**	
	Adjustments				
	NOMINAL				
	POS	mgal.		mgal.	
	NEG	mgal.		mgal.	
	.36 (POS - NEG)	**mrad**		**mrad**	
	Adjustments				
	NOMINAL				
	POS	mgal.		mgal.	
	NEG	mgal.		mgal.	
	.36 (POS - NEG)	**mrad**		**mrad**	
	Adjustments				
	NOMINAL				

PRE-SHIPMENT SYSTEM CHECKOUT

SENSOR S/N	221	DATE	12 FEB 08
CPS S/N	324	TIME (Z)	0020
PLATFORM S/N	324		
SCALE FACTOR	5.0178887349		
BIAS	855285.8561		

SENSOR TEST POINTS		CPS MONITOR	
1	30.08	1	14.80
2	27.98	2	10.02
3	18.50	3	1.006
4	17.62	4	0.00
5	15.09	5	0.00
6	−15.00	6	−0.02
7	—	7	0.727
8	5.02	8	−0.045
9	13.67	9	0.025
10	17.68		
11	4.50		
12	−0.07		
13	5.0 — 0		
14	−17.95		
15	−4.92		
16	0.00		

ACCEL OVEN	80
PRC OVEN	50
BPTC OVEN	.65
BAT VOLTAGE	28.0
ELEX VOLTAGE	29.4
ELEC CURRENT	.16A
CHGR CURRENT	.03A

AARV SYSTEM

POST INSTALLATION SYSTEM CHECKOUT					
SENSOR S/N	221	DATE	28 FEB 08		
CPS S/N	324	TIME (Z)	1700		
PLATFORM S/N	324				
SCALE FACTOR	5.017387349				
BIAS	855285.84				
SENSOR TEST POINTS		CPS MONITOR			
1	29.95	1	14.82		
2	27.87	2	10.04		
3	18.41	3	1.005		
4	17.55	4	0.00		
5	15.03	5	0.00		
6	-14.93	6	1.22		
7	—	7	-.076		
8	5.00	8	-.053		
9	13.60	9	.024		
10	17.60				
11	6.47				
12	.005				
13	O/L				
14	-17.87				
15	-6.90				
16	0.000				
ACCEL OVEN	75				
PRC OVEN	44				
BPTC OVEN	.64				
BAT VOLTAGE	28.5				
ELEX VOLTAGE	29.5				
ELEC CURRENT	.16				
CHGR CURRENT	.02				

Post-installation

AARV SYSTEM

BGM-3 PLATFORM TESTS

28FEB08

Sensor Subsys.	**S/N** 221
C.P.S.	**S/N** 324
Platform	**S/N** 324

180 SECOND FILTER

ZERO DAMP period (SPEC: 533 SEC +/- 5)

	ROLL (R49)	**PITCH (R65)**	
1720Z	530 sec. OK	(526) sec.	1732Z
	sec.	sec.	R65 4 CCW
	sec.	534 sec.	1833Z OK

TILT TEST (SPEC: +/- 0.7 MRAD)

		ROLL (R41)	**PITCH (R56)**	
	NOMINAL	979 730.50		
1800Z	POS	29.85 mgal.	29.55 mgal.	1815Z
	NEG	29.21 mgal. OK	29.59 mgal. OK	
	.36 (POS - NEG) .64	0.230 **mrad** -.04	-.014 **mrad**	
	Adjustments	NONE	NONE	
1846Z	NOMINAL	979730.50		
	POS	mgal.	mgal.	
	NEG	mgal.	mgal.	
	.36 (POS - NEG)	**mrad**	**mrad**	
	Adjustments			
	NOMINAL			
	POS	mgal.	mgal.	
	NEG	mgal.	mgal.	
	.36 (POS - NEG)	**mrad**	**mrad**	
	Adjustments			
	NOMINAL			
	POS	mgal.	mgal.	
	NEG	mgal.	mgal.	
	.36 (POS - NEG)	**mrad**	**mrad**	
	Adjustments			
	NOMINAL			
	POS	mgal.	mgal.	
	NEG	mgal.	mgal.	
	.36 (POS - NEG)	**mrad**	**mrad**	
	Adjustments			
	NOMINAL			

