WHOI-2009-03

Woods Hole Oceanographic Institution

Stratus 9/VOCALS
Ninth Setting of the Stratus Ocean Reference Station
& VOCALS Regional Experiment

Cruise RB-08-06
September 29–December 2, 2008
Leg 1: Charleston–Arica, September 29–November 3, 2008
Leg 2: Arica–Arica, November 9–December 2, 2008

by

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Woods Hole Oceanographic Institution, Woods Hole, Massachusetts
April 2009

Technical Report

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Upper Ocean Processes Group
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
UOP Technical Report 2009-02

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Approved for Distribution:

Robert A. Weller

Robert A. Weller, Chair

Department of Physical Oceanography

Abstract

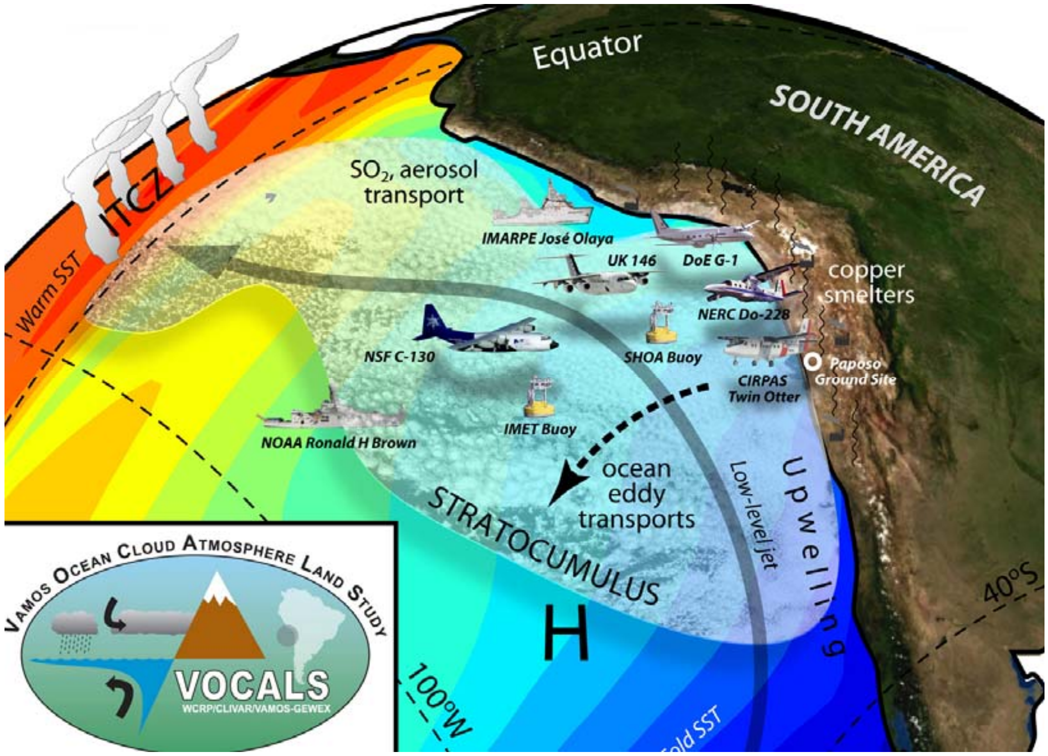
The Ocean Reference Station at 20°S, 85°W under the stratus clouds west of northern Chile is being maintained to provide ongoing climate-quality records of surface meteorology; air-sea fluxes of heat, freshwater, and momentum; and of upper ocean temperature, salinity, and velocity variability. The Stratus Ocean Reference Station (ORS Stratus) is supported by the National Oceanic and Atmospheric Administration's (NOAA) Climate Observation Program. It is recovered and redeployed annually, with cruises that have come between October and December.

During the 2008 cruise on the NOAA ship *Ronald H. Brown* to the ORS Stratus site, the primary activities were recovery of the Stratus 8 WHOI surface mooring that had been deployed in October 2007, deployment of a new (Stratus 9) WHOI surface mooring at that site; in-situ calibration of the buoy meteorological sensors by comparison with instrumentation put on board by staff of the NOAA Earth System Research Laboratory (ESRL); and observations of the stratus clouds and lower atmosphere by NOAA ESRL. A buoy for the Pacific tsunami warning system was also serviced in collaboration with the Hydrographic and Oceanographic Service of the Chilean Navy (SHOA). The DART (Deep-Ocean Assessment and Reporting of Tsunami) carries IMET sensors and subsurface oceanographic instruments. A DART II buoy was deployed north of the STRATUS buoy, by personnel from the National Data Buoy Center (NDBC) Argo floats and drifters were launched, and CTD casts carried out during the cruise.

The ORS Stratus buoys are equipped with two Improved Meteorological (IMET) systems, which provide surface wind speed and direction, air temperature, relative humidity, barometric pressure, incoming shortwave radiation, incoming longwave radiation, precipitation rate, and sea surface temperature. Additionally, the Stratus 8 buoy received a partial CO_2 detector from the Pacific Marine Environmental Laboratory (PMEL). IMET data are made available in near real time using satellite telemetry. The mooring line carries instruments to measure ocean salinity, temperature, and currents.

The ESRL instrumentation used during the 2008 cruise included cloud radar, radiosonde balloons, and sensors for mean and turbulent surface meteorology.

Finally, the cruise hosted a teacher participating in NOAA's Teacher at Sea Program.


Equator
SOUTH AMERICA
ITCZ
Warm SST
SO2, aerosol transport
IMARPE José Olaya
UK 146
DoE G-1
copper smelters
NERC Do-228
NSF C-130
SHOA Buoy
Paposo Ground Site
CIRPAS Twin Otter
IMET Buoy
NOAA Ronald H Brown
ocean eddy transports
Low-level jet
Upwelling
STRATOCUMULUS
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40°S
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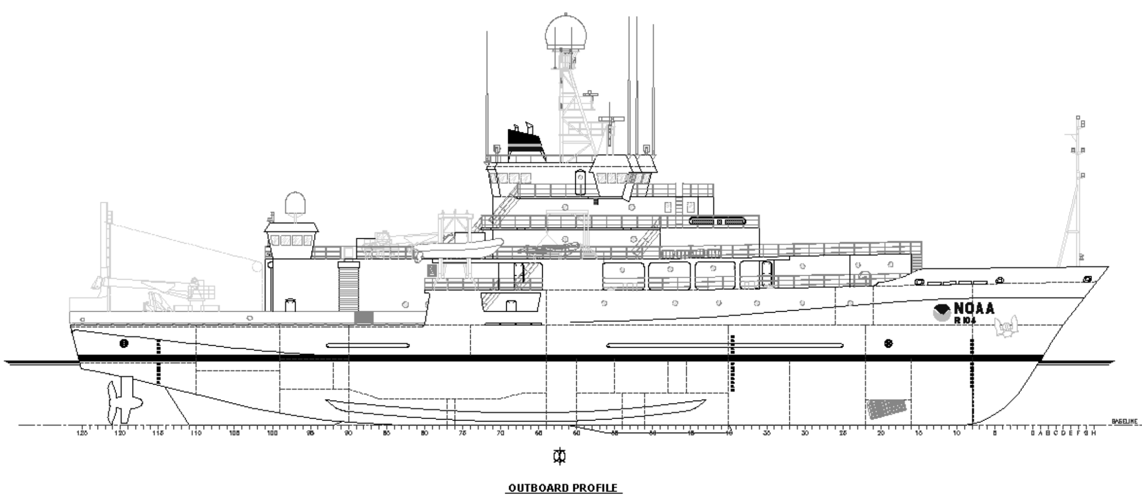
NOAA
OUTBOARD PROFILE

TABLE OF CONTENTS

List of Figures

List of Tables

1. Introduction

Background and Purpose

The presence of a persistent stratus deck in the subtropical eastern Pacific is the subject of active research in atmospheric and oceanographic science. Its origin and maintenance are still open to discussion. A better understanding of the processes responsible for this system is desirable not only because the nature of air-sea interactions in this region could be of valuable and maybe unique interest, but also because the regional radiative budget, altered by the clouds, seems to introduce errors in the South Pacific SST field from current computer models. There is also a desire to monitor in-situ data because of the inability of satellites to cover the area under the stratus deck.

The Ocean Reference Station at 20°S, 85°W under the stratus clouds west of northern Chile is being maintained to provide ongoing, climate-quality records of surface meteorology, of air-sea fluxes of heat, freshwater, and momentum, and of upper ocean temperature, salinity, and velocity variability. The Stratus Ocean Reference Station (ORS Stratus) is supported by the National Oceanic and Atmospheric Administration's (NOAA) Climate Observation Program. It is recovered and redeployed annually, with cruises that have come between October and December.

During the October 2008 cruise of NOAA's R/V *Ronald H. Brown* (RHB) to the ORS Stratus site, the primary activities were recovery of the WHOI surface mooring that had been deployed in October 2007, deployment of a new WHOI surface mooring at that site, in-situ calibration of the buoy meteorological sensors by comparison with instrumentation put on board by staff of the NOAA Earth System Research Laboratory (ESRL, formerly ETL), and observations of the stratus clouds and lower atmosphere by NOAA ESRL.

The ORS Stratus buoys are equipped with two Improved Meteorological (IMET) systems, which provide surface wind speed and direction, air temperature, relative humidity, barometric pressure, incoming shortwave radiation, incoming longwave radiation, precipitation rate, and sea surface temperature. The buoy is also outfitted with a PCO_2 sampling system. The IMET data are made available in near real time using satellite telemetry. The mooring line carries instruments to measure ocean salinity, temperature, and currents. The ESRL instrumentation used during the 2008 cruise included cloud radar, radiosonde balloons, and sensors for mean and turbulent surface meteorology.

2. Pre-Cruise Operations

a. Staging and Loading Charleston

Two flatbed trucks and a 53-foot box truck were loaded with the Stratus buoy, mooring components, support gear, and spares. WHOI personnel traveled to Charleston to meet the cargo and begin the buoy build up and cruise preparations.

The 53-foot box truck arrived at the pier in Charleston. The truck was unloaded, and most components were craned onto the deck. This truck contained most of the lab equipment and components to build up and test the buoy tower and meteorological systems. Work began on buoy assembly and lab setup.

The two flatbed trucks with the remaining gear arrived in Charleston. A crane was hired to position the containers and heavy equipment onto the ship. At the same time the equipment was being loaded on the ship, personnel were setting up computers and equipment in the lab. The flux system was mounted on the bow mast, and all GPS (global positioning system) and Argos receivers were set up and antenna wires run throughout the ship.

The build up of the buoy well and tower was completed, and the system was checked for proper function. The buoy was moved into an empty parking lot to perform a check of the compasses on the buoy's wind modules.

Transmissions from the instruments on the buoy were received with an Alpha Omega uplink receiver to check the validity of data as part of the final burn-in. The buoy was then loaded onto the ship. RHB departed from Charleston and arrived in Rodman, Panama. The ship tied up along the fuel dock in Rodman. The ship refueled, the science party boarded, and the ship departed to begin the first leg of the Stratus 9 cruise.

b. Sensor Evaluation

Testing for the ASIMET units deployed on the Stratus 8 buoy began on June 27, when the primary loggers were powered up, and continued until the instruments were powered down and disassembled for shipping on September 21. A third logger, SN L-05, was also instrumented and underwent burn-in as a spare unit starting on July 25. Data quality of the three systems was monitored beginning in late June and early July for the primary units. Modules that did not perform well during burn in were replaced.

Once the buoy was reassembled in Charleston, a last phase of the instrument check-out for meteorological sensors began. Using an Alpha Omega Uplink Receiver on the ship, hourly averaged data transmitted by the loggers to the Argos satellite system were continuously monitored until after the buoy was deployed.

All instruments were performing well when the buoy was disassembled for shipping to Charleston. Plots of both the internally recorded 1-minute data and the hourly averaged satellite transmitted data during the burn-in period show some disagreement between some pairs of sensors, documented here in plots of one day near the end of the burn in. Wind, relative humidity, and barometric pressure data is shown for September 19, the day in which the buoy was outdoors and undisturbed. Radiometer data is shown for September 14, the last sunny day of the burn in. Data from precipitation sensors are shown on July 27, the day they were tested. The SBE-37 SSTs were found to be functioning as expected.

We usually see some effect of RF noise caused by the Argos PTT transmitters, especially in burn-in data; this effect is almost always much less after deployment.

Buoy spins were conducted and were found to meet expectations. The buoy spin is a procedure to check the compass on the buoy. A visual reference direction is first set using an external compass. The buoy is then oriented successively at 8 different angles and the vanes of the anemometers are visually oriented towards the reference direction, and blocked. Wind is recorded for 15 minutes at the end of which the average compass and wind direction is read. The sum should correspond to the reference heading, within errors due to approximations in orientation, compass precision, and any deformation of the magnetic field due to the buoy metallic structure. A first buoy spin was made in Woods Hole and a second one in Charleston. Stratus 8 wind deployment consisted of: System 1 (L-01) Sonic Wind 203. System 2 (L-02) R.M. Young Wind 211. Stand alone R.M. Young wind 343.

3. Stratus 9 Mooring Description

a. Mooring Design

The buoys used in the Stratus project are equipped with surface meteorological instrumentation, including two Improved Meteorological (IMET) systems, see Table 3-1. The mooring line also carries subsurface instrumentation that measures conductivity and temperature and a selection of acoustic current meters and vector measuring current meters.

The WHOI mooring is an inverse catenary design utilizing wire rope, chain, nylon and polypropylene line and has a scope of 1.25 (scope is defined as slack length/water depth). The Stratus 8 surface buoy has a 2.7-meter diameter foam buoy with an aluminum tower and rigid bridle. The design of these surface moorings takes into consideration the predicted currents, winds, and sea-state conditions expected during the deployment duration.

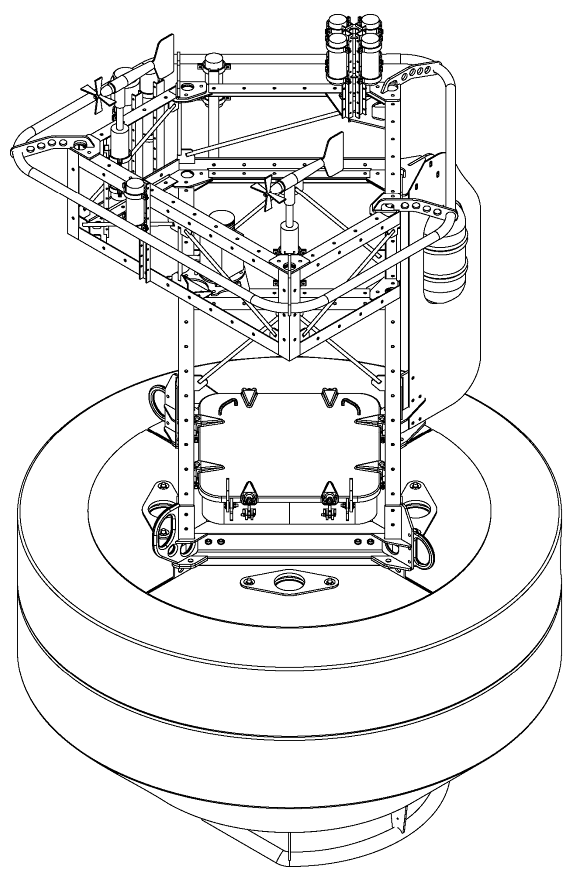

Figure 3-1: Representation of Stratus 9 ASIMET buoy.

b. Buoy Surface Instrumentation

The SST (Sea Surface Temperature) and SSS (Sea Surface Salinity) were measured using SBE37s on the Bridle. All the ASIMET modules were sampled at 60 a second sample rate. Table 3-1 indicates modules on Stratus 9 deployment.

i. ASIMET

Stratus 9 Serials/Heights

System 1

Module	Serial	Firmware Version	CM Above Water Line
Logger	I-04	LOGR53 V2.70	
HRH	501	VOS HRH53 V3.2	289
BPR	218	VOS BPR53 4.03CF	299
SWND	2	V4.10 CF SONIC WND53	329
PRC	216	VOS PRC53 V3.4	308
LWR	503	VOS LWR53 V3.5	340
SWR	502	VOS SWR53 V3.3	341
SST/SSS	2053		-148
PTT	12789	27916, 27917, 27918	

System 2

Module	Serial	Firmware Version	
Logger	I-15	LOGR53 V2.70	
HRH	213	VOS HRH53 V3.2	289
BPR	207	VOS BPR53 V3.3 (Heise)	299
WND	344	VOS WND53 V3.5	329
PRC	501	VOS PRC53 V3.4	308
LWR	219	VOS LWR53 V3.5	340
SWR	212	VOS SWR53 V3.3	341
SST/SSS	1838		-148
PTT	18171	27919, 27920, 27921	

Stand-Alone Module(s)

Module	Serial		
MINIMET	4	START 10/15/08 0100 60 MINUTES	287
PCO_2	17		

Table 3-1: Stratus 9 Serials/Heights

ii. Sea Surface Temperature

A Sea-Bird SBE-39 was placed in a floating holder (a buoyant block of syntactic foam that slides up and down along 3 stainless steel guide rods with stainless springs) in order to sample the sea temperature as close as possible to the sea surface. A Brancker TR-1060 temperature was fixed to the floating SST frame and an array of TR-1060s were placed in holes in the buoy hull. Table 3-2 is instrument array.

Instrument	Serial	Location	Meters Below Deck	Orientation Degrees
TR-1060	14875	Hole #1	0.84	180
TR-1060	14878	Hole #2	0.95	180
TR-1060	14879	Hole #3	1.04	180
TR-1060	14880	Hole #4	0.83	240
TR-1060	14883	Hole #5	0.93	240
TR-1060	14874	FSST Bracket	1.25	180
SBE39	0718	FSST	Float	180

Table 3-2: Stratus 9 Sea Surface Temperature Array

iii. Bridle SSTS

Two Sea-Bird SBE 37s are mounted to the bottom of the buoy hull at approximately 1 meter depth. These instruments are part of the IMET system and provide near-real time data of temperature and conductivity near the sea surface.

iv. Subsurface Argos Transmitter

A Subsurface Mooring Monitoring Beacon (SMM 500), built by Sensoren Instrumente Systeme GnbH (SiS), was mounted upside down on the bottom of the buoy. This is a backup recovery aid in the event that the mooring parts and the buoy capsizes.

v. Telemetry

Each ASIMET module onboard the buoy samples data every minute and records it on a dedicated flashcard. The logger receives and stores this data. It also computes hourly averages for Argos transmissions. These Argos transmissions can be picked up as well by an Alpha Omega Uplink receiver directly from the Argos antenna on the buoy. The hourly averages help to monitor the status of instruments and the quality of data they provide.

vi. PCO$_2$

Upwelling in the equatorial Pacific leads to enhanced productivity and degassing of CO_2 across a region ranging from the coast of South America to past the International Date Line. The vast area affected makes this region a significant contributor to global biogeochemical cycles. Variability in the South American upwelling region has been linked to a wide range of ecosystem and biogeochemical changes. Understanding this variability is a primary reason for the ongoing work at the Stratus site. The PCO_2 system on the Stratus mooring is a component in the OceanSITES moored PCO_2 network. Figure 3-2 is an intercomparison of PCO_2 systems.

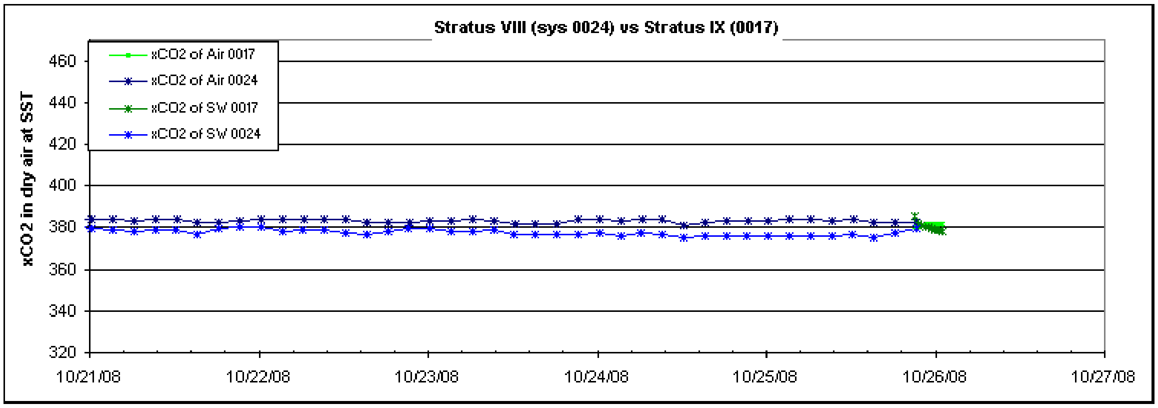

Fig 3-2: PCO_2 Intercomparison

CO2 measurements are made every three hours in marine boundary layer air and air equilibrated with surface seawater using an infra-red detector. The detector is calibrated prior to each reading using a zero gas derived by chemically stripping CO_2 from a closed loop of air and a span gas (414 ppm CO_2) produced and calibrated by NOAA's Earth System Research Laboratory (ESRL).

A summary file of the measurements is transmitted once per day and plots of the data are posted in near real-time to the web. To view the daily data, visit the NOAA PMEL Moored CO_2 Website:http://www.pmel.noaa.gov/co2/moorings/stratus/stratus_main.htm. Within a year of system recovery, the final processed data are submitted to the Carbon Dioxide Information Analysis Center (CDIAC) for release to the public.

vii. Sonic Wind

A Gill Sonic Wind Sensor was incorporated into the Stratus 8 buoy. The anemometer measures the time taken for an ultrasonic pulse to travel from one transducer to the opposite transducer and then compares it with the time taken for another pulse to travel in the opposite direction. Likewise, differences are measured between other pairs of transducers allowing calculations of both wind speed and direction.

viii. Wave Package

The WAMDAS wave system used on the Stratus 8 buoy, is made by Neptune Sciences and acquired from NDBC. This includes wave measurements, GPS positions, and GPS times. It utilizes a 3-axis motion pack made by MicroStrain Inc. The WAMDAS is capable of transmitting and storing data. The transmitted data is sent via Iridium communications on an hourly basis. This message is ultimately transmitted to NDBC where the data are subjected to automated quality-control checks and then posted on the NDBC web site. The data is stored in raw and processed format on a 1 GB compact flash card in the instrument.

c. Subsurface Instrumentation

The following sections describe individual instruments on the buoy bridle and mooring line. Where possible, instruments were protected from being fouled by fishing lines using “trawl-guards” designed and fabricated at WHOI. These guards are meant to keep lines from hanging up on the in-line instruments.

Before a buoy launch and after its recovery, different physical signals are imprinted in the instruments' records at determined times. This reveals the possible presence of a drift in the internal clock of instruments. Temperature and salinity sensors are plunged into a large bucket filled with ice and fresh water for about an hour. VMCM rotors are spun and then blocked.

Table 3-3 summarizes the moored instrumentation.

Table 3-3: Stratus 9 Subsurface Instrumentation

Instrument	Serial	Depth Meters	Sample Rate
SBE37__SST_	2053	Bridle	1 min
SBE37__SST_	1838	Bridle	1 min
SBE37	1325	3.7	5 min
SBE37	1326	6.75	5 min
SBE37	1328	16	5 min
SBE37	1329	30	5 min
SBE37	1330	37.5	5min
SBE37	1906	40	5 min
SBE37	1908	62	5 min
SBE37	1909	85	5 min
SBE37	2012	96.3	5 min
SBE37	2015	130	5 min
SBE39	**0718**	FSST	5 min
SBE39	**0035**	3	5 min
SBE39	**0038**	5	5 min
SBE39	**0048**	6	5 min
SBE39	**0049**	7.9	5 min
SBE39	**0102**	12	5 min
SBE39	**0103**	*25*	5 min
SBE39	**0276**	77.5	5 min
SBE39	**0284**	*35*	5 min
SBE39	**0476**	*70*	5 min
SBE39	**0719**	92	5 min
SBE39	**0720**	100	5 min
SBE39	**1498**	115	5 min
SBE39	**1499**	175	5 min
SBE39	**1500**	400	5 min
SBE39	**1501**	450	5 min
XR420 CT	15218	2	60 sec
TR-1060	14874	FSST Bracket	15 sec
TR-1060	14875	Hole # 1	15 sec
TR-1060	14878	Hole # 2	15 sec
TR-1060	14879	Hole # 3	15 sec
TR-1060	14880	Hole # 4	15 sec
TR-1060	14883	Hole # 5	15 sec

Table 3-3 (continued): Stratus 9 Subsurface Instrumentation			
Instrument	**Serial**	**Depth Meters**	**Sample Rate**
SBE16	146	160	5 min
SBE16	991	190	5 min
SBE16	1873	220	5 min
SBE16	1875	250	5 min
SBE16	1881	310	5 min
VMCM painted	9	45	1 min
VMCM painted	21	55	1 min
VMCM	4	145	1 min
VMCM	012	183	1 min
VMCM	016	235	1 min
VMCM	019	290	1 min
VMCM 12.83	042	320	1 min
VMCM	008	350	1 min
VMCM	075	852	1 min
VMCM	083	1605	1 min
AANDERRA	13	20	3 mins
AANDERRA	78	32.5	3 mins
AANDERRA	79	10	3 mins
SEAGUARD	106	50	15 mins
RDI ADCP	1218	135	1 hr
NORTEK ADCP	2128	15	1 hr
SONTEK ADCM	197	192	1 hr

i.VMCMs

The VMCM has two orthogonal cosine response propeller sensors that measure the components of horizontal current velocity parallel to the axles of the two-propeller sensors. The orientation of the instrument relative to magnetic north is determined by a flux gate compass. East and north components of velocity are computed continuously, averaged and then stored. All the VMCMs deployed from Stratus 4 onward have been next generation models that have newer circuit boards and record on flash memory cards instead of cassette tape. Temperature was also recorded using a thermistor mounted in a fast response pod, which was mounted on the top end cap of the VMCM.

ii. RDI Acoustic Doppler Current Profiler

The RD Instruments (RDI) Workhorse Acoustic Doppler Current Profiler (ADCP, Model WHS300-1) is mounted looking upwards on the mooring line. The RDI ADCP measures a profile of current velocities.

iii. Nortek

The Nortek Aquadopp current profiler uses Doppler technology to measure currents. It has 3 beams tilted at 25 degrees and has a transmit frequency of 1 MHz. The internal tilt and compass sensors give current direction

iv. SonTek Argonaut MD Current Meter

SonTek Argonaut MD current meters have been used in the upper portion of the mooring line. The three-beam 1.5Mhz single point current meter is designed for long term mooring deployments, and can store over 90,000 samples.

v. Aanderaa RCM 11s

The Aanderaa RCM 11 measures the horizontal current speed and direction, as well as temperature. The instrument can operate continuously or in eight intervals from 1 to 120 minutes.

vi. Aanderaa SEAGUARD RCM

The new SEAGUARD RCM series replaces the industry Standard RCM 9 and RCM 11 series. It has been completely redesigned from bottom up and employs modern technology in the datalogger section and in the different sensor solutions, see Figure 3-2.

Fig 3-3: SEAGUARD RCM

vii. SBE-39 Temperature Recorder

The Sea-Bird model SBE-39 is a small, light weight, durable and reliable temperature logger. It is a high-accuracy temperature (pressure optional) recorder with internal battery and non-volatile memory for deployment at depths up to 10,500 meters (34,400 feet).

viii. SBE37 MicroCat Conductivity and Temperature Recorder

The MicroCat, model SBE37, is a high-accuracy conductivity and temperature recorder with internal battery and memory. It is designed for long-term mooring deployments and includes a standard serial interface to communicate with a PC. Its recorded data are stored in non-volatile

FLASH memory. The temperature range is -5° to +35ºC, and the conductivity range is 0 to 6 Siemens/meter. The pressure housing is made of titanium and is rated for 7,000 meters. The instruments were mounted on in-line tension bars and deployed at various depths throughout the moorings. The conductivity cell is protected from bio-fouling by the placement of antifoulant cylinders at each end of the conductivity cell tube.

ix. SBE16 SeaCat Conductivity and Temperature Recorders

The model SBE 16 SeaCat was designed to measure and record temperature and conductivity at high levels of accuracy. Powered by internal batteries, a SeaCat is capable of recording data for periods of a year or more. Data are acquired at intervals set by the user. An internal back-up battery supports memory and the real-time clock in the event of failure or exhaustion of the main battery supply. These were mounted on in-line tension bars and deployed at various depths throughout the moorings. The conductivity cell is protected from bio-fouling by the placement of antifoulant cylinders at each end of the conductivity cell tube

x. Brancker XR-420 Temperature and Conductivity Recorder

The Brancker XR-420 CT is a self-recording temperature and conductivity logger. The operating temperature range for this instrument is -5° to 35°C. It has internal battery and logging, with the capability of storing 1,200,000 samples in one deployment. A PC is used to communicate with the Brancker via serial cable for instrument set-up and data download.

xi. High-Resolution Pulse-to-Pulse Coherent Doppler Sonars
Upper Ocean Turbulence

As part of the Stratus (S9) buoy deployed during the VOCALS 2008 cruise, pulse-to-pulse coherent Doppler sonars were added to the subsurface instrumentation of the buoy for measurements of the turbulence and mixing within and below the mixed layer. See Table 3-4. The coherent Doppler sonars are Nortek model Aquadopp HR profilers and measure the current velocity. The Aquadopp HR profilers operate at a transmit frequency of 2 MHz and have a firmware upgrade that allows for a high-resolution mode with bin sizes capable of 13 mm to capture the inertial-dissipation range for turbulent kinetic energy (TKE) dissipation rate estimates. The Aquadopp HR profilers have a custom sensor head with 3 beams; two orthogonal beams in a plane that is orthogonal to the cylindrical axis and a third beam that is directed upward 45° to this plane and 45° between the two horizontal orthogonal beams.

The coherent Doppler sonars were placed at 6 depths within the top 110 m of the ocean; 8.4 m, 27.5 m, 47.5 m, 66.7 m, 87.4 m, and 107.5 m. Two Aquadopp HR profilers were placed on a vane system at 5 of the depths (all except the 47.5 m depth) as shown in Figure 3-4. One sonar was placed forward with Beam 1 directed forward in-stream with the vane. The second sonar was placed just behind the forward sonar with Beam 1 directed orthogonal in the cross-stream direction to the vane.

At the 47.5 m depth, a single Aquadopp HR profiler was paired with a Nortek Vector acoustic Doppler velocimeter (ADV) instead of another coherent Doppler sonar as shown in Figure 3-5. The Vector transmits at 6 MHz and was mounted behind the Aquadopp HR profiler. The Vector has a custom 90° probe such that the probe volume is roughly 20 cm above the Aquadopp HR forward-looking Beam 1. The objective of the ADV paired with the coherent Doppler sonar is to test the efficacy of the Taylor frozen field hypothesis in open-ocean environments. For all instrument above 70 m, the housings were painted with EPaint ZO anti-fouling paint that is described in detail later. For all acoustic instruments at all depths, the transducer heads were coasted with the proprietary EPaint formula called Bio-Grease. This two-pronged approach inhibits the settling of larvae of fouling organisms.

