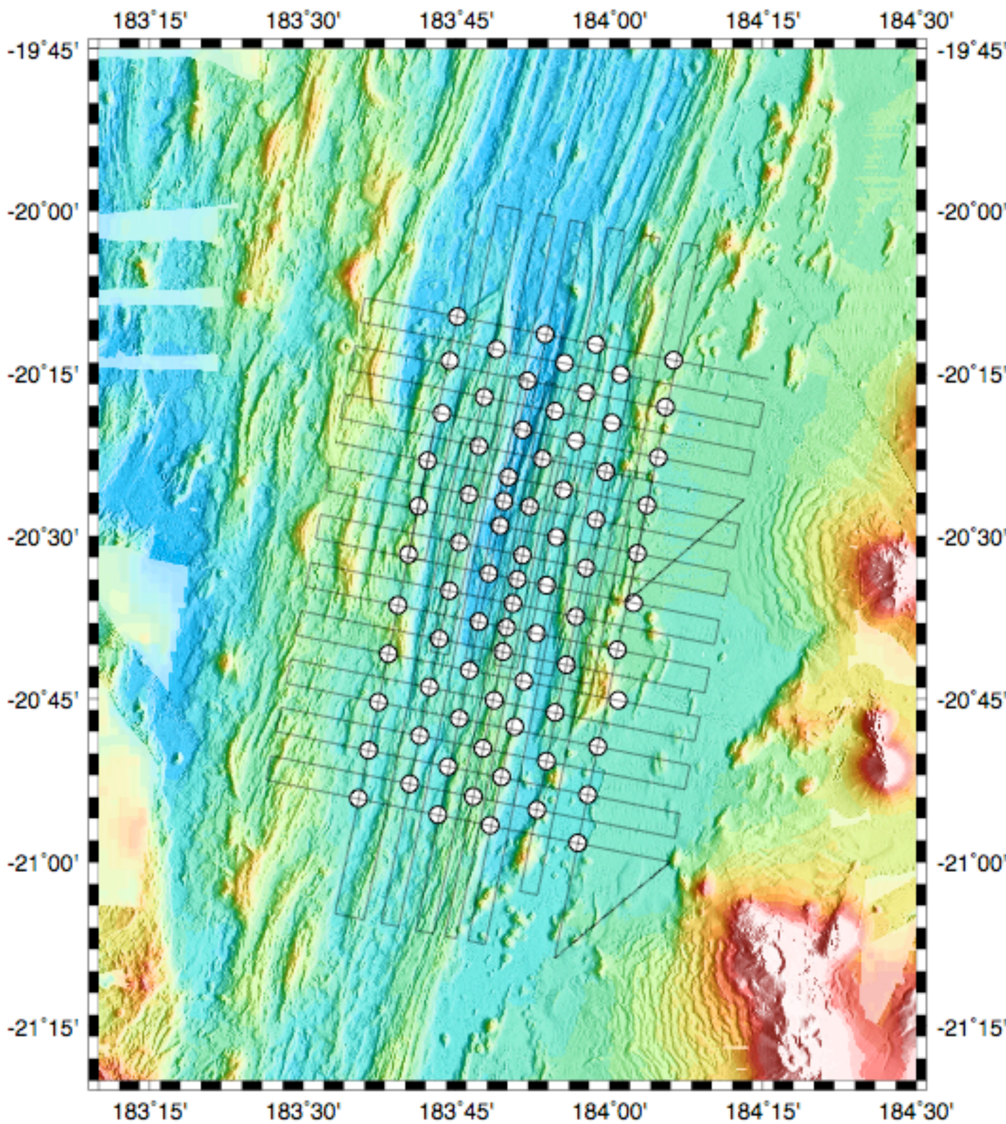
CRUISE REPORT

R/V Marcus G. Langseth

Crustal Accretion and Mantle Processes Along the Subduction-Influenced Eastern Lau Spreading Center

Project: L-SCAN

(Lau Spreading Center Active-source Investigation)



Chief Scientist: Robert A. Dunn

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(R. Dunn – Honolulu, HI March 2009)

Crew and Science Party Manifest

Departure: Nuku'alofa, Tonga
Date: January 24, 2009

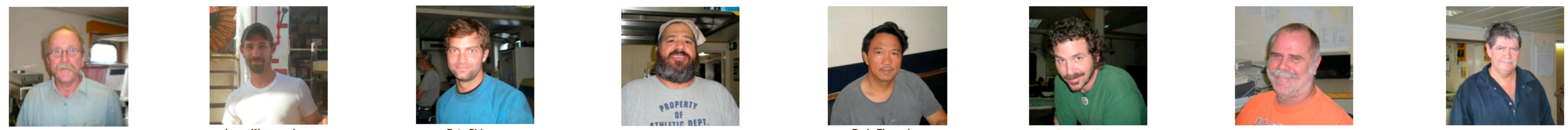
Ship's Manifest

	Name	Position
1	Capt. Stan Zeigler	Captain
2	Dave Wolford	Chief Mate
3	Breck Crum	2nd Mate
4	Nick Gasper	3rd Mate
5	Anthony Johnson	Tech in Charge
6	Bern McKiernan	Acq/Nav - Night Shift Leader
7	Ted Kocynzski	Chief Acq. - Day Shift Leader
8	Gary Brodock	Steward
9	Ricky Rios	Cook
10	Nicky Applewhite	Utility
11	Gordon Baxter	AB
12	George Cereno	AB
13	Ricki Redito	AB
14	Villiami Maea	OS
15	Jason Woronowicz	Bosun
16	Jack Schwartz	Electrician
17	David Ng	IT
18	Fernando Uribe	Oiler
19	Rudy Florendo	Oiler
20	Charles Billips	Oiler
21	Tom Spoto	Chief Sound Source
22	Chip Maxwell	Sound Source Mechanic
23	Jenny White	Sound Source Mechanic
24	Carlos Gutierrez	Sound Source
25	Brian Goodlick	Sound Source
26	Al Karlyn	Chief Engineer
27	Pete Chizmar	1st Engineer
28	Josh Reed	2nd Engineer
29	Ryan Vetting	3rd Engineer
30	Meike Holst	MMO
31	John Nicolas	MMO
32	Claudio Fosatti	MMO, Lead
33	Brad Dawe	MMO
34	Brendan Hurley	MMO

Science Party

	Name	Position	Institution	email
1	Dunn, Robert	Chief Scientist	Univ. Hawaii	dunnr@hawaii.edu
2	Martinez, Fernando	Scientist	Univ. Hawaii	fernando@hawaii.edu
3	Conder, James	Scientist	S. Illinois Univ.	conder@geo.siu.edu
4	Conley, Michaela	Graduate Student	Univ. Hawaii	mconley@hawaii.edu
5	Austin, Regan	Graduate Student	Univ. Hawaii	regana@hawaii.edu
6	Sleeper, Jonathan	Graduate Student	Univ. Hawaii	jsleeper@hawaii.edu
7	Emry, Erica	Graduate Student	Washington U.	ericae@seismo.wustl.edu
8	Hernandez, Olga	Graduate Student	Univ. Toulouse	olgahernand@gmail.com
9	Gardner, Alan	OBSIP	WHOI, Lead	agardner@whoi.edu
10	DuBois, David	OBSIP	WHOI	ddubois@whoi.edu
11	Kane, Timothy	OBSIP	WHOI	
12	Rapa, Martin	OBSIP	Scripps, Lead	mrapa@ucsd.edu
13	Hollinshead, Crispin	OBSIP	Scripps	
14	Thai, Philip	OBSIP	Scripps	pthai@ucsd.edu

Total Crew and Scientists: 47



Stan Zeigler
Captain

Jason Woronowicz
Bosun

Pete Chizmar
1st Engineer

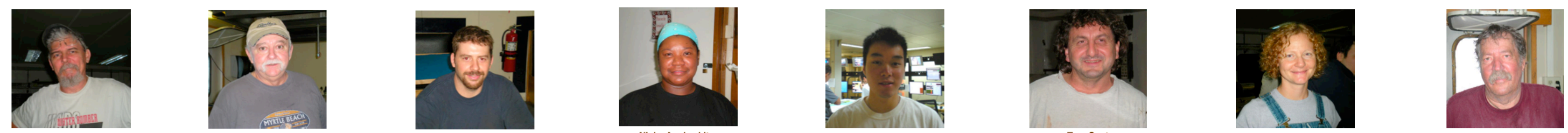
Ricky Rios
Cook

Rudy Florendo
Oiler

Bern McKiernan
Watch leader

Chip Maxwell
Sound Source

Fernando Uribe
Oiler



Ted Kocynzski
Day shift leader

Gary Brodock
Steward

Josh Reed
2nd Engineer

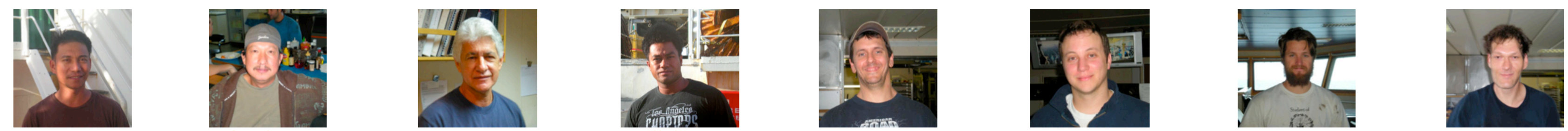
Nicky Applewhite
Utility

David Ng
IT

Tom Spoto
Chief Sound Source

Jenny White
Sound Source

Gordon Baxter
AB



Ricky Redito
AB

George Cereno
AB

Carlos Gutierrez
Sound Source

Viliami Maea
OS

Brian Goodick
Sound Source

Anthony Johnson
Tech in Charge

Breck Crum
2nd Mate

Charlie Billips
Oiler

Olga Hernandez
Grad Student

Rob Dunn
PI

Jack Schwartz
Electrician

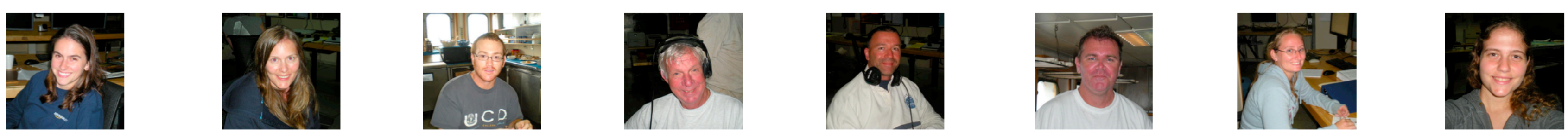
Dave Wolford
Chief Mate

Phil Thai
OBS Tech

Tim Kane
OBS Tech

Ryan Vetting
3rd Engineer

Nick Gasper
3rd Mate



Michaela Conley
Grad Student

Micah Holst
MMO

Brendan Hurley
MMO

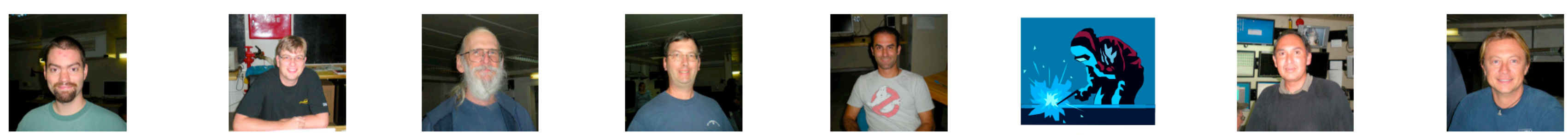
John Nicolas
MMO

Claudio Fosatti
MMO

Brad Dawe
MMO

Regan Austin
Grad Student

Erica Emry
Grad Student



Alan Gardner
OBS Tech

James Condor
Scientist

Chris Holishead
OBS Tech

David DuBois
OBS Tech

Jon Sleeper
Grad Student

Al Karlyn
Chief Engineer

Fernando Martinez
Scientist

Martin Rapa
OBS Tech

R/V Marcus Langseth Technical Support Organizational Chart
Technical Support Organizational Chart
Cruise MGL0903 v1.2

Tech-in-charge
Anthony Johnson

Chief Acquisition
Ted Koczynski

Chief IT/Nav
Anthony Johnson

Operational Watches Acquisition and IT/Navigation

Midnight to Noon		*Noon to Midnight*	
Watch Leader		Watch Leader	
Bern McKiernan		Ted Koczynski	
Acquisition Leader	Nav Leader	Acquisition Leader	Nav Leader
Bern McKiernan	Bern McKiernan	Ted Koczynski	David Ng
Acq Watch Stander A	Nav Watch Stander A	Acq Watch Stander A	Nav Watch Stander A
Visiting Science Party	Visiting Science Party	Visiting Science Party	Visiting Science Party

Chief Sound Source Handling
Tom Spoto

Operational Watches Sound Source/Handling

Midnight to Noon	*Noon to Midnight*
Watch Leader	Watch Leader
Brian Goodick	Carlos Gutierrez
Sound Source Mechanic	Sound Source Mechanic
Chip Maxwell	Jenny White

Captain	Stan Zeigler		
Chief Engineer	Al Karlyn		
PI	Robert Dunn		
Science Party Leader Shift 1	Fernando Martinez	Science Party Leader Shift 2	James Conder
	Regan Austin		Olga Hernandez
	Jonathan Sleeper		Michaela Conley
	Erica Emry		

NOTES:

*Each of the three Technical Groups (Acquisition, IT/Nav, and Sound Source/Handling) will fully transition to 2 watches when necessary to leave flexibility to support Seismic gear deployment. Science operations manned 24 hours whenever data is being collected.

*Tech-in-charge and PI will work out schedule for watch standing visiting science party including shift leaders and on deck responsibilities and seismic deployments.

Scientific and Operational Objectives

Science Summary

The Eastern Lau Spreading Center (ELSC) is a RIDGE Integrated Study Site where researchers from many disciples come together to study the integrated mantle-to-microbes processes interacting within the ridge system. The spreading center exhibits a tremendous along-strike variation in geochemistry, petrology, spreading rate, crustal structure, and morphology. Because of this variation, the ELSC represents the optimum location for an experiment to study the relationship between mantle melt production, mantle flow, and spreading center processes. This active-source seismic experiment is one part of a two-part study (the other being a large broadband seismic study of the mantle beneath the ELSC) that is designed to test the following hypothesis: Variations in the mantle melt supply control ridge crest features such as morphology, thermal structure, and hydrothermal venting.

The experiment consists of 84 OBS deployments along a 150 km section of the ELSC extending from north of the inflated Valu Fa region to the magma-starved northern ELSC where the axial melt lens is absent. Lines of ridge-parallel and ridge-perpendicular airgun shots cover the area and provide seismic sources for imaging the crust and uppermost ~2 km of the mantle. This experiment will image structure on a scale of 1-3 km, and will provide detailed constraints on thermal structure and melt distribution immediately beneath the ELSC.

Scientific Overview

The generation and transport of melt beneath oceanic spreading centers is one of the most important geological process shaping the earth; it produces over two thirds of the global crust and is a primary means of chemical differentiation in the Earth. Yet the physical mechanisms controlling melt aggregation, transport, and collection within the axial crust are poorly understood. Most of our understanding of melt dynamics beneath ridges results from petrological and geochemical studies of the materials output by this process. In contrast, the spatial distribution of melt and the associated convective mantle structure have been imaged in few locations. Both surface morphology and geochemical outputs vary substantially along and between ridge segments so our goal is to take advantage of this fact to understand the relationship between mantle melt processes and the surface manifestation of these processes along the ridge. Careful documentation of both crustal and upper mantle structure along a single ridge segment, combined with modeling of mantle flow and melting are required to accomplish this goal. To date, such a combined 3-D imaging study has not been attempted along an oceanic spreading center.

The Eastern Lau Spreading Center (ELSC) provides one of the best locations for this work. The ELSC was chosen by the RIDGE 2000 (R2K) program for focused, multidisciplinary study, due to its backarc setting and the exceptional along-strike variability in chemistry, petrology, morphology, and hydrothermal flux. Detailed 3-D imaging of the uppermost mantle and crust will allow us to fulfill, in part, three of the seven objectives of the Lau Integrated Studies Implementation Plan**:** (1) characterize the mantle flow pattern and the magma production and transport regions; (2) understand the origin and consequences of gradients in lava composition along the ELSC; (3) understand the spatial-temporal variations of crustal architecture.

The active-source seismic experiment along the ELSC is designed to image uppermost mantle and crustal properties and their along-strike variation over a 150-km-long section of the ELSC to evaluate whether variations in the mantle melt supply control ridge crest features such as morphology, thermal structure, and hydrothermal venting.

The Eastern Lau Spreading Center

The ELSC is characterized by rapid along-strike changes in many variables and thus presents an excellent opportunity to understand the importance of various forcing functions in controlling ridge processes. Going from south to north, the spreading rate increases from 40 to 95 mm/yr [*Zellmer and Taylor*, 2001], the ridge axis changes from inflated to an axial valley [*Martinez and Taylor*, 2002], the melt lens disappears and layer 2A thins [*Collier and Sinha*, 1992; *Harding et al.*, 2000], the crustal composition changes from andesitic to tholeiitic [*Vallier et al.*, 1991; *Peate et al.*, 2001], and isotopic values change from Pacific to Indian Ocean mantle domains [*Pearce et al*., 1995]. Furthermore, the depth of the spreading axis increases and the mantle Bouguer gravity values increase [*Fouquet et al*., 1991; *Bortnikov et al*., 1993]. The distance of the ridge from the Tonga arc increases from 30 km to 100 km and the depth to the underlying slab increases from 150 km to 250 km.

It is hypothesized that many of the along-strike changes in the ELSC are produced by variable geochemical and petrological inputs via subduction, with the greatest influence in the south where the ridge is closest to the arc [*Pearce et al.*, 1995; *Martinez and Taylor*, 2002]. It is likely that the unusual chemistry observed in Valu Fa hydrothermal vents, particularly the enrichment in Zn and other metals, is related to the enriched andesitic crustal composition and the influence of slab-derived volatiles [*Fouquet et al.*, 1993; *Herzig et al.*, 1993]. Thus, mantle-melting processes appear to play a vital role in forming the chemical systems that are fundamental to the Lau vent ecosystems.