BASE CALIBRATION READINGS

BGM S/N: 221 /AARV SURVOPS: _____ ACC NO: _____

SHIP: HEALY SURVOPS DATES: _____ TO: _____

PORTS: SEATTLE, WA TO: _____

PERSONNEL: HERR

DEPARTURE BASE CALIBRATION READINGS

DATE: 29 FEB 08 J.D. 060 TIME GMT: 1700 TO: 1800 MEAN: 1730

STA.# : _____

STA. NAME: PIER 36 STA GRAV @ PIER LEVEL 980728.35 MGALS

PIER STA HGT 7.4' X .094 + .70 MGALS

BASE g @ WATER LEVEL 980729.05 MGALS

S.F. : 5.017387 BGM OBS GRAV 980729.34 MGALS

CORR. BIAS : 855284.64 OBS g – BASE g + 0.29 MGALS

DRIFT CORR. ENTERED: N/A

ARRIVAL BASE CALIBRATION READINGS

DATE: _____ J.D.: _____ TIME GMT: _____ TO: _____ MEAN: _____

STA.#: _____

STA. NAME: _____ STA GRAV @ PIER LEVEL _____ MGALS

PIER STA HGT _____ X .094 + _____ MGALS

BASE g @ WATER LEVEL _____ MGALS

S.F.: _____ BGM OBS GRAV _____ MGALS

CORR. BIAS: _____ OBS g – BASE g _____ MGALS

LAND METER NO. _____

DEPARTURE J. D.: _____ TIME GMT: _____ VALUE: _____ C.D. = _____ MGALS

ARRIVAL J. D.: _____ TIME GMT: _____ VALUE: _____ C.D. = _____ MGALS

DIFFERENCE: _____ MGALS

STA.GRAV @ PIER LEVEL DIFFERENCE: _____ MGALS

MISTIE: _____ MGALS

BCR BY: _____ CHECKED BY:

Serial # 222

BGM-3 PLATFORM TESTS

Sensor Subsys.	S/N 222
C.P.S.	S/N 325
Platform	S/N 325

ZERO DAMP period (SPEC: 533 SEC +/- 5)

11 FEB 08

	ROLL (R49)	PITCH (R65)	
2222Z	533 sec.	534 sec.	2236Z
	sec.	sec.	
	sec.	sec.	

TILT TEST (SPEC: +/- 0.7 MRAD)

		ROLL (R41)		PITCH (R56)	
2343Z	NOMINAL	979315.24			12 Feb 08
	POS	312.18 mgal.		312.06 mgal.	0001
	NEG	312.21 mgal.		312.30 mgal.	
	.36 (POS - NEG)	-0.03	-0.0108 mrad	-.24	-0.0864 mrad
	Adjustments	None		None	
12 Feb 08 0014	NOMINAL	979313.31			
	POS	mgal.		mgal.	
	NEG	mgal.		mgal.	
	.36 (POS - NEG)	mrad		mrad	
	Adjustments				
	NOMINAL				
	POS	mgal.		mgal.	
	NEG	mgal.		mgal.	
	.36 (POS - NEG)	mrad		mrad	
	Adjustments				
	NOMINAL				
	POS	mgal.		mgal.	
	NEG	mgal.		mgal.	
	.36 (POS - NEG)	mrad		mrad	
	Adjustments				
	NOMINAL				
	POS	mgal.		mgal.	
	NEG	mgal.		mgal.	
	.36 (POS - NEG)	mrad		mrad	
	Adjustments				
	NOMINAL				