For each Aquadopp HR profiler, the system was set to sample one (Beam 1) of the three possible beams to maximize the sample rate at 4 Hz. The system sampled the along-beam velocity in 53 bins each with a size of 26 mm with a profile range of 1.38 m. The first 5 cm is considered the blanking distance and are not useful data. The nominal velocity range in each bin is ±21 cm s-1. 540 pings were sampled every hour on the hour for the forward Aquadopp HR profiler and on the half hour for the rear profiler. The Aquadopp HR profilers are configured to last for roughly 420 days of operation. The Aquadopp used firmware v.3.08 and the NIP logger used firmware v.1.02.

For the Vector ADV, the system was set to sample at 16 Hz. The system sampled the 3-dimensional velocity in the sample volume with a size of 14.9 mm. The nominal vertical and horizontal velocity range are ±20 cm s-1 and ±80 cm s-1, respectively. 6720 samples (7 minutes) were made every 2 hours on the half hour. The Vector ADV was configured to last for roughly 75 days of operation. The Vector used firmware v.1.20.

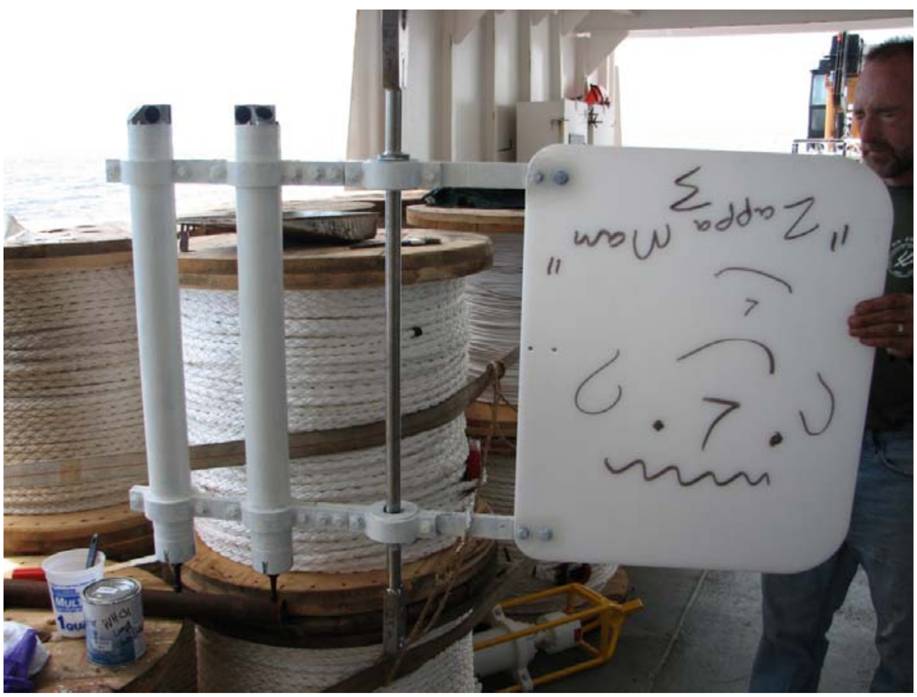

Figure 3-4: Picture of the vane system with two Aquadopp HR profilers. Note that the Aquadopp HR profilers and mounting brackets are painted with white anti-foul paint.

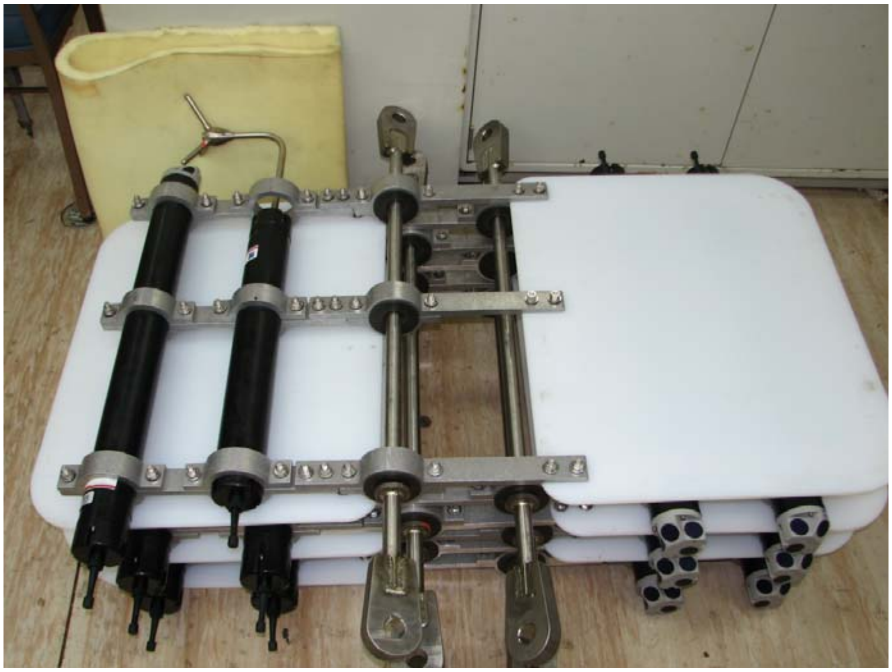

Figure 3-5: Picture of the vane system on Aquadopp HR profiler and one Vector ADV.

Instrument	Serial	Depth (m)	Orientation	Samples	Sample Rate (Hz)	Burst Interval (s)	Start Date	Start Time (UTC)	Deploy Date	In-Water Time (UTC)
NORTEK LDEO	3224	8.4	In-Line	540	4	3600	24-Oct-08	0200	25-Oct-08	1235
NORTEK WHOI	3131	8.4	Cross-Stream	540	4	3600	24-Oct-08	0230	25-Oct-08	1235
NORTEK LDEO	3132	27.5	In-Line	540	4	3600	24-Oct-08	0200	25-Oct-08	1221
NORTEK WHOI	3184	27.5	Cross-Stream	540	4	3600	24-Oct-08	0230	25-Oct-08	1221
ADV LDEO	4630	47.5	In-Line Over Top	6720	16	7200	22-Oct-08	1730	25-Oct-08	1332
NORTEK WHOI	3128	47.5	In-Line Front	540	4	3600	24-Oct-08	0230	25-Oct-08	1332
NORTEK LDEO	3185	66.7	In-Line	540	4	3600	24-Oct-08	0200	25-Oct-08	1346
NORTEK WHOI	3133	66.7	Cross-Stream	540	4	3600	24-Oct-08	0230	25-Oct-08	1346
NORTEK LDEO	3183	87.4	In-Line	540	4	3600	24-Oct-08	0200	25-Oct-08	1353
NORTEK WHOI	3223	87.4	Cross-Stream	540	4	3600	24-Oct-08	0230	25-Oct-08	1353
NORTEK LDEO	3135	107.5	In-Line	540	4	3600	24-Oct-08	0200	25-Oct-08	1404
NORTEK WHOI	3181	107.5	Cross-Stream	540	4	3600	24-Oct-08	0230	25-Oct-08	1404

Table 3-4: Stratus 9 deployment setup for the pulse-to-pulse coherente Doppler sonars.

Xii . Acoustic Release

The acoustic release used on the Stratus 9 mooring is an EG&G Model 8242. This release can be triggered by an acoustic signal and will release the mooring from the anchor. Releases are tested at depth prior to deployment to ensure that they are in proper working order (Table 3-5).

Instrument	Serial
Model 8242	32483
Model 8242	32480

Table 3-5: Stratus 9 Releases

d. Antifouling Coatings

Early moorings at this site have been used as test beds for a number of different antifouling coatings. The desire has been to move from organotin-based antifouling paints to a product that is less toxic to the user, and more environmentally friendly. These tests have previously led the Upper Ocean Process group to rely on E Paint Company's, Sunwave product as the anti fouling coating used on the buoy hull, and ZO for the majority of instruments deployed from the surface down to 70 meters.

Instead of the age-old method of leaching toxic heavy metals, the patented E Paint approach takes visible light and oxygen in water to create peroxides that inhibit the settling larvae of fouling organisms. Photogeneration of peroxides and the addition of an organic co-biocide, which rapidly degrades in water to benign by-products, make E Paint's Sunwave and ZO an effective alternative to organotin antifouling paints. This paint has been repetitively tested in the field and has shown acceptable bonding and anti-fouling characteristics, as well as a good service life up to one year. However, certain instruments are adversely affected by even the slightest fouling. To date, adjuncts must be used to insure the most protection on those instruments.

Table 3-6 below shows methods used for coating the buoy hull and instrumentation for the Stratus 9 deployment, as well as observations of each instrument.

DEPTH	INSTRUMENT	ANTI FOULING APPLIED
Surface	Buoy Hull	E-Paint, Sunwave, 6 coats - white
Surface	Floating SST and Fixed SSTs (6)	E-Paint ZO, 2 heavy coats
1 M	SBE 37 – SST (2)	E-paint ZO- 2 heavy coats, copper shield. Bio grease on cell
2 M	XR 420 – (CT)	E-paint ZO- 2 heavy coats, bio-grease around coil
3M	SBE - 39	E-paint ZO - 2 heavy coats
3.7, 6.75, 16, 30, 37.5 M	SBE 37 (C/T)	E-paint ZO- 2 heavy coats over plastic tape, copper shield. Bio grease on cell
5 ,6, 12, 25, 35, M	SBE - 39	E-paint ZO - 2 heavy coats
40, 62 M	SBE 37 (C/T)	E-paint ZO- 2 heavy coats over plastic tape, copper shield.
10, 20, 32.5, 50 M	Aanderaa ADCM	E-paint ZO - 2 heavy coats, tape over head housing, bio-grease on transducers.
15 M	NORTEK ADCP	E-paint ZO- 2 heavy coats over plastic tape, bio grease on transducers
16 M	SBE 37 (C/T)	E-paint ZO w/adjunct, 2 heavy coats
20 M	NORTEK ADCM	Copper foil over tape near transducer heads, ZO over tape on body & at seams near heads. Bio-grease on transducer heads
12.5, 27.5, 47.5, 66.7 M	Double Nortek ADCMs on vaned strongback	E-paint -2 heavy coats, bio grease on transducers.

Table 3-6: Stratus 9 Anti Fouling Applications

4. Stratus 9 Mooring Deployment

a. Deployment

The Stratus 9 surface mooring was set using a two-phase mooring technique. Phase 1 involves the lowering of approximately 50 meters of instrumentation followed by the buoy, over the port side of the ship. Phase 2 is the deployment of the remaining mooring components through the A-frame on the stern.

The TSE winch drum was pre-wound with the following mooring components listed from deep to shallow:

- 200 m 7/8” nylon – nylon to wire shot
- 100 m 3/8” wire - nylon to wire shot
- 250 m 3/8” wire
- 250 m 3/8” wire
- 500 m 3/8” wire
- 500 m 3/8” wire
- 27.5 m 7/16” wire
- 38 m 7/16” wire
- 27 m 7/16” wire
- 20 m Spectra working line

A tension cart was used to pre-tension the nylon and wire during the winding process.

The ship was positioned 10 nautical miles downwind and down current from the desired anchor site. An earlier bottom survey indicated this track would take the ship over large area with consistent ocean depth.

Prior to the deployment of the mooring, the spectra working line, and wire rope passed out through the center of the A-frame, around the aft port quarter and forward along the port rail to the instrument lowering area.

Four wire handlers were stationed around the aft port rail and A-frame. The wire handlers’ job was to keep the hauling wire from fouling in the ship’s propellers and to pass the wire around the stern to the line handlers on the port rail.

To begin the mooring deployment, the ship hove to with the bow positioned with the wind slightly on the port bow. The crane boom was positioned over the instrument lowering area to allow a vertical lift of at lease five meters. All subsurface instruments for this phase had been staged in order of deployment on the port side main deck. All instrumentation had chain or wire rope shackled to the top of the instrument load bar or cage. A shackle and ring was attached to the top of each shot of chain or wire.

The first instrument segment to be lowered was a VMCM current meter at 45m. This instrument had a 3.3-meter shot of ¾” chain shackled to the top of the instrument cage, and a 0.68-meter wire rope segment shackled to the bottom. This segment of chain was shackled into the working line coming from the winch. The crane hook, suspended over the instrument lowering, area was lowered to approximately 1 meter off the deck. An eight-foot sling was hooked onto the crane and passed through a ring to the top of the 3.3-meter shot of chain shackled to the top of the current meter.

The crane was raised so the chain and instrument were lifted off the deck. The crane slowly lowered the wire and attached mooring components into the water. The wire handlers positioned around the stern eased line over the port side, paying out enough to keep the mooring segment vertical in the water. An air tugger with a chain hook was used to haul on the chain and take the load from the crane. A stopper was attached to the top link of the instrument array as a back up. The hook on the crane was removed. Lowering continued with 20 more instruments and chain segments being picked up and placed over the side.

The operation of lowering the upper mooring components was repeated up to the 5 meter SBE 39 temperature logger. The load from this instrument array was stopped off using a slip line passed through a pear link shackles into the termination above the load bar. The two, three, and 3.7-meter instruments were shackled to hardware and chain connecting them to the universal joint on the bottom of the buoy. The vertical instrument array hanging in the water was joined to the three instruments attached to the bottom of the buoy.

The second phase of the operation was launching the buoy. Three slip lines were rigged on the buoy to maintain control during the lift. Lines were rigged on the buoy bottom, the tower, and a buoy deck bail. The 30 ft. slip line was used to stabilize the bottom of the buoy at the start of the lift. The 50 ft. tower slip line was rigged to check the tower as the hull swung outboard. A 75 ft. buoy deck bail slip line was rigged to prevent the buoy from spinning as the buoy settled in the water. This is used so the quick release hook, hanging from the crane, could be released without fouling against the tower. The deck slip line was removed just following the release of the buoy. An additional line was tied to the crane hook to help pull the crane block away from the tower's meteorological sensors once the quick release hook had been triggered and the buoy cast adrift.

With the three slip lines in place, the crane was positioned over the buoy. The quick release hook, with a 1" sling link, was attached to the crane block. Slight tension was taken up on the crane to hold the buoy. The ratchet straps securing the buoy to the deck were removed. The buoy was raised up and swung outboard as the slip lines kept the hull in check. The stopper line holding the suspended 45 meters of instrumentation was eased off to allow the buoy to take the hanging load. The lower slip line was removed first, followed by the tower slip line. Once the discus had settled into the water (approximately 20 ft. from the side of the ship), and the release hook had gone slack, the quick release was tripped. The crane swung forward to keep the block away from the buoy. The slip line to the buoy deck bail was cleared at about the same time. The ship then maneuvered slowly ahead to allow the buoy to come around to the stern.

The winch operator slowly hauled in the slack wire once the buoy had drifted behind the ship. The ship's speed was increased to 1 knot through the water to maintain a safe distance between the buoy and the ship. The bottom end of the shot of wire shackled to the hauling wire was pulled in and stopped off at the transom.

A traveling block was suspended from the A-frame using the heavy-duty air tugger to adjust the height of the block. The next instrument, a 47.5 meter depth frame with two Nortek current meters and pre-attached chain shot was shackled to the end of the stopped off mooring. The bottom of this chain was shackled into top of the instrument cage for the 50-meter Aanderaa current meter with 1.2-meter chain on the bottom. The free end of the hauling wire was passed through the block and shackled to the free end of chain on the Aanderaa. The hauling line was pulled onto the TSE winch to take up the slack. The winch slowly took the mooring tension from the stopper lines.

The block was hauled up to about 8 feet off the deck, lifting the current meter off the deck as it was raised. By controlling the A-frame, block height, and winch speed, the instrument was lifted clear of the deck and over the transom. The winch was payed out to the next termination. The termination was stopped off using lines on cleats, and the hauling wire removed while the next instrument was attached to the mooring.

The next several instruments were deployed in a similar manner. When pulling the slack on the longer shots of wire, the terminations were covered with a canvas wrap before being wound onto the winch drum. The canvas covered the shackles and wire rope termination to prevent damage from point loading the lower layers of wire rope and nylon on the drum. This process of instrument insertion was repeated for the remaining instruments down to 1605 meters.

While the wire and nylon line were being payed out, the crane was used to lift the 96 glass balls out of the rag top container. These balls were staged fore and aft, in four ball segments, on the port side of the deck. When all the wire and nylon on the winch drum were payed out, the end of the nylon was stopped off to a deck cleat.

An H-bit cleat was positioned in front of the TSE winch and secured to the deck. The free end of the 3000 meter shot of nylon/polypropylene line, stowed in three wood-lined wire baskets was dressed onto the H-bit and passed to the stopped off mooring line. The shackle connection between the two nylon shots was made. The line handler at the H-bit pulled in all the residual slack and held the line tight against the H-bit. The stopper lines were then eased off and removed.

The person handling the line on the H-Bit kept the mooring line parallel to the H-bit with moderate back tension. The H-bit line handler and one assistant eased the mooring line out of the wire basket and around the H-bit at the appropriate payout speed relative to the ship’s speed.

When the end of the polypropylene line was reached, pay out was stopped and a Yale grip was used to take tension off the polypropylene line. The winch tag line was shackled to the end of the polypropylene line. The polypropylene line was removed from the H-Bit. The winch line and mooring line were wound up taking the mooring tension away from the stopper line on the Yale grip. The stopper lines and Yale grip were removed. The TSE winch payed out the mooring line until all but one meter of the polypropylene line was over the transom.

The 96 glass balls were bolted on 1/2” trawler chain in 4 ball (4 meter) increments. The first two sets of glass balls were dragged into position and shackled together. One end was attached to the mooring at the transom. The other end was shackled to the winch leader. The winch pulled the mooring line tight, stopper lines were removed, and the winch payed out until seven of the eight balls were off the stern. Stopper lines were attached, the winch leader was removed, and the process repeated until all 96 balls were deployed.

A 5-meter shot of chain was shackled to the last glass ball segment. The acoustic releases were shackled to the chain. Another 5-meter chain section was shackled to the releases. A 20-meter Nystron anchor pendant was shackled to that chain, and another 5-meter section of ½" chain was shackled to the anchor pendant. The mooring winch wound up these components until it had the tension of the mooring. The acoustic releases were laying flat on the deck.

The air tugger hauling line was passed through a block hung in the A-frame. A ½" chain hook was shackled to the end of the tugger line. The chain hook was attached to the mooring about two meters below the acoustic releases. The A-frame was positioned all the way in. The tugger line was pulled in and the releases were raised from the deck. As the winch payed out, the A-frame moved out and eased the release over the transom without touching the deck. The tugger payed out and the chain hook was removed.

The winch continued to pay out until the final 5-meter shot of chain was just going over the transom. A shackle and link was attached one meter up this segment of chain. A heavy-duty slip line was passed through the link and secured to two cleats on the deck. The winch payed out until tension was transferred to the slip line. The chain lashings were removed from the anchor. The end of the chain was removed from the winch and shackled to the anchor on the tip plate.

The starboard crane was shifted so the crane boom would hang over, and slightly aft of the anchor. Deck bolts were removed from the anchor tip plate. The crane was lowered and the hook secured to the tip plate bridle. A slight strain was applied to the bridle. The slip line was removed, transferring the mooring tension to the 1/2" chain and anchor. The line was pulled clear and the crane raised 0.5 meters lifting the forward side of the tip plate causing the anchor to slide overboard.

The deployment started at 12:00 (UTC), October 25th and the anchor was dropped at 18:40 (UTC).

b. Anchor Survey

Following the anchor drop, the *Brown* moved off the deployment line and allowed time for the anchor to reach the sea floor. Three points were selected for the anchor survey at ranges approximately 2000 meters from the estimated anchor location.

At each of these sites an Edgetech 8011A deck unit was used to communicate with the acoustic release on the mooring. Signal travel time was recorded at each site. Travel time and ship's coordinates for each site were entered into Arthur Newhall's Acoustic Survey Software to calculate anchor position. The program uses the intersection of each range arc to calculate anchor position, see Figure 4-1.

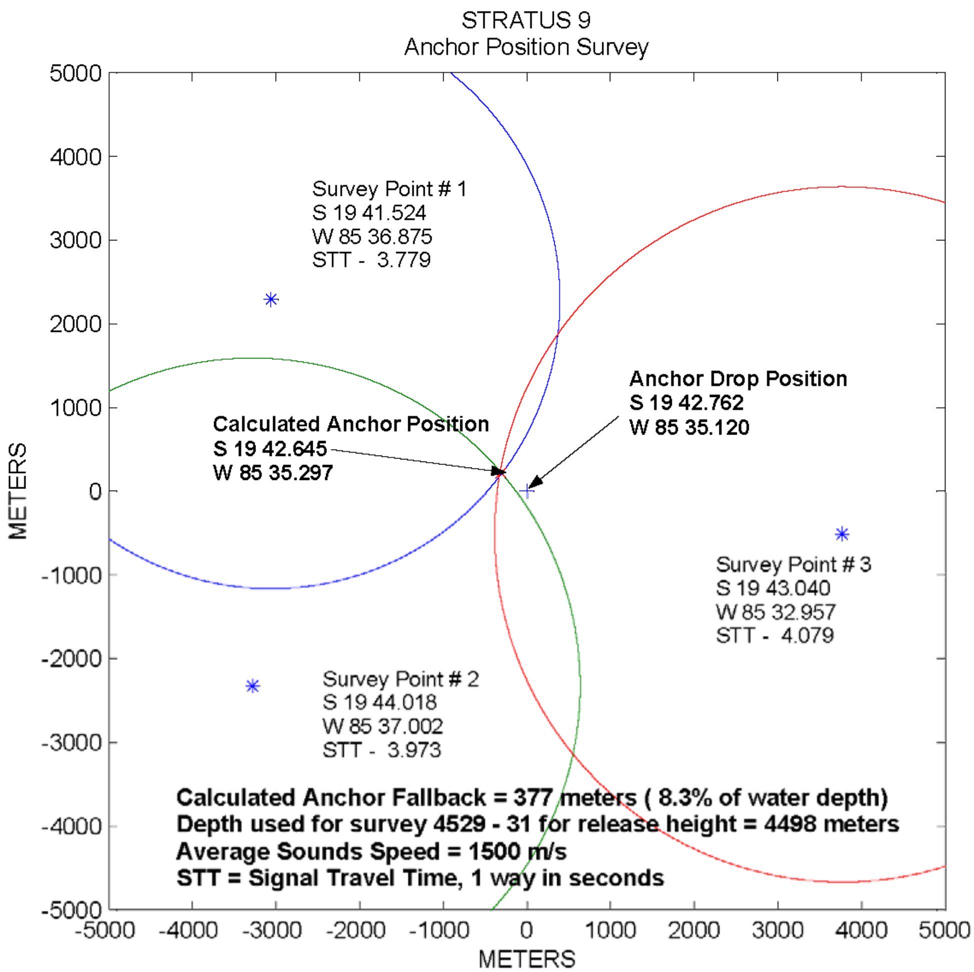

Figure 4-1: Stratus 9 Anchor Survey Details

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5. Stratus 8 Mooring Recovery

a. Recovery

The Stratus 8 mooring was recovered on October 27, 2008. To prepare for recovery the *Ronald Brown* was positioned roughly ¼ mile to the side of the anchor position, with the buoy streaming down wind. The release command was sent to the acoustic release to separate the anchor from the mooring line at 10:57 UTC. After about 50 minutes, the glass balls surfaced. Once the glass balls were on the surface, the ship approached the cluster of balls along the starboard side. The yellow polypropylene line was floating on the surface between the glass ball cluster and the ship. Recovery commenced by grappling the poly line and bringing it through the A-frame. The poly line was secured with a locking stopper line, and the end leading to the glass balls was cut and connected to the winch leader.

The winch hauled in as the ship steamed ahead to get the balls lined up behind it. At this point, the ship was towing the glass balls from the winch, and the rest of the mooring was stopped off on a cleat. With the A-frame fully outboard, the glass balls were slowly lifted from the water. The A-frame was brought inboard as the winch hauled in, lifting the cluster of glass above the deck. Three air tuggers were used to stabilize the cluster, and haul it forward. When the cluster was clear of the transom; it was lowered to the deck. A stopper line was used to secure the chain hanging over the stern with two acoustic releases attached to it. The winch was disconnected from the glass ball cluster, and shackled to the release chain. The chain was disconnected from the glass ball cluster, and the winch hauled in to get the releases onto the deck.

The glass balls were disconnected and hauled to the port side to be lifted by crane into the ragtop container on the main deck. The ship continued to steam slowly into the wind during this operation. Once the deck was clear, a traveling block was hung from A-frame, using the large air tugger to adjust the height. A working line was tied to the 1-1/8” polyethylene line, led through the block, and wrapped onto the high speed capstan. The 1500m of polypropylene, 100m of 1” nylon and 1650m of 7/8” nylon were hauled in and fed into three wire baskets.

Hauling stopped at the end of the 1650-meter shot of nylon. Stopper lines were connected into the link between the 1650 and 200-meter shots of nylon and made fast to the deck cleats. The mooring load was then transferred from the capstan to the stopper lines. The shackle to the 1650 meter shot of nylon was removed. The winch leader was led through the traveling block and shackled to the mooring line on the stoppers. The winch then took the load and the stopper lines were removed.

The winch continued recovering the 200nylon/100m 3/8” wire rope with special termination and the four shots of 3/8” wire rope (200m, 300m, 2 x 500m). VMCMs at 1557m, 1355m and 852 m were brought aboard and removed from the mooring. The two SBE-39s clamped on the 3/8” wire rope were removed.

The procedure for recovering the instruments went as follows: with A-frame boomed out over the stern, the winch hauled in the wire. The first instrument was stopped about 2 feet above the deck and the A-frame was moved in. Two stopper lines were hooked into the sling link and made fast to the deck cleats. The winch payed out slowly lowering the instrument to the deck. The instrument was disconnected from the hardware and moved to a staging area for pictures. The wire rope from the winch was then shackled to the load. The winch took up the slack and the stopper lines were eased off and then cleared. The A-frame was boomed out and hauling continued until the next instrument.

The above procedure was continued throughout the recovery operation until the Nortek current meter at 45 meters was recovered. Once the current meter was recovered, a slip line, passed through the link at the bottom of the 3.66m chain, was used to set the buoy and remaining 40 meters of instruments adrift.

Once the buoy was set adrift from the stern recovery operation, The *Brown* slowly approached buoy, keeping it along the port side of the ship. While the ship was maneuvering, tuggers and deck equipment were readied for the final recovery. The port crane was positioned above the recovery area. As the ship maneuvered the buoy, a pickup pole with snap hook and 12-foot sling were used to grab the lifting bale on the buoy. The sling was hooked into the block of the crane. The crane lifted the buoy from the water and swung inboard so the buoy would rest on the side of the ship. A tugger line was attached to a buoy deck bales, and a steadying line was looped through the crash bar on the tower on the buoy. The buoy was hoisted up and then swung inboard while the tugger and line kept the buoy from swinging.

Once the buoy was on deck aircraft straps were used to secure the buoy. A stopper line was used to stop off on the 0.37 m shot of 3/4" chain between the first and second instruments. Tugger lines were removed from the buoy. The shackle was disconnected from the universal plate on the bottom of the buoy.

The large port side crane was disconnected from the buoy and stowed. The smaller Hiab crane on the main deck set up above the final instrument recovery area. The forward air tugger was fitted with a chain hook to aid in the recovery.

An 8-foot lift all sling was placed through the link at the top of the first instrument and hooked in the crane's hook. The crane took the load, and the stopper line was eased off and cleared. The crane hoisted the first two instruments and the tugger line with chain hook line was attached a section of chain and pulled tight. A safety stopper was attached to the link below the instruments hanging from the crane. Once the tugger had the load, the crane lowered the instruments to the deck. The instruments were disconnected and the crane was repositioned over the load. The sling was placed through the sling at the top of the remaining instrument array hooked into the crane. The crane took the load and the tugger and safety stopper lines were eased off and cleared. The crane lifted the next section of instruments and the above procedure was repeated to recover the remaining instruments.

b. Stratus 8 Subsurface Instrumentation and Data Return

The primary data processing task, after recovering a buoy, is to duplicate all the instrument data to prevent possible loss. Further processing for inventory purposes and first-look troubleshooting is also done as time allows. On the Stratus 8 recovery cruise, the instruments were processed through the inventory stage. Table 5-1 shows subsurface instrumentation and recovery information.