Despite the inferences that can be made based on petrology and geochemistry, how mantle melting may influence the ELSC to produce these systematic variations are unknown. The missing links are (1) the pattern of flow in the mantle wedge and its relation to variation in melt chemistry, distribution, and migration paths to the ridge; and (2) the pattern of melt delivery to the ridge axis at the base of the crust, and (3) crustal-level melt storage and thermal structure.

Scientific Objectives

Using a grid of OBSs extending 150 km along the ELSC, with a station spacing of ~8 km, and a grid of airgun shot lines, with a spacing of 1-4, km this experiment is designed to:

(1) Map the seismic velocity structure of the uppermost ***mantle*** *beneath a 150-km-long section of the spreading center.*

(2) Image the seismic velocity structure of the ***crust*** *along this 150-km-long section of the ELSC.*

(3) Construct a map of ***crustal thickness*** *variations along and across the spreading center.*

Operational Objectives (cruise plan and experiment layout)

Number of OBS Deployments and Recoveries

The experiment is divided into two OBS grids (A and B) and two shot grids (1 and 2)
OBS Deployments Group A: 59
OBS Recoveries Group A: 25
Number left on seafloor after first shooting leg: 34 OBS

OBS Deployments Group B: 18
OBS Recoveries Group B: 52 (including those from group A left on the seafloor)
Total Number of deployments: 77 deployments
Total Number of recoveries: 77 recoveries

Parameters Used to Design the Active-Source Seismic Experiment

Ship speed deploy/recovery: 8 knots
Ship speed shooting: 4.5 knots
Airgun depth = 9 m (the marine mammal permit asks for 9-12 m)
Shot interval: every 450 meters (~3.25 min)
Station deployment time (each): 1 hour
Station recovery time (each): 2.5 hours

Basic Plan: 59 instruments are placed on the seafloor (group A) and then Shot Pattern #1 is carried over these instruments. 25 of these instruments are then recovered (the southern section of the OBS grid) and 18 of these are reset and re-deployed to the north of the OBS that are still on the seafloor. Shot Pattern #2 is carried out over all instruments on the seafloor. All 52 instruments are then recovered. Figures below show the layout of Groups A and B and the Shot Lines for Patterns #1 and #2.

Contingency Days: There are 5 contingency days built into the program for weather and marine mammal delays*. If some or all of this time is not needed, the plan will be (1) deploy the additional 7 instruments at the northern extreme of the array, (2) shoot additional along-axis lines during Shooting Campaign I or II. * See also bad weather contingency plan below.

Cruise Plan

Transit time Nuku'alofa to Experiment: 0.85 days
(includes 0.25 day to get out of port and 0.33 day for instrument release tests)

Deployment A: 59 instruments
Total time at sites: 2.46 days (1 hour to release each instrument)
Transit days: 1.2 days
Total transit length: 433 km
Total days: **3.68 days**

Shooting A: (15 east-west lines and 13 north-south lines)
Gun deployment: 7 hours
Gun maintenance: 4 hours/48 hours
Gun recovery: 2 hours
Actual Shooting: 11.46 days
Total days: 12.67 days

Recovery A: 25 instruments
Total time at sites: 2.6 days (2.5 hours each instrument recovery)
Transit days: 0.54 days
Total transit length: 192 km
Total days: 3.15 days

Deployment B: 25 instruments
Total time at sites: 1.04 days (1 hour each instrument)
Transit days: 0.54 days
Total transit length: 187 km
Total days: 1.57 days

Shooting B: (8 east-west lines and 14 north-south lines)
Gun deployment: 2 hours
Gun maintenance: 4 hours/48 hours
Gun recovery: 2 hours
Actual Shooting: 8.3 days
Total days: 9.2 days

Recovery B: 59 instruments
Total time on site: 6.1 days (2.5 hours each instrument)
Transit days: 1.26 days
Total transit length: 447 km
Total days: 7.4 days

Transit time from Experiment to Suva: 2 days
(includes 0.25 day to get into port)

Total Number of Days = 40.5 + 3.5 days contingency

Instrument Location and Shot Line Maps (planned)

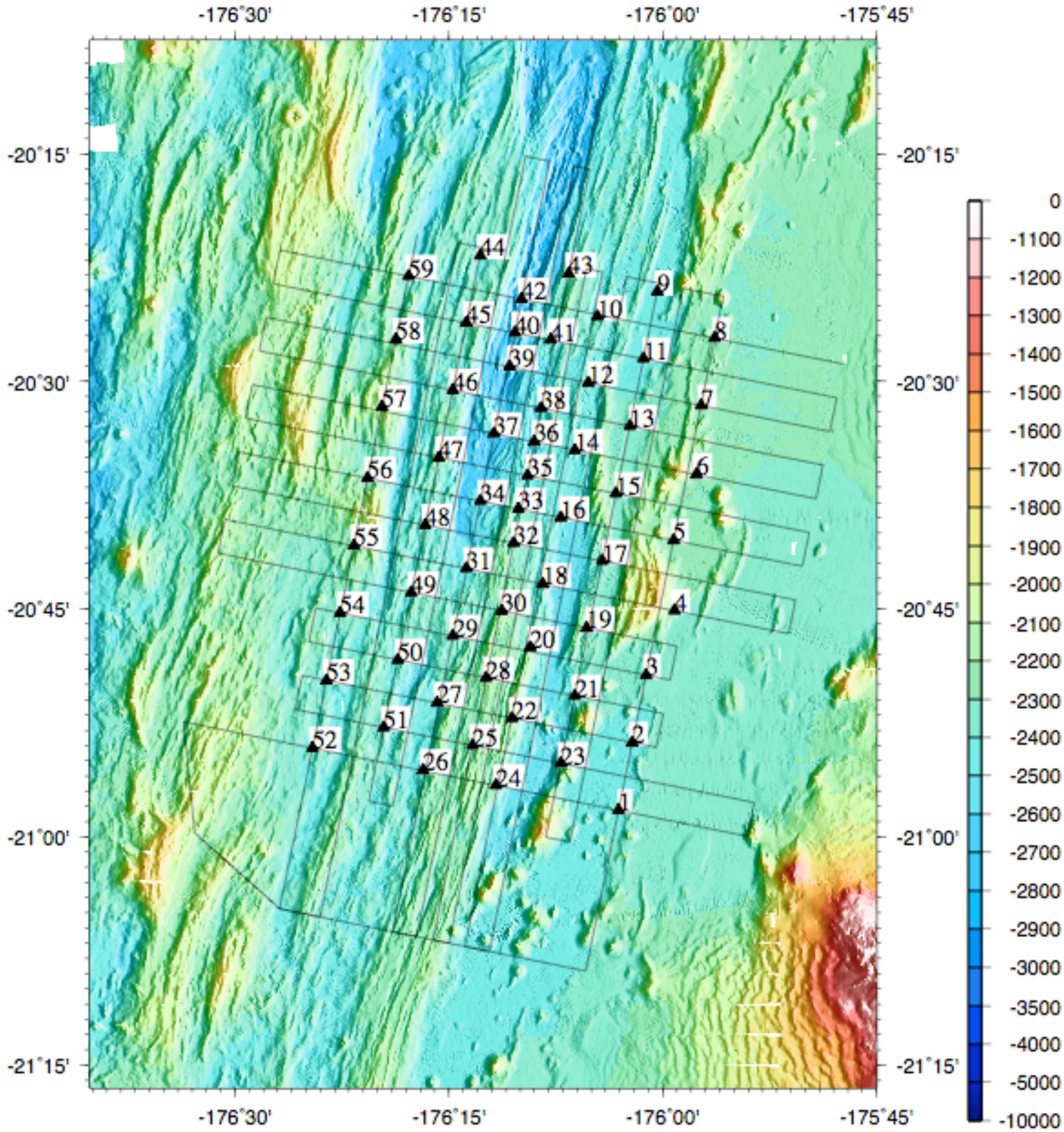


Figure 0.1. Group A OBS layout and Shot Pattern #1.

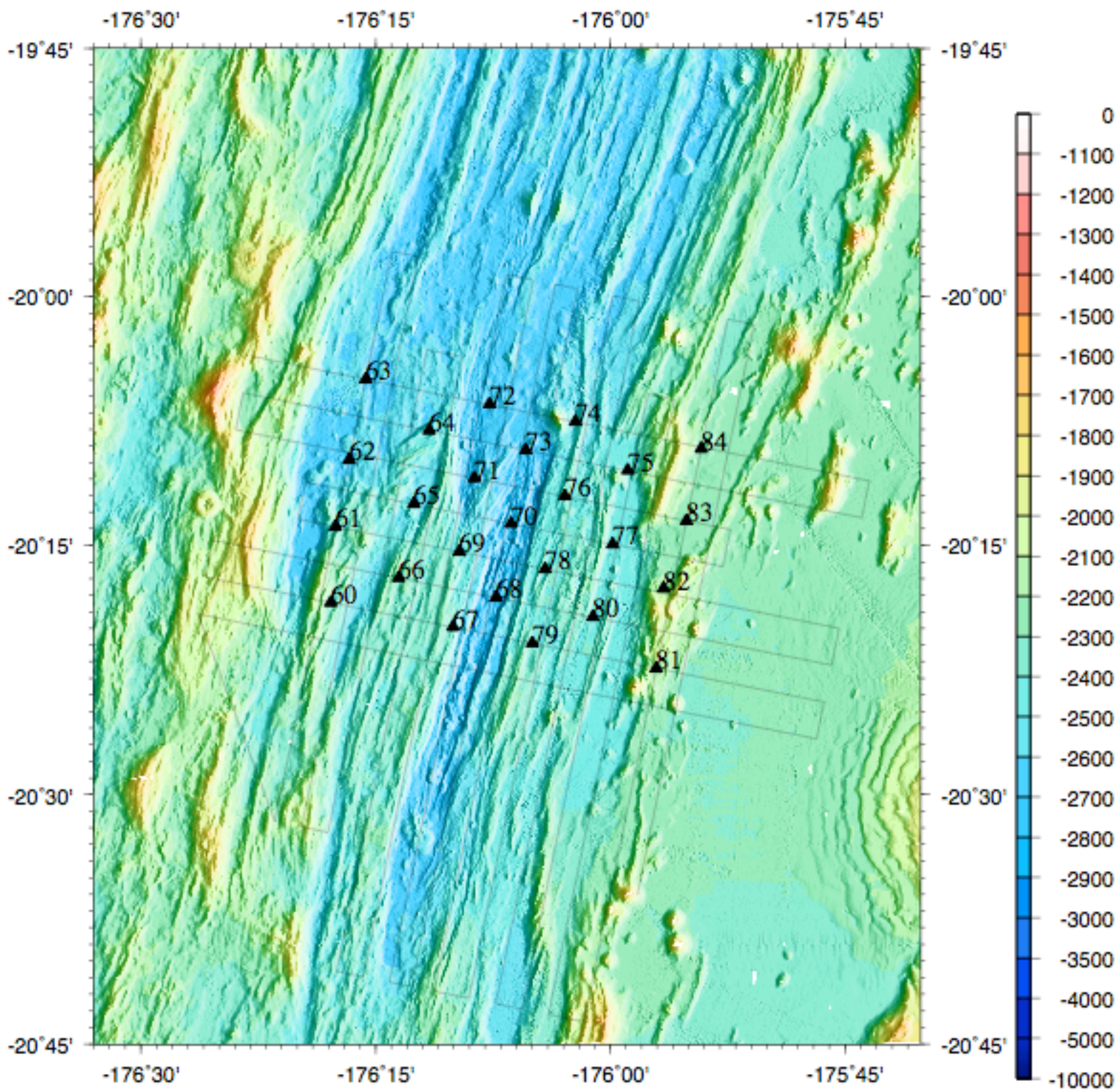


Figure 0.2. Group B OBS layout and Shot Pattern #2. Numbers indicate order of deployment. Some stations from Group A remain on the seafloor during shooting pattern #2 (not shown).

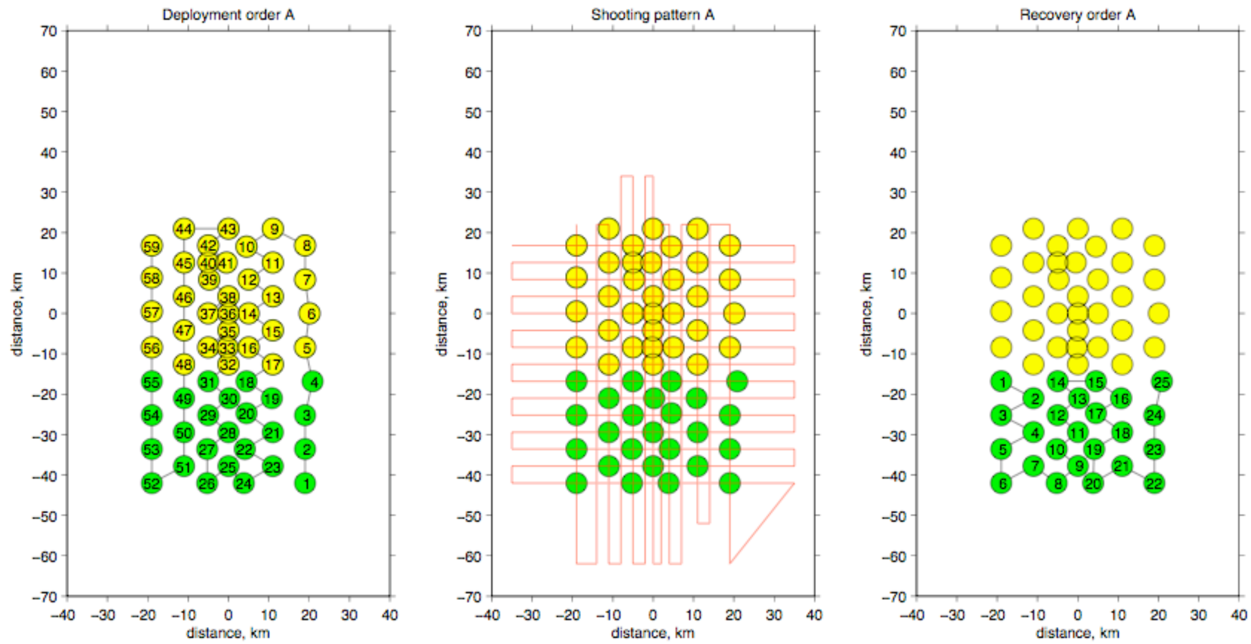


Figure 0.3. (Left) Deployment order Group A. **(Middle)** Shot Pattern #1. **(Right)** Recovery order of partial Group A. Note that order is specified such that last drop corresponds to location where shooting starts and shooting ends close to where the first pickup is to be made. Yellow instrument remain on seafloor and are recovered with Group B.

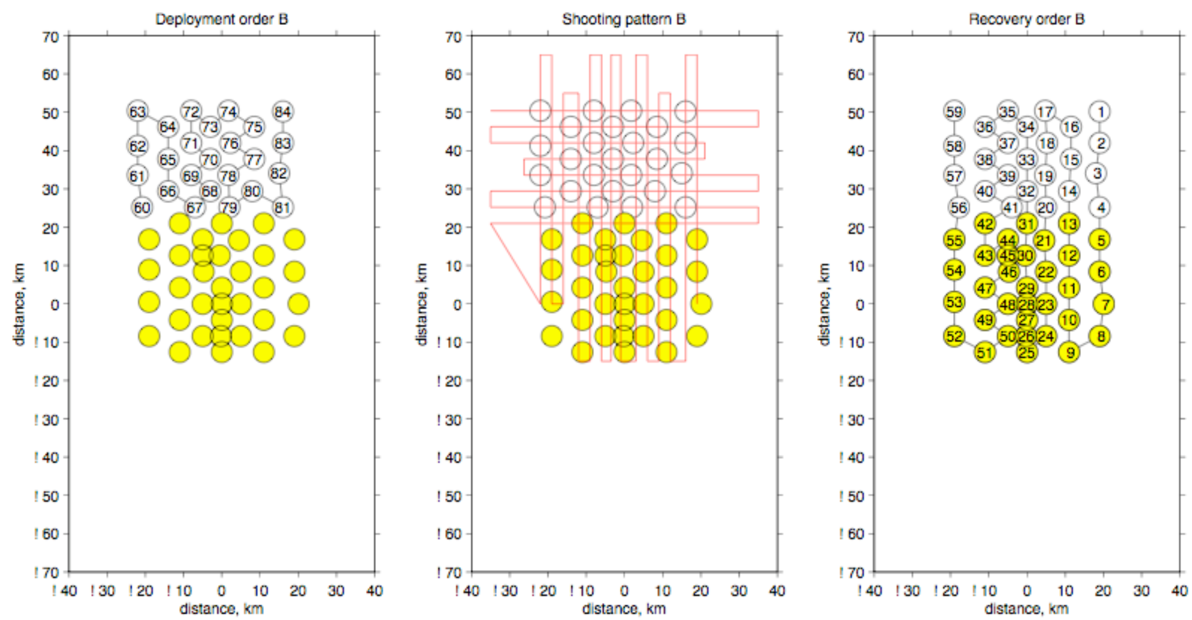


Figure 0.4. (Left) Deployment order of Group B. (Middle) Shot Pattern #2.
(Right) Recovery order of Group B and remaining Group A.