PRE-SHIPMENT SYSTEM CHECKOUT

SENSOR S/N	222	DATE	12 FEB 08
CPS S/N	325	TIME (Z)	0015
PLATFORM S/N	325		
SCALE FACTOR	4.949006443		
BIAS	856735.6963		

SENSOR TEST POINTS		CPS MONITOR	
1	30.23	1	14.50
2	28.06	2	9.90
3	18.54	3	0.985
4	17.74	4	0.05
5	15.04	5	0.05
6	-14.98	6	-0.691
7	—	7	1.013
8	5.04	8	-0.071
9	13.86	9	-0.012
10	18.08		
11	4.52		
12	-.04		
13	5.0 - 0		
14	-18.23		
15	-4.94		
16	.02		

ACCEL OVEN	100
PRC OVEN	45
BPTC OVEN	.65
BAT VOLTAGE	26.5
ELEX VOLTAGE	27.8
ELEC CURRENT	.15 A
CHGR CURRENT	.02 A

HEALY SYSTEM

POST INSTALLATION SYSTEM CHECKOUT

SENSOR S/N	222	DATE	28 FEB 08
CPS S/N	325	TIME (Z)	1710
PLATFORM S/N	325		
SCALE FACTOR	4.949006443		
BIAS	~~855285.84~~ 856735.70		

SENSOR TEST POINTS		CPS MONITOR	
1	30.01	1	14.47
2	27.95	2	9.92
3	18.45	3	-985
4	17.66	4	.04
5	14.95	5	.105
6	-14.95	6	.373
7	—	7	.281
8	4.99	8	-.073
9	13.77	9	-.010
10	17.93		
11	6.47		
12	.016		
13	O/C		
14	-18.18		
15	-6.94		
16	0.000		

ACCEL OVEN	95
PRC OVEN	45
BPTC OVEN	.65
BAT VOLTAGE	26.9
ELEX VOLTAGE	28.0
ELEC CURRENT	.17
CHGR CURRENT	.02

POST-INSTALLATION

HEALY SYSTEM

BGM-3 PLATFORM TESTS

28 FEB 08

Sensor Subsys.	**S/N** 222
C.P.S.	**S/N** 325
Platform	**S/N** 325

ZERO DAMP period (SPEC: 533 SEC +/- 5)

	ROLL (R49)	**PITCH (R65)** OK
1930Z	532 sec. OK	535 sec. 1945Z
	sec.	sec.
	sec.	sec.

TILT TEST (SPEC: +/- 0.7 MRAD)

	ROLL (R41)	**PITCH (R56)**
1843Z NOMINAL	979 724.92	
POS	23.82 mgal.	24.03 mgal. 1859Z
NEG	24.16 mgal.	23.92 mgal.
.36 (POS - NEG) -.32	-.115 **mrad** .11	.039 **mrad**
Adjustments	NONE OK	NONE OK
NOMINAL		
POS	mgal.	mgal.
NEG	mgal.	mgal.
.36 (POS - NEG)	**mrad**	**mrad**
Adjustments		
NOMINAL		
POS	mgal.	mgal.
NEG	mgal.	mgal.
.36 (POS - NEG)	**mrad**	**mrad**
Adjustments		
NOMINAL		
POS	mgal.	mgal.
NEG	mgal.	mgal.
.36 (POS - NEG)	**mrad**	**mrad**
Adjustments		
NOMINAL		
POS	mgal.	mgal.
NEG	mgal.	mgal.
.36 (POS - NEG)	**mrad**	**mrad**
Adjustments		
NOMINAL		