Table 5-1 Stratus 8 Subsurface Instrumentation and Data Return

Instrument	Serial	Depth	TIME CHECK: UTC Time	TIME CHECK: UTC Date	TIME CHECK: Internal Time	TIME CHECK: Internal Date	DATA: Stop Sampling /sample rate	DATA: Records	Post Recovery Spike: Start Time	Post Recovery Spike: Start Date	Post Recovery Spike: Stop Time	Post Recovery Spike: Stop Date
SBE37	1901	2	11:05:00	29-Oct	11:05:14	29-Oct	11:05:30 / 5 min	109561	17:01:00	28-Oct	18:14:00	28-Oct
SBE37	1902	3.7	11:00:00	29-Oct	11:00:10	29-Oct	11:00:30 / 5 min	109561	17:01:00	28-Oct	18:14:00	28-Oct
SBE37	1903	7	0:38:00	29-Oct	0:37:57	29-Oct	0:38:30 / 5 min	109436	17:01:00	28-Oct	18:14:00	28-Oct
SBE37	1905	16	13:11:00	29-Oct	13:10:55	29-Oct	13:11:30 / 5 min	109587	17:01:00	28-Oct	18:14:00	28-Oct
SBE37	1907	30	0:36:00	29-Oct	0:36:12	29-Oct	0:37:30 / 5 min	109436	17:01:00	28-Oct	18:14:00	28-Oct
SBE37	1910	40	11:03:00	29-Oct	11:03:39	29-Oct	11:03:30 / 5 min	109561	17:01:00	28-Oct	18:14:00	28-Oct
SBE37	1912	62.5	0:39:00	29-Oct	0:39:42	29-Oct	0:40:30 / 5 min	109436	17:01:00	28-Oct	18:14:00	28-Oct
SBE37	2011	85	0:41:00	29-Oct	0:41:00	29-Oct	0:41:30 / 5 min	109437	17:01:00	28-Oct	18:14:00	28-Oct
SBE37	3639T	130	10:58:00	29-Oct	10:57:32	29-Oct	10:58:30 / 5 min	109560	17:01:00	28-Oct	18:14:00	28-Oct
SBE39	0203	25	21:34:00	29-Oct	21:33:38	29-Oct	21:34:00 / 5 min	109687	15:33:00	28-Oct	16:50:00	28-Oct
SBE39	0721	35	21:31:00	29-Oct	21:30:25	29-Oct	21:32:00 / 5 min	109687	15:33:00	28-Oct	16:50:00	28-Oct
SBE39	3423	70	20:39:00	29-Oct	20:39:46	29-Oct	20:40:00 / 5 min	109676	15:33:00	28-Oct	16:50:00	28-Oct
SBE39	3434	77.5	20:38:00	29-Oct	20:38:41	29-Oct	10:39:00 / 5 min	109676	15:33:00	28-Oct	16:50:00	28-Oct
SBE39	3435	92.5	20:41:00	29-Oct	20:41:42	29-Oct	20:40:00 / 5 min	109677	15:33:00	28-Oct	16:50:00	28-Oct
SBE39	3436	115	21:29:00	29-Oct	21:29:49	29-Oct	21:29:00 / 5 min	109686	15:33:00	28-Oct	16:50:00	28-Oct
SBE39	3437	175	20:42:00	29-Oct	20:43:08	29-Oct	20:43:30 / 5 min	109677	15:33:00	28-Oct	16:50:00	28-Oct
SBE39	3438	400	14:06:00	30-Oct	14:06:27	31-Oct	14:07:00 / 5 min	109886	15:33:00	28-Oct	16:50:00	28-Oct
SBE39	3439	450	21:33:00	29-Oct	21:34:09	29-Oct	21:33:00 / 5 min	109687	15:33:00	28-Oct	16:50:00	28-Oct
SBE39	1446	FSST	14:07:00	30-Oct	14:07:40	29-Oct	14:08:00 / 5 min	109886	15:33:00	28-Oct	16:50:00	28-Oct
XR420	10515	2	19:48:00	29-Oct	19:47:49	29-Oct	19:49 / 5 min	110k	19:36:00	28-Oct	21:14:00	28-Oct
TR-1050	10983	FSST	22:16:00	29-Oct	22:16:48	29-Oct	22:16 / 5 min	110k	15:33:00	28-Oct	16:50:00	28-Oct
SBE16	927	160	14:28:00	29-Oct	14:26:30	30-Oct	14:31 / 5 min	109603	18:16:00	28-Oct	19:35:00	28-Oct
SBE16	928	190	16:31:30	29-Oct	16:29:51	30-Oct	16:32 / 5 min	109627	18:16:00	28-Oct	19:35:00	28-Oct
SBE16	993	220	15:53:00	29-Oct	15:50:25	30-Oct	15:53 / 5 min	109619	18:16:00	28-Oct	19:35:00	28-Oct
SBE16	994	250	15:47:30	29-Oct	15:44:01	30-Oct	15:48 / 5 min	109618	18:16:00	28-Oct	19:35:00	28-Oct
SBE16	1877	310	13:34:04	29-Oct	13:31:10	30-Oct	13:35 / 5 min	109592	18:16:00	28-Oct	19:35:00	28-Oct

Table 5-1 Stratus 8 Subsurface Instrumentation and Data Return
Continued

Instrument	Serial	Depth	UTC Time	UTC Date	Internal Time	Internal Date	Stop Sampling /Sample rate	Records	Start Time	Start Date	Stop Time	Stop Date
			[-----------------TIME CHECK-------------]				[--------------DATA-----------------]		[---------Post Recovery Spike------------]			
VMCM	10	100	16:28:00	1-Nov	1-Nov	1-Nov	Dead Batteries / 1min	543102	22:25:00	29-Oct	~	~
VMCM	29	145	16:36:00	1-Nov	1-Nov	1-Nov	Dead Batteries / 1min	394603	22:25:00	29-Oct	~	~
VMCM	30	183	18:18:00	1-Nov	1-Nov	1-Nov	Dead Batteries / 1 min	409696	22:25:00	29-Oct	~	~
VMCM	57	235	18:26:00	1-Nov	1-Nov	1-Nov	Dead Batteries / 1 min	336242	22:25:00	29-Oct	~	~
VMCM	58	290	23:21:00	29-Oct	29-Oct	29-Oct	23:22 / 1 min	549997	22:25:00	29-Oct	~	~
VMCM	66	350	16:54:00	1-Nov	1-Nov	1-Nov	Dead Batteries / 1 min	435084	22:25:00	29-Oct	~	~
VMCM	68	852	18:33:00	1-Nov	1-Nov	1-Nov	Dead Batteries / 1 min	210998	22:25:00	29-Oct	~	~
VMCM	76	1555	16:45:00	1-Nov	1-Nov	1-Nov	Dead Batteries / 1 min	302036	22:25:00	29-Oct	~	~
ADCP	1220	135	instrument exploded- flash cards extracted									
NORTEK	1688	20	17:24:05	24-Nov	17:25:11	24-Nov	17:05 / 1 hr	3632KB	19:36:00	28-Oct	21:14:00	28-Oct
NORTEK	1666	15	16:34:00	24-Nov	16:34:46	24-Nov	15:55 / 1 hr	3632KB	19:36:00	28-Oct	21:14:00	28-Oct
NORTEK	2064	45	15:13:00	30-Oct	15:13:47	30-Oct	15:50 / 1 hr	3488772	19:36:00	28-Oct	21:14:00	28-Oct
NORTEK	2082	55	15:46:00	30-Oct	15:46:46	30-Oct	15:17 / 1 hr	3488814	19:36:00	28-Oct	21:14:00	28-Oct
NORTEK P	333	10	17:00:00	24-Nov	17:00:50	24-Nov	16:36 / 1 hr	1429 KB	19:36:00	28-Oct	21:14:00	28-Oct
SONTEK P	D193	33	downloaded				/ 15 min		19:36:00	28-Oct	21:14:00	28-Oct
SBE37__SST_	1840		16:23:30	29-Oct	16:24:30	29-Oct	16:24:30 / 5 min	66596	18:57:00	27-Oct	~	~
SBE37__SST_	1834		13:24:00	29-Oct	13:24:50	29-Oct	13:24:30 / 5 min	111462	18:57:00	27-Oct	~	~

c. Stratus 8 Surface Instrumentation and Data Return

The primary data processing task, after recovering a buoy, is to duplicate all the instrument data to prevent possible loss. Further processing for inventory purposes and first-look troubleshooting is also done as time allows. On the Stratus 8 recovery cruise, the instruments were processed through the inventory stage.

d. Stratus 8 Anti-Fouling Applications

DEPTH	INSTRUMENT	ANTI FOULING APPLIED	COMMENTS UPON RECOVERY
Surface	Buoy Hull	E-Paint, Sunwave, 6 coats	Heavy fouling of medium sized barnacles at waterline. Foam still had paint and fewer, smaller barnacles below water line. Alum base had many large clumps around hardware, rubber, instruments.
Surface	Floating SST and Fixed SST	E-Paint ZO, 2 heavy coats	Not clean, but floating freely
1 M	SBE 37 – SST 1 (C/T)	E-paint ZO w/adjunct, 2 heavy coats	Heavy fouling
1 M	SBE 37 – SST 2 (C/T)	Copper tape over plastic tape on body, w ZO on sensor tube and shield	Relatively light fouling around shield
2 M	SBE 37 (C/T)	E-paint ZO w/adjunct, 2 heavy coats	Heavy fouling at seams and clamps. Bare spots on pressure cases.
2 M	XR 420 – (CT)	E-paint ZO w/adjunct, 2 heavy coats	Heavy fouling at seams and clamps. Bare spots on pressure cases.
3.7 M	SBE 37 (C/T)	E-paint ZO w/adjunct, 2 heavy coats	Heavy fouling all over.
7 M	SBE 37 (C/T)	E-paint ZO w/adjunct, 2 heavy coats	Heavy Fouling over most. Shield area relatively clean. Most of the paint gone.
10 M	NORTEK ADCP	E-paint ZO over tape on body, copper tape on upper 6” near transducer heads. ZO on seams, clamps, and top. Bio-grease on transducer heads.	Heavy fouling on load bar and clamps. Very little paint left on body, but few barnacles on tape. Most of the copper was gone, with few barnacles in its place. Heads clear
15 M	NORTEK ADCM	Copper foil over tape on body, ZO on seams and clamps. Bio-grease on transducer heads.	Body pretty clean. Most copper gone. Heavy fouling on load bar.

Table 5-2: Stratus 8 anti-fouling applications.

DEPTH	INSTRUMENT	ANTI FOULING APPLIED	COMMENTS UPON RECOVERY
16 M	SBE 37 (C/T)	E-paint ZO w/adjunct, 2 heavy coats	Much less fouling than others. Paint gone. Most growth around load bar and clamps. Some in shields.
20 M	NORTEK ADCM	Copper foil over tape near transducer heads, ZO over tape on body & at seams near heads. Bio-grease on transducer heads	Body fairly clear. Doesn't appear to be much difference between the copper or painted parts. Most of the copper is gone; most of the paint is gone. Tape is pretty clean. Heads are mostly clean with a couple mature barnacles adjacent to one head.
25 M	SBE 39 (Temp)	E-paint ZO w/adjunct, 2 heavy coats	Body pretty clean. Mature barnacles on load bar.
30 M	SBE 37 (C/T)	E-paint ZO w/adjunct, 2 heavy coats	Fewer barnacles. Instrument pretty clean. Mature on load bar. Some paint left.
33 M	SONTEK ADCM	ZO on top 4" near transducer heads	Not much difference between top 4" and rest of body. Pretty clean, with barnacles around clamps and load bar.
35 M	SBE 39 (Temp)	E-paint ZO w/adjunct, 2 heavy coats	Brown slime, few barnacles
40 M	SBE 37 (C/T)	E-paint ZO w/adjunct, 2 heavy coats	Instrument clean, painted or not. Some residual paint seemed to help on load bar. Unpainted area on load bar had more barnacles.
45 M	NORTEK ADCM	ZO on top 6", no tape	Body pretty clean. Fewer barnacles where painted at top. Heads clean.
55 M	NORTEK ADCM	ZO on top 6", no tape	Body pretty clean. Fewer barnacles where painted at top. Heads clean. Less slime
62.5 M	SBE 37 (C/T)	E-paint ZO w/adjunct, just around sensor and guard	Pretty clean. Some paint left.

Table 5-2 (continued): Stratus 8 anti-fouling spplications.

Stratus 8 Recovery Antifouling Performance

Refer to Table 5-2 for application information.

- Traces of SUNWAVE paint were still visible on the foam section of the buoy hull, especially on the chine where additional coats of paint were applied. Gooseneck barnacles were attached to the foam from the waterline to the base of the buoy. The heaviest fouling on the foam was above the chine, at the water line. There were a few mature barnacles, but most appeared to be young. The application of a tie coat, plus additional coats of SUNWAVE appears to have improved performance of the SUNWAVE product.
- In areas where paint was rubbed off the buoy foam prior deployment, barnacles were heavy and hard to remove.
- Fouling on the buoy base was moderate. Mature barnacles were mostly on areas with little or no coatings, such as the tie rods and hardware.
- Barnacles on the foam and buoy base were easily removed with a scraper.
- Overall fouling on instrumentation appeared typical for the Stratus moorings. Instruments in the first 20 meters were heavily fouled.
- The coil on the XR420 C/T at 2 meters was surrounded by barnacles. The heads of all acoustic Doppler current meters and profilers remained clear.
- Moderate fouling ended at 30 meters, and fouling below 70 meters was negligible. There were no barnacles below 170 meters.
- Most of the E-paint used on instruments had ablated almost completely. On some instruments below 20 meters, it appears to have been effective at reducing fouling near the instrument sensors.
- There is no significant fouling on Ti trawl guards or Stainless Steel cage parts. It does not appear worthwhile to paint these parts.
- Load bars get some fouling whether coated or not due to hardware, clamps, seams and holes.
- Barnacle density is heaviest near neoprene strips, and at crevices such as where Delrin clamps wrap around an instrument, or where T/C shield mount to pressure cases.
- Cayenne pepper added to the e-Paint did not seem to improve performance in any way.
- Copper foil tape work as well as e-Paint, but was almost completely gone by the time the mooring was recovered.
- The application of 2” wide electrical tape n some of the pressure cases seemed to reduce the number of barnacles, and make cleaning of the pressure cases much easier.

6. SHOA DART Tsunami Buoy

Overview

The Hydrographic and Oceanographic Service of the Chilean Navy (SHOA) made an effort to acquire and deploy a DART II system (Deep-Ocean Assessment and Reporting of Tsunami) for its early tsunami detection and real-time reporting capability. Although seismic networks and coastal tide gauges are indispensable for assessing the hazard during an actual event, an improvement in the speed and accuracy of real-time forecasts of tsunami inundation for specific sites requires direct tsunami measurement between the source and a threatened community. Currently, only a network of real-time reporting, deep-ocean bottom pressure (BPR) stations can provide this capability.

Tsunamis can be highly directional. DART stations must be properly spaced to provide reliable estimates of the primary direction and magnitude of the energy propagation. A method for establishing a detection system's location will consider various tradeoffs between early tsunami detection, adequate source zone coverage, and DART system survivability. A proposed network will be designed to provide adequate coverage of tsunamis originating in source regions that threaten Chile coastal communities: The Nazca Subduction Zone.

The DART mooring system is illustrated in Figure 6-1. Each system consists of a seafloor BPR and a moored surface buoy with related electronics for real-time communications. The BPR uses a pressure transducer manufactured by Paroscientific, Inc., to make 15-second averaged measurements of the pressure exerted on it by the overlying water column. These transducers use a very thin quartz crystal beam, electrically induced to vibrate at their lowest resonant mode. In DART II applications, the transducer is sensitive to changes in wave height of less than a millimeter. An acoustic link is used to transmit data from the BPR on the seafloor to the surface buoy. The data are then relayed via Iridium satellite link to ground stations, which demodulate the signals for immediate dissemination to Sistema Nacional de Alarma de Maremotos (SNAM) in SHOA, via internet.

The buoy, installed on the ocean's surface establishes real-time communication with the iridium satellite. The system has two ways of reporting the information, one standard system, and one warning system. The standard is the normal operation mode by which four assessments of the ocean level, averaged every 15 minutes, are received every hour. When the internal software detects the generation of an event, a variation of more than 4 cm, the system stops the standard operation mode and switches to the warning mode. While in warning mode, it submits average assessments every 15 seconds; these are forwarded for a few minutes during the first messages, then following are one-minute average messages for at least three hours if no other event is detected.

The DART (Deep-Ocean Assessment and Reporting of Tsunami) Project was created in order to efficiently and quickly confirm the generation of a potentially destructive tsunami, as well as to support the ongoing effort to develop and implement an early detection capability and real-time report of tsunamis in the deep ocean. This project was created as part of the National Tsunami Hazard Mitigation Program (NTHMP) of the United States.

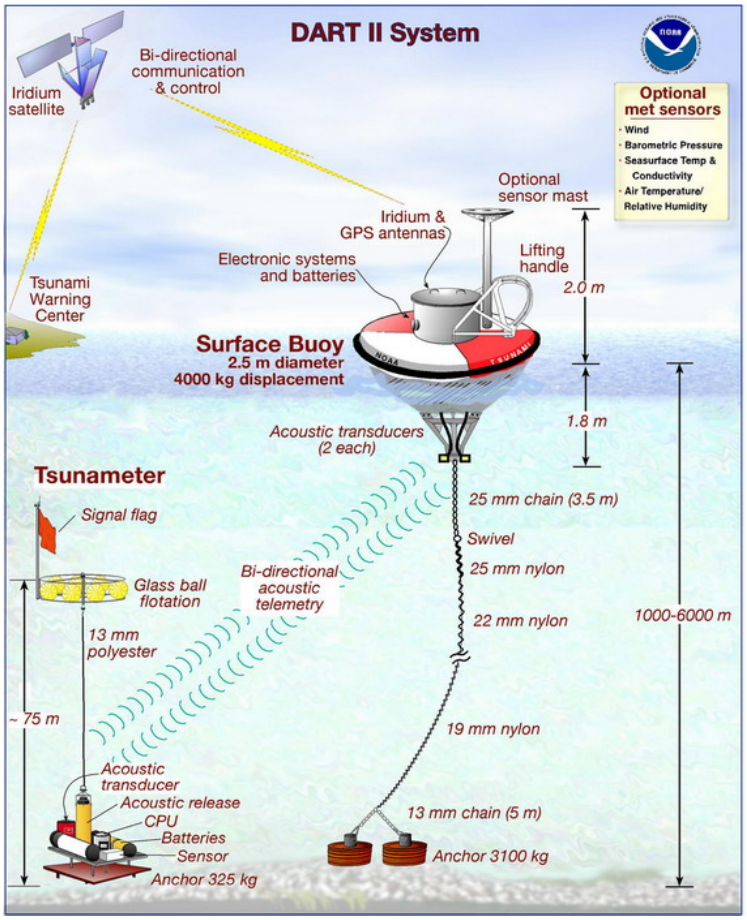

Figure 6-1: Schematic of the DART mooring system

The Hydrographic and Oceanographic Service of the Chilean Navy, in charge of the National Seaquake Warning System of Chile (SNAM), is making an effort to improve its capabilities to comply with responsibilities assigned by law; therefore in November 2003, a DART system was installed off the north coast of Chile, near Iquique. Unfortunately, the system had a problem with the batteries and in June 2004 the DART buoy and BPR was removed. The DART I system had been designed to operate for at least two years without maintenance. DART I buoy was deployed on December 6, 2004, and recovered on October 22, 2006.

The DART II system was developed to keep the BPR 4 years under the water, and the surface buoy can receive service every 2 years. This year, the SHOA people in accordance with WHOI scientists, replaced the batteries, mooring and anchor. The work was carried out between October 31 and November 1.

The DART system’s technology will allow the National Seaquake Warning System to improve its capability to evaluate and disseminate warnings in an efficient and timely manner and will avoid false alarms and possible losses as a consequence. The anchoring of this first DART II buoy in Chile (19º35.9841'S, 74º46.9369'W) and in South America, is a big step towards mitigation efforts against tsunamigenic events in close and long-range sites. This is not only a great contribution to the Chilean coastal communities, but also to the coastal communities in the Pacific Basin and to the International Tsunami Warning System.

Figure 6-2: DART II surface mooring with a complete set of IMET sensors.

a. Recovered

After two years in service, the DART II buoy recovered on October 30, 2008. New batteries were installed in the Tsunami warning system before deploying it again on October 31. The ASIMET modules and batteries for ASIMET were also replaced. A new mooring and anchor system were deployed, as well as replacement subsurface instruments.

The recovery was completed buoy first, through the A-frame. The ship maneuvered to the buoy on the starboard side. A “happy hooker” was used to thread a working line and lifting sling through the pickup bale on the buoy. This lifting sling was shackle into the mooring winch line that ran through a trawl block on the A-frame. As soon as the buoy was connected to the winch line, the acoustic release was actuated to separate the mooring from the anchor.

The ship moved ahead slowly to position the buoy behind it. The mooring winch hauled in, and as the buoy was raised from the water, the A-frame moved in to get the buoy on the deck. Air tuggers were attached the rings on the buoy deck to keep it from swinging. As soon as the buoy was one the deck, two stopper lines were attached to the 1” chain below the buoy. An air tugger was used to remove the slack from the mooring line, so the shackle connecting the buoy to the mooring could be removed. Once free from the mooring, the buoy was moved ahead and lashed to the deck.

The recovery continued by slowly hauling in on the mooring winch and removing subsurface instruments that had been clamped to the wire rope in the first 310 meters of the mooring wire. Once the instruments were removed, the winch hauled in at a greater speed until all 700 meters of wire were recovered. The mooring was stopped doff on the deck at the termination between the wire rope and nylon line. A traveling block was rigged on the a-frame, and a working line was tied to the nylon mooring line and run around the ship's capstan. The capstan was used to haul in the 4100 meters of nylon line. The line was flaked into wire baskets as it came off the capstan.

At the end of the nylon line was some ½" chain and the acoustic release, which were easily pulled onto the deck.

Once the mooring was recovered, the buoy was cleaned off, and replacement of batteries began.

Table 6-1 contains recovered DART ASIMET instrument data. Table 6-2 is recovered DART subsurface instrumentation.

DART 2008 RECOVERY

		[------------------TIME CHECK--------------]				[---------------DATA------------------]		[----------Post Recovery Spike------------]	
		UTC Time	UTC Date	Internal Time	Internal Date	Stop Samp / Sample Rate	Records	Start Time	Start Date
HRH	502	22:52:00	30-Oct-08	23:00:26	30-Oct-08	10/30/2008 14:25 / 1 min		13:10:00	30-Oct-08
WND	214	stolen							
LWR	208	22:53:00	30-Oct-08	22:58:42	30-Oct-08	10/30/2008 14:25 / 1 min	8954	13:10:00	30-Oct-08
SWR	202	22:55:00	30-Oct-08	22:59:03	30-Oct-08	10/30/2008 14:25 / 1 min	8954	13:10:00	30-Oct-08

Table 6-1: Recovered Dart ASIMET

			[------------------TIME CHECK--------------]				[---------------DATA------------------]		[----------Post Recovery Spike-------------]			
Instrument	Serial		UTC Time	UTC Date	Internal Time	Internal Date	Stop Sampling / Sample Rate	Records	Start Time	Start Date	Stop Time	Stop Date
XR420-CT	12942	Flooded										
XR420-CT	12943		19:04:00	30-Oct	19:05:14	30-Oct	14:25:00 / 3 min	365K	16:50	30-Oct	17:25	30-Oct
XR420-CT	12944		19:22:00	30-Oct	19:24:04	30-Oct	14:25:00 / 3 min	365K	16:50	30-Oct	17:25	30-Oct
XR420-CT	12945		19:14:00	30-Oct	19:16:08	30-Oct	14:25:00 / 3 min	365K	16:50	30-Oct	17:25	30-Oct
XR420-CT	12946		19:29:00	30-Oct	19:33:02	30-Oct	14:25:00 / 3 min	365K	16:50	30-Oct	17:25	30-Oct
TR-1050	12694		21:01:00	30-Oct	21:02:04	30-Oct	21:01:00 / 2 min	548K	16:50	30-Oct	17:25	30-Oct
TR-1050	12695	Dead batteries						416K	16:50	30-Oct	17:25	30-Oct
TR-1050	12696		20:08:00	30-Oct	20:08:54	30-Oct	20:08:00 / 2 min	365K	16:50	30-Oct	17:25	30-Oct
TR-1050	12697		20:36:00	30-Oct	20:37:07	30-Oct	20:36:00 / 2 min	548K	16:50	30-Oct	17:25	30-Oct
TR-1050	12698		21:18:00	30-Oct	21:33:15	30-Oct	21:18:00 / 2 min	548K	16:50	30-Oct	17:25	30-Oct
TR-1050	12699	Dead batteries						492K	16:50	30-Oct	17:25	30-Oct
TR-1050	12700		20:19:00	30-Oct	20:20:20	30-Oct	20:19:00 / 2 min	548K	16:50	30-Oct	17:25	30-Oct
TR-1050	12701		21:31:00	30-Oct	21:28:14	30-Oct	21:32:00 / 2 min	548K	16:50	30-Oct	17:25	30-Oct
TR-1050	12702		21:25:00	30-Oct	21:25:54	30-Oct	21:25:00 / 2 min	548K	16:50	30-Oct	17:25	30-Oct
TR-1050	12703		22:09:00	30-Oct	22:09:55	30-Oct	22:09:00 / 2 min	548K	16:50	30-Oct	17:25	30-Oct

Table 6-2: Recovered DART Subsurface Instrumentation

Fig 6-3: Working on the DART buoy

As the SHOA team worked on the battery replacement of the Tsunami warning system, WHOI personnel replaced ASIMET sensors and batteries on the buoy.

The DART II surface buoy was redeployed on October 31. In preparation for deployment, the 1" chain and the end of the 700-meter shot of wire rope were shackled to the bottom of the buoy. Fifty meters of wire rope were flaked out on deck, and several subsurface instruments were clamped to the wire at predetermined intervals.

The ship's trawl winch was passed through a block on the A-frame and attached to a quick release hook. This device was attached to the buoy. Tag lines were used on each side of the buoy to keep it from swinging as it was lifted into the water. The trawl winch lifted the buoy, and the A-frame swung out to get the buoy over the water. The port side tag line was removed, and the starboard side tag line was held tightly so the buoy could rotate 90 degrees and keep the quick release line from tangling. As the buoy settled into the water, the release was tripped and the tag line removed.

The ship moved ahead slowly, and the wire and instruments that had been laid on the deck followed the buoy into the water. Personnel eased the instrumented over the transom. Once 60 meters of wire was payed out, the traveling snatch block was inserted on the wire and hauled up on the A- frame. Additional instruments were added at specified depths as the wire payed out.

The end of the 700-meter wire rope was stopped off near the transom. The end of the 4130-meter nylon line was led out of a wire basket, around the ships capstan, and shackled to the wire rope. This line was payed out as the ship steamed toward the anchor drop site. The end of this nylon line was stopped off after it was fed over the capstan by a working line. The ½” chain, acoustic release, and Nystron pendant were attached to the nylon line and the winch leader. Tension was taken on the winch, and these components were deployed over the transom. The final four-meter shot of chain was stopped off using a slip line through a line approximately 1 meter from the top of the chain. The mooring was towed in this configuration for approximately one hour as we approached the original anchor location.

The ships trawl wire was passed through a block on the a-frame, and connected to the quick release on the anchor chain. At 0.2 nm from the drop site, the mooring load was transferred from the slip line to the anchors. At 0.1 nm, the trawl wire and A-frame lifted the anchors over the stern of the ship. They were lowered into the water. At the drop site, the quick release was pulled and the anchors dropped to the sea floor.

b. Deployed

The DART II buoy received a complete set of meteorological and several subsurface instruments from WHOI. The picture in Figure 6-2 shows the buoy with its wind, precipitation, humidity, barometric pressure, longwave and shortwave radiation sensors. The surface modules are stand alone units. Tables 6-3 and 6-4 have the details of the surface instrumentation. Table 6-5 has the release information.

MODULE	Serial	FIRMWARE	HEIGHT	Start
HRH	505	VOSHRH53 v3.2	199	10/31/08 10:45
WND	228	VOSWND53 v3.5	252	10/31/08 10:45
PRC	503	VOSPRC53 v3.4	232	10/31/08 10:45
LWR	206	VOSLWR53 v3.5	232	10/31/08 10:45
SWR	216	VOSSWR53 v3.3	236	10/31/08 10:45
BPR	201	VOSBPR53 v3.3	214	10/31/08 10:45
LASCAR	5		183	10/30/08 1:00

Table 6-3: 2008 DART Deployed surface instruments.

2008 Subsurface Deployed						
Instrument	**Serial**	**Depth**	**Sample**	**Start**	**Spike**	
SBE39	44	Bridle	8 minutes	10/18/08 1800	10/19/2008 12:08	10/19/2008 13:39
SBE39	46	30m	8 minutes	10/18/08 1800	10/19/2008 12:08	10/19/2008 13:39
SBE39	47	40m	8 minutes	10/18/08 1800	10/19/2008 12:08	10/19/2008 13:39
SBE39	282	62.5m	8 minutes	10/18/08 1800	10/29/2008 21:13	10/29/2008 22:03
SBE39	1503	77.5m	8 minutes	10/18/08 1800	10/19/2008 12:08	10/19/2008 13:39
SBE39	1504	115m	8 minutes	10/18/08 1800	10/19/2008 12:08	10/19/2008 13:39
SBE39	1505	175m	8 minutes	10/18/08 1800	10/19/2008 12:08	10/19/2008 13:39
SBE39	1506	220m	8 minutes	10/18/08 1800	10/19/2008 12:08	10/19/2008 13:39
SBE39	1508	250m	8 minutes	10/18/08 1800	10/19/2008 12:08	10/19/2008 13:39
SBE39	1510	310m	8 minutes	10/18/08 1800	10/19/2008 12:08	10/19/2008 13:39
XR420	10514	145	3 Minutes	10/18/08 0100	10/19/2008 12:08	10/19/2008 13:39
XR420	15214	10	3 Minutes	10/18/08 0100	10/19/2008 12:08	10/19/2008 13:39
XR420	15215	20	3 Minutes	10/18/08 0100	10/19/2008 12:08	10/19/2008 13:39
XR420	15216	50	3 Minutes	10/18/08 0100	10/19/2008 12:08	10/19/2008 13:39
XR420	15217	92.5	3 Minutes	10/18/08 0100	10/19/2008 12:08	10/19/2008 13:39

Table 6-4: 2008 Subsurface Deployed

Instrument	Serial Number	Depth (m)
Model 8242	33038	4943

Table 6-5: 2008 DART Release

c. Anchor Survey

Following the anchor drop, the Brown moved off the deployment line and allowed time for the anchor to reach the sea floor. Three points were selected for the anchor survey at ranges approximately 2000 meters from the estimated anchor location.

At each of these sites an Edgetech 8011A deck unit was used to communicate with the acoustic release on the mooring. Signal travel time was recorded at each site. Travel time and ship's coordinates for each site were entered into Arthur Newhall's Acoustic Survey Software to calculate anchor position. The program uses the intersection of each range arc to calculate anchor position.

Details for the anchor survey of the surface mooring are summarized in Figure 6-4.

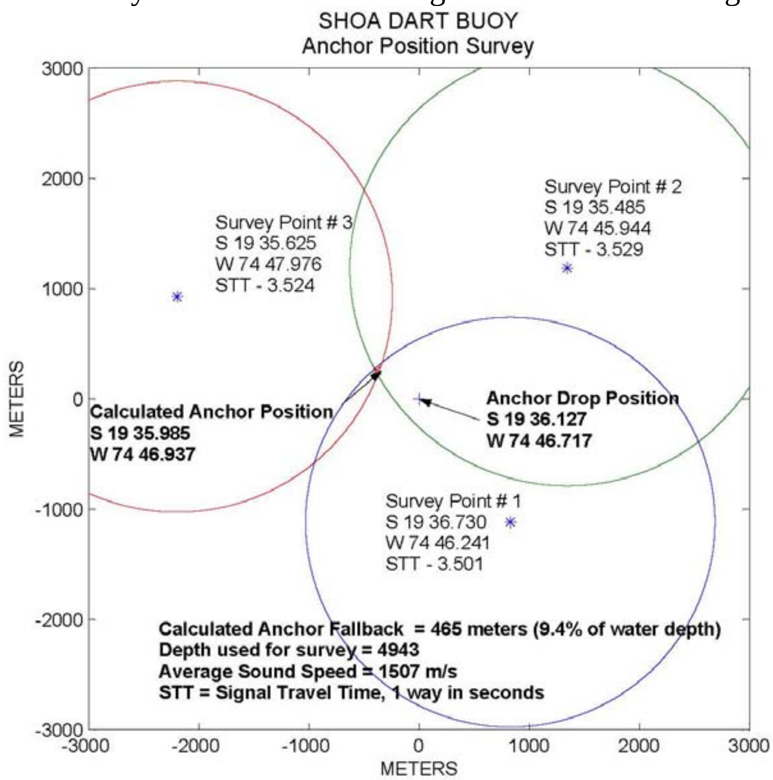

Figure 6-4: DART II anchor triangulation plot from Acoustic Survey Software.

7. Underway CTD

The UCTD is an underway system for acquiring conductivity and temperature profiles at ships speeds up to and exceeding 13 knots. It is manufactured, packaged, and sold by *Oceanscience* in Oceanside, California. It was acquired and subsequently tested aboard the NOAA ship *Ronald H Brown* by the Upper Ocean Processes Group on the Stratus 2007 cruise in October of 2007.

The locations of UCTD profiles are shown Figure 7.1.