Instrument Group A and B Drop Positions

A	Drop Number	Longitude (˚)	Latitude (˚)		Drop Number	Longitude (˚)	Latitude (˚)		
	1	183.9484	-20.9709		47	183.7384	-20.5840		
	2	183.9645	-20.8969		48	183.7223	-20.6580		
	3	183.9806	-20.8228		49	183.7062	-20.7320		
	4	184.0141	-20.7521		50	183.6902	-20.8060		
	5	184.0128	-20.6748		51	183.6741	-20.8801		
	6	184.0392	-20.6027		52	183.5907	-20.9027		
	7	184.0449	-20.5267		53	183.6068	-20.8287		
	8	184.0610	-20.4527		54	183.6229	-20.7547		
	9	183.9938	-20.4013		55	183.6390	-20.6807		
	10	183.9241	-20.4289		56	183.6551	-20.6066		
	11	183.9777	-20.4753		57	183.6721	-20.5282		
	12	183.9132	-20.5016		58	183.6882	-20.4542		
	13	183.9616	-20.5494		59	183.7033	-20.3845		
	14	183.8971	-20.5756						
	15	183.9455	-20.6234						
	16	183.8810	-20.6497						
	17	183.9294	-20.6974						
	18	183.8602	-20.7228						
	19	183.9110	-20.7710						
	20	183.8451	-20.7924						
	21	183.8972	-20.8455	**B**	**Drop Number**	**Lon (˚)**	**min**	**Lat (˚)**	**min**
	22	183.8238	-20.8700		60	-176	17.8518	-20	18.4369
	23	183.8812	-20.9195		61	-176	17.5643	-20	13.8661
	24	183.8053	-20.9436		62	-176	16.6853	-20	09.8209
	25	183.7776	-20.8998		63	-176	15.6339	-20	04.9825
	26	183.7201	-20.9274		64	-176	11.5983	-20	8.0640
	27	183.7362	-20.8534		65	-176	12.5635	-20	12.5058
	28	183.7937	-20.8258		66	-176	13.5287	-20	16.9476
	29	183.7547	-20.7798		67	-176	10.0578	-20	19.9216
	30	183.8121	-20.7522		68	-176	07.3161	-20	18.1310
	31	183.7708	-20.7058		69	-176	09.6574	-20	15.3722
	32	183.8259	-20.6777		70	-176	06.3509	-20	13.6892
	33	183.8316	-20.6402		71	-176	08.6922	-20	10.9304
	34	183.7868	-20.6317		72	-176	07.7270	-20	06.4886
	35	183.8420	-20.6037		73	-176	05.3857	-20	09.2474
	36	183.8500	-20.5667		74	-176	02.2204	-20	07.5376
	37	183.8029	-20.5577		75	-175	58.8907	-20	10.4846
	38	183.8580	-20.5297		76	-176	02.9032	-20	12.0331
	39	183.8214	-20.4841		77	-175	59.8559	-20	14.9264
	40	183.8271	-20.4467		78	-176	04.1508	-20	16.4211
	41	183.8694	-20.4547		79	-176	04.9748	-20	20.8898
	42	183.8351	-20.4096		80	-176	01.1035	-20	19.3144
	43	183.8902	-20.3816		81	-175	57.0679	-20	22.3960
	44	183.7867	-20.3619		82	-175	56.6100	-20	17.5822
	45	183.7706	-20.4359		83	-175	55.1375	-20	13.5124
	46	183.7545	-20.5099		84	-175	54.1952	-20	09.1764

Shot Lines Campaign I

Notes: shooting is expected to be continuous from line-to-line and there are no large turns required, since there will be no streamer. East-west lines and many north-south lines are spaced at >3 km apart. However, few north-south lines are spaced 2-2.5 km apart. It is preferred that the ship will swing around wide to make the turns at the ends of these lines, rather than hop across lines and then return to missed lines, since the latter method will eat up hours of additional time. Line times are for 4.5 knots over ground.

Line No.	Longitude (˚)	Latitude (˚)	Line times turn times
1	183.7133	-20.3387	10.0792
	183.5524	-21.0790	0.6000
2	183.5995	-21.0880	10.0792
	183.7604	-20.3477	0.3600
3	183.7886	-20.3531	10.0792
	183.6277	-21.0934	0.3600
4	183.6560	-21.0987	11.5191
	183.8398	-20.2527	0.3600
5	183.8680	-20.2581	11.5191
	183.6842	-21.1041	0.3600
6	183.7124	-21.1095	11.5191
	183.8963	-20.2634	0.2400
7	183.9151	-20.2670	11.5191
	183.7313	-21.1131	0.2400
8	183.7501	-21.1167	10.0792
	183.9110	-20.3764	0.2400
9	183.9298	-20.3800	10.0792
	183.7689	-21.1202	0.3600
10	183.7972	-21.1256	10.0792
	183.9580	-20.3853	0.4800
11	183.9957	-20.3925	10.0792
	183.8540	-21.0447	0.3600
12	183.8822	-21.0500	10.0792
	184.0239	-20.3979	0.6000
13	184.0710	-20.4068	10.0792
	183.9101	-21.1471	3.0733
14	184.0990	-20.9996	8.3993
	183.4401	-20.8741	0.5040
15	183.4482	-20.8370	8.3993
	184.1071	-20.9626	0.5040
16	184.1151	-20.9255	8.3993
	183.4562	-20.8000	0.5040
17	183.4642	-20.7630	8.3993
	184.1232	-20.8885	0.5040
18	184.1312	-20.8515	8.3993
	183.4723	-20.7260	0.5040
19	183.4803	-20.6890	8.3993
	184.1392	-20.8145	0.5040
20	184.1473	-20.7775	8.3993
	183.4884	-20.6520	0.5040
21	183.4964	-20.6150	8.3993
	184.1553	-20.7405	0.5040
22	184.1634	-20.7035	8.3993
	183.5045	-20.5779	0.5040
23	183.5125	-20.5409	8.3993
	184.1714	-20.6664	0.5040
24	184.1795	-20.6294	8.3993

	183.5205	-20.5039	0.5040
25	183.5286	-20.4669	8.3993
	184.1875	-20.5924	0.5040
26	184.1955	-20.5554	8.3993
	183.5366	-20.4299	0.5040
27	183.5447	-20.3929	8.3993
	184.2036	-20.5184	0.5040
28	184.2116	-20.4814	8.3993
	183.5527	-20.3559	

* 11.56 to shoot just the lines at 4.5 knots

Instrument Recovery Group A (partial) and Instrument Group B Drop Positions

Recovery Order	East_Longitude (˚)	Latitude (˚)	Drop Number		Drop Number	deg	min	deg	min
1	183.6390	-20.6807	55		60	-176	17.8518	-20	18.4369
2	183.7062	-20.7320	49		61	-176	17.5643	-20	13.8661
3	183.6229	-20.7547	54		62	-176	16.6853	-20	09.8209
4	183.6902	-20.8060	50		63	-176	15.6339	-20	04.9825
5	183.6068	-20.8287	53		64	-176	11.5983	-20	8.0640
6	183.5907	-20.9027	52		65	-176	12.5635	-20	12.5058
7	183.6741	-20.8801	51		66	-176	13.5287	-20	16.9476
8	183.7201	-20.9274	26		67	-176	10.0578	-20	19.9216
9	183.7776	-20.8998	25		68	-176	07.3161	-20	18.1310
10	183.7362	-20.8534	27		69	-176	09.6574	-20	15.3722
11	183.7937	-20.8258	28		70	-176	06.3509	-20	13.6892
12	183.7547	-20.7798	29		71	-176	08.6922	-20	10.9304
13	183.8121	-20.7522	30		72	-176	07.7270	-20	06.4886
14	183.7708	-20.7058	31		73	-176	05.3857	-20	09.2474
15	183.8602	-20.7228	18		74	-176	02.2204	-20	07.5376
16	183.9110	-20.7710	19		75	-175	58.8907	-20	10.4846
17	183.8451	-20.7924	20		76	-176	02.9032	-20	12.0331
18	183.8972	-20.8455	21		77	-175	59.8559	-20	14.9264
19	183.8238	-20.8700	22		78	-176	04.1508	-20	16.4211
20	183.8053	-20.9436	24		79	-176	04.9748	-20	20.8898
21	183.8812	-20.9195	23		80	-176	01.1035	-20	19.3144
22	183.9484	-20.9709	1		81	-175	57.0679	-20	22.3960
23	183.9645	-20.8969	2		82	-175	56.6100	-20	17.5822
24	183.9806	-20.8228	3		83	-175	55.1375	-20	13.5124
25	184.0141	-20.7521	4		84	-175	54.1952	-20	09.1764

Shot Lines Campaign II

Notes: East-west lines and many north-south lines are spaced at >3 km apart. However, a few north-south lines are spaced 2.5 km apart.

Line No.	deg	min	deg	min
01	-175	58.2692	-20	36.0441
	-175	50.8003	-20	01.6731
02	-175	52.4946	-20	01.3504
	-176	01.6871	-20	43.6531
03	-176	03.9462	-20	43.2227
	-175	55.9028	-20	06.2079
04	-175	57.5971	-20	05.8851
	-176	05.6406	-20	42.9000

05	-176	07.3349	-20	42.5773
	-175	58.1424	-20	00.2745
06	-175	59.8368	-19	59.9518
	-176	09.0292	-20	42.2545
07	-176	11.2884	-20	41.8242
	-176	02.0959	-19	59.5215
08	-176	03.5078	-19	59.2525
	-176	12.7003	-20	41.5552
09	-176	14.1123	-20	41.2863
	-176	04.9198	-19	58.9836
10	-176	06.6141	-19	58.6608
	-176	15.8066	-20	40.9635
11	-176	17.5010	-20	40.6408
	-176	09.4575	-20	03.6259
12	-176	11.7167	-20	03.1956
	-176	18.0365	-20	32.2787
13	-176	19.7308	-20	31.9559
	-176	12.2619	-19	57.5850
14	-176	13.9563	-19	57.2622
	-176	21.4252	-20	31.6332
15	-176	26.3543	-20	19.1302
	-175	46.8196	-20	26.6609
16	-175	46.3370	-20	24.4400
	-176	25.8717	-20	16.9093
17	-176	25.3891	-20	14.6884
	-175	45.8544	-20	22.2191
18	-175	45.3718	-20	19.9982
	-176	19.9647	-20	13.4088
19	-176	19.4820	-20	11.1879
	-175	52.7962	-20	16.2712
20	-175	52.3136	-20	14.0503
	-176	23.9413	-20	08.0257
21	-176	23.4587	-20	05.8048
	-175	43.9240	-20	13.3356
22	-175	43.4414	-20	11.1147
	-176	22.9761	-20	03.5839
23	-176	22.9761	-20	03.5839
	-176	22.4935	-20	01.3630
24	-176	01.0318	-20	05.4511
	-176	11.6491	-20	54.3108
25	-176	13.9082	-20	53.8804
	-176	03.2909	-20	05.0208
26	-175	53.6896	-20	06.8497
	-176	04.3070	-20	55.7093
27	-176	24.0743	-20	51.9440
	-176	12.9514	-20	00.7577

total time for lines is 8.2 days at 4.5 knots over ground.

Instrument Recovery - Group B and Group A (remaining) after Shot Pattern #2

Recovery Order	deg	min	deg	min	drop number
1	-175	52.5009	-20	09.4991	84
2	-175	53.4431	-20	13.8351	83
3	-175	54.9157	-20	17.9050	82
4	-175	55.3735	-20	22.7187	81

5	-175	56.3387	-20	27.1605	8
6	-175	57.3040	-20	31.6023	7
7	-175	57.6479	-20	36.1624	6
8	-175	59.2344	-20	40.4858	5
9	-176	04.2352	-20	41.8461	17
10	-176	03.2700	-20	37.4043	15
11	-176	02.3048	-20	32.9625	13
12	-176	01.3396	-20	28.5207	11
13	-176	00.3744	-20	24.0789	9
14	-175	59.4092	-20	19.6372	80
15	-175	58.1616	-20	15.2492	77
16	-175	57.1964	-20	10.8074	75
17	-176	00.5260	-20	07.8603	74
18	-176	01.2089	-20	12.3559	76
19	-176	02.4565	-20	16.7439	78
20	-176	03.2805	-20	21.2126	79
21	-176	04.5568	-20	25.7327	10
22	-176	05.2109	-20	30.0961	12
23	-176	06.1761	-20	34.5379	14
24	-176	07.1413	-20	38.9797	16
25	-176	10.4478	-20	40.6627	32
26	-176	10.1064	-20	38.4149	33
27	-176	09.4826	-20	36.2209	35
28	-176	09.0000	-20	34.0000	36
29	-176	08.5174	-20	31.7791	38
30	-176	07.8346	-20	27.2835	41
31	-176	06.5870	-20	22.8955	43
32	-176	05.6218	-20	18.4538	68
33	-176	04.6566	-20	14.0120	70
34	-176	03.6913	-20	09.5702	73
35	-176	06.0326	-20	06.8114	72
36	-176	09.9039	-20	08.3868	64
37	-176	06.9979	-20	11.2532	71
38	-176	10.8691	-20	12.8286	65
39	-176	07.9631	-20	15.6949	69
40	-176	11.8344	-20	17.2703	66
41	-176	08.3635	-20	20.2443	67
42	-176	12.7996	-20	21.7121	44
43	-176	13.7648	-20	26.1539	45
44	-176	09.8935	-20	24.5785	42
45	-176	10.3761	-20	26.7994	40
46	-176	10.7175	-20	29.0472	39
47	-176	14.7300	-20	30.5957	46
48	-176	11.8239	-20	33.4621	37
49	-176	15.6952	-20	35.0375	47
50	-176	12.7891	-20	37.9039	34
51	-176	16.6604	-20	39.4793	48
52	-176	20.6960	-20	36.3977	56
53	-176	19.6734	-20	31.6915	57
54	-176	18.7082	-20	27.2498	58
55	-176	17.8004	-20	23.0724	59
56	-176	16.1575	-20	18.7597	60
57	-176	15.8700	-20	14.1888	61
58	-176	14.9910	-20	10.1436	62
59	-176	13.9396	-20	05.3052	63

Lau Basin Currents

Ocean surface currents effect transit speeds over-ground and shooting speeds and timing. Surface currents are seasonal and exhibit short-term fluctuations, in particular during storms. Near-real time ocean surface currents, derived from satellite altimeter and scatterometer data, can be found at http://www.oscar.noaa.gov/datadisplay. A recent 5-day average (about Dec. 21, 2008) shows SSE flow at <0.100 m/s (0.36 km/hr). The monthly mean (about Dec. 15, 2008) shows SE flow at ~0.05 m/s (~0.18 km/hr). A seasonal mean from Feb. 1, 2007 to March 1, 2008 shows a SSE flow at ~0.04 m/s (~0.14 km/hr). For a current of 0.20 km/hr and a shot interval of 450 meters, the timing of the shots will be delayed/advanced by only ~5 s. If surface currents become as high as 1 km/hr the shot timing will be delayed/advanced by 26 s. Since we wish to keep the shots greater than 3 minutes apart, only currents over 1 km/hr are of concern when the ship is traveling with the current.

Deep basin currents are expected to be significantly less than surface currents, but do impact instrument drops. The LAUB-FLEX project directly samples the deep-flow field in the Lau Basin with floats that are programmed to drift at depth and periodically return to the surface in order to transmit data back to shore. Once a month the float data are quality-controlled, processed and made publicly available at www.ldeo.columbia.edu/~ant/LAUB-FLEX as downloadable data and web animations.

Currently, there are 10 floats, which were deployed during three cruises in 2004-05, drifting in the Lau Basin. The available data span three- and four-week-long drift cycles and cover a good portion of the Lau Basin. The mean meridional (north-south) velocity recorded so far is 4.1(+/-0.9) mm/s (0.014 km/hr) to the north, while the zonal (east-west) flow is as yet indistinguishable from zero. Individual float-cycle-averaged velocities are omni-directional and associated with speeds up to 9 cm/s. Thus, on timescales of months, horizontal flow in the deep interior of the Lau Basin is primarily omni-directional, while the observed northward mean flow becomes important on longer (multi-year) timescales. **Peak velocities averaged over 3-4 week intervals can be as high as 30 mm/s (~0.100 km/hr).** Peak velocities averaged over shorter time periods are unknown. It can take 1-1.5 hours for an instrument to fall to the bottom (30 m/min); seafloor locations may be off by 100-150 m.

Contingency Plan

In the event that storms or other unforeseeable circumstances divert the ship for a short period of time from its main objectives of carrying out a seismic tomography study of the Eastern Lau Spreading Center, the following activities are proposed:

(1) Shoot lines of airguns to the moored hydrophone array of Bohnenstiehl et al. Airgun shots are used to calibrate acoustic wave travel time and transmission loss models. Proposed lines:
(183.000˚E, 23.000˚S) to (182.000˚E, 23.000˚S)
(182.883˚E, 20.000˚S) to (182.883˚E, 18.500˚S)
(183.000˚E, 20.425˚S) to (182.250˚E, 20.425˚S)
(183.000˚E, 21.000˚S) to (183.500˚E, 19.750˚S)

(2) Survey areas for seismometer deployments that will occur during the Wiens et al. broadband seismic cruise that is expected to occur in late 2009. There are some gaps in the current seafloor maps of the area and pre-surveying those gaps would save time for positioning instruments during the Wiens et al cruise that is expected to occur late 2009.

(3) Survey areas of the Western Lau basin using a multi-beam system and gravimeter. Large gaps in the detailed seafloor maps of the western basin could be at least partly filled in, so as to achieve a better understanding of the history of plate tectonics of the area (see justification below).

No time-frame for this potential work is specified (other than the time-frame of the cruise Jan 16-Feb 28). We would return to the main experiment site immediately when able to do so. Depending on a storm's location and track, we could divert to any area in the region from 178.5W - 176.5W; 23S-18.5S. Which includes excursions into territory claimed by Fiji.

MGL0903

L-SCAN: **L**au **S**preading **C**enter **A**ctive-Source **IN**vestigation

L-SCAN Operations Report

Narrative

(dates and times are referenced Tonga local)

23 Jan 2009 (Tongatapu) – The academic science party moved aboard today along with the Marine Mammal Observers. The OBSIP group preceded us the day before. We spent the day readying the lab, tying down computers, connecting to the ships network and the internet (high-seas network), discussing the experiment, and stowing gear.