BASE CALIBRATION READINGS

BGM S/N: 222/HEALY SURVOPS: _____ ACC NO: _____

SHIP: HEALY SURVOPS DATES: _____ TO: _____

PORTS: SEATTLE, WA TO: _____

PERSONNEL: HERR

DEPARTURE BASE CALIBRATION READINGS

DATE: 29 FEB 08 J.D. 060 TIME GMT: 1700 TO: 1800 MEAN: 1730

STA.# : _____

STA. NAME: PIER 36 STA GRAV @ PIER LEVEL 980728.35 MGALS

PIER STA HGT 7.4' X .094 + .70 MGALS

BASE g @ WATER LEVEL 980729.05 MGALS

S.F. : 4.949006 BGM OBS GRAV 980729.26 MGALS

CORR. BIAS : 856740.23 OBS g – BASE g +0.21 MGALS

DRIFT CORR. ENTERED: N/A

ARRIVAL BASE CALIBRATION READINGS

DATE: _____ J.D.: _____ TIME GMT: _____ TO: _____ MEAN: _____

STA.#: _____

STA. NAME: _____ STA GRAV @ PIER LEVEL _____ MGALS

PIER STA HGT _____ X .094 + _____ MGALS

BASE g @ WATER LEVEL _____ MGALS

S.F.: _____ BGM OBS GRAV _____ MGALS

CORR. BIAS: _____ OBS g – BASE g _____ MGALS

LAND METER NO. _____

DEPARTURE J. D.: _____ TIME GMT: _____ VALUE: _____ C.D. = _____ MGALS

ARRIVAL J. D.: _____ TIME GMT: _____ VALUE: _____ C.D. = _____ MGALS

DIFFERENCE: _____ MGALS

STA.GRAV @ PIER LEVEL DIFFERENCE: _____ MGALS

MISTIE: _____ MGALS

BCR BY: _____ CHECKED BY:

Climate Control Chambers Sensors

It is unknown what Chamber each of these sensors is associated with. The sensors are installed in a manner that makes inspecting the serial numbers difficult. At this time it was decided not to mess with the sensors since they are working.

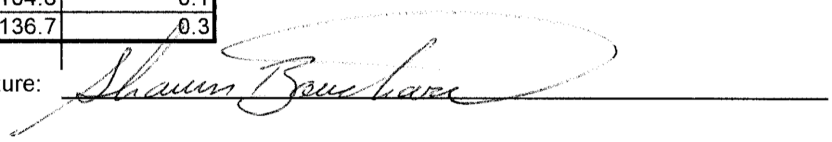
Serial # CPABUDG

SensaTronics
ENVIRONMENTAL SENSING
Sensatronics, LLC 20A Dunklee Road, Bow, NH 03304
Fax: (603) 224-2401 Phone: (603) 224-0167
Email: sales@sensatronics.com www.sensatronics.com
Using Technology For Environmental Tracking

NIST report for probe CPABUDG

Test date:		9/11/2007		Tester:	Shawn Bouchard
Test result	PASS			Standard (NPAACER) traceable to N.I.S.T., avail. on req.	
Test environment:		Stirred liquid bath		NPAACER calibration date: 9/27/2005	
				NPAACER due for recalibration: 9/27/2008	
Acceptable accuracy is +- 0.5 F from -20 to 120 F, +- 1.5F from -40 to -20 and 120 to 140.					

Target (NPAACER)	CPABUDG	Error
3.3	3.2	-0.1
42.1	42.4	0.3
72.5	72.6	0.1
104.7	104.8	0.1
136.4	136.7	0.3

Signature: 

Equipment used:
Sensatronics precision probe serial # NPAACER

Note: Precision probes are not a standard Sensatronics product and are for internal use only. Their analog accuracy is 0.05 F, and the digital conversion equipment used is 10 times as precise as standard Sensatronics Model E/Cryo/EM1 products.

Serial # CPABUDI

SensaTronics
ENVIRONMENTAL SENSING
Sensatronics, LLC 20A Dunklee Road, Bow, NH 03304
Fax: (603) 224-2401 Phone: (603) 224-0167
Email: sales@sensatronics.com www.sensatronics.com
Using Technology For Environmental Tracking

NIST report for probe CPABUDI

Test date:	9/11/2007		Tester:	Shawn Bouchard	
Test result	PASS		Standard (NPAACER) traceable to N.I.S.T., avail. on req.		
Test environment:	Stirred liquid bath		NPAACER calibration date: 9/27/2005		
			NPAACER due for recalibration: 9/27/2008		
Acceptable accuracy is +- 0.5 F from -20 to 120 F, +- 1.5F from -40 to -20 and 120 to 140.					