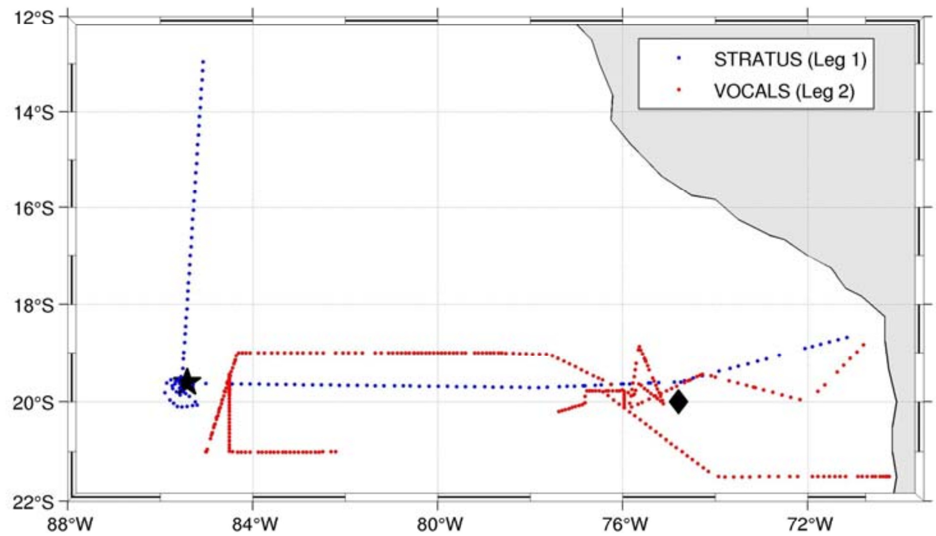

Figure 7-1: Profile locations.

Figure 7-2 shows UCTD components.

Components

-Sea-Bird CTD Probe 10-400
-Tail Spool
-Tail Spool Re-winder
-Winch with Level Wind
-1400 Meters of 300 and 500 lbs Spectra Line
-Davit and Block
-Mounting Pedestal
-Power Supply
-UCTD software
-Bluetooth Software

Figure 7-2: Probe and Tail Spool, Re-winder & Winch

Operation

The system is operated from the after portion of the stern deck. See Figure 7-3 for assembled UCTD. A length of line equal to the desired cast depth is wound onto the CTD's tail spool. While the ship steams away from the drop site, the probe plunges vertically with a nearly constant drop rate independent of the ships speed.

Line is spooled automatically off the probe’s tail while it drops through the water and line is manually payed out from the winch spool. The simultaneous payout of line from the probe’s tail and winch effectively makes the line velocity through water zero, allowing freefall. See Table 7-1 for typical profiling cycles.

The CTD probe samples conductivity, temperature, and depth at a sampling rate of 16 Hz while descending vertically through the water column at ~4 meters per second. Data is stored internally in flash memory and downloaded wirelessly via Bluetooth to a host computer or PDA after recovery.

The latitude and longitude of individual casts is obtained by matching an internal time stamp in the data file header to an externally collected GPS file. Synchronization of instrument and GPS time is important. MATLAB scripts were used for processing.

Figure 7-3: UCTD Assembled

Depth	Speed	Turn-Around
200 Meter Tow-Yo	10 knots	10 Minutes
200 Meters	12 knots	30 minutes
800 Meters	4 knots	40 Minutes
1200 Meters	1 Knot	35 minutes

Table 7-1. Typical Profiling Cycles

CTD Sensor Specifications

The range of the temperature sensor is 5 to 43 degrees Celsius, conductivities can be measured from 0 to 9 S/m, and the pressure range is 0 to 2000 m. The pressure housing is rated for a depth of 2000 meters although the operating depth is normally less than 1000 meters. Typical accuracies of the processed data are 0.005-0.02 degrees celsius for temperature, 0.002-0.005 S/m for conductivity, 1 dbar for pressure, and 0.02 -0.05 psu for salinity. See Table 7-2 for sensor Specifications.

	Conductivity [S/m]	Temperature [°C]	Depth [dbar]	Salinity [psu]
Resolution	0.0005	0.002	0.5	0.005
Raw Data Accuracy	0.03	0.01 to 0.02	4	0.3
Processed Data Accuracy	0.002 to 0.005	0.004	1	0.02 to 0.05
Range	0 to 9	-5 to 43	0 to 2000	0 to 42

Table 7-2: Sensor Specifications

8. Deployment of Argo Floats and Drifters

During the Stratus 2008 cruise, a 24-hour under way watch schedule was established. Watch standers were responsible under way CTD casts, and for Argo float and surface drifter deployments. See Table 8-1 and Table 8-2 for all cruise drifter and float deployments.

Argo (*http://www.argo.net/)* is an international program using autonomous floats to collect temperature, salinity, and current data. A broad-scale global network of profiling floats, 3° by 3° spaced is being implemented (since late 1999) and will be maintained, as a major component of the ocean observing system.

The modern surface drifter, Figure 8-1, is a high-tech version of the "message in a bottle". It consists of a surface buoy and a subsurface drogue (sea anchor), attached by a long, thin tether. The buoy measures temperature and other properties, and has a transmitter to send the data to passing satellites. The drogue dominates the total area of the instrument and is centered at a depth of 15 meters beneath the sea surface. More information on the Global Drifter Program can be found at http://www.aoml.noaa.gov/phod/dac/gdp.html (see Figures 8-2 and 8-3).

Figure 8-1: Typical Surface Drifter

The floats and drifters were deployed at specified locations. The ship was not slowed for deployments of the Argo floats or surface drifters.
Deployment details are given in Table 8-1 and Table 8-2.

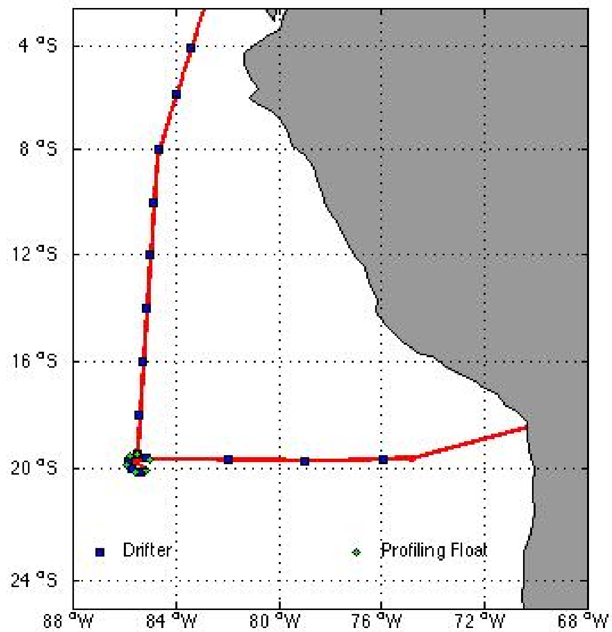

Figure 8-2: Leg 1 Drifter and Floats

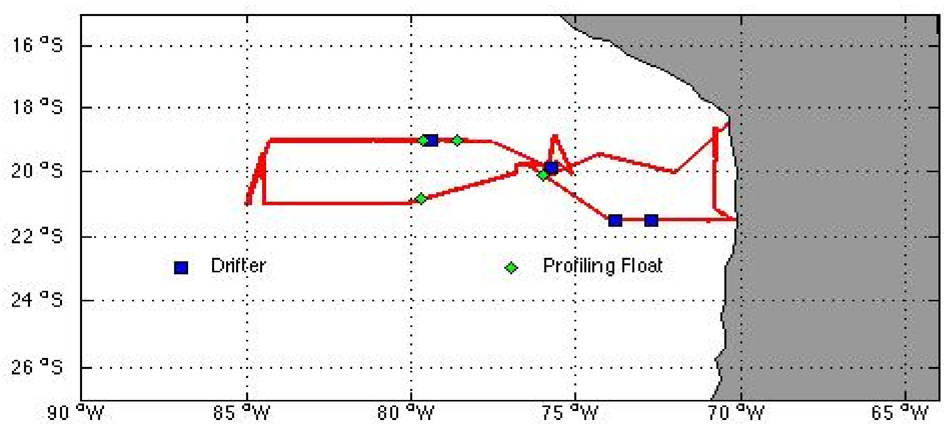

Figure 8-3: Leg 2 Drifter and Floats

FLOAT/DRIFTER SERIAL # OR ID	DATE AND TIME OF START UP	DATE AND TIME OF DEPLOYMENT	NOMINAL LATITUDE ACTUAL LATITUDE	NOMINAL LONGITUDE ACTUAL LONGITUDE
DRIFTER 1 **# 78997**	**NA** **NA**	10/21/2008 1415 GMT	-4° 00' **04° 01.33**	-83°24.8' **-83° 24.7**
DRIFTER2 **# 78998**	**NA** **NA**	10/22/2008 0100 GMT	-6°00' **-5° 49.6'**	-84°03.15' **-83° 59.5'**
DRIFTER3 **# 78996**	**NA** **NA**	10/22/2008 1205 GMT	-8°00' **-8° 00'**	-84°40' **-84° 39.8'**
DRIFTER4 **# 78995**	**NA** **NA**	10/22/2008 2355 PM	-10°00' **-9° 59.9'**	-84°51.8' **84° 51.8'**
DRIFTER5 **# 78994**	**NA** **NA**	10/23/2008 1014 GMT	-12°00' **12° 01.0'**	-85°12.1' **-85° 00.0'**
DRIFTER6 **# 78989**	**NA** **NA**	10/23/2008 2028 GMT	-14°00' **14° 01.0'**	-85°07.4' **-85° 08.4'**
DRIFTER7 **# 78990**	**NA** **NA**	10/24/2008 0653 GMT	-16°00' **16° 02.4'**	-85°16.0' **-85° 16.7'**
DRIFTER8 **# 78992**	**NA** **NA**	10/24/2008 1730 GMT	-18°00' **17°59.92'**	-85°25.2' **85°25.02'**
PF1 **# 866/2330**	10/24/2008 1830 GMT	10/25/2008 0115 GMT	-19°17.367' **19°21.19'**	-85°30.882' **-85°30.86'**
DRIFTER9 **# 78991**	**NA** **NA**	10/25/2008 0147 GMT	-19°27.48' **19°26.88'**	-85°31.28' **-85°31.47'**
PF2 **# 865/6670**	10/25/2008 2101 GMT	10/25/2008 2150 GMT	-20°03.254' **-20°03.37'**	-85°09.280' **-85°10.48'**
DRIFTER10 **# 78993**	**NA** **NA**	10/25/2008 2250 GMT	-20°05.039' **-20°05.18'**	-85°22.781' **-85°23.23'**
PF3 **# 856/1400**	10/25/2008 2030 GMT	10/25/2008 2350 GMT	-20°07.078' **-20° 06.90'**	-85°35.742' **-85° 36.06'**
DRIFTER11 **# 79002**	**NA** **NA**	10/26/2008 0046 GMT	-19°59.428' **-19°59.60'**	-85°45.328' **-85°45.10'**
PF4 **# 860/3340**	10/25/2008 2050 GMT	10/26/2008 0144 GMT	-19°52.026' **-19° 51.77'**	-85°54.239' **-85° 54.19'**
DRIFTER12 **# 79003**	**NA** **NA**	10/26/2008 0237 GMT	-19°41.552' **-19°41.25'**	-85°52.214' **-85°52.12'**
PF5 **# 867/6730**	10/25/2008 2040 GMT	10/26/2008 0335 GMT	-19°30.939' **-19°31.31'**	-85°50.189' **-85°49.26'**
DRIFTER13 **# 79000**	**NA** **NA**	10/26/2008 1132 GMT	-19°37.462' **-19°37.0'**	-85°12.115' **-85°11.80'**
PF6 **# 841/7370**	10/25/2008 2032 GMT	10/26/2008 1220 GMT	-19°37.845' **-19°37.4'**	-85°03.070' **-85°02.8'**
DRIFTER14 **# 78999**	**NA** **NA**	10/28/2008 0143 GMT	-19°40.226' **-19°39.588'**	-82°00' **-81°59.134'**
DRIFTER15 **# 79001**	**NA** **NA**	10/29/2008 0501 GMT	-19°39.714' **-19°41.716'**	-79°00' **-78°59.75'**
DRIFTER16 **# 78988**	**NA** **NA**	10/29/2008 2016 GMT	-19°37.669' **-19°38.22'**	-76°00' **-75°59.37'**

Table 8-1: Leg 1 Drifter and Float Deployments

FLOAT/DRIFTER SERIAL # OR ID	DATE AND TIME OF START UP	DATE AND TIME OF DEPLOYMENT	NOMINAL LATITUDE ACTUAL LATITUDE	NOMINAL LONGITUDE ACTUAL LONGITUDE
Drifter **78987**	11/14/2008 18:10	11/14/2008 18:15	-19 51.893	75 46.184
Float **850/1360**	11/16/2008 15:05	11/16/2008 15:10	-19 00.000	78 36.939
Drifter **78984**	11/17/2008 17:55	11/17/2008 18:00	-18 59.999	79 23.430
Float **857/5360**	11/17/2008 20:30	11/17/2008 20:34	-18 59.998	79 37.224
Float **890-9670**	11/28/2008 4:50	11/28/2008 4:50	-20 05.915	75 58.311
Drifter **78986**	11/29/2008 13:00	11/29/2008 13:00	-21 30.122	73 47.960
Drifter **78985**	11/29/2008 20:30	11/29/2008 20:30	-21 30.006	72 20.032
Float **851-5370**	11/26/2008 14:23	11/26/2008 14:23	-20 51.703	79 41.751

Table 8-2: Leg 2 Drifter and Float Deployments

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9. VOCALS 2008 Leg 1 Rawinsonde Observations

Investigators on the NOAA Research Vessel *Ronald H. Brown* released rawinsondes into the atmosphere every 4 hours between October 21 and November 1, providing pressure, temperature, humidity, and wind observations of the troposphere and lower stratosphere.

Methods and data collection and handling

Vaisala RS292-SGP global positioning system (GPS) rawinsondes measure pressure, temperature, relative humidity, and GPS latitude, longitude, and altitude as they rise tethered to a helium-filled latex weather balloon. Before release the sonde is conditioned by heating the humidity sensor for 3 minutes in the presence of dessicant chemicals.

The rawinsonde is powered by a battery and left on the fantail to equilibrate to outdoor surface conditions. Some heat island effects from the ship, and radiation warming in sunny conditions, are expected but are found to be minimal. The sensors are silvered and quite small, minimizing surface area incident to radiation and minimizing heat capacity, so that they are adequately ventilated by flow relative to the deck of the ship. The pressure, temperature, and relative humidity surface observations from the rawinsonde are manually entered into to the sounding computer and the sounding processing software includes them as the first line in the data files. Balloons are filled in the staging bay with ~1.5 kg of helium gas (approximate 10 m^3 displacement at surface pressure) and released from the fantail of the *Ronald H. Brown*.

Vaisala RS292-SGP rawinsondes telemeter pressure, temperature, relative humidity, and GPS latitude, longitude, and altitude to a Sounding Processing Subsystem SPS311 radio receiver on the ship. Vaisala DigiCora software downloads telemetered messages, archives them as DC3DB-formatted binary files, and converts them to human-readable LATLON text files with GPS latitude and longitude of the sonde during flight. These LATLON files are distributed to representatives of nations from whose waters the sondes were deployed. NOAA software converts data at standard synoptic levels and transfers these files to the Global Telecommunication System (GTS), where they are internationally available for inclusion in synoptic charts, data assimilation, and initialization and verification of numerical weather prediction models.

Format of the EDT files

The LATLON EDT files from VOCALS 2008 are formatted text files with names:

yymmddHHMM_EDT_LATLON.txt

The text files have a **10-line header** before the lines of formatted data. The header starts with 4 lines containing serial number of the radiosonde used, station name, time of day, and date. These lines are followed by a description, and two lines of headers for the formatted columns of rawinsonde data. Spaces are used to align columns, so the format is clearest when examining the file in a plain text editor with a fixed-width font. The top of one of the LATLON files is shown in Table 9-1. Column headers describe the 11 columns of data from the radiosonde flight:

1	time of flight	s
2	hypsometric height	m
3	pressure	hPa
4	temperature	degree C
5	dew point temperature	degree C
6	relative humidity	%
7	wind speed	m s-1
8	wind direction	degree
9	GPS latitude	degree
10	GPS longitude	degree
11	GPS altitude	m

Table 9-1: LATLON File

On the ship, researchers routinely process LATLON rawinsonde files to monitor quality of measurement and atmospheric conditions. Figures 9-1 and 9-2 show examples of output for two soundings generated from LATLON files during VOCALS 2008.

The sampling strategy was to release 6 rawinsondes per day, every 4 hours at 00, 04, 18, 12, 16, and 20 universal time (UT). Figure 9-3 illustrates the locations at which rawinsondes were deployed. The track of the cruise can be described in two sections, separated by turning around the Woods Hole Ocean Reference Station (WORS) at 20S, 85W. The ship steamed southward in a latitude section from Panama to the WORS. This section began October 20 at 81W longitude, crossed west of 84W at 6S, and then headed more directly south along 85W, arriving at the WORS location October 25. We refer to this latitude section as the 85W section. The second section, called the 20S section, began October 28 at the WORS location, traversed east to the SHOA tsunami buoy (October 30; 20S, 75W), and terminated in Arica, Chile. The 20S section to the stratus buoy WORS has been traversed in by 6 previous cruises in 2001, 2003, 2004, 2005, 2006, and 2007.

85°W latitude section

Profiles of the atmosphere from rawinsondes released October 20-25 are compiled into the 85W latitude-vertical section in Figure 9-4. Shaded contours in the four panels show potential temperature, specific humidity, zonal wind, and meridional wind. The horizontal axis is degrees latitude, and the times of soundings are indicated as ticks along the top of each panel. Longer ticks indicate soundings at approximately 0 hours universal time (UT), with the date of October shown between UT soundings. As the ship moved southward, time progresses from right to left. The marine atmospheric boundary layer (MABL) can identified as a relatively uniform moist and cool layer in the lowest 1-1.5 km in the potential temperature and specific humidity sections. The inversion MABL capping inversion strength is measured by the difference between the local maximum temperature above the inversion and the minimum temperature at inversion base. The inversion strength is 5°C or greater south of 5S, and about 10°C between 8 and 14S. North of the equator the inversion is weaker due to penetrating convection, but it is still detected by our objective algorithm. Humidity is especially high in and near the MABL north of the equator, reaching 15 g kg^{-1} at 2N. This northern air mass lies over the eastern Pacific warm pool. Intense precipitation was observed on the ship on October 19-20 UT.

In the top panel of Figure 9-5, the cloud top from the temperature sounding is shown with magenta dots. Cloud top is diagnosed as the height of minimum temperature beneath the maximum gradient (increasing with height) of temperature, between 990 and 800 hPa. Cloud base is determined from the Vaisala CL31 laser ceilometer as the 85th percentile of the lowest cloud base detected, or of the second lowest cloud base if more than one cloud base is detected. This cloud base algorithm is used to detect the stratocumulus cloud base, but it occasionally detects cumulus below the stratocumulus deck, or higher clouds when stratocumulus are not present.

Winds in the MABL are relatively mixed through its height, and are representative of climatological surface winds. Weak 1-5 m s^{-1} westerlies are observed near the equator north of 2S. Easterlies are observed south of 6S, reaching ~8 m s^{-1} between 8-20S. Meridional wind is southerly in the MABL everywhere along the 85W section, though its strength varies from 1 to 10 m s^{-1}.

The free troposphere above the inversion is stably stratified at 5.4 K km^{-1} of potential temperature. The free tropospheric humidity is below 2 g kg^{-1} south of 10S. Near and north of the equator deep convection pumps moisture of 10 g kg^{-1} up to 3 km. The lower free troposphere is warmest at 8S, coincident with an easterly jet of more than 10 m s^{-1} and dry specific humidity <2 g kg^{-1} at 2-3 km altitude. At 12-16S, 2-5 km, a westerly jet coincides with a plume of relatively moist (~4 g kg^{-1}) cool air. These plumes seem to tilt northward with height. This tilt may be an artifact of sampling large-scale descent of air masses from north to south. Absent any tilt, the plumes would have descended on the order 2 km day^{-1} or 2 cm s^{-1}.

On station at the WORS, 20S, 85W

The ship was on station at the WORS for approximately 3 days, October 25-27. This provides a snapshot of climate conditions which are relatively constant. It is possible to compare the mean and diurnal cycle observed in 2008 with 6 previous years, when the ship spent more time at the buoy.

20°S longitude section

From the WORS at 85W, the ship steamed along 20S to the SHOA buoy at approximately 75W, 20S. This transit was made mostly on October 28 and 29. Figure 9-5 shows longitude section of potential temperature, specific humidity, zonal wind and meridional wind retrieved by the rawinsondes. The boundary layer was quite uniform across 75-85W. The boundary layer structure is similar to that seen in the latitude section. The free troposphere is uniformly stratified and dry with humidity below 1 g kg^{-1}. The inversion at 1.5 km is sharply visible in the humidity, with specific humidity 6-10 g kg^{-1} in the MABL.

The winds are distributed over a different vertical scale than the boundary layer, with 10-12 m s^{-1} southeasterlies reaching 2-3 km, switching to northwesterlies around 4 km height. The northwesterlies are stronger east of 78W.

The boundary layer inversion is indicated by two magenta dots for each sonde in Figure 9-5 Magenta dots indicate both the top and base of the inversion. The top is identified as the temperature maximum above the stable temperature stratification. The strength of the inversion changes little over the 2 days of the 20S longitude section.

Mixed and decoupled MABLs

Two cases with different vertical cloud structures are reflected in the profiles of temperature and humidity measured by the sondes. The soundings in Figs. 9-1 and 9-2 are examples of two vertical structures of clouds frequently observed within the MABL. Figure 9-1, from October 21, 19:24UT (14:44 local at 85W) exemplifies a stratocumulus cloud-capped mixed boundary layer. The boundary layer is 1 km deep, with its top 400 m occupied by cloud. The lapse rate shows that boundary layer is adiabatic below the cloud layer, and moist-adiabatic (decreasing less steeply with height due to condensation of water) within the cloud layer, indicating the presence of dry and moist mixing processes. In the free troposphere above the boundary layer there are layers of moisture several hundred meters thick.

The sounding in Figure 9-2, from October 27 23:26UT (17:46 local) shows two cloud layers in the boundary layer. The air temperature follows a dry adiabat from the surface to 450 m, a moist adiabat from 450-550 m, a dry adiabat from 550-1100 m, and a moist adiabat to the MABL inversion at 300 m. The cloud at the top of the boundary layer is saturated, indicating that the sonde flew through the cloud. In contrast, the lower moist adiabatic layer is subsaturated at only at 90% relative humidity. This suggests condensation though the sonde did not pass directly through cloud. Perhaps nearby clouds were communicating their thermal stratification to the layer, or had recently mixed the air along a moist adiabat. The lower moist layer is typical of intermittent shallow cumulus observed to rise into stratocumulus clouds.

We refer to this two-tiered boundary layer stratification as *decoupled* because the subsaturated moist adiabatic layer is stably stratified with respect to parcels undergoing dry thermodynamic processes such as subcloud mixing. Nevertheless, if significant moisture builds in the lower boundary layer, condensing moist convection can penetrate the decoupled weakly stable layer and reach the stratocumulus cloud. The boundary layer is strongly capped by an 8°C inversion at 1.4 km. The free tropospheric relative humidity is extremely dry, below 10%.

RS Serial #: D3333063
Station Name: WTEC
Launch Time: 1925Z
Launch Date: 27 OCT 08

EDT LEVEL OUTPUT with GPS Lat, Long, Alt

Time sec	Height mtrs	Pressure hPa	Temp øC	Dew P. øC	RH Pct	W Spd m/s	W Dir Az ø	Lat Decimal ø	Long Decimal ø	GPS Alt mtrs
-0.14	7.0	1019.2	19.35	17.1	87	8.0	135.0	-19.6653701	-85.3714346	13.1
0.86	11.7	1018.6	18.62	16.0	85	6.9	142.1	-19.6653355	-85.3714304	17.2
1.86	17.2	1018.0	17.77	14.7	82	5.7	154.0	-19.6652890	-85.3714231	18.1
2.86	21.9	1017.4	17.43	14.3	82	5.6	157.3	-19.6652069	-85.3714503	24.8
3.86	26.4	1016.9	17.18	14.1	82	5.7	158.8	-19.6651103	-85.3715333	28.2
4.86	30.9	1016.4	17.02	14.0	82	6.0	158.5	-19.6650586	-85.3715724	30.2
5.86	35.4	1015.9	16.87	13.9	82	6.4	158.1	-19.6649974	-85.3715797	33.1
6.86	39.9	1015.3	16.76	13.8	82	6.7	158.0	-19.6649514	-85.3715754	39.2
7.86	44.4	1014.7	16.66	13.8	83	7.0	158.0	-19.6648866	-85.3715966	46.3
8.86	49.7	1014.0	16.56	13.7	83	7.3	158.5	-19.6647900	-85.3716220	50.6
9.86	55.2	1013.4	16.46	13.7	84	7.6	158.9	-19.6646972	-85.3716550	57.4
10.86	61.2	1012.7	16.41	13.7	84	7.8	159.0	-19.6646339	-85.3717178	63.6
11.86	67.2	1012.0	16.36	13.7	85	8.0	159.0	-19.6645855	-85.3717938	68.0
12.86	72.7	1011.3	16.31	13.8	85	8.2	159.0	-19.6645302	-85.3718214	74.1
13.86	78.2	1010.7	16.26	13.9	86	8.5	159.0	-19.6644727	-85.3718238	79.7
14.86	84.2	1010.0	16.21	14.0	86	8.6	159.0	-19.6643917	-85.3718280	86.4
15.86	90.2	1009.4	16.16	14.0	87	8.8	159.0	-19.6642809	-85.3718593	95.1
16.86	96.2	1008.7	16.15	14.1	87	8.9	159.0	-19.6641621	-85.3719007	101.8
17.86	102.2	1007.9	16.15	14.1	87	9.1	159.0	-19.6640495	-85.3719708	106.6

Sample containing the header and first few data lines of 0810271925_EDT_LATLON.txt.

Table 9-2: Sample LATLON

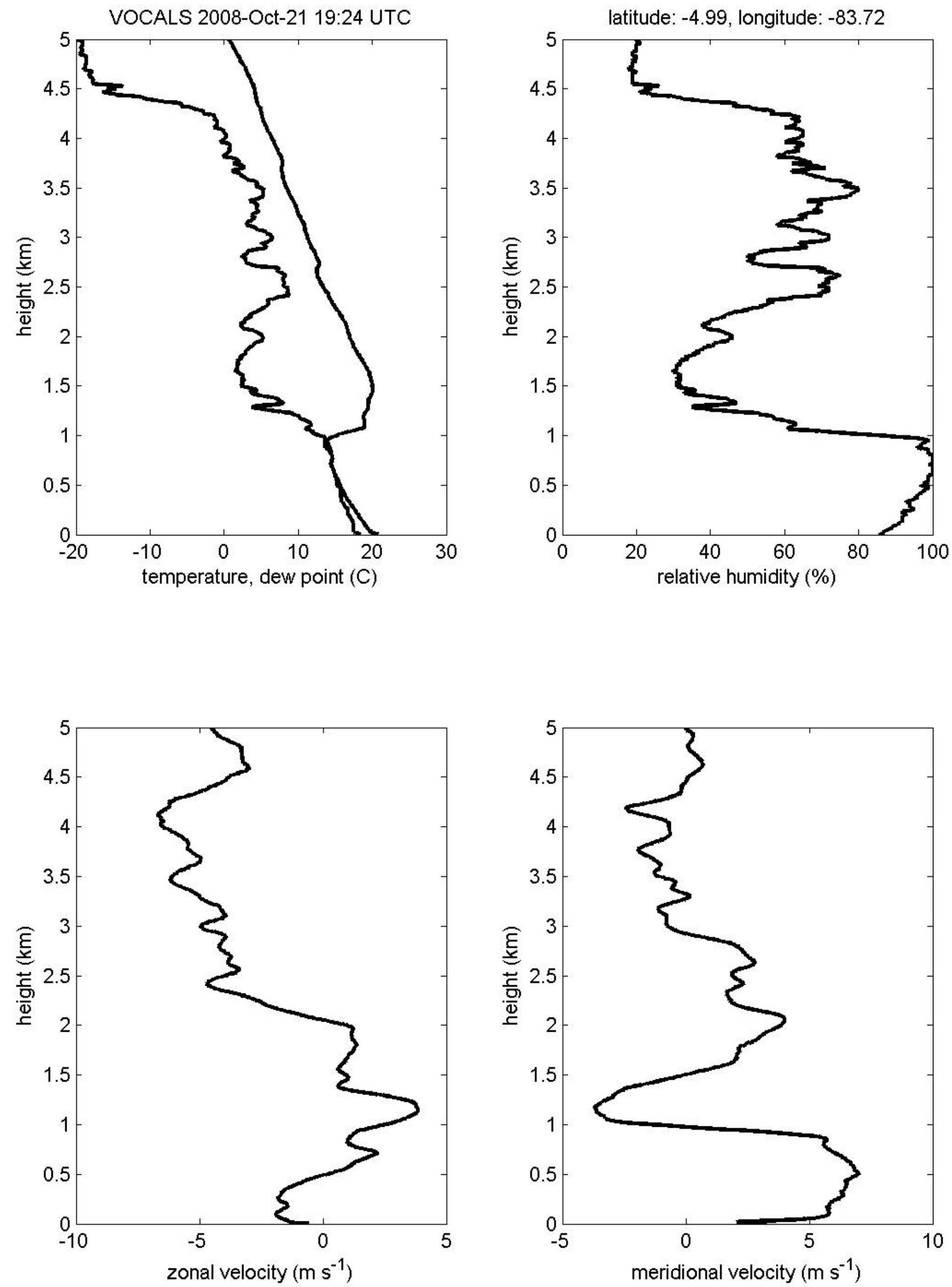

Figure 9-1: Rawinsonde profile at 4S, 83W from October 21, 20 UT. The boundary layer is 1 km deep, capped by a 400 m deep cloud. Above the boundary layer the humidity is quite moist, with layers of moisture several hundred meters thick.