24 Jan 2009 – Depart Nuku'alofa, Tonga just after 8 am local time with all hands aboard. Harbor pilot was picked up by small boat soon thereafter. We slowly maneuvered north from the island through several small islands and shoals. Once clear of the shallows, we turned west into the Lau basin toward the experiment area and the first instrument drop about 5 hours later. That instrument, a WHOI OBS, was deployed with only one hiccup: the small winch used for the A-frame was stuck and no amount of begging and cajoling could get it to work. Instead, we used a small deck crane, a rather difficult operation as the crane was required to clear the OBS frames on the deck, making it difficult for the deck hands to control the instrument as it hung from the cable. The A-frame winch is obviously poorly located, being on the main deck and subject to the constant sloshing of seas over the starboard side. It shows significant rust and may prove to cause problems down the road. Perhaps a better placement would be on the level above, with the controls at the A-frame. That would allow one operator to control both the A-frame and the winch, rather than the two operators that are currently required. The winch was later fixed by Ted, who used a tried-and-true, if not old-fashioned, methodology that one can't find in the repair manual. Afterward, we moved to a new position west of the OBS drop in >2500m of water for the SIO release tests. We then held station at that location throughout the night and into the next day (~15 hours) for three up and down tests of the instrument releases. This test took ~6-7 hours longer than anticipated due to the inoperable main winch; the ships crew jury-rigged an alternate system using a streamer capstan, rope, several pulleys, and the main winch's boom. Aye! Another winch problem! Medium swell from low-pressure system passing through the area made for a rough first day for some of the less-seaworthy aboard.

25 Jan 2009 – By about 9 am we had finished the release tests and had moved to the next station where we deployed a Scripps OBS. We then continued to deploy instruments at an increasing rate, taking from about 1 hour 20 minutes between each drop to about 50 minutes. One hour from drop-to-drop gives the OBSIP team enough time to ready their instruments for deployment. Less time from drop-to-drop and the OBSIP groups began to strain. Since I have allotted 90 minutes or more for the time between each deployment, we will have already made up much of the time lost to the release tests. OBS guys have no complaints about their set up, though the deck gets plenty wet.

26 Jan 2009 – By noon we have deployed 29 of the 59 instruments. We have one bad SIO clock and problems with two WHOI instruments. By 1 pm it looks like the SIO instrument is dead, but there are two WHOI instruments extra (a nice surprise!) so we may be able to deploy to all 59 locations if they get at least one of their faulty instruments up and running. The OBS teams (a mix of WHOI and SIO members for each 12 hour shift) have really gotten into the swing of things today. The shortest time between drops was 39 minutes. These guys are really going all out and we will owe them considerably in the end. A tropical disturbance is pressing down on us from the north, moving slowly, it should arrive soon.

27 Jan 2009 – The tropical depression "arrived" around midnight or thereabouts. The main deck from which OBS are deployed was often awash and more than one OBS tech was washed about on the deck. One wave caught the frame and floats of an SIO instrument and smashed it against the WHOI van crushing a glass ball; there was a replacement available. Winds are 20-25 knots and the sea state is medium swell with lots of chop and whitecaps. Had a conference call this morning with Lamont concerning Marine Mammal Incidental Harassment Authorization. We were told that the extension for the permit (due to cruise date delays) will be granted. We finished dropping the last OBS (all 59 requested were deployed) at 0215 local time. One and a quarter days ahead of schedule! One or two WHOI instruments will have a time-base problem, but apparently it is known and can be corrected after recovery of the data. We ran east to avoid the storm and get the guns out and tested, but by the time we were ready to shoot the seas were kicking up hard. As we turned on to the first shot line back towards the west we were getting pounded. I think we might have fired two shots when, just as we were deciding whether to continue shooting, a compressor went down due to a clogged intake valve (my understanding of it at the time). So we brought the guns back in to weather out the storm safely. Some OBS techs went out on deck in the night to better secure their now-empty frames. They took a beating. At this point we are still ahead of schedule.

28 Jan 2009 – Rode out the storm this morning by heading to the southeast corner of the experiment in hopes of deploying guns in better weather there. As it turned out, after we had the guns all tested on deck and ready to deploy the seas kicked up and the gun slip became a nasty place to work. The crew were willing to deploy the guns (the ship has a great crew that seems to work very well together) but my understanding was that they wouldn't be able to bring them back aboard in such weather and if the weather worsened we would be stuck with them out, possibly resulting in damage. Weather reports indicated higher winds in our future. In heavy seas and high wind conditions the seismic source isn't very good and the data noise levels are high (from past experience). In the waning daylight hours I made the decision not to deploy the guns given that the risk to guns and crew was too great considering that the data would be poor anyway. We woke Fernando M., our mapping specialist, and charted a new course along the eastern margin of the experiment that would both cover some new ground and steer us clear of the tropical depression to our west. We made little headway during the night due to high seas (1-3.5 knots) and the multibeam data is noisy. The tropical depression continued south-south-west and grew into Tropical Cyclone Hettie during the night.

29 Jan 2009 - By morning the ship was located just north-east of the shooting grid and the seas had calmed considerably for us. Anthony and team fired up the guns and deployed all 4 strings. One string (#2) was having problems so I decided to go ahead with only three strings and allow the gunners to fix #2. On the way in, #2 flooded due to an o-ring failure and by noon it was on deck and being cleared out. I decided to run the east-west lines first, because the north-south lines would immediately take us closer to the cyclone. Also, the east-west lines are a bit less important than the north-south lines and I would like to do the north-south lines in better weather if at all possible. By noon we were sitting just at the cyclone's north-eastern edge and starting on to our first shot line. Weather at this location is good and seas are moderate. Shots are being recorded as I write. We are a fraction of a day behind schedule. Hopefully we can get back on and stay on, or a little ahead of, schedule. There is another tropical disturbance coming down the pipeline; it is currently located north-west of New Caledonia. We won't see it for several days if at all.