Target (NPAACER)	CPABUDI	Error
3.3	3.0	-0.3
42.1	42.1	0.0
72.5	72.4	-0.1
104.7	104.5	-0.2
136.4	136.6	0.2

Signature: Shawn Bouchard

Equipment used:
Sensatronics precision probe serial # NPAACER

Note: Precision probes are not a standard Sensatronics product and are for internal use only. Their analog accuracy is 0.05 F, and the digital conversion equipment used is 10 times as precise as standard Sensatronics Model E/Cryo/EM1 products.

Serial # EM3I9H0T155

SensaTronics
ENVIRONMENTAL SENSING
Sensatronics, LLC 20A Dunklee Road, Bow, NH 03304
Fax: (603) 224-2401 Phone: (603) 224-0167
Email: sales@sensatronics.com www.sensatronics.com
Using Technology For Environmental Tracking

NIST report for unit EM3I9H0T155

Test time:	9/11/07 5:57 AM		Tester:	Shawn Bouchard				
Test result:	PASS		Standard (NC3G0C0T101) traceable to N.I.S.T., avail. on req.					
Test environment:	21C +- 3C		NC3G0C0T101 calibration date: 4/15/2005					
	40% +- 20% RH		NC3G0C0T101 due for recalibration: 4/15/2006					
Acceptable accuracy for all ports: +- 0.3 degrees F from -20 to 120, +- 1.5 degrees F from -40 to -20 and from 120 to 140, +- 0.5 %RH								
Target temp	Group 1	Error	Group 2	Error	Group 3	Error	Group 4	Error
131.3	131.0	-0.3	131.4	0.1	131.5	0.2	131.7	0.4
117.4	117.3	-0.1	117.6	0.2	117.6	0.2	117.8	0.4
96.8	96.8	0.0	96.9	0.1	97.0	0.2	97.1	0.3
62.1	62.0	-0.1	62.1	0.0	62.1	0.0	62.2	0.1
29.4	29.4	0.0	29.4	0.0	29.4	0.0	29.4	0.0
-1.1	-1.1	0.0	-1.2	-0.1	-1.2	-0.1	-1.1	0.0
-16.8	-16.9	-0.1	-16.9	-0.1	-17.0	-0.2	-17.0	-0.2
-34.7	-34.7	0.0	-34.7	0.0	-34.7	0.0	-34.7	0.0
Target humidity								
74.8	75.2	0.4	75.0	0.2	75.0	0.2	75.0	0.2

Signature: Shawn Bouchard

Serial # EM4I9H0T155

SensaTronics
ENVIRONMENTAL SENSING
Sensatronics, LLC 20A Dunklee Road, Bow, NH 03304
Fax: (603) 224-2401 Phone: (603) 224-0167
Email: sales@sensatronics.com www.sensatronics.com
Using Technology For Environmental Tracking