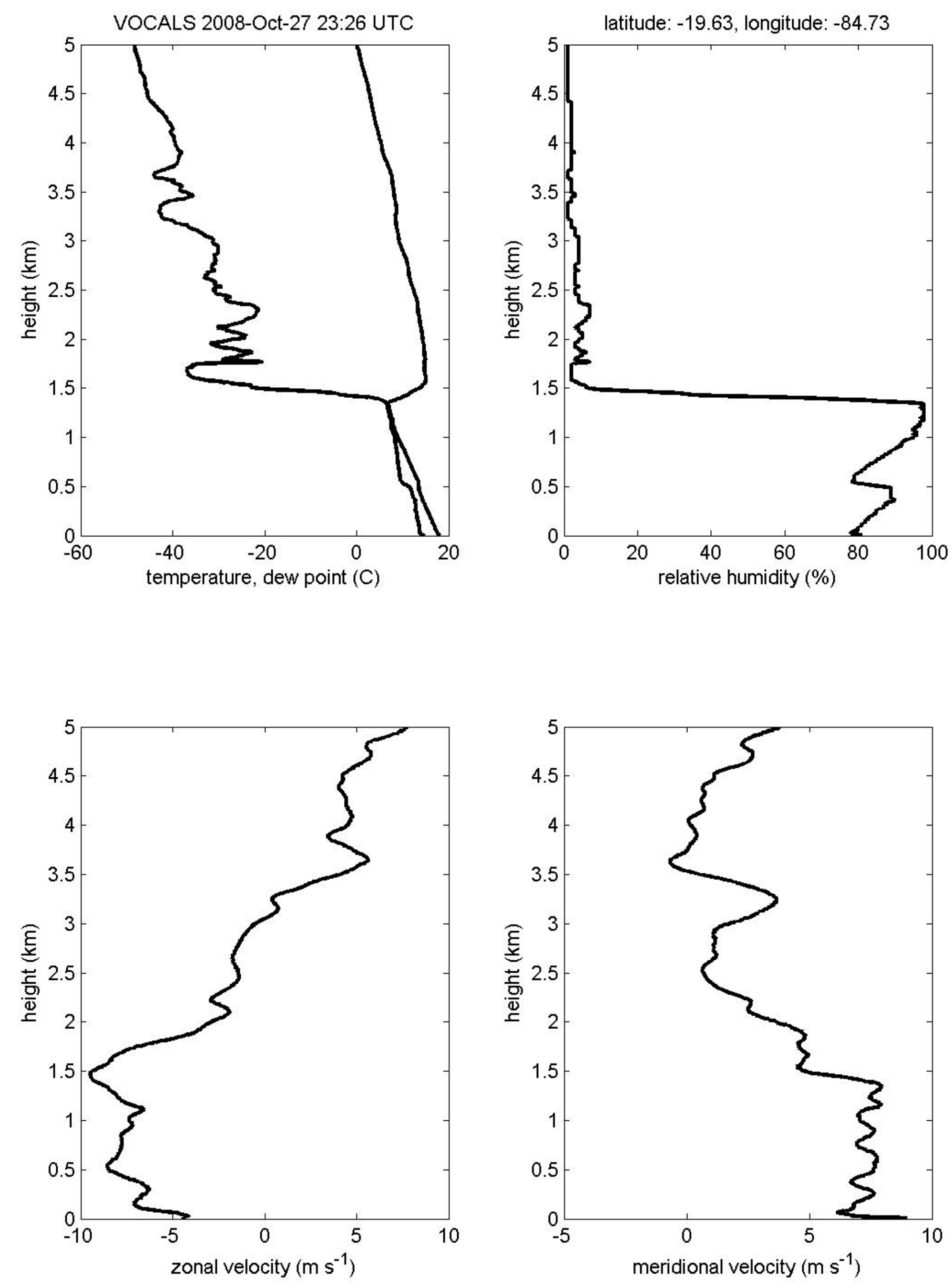

Figure 9-2: Sounding from October 28, 00 UT near 20S, 85W. The boundary layer is strongly capped by an 8°C inversion at 1.4 km. The marine boundary layer density structure is decoupled by a 90% relative-humidity layer with moist-adiabatic stratification below the capping stratocumulus layer. The free tropospheric relative humidity is below 10%.

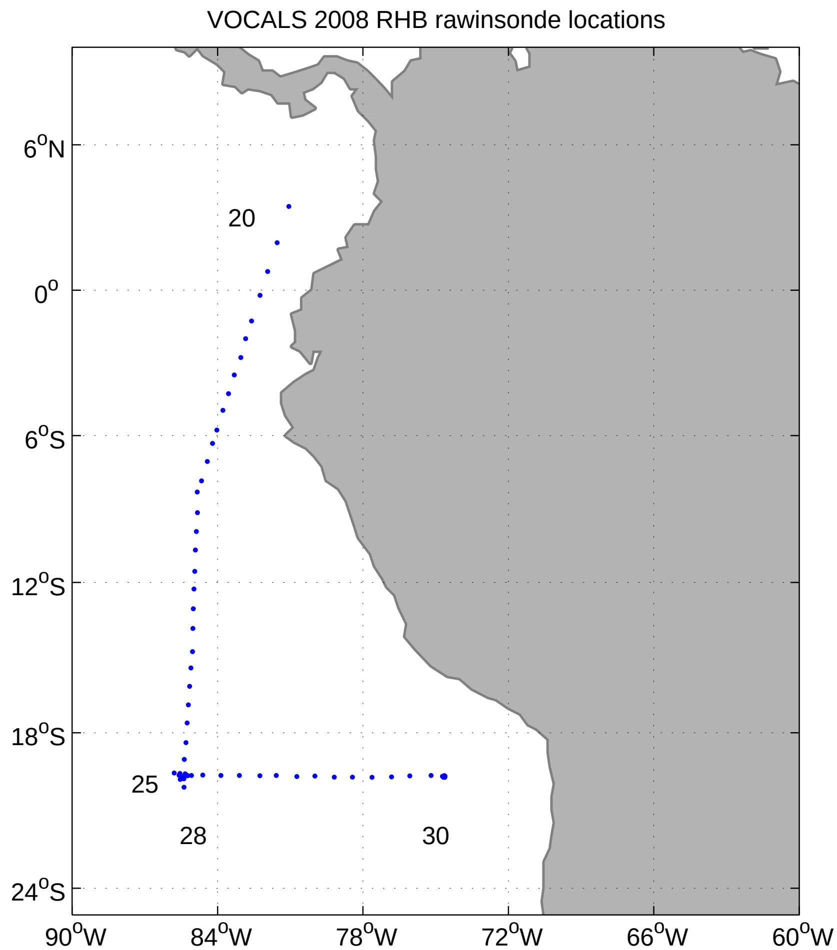

Figure 9-3: Locations of rawinsonde deployments from the NOAA Research Vessel *Ronald H. Brown* during leg 1 of VOCALS 2008. The track consists of a latitude section, from 3N-20S along approximately 85W; and a longitude section from 85W to the coast along 20S. The day of October is printed alongside the track.

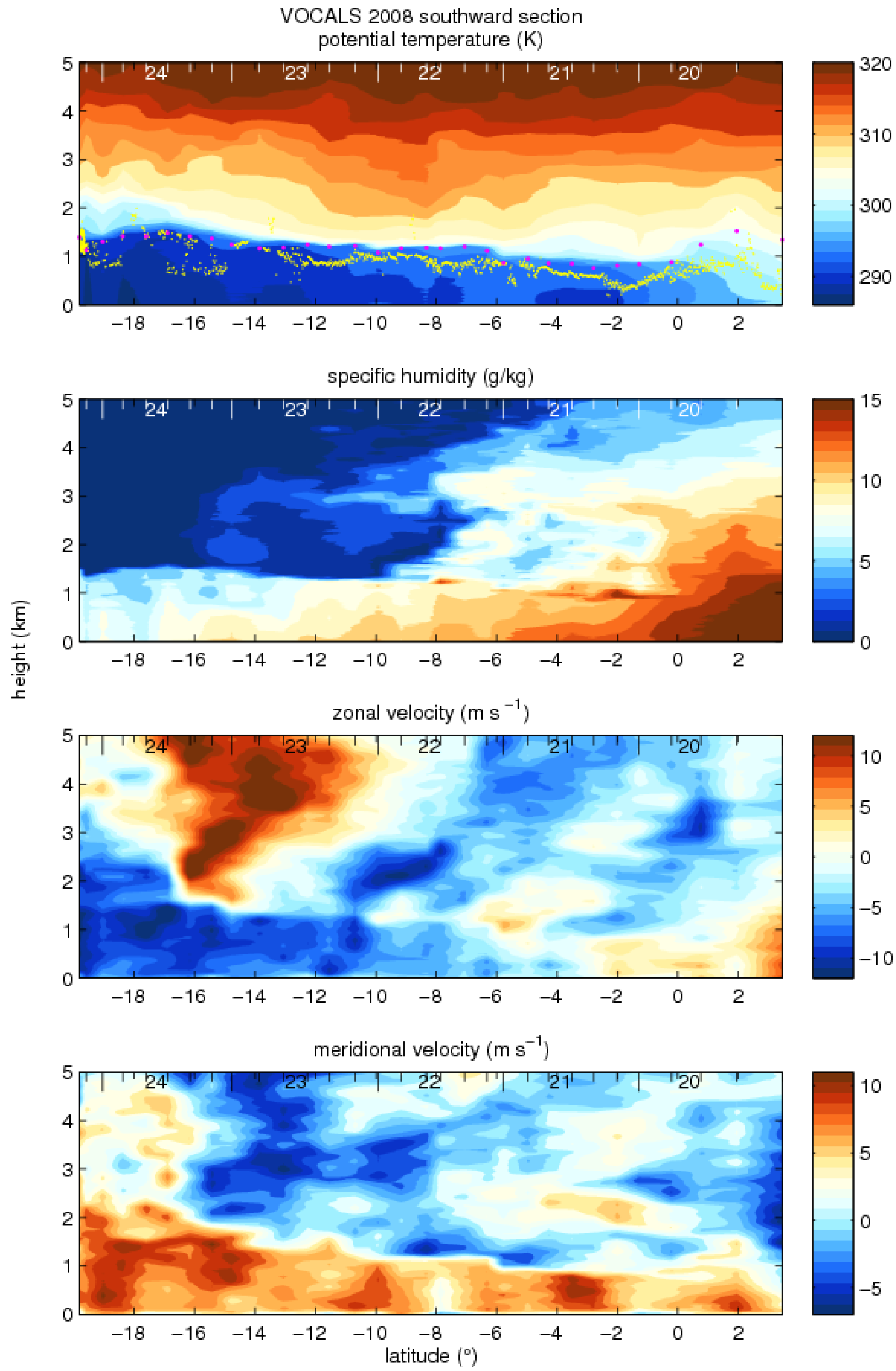

Figure 9-4: Vertical-latitude section from rawinsondes released near 85W. Contoured variables in panels, from top to bottom, are potential temperature, specific humidity, zonal wind, and meridional wind. Magenta dots in the top panel show cloud top height calculated from the sonde temperature profile, and yellow dots show cloud base from a laser ceilometer.

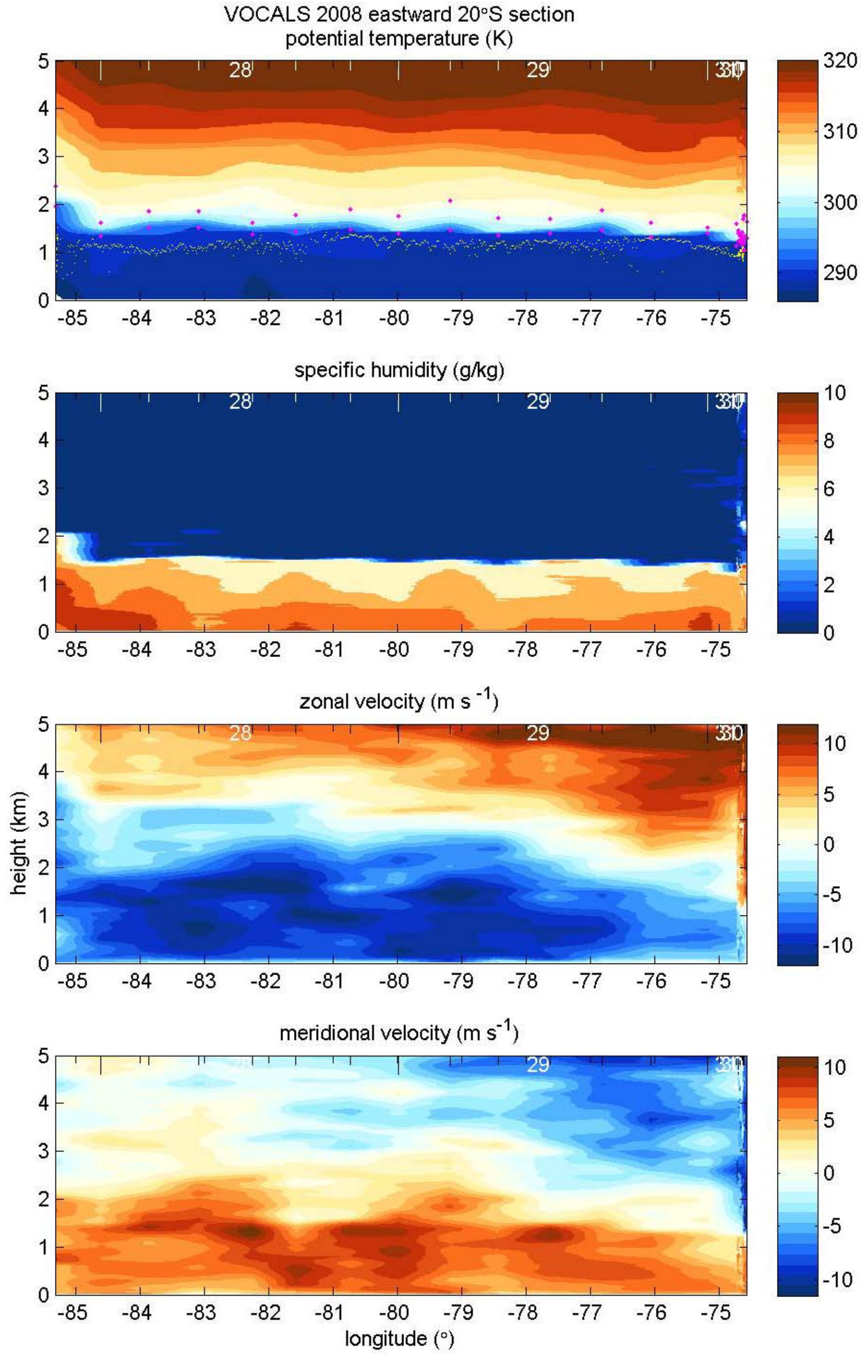

Figure 9-5: Potential temperature, specific humidity, and winds for a longitude section along 20°S latitude. Magenta dots in the top panel show inversion top and base.

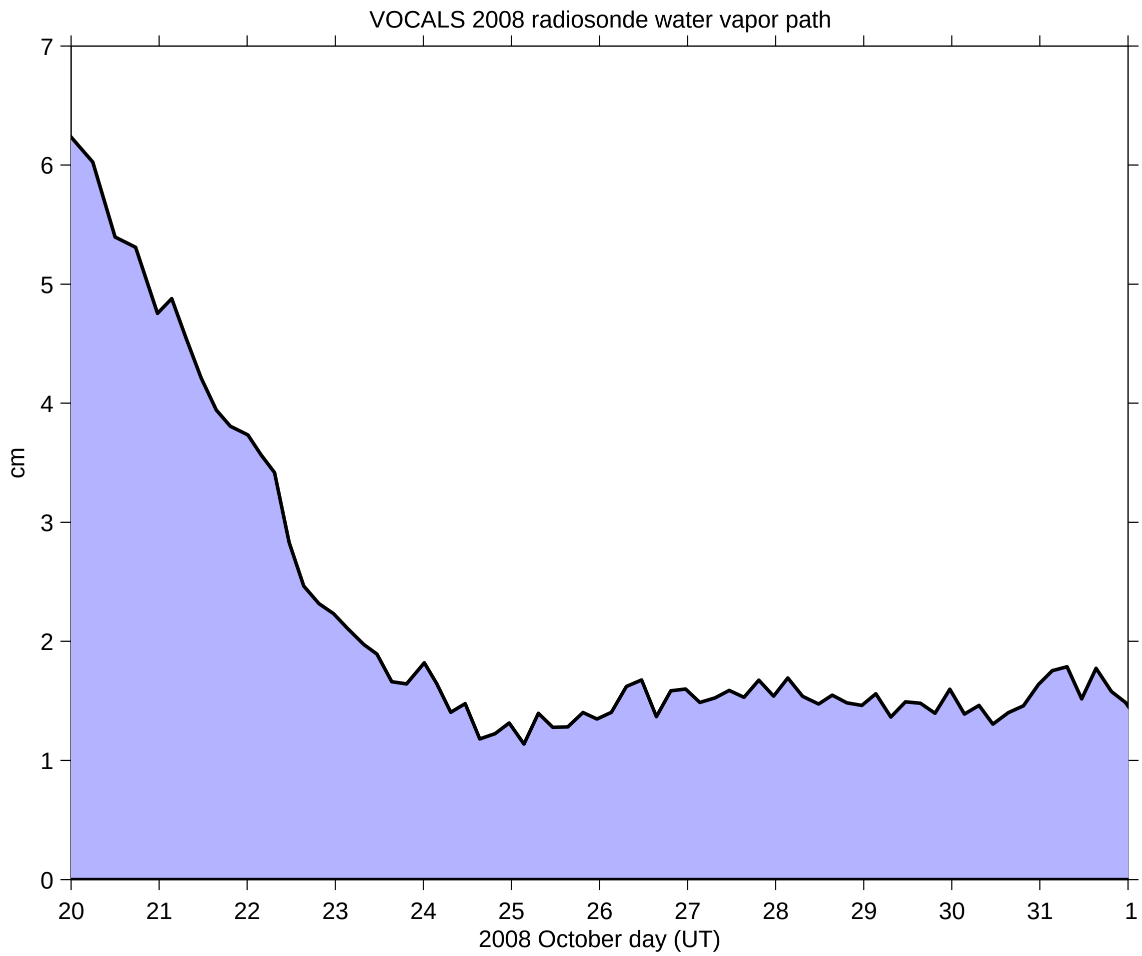

Figure 9-6: Integral of water vapor path from rawinsondes.

10. Atmospheric DMS Flux Measurement

Sea-to-air flux of Dimethyl Sulfide (DMS) from Eddy Correlation

We measured the concentration of DMS gas in the atmosphere at 20 hz which allowed us to compute the sea-to-air DMS flux by correlating concentration with the vertical wind velocity (W). The Atmospheric Pressure Ionization Mass Spectrometer (APIMS) that is used for continuously measuring the atmospheric DMS performed well during the leg 1 of VOCALS 2008. At the same rate as the DMS measurement, wind velocities in 3 axes and motion (linear acceleration and rotational rates) were recorded by a Sonic Anemometer and a Motionpak, respectively. The Sonic Anemometer was mounted on the jackstaff at 17.5 m above the sea surface with the gas inlet and Motionpak 1 m below. Gas lines about 20 m in length ran from the jackstaff into the starboard side van on the O2 deck, where the APIMS is located.

A time series of the atmospheric DMS concentration during Leg 1 is shown in Figure 10-1. The concentration was uniformly low in the Stratus region (most of the time 20~80 ppt), and often showed a clear diurnal signal: dusk (~23:00 GMT) marked the onset of DMS nighttime increase, whereas dawn (~12:00 GMT) signaled the beginning of DMS daytime decrease as a result of photolysis (see insert in Figure 10-1). The fact that we can see this diurnal cycling implies very stable and homogenous conditions with little mesoscale variability. There was a large peak in the atmospheric DMS concentration (over 1 ppb) in the Ecuador EEZ (at 0600 on 10/21/08), when the seawater DMS concentration also increased from a few nM to over 80 nM. This bloom of biological activity took place at an interface between two clearly different water masses, as indicated by the sharp changes in both sea surface temperature and salinity.

Despite the low concentration of DMS in the atmosphere, the APIMS was sensitive enough to resolve the fluctuations in the DMS concentration as a result of its air-sea exchange. Using data from the Motionpak, relative wind velocities measured by the Sonic were corrected for ship's motion according to Edson et al. (1998). The DMS flux was then calculated in hourly intervals as the direct covariance between DMS and motion-corrected W. Judging from the cospectrum of DMS:W, most of the flux was found between frequencies of 0.01 to 0.5 hz (Figure 10-2), corresponding to eddies in the atmosphere with length scales of 2 to 100 seconds. Little flux was found at a frequency higher than 1 hz, though there was sometimes a small amount of flux in the very low frequency end that is difficult to quantify.

The hourly-averaged DMS flux in the Stratus region is shown in Figure 10-3. We are interested in this flux because of the role of DMS in cloud formation in the remote marine atmosphere. It has been postulated that once emitted to the atmosphere, this reduced sulfur compound derived from phytoplankton is oxidized through a chain of reactions to sulfuric acid aerosol, which as cloud condensation nuclei can change the optical properties, coverage, and lifetime of clouds, and hence participate in a climate feedback loop (Charlson et al., 1987). Joining DMS with aerosol and cloud data may point us to the right direction in determining the climatic importance of this sulfur species.

Knowing the sea-to-air flux of DMS also allows us to calculate the transfer velocity of this gas when its air/sea concentration gradient is known (Our seawater DMS concentration is obtained from PMEL's Underway DMS System, which sampled every 15 or 30 minutes). Transfer velocity of a gas between the water and the air phase is an important parameter in any elemental cycling or climate model. Because direct measurements of air-sea exchange of a gas in the open ocean are difficult and have been scarce, there have been a number of parameterizations of the transfer velocity against some easily obtainable quantity, often wind speed, with large discrepancies, however (Liss and Merlivat, 1986; Wannikhof, 1992; Wannikhof and McGillis, 1999; Nightingale et al., 2000). Subsequent papers have suggested that in addition to wind speed, other controlling factors, such as bubbles, surfactant, and wave state, affect transfer velocity as well. We hope to test first, given the most stable conditions and the highest sampling qualities, how well transfer velocity can be constrained by mean variables, such as wind speed and wind stress. We can then turn to the other controlling factors (wave state being one of the available measurements on board) to reconcile the deviations away from the mean trend. To gain more understanding of the physical principals involved in gas exchange, rather than looking for a simple parameterization of transfer velocity, we will also incorporate our data into the physics-based models. With simultaneous CO_2 flux measurements from Chris Fairall's Group, we should have an opportunity to make a direct comparison between the DMS and CO_2 flux.

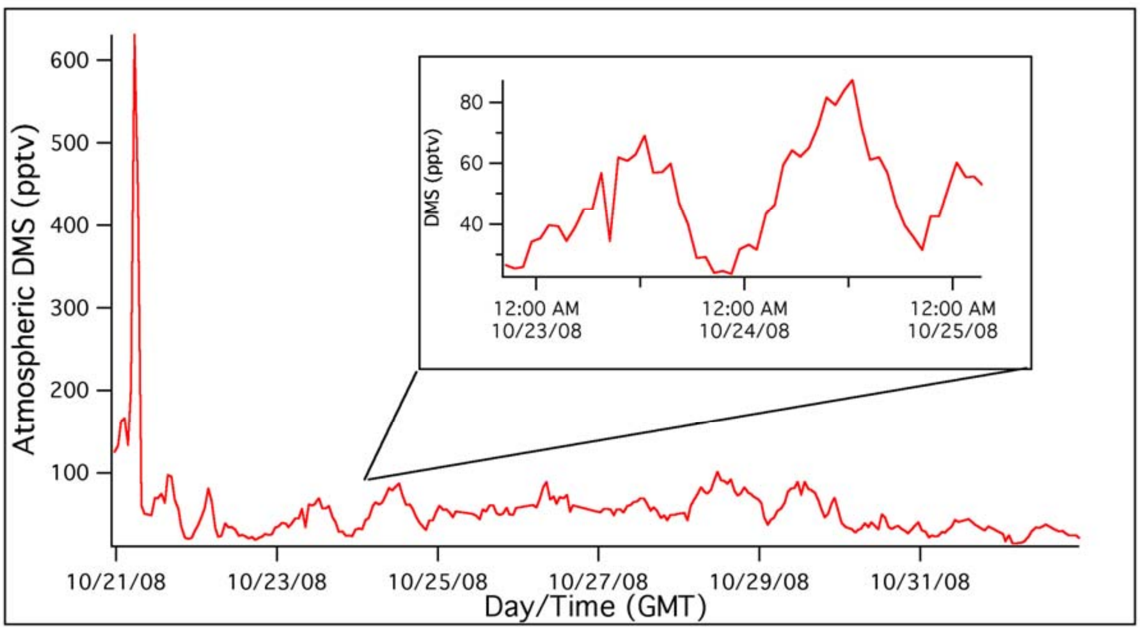

Figure 10-1: Time series of DMS in the Stratus region. A peak of DMS was observed west of Ecuador at an interface between two distinct water masses. A clear diurnal signal with a nighttime increase and daytime depletion (due to photolysis) was also seen in many of the days.

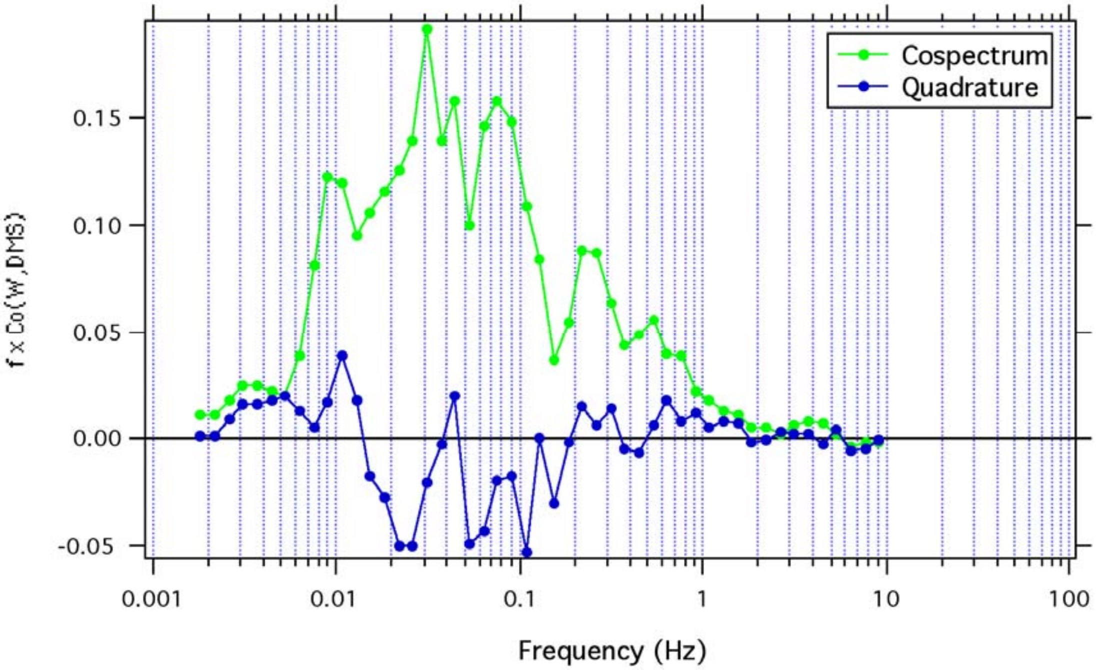

Figure 10-2: A typical cospectrum between DMS and W, the motion-corrected vertical wind velocity. The sea-to-air flux of DMS was derived both from the direct covariance between DMS and W and also from the integral of the above spectrum. Most of the flux was found between 0.01 to 0.5 hz.

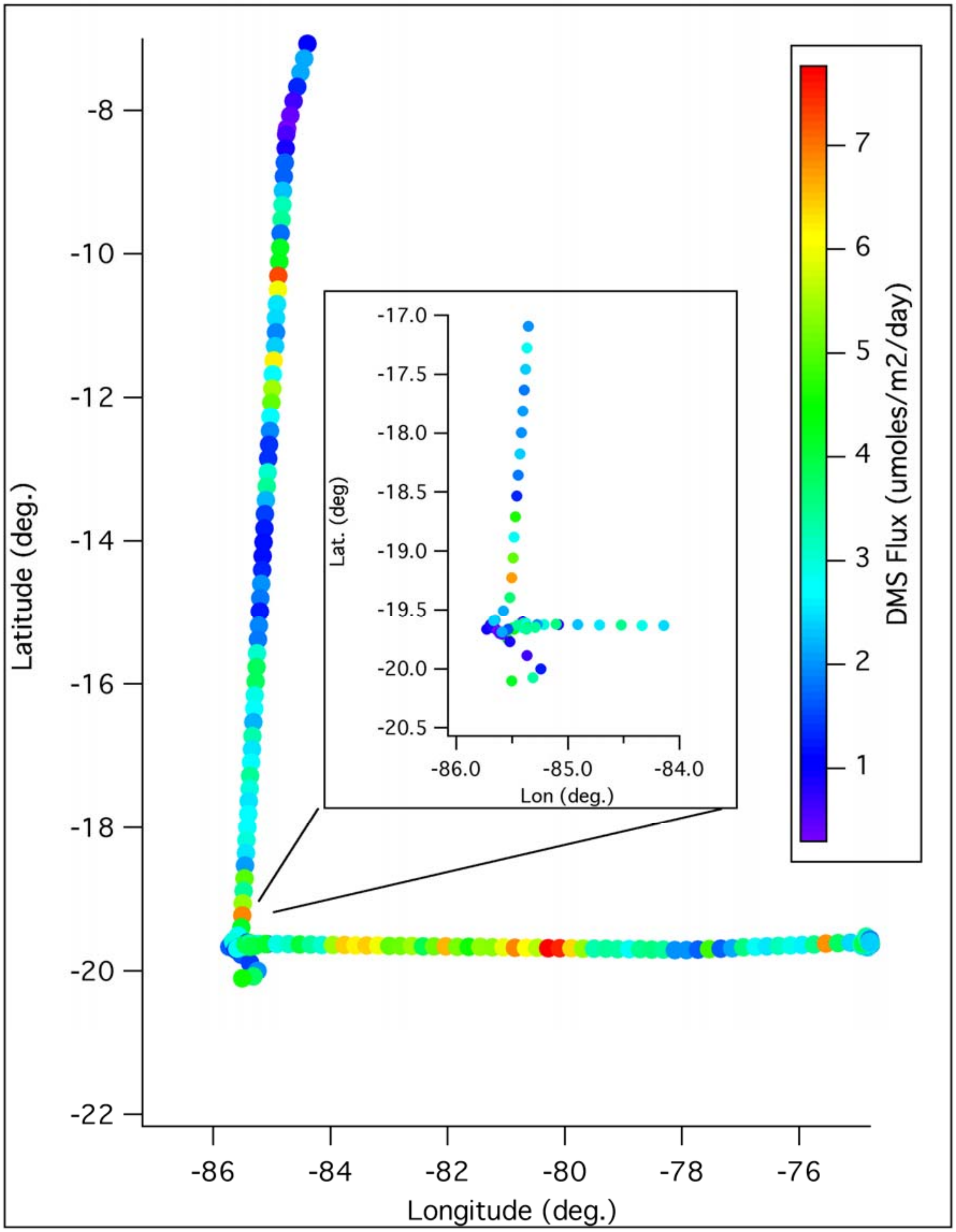

Figure 10-3: Hourly-averaged DMS flux for the Stratus region. The flux was usually quite small due to the relatively low seawater DMS concentration and only moderate winds and seas.

11. Phytoplankton

Overview

The VOCALS Regional Experiment portion of the Stratus cruise is an international multidisciplinary experiment that will allow a better understanding of the physical and chemical processes in the Southeastern Pacific Region (SEP). The biological component represented by phytoplankton reveals a great importance to achieve that goal. This is the reason why its study in the water column would be too interesting.

Another important aspect of the phytoplankton, in addition to the ability of carrying out photosynthesis, is that they act as atmospheric carbon drains. Besides, because of its quick adaptation, phytoplankton populations can increase or decrease according to environmental changes, producing some variable effects such red tides, bioluminescence, nitrogen fixation and its influence in the climatic global change, for what is in the ocean and atmosphere conditions.

Among the focused objectives are:

- Document the geographical distribution of the first trophic chain (distribution of the phytoplankton composition and concentration) in response to the large and mesoscale dynamics between Peru and northern Chile.
- Detect changes in the plankton community structure in relation with the physical environment (water masses and circulation).

Sampling efforts

A one liter volume of the chemical reagent used for the phytoplankton preservation: formaldehyde solution 20% was confiscated at the airport in Lima, so it had to be bought in the return to Panama. I made contact with a Panamanian distributor to get the reagents to prepare the solution.