Tropical Cyclone - Gale and Storm A

```
Gale Warning 032 ISSUED FROM RSMC NADI Jan 29/0111 UTC 2009 UTC.

Tropical Cyclone HETTIE 08F [995hPa] centre was located near
22 decimal 6 South 177 decimal 8 West at 290000 UTC.
Position Fair.
Repeat position 22.6S 177.8W at 290000 UTC.
Cyclone moving south-southwest at about 7 knots.
Expect sustained winds of 35 knots within 240 nautical miles of
centre
in the southeastern quadrant.

Forecast position near 23.7S 178.9W at 291200 UTC.
and near 24.2S 179.7E at 300000 UTC.

All vessels within 300 nautical miles of centre are requested to
send
reports every three hours. VOS reporting ships use normal channels.
Other vessels fax plus 679 6720190 or email naditcc at met dot gov
dot fj.

This warning cancels and replaces warning 031.
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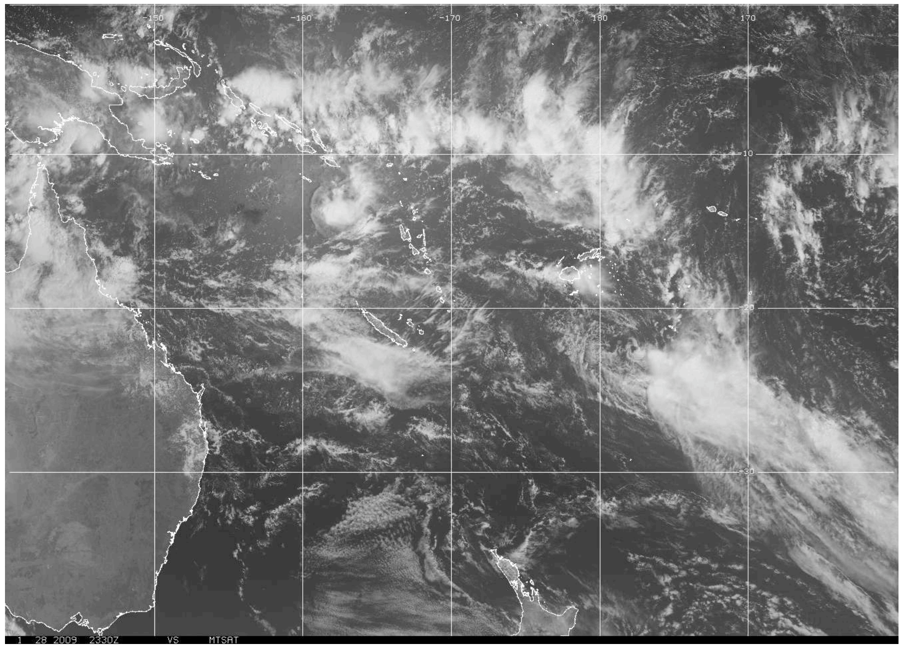
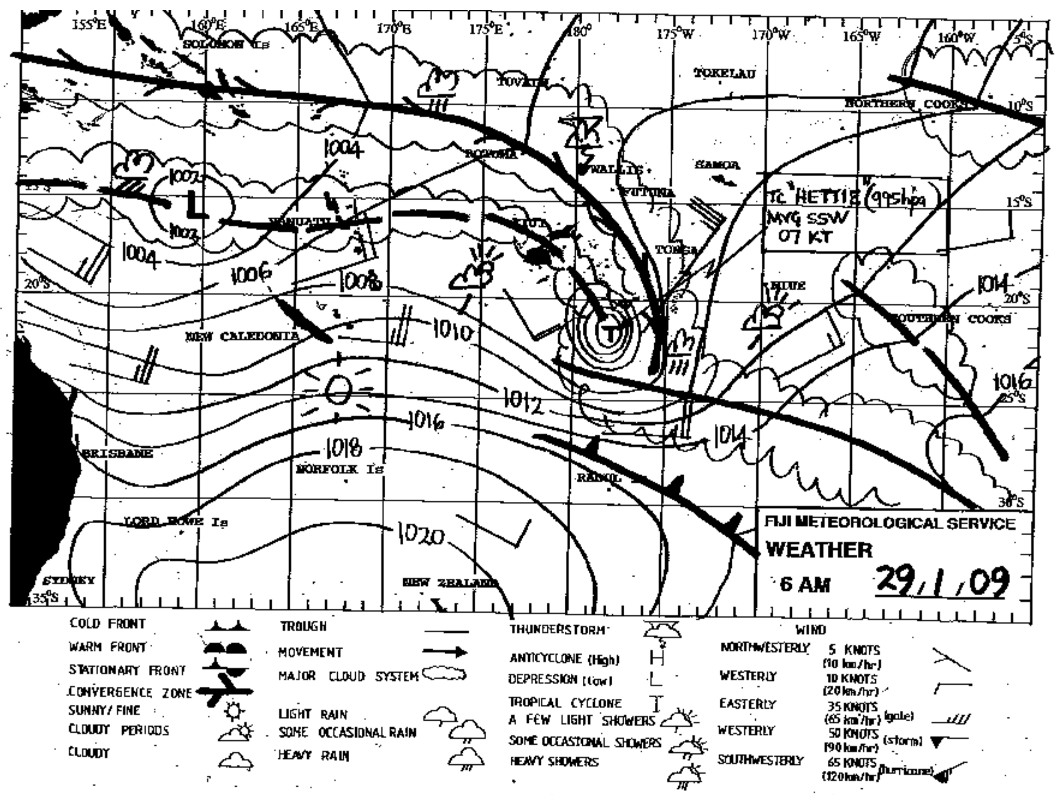
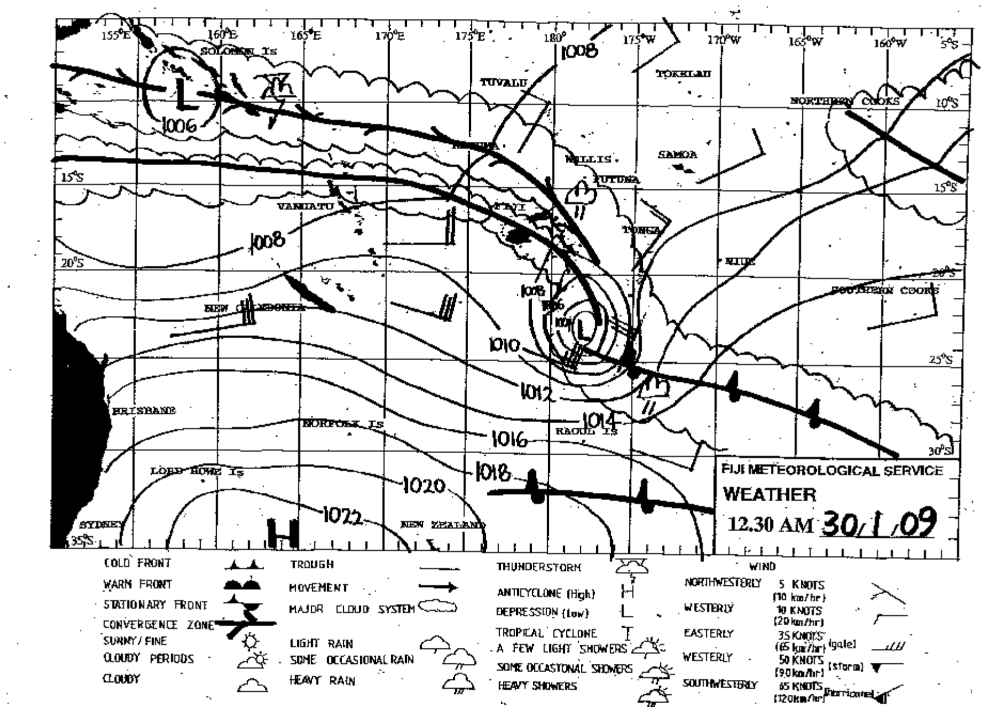
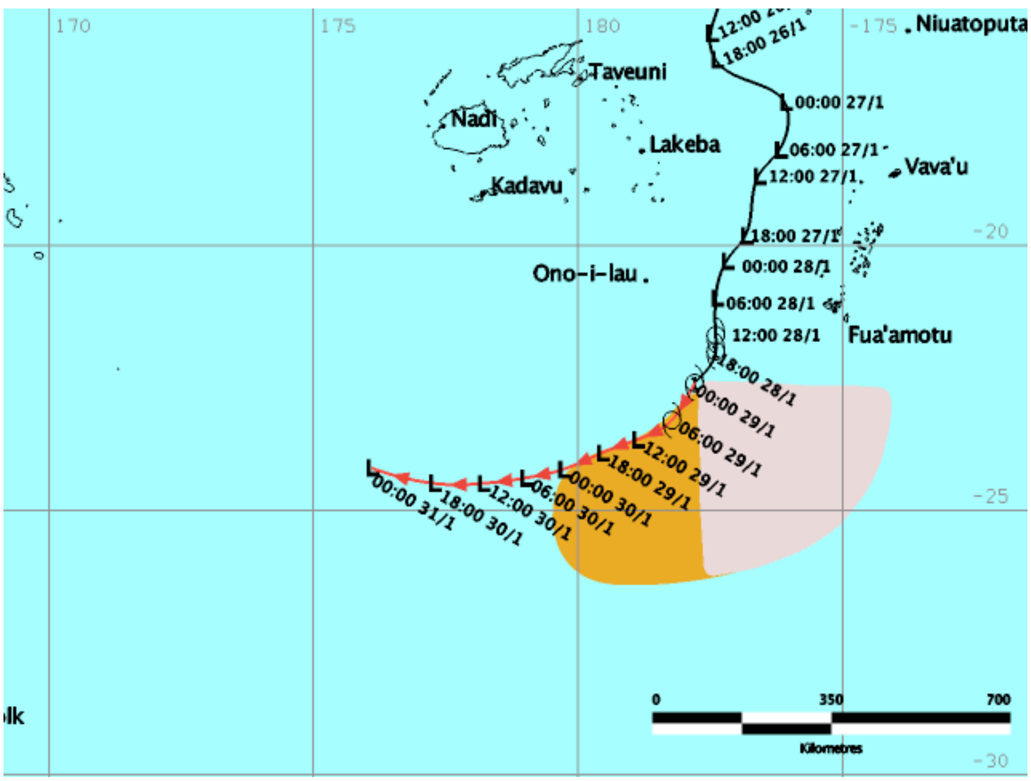




30 Jan 2009 – This morning the weather has cleared considerably and the sea state is much improved. We passed through several squalls last night and expect those to continue, since we are sitting in a large “monsoon trough” weather-wise. Cyclone Hettie continues southward and has lost its cyclone status. We are still having problems with string #2 and guns #9&10 on string #4 haven’t worked at all (bad module?). So at the end of our second shot line we are pulling in strings #2 and #4 for more fixing (we pulled in #2 last night at the beginning of this shot line for repairs that only partially worked).





31 Jan 2009 – Calm seas and light showers. Continued shooting east-west lines over deployment A. Guns have required repairs during most of the turns, air leaks and drop-outs, but the repairs are quick (~1.5-2 hours each) and performed at the full 4.5 knots and at the ends of the lines where the full source is less important. The repairs are burdensome, but break up the monotony. Weather forecast continues to look good.

1 Feb 2009 – Calm seas no showers. Continued shooting east-west lines over deployment A. Schedule continues to slip due to gun problems.

2 Feb 2009 – Calm seas no showers earlier in the day; a little swell and showers later in the day. Continued shooting east-west lines over deployment A. Dropped the ends of half-a-dozen shot lines due to delays resulting from gun problems. Once these east-west lines are completed, we should be back on schedule. Apparently Tom's torque wrench used to tighten the bolts on the guns etc. is untrustworthy – i.e., he doesn't trust the calibration scale – and he is unsure if the bolts are set at the right torque. This may be part of the cause of some of the gun problems. We tested a depressor today for the magnetometer. The issue there is that it must be towed well behind the ship to avoid data corruption from the ship's structure. However, the magnetometer cannot be towed past the guns for fear of entangling the cable with the guns. The magi manufacturer does make a depressor and a weight set designed to push the tow depth below the gun depth allowing for a longer ship-to-magi offset, but we don't have that aboard, so we are designing one of our own. Initial tests indicate that it is a little small, so we will do some more modifications and tests tomorrow.

3 Feb 2009 – Calm seas and gray skies with occasional showers. Regional weather looks good overall. There is a large low-pressure system developing 400 km to the west-north-west and is so far stationary in location. Fernando edited the bathymetry that we have collected so far to date. Looks good. He was even able to clean up the very noisy data that we collected the night of the cyclone. Gun one on string one went down today. We pulled it in and the shield around the solenoid block had literally torn loose (1/4" steel) due to the guns crashing into each other during recoil on firing. Lamont needs to consider attaching spreader bars on the gun clusters, especially the front ones, since this recoil problem appears to be the source of many of our gun woes and has resulted in a lot of lost time and data during this experiment.

4 Feb 2009 – Ended East-west lines for deployment A and began north-south lines. Had one gun problem at the end of the first line, but was easily fixed after pulling in String #1. The guns have been better behaved for the past 36 hours. Magi depressor tests did not turn out as well as hoped and we won't tow it behind the guns.

5 Feb 2009 – Calm seas good weather, continued shooting. Continued repairing guns as necessary. Depressor tests for magnetometer fail. We will tow Maggie forward of guns.

6 Feb 2009 – The gun array seemed to fall apart this morning beginning around 5:30 am. Air leaks, gun loss, miss firing, cross firings, and other inexplicable problems. We pulled in #3 and the gunners worked on it for some time, meanwhile #2 fell apart. We went off line and began 20 s shots to sort it all out. By turning various guns on and off and switching coms and power links Anthony and team were able to get most of the array back up to full power. We went back online and continued down the shot line, but we will need to go back and reshoot the missed portion of the line later. The tropical depression that was west of us has moved south-west of us. Though it continues to move southward, things could get nasty for us if it were to hook north. For that reason, we'll continue shooting the main lines while the weather is good, rather than loop back around to pick up the lost line. Lots of complaints from the gunners that they do not have enough spare parts aboard. We are starting to fall behind schedule bit by bit due to the gun problems. We have about 3 days of shooting left before picking up the first 25 instruments and before bringing in the guns for a major overhaul.

7 Feb 2009 – Calm seas good weather. Continuing shooting north-south lines. Added a small 6 hour loop to the experiment to re-shoot a section of line that we missed yesterday due to the gun problems. Finished the day without any further gun problems.

8 Feb 2009 – Calm seas and sunny weather. The topical depression to our southwest continued moving south last night, entering cool waters and eventually faded away. Weather looks exceptional for the next 2-3 days at the least. We had a BBQ on the sundeck tonight. It was enjoyed greatly by all. We have been shooting a long time and everyone needed something new.

9 Feb 2009 – Calm seas and scattered showers.

10 Feb 2009 – Finished last shot of the first shot campaign at just before 1100 local. The guns and PAM were out of the water in a little over an hour after that. We then had the first OBS aboard by 1330. The next instrument was aboard after another 1.5 hours.

11 Feb 2009 – Continued good weather; instrument recoveries progressing rapidly.

15 Feb 2009 – Completed recoveries several days earlier. All 25 instruments were aboard in ~36 hours. We then redeployed all 25 instruments in about 19 hours start-to-finish. By Feb 13 0800 local we were deploying the guns and lining up for the first shot line. Shot Campaign II will take about 9 days and we may have some time for a few more shot lines than planned. Found out yesterday that our Tongan permits for operating in their EEZ are unclear as to when we would need to be finished with all research activities. Our main permit lasts until March 3, and although we were to understand that we had an extension until March 11, the extension was not clearly verified via a letter from the Tongan government. Rupert at the marine office swears that we are OK to continue operations after the 3rd, but it is painfully clear that the paperwork is not in order. He has been in contact with the State Dept. for clarification, but it looks like that clarification will need to come from the U.S. Embassy in Fiji (which also services Tongan requests). We are all waiting to hear the outcome. Came across two fishing vessels late in the day. They had out long lines. We skirted the tail buoy of the closest line by maybe 90 meters just as the sun set.

16 Feb 2009 – Calm seas and weather. Continued shooting; continued to have miscellaneous gun problems. Still not enough spare parts.

17 Feb 2009 – Same. Lost full volume for a good portion of one of the north-south lines on the western side of the ridge. Decided not to loop around to fill the gap since we do not have permission to operate here after the 3rd and we need to continue filling in the grid.

18 Feb 2009 – More "assurances" from the marine office about the Tongan extension. And then finally an admission that the Tongan's have not yet given us the date change permission and that we will be operating after March 3 in violation of the current agreement. Rupert is looking into getting the continuation and also some clarification as to whether we must stop all activities on March 3 or just the airgun activity. Permission to have gear on the seafloor after March 3 is all we need to carry out the cruise plan, since shooting will stop before March 3 in any case.

20 Feb 2009 – Capt'n received some clarification from the marine office as to whether we can have gear on the seafloor after March 3. The answer is affirmative, so we will stick to the plan and continue shooting the lines for Campaign II. Although we will be pulling in the guns around the 25th or so, we need the time after March 3rd to pull up the instruments if there are any delays due to weather or instruments.

23 Feb 2009 – Still working on reading the SEGY seismic data files from the two groups. The file formats have changed and also the two OBS groups, which are supposed to form a coherent instrument pool, do not use the same information in the SEG-Y headers.

24 Feb 2009 – Found mistake in SIO header (lat and lon swapped by accident) and that should clear up things immensely. Working on analysis code to pick the data using either OBS group's format; also Michaela is writing an instrument relocation code to use the water waves to locate the instrument seafloor positions.

25 Feb 2009 – Last shot at 0400 LT (shot #113119). Our last lines included re-shooting some areas where we did not have full gun volume, and we re-shot 7 previously shot lines so that we could stack the data for better returns, since initial analysis of the data revealed poor mantle returns. Guns were out of the water by ~0600 LT and we started recovering instruments at first light. Instrument recoveries progressing rapidly due to mild sea state. Fernando started laying out his tracks for surveying the western basin. The lack of a Tongan permit after the 3rd is still a pain in the neck as far as the surveying is concerned. First we rushed through the seismic experiment to get it done and now we will rush through the mapping phase. We may need to do all Tongan areas first and then proceed to Fijian waters. Capt'n is concerned about "shallow areas" in the survey plan. Shoals are marked on his charts, but they look to be in 2000+ meters of water according to the existing multibeam data.

26 Feb 2009 – Emailed Kelepi Mafi at the Tongan Ministry that is in charge of vetting our permits. I told him that our current permits runs out on March 3 and was wondering if he had seen our request for extension. He was very apologetic that we had not received the permission, and that he had not yet seen our UN request form. He later replied that he would see to it that the appropriate cabinet minister would see our request.

27 Feb 2009 – No word from Kelepi today, other than a request for collaboration with Fernando Martinez to write up something on the Tonga-Kermadec Ridge which he needs for an extended continental shelf claim by his government. Looks like we won't get the extension in time. Soon we will begin executing an alternate plan.

28 Feb 2009 – Pulled up last OBS at ~2100 LT. The good weather facilitated getting all instruments up in record time (1.5 hours station-to-station). 100% instrument recovery; 84 total deployments and 84 recoveries. Secured deck, including deck winch used for instrument recoveries; deployed magnetometer, turned on multi-beam and 3.55 KHz systems, which had been turned off for instrument recoveries (pings interfere with ability to talk to instruments). Transited west to begin geophysical mapping.

01 March 2009 – Mapping all day along EEZ border in Tongan waters in order to complete Tongan regions before permit runs out. The coverage we are getting is not optimal.