NIST report for unit EM4I9H0T155

Test time:	9/11/07 5:57 AM		Tester:	Shawn Bouchard				
Test result:	PASS		Standard (NC3G0C0T101) traceable to N.I.S.T., avail. on req.					
Test environment:	21C +- 3C		NC3G0C0T101 calibration date: 4/15/2005					
	40% +- 20% RH		NC3G0C0T101 due for recalibration: 4/15/2006					
Acceptable accuracy for all ports: +- 0.3 degrees F from -20 to 120, +- 1.5 degrees F from -40 to -20 and from 120 to 140, +- 0.5 %RH								
Target temp	Group 1	Error	Group 2	Error	Group 3	Error	Group 4	Error
131.3	131.0	-0.3	131.4	0.1	131.5	0.2	131.7	0.4
117.4	117.3	-0.1	117.6	0.2	117.6	0.2	117.8	0.4
96.8	96.8	0.0	96.9	0.1	97.0	0.2	97.1	0.3
62.1	62.0	-0.1	62.1	0.0	62.1	0.0	62.2	0.1
29.4	29.4	0.0	29.4	0.0	29.4	0.0	29.4	0.0
-1.1	-1.1	0.0	-1.2	-0.1	-1.2	-0.1	-1.1	0.0
-16.8	-16.9	-0.1	-16.9	-0.1	-17.0	-0.2	-17.0	-0.2
-34.7	-34.7	0.0	-34.7	0.0	-34.7	0.0	-34.7	0.0
Target humidity								
74.8	75.2	0.4	75.0	0.2	75.0	0.2	75.0	0.2

Signature: Shawn Bouchard

Serial # RT1I6I1T101

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NIST report for probe RT1I6I1T101

Test date:	9/25/2007		Tester:	SHAWN BOUCHARD	
Test result:	PASS				
Test environment:	Environmental chamber		Standard (A4230093) traceable to N.I.S.T., avail. on req.		
Acceptable accuracy for all ports: +- 0.5 degrees F from -20 to 120 @ 40% RH, +- 1.5 degrees F from -40 to 140 +- 3% RH (full range)					

Target (°F) (A4230093)	RT1I6I1T101	Error	Target (A4230093)	RT1I6I1T101	Error
74.3	74	-0.3	13.6%	13.6%	0.0%
72.4	72.2	-0.2	43.9%	46.0%	2.1%
73.5	73.9	0.4	67.8%	67.4%	-0.4%

Signature: 

Equipment used:

Company	Model	Serial	Accuracy	Cal date	Due for recal
Vaisala	HMI41	A4230093	-0.03	01/29/07	01/29/08

Serial # RT3I5I1T101

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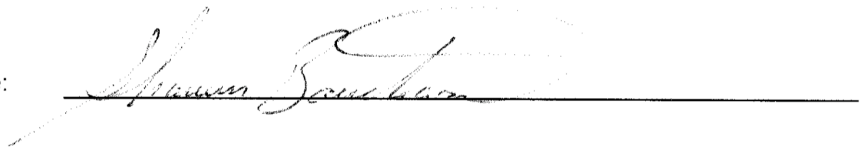
NIST report for probe RT3I5I1T101

Test date:	9/25/2007		Tester:	SHAWN BOUCHARD	
Test result:	PASS				
Test environment:	Environmental chamber		Standard (A4230093) traceable to N.I.S.T., avail. on req.		
Acceptable accuracy for all ports: +- 0.5 degrees F from -20 to 120 @ 40% RH, +- 1.5 degrees F from -40 to 140 +- 3% RH (full range)					

Target (°F) (A4230093)	RT3I5I1T101	Error	Target (A4230093)	RT3I5I1T101	Error
74.3	74.1	-0.2	13.6%	13.3%	-0.3%
72.4	72.7	0.3	43.9%	45.0%	1.1%
73.5	73.7	0.2	67.8%	66.8%	-1.0%

Signature: 

Equipment used:

Company	Model	Serial	Accuracy	Cal date	Due for recal
Vaisala	HMI41	A4230093	-0.03	01/29/07	01/29/08

Serial # RT6I4I1T101

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NIST report for probe RT6I4I1T101

Test date:	9/25/2007	Tester:	SHAWN BOUCHARD
Test result:	PASS		
Test environment:	Environmental chamber	Standard (A4230093) traceable to N.I.S.T., avail. on req.	