Water sampling

Twenty four water samples were taken in eleven stations (Figure 11-1) belonging to Chicama (08°17.369'S – 84°44.858'W in Peru) and to Arica (19°.36.632'S–74°47.281'W in Chile).

Thirteen of these samples were obtained from 3.1 m to 75 m of depth using a CTD and rosette water sampler equipped with 30 L Niskin bottles. Eleven water samples were collected from the surface with a bucket for a further quantitative analysis of the phytoplankton in the laboratory at IMARPE (Peruvian Marine Research Institute) by Uthermohl method.

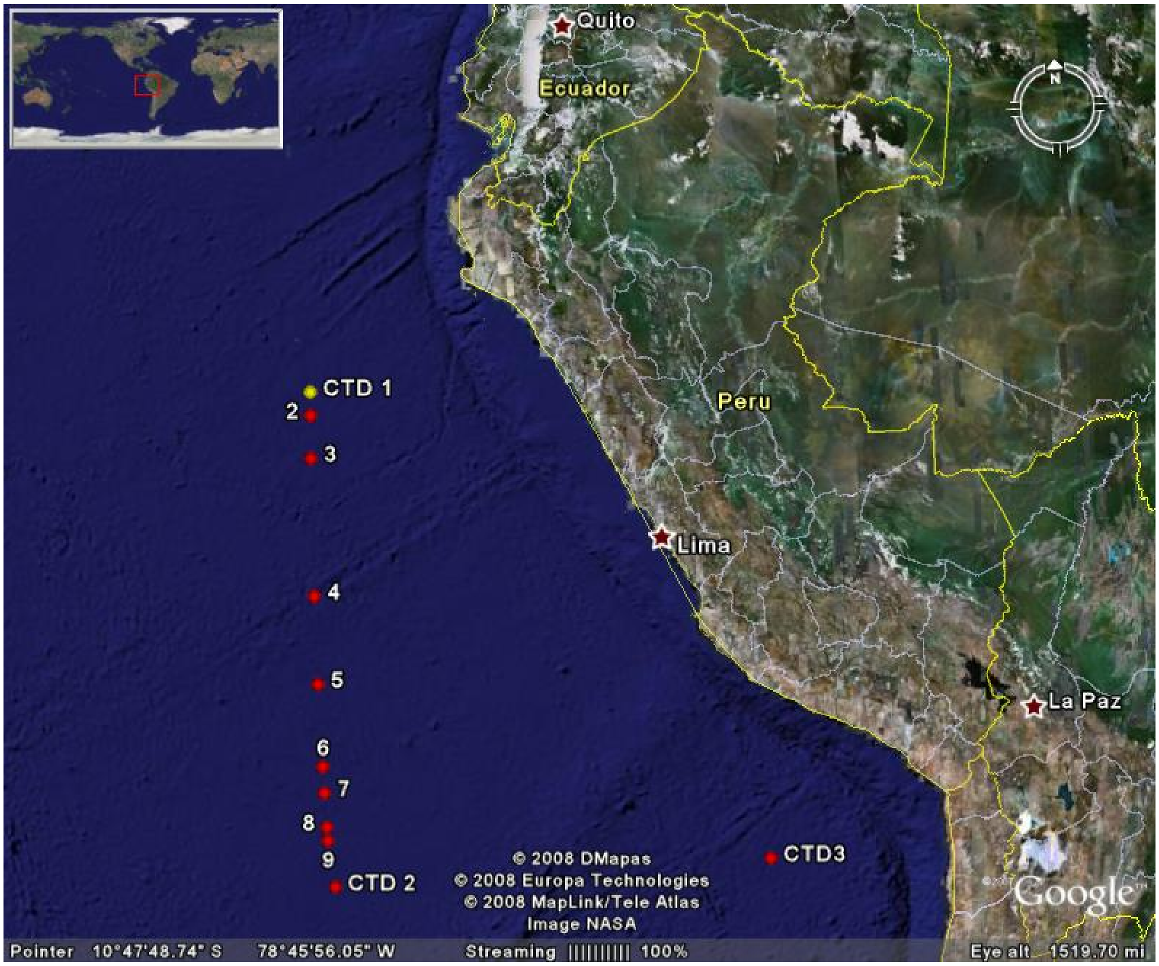

Figure 11-1: Water Samples Taken

12. Surface Based Aerosol Measurements

Measurements of the physical, chemical, optical and cloud nucleating properties of aerosols were made aboard the NOAA RV *Ronald H. Brown* during both legs of the VOCALS-REx cruise. These measurements focus on aerosol parameters relevant to cloud condensation nuclei and cloud droplet and precipitation formation in subtropical stratocumulus (Sc). These aerosol parameters modulate cloud processes to some extent and are, in turn, modulated by clouds especially through drizzle and coalescence scavenging. As such they are essential to the cloud modeling efforts within VOCALS.

Our overall goal is to elucidate the processes and cause-and-effect relationships between aerosols, cloud physics and cloud-precipitation interactions which influence cloud optical and structural properties (cloud cover, thickness, cloud droplet size and initiation of drizzle) over the South East Pacific (SEP). The focus is on particles in the 20nm to 10µm diameter size range including the Aitken and accumulation and sea salt modes which are observed in the SEP marine boundary layer (MBL) and which contribute most to the total particle number concentration and cloud condensation nuclei, CCN, subset. The sea salt component of the accumulation and coarse modes is likely important for the initiation of large droplets and subsequently, drizzle.

Of the hypotheses enumerated for testing in VOCALS, we address the following that relate most directly to aerosols and aerosol-cloud-precipitation interaction.

Hypothesis 1a: The physical and chemical properties of the SEP MBL aerosol have a measurable impact on Sc drizzle formation.

Hypothesis 1c: The small effective radii in near-coastal SEP Sc are controlled by the aerosol size and concentration field from natural and anthropogenic continental sources.

Hypothesis 1d: The depletion of aerosol particle concentration by drizzle and coalescence scavenging is necessary to maintain pockets of open cells, POC.

Hypothesis 2b: Regions of upwelling in the SEP with different chemistry and biology have an effect on aerosol precursor gases and eventually the MBL aerosol.

Aerosol Measurements and Methods

The following are the aerosol and related measurements made on the RHB during legs one and two from the container laboratories and sampling inlet 18 m above sea level, forward on the O2 deck. Details of the measurements along with their significance to aerosol-cloud-precipitation interactions and integration within the larger VOCALS-REx are given below.

1. Particulate number-size distribution from 20 nm to 10 µm diameter (and higher moments).
2. Particulate bulk chemical composition with size resolution of 2 and 7 increments, 0.1 to 10 µm.
3. Particulate chemical composition with respect to sulfate, nitrate, ammonium and organic compounds with high time and size resolution in the 60 nm to 800 nm diameter range.
4. Particulate bulk organic functional group analysis.
5. Cloud condensation nuclei concentration spectrum 0.15% to ca. 2%.

6. Aerosol optical properties: light scattering and absorption in sub- and supermicrometric ranges, relative humidity dependence of submicrometric scattering, aerosol optical depth.
7. Trace gas concentrations, ^{222}Rn, SO_2 and O_3.
8. Meteorological parameters: temperature, relative humidity, dew point, wind speed and direction.

Aerosol Size Distribution

The particle number-size distribution was measured in the range 20 nm to 10 µm diameter with 5 to 15 minute time resolution depending on ambient concentration with a set of two differential mobility analyzers (Hauke, Vienna, AU) for the Aitken and accumulation modes and an aerodynamic particle sizer (Model 3022 APS, TSI, St Paul, MN) for the coarse range, greater than 800 nm. This time resolution is adequate to define the aerosol variability along the coast and near POC boundaries where gradients due to anthropogenic sources, and scavenging and new particle production may be large. This size range includes the majority of the total particle number and mass and the sub-ranges of particles in the SEP from various sources that contribute to cloud nuclei. In particular it includes the Aitken and accumulation and large sea salt modes, 20 to 100 nm, 100 to 800 nm and 800 nm to 109 µm diameter, respectively. It does not include the larger, giant sea salt particles that may play a role in drizzle droplet formation. These particles are sampled and analyzed by other VOCALS investigators. Previous size distribution measurements in the SEP showed the ubiquitous bimodal number distribution characteristic of marine aerosol with number maxima near 60 nm and 200 nm and a minimum near 100 nm. These bimodal distributions were relatively stable with time. However, notable exceptions to this distribution occurred in the vicinity of POC where lower accumulation mode concentrations and occasionally very low total concentrations ($<100\ cm^{-3}$) and a nuclei mode ($D_p<40$ nm) were observed.

The sectional data or modal parameters (geometric mean diameter, standard deviation and concentration) of the Aitken and accumulation modes are determined and provided to the integrated data sets as prognostic variables for the LES models. The number concentration in the accumulation mode is considered to be a measure of cloud condensation nuclei (CCN, see below) concentration or the number of particles available for cloud droplet nucleation in clouds with low supersaturations, ca. 0.2% while the Aitken number concentration is a measure of CCN available in clouds with SS% up to 1 or 2%. The diameter interval between the Aitken mode maximum and the Aitken/accumulation mode minimum is taken as a measure of the critical diameter, D_{crit}, in the clouds processing the MBL aerosol and their supersaturation distribution function. The sectional number distributions are converted to surface, volume and mass-size distributions to check for data consistency with the chemical and mass measurements and to relate to gas phase sinks.

Cloud Condensation Nuclei

Cloud condensation nuclei (CCN) concentration was measured with two continuous flows, thermal gradient instruments (DMT, Boulder, CO) under two different operating conditions, spectral mode and monodisperse mode.

The spectral CCN is operated at two or more supersaturations, SS%, between 0.15% and 2% with a time resolution of 60 minutes. For an aerosol with chemical composition of ammonium bisulfate, a SS% of 0.15 corresponds to a critical diameter, D_{crit}, of approximately 100nm, the previously observed minimum between the Aitken and accumulation modes in the SEP. Thus, the 0.15% SS CCN data should represent the CCN concentration from the accumulation mode. CCN at SS% of 2% should represent the additional contribution of the Aitken mode to potential CCN. For the fastest time response and best counting statistics in the expected clean conditions of the SEP and particularly the POC areas, ca. 30 minutes, these two supersaturations are used. When concentrations are higher more supersaturations within this range are used.

The monodisperse CCNC is operated on a narrow increment of the atmospheric number size-distribution centered on 80 nm within the Aitken mode. CCN at supersaturations from 0.15 to 0.4 are measured. The slope of the CCN spectra measured across this increment is related to the chemistry of the particles at this size and is analyzed in conjunction with the aerosol mass spectrometry data, see below.

Finer detail of the supersaturation spectrum that is important to droplet formation in Sc can be modeled with the combined number-size distribution and aerosol chemistry data. Comparison of the two-point supersaturation spectrum from the CCN data and the integrals from the modeled CCN spectra integrals can be used to test closure between these two techniques and the validity of the modeled CCN at lower SS%. The integrals of particle number in the accumulation and Aitken mode size distributions are compared to CCN at the relevant SS% and to the cloud droplet number, N_{cd}, from aircraft observations and model output.

Aerosol Chemistry

The chemical composition of the SEP MBL aerosol is important for understanding the sources and solubility of the particles, i.e., the chemical effect in determination of CCN.

Bulk chemical analysis

Major water soluble inorganic anions and cations, total organic carbon, elemental carbon, trace metals, and total particulate mass were analyzed in impactor samples with a time resolution of 6 to 12 hours. Size resolution for all analyses except inorganic ions is limited to two ranges, 100 nm to 1.0 µm and 1.0 µm to 10 µm. Inorganic ion data include the sub- and super-micrometric size ranges as well as 7 size increments between 100 nm and 10 µm.

Aerosol Mass Spectrometry and Fourier Transform Infrared Spectroscopy

In order to observe changes in aerosol composition on faster time scales, an aerosol mass spectrometer (AMS, Aerodyne, Inc., Billerica, MA) was operated by Scripps Institution of Oceanography (SIO) to measure inorganic ions with 15 minute or less time resolution. Organic composition information was acquired by FTIR analysis of filter samples. The AMS collected real-time, 5-minute resolution concentrations of non-refractory sulfate, nitrate, ammonium, and organic compounds in aerosol particles in the range 60 nm to 800 nm diameter. The instrument alternates between scanning the entire mass spectrum and measuring only a select few mass fragments. The latter provides a chemically-resolved size distribution for the submicron aerosol population.

To complement the AMS and PMEL's major component analysis, 12-hour, submicrometric particulate samples were collected on teflon filters. Simultaneous, 24-hour filters were also collected. These filters are sent to SIO for quantitative Fourier Transform Infrared (FTIR) spectroscopic analysis of several functional groups. The measured groups include saturated aliphatic C-C-H, unsaturated aliphatic C=C-H, aromatic C=C-H, alcohol C-OH, carboxylic acid COOH, non-carboxylic carbonyl C=O, and amine N-H2.

The goal of the AMS analysis is to observe changes in aerosol chemical composition at short enough time scales to resolve possible particle sources and sinks associated with continental and sea surface emissions, photochemical production, MBL mixing and clouds. At this time resolution, ship track pollution and mesoscale, cloud-related processes can be isolated from longer range transport. The chemically resolved size distributions indicate whether the particles are chemically different across the size spectrum. FTIR spectroscopic analysis provides more detailed information about the organic fraction, its age or history, and its source. Oxygenated organic groups like alcohol, carbonyl, and carboxylic acid in aerosol particles are commonly associated with "aged or processed" aerosol while "more freshly emitted" aerosol is primarily composed of saturated and unsaturated aliphatic hydrocarbons. Additional source information can be gained from aromatic and amine compounds, which are usually associated with anthropogenic activity. We also compare total organic mass measured by the AMS to organic mass from FTIR spectroscopy to test the degree of closure between the two independent methods.

Gas phase measurements

The concentration of ^{222}Rn (half-life 3.8 days) was measured with a dual-flow loop two-filter detector. The photomultiplier counted the radon daughters produced in the 750 l decay/counting tank with a lower limit of detection of 80 mBq m-3 for a 30 minute count (with 30% error). The radon detector was standardized using radon emitted from a dry radon source (RN-25, Pylon Electronics Corp., 2850 mBq min-1)

A uv photometric ozone analyzer (Model 49C, Thermo Electron Co., Franklin PA) calibrated to a NIST traceable analyzer was used to measure ozone concentration on a 10 s time base. The detection limit was 2 ppbv and the overall uncertainty was ± 2 ppbv + 5%.

A trace level, pulsed fluorescence SO_2 analyzer (Model 43C, Thermo Electron Co., Franklin PA) was used to measure SO_2 concentration on a 10 s time base. Zero and span gas were introduced every 6 and 24 hours, respectively. The limit of detection for the 1 min data is 100 ppt; uncertainties in the concentrations based on the permeation tube weight and dilution flows are < 5%.

These trace gases in combination with other meteorological and aerosol parameters we measure are a good indicator of the source of air parcels at the ship. High radon levels indicate recent contact with land, high Sulfur dioxide is an indicator of plumes from urban areas, ships or smelters on land. Ozone is an indicator of mixing with the free troposphere or photochemical activity in urban plumes. Carbon or light absorbing carbon, see optics below, is a measure of combustion sources. Comparison of the time and location variability of these parameters in combination with trajectory analysis from the University of Washington and Flexpart help to pinpoint the sources of particular aerosol and its chemical composition cf. the general SEP MBL aerosol.

Aerosol Optics

Aerosol optical depth was measured as cloud-free conditions permitted with a MICROPTOPSII sunphotometer (SolarLight, Philadelphia, PA). Derived parameters of Ångström exponent, single scattering albedo and backscattering fraction are derived from the primary, measured parameters. The combination of the scattering and absorption Ångström exponents and single scattering albedo is a good indicator of aerosol types which can be used to distinguish between combustion, mineral dust and marine sources with high time resolution.

Preliminary report on sampling done within Peruvian maritime boundaries during RHB Cruise 06-08

This is a preliminary report describing the sampling done by this research group while within Peruvian maritime boundaries, between 07:47 local October 21, 2008, and 03:45 local October 22, 2008. This report is accompanied by the release to Ecuador of the preliminary data. It is acknowledged that a final report and final version of the data is due to the Chief Scientist for submission to Peru via the U.S. Department of State. That report should include a description of the data, the pertinent metadata, and any software tools required to read the data.

Completion of this report, and of the final report, are required to release the data for scientific analysis and publication and further distribution. This report will be submitted to NOAA NMAO, the U.S. Department of State, and Peruvian authorities.

Research Group: Aerosols, University of Washington, Department of Atmospheric Sciences, NOAA PMEL Aerosol Chemistry Group and Scripps Institution of Oceanography
Principal Investigator(s) (print/type): David Covert, Tim Bates, Lynn Russell
Contact Information (email and phone): dcovert@u.washington.edu 206 685 7461

Summary of data collected:
Aerosol and Related Measurements were made by NOAA PMEL Aerosol Chemistry Group, University of Washington, Department of Atmospheric Sciences, JISAO and Scripps Institution of Oceanography.

We sampled ambient air from a level 18 meters above the surface on the NOAA ship RV *Ronald H. Brown*. The measurements and analyses made on the sampled air include the physical, chemical and optical parameters of aerosol particles and trace gases listed below.

Aerosol Physics:
  Number concentrations of aerosol particles greater than 10 nm in diameter

Aerosol Chemistry:
  Major water soluble inorganic anions and cations,
  Total organic carbon,
  Elemental carbon,

Volatile organic carbon,
Organic functional groups,
Trace metals,
Total particulate mass.
Evaluation of these sample will be done post-cruise at the respective laboratories.

Aerosol Optics:
Light scattering and absorption coefficients.

Aerosol gas phase:
Radon levels in the atmosphere,
Sulfur dioxide,
Ozone.

Additionally position and standard meteorological variables were measured.

The parameters measured were typical for the remote marine boundary layer with some land influence. The light scattering coefficient was dominated by seasalt particles. Sulfur dioxide was below detection limit except for the calibration at midnight.

Description of preliminary data release accompanying this report:
The preliminary data are provided on readable disk as 10 minute averages of the above listed parameters. The file is in tab delimited text format readable by Microsoft Excel. The time format is UTC. The units for the parameters listed are in a header in the file.

13. University of Miami (UM)

The group focused on studying several aspects of the cloud-topped marine boundary layer structure along with the radiative properties of the stratocumulus cloud deck. The instruments deployed by UM group are summarized as follows:

2 microwave radiometers (PI, Dr. Paquita Zuidema):
183 GHz radiometer: The high frequency channels, extremely sensitivity to the liquid water, will provide liquid water path (LWP) retrievals with a high accuracy. The 183 GHz radiometer will also be used to help validate an airborne 183 GHz instrument on the NCAR C130 plane used for VOCALS. 2 channels radiometer, 23 GHz and 31 GHz: The robust calibration of this instrument will provide consistent high-quality LWP. While the water vapor cannot be estimated from the 183 GHz radiometer, the 23 GHz channel will retrieve this variable. Cloud liquid water paths are arguably the most important parameter to know in marine boundary layer clouds: they impact the top-of-cloud albedo to first-order, are crucial to the identification of all aerosol indirect effects and aerosol-cloud-precipitation interactions, and are the most commonly compared variable between models and observations. The above efforts will increase our capacity for the retrieval of state-of-the-art LWPs that can be applied to all of these functions.

UM radars: (PI, Dr. Bruce Albrecht):
The objective is the use of observations from the upward facing UM 95 and 9.5 GHz radars to characterize the vertical structure of boundary layer clouds observed over the ship during VOCALS cruise. These characterizations include cloud-top heights, reflectivity and Doppler vertical velocities in the cloud, and drizzle falling from the cloud to the surface and will be compared with those from the NOAA ETL radar. The observing strategy is to make continuous high temporal resolution (1/s) observations while in the VOCALS observing.

Dr. Paquita Zuidema, U of Miami, provided two microwave radiometers: a standard 2-channel mailbox radiometer (23.8 and 31.4 GHz frequencies) on loan from Dr. Peter Minnett, and a 14-frequency 183 GHz radiometer made available through an instrument request to the Atmospheric Radiation Measurement (ARM) program. These, in combination with the NOAA 90-GHz microwave radiometer, will be used to retrieve water vapor paths (WVPs) and cloud liquid water paths (LWPs) of the highest accuracy attainable, relying on a physical retrieval that will also invoke the soundings and ceilometer cloud base heights. Ultimately the data will be used address aerosol indirect effects upon clouds, help quantify the dependence of cloud drizzle upon cloud liquid water path, help elucidate the diurnal cycle in free troposphere subsidence variability upon the boundary layer, and, in combination with the NOAA W-band cloud radar, contribute to further cloud microphysical retrievals.

A first cut was made at WVP and LWP estimates using solely the 2channel mailbox frequencies, with the data provided at its original data resolution (typically 20 seconds), and as a 10-minute and hourly average. Comparisons of the microwave WVPs against the sonde- derived WVPs are shown for both legs of the cruise in plots made available through the shared VOCALS directory. Typically the microwave WVPs are low compared to the sonde values. The comparisons indicate that more work needs to be done on the retrievals, but with the exception of the last few days of the cruise, the variability in the microwave retrieved WVP values seems reasonable. This indicates the variability in the retrieved LWP values is probably also reasonable, with the absolute values in question. Focus will be on improving the dataset to have finished for the VOCALS science meeting.

14. Teacher At Sea

a. Experience, David Grant, Brookdale School

The Teacher at Sea Program began in 1990 and has taken more than 450 teachers to sea. The program allows teachers to work alongside scientists out at sea, thus giving them a unique and hands on experience.

The Teacher At Sea (TAS) program was initiated in 1990 and has included over 450 teachers; and I feel privileged to be chosen for a cruise. TAS is a unique opportunity to work on NOAA vessels and assist scientists on a variety of projects; and to share that experience with students in real-time over the Internet and with logs posted by NOAA at their website. The information gained during a cruise is also valuable in developing learning activities back in the classroom and enhancing teaching skills. One important aspect of this hands-on experience is the increased awareness about careers in science that can be directly conveyed to students. Besides the science components of the cruise, teacher-participants gain insight into technical and vocational careers with NOAA and in ocean-related industries to share with students of all ages and skill levels.

My time spent on the *Ron Brown* has been enlightening, challenging and productive. Scientists and crew have shown great interest in each others projects and needs, and I have found everyone to be flexible and agreeable. The depth of knowledge of the science party and ship's crew is outstanding and I have benefited from their information and experience. Since my background is not in meteorology, most of the activities I have assisted with are new and informative, and will augment my depth of knowledge and teaching abilities. The hands-on experience of launching and monitoring weather-sounding balloons, recovering water samples, launching drifters, and collecting CTD data has been invaluable, and I look forward to interacting with the other scientists over the next year to learn more about their research and results. Their overviews during the evening meetings were an excellent format to review and clarify complicated and diverse data and theories.

In a short time I have gained a semester's worth of knowledge and teaching materials to enhance my own science and non-science classes. All of this can be incorporated within the learning matrix of the Ocean Literacy guidelines, especially:

- Science as a human endeavor,
- Changes in environments,
- Understanding about science and technology,
- Abilities necessary to do scientific Inquiry,
- Abilities of technological design,
- Science and technology in global challenges,

Activities:

During the cruise I have:

- Interacted with scientists and crew and gained important insight into oceanographic and atmospheric processes,

- Taken innumerable observations and photographs to use as educational material and share with the general public,
- Observed and identified different species of marinelife including over 29 species of birds,
- Posted Internet blogs for teachers and students at the TAS website,
- Interacted with researchers from other countries,
- Communicated and interacted with students from my current college classes (Human Geography, Oceanography, and Environmental Studies); and with elementary grade students; facilitated quizzes, graded tests and homework, and advised them via email; and responded to questions from teachers, including the previous TAS on the *Brown*.

Anticipated Outcomes:

When back at school I will share these materials with students; use some data for classroom exercises; do presentations for the college's public audiences and at least one teacher conference; post images, information on NOAA, the TAS program and the *Brown* on the college's website; and develop curriculum materials on careers, weather, ocean circulation, and pelagic marinelife like seabirds.

Comments:

This is a great opportunity for teachers and it has been enriching for me in many ways.
I already feel that these four weeks of smooth sailing will not be enough to satisfy my curiosity, and now better appreciate the statement by Heinrich Heines:

"I love the sea as I do my own soul."

b. Teacher at Sea Seabird Observations from the *Ron Brown*
Arica, Chile - 11/10/08 – 12/2/08

The wind sails the open sea
Steered by the albatross
That glides, falls, dances, climbs,
hangs motionless in the fading light,
touches the waves' towers…
Pablo Neruda

There are about 9,000 species of birds in the world, but only a fraction of them are classified as *seabirds* – those that primarily use the marine environment outside of the breeding season. All birds breed on land and many of the seabirds are restricted to islands that are free of land predators – primarily mammals.

Of the seven Orders, 20 Families and 372 species that are classified as seabirds. The Southern Hemisphere has a greater number of species reported than the Northern Hemisphere (318 species, as opposed to 236), and the west coast of South America, swept by the cold, rich waters of the Humboldt Current and noted for its upwelling, is particularly rich in marinelife, especially seabirds.

Birds that are considered strictly marine belong to the families: Diomedeidae (albatrosses), Procellariidae (shearwaters and petrels), Hydrobatidae (storm-petrels), Pelicanoididae (diving petrels), Phaethonidae (tropicbirds), Sulidae (gannets and boobies), Fregatidae (frigatebirds), and Alcidae (auks). Other groups like the cormorants (Phalacrocoracidae) are primarily marine and coastal; and with the exception of two of the phalaropes, which winter on the ocean, most shorebirds (Scolopacidae) are confined to the littoral zone. Finally, the gulls and terns (Laridae and Sternidae) are mostly marine, but some species can be found near any large body of water.

The oceans cover about 73% of the globe, and yet seabirds account for only 3.8% of Avian species. However, many of these species are extremely abundant and are major components in many marine ecosystems. Some authorities consider the Wilson's petrel (<u>Oceanites</u> <u>oceanicus</u>) to be the most abundant bird on Earth; and the Peruvian boobies and cormorants colonizing the "guano islands" off Peru are thought to number 10-million.

Casual monitoring of seabirds was done during VOCALS Leg 2, and we spotted 29 different types of birds from three Orders and eleven Families. The most abundant and most frequently sighted were storm–petrels; followed by gadfly petrels. Other species in the order of abundance are: boobies, cape petrels, shearwaters, gulls and terns. Birds were reported every day, but were particularly abundant on three occasions:

- 11/16 (19º00" – 078º30") Mostly storm petrels
- 11/18 (18º59" – 080º43") Mostly storm petrels
- 11/27 (19º46" – 076º18") Gadfly petrels feeding (Whales spotted too)

Worth mentioning perhaps is that on those three occasions and a fourth --- when the largest school of dolphins were spotted (11/26/08 – 19º53' / 079º48') DMS levels in the water samples were described by researchers as *very high* to *super high.*

There are few observations that were significant in the evenings. Peregrine falcons roosted overnight, but no other live birds were found on deck. Storm petrels darted under the aft lights on a few occasions 11/18 and 11/19; and birds (terns?) were heard but not seen the night of 11/29; 78NM off of Tocopilla, Chile (21º30 – 071º27). Grey gulls became the dominant bird once we reached the coastal waters.

Perhaps the most unexpected sightings were land birds that were temporary stowaways on the ship; in both instances, a surprising distance from shore. A pair of cattle egrets stayed on the ship on 11/13 (19º37.8 – 075º39.2, approximately 241 nautical miles from Arica) then flew to the north before sunset. Two different peregrine falcons traveled with the ship; one each on two occasions:

- 11/14–15; 249-NM from Arica,
- 11/22–30; 624NM from Puerto Caballa, Peru, until we reached our last sampling station a few miles off the coast.

Both falcons fed primarily on storm petrels; to a lesser extent on the larger gadfly petrels; and on at least one occasion, a tern; taking perhaps six birds per day. Presumably they are the major predator of these birds when they are at sea (Table 14-1).

Order	Family	Common Names	Genus
Procellariformes	Diomedeidae Procellaridae Hydrobatidae	Albatrosses Petrels and Shearwaters Diving-petrels Storm-petrels	Diomedea Daption Procellaria Pterodroma Puffinus Halobaena Pachyptila _______________ Fregetta Oceanites Oceanodroma
Pelecaniformes	Pelicanidae Sulidae Phalacrocoracidae	Pelicans Boobies Cormorants	Pelicanus Sula (2) Phalacrocorax (2)
Charadriiformes	Scolopacidae	Shorebirds	Numenius Arenaria Haematopus Chalidris
	Laridae	Gulls	Creagrus Larus (3)
	Sternidae	Terns	Larosterna Sterna (3)
(Land birds) Falconiformes Ciconiformes	 Falconiae Ardeidae	 Peregrine Falcon Cattle egret	 Falco Bubulcus
Totals 5 Orders	11 Families	29 Species	29 Species

Table 14-1: Birds spotted on the *Ronald Brown* 11/10-12/2/2008

It is recommended that future cruises include scheduled and more thorough observations of seabirds and other marine life to present a more complete picture of the SEP environment, and to explore possible correlations between DMS levels and the concentration of marinelife like birds.

I am grateful to NOAA's Teacher At Sea program, and the crew and scientists of various other organizations for allowing me to fully participate in this cruise. It was a rewarding experience that will greatly enhance my teaching skills.

Below is an excerpt from R.B.Robertson's book, Of Whales and Men, offering a facetious account explaining the lack of albatross, but in praise of the *Brown*'s kitchen staff.

> "There are various theories to explain why no whaling ship ever sights a pure-white adult wandering albatross. One is that the older members of the species are too delicate to stand the cold of the Southern Ocean and always head North from their nesting grounds. The other is that, when they have turned pure white, they are old and wise enough to know that they'll find damned little grub thrown overboard from a British whaleship with a Norwegian steward, so they fly up astern of us, take one look at our port of registration, smell the Norwegian cooking, and sheer off in panic to find an American ship with an Argentine chief steward."

Acknowledgments

This project was funded through grants from the Climate Observation Program and Climate Prediction Program for the Americas of the National Oceanic and Atmospheric Administration (NOAA Grant NA17RJ1223). The UOP Group would like to thank the crew of the R/V *Ronald H. Brown* and all of the scientific staff for their help during the Stratus 2008 cruise.