02 March 2009 – Kelepi wrote to say that the request wasn't considered last week, but it would be considered at a March 4th cabinet meeting. Unfortunately that is too late and we have already rushed through our plans to be "finished" by the 3rd midnight.

03 March 2009 – Continued mapping. Western basin shows signs of more recent volcanism. Also sediments here are easily penetrated by the 3.55KHz system, unlike the volcanoclastics to the east of the spreading center.

04 March 2009 - Continued mapping. Heard that our extension was approved during yesterdays cabinet meeting.

05 March 2009 – Continued mapping.

06 March 2009 – Continued mapping.

07 March 2009 - Continued mapping. Heading to port.

08 March 2009 – In port.

Time Line

Event	Time Mark Panned (days)	Time Mark Actual (days)	Notes
Departure	0	0.02	Jan 24 0800 (LT) Expected
Finished release tests	.85	1.04	
Finished deploying OBS grid A	4.53	3.26	1.27 days ahead of schedule
Deploy Guns and begin A lines	4.83	4.93	0.1 days behind schedule 1st line started on Jan 29 @ 0054 local time
Completed east-west lines numbered18-28.	8.89	9.16	(4.06 days expected / 4.23 days of actual shooting) 6.5 hours behind schedule Shortened some east-west lines to save time.
Completed all east-west lines for deployment A	10.5	10.9	(5.67 days expected / 5.77 days actual shooting)
Completed all north-south lines for deployment A – guns recovered	17.2 (by 1 pm Feb 10 local)	17.17	(6.7 days for N-S lines expected) Completed 10 Feb 1200
Recovered 25 Instruments	20.35	18.7	0100 Feb 12 LT
Redeployed ## Instruments	21.47	19.77	0330 Feb 13 all deployed
Finished North-South Lines II			
Finished East-West Lines II	30.67	31.92	(Midnight Feb 23 expected/ 0400 LT Feb 25 actual – added extra lines)
All instruments Recovered	38.07	35.5	(10 am March 3 expected; Feb 28 9 pm actual)
Geophysical Mapping	41.5	42.5	
Transit to Suva	43	43	(Arrive 0800 LT expected)

Calendar Day Conversion

Day	JDay	UTC Day		Day	JDay	UTC Day		Day	JDay	UTC Day
0	24	24 Jan 2009								
1	25	25 Jan 2009		16	40	09 Feb 2009		31	55	24 Feb 2009
2	26	26 Jan 2009		17	41	10 Feb 2009		32	56	25 Feb 2009
3	27	27 Jan 2009		18	42	11 Feb 2009		33	57	26 Feb 2009
4	28	28 Jan 2009		19	43	12 Feb 2009		34	58	27 Feb 2009
5	29	29 Jan 2009		20	44	13 Feb 2009		35	59	28 Feb 2009
6	30	30 Jan 2009		21	45	14 Feb 2009		36	60	01 Mar 2009
7	31	31 Jan 2009		22	46	15 Feb 2009		37	61	02 Mar 2009
8	32	01 Feb 2009		23	47	16 Feb 2009		38	62	03 Mar 2009
9	33	02 Feb 2009		24	48	17 Feb 2009		39	63	04 Mar 2009
10	34	03 Feb 2009		25	49	18 Feb 2009		40	64	05 Mar 2009
11	35	04 Feb 2009		26	50	19 Feb 2009		41	65	06 Mar 2009
12	36	05 Feb 2009		27	51	20 Feb 2009		42	66	07 Mar 2009
13	37	06 Feb 2009		28	52	21 Feb 2009		43	67	08 Mar 2009
14	38	07 Feb 2009		29	53	22 Feb 2009				
15	39	08 Feb 2009		30	54	23 Feb 2009				

Local Time (Tongan) is GMT+13

Instrument Drop Points

Instrument Group A Drop Order and Positions

Drop Order	Site No.	Drop Longitude (˚)	Drop Latitude (˚)	Water Depth (m)	Inst. Man.
1	**1**	-176˚ 03.103	-20˚ 58.239	2406	W
2	**24**	-176˚ 11.918	-20˚ 56.570	2202	S
3	**23**	-176˚ 07.041	-20˚ 55.177	2293	S
4	**2**	-176˚ 02.158	-20˚ 53.810	2416	W
5	**3**	-176˚ 01.192	-20˚ 49.380	2334	W
6	**4**	-175˚ 59.153	-20˚ 45.139	2200	W
7	**5**	-175˚ 59.229	-20˚ 40.529	2255	S
8	**6**	-175˚ 57.740	-20˚ 36.789	2285	S
9	**7**	-175˚ 57.319	-20˚ 31.614	2242	S
10	**8**	-175˚ 56.345	-20˚ 27.167	2289	S
11	**9**	-176˚ 00.395	-20˚ 24.066	2431	S
12	**10**	-176˚ 04.736	-20˚ 25.588	2452	S
13	**11**	-176˚ 01.408	-20˚ 28.491	2411	S
14	**12**	-176˚ 05.204	-20˚ 30.094	2447	S
15	**13**	-176˚ 02.291	-20˚ 32.968	2333	S
16	**14**	-176˚ 06.199	-20˚ 34.533	2425	S
17	**15**	-176˚ 03.277	-20. 37.402	2313	S
18	**16**	-176˚ 07.203	-20˚ 39.002	2416	S
19	**17**	-176˚ 04.267	-20˚ 41.841	2300	W
20	**18**	-176˚ 08.398	-20˚ 43.362	2330	W
21	**19**	-176˚ 05.396	-20˚ 46.225	2304	W
22	**20**	-176˚ 09.338	-20˚ 47.513	2217	W
23	**21**	-176˚ 06.147	-20˚ 50.738	2389	W
24	**22**	-176˚ 10.626	-20˚ 52.206	2099	W
25	**25**	-176˚ 13.370	-20˚ 53.974	2247	W
26	**26**	-176˚ 16.805	-20˚ 55.638	2422	W
27	**27**	-176˚ 15.811	-20˚ 51.196	2483	W
28	**28**	-176˚ 12.362	-20˚ 49.547	2143	W
29	**29**	-176˚ 14.697	-20˚ 46.790	2359	W
30	**30**	-176˚ 11.266	-20˚ 45.134	2129	W
31	**31**	-176˚ 13.708	-20˚ 42.390	2480	S
32	**32**	-176˚ 10.465	-20˚ 40.662	2215	S
33	**33**	-176˚ 10.186	-20˚ 38.271	2418	S
34	**34**	-176˚ 12.794	-20˚ 37.916	2567	S
35	**35**	-176˚ 09.488	-20˚ 36.229	2469	S
36	**36**	-176˚ 09.039	-20˚ 33.984	2540	S
37	**37**	-176˚ 11.847	-20˚ 33.460	2541	S
38	**38**	-176˚ 08.511	-20˚ 31.786	2511	S
39	**39**	-176˚ 10.733	-20˚ 29.047	2656	S
40	**40**	-176˚ 10.402	-20˚ 26.794	2663	S
41	**41**	-176˚ 07.653	-20˚ 27.353	2418	S
42	**42**	-176˚ 09.880	-20˚ 24.600	2704	S
43	**43**	-176˚ 06.626	-20˚ 22.886	2364	S
44	**44**	-176˚ 12.969	-20˚ 21.655	2343	S
45	**45**	-176˚ 13.777	-20˚ 26.146	2375	S
46	**46**	-176˚ 14.756	-20˚ 30.599	2375	W
47	**47**	-176˚ 15.716	-20˚ 35.016	2273	W
48	**48**	-176˚ 16.684	-20˚ 39.478	2367	W
49	**49**	-176˚ 17.638	-20˚ 43.947	2365	W
50	**50**	-176˚ 18.595	-20˚ 48.384	2432	W
51	**51**	-176˚ 19.500	-20˚ 52.827	2250	S
52	**52**	-176˚ 24.599	-20˚ 54.168	2408	S
53	**53**	-176˚ 23.572	-20˚ 49.737	2413	S
54	**54**	-176˚ 22.652	-20˚ 45.304	2330	S
55	**55**	-176˚ 21.700	-20˚ 40.848	2243	S

56	**56**	-176˚ 20.722	-20˚ 36.407	2313	S
57	**57**	-176˚ 19.739	-20˚ 31.718	2032	S
58	**58**	-176˚ 18.719	-20˚ 27.228	2259	S
59	**59**	-176˚ 17.830	-20˚ 23.045	2447	S

Instrument Group B Drop Order and Positions

Drop Order	Site No.	Drop Longitude (˚)	Drop Latitude (˚)	Water Depth (m)	Inst. Man
1	**60**	-176˚ 17.868	-20˚ 18.417	2298	W
2	**61**	-176˚ 17.582	-20˚ 13.856	2390	W
3	**62**	-176˚ 16.702	-20˚ 09.788	2607	W
4	**63**	-176˚ 15.653	-20˚ 04.944	2623	W
5	**64**	-176˚ 11.596	-20˚ 08.067	2466	W
6	**65**	-176˚ 12.548	-20˚ 12.493	2489	W
7	**66**	-176˚ 13.528	-20˚ 16.906	2317	S
8	**67**	-176˚ 10.040	-20˚ 19.863	2365	S
9	**68**	-176˚ 07.316	-20˚ 18.115	2758	S
10	**69**	-176˚ 09.637	-20˚ 15.374	2421	S
11	**70**	-176˚ 06.350	-20˚ 13.674	2780	S
12	**71**	-176˚ 08.671	-20˚ 10.933	2583	S
13	**72**	-176˚ 07.700	-20˚ 06.455	2712	S
14	**73**	-176˚ 05.331	-20˚ 09.223	2675	S
15	**74**	-176˚ 02.147	-20˚ 07.460	2504	W
16	**75**	-175˚ 58.868	-20˚ 10.501	2352	W
17	**76**	-176˚ 02.892	-20˚ 12.011	2382	W
18	**77**	-175˚ 59.842	-20˚ 14.927	2432	W
19	**78**	-176˚ 04.191	-20˚ 16.421	2445	W
20	**79**	-176˚ 04.984	-20˚ 20.910	2392	W
21	**80**	-176˚ 01.103	-20˚ 19.282	2416	W
22	**81**	-175˚ 57.062	-20˚ 22.408	2132	W
23	**82**	-175˚ 56.649	-20˚ 17.570	2150	W
24	**83**	-175˚ 55.146	-20˚ 13.491	2207	W
25	**84**	-175˚ 54.202	-20˚ 09.144	2259	W

Instrument Recoveries

Instrument Recovery Group A (partial)

Rec. Order	Drop Longitude (˚)	Drop Latitude (˚)	Drop No.	Instr. Type	Recovery Longitude (˚)	Recovery Latitude (˚)	Drift (m)	Drift Az. (˚)
1	-176˚ 21.700	-20˚ 40.848	55	S	-176 21.552	-20 40.961	344	127
2	-176˚ 17.638	-20˚ 43.947	49	W	-176 17.592	-20 43.908	089	050
3	-176˚ 22.652	-20˚ 45.304	54	S	-176 22.718	-20 45.378	183	222
4	-176˚ 18.595	-20˚ 48.384	50	W	-176 18.618	-20 48.446	122	200
5	-176˚ 23.572	-20˚ 49.737	53	S	-176 23.603	-20 49.868	250	193
6	-176˚ 24.599	-20˚ 54.168	52	S	-176 24.706	-20 54.331	359	213
7	-176˚ 19.500	-20˚ 52.827	51	S	-176 19.435	-20 52.899	179	138
8	-176˚ 16.805	-20˚ 55.638	26	W	-176 16.845	-20 55.794	298	194
9	-176˚ 13.370	-20˚ 53.974	25	W	-176 13.375	-20 53.962	024	000
10	-176˚ 15.811	-20˚ 51.196	27	W	-176 15.803	-20 51.231	067	167
11	-176˚ 12.362	-20˚ 49.547	28	W	-176 12.330	-20 49.567	070	122
12	-176˚ 14.697	-20˚ 46.790	29	W	-176 14.644	-20 46.792	098	92
13	-176˚ 11.266	-20˚ 45.134	30	W	-176 11.239	-20 45.184	106	152
14	-176˚ 13.708	-20˚ 42.390	31	S	-176 13.670**	-20 42.514**	241	163
15	-176˚ 08.398	-20˚ 43.362	18	W	-176 08.418	-20 43.414	104	201
16	-176˚ 05.396	-20˚ 46.225	19	W	-176 05.350	-20 46.149	165	31
17	-176˚ 09.338	-20˚ 47.513	20	W	-176 09.261	-20 47.462	171	57
18	-176˚ 06.147	-20˚ 50.738	21	W	-176 06.157	-20 50.699	075	346
19	-176˚ 10.626	-20˚ 52.206	22	W	-176 10.556	-20 52.139	179	46
20	-176˚ 11.918	-20˚ 56.570	24	S	-176 11.852	-20 56.547	129	71
21	-176˚ 07.041	-20˚ 55.177	23	S	-176 06.951	-20 55.055	281	36
22	-176˚ 03.103	-20˚ 58.239	1	W	-176 03.215	-20 58.217	211	281
23	-176˚ 02.158	-20˚ 53.810	2	W	-176 02.123	-20 53.702	210	18
24	-176˚ 01.192	-20˚ 49.380	3	W	-176 01.115	-20 49.319	182	52
25	-175˚ 59.153	-20˚ 45.139	4	W	-175 59.076	-20 45.020	263	33

**On deck position, not hook position.

Instrument Recovery Group A (remaining) and B

Drop No.	Drop Lat (˚)	Drop Lon (˚)	Instr. Type	Inst. No.	Recovery Lon. (˚)	Recovery Lat. (˚)
84	-20˚ 09.144	-175˚ 54.202	W	D34	20 09.059	175 54.353
83	-20˚ 13.491	-175˚ 55.146	W	D03	20 13.395	175 55.164
82	-20˚ 17.570	-175˚ 56.649	W	D25	20 17.506	175 56.621
81	-20˚ 22.408	-175˚57.062	W	D50	20 22.349	175 57.097
8	-20˚ 27.167	-175˚ 56.345	S	57	20 27.121	175 56.382
7	-20˚ 31.614	-175˚ 57.319	S	58	20 31.544	175 57.319
6	-20˚ 36.789	-175˚ 57.740	S	60	20 36.171	175 57.800
5	-20˚ 40.529	-175˚ 59.229	S	47	20 40.596	175 59.163
17	-20˚ 41.841	-176˚ 04.267	W	D39	20 41.819	176 04.176
32	-20˚ 40.662	-176˚ 10.465	S	SP094	20 40.650	176 10.371
48	-20˚ 39.478	-176˚16.684	W	D51	20 39.503	176 16.598
56	-20˚ 36.407	-176˚ 20.722	S	38	20 36.440	176 20.622
57	-20˚ 31.718	-176˚ 19.739	S	61	20 31.663	176 19.634
58	-20˚ 27.228	-176˚ 18.719	S	13	20 27.135	176 18.603
59	-20˚ 23.045	-176˚ 17.830	S	019	20 23.033	176 17.579
60	-20˚ 18.417	-176˚ 17.868	W	D44	20 18.509	176 17.808
61	-20˚ 13.856	-176˚ 17.582	W	D15	20 13.966	176 17.424
62	-20˚ 09.788	-176˚ 16.702	W	D62	20 09.827	176 16.611
63	-20˚ 04.944	-176˚ 15.653	W	D08	20 04.930	176 15.593
64	-20˚ 08.067	-176˚ 11.596	W	D32	20 08.008	176 11.515
72	-20˚ 06.455	-176˚ 07.700	S	SP-086	20 06.397	176 07.662

73	-20˚09.223	-176˚ 05.331	S	SP-085	20 09.218	176 05.297
74	-20˚ 07.460	-176˚ 02.147	W	D11	20 07.387	176 02.146
75	-20˚ 10.501	-175˚ 58.868	W	D49	20 10.467	175 58.853
77	-20˚ 14.927	-175˚ 59.842	W	D09	20 14.888	175 59.763
80	-20˚ 19.282	-176˚ 01.103	W	D10	20 19.191	176 01.048
9	-20˚ 24.066	-176˚ 00.395	S	95	20 24.095	176 00.408
11	-20˚ 28.491	-176˚ 01.408	S	10	20 28.546	176 01.370
13	-20˚ 32.968	-176˚ 02.291	S	136	20 32.979	176 02.242
15	-20. 37.402	-176˚ 03.277	S	0078	20 37.309	176 03.207
16	-20˚ 39.002	-176˚ 07.203	S	093	20 38.849	176 07.166
33	-20˚ 38.271	-176˚ 10.186	S	0001	20 38.173	176 10.242
34	-20˚ 37.916	-176˚ 12.794	S	SP-092	20 37.911	176 12.827
47	-20˚ 35.016	-176˚ 15.716	W	D40	20 35.047	176 15.744
46	-20˚ 30.599	-176˚ 14.756	W	D07	20 30.625	176 14.765
45	-20˚ 26.146	-176˚ 13.777	S	SP-138	20 26.201	176 13.536
44	-20˚ 21.655	-176˚ 12.969	S	SP-141	20 21.730	176 12.735
66	-20˚ 16.906	-176˚ 13.528	S	3	20 16.771	176 13.462
65	-20˚ 12.493	-176˚ 12.548	W	D26	20 12.337	176 12.481
71	-20˚ 10.933	-176˚ 08.671	S	0056	20 10.755	176 08.671
70	-20˚ 13.674	-176˚ 06.350	S	SP-088	20 13.552	176 06.423
76	-20˚ 12.011	-176˚ 02.892	W	D55	20 12.023	176 02.883
78	-20˚ 16.421	-176˚ 04.191	W	D02	20 16.470	176 04.126
79	-20˚ 20.910	-176˚ 04.984	W	D06	20 20.917	176 04.988
10	-20˚ 25.588	-176˚ 04.736	S	17	20 25.585	176 04.732
12	-20˚ 30.094	-176˚ 05.204	S	75	20 30.087	176 05.151
14	-20˚ 34.533	-176˚ 06.199	S	002	20 34.420	176 06.206
35	-20˚ 36.229	-176˚ 09.488	S	SP-089	20 36.128	176 09.538
36	-20˚ 33.984	-176˚ 09.039	S	090	20 33.943	176 09.159
37	-20˚ 33.460	-176˚ 11.847	S	0032	20 33.529	176 11.966
38	-20˚ 31.786	-176˚ 08.511	S	0021	20 31.908	176 08.574
39	-20˚ 29.047	-176˚ 10.733	S	0055	20 29.198	176 10.810
40	-20˚ 26.794	-176˚ 10.402	S	SP-139	20 26.901	176 10.388
41	-20˚ 27.353	-176˚ 07.653	S	SP-137	20 27.408	176 07.648
42	-20˚ 24.600	-176˚ 09.880	S	0027	20 24.622	176 09.855
43	-20˚ 22.886	-176˚ 06.626	S	0077	20 22.863	176 06.645
67	-20˚19.863	-176˚ 10.040	S	SP-087	20 19.769	176 10.091
68	-20˚ 18.115	-176˚ 07.316	S	SP-140	20 18.021	176 07.386
69	-20˚ 15.374	-176˚ 09.637	S	0007	20 15.281	176 09.648

Shot Line Log Campaigns I and II

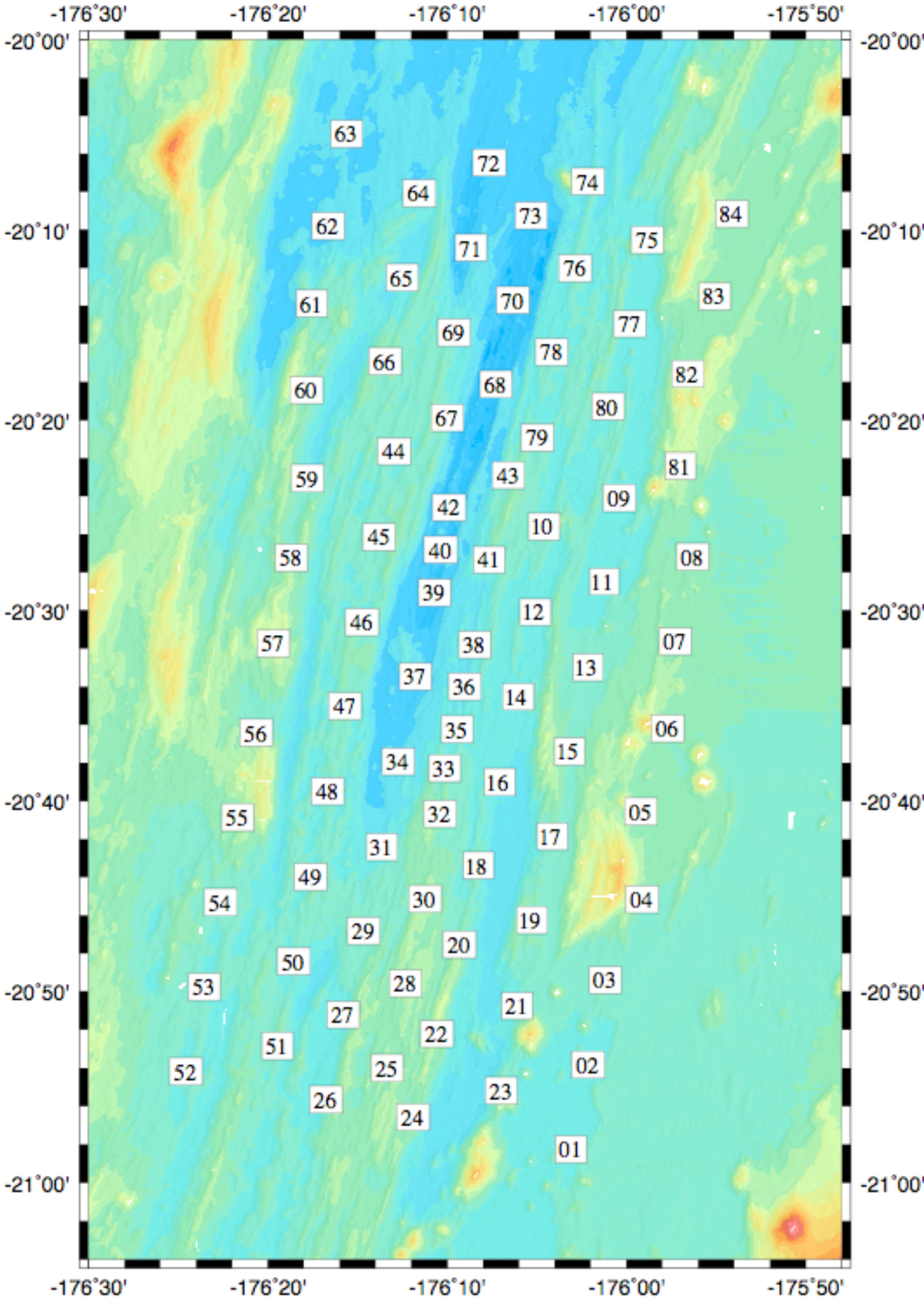
Seq #	Line #	Date	Time (UTC)	Date	Time (UTC)
1	Lau_Ax001				
2	Lau_A002	-	-	-	-
3	Lau_A028	29-Jan-09	00:54:00	29-Jan-09	10:01:18
4	Lau_A027	29-Jan-09	11:58:06	29-Jan-09	19:57:33
5	Lau_A026	29-Jan-09	22:52:00	30-Jan-09	07:11:37
6	Lau_A025	30-Jan-09	07:40:09	30-Jan-09	16:19:59
7	Lau_A024	30-Jan-09	16:46:52	31-Jan-09	01:34:16
8	Lau_A023	31-Jan-09	02:00:58	31-Jan-09	10:41:55
9	Lau_A022	31-Jan-09	11:11:57	01-Jan-09	19:34:40
10	Lau_A021	31-Jan-09	20:04:36	01-Feb-09	01:12:55
11	Lau_A022A	01-Feb-09	01:51:03	01-Feb-09	02:47:51
12	Lau_A021	01-Feb-09	03:12:38	01-Feb-09	08:00:02