Acceptable accuracy for all ports: +- 0.5 degrees F from -20 to 120 @ 40% RH,
+- 1.5 degrees F from -40 to 140
+- 3% RH (full range)

Target (°F) (A4230093)	RT6I4I1T101	Error	Target (A4230093)	RT6I4I1T101	Error
74.3	74.6	0.3	13.6%	13.7%	0.1%
72.4	72.6	0.2	43.9%	45.9%	2.0%
73.5	73.2	-0.3	67.8%	68.9%	1.1%

Signature: 

Equipment used:

Company	Model	Serial	Accuracy	Cal date	Due for recal
Vaisala	HMI41	A4230093	-0.03	01/29/07	01/29/08

Serial # RT6I5I1T101

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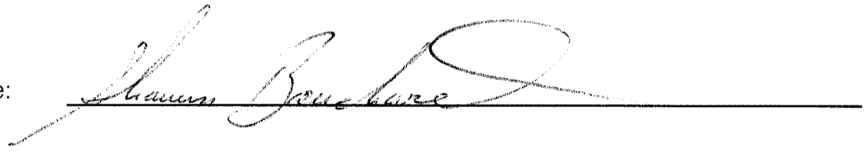
NIST report for probe RT6I5I1T101

Test date:	9/25/2007	Tester:	SHAWN BOUCHARD
Test result:	PASS		
Test environment:	Environmental chamber	Standard (A4230093) traceable to N.I.S.T., avail. on req.	

Acceptable accuracy for all ports: +- 0.5 degrees F from -20 to 120 @ 40% RH,
+- 1.5 degrees F from -40 to 140
+- 3% RH (full range)

Target (°F) (A4230093)	RT6I5I1T101	Error	Target (A4230093)	RT6I5I1T101	Error
74.3	74.5	0.2	13.6%	13.6%	0.0%
72.4	72.1	-0.3	43.9%	45.7%	1.8%
73.5	73.9	0.4	67.8%	69.3%	1.5%

Signature: 

Equipment used:

Company	Model	Serial	Accuracy	Cal date	Due for recal
Vaisala	HMI41	A4230093	-0.03	01/29/07	01/29/08