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Appendix 1: Science Party First Leg

The Chief Scientist was Dr Robert Weller, who is affiliated with WHOI

Leg 1 Personnel – NOAA Ship *Ronald H. Brown* – Stratus

	Name	Affiliation	Email	Notes
1	R. Weller	WHOI	rweller@whoi.edu	Chief Scientist
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11	Simon DeSzoeke	NOAA/ESRL	Simon.deSzoeke@noaa.gov	Clouds
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13	S. Tucker	NOAA ESRL	Sara.Tucker@noaa.gov	Lidar
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22	Catherine Hoyle	JISAO	tapirrojo@yahoo.com	aerosol
23	Lelia Hawkins	SIO	lnahid@ucsd.edu	aerosol
24	Mingxi Yang	U Hawaii	mingxi@hawaii.edu	DMS
25	David Painemal	RSMAS Miami	dpainemal@rsmas.miami.edu	student

Appendix 2: Science Party Second Leg

The Chief Scientist was Dr. Chris Fairall, who is affiliated with the ESRL

Leg 2 Personnel – NOAA Ship *Ronald H. Brown* – VOCALS Rex

	Name	Affiliation	Email	Ge	Notes	
1	Chris Fairall	ESRL	chris.fairall@noaa.gov	M	Chief Scientist	03-42-2
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4	Sean Whelan	WHOI	swhelan@whoi.edu	M	Ocean tech	02-22-4
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6	Carolina Gaete			F	Observer	01-27-6
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23	Rebecca M Simpson	U Hawaii	rmcs@hawaii.edu	F	Grad student	02-40-2
24	Dave Grant	NOAA/ Brookdale School	dgrant@brookdalecc.edu	M	Teacher-at-Sea	02-57-1

Appendix 3: Stratus 8 Station Log Complete

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. Stratus 8 MOORED STATION NO. 1193

Launch (anchor over)

Date (day-mon-yr) 27-OCT-2007 Time 18:27 UTC

Latitude (N/S, deg-min) 19°37.355 S Longitude (E/W, deg-min) 85 22.536 W

Deployed by LORD Recorder/Observer GALBRAITH

Ship and Cruise No. RON BROWN Intended Duration 12 MONTHS

Depth Recorder Reading 4448.02 m Correction Source MATTHEWS TABLE

Depth Correction 5 m SEABEAM / SEA SURVEY

Corrected Water Depth 4453.02 m Magnetic Variation (E/W)

Argos Platform ID No. Additional Argos Info on pages 2 and 3

Surveyed Anchor Position

Lat (N/S) 19° 37.2147 Long. (E/W) 85° 22.7262

Acoustic Release Model 8242 XS

Release No. 30846 / 31269 Tested to m

Receiver No. 18156 Release Command 151376 / 444155

Enable 166561 / 460272 Disable 166603 / 460303

Interrogate Freq. 11 Reply Freq. 12

Recovery (release fired)

Date (day-mon-yr) 27-Oct-2008 Time 10:45 UTC

Latitude (N/S, deg-min) 19° 37.370 Longitude (E/W, deg-min) 85 22.755

Recovered by LORD Recorder/Observer GALBRAITH

Ship and Cruise No. Ron Brown 08-06 Actual duration 365 days

Distance from actual waterline to buoy deck m

1

STRATUS 8 #1193

Surface Components

Buoy Type Foam 2.7m **Color(s) Hull** Yellow **Tower** White

Buoy Markings ON HATCH: IF FOUND CONTACT WOODS HOLE OCEANOGRAPHIC WOODS HOLE
ON SIDE WHOI 508-457-1401 USA -50- -60 --70 IF FOUND ADRIFT

Surface Instrumentation

Item	ID #	Height*	Comments
HRH	222	230	System #1
BPR	502	234	
WND	Sonic 203	280	
PRC	502	240	
LWR	505	282	
SWR	214	282	
SST	1834		
Logger	L-01		FIRMWARE LOGR53V2.70
PTT #14612			IDS 24337, 27970, 27971
HRH	225	230	System #2
BPR	210	235	
WND	211	272	
PRC	506	240	
LWR	502	282	
SWR	223	282	
SST	1840		
Logger	L-02		
PTT # 14709			IDS 9805, 9807, 9811
WND	343	272	Stand alone

*Height above buoy deck in centimeters

2

STRATUS 8 1193

Subsurface Instrumentation on Buoy and Bridle			
Item	**ID #**	**Depth†**	**Comments**
SBE 39	1446		floating SST
TR 1050	10983		~~floating~~ SST - fixed
pCO_2			clean - no fouling on tube
Argos beacon	SN 22		Subsurface Argos ID# 11427
WAMDAS			WAVE PACKAGE, NDBC STATION WHOI ~~I~~
			IRIDIUM MODEM 24536

†Depth below buoy deck in centimeters

3

Moored Station Number 1193 Stratus 8

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	NOMINAL Depth (m)	Time Back	Notes
1		BUOY		1224					1703 HOOKED ON TOWER
2	.22	3/4" CHAIN							
3		SBE 37	1901	1223	MICROCAT		2	1707	
4		XR420	10515					1707	
5	.37	3/4" CHAIN							
6		SBE 37	1902	1211			3.7	1720	
7	1.95	3/4" CHAIN							
8		~~ADCP~~ SBE37	1903	1207			7	1724	
9	1.95	3/4" CHAIN							
10		ADCP	333	1207	NORTEK P HEAD UP		10	1725	
11	3.66	3/4" CHAIN							
12		ADCM	1666	1205	NORTEK HEADS UP		15	1729	
13		SBE 37	1905	1205			16	1729	
14	2.55	3/4" CHAIN							
15		ADCM	1688	1204	NORTEK		20	1732	
16	3.66	~~SBE 39~~ CHAIN							
17		SBE 39	203	1202			25	1734	
18	3.66	CHAIN							
19		SBE 37	1907	1200			30	1735	
20	.9	CHAIN							
21		ADCM	D193	1200	SONTEK		33	1737	
22	1.2	CHAIN							

1193 - Stratus 8

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
23		SBE 39	0721	1158			35	1738	
24	3.66	CHAIN							
25		SBE 37	1910	1157			40	1631	
26	366	CHAIN							
27		ADCM	2064	1155	~~HEADS UP~~		45	1628	
28	8.75	WIRE							
29		ADCM	2082	1238	HEADS UP		55	1826	
30	6.1	WIRE							
31		SBE 37	1912	1242			62.5	1623	
32	21.1	WIRE W/							
33		SBE 39	3423	1244			70	1622	
34		SBE 39	3434	1245			77.5	1620	
35		SBE 37	2011	1250			85	1617	
36	13.3	WIRE							
37		SBE 39	3435	1251			92.5	1615	
38		VMCM	10	1258	1255 BANDS OFF		100	1614	SPINNING WELL BANDS ON 1615
39	27.8	WIRE							
40		SBE 39	3436	1300			115	1611	
41		SBE 37	3639T	1304			130	1608	
42	3.66	~~WIRE~~ CHAIN							
43		ADCP	1220	1306			135	1605	
44	8	WIRE							
45		VMCM	29	1310	BANDS OFF 1308 (CASE LABELLED #76)		145	1601	SPINNING. 1603 BANDS ON

5

Moored Station Number 1193 - Stratus 8

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
46	12.8	WIRE							
47		SBE 16	927	1314			160	1558	
48	21.3	WIRE							
49		SBE 39	3437	1315			175	1557	
50		VMCM	30	1319	BANDS OFF "ABOUT" 1317		183	1553	SPINNING 1556 BANDS ON
51	4.8	WIRE ~~SBE 16~~							
52		SBE 16	928	1323			190	1550	
53	28.5	WIRE							
54		SBE 16	993	1326			220	1546	
55	13	WIRE							
56		VMCM	57	1330	BANDS OFF 1328		235	1541	"TEETH" MARKS ON PROPS BANDS ON 1544
57	13	WIRE							
58		SBE 16	994	1336			250	1539	
59	38	WIRE							
60		VMCM	58	1340	1337 BANDS OFF		290	1534	LOOKS GOOD. BANDS ON 1537
61	18	WIRE							
62		SBE 16	1877	1346			310	1532	POISON PLUG GONE
63	38	WIRE							
64		VMCM	66	1352	1348 BANDS OFF		350	1528	PROPS LOOK GOOD BANDS ON 1531
65	500	WIRE						1515-1529	
66		SBE 39	3438	1356			400	1526	SENSOR GUARD GONE
67		SBE 39	3439	1359			450	1524	LOOKS CLEAN

1193-Stratus 8

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
68		VMCM	68	1433	1432 BANDS OFF		852	1512	PROPS GOOD BANDS ON 1515
69	500	WIRE			1434-1456			1500 –	
70	200	WIRE		1457-				1450 –	
71		VMCM	76	1510	1505 BANDS OFF		1555	1450	PROPS SPINNING FREELY 1456 BANDS ON
72	300	WIRE	Nou	1510 -				1443	
73	100	WIRE		1524 -				1439 -	
74	200	NYLON 7/8 ~~WIRE~~		1530 -				-1439	
75	1650	NYLON 7/8		1543 -				1340 - 1423	
76	100	NYLON 1"						1338 - 1340	
77	1500	POLYPRO 1 1/8		1620 -				1205 - 1338	
78		GLASS BALLS	88				~~1223~~	1223	BALLS SIGHTED 1130 HOOKED ON TO
79	5	CHAIN 1/2"		1800					
80		RELEASES		1815				1226	
81	5	CHAIN 1/2"							
82	20	NYSTRON 1"		1817					
83	5	CHAIN 1/2"							
84		ANCHOR		1827	DROP POSITION: -19 37.355 -85° 22.536				
85									
86									
87									
88									
89									
90									

7

Moored Station Number 1193-Stratus 8

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
91									
92									
93									
94									
95									
96									
97									
98									
99									

Date/Time	Comments
	COUNTING BALLS, DEPLOYMENT NEED 22 CLUSTERS OF 4 ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ,
	RM YOUNGS SLIGHTLY IMPACTED BY LINE ON RECOVERY BUT NOT APPARENTLY
	DAMAGED: LOOKS LIKE GUANO ON RADIATION MODULE CASES BUT LENSES
	LOOK CLEAN. PRECIP SENSORS SHOW SOME GUANO ON OUTSIDE & WIRES ARE
	BENT OR GONE.
	FLOATING SST NOT FLOATING

03-G0463

Appendix 4: Stratus 9 Station Log Deployed

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. Stratus 9   MOORED STATION NO. 1206

Launch (anchor over)

Date (day-mon-yr) 25-10-2008	Time 1846 UTC
Latitude (N/S deg-min) 19° 42.762	Longitude (E/W deg-min) 85 35.120
Deployed by Lord	Recorder/Observer Galbraith
Ship and Cruise No. Ron Brown 08-06	Intended Duration 12 m
Depth Recorder Reading 4524 m	Correction Source Matthews Table
Depth Correction +5m m	
Corrected Water Depth 4529 m	Magnetic Variation (E/W) 7.4
Argos Platform ID No.	Additional Argos Info on pages 2 and 3

Surveyed Anchor Position

Lat (N/S) 19 42.6446 S	Long. (E/W) 85 35.2971 W

Acoustic Release Model 8242XS BACS (RCVD MARCH '04)

Release No. 32483	32480	Tested to 1500 m	
Receiver No.		Release Command 132174	132111
Enable 114703	114556	Disable 114720	114575
Interrogate Freq. 11	11	Reply Freq. 12	12

Recovery (release fired)

Date (day-mon-yr)	Time UTC
Latitude (N/S, deg-min)	Longitude (E/W, deg-min)
Recovered by	Recorder/Observer
Ship and Cruise No.	Actual duration days

Distance from actual waterline to buoy deck m

1

Surface Components

Buoy Type Surlyn foam 2.7m Color(s) Hull Yellow (WHITE BELOW) Tower WHITE

Buoy Markings IF FOUND ADRIFT CONTACT/WOODS HOLE OCEANOGRAPHIC/WOODS HOLE MA 02543 USA 508 457 1401 50-60-70-80

Surface Instrumentation

Item	ID #	Height*	Comments
ASIMET SN 4	4		
HRH	501	226	
BPR	218	236	
WND	2	266	SONIC, WITH INTERNAL ATMP
PRC	216	245	bird wires flattened
LWR	503	277	
SWR	502	278	
SST	2053	-148	SBE 37
PTT	12798(SN)		IDS 27916 27917 27918 SEIMAC WILDCAT
ASIMET	15		
HRH	213	226	
BPR	207	236	
WND	344	266	
PRC	501	245	bird wires flat; bird guano
LWR	219	277	
SWR	212	278	
SST	1838	-148	SBE 37
PTT	18171(SN)		IDS 27919 27920 27921 SEIMAC WILDCAT
WAMDAS			NDBC WAVE PACKAGE 32012
MiniMet	4	224	ATMP + HRH
Waterline	63cm	from the	deck

*Height above buoy deck in centimeters

2

Subsurface Instrumentation on Buoy and Bridle

Item	ID #	Depth†	Comments
		cm	
SBE 39	0718	FLOATING	180° FROM VANE
TR 1060	14875	.84	" BEHIND FSST FRAME
"	14878	.95	
"	14879	1.04	
TR 1060	14880	.83	~240° FROM VANE, CLOCKWISE
"	14883	.93	"
TR1060	14874	1.25	ON FSST FRAME
Argos SIS	24576 ID		
PCO_2	17		PMEL SYSTEM

†Depth below buoy deck in ~~centi~~meters

3

4

Moored Station Number 1206 STRATUS 9

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
1		BUOY		1310					
2	.22	3/4" CHAIN							
3		XR 420	15218	1310			2		
4		SBE 39	35	1310	UP		3		
5		MCAT	1325	1310	SBE37)		3.7		
6		SBE39	38	1242	DOWN		5		
7	.45	CHAIN SBE 39	48	1242	UP		6		
8		MCAT	1326	1242			6.75		
9		SBE 39	49	1242	UP		7.9		
10	1.2	3/4" CHAIN							
11		ADCM AANDERAA	79	1230	HEADS UP		10		
12	.45	3/4" CHAIN							
13		SBE 39	102	1230	DOWN		12		
14		TWIN ADCM	3224 3131	1235	* OVER SIDE, ~~...~~ IN WATER, NORTEKS, HEADS UP 1241		~~12.5~~ 8		
15	.75	CHAIN							
16		ADCP	2128	1226	NORTEK HEADS UP		15		
17		MCAT	1328	1226			16		
18	2.63	CHAIN							
19		AANDERAA ADCM	13	1225	HEADS UP		20		
20	3.66	3/4" CHAIN							
21		SBE 39	103	1221	SENSOR UP		25		
22									

1206 STRATUS 9

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
23	1.5	3/4" CHAIN							
24		TWIN ADCM	3132 3184	1221	HEADS UP w/VANE		27.5		
25	.75	3/4" CHAIN							
26		MCAT	1329	1217			30		
27	1.20	3/4" CHAIN							
28		ADCM	78	1215	AANDERAA HEADS UP		32.5		
29	1.20	3/4" CHAIN							
30		SBE 39	284	1215	UP		35		
31	1.35	3/4 CHAIN							
32		MCAT	1330	1214	UP		37.5		
33	1.20	3/4" CHAIN							
34		MCAT	1906	1214			40		
35	3.30	3/4" CHAIN							
36		VMCM	~~X~~9	12:10			45		
37	.68	3/4" CHAIN							
38		~~TWIN~~ ADV/ ADCM	4630 3128	1332	AANDERAA ADV + NORTEK ADCM NORTEK, WITH VANE		47.5		
39	.75	3/4" CHAIN							
40		ADCM	106	1332	AANDERAA SEAGUARD		50		
41	2.63	3/4" CHAIN							
42		VMCM	~~X~~ 21	1336	1334 HANDS OFF		55		
43	5.25	7/16" WIRE			7/16"				
44		MCAT	1908	1338			62		
45	3.53	3/4" CHAIN							

5

Moored Station Number 1206 STRATUS 9

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
46		TWIN ADCM	3185 3133	1346	NORTEK - HEADS UP		66.7		
47	16.25	7/16 WIRE							
48	↓	SBE39	476	1346			70		
49	↓	SBE39	~~26~~ 276	1347			77.5		
50		MCAT	1909	1350			85		
51	1.2	3/4" CHAIN							
52		TWIN ADCM	3183 3223	1353	NORTEK - HEADS UP		87.4		
53	1.2	7/16" WIRE							
54	↓	SBE 39	719	1355			92		
55		MCAT	2012	1357			96.3		
56	10	7/16" WIRE							
57	↓	SBE 39	720	1400			100		
58		TWIN ADCM	3135 3181	1404	NORTEK HEADS UP		107.5		
59	21	7/16" WIRE							
60	↓	SBE 39	1498	1405			115		
61		MCAT	2015	1408			130		
62	3.66	3/4" CHAIN ADCP	1218	1413	RDI WORKHORSE		135		
63	7.5	7/16" WIRE							
64		VMCM	4 X	1417	BANDS OFF 1414		145		
65	13	7/16" WIRE							
66		SEACAT	146	1421	SBE 16		160		
67	-21	7/16" WIRE							

6

1206 STRATUS 9

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
68	↓	SBE 39	1499	1423			175		
69		VMCM	12	1425	BANDS OFF 1423		183		
70	5	7/16" WIRE							
71		SEACAT	991	1432			190		
72		ADCM	197	1432	SONTEK - HEADS DOWN		192		
73	27	7/16" WIRE					2		
74		SEACAT	1873	1435 ~~1432~~			220		
75	13	7/16" WIRE							
76		VMCM	16	1438	bands 1444		235		
77	13	7/16" WIRE							
78		SEACAT	1875	1442			250		
79	38	3/8" WIRE							
80		VMCM	19	1446	BANDS OFF 1442		290		
81	18	3/8" WIRE							
82		SEACAT	1881	1449			310		
83	8.5	3/8" WIRE							
84		VMCM	42	1452	BANDS OFF 1449		320		
85	27.5	3/8" WIRE							
86		VMCM	~~X~~ 8	1456	BANDS OFF 1452		350		
87	500	3/8" WIRE							
88	↓	SBE 39	1500	1458			400		
89	↓	SBE 39	1501	1502			450		
90		VMCM	75	1516	BANDS OFF 1515		852		

Moored Station Number 1206 STRATUS 9

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
91	500 250	3/8" WIRE 3/8" WIRE							
92	~~VMCM~~	VMCM	83	1544	BANDOFF 1542		1605		
93	250	3/8" WIRE							
94	100 200	3/8" WIRE 7/8" NYLON		1557 - 1594 -	ONE PIECE, WRAPPED TERM-INATION				
95	1650 100 1500	7/8 NYLON 1" NYLON 1 1/8 POLY		1652 1653 -	ONE PIECE				
96		GLASS BALLS		-1814	96 17" BALLS ON 1/2" TRAWLER CHAIN				
97	5 5	1/2" CHAIN RELEASES 1/2" CHAIN		1824	DUAL EGG MODEL 8242 JOINED BY 1m CHAIN				
98	20	1" SAMSON NYLON		1832 -					
99	5	1/2" CHAIN ANCHOR		1846	WET WEIGHT 8000 LBS		4413		

Date/Time	Comments

03-G0463

Appendix 5: SHOA/DART Station Log

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. SHOA / DART MOORED STATION NO. III

Launch (anchor over)

Date (day-mon-yr) 31-10-2008 Time 19 41 30 UTC

Latitude (N/S deg-min) 19 36.127 Longitude (E/W deg-min) 74 46.717

Deployed by J. LORD Recorder/Observer N. GALBRAITH

Ship and Cruise No. RON BROWN 08-06 Intended Duration

Depth Recorder Reading 4938 m Correction Source MATTHEWS TABLE

Depth Correction +5 m

Corrected Water Depth 4943 m Magnetic Variation (E/W)

Argos Platform ID No. NA Additional Argos Info on pages 2 and 3

Surveyed Anchor Position

Lat (N/S) 19° 35.9841' S Long. (E/W) 74° 46.9369' W

Acoustic Release Model

Release No. 33038 Tested to m

Receiver No. Release Command 332157

Enable 314136 Disable 314153

Interrogate Freq. 11 Reply Freq. 12

Recovery (release fired)

Date (day-mon-yr) Time UTC

Latitude (N/S, deg-min) Longitude (E/W, deg-min)

Recovered by Recorder/Observer

Ship and Cruise No. Actual duration days

Distance from actual waterline to buoy deck m

1

Surface Components

Buoy Type DART-II Color(s) Hull ORANGE/WHITE Tower WHITE

Buoy Markings TSUNAMI

Surface Instrumentation

Item	ID #	Height*	Comments
HRH	505	199	VOS HRH 53 v 3.2
PRC	503	232	V 3.4
LWR	206	232	V 3.5
SWR	216	236	V 3.3
BPR	201	214	
WND	228	253	V 3.5
LASCAR MINIMET	5	183	START 10/30/2008 0100

*Height above buoy deck in centimeters

2

Subsurface Instrumentation on Buoy and Bridle

Item	ID #	Depth†	Comments
SBE 39	44		

†Depth below buoy deck in centimeters

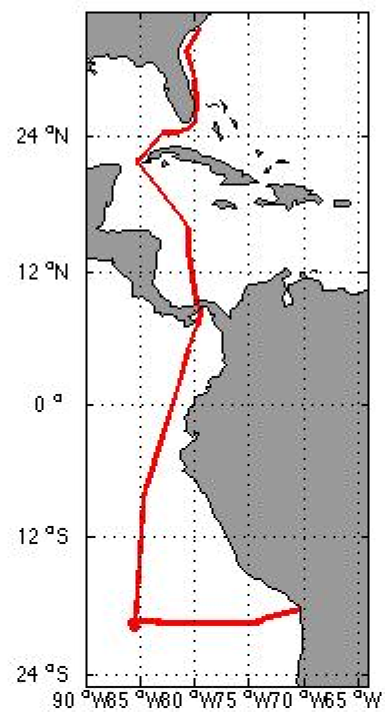
Moored Station Number ____________

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
1		BUOY		1614					
2	3.5	1" CHAIN			LONGLINE				
3		SWIVEL							
4	.5	1" CHAIN							
5	700	7/16 WIRE							
6		XR420	15214	1614			10		
7		XR420	15215	1614			20		
8		SBE 39	46	1614			30		
9		SBE 39	47	1615			40		
10		XR 420	15216	1615			50		
11		SBE 39	282	1617			62.5		
12		SBE 39	1503	1618			77.5		
13		XR 420	15217	1625			92.5		
14		SBE 39	1504	1626			115		
15		XR420	10514	1629			145		
16		SBE 39	1505	1631			175		
17		SBE 39	1506	1633			220		
18		SBE 39	1508	1635			250		
19		SBE 39	1510	1637			310		
20				-1648					
21	4096	1" NYLON		1453-					
22		7/8" NYLON							

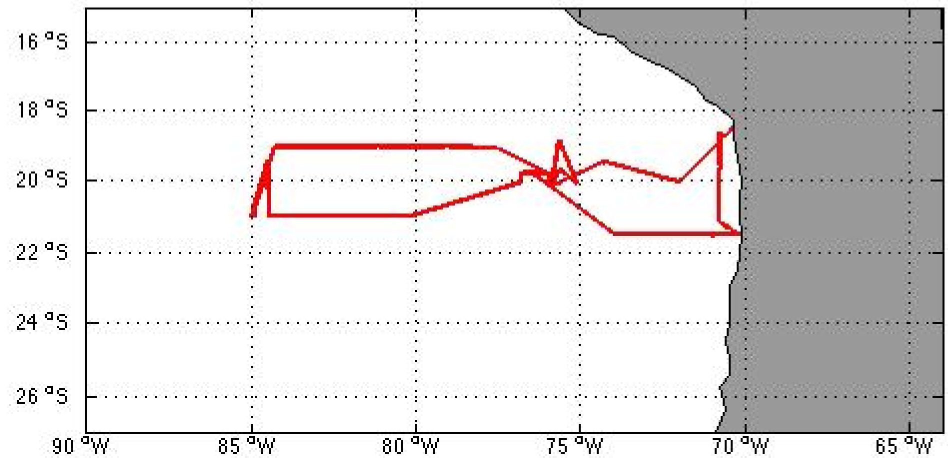
Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
23		3/4" NYLON		N ~~1725~~					
24									
25		3/4" NYLON		N1725					
26	36	3/4" NYLON		1806					
27	1	1/2 CHAIN							
28	~~20~~	~~NYSTRON~~							
29									
30		RELEASE		1815					
31	1	1/2 CHAIN							
32									
33	20	NYSTRON		1820					
34									
35	4	1/2 CHAIN		1826 -					
36									
37		ANCHOR		1941					
38									
39									
40									
41									
42									
43									
44									
45									