13	Lau_A020	01-Feb-09	08:28:26	01-Feb-09	17:06:32
14	WTURNS	01-Feb-09	17:11:17	01-Feb-09	17:33:00

15	Lau_A019	01-Feb-09	17:33:37	02-Feb-09	00:28:16
16	Lau_A018	02-Feb-09	01:02:23	02-Feb-09	06:28:04
17	WTURNS	02-Feb-09	06:41:45	02-Feb-09	06:52:41
18	Lau_A017	02-Feb-09	06:59:59	02-Feb-09	12:32:00
19	ETURNS	02-Feb-09	12:36:00	02-Feb-09	12:56:00
20	Lau_A016	02-Feb-09	13:00:25	02-Feb-09	18:18:00
21	WturnB	02-Feb-09	18:24:40	02-Feb-09	18:45:00
22	Lau_A015	02-Feb-09	18:47:17	03-Feb-09	01:29:39
23	Lau_A014	03-Feb-09	02:11:30	03-Feb-09	10:35:49
24	Lau_A014A	03-Feb-09	10:44:33	03-Feb-09	12:08:13
25	Lau_A014B	03-Feb-09	12:11:42	03-Feb-09	13:50:28
26	Lau_A014C	03-Feb-09	13:52:51	03-Feb-09	18:24:07
27	Lau_A013	03-Feb-09	18:29:12	04-Feb-09	04:19:31
28	Lau_A013A	04-Feb-09	04:27:06	04-Feb-09	04:55:36
29	Lau_A012	04-Feb-09	04:58:09	04-Feb-09	13:01:02
30	Lau_A012A	04-Feb-09	13:11:51	04-Feb-09	13:22:09
31	Lau_A011	04-Feb-09	13:25:06	04-Feb-09	21:43:01
32	Lau_A011A	04-Feb-09	21:53:50	04-Feb-09	22:07:19
33	Lau_A010	04-Feb-09	22:15:28	05-Feb-09	08:14:49
34	Lau_A010A	05-Feb-09	08:19:35	05-Feb-09	08:36:05
35	Lau_A009	05-Feb-09	08:37:41	05-Feb-09	18:39:33
36	Lau_A009A	05-Feb-09	18:48:57	05-Feb-09	19:06:17
37	Lau_A008	05-Feb-09	19:15:00	05-Feb-09	21:24:19
38	Lau_A008	5-Feb-09	22:23:00	05-Feb-09	22:27:00
39	Lau_A008	5-Feb-09	22:30:00	06-Feb-09	05:30:35
40	Lau_A007	6-Feb-09	05:44:13	06-Feb-09	17:09:57
41	Lau_A006	6-Feb-09	17:38:07	07-Feb-09	04:58:52
42	Lau_A006A	7-Feb-09	05:05:10	07-Feb-09	05:17:10
43	Lau_A005	7-Feb-09	05:18:10	07-Feb-09	15:03:05
44	Lau_A028A	7-Feb-09	15:15:57	07-Feb-09	15:50:36
45	Lau_A008R	7-Feb-09	15:53:51	07-Feb-09	18:59:22
46	Lau_A005A	7-Feb-09	19:19:07	07-Feb-09	22:23:58
47	Lau_A005	7-Feb-09	22:30:48	08-Feb-09	00:06:14
48	Lau_A005B	8-Feb-09	00:12:11	08-Feb-09	00:23:26
49	Lau_A004	8-Feb-09	00:25:46	08-Feb-09	10:01:53
50	Lau_A004A	8-Feb-09	10:09:50	08-Feb-09	10:21:41
51	Lau_A003	8-Feb-09	10:24:00	08-Feb-09	18:31:34
52	Lau_A003A	8-Feb-09	18:35:07	08-Feb-09	18:51:16
53	Lau_A002	8-Feb-09	18:54:04	09-Feb-09	04:51:36
54	Lau_A002A	9-Feb-09	05:13:57	09-Feb-09	05:21:26
55	Lau_A001	9-Feb-09	05:24:09	09-Feb-09	15:26:45
56	Lau_A001A	9-Feb-09	15:45:35	09-Feb-09	19:26:53
57	Lau_A001B	9-Feb-09	19:30:25	09-Feb-09	21:51:34

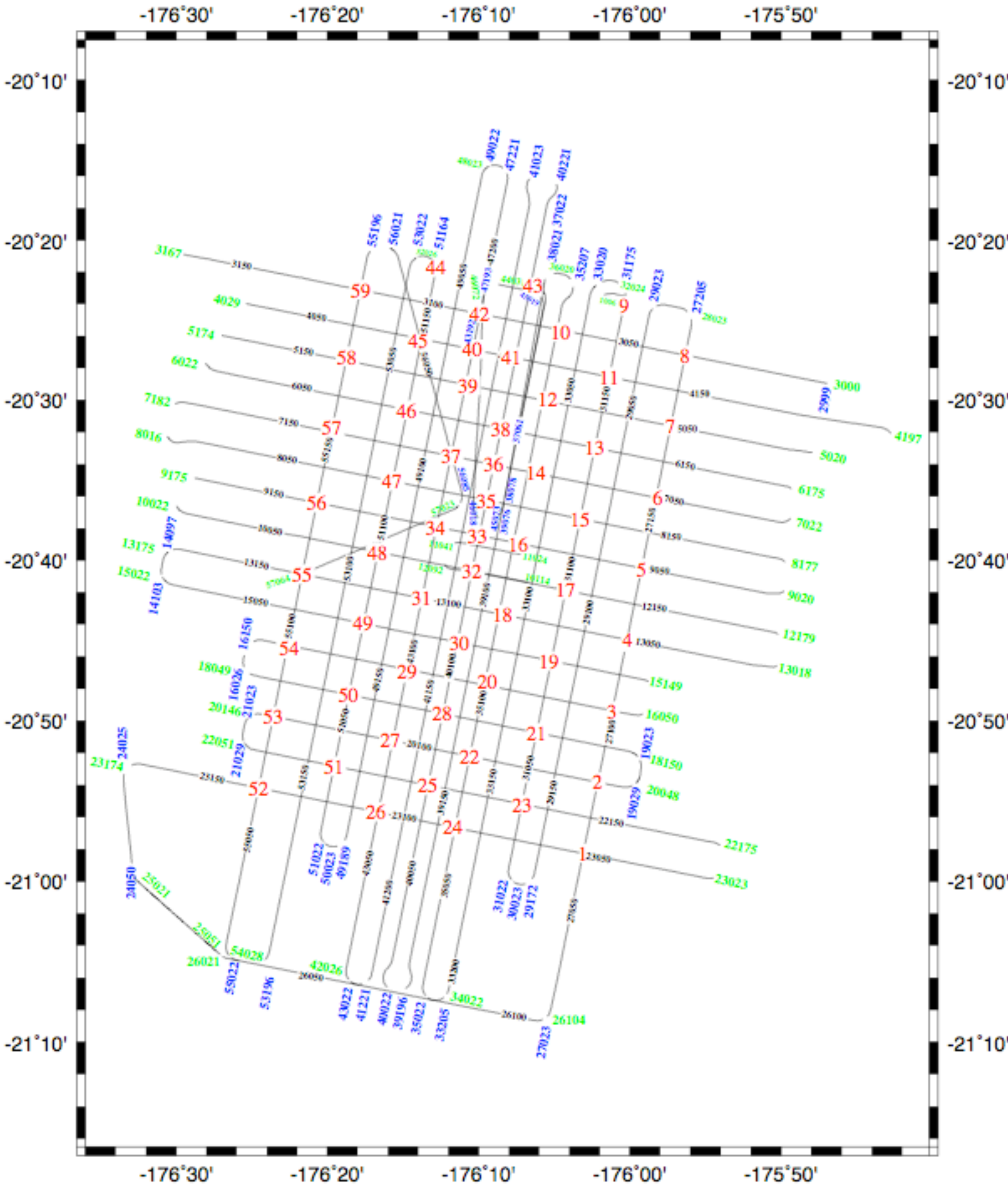
Seq #	Line #	Date	Time (UTC)	Date	Time (UTC)
58	Lau_B001	12-Feb-09	23:48:59	13-Feb-09	07:56:34
59	Lau_B001B	13-Feb-09	07:59:44	13-Feb-09	08:11:58
60	Lau_B002	13-Feb-09	08:37:21	13-Feb-09	17:47:23
61	Lau_B002A	13-Feb-09	17:49:44	13-Feb-09	18:08:57
62	Lau_B003	13-Feb-09	18:13:52	14-Feb-09	02:31:53
63	Lau_B004	14-Feb-09	03:12:44	14-Feb-09	11:48:01
64	Lau_B004A	14-Feb-09	11:51:15	14-Feb-09	12:07:30
65	Lau_B005	14-Feb-09	12:13:17	14-Feb-09	21:35:52
66	Lau_B005A	14-Feb-09	21:39:04	14-Feb-09	21:55:52
67	Lau_B006	14-Feb-09	21:57:29	15-Feb-09	07:48:07
68	Lau_B006A	15-Feb-09	07:49:50	15-Feb-09	08:13:35
69	Lau_B007	15-Feb-09	08:37:06	15-Feb-09	18:17:31
70	Lau_B007A	15-Feb-09	18:23:39	15-Feb-09	18:39:10
71	Lau_B008	15-Feb-09	18:44:10	16-Feb-09	05:27:43
72	Lau_B009	16-Feb-09	07:21:26	16-Feb-09	16:55:33
73	Lau_B009A	16-Feb-09	16:58:52	16-Feb-09	17:16:01
74	Lau_B010	16-Feb-09	17:17:51	17-Feb-09	02:54:30
75	Lau_B010A	17-Feb-09	02:57:21	17-Feb-09	03:05:27
76	Lau_B011	17-Feb-09	03:19:49	17-Feb-09	12:07:22
77	Lau_B011A	17-Feb-09	12:10:00	17-Feb-09	12:33:36
78	Lau_B012	17-Feb-09	12:39:15	17-Feb-09	19:04:00
79	Lau_B012A	17-Feb-09	19:07:56	17-Feb-09	19:24:24
80	Lau_B013	17-Feb-09	19:25:38	18-Feb-09	03:41:25
81	Lau_B013A	18-Feb-09	03:45:10	18-Feb-09	04:02:30
82	Lau_B014	18-Feb-09	04:45:24	18-Feb-09	12:32:37
83	Lau_B014A	18-Feb-09	12:55:47	18-Feb-09	15:38:15
84	Lau_B015	18-Feb-09	15:46:00	19-Feb-09	00:19:12
85	Lau_B015A	19-Feb-09	00:39:45	19-Feb-09	00:50:23
86	Lau_B016	19-Feb-09	01:17:40	19-Feb-09	09:44:50
87	Lau_B016A	19-Feb-09	09:47:22	19-Feb-09	10:10:34
88	Lau_B017	19-Feb-09	10:13:24	19-Feb-09	19:14:08
89	Lau_B017A	19-Feb-09	19:16:17	19-Feb-09	19:40:32
90	Lau_B018	19-Feb-09	20:10:55	20-Feb-09	03:33:00
91	Lau_B018A	20-Feb-09	03:37:17	20-Feb-09	03:56:14
92	Lau_B019	20-Feb-09	04:40:09	20-Feb-09	10:00:28
93	Lau_B019A	20-Feb-09	10:04:29	20-Feb-09	10:22:50
94	Lau_B020	20-Feb-09	10:24:53	20-Feb-09	17:04:04
95	Lau_B020A	20-Feb-09	17:06:52	20-Feb-09	17:29:43
96	Lau_B021	20-Feb-09	17:32:20	21-Feb-09	02:23:56
97	Lau_B021A	21-Feb-09	02:26:17	21-Feb-09	02:33:58
98	Lau_B022	21-Feb-09	03:23:08	21-Feb-09	11:39:41
99	Lau_B022A	21-Feb-09	11:47:23	21-Feb-09	12:02:11
100	Lau_B023	21-Feb-09	12:16:34	21-Feb-09	16:36:00
101	Lau_B006R	21-Feb-09	16:42:37	22-Feb-09	03:35:52

102	Lau_B006RA	22-Feb-09	03:41:05	22-Feb-09	03:41:05
103	Lau_B007R	22-Feb-09	04:06:55	22-Feb-09	14:54:06
104	Lau_B023B	22-Feb-09	14:57:15	22-Feb-09	16:49:28
105	Lau_B002R	22-Feb-09	17:03:34	23-Feb-09	03:48:12
106	Lau_B015R	23-Feb-09	04:08:02	23-Feb-09	04:08:02
107	Lau_B015R	23-Feb-09	04:21:26	23-Feb-09	07:57:13
108	Lau_A001R	23-Feb-09	08:12:41	23-Feb-09	12:25:20
109	Lau_B013R	23-Feb-09	12:28:41	23-Feb-09	19:24:37
110	Lau_B023A	23-Feb-09	19:39:42	23-Feb-09	19:44:09
111	Lau_B012R	23-Feb-09	20:00:43	24-Feb-09	02:44:44
112	Lau_B011R	24-Feb-09	03:13:59	24-Feb-09	10:01:27
113	Lau_B024A	24-Feb-09	10:07:58	24-Feb-09	15:05:05

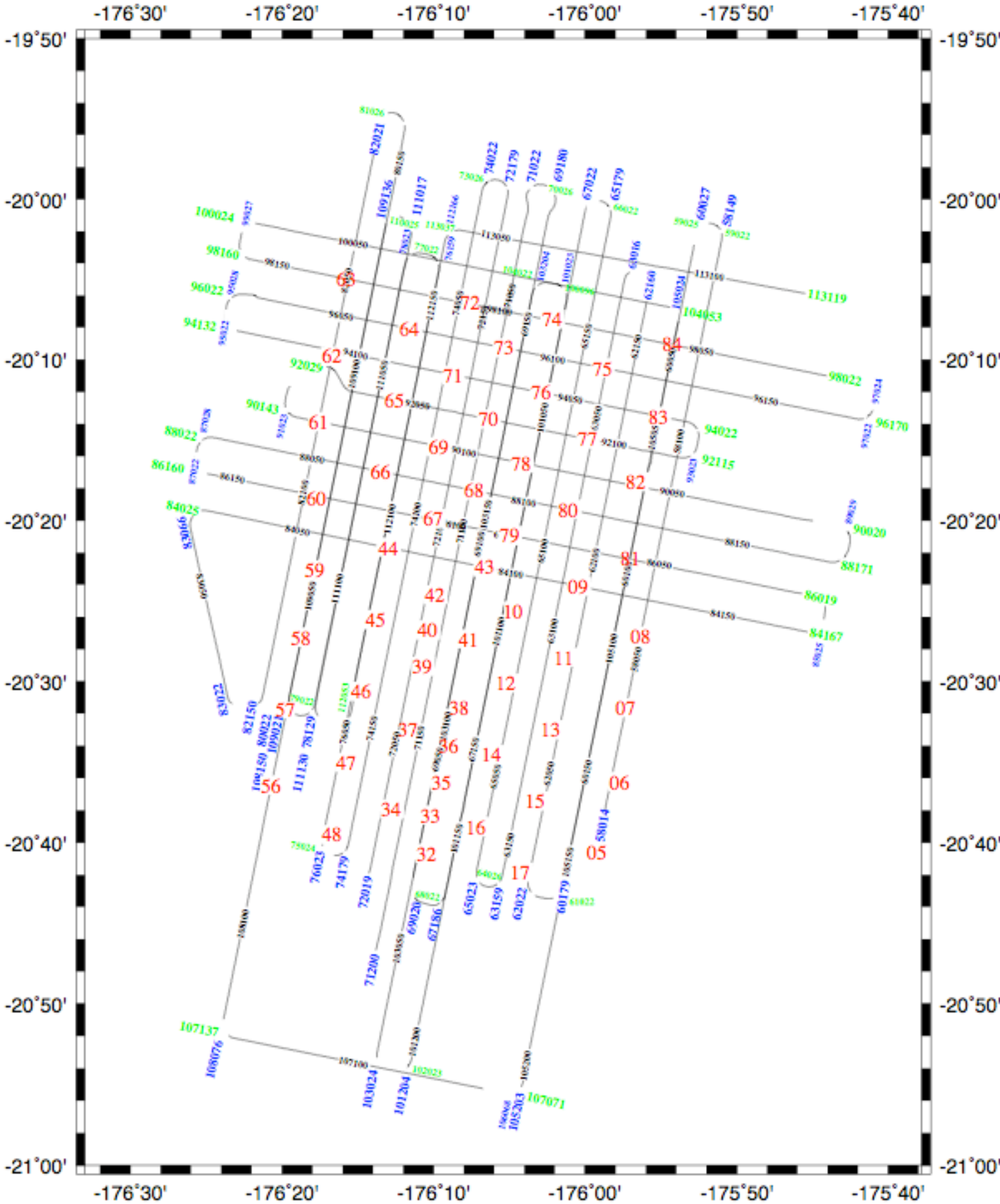
Instrument Deployment Map



Shot Line Map – Campaign I



Shot Line Map – Campaign II



Summary OBS Recovery Rates

Site	Time			
Number	*Surface*	*Hooked*	*On Deck*	*SOI/W*
84	18:13	18:20	18:23	W
83	19:34	19:45	19:48	W
82	21:06	21:16	21:19	W
81	22:26	22:36	22:39	W
8	0:17	0:21	0:23	S
7	1:37	1:42	1:44	S
6	3:04	3:25	3:27	S
5	4:40	4:49	4:52	S
17	6:10	6:19	6:22	W
32	7:45	7:52	7:55	S
48	9:11	9:19	9:21	W
56	10:42	10:45	10:48	S
57	12:01	12:12	12:17	S
58	13:38	13:46	13:48	S
59	15:06	15:38	15:42	S
60	17:00	17:14	17:16	W
61	18:34	18:40	18:43	W
62	19:52	19:58	20:00	W
63	21:14	21:21	21:23	W
64	22:38	22:47	22:49	W
72	0:07	0:14	0:16	S
73	1:29	1:35	1:37	S
74	2:46	2:52	2:54	W
75	4:11	4:16	4:18	W
77	5:31	5:38	5:40	W
80	6:54	7:02	7:04	W
9	8:25	8:31	8:33	S
11	9:53	9:58	10:01	S
13	11:21	11:29	11:31	S
15	12:57	13:02	13:05	S
16	14:29	14:37	14:39	S
33	15:49	16:00	16:03	S
34	17:16	17:24	17:28	S
47	18:44	18:50	18:52	W
46	20:11	20:14	20:17	W
45	22:03	22:10	22:13	S
44	23:34	23:43	23:46	S
66	1:01	1:05	1:07	S
65	2:27	2:36	2:38	W
71	4:07	4:16	4:18	S
70	5:39	5:47	5:50	S
76	6:52	6:57	6:58	W
78	8:25	8:36	8:38	W
79	10:07	10:11	10:13	W
10	11:35	11:43	11:47	S
12	13:09	13:17	13:38	S
14	15:06	15:18	15:21	S
35	16:37	16:43	16:46	S
36	17:54	18:04	18:06	S
37	19:18	19:21	19:23	S

38	20:34	20:38	20:41	S
39	22:00	22:05	22:08	S
40	23:25	23:33	23:35	S
41	0:37	0:43	0:45	S
42	1:57	2:04	2:06	S
43	3:20	3:31	3:33	S
67	4:44	4:54	4:56	S
68	6:08	6:18	6:20	S
69	7:29	7:36	7:38	S

Instrument Performance

Instrument performance was examined during the cruise by plotting record sections of the data. **The analysis of channel noise in the following two tables is qualitative only; and is based on a quick look at 2 hours of data when there were no airgun shots recorded.** Flag oscillation noise effects random sections of the signal on the SIO 3-component instruments. Instrument noise spikes and square-wave noise affects large amounts of the SIO 3-component instruments.

Deployment 1

Site #	Instr. #	Data Recorded (MBytes in SEGY files not raw)	Recorded Channels				Comments
			X	Y	Z	H	(WHOI: X=EL1; Y=EL2; Z=ELZ; H=EDH) (SIO: X=0; Y=1; Z=2; H=3)
							G=Good; D=Dead; n=some noise; N = HighNoise; S = Spikes; s = spikes but probably useful N or n may indicate low output of the sensor or high environmental noise.
1.1	D15	975	G	G	G	G	
1.2	D44	975	G	G	G	G	
1.3	D02	975	G	n	G	G	
1.4	D49	975	G	G	G	G	
1.5		4X466	S	S	S	G	
1.6		4X466	s	s	s	G	
1.7		4X466	S	S	s	G	
1.8		4X466	S	S	S	G	
1.9		4X466	s	s	s	G	
1.10		4X466	g	g	g	G	a little spiky but not too bad
1.11		4X466	S	S	s	G	
1.12		4X466	S	S	s	G	
1.13		4X466	s	D	s	n	
1.14		4X466	s	s	s	n	
1.15		4X466	S	S	S	n	
1.16		4X466	S	S	S	G	
1.17	D39	1.862GB	G	G	G	G	
1.18	D08	975	G	G	G	G	
1.19	D32	975	G	G	n	G	
1.20	D25	975	N	n	G	G	
1.21	D03	975	G	G	G	G	
1.22	D62	975	G	G	G	G	
1.23		4X0	D	D	D	D	Power failure shortly after launch

1.24	S140	4X244	S	S	s	G	
1.25	D55	975	G	G	G	G	
1.26	D34	975	G	G	G	G	
1.27	D09	975	N	N	N	G	
1.28	D31	975	G	G	G	G	
1.29	D11	975	G	N	G	G	
1.30	D26	975	G	G	G	G	
1.31		4X244	S	S	S	n	
1.32		4X466	S	S	S	n	
1.33		4X466	s	s	s	G	
1.34		4X466	S	S	s	G	
1.35		4X466	S	S	s	G	
1.36		4X466	S	S	s	G	
1.37		4X466	s	s	s	G	
1.38		4X466	s	s	s	G	
1.39		4X466	s	s	s	g	
1.40		4X466	s	s	S	g	
1.41		4X466	S	S	S	g	
1.42		4X466	S	S	S	G	
1.43		4X466	S	S	S	G	
1.44		4X466	S	D	S	G	
1.45		4X466	S	S	S	n	
1.46	D07	1.862 GB	G	G	G	G	
1.47	D47	1.862 GB	G	N	G	G	
1.48	D51	1.862 GB	G	G	G	G	Partially flooded – data drive good – usual clock correction not possible.
1.49	D06	975	n	n	G	G	
1.50	D10	975	G	G	G	G	
1.51		4X244	S	S	S	G	H is very good.
1.52		4X244	S	S	S	n	ringy noise on H; may be an environmental source
1.53		4X244	S	S	S	n	ringy noise on H; may be an environmental source
1.54		4X244	S	S	S	G	H is very good.
1.55		4X244	D	D	D	G	L28 not plugged in. Spikes appear in recorded “data” anyway, so this noise problem probably could have been observed in the lab with a simple look at the self-noise of the instrument.
1.56		4X466	S	D	N	G	
1.57		4X466	S	S	S	N	
1.58		4X466	S	S	S	G	
1.59		4X466	s	s	s	G	

Deployment 2

Site #	Instr. #	Data Recorded (MBytes in SEGY files not raw)	Good Channels				Comments
			X	Y	Z	H	
2.60	D44	888	G	G	G	G	
2.61	D15	888	G	G	G	G	
2.62	D62	888	G	G	G	G	
2.63	D08	888	G	G	G	G	Odd stuff on noise test records – disk spins?
2.64	D32	888	G	G	G	G	

2.65	D26	888	G	G	G	G	Odd stuff on noise test records – disk spins?
2.66		4X222	s	s	s	G	
2.67		4X222	s	s	s	G	
2.68		4X222	S	S	S	G	
2.69		4X222	s	s	s	G	
2.70		4X222	S	S	S	N	
2.71		4X222	S	S	s	G	
2.72		4X222	S	S	s	G	
2.73		4X44	S	S	s	G	
2.74	D11	888	G	G	G	G	
2.75	D49	888	G	G	G	G	
2.76	D55	888	G	G	G	G	
2.77	D09	888	G	G	G	G	
2.78	D02	888	G	G	G	G	
2.79	D06	888	G	G	G	G	
2.80	D10	888	G	n	G	G	
2.81	D50	888	G	G	G	G	
2.82	D25	888	G	G	G	G	
2.83	D03	888	D	G	G	G	
2.84	D34	888	G	G	G	G	Large spikes in test records (121-240) = pings to instrument for recovery.

Assessment of OBS Operations and Instrumentation

We deployed all 59 instruments initially; we then recovered 25 and immediately redeployed them for a total of 84 deployments and recoveries. Deployments took ~10 minutes on site and on average about 30-40 minutes from station to station to complete. This was much faster than planned (1 hour + transit as per OBSIP guidelines). Recoveries also took much less time than planned, 1.5 hours from the time one instrument landed on deck to the next (as compared to the 2.5 hours + transit as per OBSIP guidelines). Overall this saved us considerable time, time which was used to make up for lost time due to hurricane Hettie and problems with the guns. The instrument handlers worked long hard hours during the deployments and recoveries and should be commended for that effort.

WHOI: The WHOI D2 instrument is a small compact OBS. The sensor is decoupled from the electronics and battery package, resulting in low ocean current induced noise on the sensor. This is an indispensable feature of this instrument and all OBSIP instruments should have the geophone decoupled from the instrument body. The data was overall of very high quality with only a little instrument noise due to hard drives spinning once an hour or so (easily filtered out due to its high frequency). The usual ship noise is evident throughout much of the records.

On the down side, according to the captain the radio beacon was only detectable by the bridge just off the ship's bow. Dead flashers or heavy fog and these instruments could be lost. There were four WHOI instruments with partial recovery aides that we recovered during daylight hours.

For multi-deployment experiments, obtaining data at sea is indispensable (to assess firing intervals and other data acquisition parameters). Mini-seed data was readily available from the WHOI group, but not readable by the standard rdseed software. That was unfortunate and required us to cobble together a quick shot file to get a section of segy data for analysis. If a miniseed reader was available for general use, it would have saved us some time, since we didn't really need the shot gathered data at that point to assess the firing interval. A data *viewer* is not enough, since a scientist needs to be able to manipulate the data stream.