Instrument Locations on the Healy

Layout plot of instrument locations

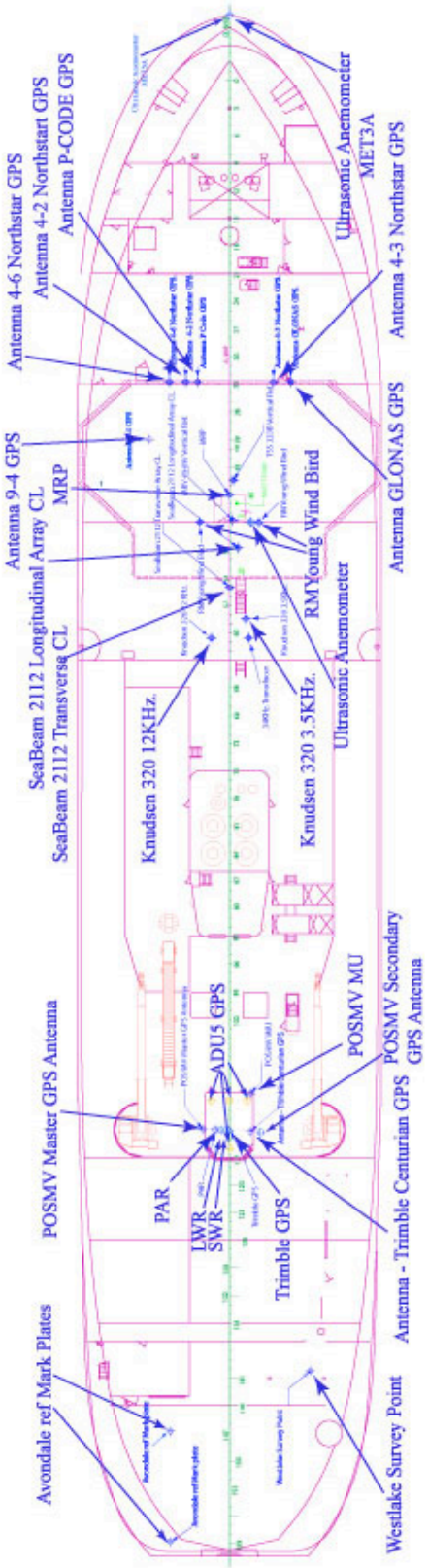


Table of Survey measurements

Consolidated Survey Data						
	Elements of:					
		Avondale Survey				
		Westlake Survey				
		Lamont Survey				
	All Measurements in *Meters* relative to MRP unless otherwise stated					
	X = fore & aft with + foreward					
	Y = port & starboard with + to starboard					
	Z= vertical with + upwards					
				X	Y	Z
Item	***Survey***	***Description***		***North***	***East***	***Elevation***
1	Avondale	**MRP**	See discussion Westlake Final Report	34.30	0.00	9.15
2	Westlake	**MRP**	by Definition	0.00	0.00	0.00
3	Westlake	**Seabeam 2112**				
		Transverse Array	Centerline	-7.679	0.030	9.242
		Longitudinal Array	Centerline	-4.386	0.711	9.238
4	Westlake	**Transducers**				
		Starboard - Forward to Aft				
		Transducer -	Bathy 2000 3.5 kHz	-10.252	1.362	9.243
		Transducer -	Bathy 1500 34 kHz *	-11.866	1.559	9.245
		Transducer -	Doppler Speed Log	-12.168	0.414	9.245
		Transducer -	Spare Transducer Well	-13.081	1.449	9.237
5	Westlake	**Port - Forward to Aft**				

		Transducer -	VM 150	-9.726	-1.395	9.230
		Transducer -	Ocean Surveyor 75 kHz	-10.819	-1.290	9.230
		Transducer -	Bathy 2000 12 kHz	-11.859	-1.492	9.234
		Transducer -	Spare Transducer Well	-13.078	-1.394	9.235
6	Westlake	Gyros				
		Starboard Gyro	Centerline	4.741	0.207	-19.604
		Port Gyro	Centerline	4.746	-0.207	-19.609
7	Westlake	**Antennas**				
		REF DWG TBD	Antenna 9-4 * - GPS Antenna (4.1.5)	4.587	-6.622	-24.000
			Antenna 4-6 * - Northstar GPS (4.1.1)	9.374	-4.970	-23.406
			Antenna 4-2 * - Northstar (4.1.2)	9.362	-3.617	-23.451
			P CODE GPS Antenna *	9.368	-2.645	-23.609
			Antenna 4-3 * - Northstar (4.1.4)	9.355	3.638	-23.363
			GLONAS GPS Antenna *	9.379	5.066	-23.515
			Antenna base (4A)	-53.872	-0.011	-22.025
			Antenna base (4B)	-49.758	0.038	-22.010
			Antenna base (4C)	-49.785	1.629	-22.020
			Antenna base (4D)	-49.771	-1.546	-22.008
			Trimble Centurion**	-52.726	-1.717	-21.113
			Time Server **	-52.671	1.838	-21.115
8	Westlake	**Vertical Ref**				
			MRV-M-MV -			
			Measured at Top of mounting bracket			

			Center (mid-point) - calculated	-2.100	0.291	-0.775
			TSS 333B - Marine Motion Sensor -			
			scribe atop mounting plate			
			Center of TSS 333B	1.210	0.329	-0.013
9	LDEO	**POS/MV**				
		From	**TO**	**X**	**Y**	**Z**
		IMU	Port Antenna (Master)	-2.9719	-3.9140	-5.5310
		MRP	IMU	-49.5710	1.7110	-16.7990
		MRP	Transmit array	-4.3860	0.7110	9.2380
		MRP	Port Antenna (Master)	-52.5429	-2.2030	-22.3300
10	Westlake Raw	**Fan Tail**				
			Aft/Port	-86.737	-4.906	-3.617
			Forward/Port	-77.600	-4.881	-3.589
			Forward/Starboard	-72.590	6.676	-3.653