5

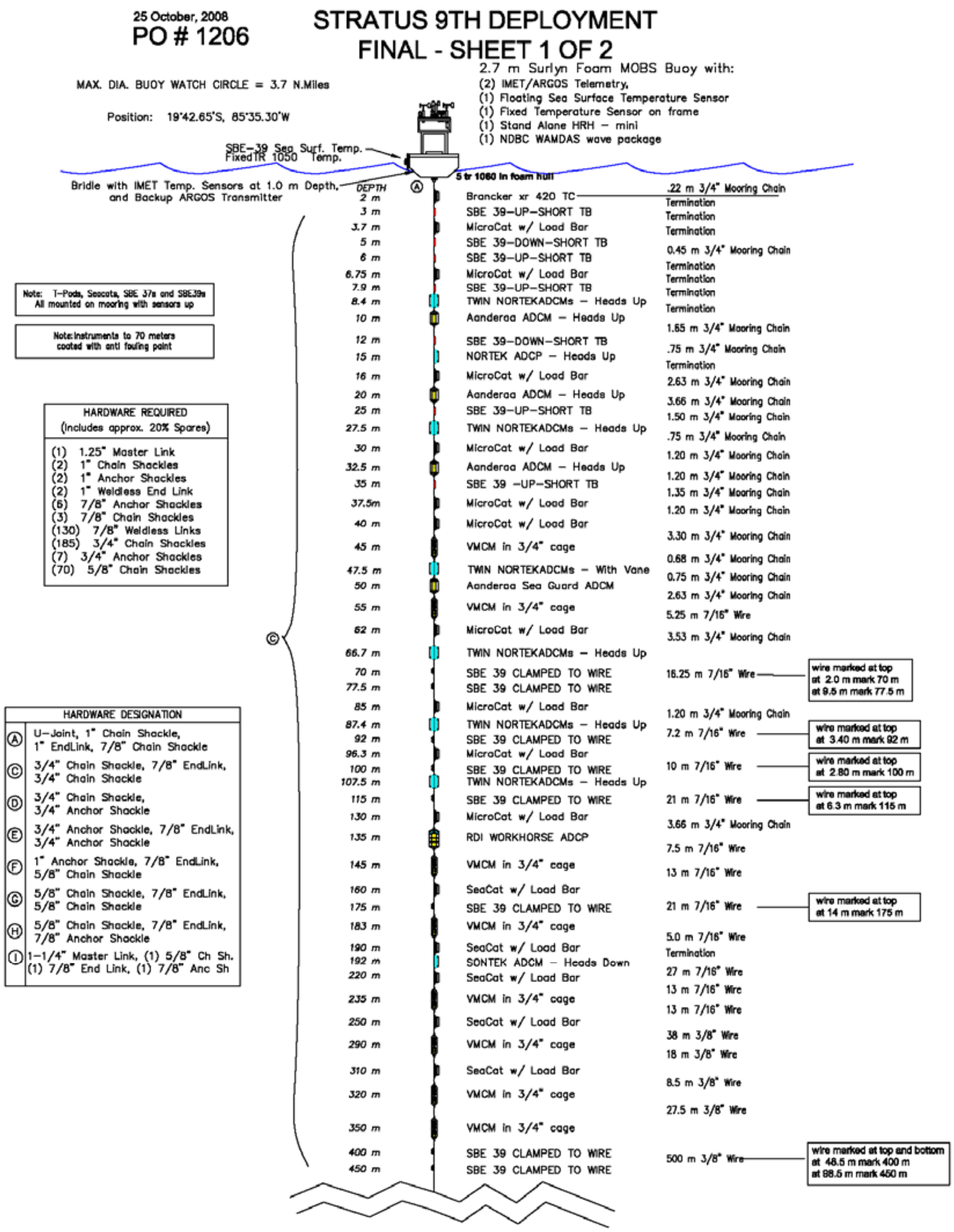
Appendix 6: Leg One Ship's Track



Appendix 7: Leg Two Ship's Track

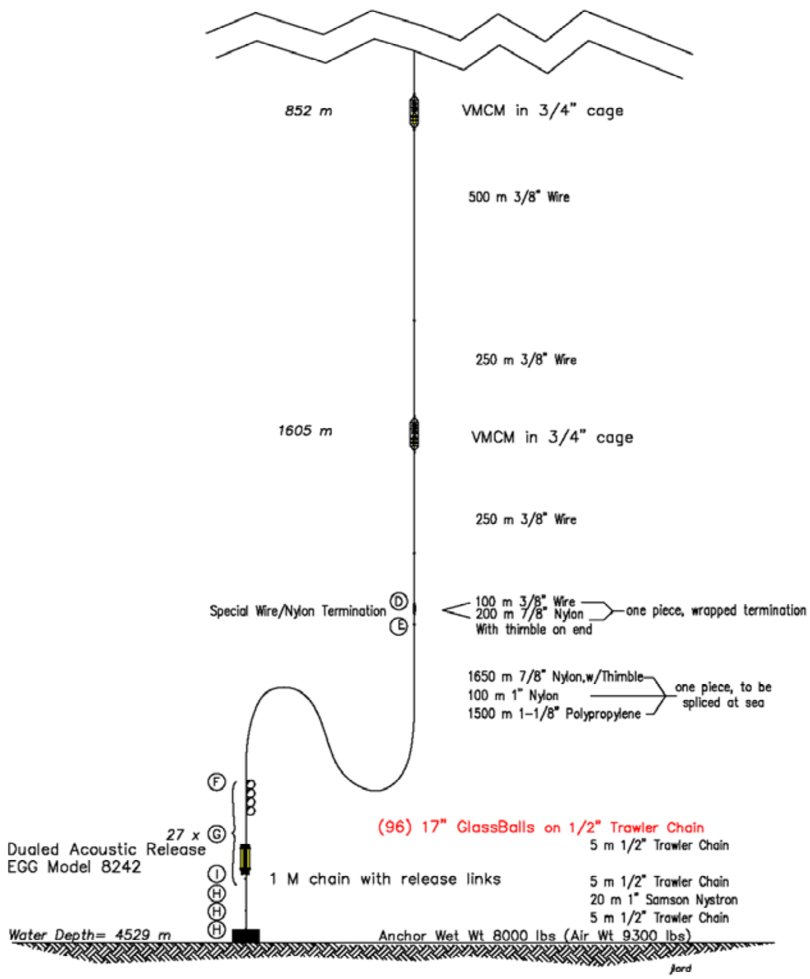


Appendix 8: Stratus 9 Mooring Diagram

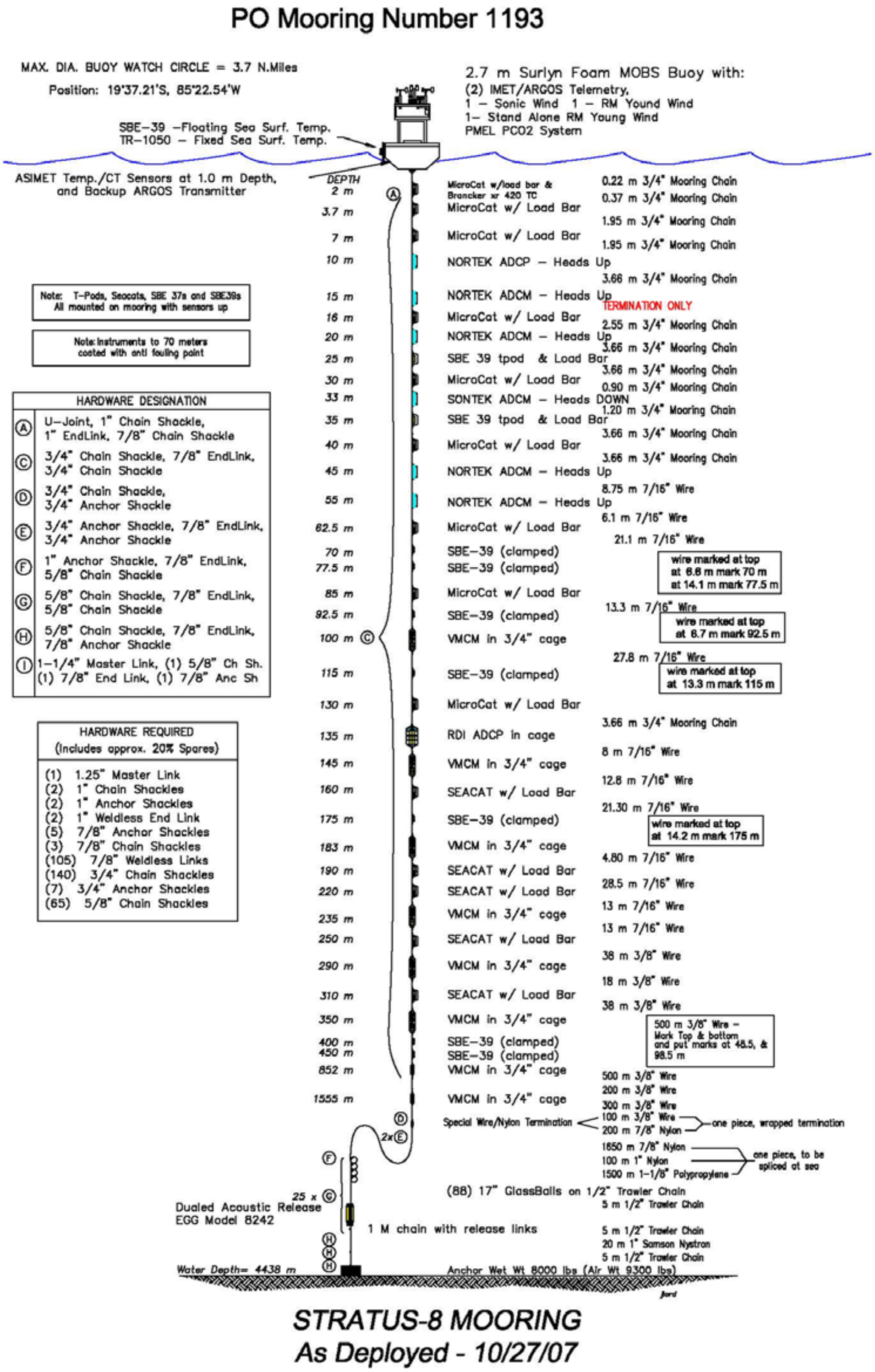


STRATUS 9TH DEPLOYMENT
FINAL
SHEET 2 OF 2

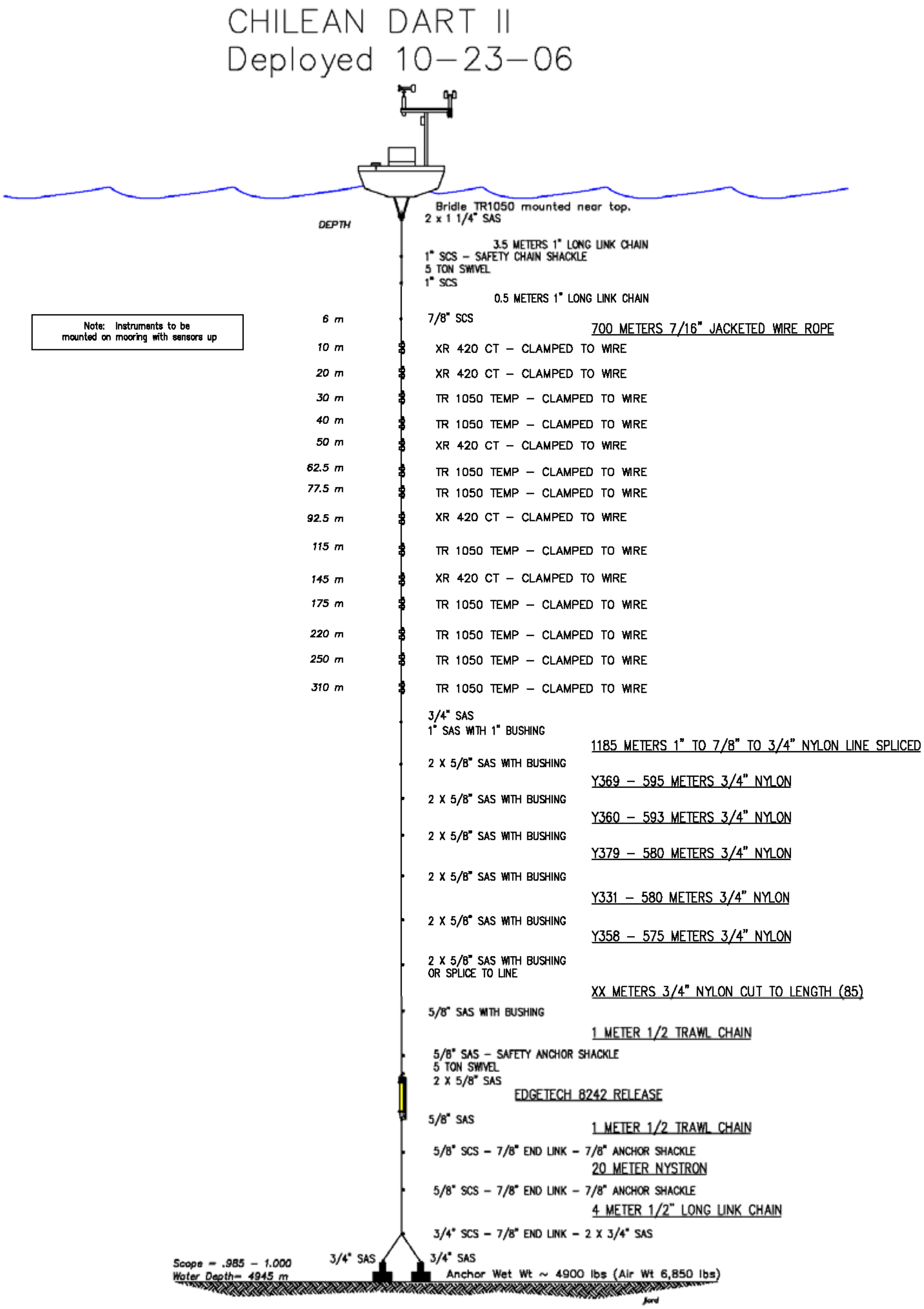
CONTINUED FROM FIRST 500 METER
SHOT OF WIRE AT 350 METERS



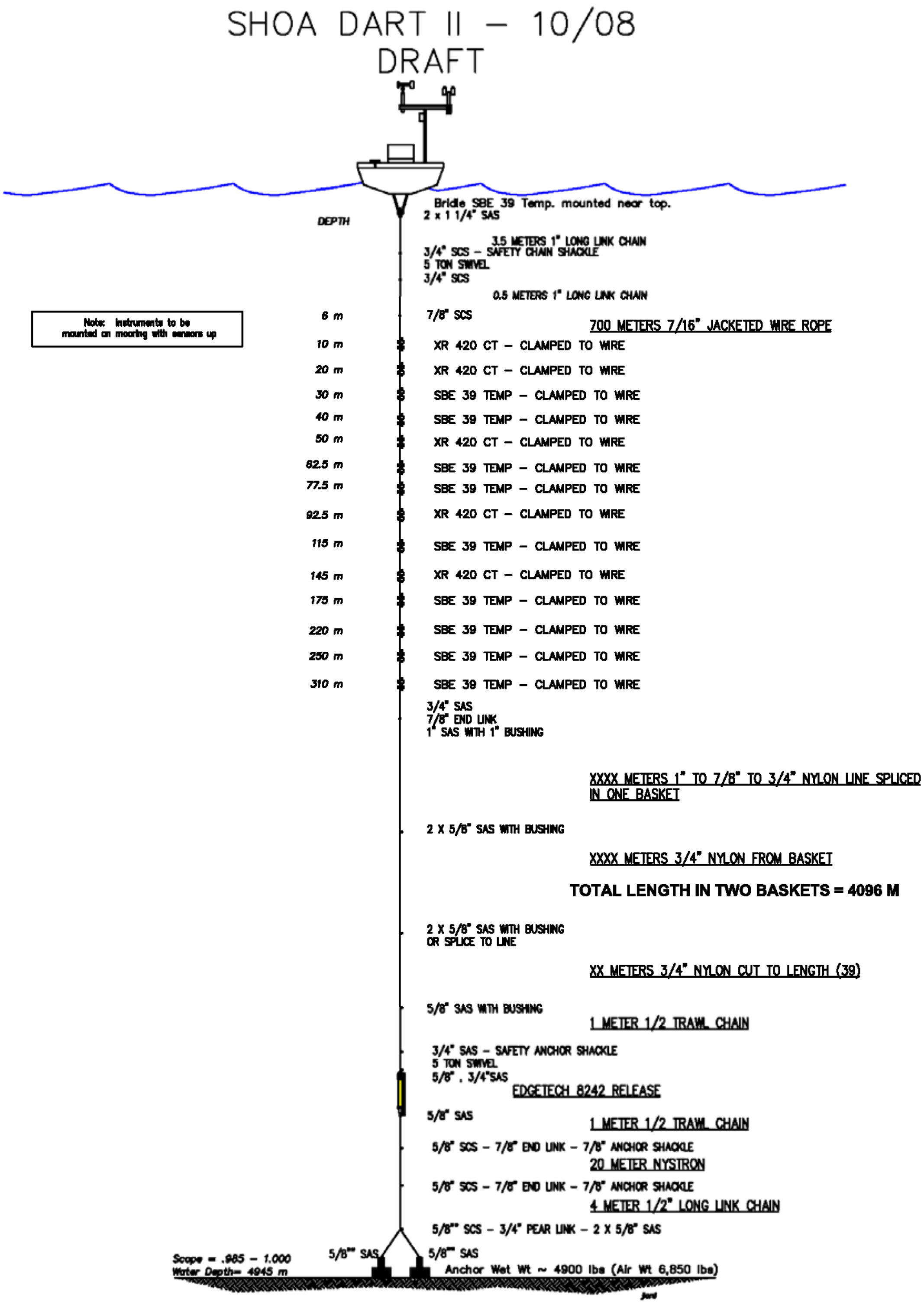
Appendix 9: Stratus 8 Mooring Diagram



Appendix 10: DART Mooring Diagram Recovered



Appendix 11: DART Mooring Diagram Deployed



Appendix 12: Dart II Station Log

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. SHOA/DART MOORED STATION NO. II

yellow deck, red hull, white tower, SHOA TSUNAMI

Launch (anchor over)

Date (day-mon-yr) 10/23/2006 Time 13:59:30 UTC

Latitude (N/S, deg-min) 19° 36.149' Longitude (E/W, deg-min) ~~75~~ 74° 46.740'

Deployed by _____ Recorder/Observer Bigorre

Ship and Cruise No. Ron Brown 06-07 Intended Duration 2 years

Depth Recorder Reading 4945 m Correction Source Mathew's table

Depth Correction 5 m

Corrected Water Depth 4950 m Magnetic Variation (E/W) _____

Argos Platform ID No. _____ Additional Argos Info on pages 2 and 3

Surveyed Anchor Position

Lat (N/S) 19°35'.413 S Long. (E/W) 74° 46' 8904 W

Acoustic Release Model

Release No. ~~444130~~, SN# 31268 Tested to _____ m

Receiver No. _____ Release Command 444130

Enable 460234 Disable 460251

Interrogate Freq. 11 kHz Reply Freq. 12 kHz

Recovery (release fired)

Date (day-mon-yr) 10/30/08 Time 11:08:30 UTC

Latitude (N/S, deg-min) _____ Longitude (E/W, deg-min) _____

Recovered by LORD Recorder/Observer GALBRAITH

Ship and Cruise No. RH Brown 06-08 Actual duration 738 DAYS days

Distance from actual waterline to buoy deck 0.40 m

1

Surface Components

Buoy Type DART II Color(s) Hull ________ Tower ________

Buoy Markings ________

Surface Instrumentation

	Item	ID #	Height*	Comments
	WND	344	245	
	LWR	213	232	
2006	SWR	201	231	
	Lascar HRH	5	196	
	Lascar HRH	6	224	
				recovered ↑
	Turned met sensors around after 1 year. Left mooring in place. Boat trip to buoy.			
	WND	WND 214		missing 2008/10/30
2007	LWR	LWR 208		
	SWR	SWR 202		
	RH/AT	HRH 502		

*Height above buoy deck in centimeters

2

Subsurface Instrumentation on Buoy and Bridle

Item	ID #	Depth†	Comments
TR 1050	12694	120 cm	

†Depth below buoy deck in centimeters

Moored Station Number DART II

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
1	3.5	1" chain						1113	HOOKED ON 1107 UTC BUOY ON DECK
2		5 ton swivel						1129	
3	0.5	1" chain							
4	700	7/16" wire							
5		XR 420	12942	10:58			10	1137	SLID DOWN? ENCASED IN LINE
6		XR 420	12943	10:58			20	1137	
7		TR 1050	12695	10:58			30	1153	
8		TR 1050	12696	10:58			40	1155	
9		XR 420	12944	10:58			50	1156	
10		TR 1050	12697	10:58			62.5	1157	
11		TR 1050	12698	10:58			77.5	1158	
12		XR 420	12945	11:01			92.5	1159	
13		TR 1050	12699	11:03			115	1200	
14		XR 420	12946	11:06			145	1202	wire repaired below
15		TR 1050	12700	11:14			175	1204	
16		TR 1050	12701	11:17			220	1205	
17		TR 1050	12702	11:22			250	1206	
18		TR 1050	12703	11:31			310	1209	wire repaired above
19	1185	nylon						1225 -	1" to 7/8" to 3/4" spliced
20	595	3/4" nylon	Y369						
21	593	3/4" nylon	Y360						
22	580	3/4" nylon	Y379						

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
23	580	3/4" nylon	Y331						
24	575	3/4" nylon	Y358						
25		3/4" nylon							
26	1	1/2 trawl chain							
27		5 ton swivel							
28		Edgetech release	31268	13:30				1414	
29	1	1/2 trawl chain							
30	20	nystron							
31	4	1/2" chain							
32		anchor					4980		wet wt 4900 lbs air wt 6850 lbs
33									
34									
35									
36									
37									
38									
39									
40									
41									
42									
43									
44									
45									

Moored Station Number ____________

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
91									
92									
93									
94									
95									
96									
97									
98									
99									

Date/Time	Comments
10 30 11:00	WIND MODULE MISSING
11:08:30	RELEASE FIRED
	TOP 2 INSTRUMENTS TOGETHER: ONE SLID
	10 M INST ENCASED IN HEAVY LINE

03-G0463

Appendix 13: Dart III Station Log

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. SHOA / DART MOORED STATION NO. III

Launch (anchor over)

Date (day-mon-yr) 31-10-2008 Time 19 41 30 UTC

Latitude (N/S, deg-min) 19 36.127 Longitude (E/W, deg-min) 74 46.717

Deployed by J. LORD Recorder/Observer N. GALBRAITH

Ship and Cruise No. RON BROWN 08-06 Intended Duration ____

Depth Recorder Reading 4938 m Correction Source MATTHEWS TABLE

Depth Correction +5 m

Corrected Water Depth 4943 m Magnetic Variation (E/W) ____

Argos Platform ID No. NA Additional Argos Info on pages 2 and 3

Surveyed Anchor Position

Lat (N/S) 19° 35.9841' S Long. (E/W) 74° 46.9369' W

Acoustic Release Model ____

Release No. 33038 Tested to ____ m

Receiver No. ____ Release Command 332157

Enable 314136 Disable 314153

Interrogate Freq. 11 Reply Freq. 12

Recovery (release fired)

Date (day-mon-yr) ____ Time ____ UTC

Latitude (N/S, deg-min) ____ Longitude (E/W, deg-min) ____

Recovered by ____ Recorder/Observer ____

Ship and Cruise No. ____ Actual duration ____ days

Distance from actual waterline to buoy deck ____ m

1

Surface Components

Buoy Type DART-II Color(s) Hull ORANGE/WHITE Tower WHITE

Buoy Markings TSUNAMI

Surface Instrumentation

Item	ID #	Height*	Comments
HRH	505	199	VOS HRH 53 V 3.2
PRC	503	232	V 3.4
LWR	206	232	V 3.5
SWR	216	236	V 3.3
BPR	201	214	
WND	228	253	V 3.5
LASCAR MINIMET	5	183	START 10/30/2008 0100

*Height above buoy deck in centimeters

2

Subsurface Instrumentation on Buoy and Bridle			
Item	ID #	Depth†	Comments
SBE 39	44		
†Depth below buoy deck in centimeters			

Moored Station Number ____________

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
1		BUOY		1614					
2	3.5	1" CHAIN			LONGLINE				
3		SWIVEL							
4	.5	1" CHAIN							
5	700	7/16 WIRE							
6		XR420	15214	1614			10		
7		XR420	15215	1614			20		
8		SBE39	46	1614			30		
9		SBE39	47	1615			40		
10		XR420	15216	1615			50		
11		SBE39	282	1617			62.5		
12		SBE39	1503	1618			77.5		
13		XR420	15217	1625			92.5		
14		SBE39	1504	1626			115		
15		XR420	10514	1629			145		
16		SBE 39	1505	1631			175		
17		SBE39	1506	1633			220		
18		SBE 39	1508	1635			250		
19		SBE39	1510	1637			310		
20				-1648					
21	4096	1" NYLON		1453-					
22		7/8" NYLON							

Appendix 14: Stratus 9 Leg 2 Cruise Log

VOCALS REX LEG 2 Log
Notes – all times in local time (Arica) = UTC – 3 hours except where UTC is specified.

Departed: 11/10/08 00:00 Arica,
steam SW 12 hours at 11 knots UCTDs underway 1-7

Waypoint 1: Station Alpha (72W, 20 S)
Arrive alpha 13:00 11/10 – remain on station until 19:00 (6 hours) to facilitate joint sampling by ship and air-craft. No CTDs or VMPS at this station.

11/10 19:00 depart Station Alpha, steam 285º 12 hours at 11 knots UCTDs underway, 8-18

Waypoint 2: Start East Eddy Survey (no stop) – (W 74º15.55, S 19º25.56)
ETA = 07:00 11/11
ETD = 07:00 11/11

Steam roughly 255º 12.5 hours at 8 knots UCTD underway, 19-33

Waypoint 3: no stop (W 75º51.86, S 20º07.82)
ETA = 19:30 11/11
ETD = 19:30 11/11

Steam roughly 020º 8.8 hours at 8 knots UCTD underway, 34-41

Waypoint 4: (W 75º39.00, S 18º51.00)
ETA = 04:40 11/12
ETD = 05:50 11/12, 1 hour stop
CTD 004 05:26 (local) 11/12 Max Depth 500m

Waypoint 4b (W 75º31.00, S 19º08.70) – aircraft encounter ~ 3 hour

Steam roughly 170º 12.5 hours at 5 knots UCTD underway 42-56

Waypoint 5: no stop (W 75º06.97, S 20º02.33)
ETA = 00:00 11/13
ETD = 00:00 11/13
Steam at 5 knots UCTD 57:64

Waypoint 6: 24 hour monitoring station (W 75º39.24, S 19º37.80) – EDDY1 MARGIN
ETA = 07:45 11/13
ETD = 08:00 11/14
CTD 005 08:20 11/13 Max Depth 1000m
VMP 006 (#018) 10:45 Max depth 736m
CTD 006 14:30 11/13 Max Depth 1000m
VMP 007 (#019) 18:10 11/13 Max depth 500m
CTD 007 22:45 11/13 Max Depth 2000m
CTD 008 06:12 11/14 Max Depth 1000m

Steam at 5 knots UCTD 65:69 (some on station some going in/out)

Waypoint 7: 24 hour monitoring station (W 75º46.18, S 19º51.90)

EDDY 1 – CLOSE TO CENTER
ETA = 11:00 11/14
VMP 008 (#20) 12:00 11/14 Max depth 620m
CTD 009 14:20 11/14 Max Depth 1000m
Surface Drifter 78987 deployed on 11/14 at 18:15 UTC W 75º46.184, S 19º51.893
VMP 009 (#21) 18:00 11/14 max depth 665m
CTD 010 22:30 11/14 Max Depth 2000m
CTD 011 05:30 11/15 Max Depth 1200m
CTD 012 08:20 11/15 Max Depth 1000m

Steam at 8 knots UCTD 70:81 (some on station some going in/out)

Waypoint 8 no stop (W 77º34.00, S 19º01.80)

Steam at 8 knots UCTD 82:88 (some on station some going in/out)

Waypoint 9: (W 78º 36.00, S 19º00.00) – North Ridge #1 (east)
CTD 013 2000m 09:00 11/16 (nutrients, salts, oxygen, phytoplankton)
VMP 010 (#22) 13:00 to 610m
Released Argo Float WHOI SOLO 850/1360
11/16/2008 18:10 UTC 78º36.94, S 19º00.00
ETA = 17:00 11/12
ETD = 17:00 11/12

Steam at 5 knots UCTD 89:97

Waypoint 10: (W 79º19.20, S 19º00.00) – North Ridge #2 (east-central)
CTD 014 100m 05:20 (nutrients, salts, oxygen, phytoplankton)
(bad CTD cast with lots of spike. After this cast the temperature, conductivity, and pump were replaced with the *Brown*'s)
VMP 011 (#023) 08:30 11/16 650m
CTD 015 3000m 13:45 11/16

Surface Drifter 78984 11/17 18:00 UTC (W 79º23.430, S 18º59.999) UCTD 98:110

WHOI SOLO Profiling Float 857/5360 11/17 20:30 UTC (W 79º37.224, S 18º59.99)
Released in CEDDY2.

Waypoint 11: (W 79º 80.30, S 19º00.00) – North Ridge #2 (west)
CTD 016 11/18 06:00 to 3000m
(Note that the deck unit had some problems on the way up, after firing two bottles at the bottom, we ended up shutting it off and restarting it – cast 016a in order to fire successive bottles. Also – I accidentally started the cast before inputting lat lon in the data file).

VMP 012 (#024) 09:00 11/18 600m
UCTD 111:
(Note we started at 5 knots and then changed to 8 knots around 15:40 local)
- passed the top (perhaps) of an anticyclone along the way

Waypoint 12: (W 84º00.00, S 19º00.00) –
CTD 017 2000m
Steaming at 5 knots

Waypoint 12A: (W 84º20.00, S 19º00.00)
No stop.

Steaming at 5 knots – this is the long southern transect that goes from C3 to A3. Halfway through it we cut through this front (subsurface) which was associated with a large DMS (ocean and atmos) spike likely due to upwelling on the northern side driven by the predominantly easterly winds.

Waypoint 13: (W 85º00.00, S 21º00.00) – 24 Hour Monitoring Station
Arrive 11/20 19:00
Depart 11/21 19:00
21:00 Stationary UCTD
23:00 Stationary UCTD
02:00 Stationary UCTD
05:00 CTD (2000m) 018
10:00 VMP 013 (#025)
13:00 Shallow CTD 019
15:00 Stationary UCTD
18:00 VMP 014 (#26)

Steaming at 11 knots to locate the position of the front and sea water DMS spike which we observed on the way south. Note that this front is associated with the interaction of a cyclone to the north (C3) and an anticyclone to the south (A3). We are interested in understanding the coupling between the oceanic frontal structure, the biology, the oceanic and atmospheric DMS. UCTDs along the way, however, we lost the 8pm probe (#16) due to failure of the light line. Switched to the heavy line (300m of spooling) used probe #9 (after briefly talking to it) but when we retrieved it appeared to be flooded.
Switched to probe #18 which has lost the anode.

In steaming back on the previous line sought to overshoot the front, and in particularly identify it via an increase in the sea water DMS, as well as an increase in the velocity. In the end while steaming at 11 knots we did see an increase in sea water DMS that coincided with an SST front and, also, with an intensification of the jet between the two eddies.

W 84º00.00, S 19º36.00 – Start of frontal survey
Steaming at variable speed from 1 to 3 knots.

Waypoint 14: (W 84º30.00, S 19º36.00) – north of front
CTD 020 06:00
Steaming at 2 knots
Note that we overshot the maximum in DMS (seawater) to locate the front and then returned to it to do a VMP and CTD.

Waypoint 15: (W 84º30.70, S 19º43.36) – Center of front
18:00 VMP 15 (#27)
18:30 CTD 021 - 1000m
Steaming at 2 knots

Waypoint 16 – Off front
22:00 CTD 022 - 1000m
NB this cast had two chlorophyll maxima
The rationale of this CTD is to get water in darkness for the DMS incubation experiment and, also, to get a CTD just after the maximum in the front.

Steamed to 21 S at 5 knots. UCTDs
At 21 S turned east (no stop) steaming at 5 knots.
While steaming east we crossed a small cyclonic circulation associated with an increase in the seawater DMS signal.

Waypoint 17 – (W 82º23.00, S 21º 00.0) West Ridge South
ETA 19:30 11/24
VMP 16 (#29) 20:00 11/24 (Note one bad VMP cast #28 this was when the VMP was in the water while the ship was positioning itself but I aborted it since it was taking a long time). This VMP cast was more difficult than usual because the ship was drifting quite a bit in the high winds and moderate waves.
CTD #023 to 3000m 11/24 22:00

Waypoint 18 – (W 81º07.00, S 21º00.0) Central Ridge South
VMP 17 (#30)
CTD #024 11/25 14:00 to 300m – Shallow cast with PAR sensor
CTD #025 11/25 14:30 to 1800m (which is the approximate depth of the ridge)

Waypoint 19 – (W 80º10.80, S 21º00.0) East Ridge South
VMP 18 (#31)
CTD #026 11/26 05:00 to 3000m (Note the bottles did not fire on the way up therefore a second cast to 300m #027 was done to get water).
Long steam at 11 knots through the cold patch. Note that we are not using the UCTD because we have only one probe left and decided to save it for the eddy survey that is coming up. While steaming through the cold patch both seawater DMS and atmospheric DMS climb rapidly to high values never observed on the cruise before. This roughly coincided with the crossing of a jet (as observed in the ADCP) and seems to be strongly modulated by the oceanic mesoscale and sub-mesoscale.

WHOI SOLO float 851-5370 W 79º41.751, S 20º51.703 14:23 UTC 11/26

Waypoint 20 – (W 77º24.23, S 20º12.27) Anticyclone Center
CTD #028 11/26 24:00 to 1000m

Resume UCTD survey while steaming at 4 knots, with heavy line. In this section we continued the line until some of the atmospheric scientists on board were having a hard time sampling due to the wind/ship angle. Hence we steamed north at 11 knots for two hours and then resumed steaming due east. The goal was to cross a front between the AC and the C. In the end we never found a north south jet but more of a northeast one. We did find several peaks of elevated atmospheric DMS which coincided with the strong jet. We continued steaming first at 4, then at 5, then at 6 knots, east until the velocities turned from northeast to southeast (slightly) and then steamed south for 18 miles trying to cut through the eddy center. Then to the northwest, at 11 knots, to get back to the DMS max.

Cut nicely through half of the eddy in the NS direction.
Released SOLO-WHOI float 890-9670 in the center of the eddy at
04:50 UTC 11/28 - W 75º58.311, S 20º05.915

Waypoint 21 – (W 76º27.0, S 19º46.56) DMS Max
CTD 029 11/28 05:00 am
VMP 19 (032)
Steam at 8 knots to the southeast
The following transect crossed through the center of the eddy we sampled last night – giving a nice full section across it. The goal of this transect is to skirt the edge of the cold patch which extends from the south. We were hoping to see a large variability in the seawater DMS associated with the crossing of fronts – however as of last night, sometime before CTD 029 the sea water DMS started giving unreasonable values. We managed to get a couple of realistic readings (~ 12) during the cast, or in the vicinity. After that the unit was turned off to see if the problem could be fixed.

Waypoint 22 – (W 74º00.0, S 21º30.00)
CTD 030 11/29 07:00 1000m
VMP 20 (033) – this cast ended early since VMP disconnected.
Started steaming at 8 knots – gradually speeding up to 11 knots. Eastern transect towards the coast. We crossed a cyclone.

Surface drifter 78986 Released 11/29 13:00 UTC W 73º47.96, S 21º30.122

Surface drifter 78985 Released 11/29 20:00 UTC W 72º20.03, S 21º30.004

Waypoint 23 – (W 72º00.0, S 21º30.00)
CTD 031 11/29 19:00 1000m
Steaming at 8 then 6 knots. We cut across a nice cyclone with a very warm surface layer, but a similar sub-surface structure to the others.

Waypoint 24 – (W 71º00.0, S 21º30.00)
CTD 032 11/30 05:00 1000m

Waypoint 25 – (W 70º30.0, S 21º30.00)
CTD 033 11/30 12:00 1000m (Ocean depth is ~ 1000m)

Waypoint 26 – (W 70º19.5, S 21º30.00)
CTD 034 11/30 17:00 500m (approximately same ocean depth)

VMP 021 11/30 18:00 (to 350m only).

Waypoint 27 – (W 70º09.5, S 21º30.00)
CTD 035 11/30 19:00 100m (approximately same ocean depth)

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16. Abstract (Limit: 200 words)

The Ocean Reference Station at 20°S, 85°W under the stratus clouds west of northern Chile is being maintained to provide ongoing climate-quality records of surface meteorology; air-sea fluxes of heat, freshwater, and momentum; and of upper ocean temperature, salinity, and velocity variability. The Stratus Ocean Reference Station (ORS Stratus) is supported by the National Oceanic and Atmospheric Administration's (NOAA) Climate Observation Program. It is recovered and redeployed annually, with cruises that have come between October and December.

During the 2008 cruise on the NOAA ship Ronald H. Brown to the ORS Stratus site, the primary activities were recovery of the Stratus 8 WHOI surface mooring that had been deployed in October 2007, deployment of a new (Stratus 9) WHOI surface mooring at that site; in-situ calibration of the buoy meteorological sensors by comparison with instrumentation put on board by staff of the NOAA Earth System Research Laboratory (ESRL); and observations of the stratus clouds and lower atmosphere by NOAA ESRL. A buoy for the Pacific tsunami warning system was also serviced in collaboration with the Hydrographic and Oceanographic service of the Chilean Navy (SHOA). The DART (Deep-Ocean Assessment and Reporting of Tsunami) carries IMET sensors and subsurface oceanographic instruments. A DART II buoy was deployed north of the STRATUS buoy, by personnel from the National Data Buoy Center (NDBC). ARGO floats and drifters were launched, and CTD casts carried out during the cruise. The ORS Stratus buoys are equipped with two improved Meteorological (IMET) systems, which provide surface wind speed and direction, air temperature, relative humidity, barometric pressure, incoming shortwave radiation, incoming longwave radiation, precipitation rate, and sea surface temperature. Additionally, the Stratus 8 buoy received a partial CO2 detector from the Pacific Marine Environmental Laboratory (PMEL). IMET data are made available in near-real-time using satellite telemetry. The mooring line carries instruments to measure ocean salinity, temperature, and currents. The ESRL instrumentation used during the 2008 cruise included cloud radar, radiosonde balloons, and sensors for mean and turbulent surface meteorology.

17. Document Analysis a. Descriptors

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air-sea interaction

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

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