Micro-seismicity in the Lau basin is high (one identifiable earthquake every ~4 minutes). This background noise appeared to be the major source of noise on the WHOI instruments. At the time of this writing a full data check has not been made, but from the preliminary analysis it seems that any self-noise of the instrument is much less than the micro-seismic noise (apart from the drive noise mentioned earlier).

One ball leaked a small amount: about 1.5 pints of water including very fine sediment. The glass ball design makes it difficult to make any repairs aboard the ship. Luckily we did not need to redeploy this particular instrument.

SEGY cut files are 1.7 GB each for the stations deployed the longest and are too large to use efficiently. A better method would be to have separate files for each channel. WHOI cuts the channels together, SIO cuts them out separately. It would be better for the users for both groups to do it the same way (separate files for each channel).

SIO: The SIO instruments are frame-mounted devices attached to a large anchor. From an overall operational perspective, instrument recoveries and deployments were not appreciably longer or shorter than for the WHOI instruments, though the techs seemed to think otherwise. The radio beacon and flashers seem to work well for the SIO instruments.

Because the 3-component sensor is mounted to the frame and anchor, it picks up a considerable amount of current generated oscillation/noise; including a persistent ~6 and ~12 Hz "hum", probably due to the orange recovery flag, that comes and goes throughout the records depending on current speeds. Many hours of data on each instrument appear to be obliterated by this noise, because it is large enough to completely swamp the 3-component channels. Due to its very high amplitude, Butterworth band pass filtering does not remove this noise, but perhaps more exotic filtering would help.

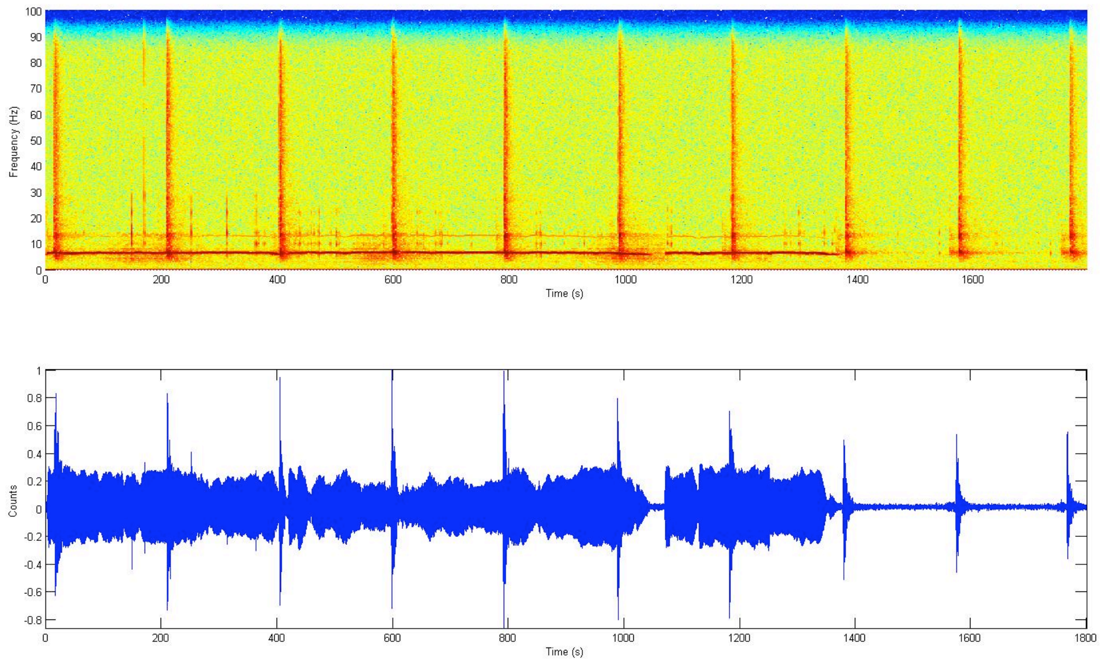


Figure. (Possible) flag or other current-induced noise on the vertical channel.

Almost all 3-component channels examined to date exhibit strong instrument noise of unknown origin that appears as large partially-aliased spikes separated by perhaps 60 ms, and at times what looks like a 4 Hz square wave, also of significant amplitude (a 4Hz spectral line can often be observed in the spectrograms). Preliminary analysis shows reveals spiky data on almost all 3-comp. channels; we have not yet examined all records for the 4-Hz "square" wave. Neither can be effectively filtered from the data. The spikes in particular are a form of white noise *that flatten the amplitude spectra of the data and make the records very ringy when high-pass filtered* (filtered spikes become sinc-like functions). If the 4Hz spectral line is truly a square wave, then it too cannot be effectively filtered out by a typical bandpass or highpass procedure due to its large bandwidth.

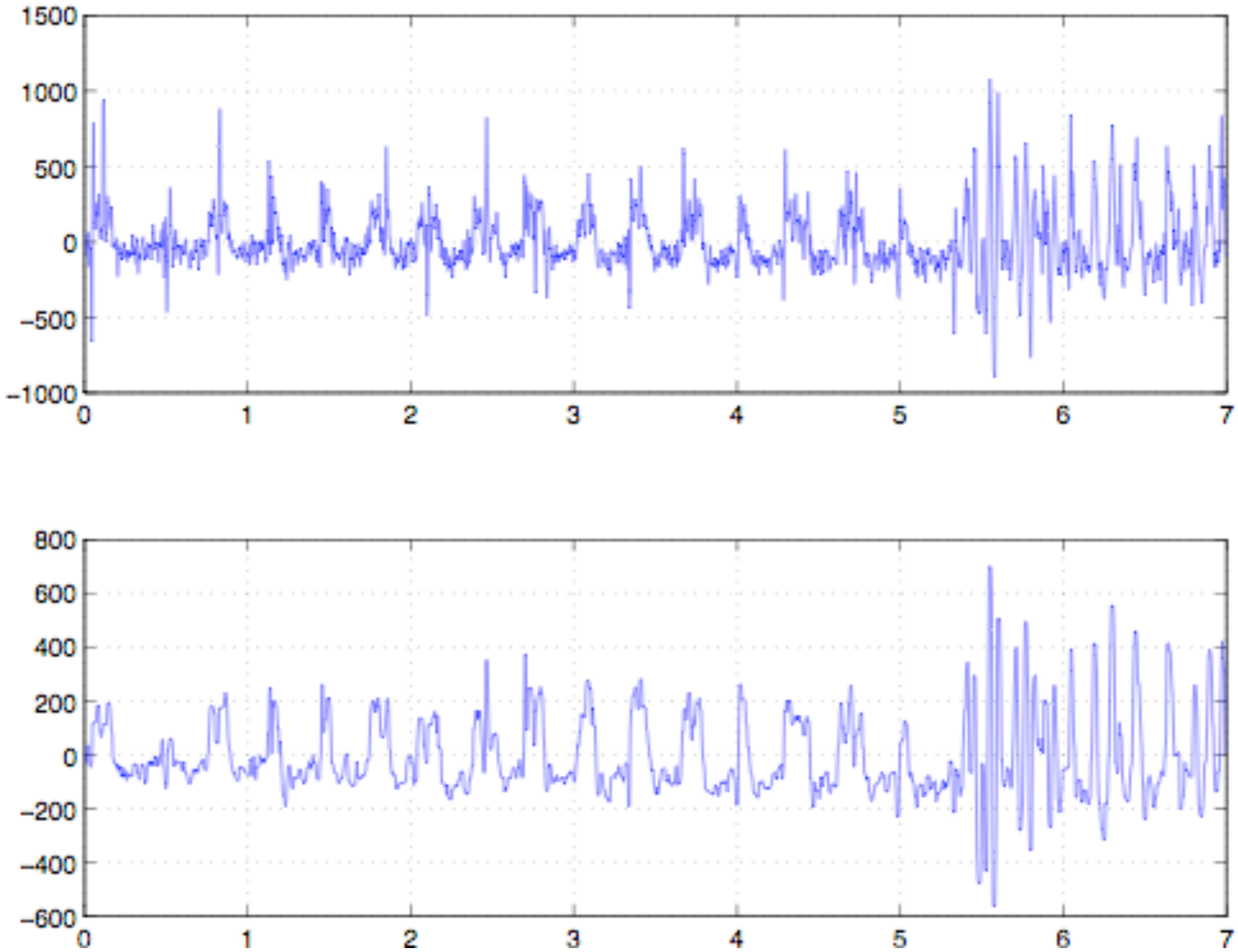


Figure. (**top**) Unfiltered record showing 4Hz square wave and noise spikes. Airgun arrival occurs at ~5.5 sec. into the trace. (**bottom**) Same data trace, but passed through a 5-point median filter.

The SIO hydrophone data for themost part looks very good; it does not suffer from either the flag problem or the instrument self-noise problem.

Passcal SEGY data (continuous data) was readily available from the SIO group and easily read by a psegy2mat program. This was very useful for getting a quick look at the data before re-deployment and shooting. All of the psegy continuous data and segy shot-cut data was provided on a 1TB disk to the PI at the end of the cruise. The SIO tech had to cut the data several times over several days due to missteps and mistakes in the header information and database (typos and bad math). Finding and following up on these problems was a huge waste of time for the science party and the SIO tech. Such mistakes would have been largely avoided if there was an agreed upon format for the Langseth shot log and a more careful data processing procedure.

Both Groups: **A simple spec sheet with channel configuration, sensor information, and a nominal sensor response should be provided.** Certain important details about the instruments were unknown by the instrument operators at sea. For example, each group records four channels, but what channel is what component of the instrument was not immediately known. Furthermore, the sign of the channels was (and still is) also unknown. Is inward pressure on the hydrophone a positive count or negative? Does the vertical component record vertical motion positive up or positive down? And what do the instruments actually record? Is it displacement, velocity, or acceleration? What about the hydrophone? Is it really pressure?

The two groups do not provide the same data products: the shot cut data do not have exactly the same header formats. Although different PIs may want different info in the header, all of the basic fields should be filled in and filled in the **same** manner. For example, SIO provides the trace start time and the shot time in different fields, because they are slightly different values, whereas the WHOI header only give the trace start time – the fact that the shot time is not exactly the same as the first sample time is lost and will generate a small amount of round-off noise in the data. Also, one group uses big-endian byte order, the other uses little-endian byte order. They should use the same.

It would be very useful if OBSIP, as a group, provided a couple of different types of data readers for their data. For example, segy2mat codes for matlab are available and an official OBSIP version would be greatly appreciated.

The OBSIP groups should agree upon a standard Shot Log format and then insist that the Langseth science techs provide that format and that format only. Since there is no standard, the shot log format causes considerable amounts of time to be wasted by the science and OBSIP parties (reformatting, misunderstanding of fields, etc).

In addition, because the OBS staging areas and Main science labs are located far from one another, the telephone was used to send drop location information from the Main Lab to the OBS lab. This led to several typos in the OBS database of drop points and thus typos in the SEGY headers. A better system would be to have the science party compile a well-checked list of the drop points for the OBS operators.

Assessment of Ship Operations

The planned experiment consisted of 77 OBS deployments along a 150 km section of the Eastern Lau Spreading Center with ~47 lines of ridge-parallel and ridge-perpendicular airgun shots to cover the area and provide seismic sources for imaging the crust and uppermost ~2 km of the mantle. Several days of contingency mapping in the western part of the basin were also planned.

Several days of weather (and marine mammal) contingency were built into the cruise plan, including contingency time for both OBS operations and shooting. After passing through Cyclone Hettie that occurred just after all OBS were deployed and caused 36-48 hours of delay, we had excellent weather. A big surprise to all was that we did not encounter any marine mammals during operations and we were not delayed on that score. We were able to make ~10% greater OBS deployments (84 versus 77) and we shot ~120-125% more seismic line than planned.

The A-frame winch used for OBS deployments is poorly located, being on the main deck and subject to the constant sloshing of seas over the starboard side. It shows significant rust, got stuck on us once, and may prove to cause problems down the road. Perhaps a better placement would be on the level above, with the controls at the A-frame. That would allow one operator to control both the A-frame and the winch, rather than the two operators that are currently required.

The main boom/winch and the CTD winches were inoperable and we instead used a streamer capstan, a rope, and several pulleys to perform the OBS release test. This test took ~6-7 hours longer than anticipated due to the inoperable winches.

During heavy seas significant water rushes over the starboard rail and could cause serious injury to OBS operators. Luckily we escaped such problems.

The gunners worked long hard hours and were very dedicated to keeping the airgun array fully functional and by the end of the cruise the airgun array was working almost flawlessly, however throughout most of the shooting we had multiple gun drop outs and many timing issues that required work at the ends of most of the seismic lines and in a few cases during the lines. We did loose full volume at the ends of the lines during repairs, which was better than loosing time to gun repairs (the Chief Scientists decision). I understand that the guns had not been used for several months, a contributing factor surely, but also there didn't seem to be enough spare parts aboard the ship for full maintenance of the problems.

The marine office did not have our permits fully in order to operate in Tongan waters and our permit expired 5 days before the end of the cruise forcing seismic operation to end early. This is an unbelievable oversight. The party in charge assured us via email that everything was in order even though it was clear to us that it was not and he did not understand that the captain was not about to risk his license over the issue. By the time it was finally admitted that the permits were not extended to the full cruise duration, it was too late to get the necessary paper work from the Tongans. We lost ~4-5 days of seismic work because of this. Luckily for us, we had such good weather that we were already ahead of schedule and by trimming off the ends of some expected lines and not shutting down for repairs, we were able to squeeze in all of the planned seismic lines. For the extra 5 days at the end where we didn't have Tongan permits, we carried out some underway-geophysical mapping in the western basin.

Pre-cruise the PI received good feedback concerning the cruise plan and science objectives from Anthony Johnson (tech in charge) and Jeff Rupert at the marine office. This feedback allowed me to redesign the experiment a bit to mesh better with the operational constraints of the ship - something that saved us much time later. The lack of full permits for the cruise window (discussed above) was clearly the low point of the cruise.

The cruise was scheduled in the middle of the cyclone season for that area. We lobbied for and received 4-5 extra weather days (1/3 chance of getting hit by a cyclone during the cruise) during the pre-cruise scheduling. We did get hit by Cyclone Hettie early on and lost a couple of days, but made that up as the cruise progressed due to subsequent excellent weather and no OBS problems. In the end, those extra days meant a world of difference in getting all of the science objectives completed. The scheduling process was very opaque and as Chief Scientist I felt that I was usually last to know of schedule changes and often found out through third parties. There was a last minute rearrangement of the inbound transit leg when it was "discovered" that Tonga would not be able to provide sufficient fuel for the ship. This was something I had previously pointed out to the Lamont marine office perhaps 2 months earlier, but was ignored. I ultimately provided them with an alternative: stop-over in Pago-Pago, Samoa for fuel.

The marine technical party was adequately staffed with seasoned veterans (and one new tech) who worked long hard hours to make sure all of our science objectives were met. Anthony Johnson was indispensable in getting this cruise through to completion. The science party worked well together and were willing to listen to each others' (and my) comments and criticisms and effectively modified operations to be as efficient as possible. They did an excellent job of training the watch standers and an excellent job of communicating their needs, thoughts, and concerns to the Chief Scientist. There was an unexpected strong sense of common purpose to achieve the science objectives. Lamont should know that they have a very good group here and I hope that the marine office considers their comments/concerns carefully. Also, Gunners need more spare parts to keep the guns going at top performance.

The marine techs should insist that OBSIP come up with an agreed-upon Standard Shot Log Format and then they should always provide that format and that format only. Since there is no standard, the shot log format changes cruise-to-cruise and causes considerable amounts of time to be wasted by the science party and the OBS party (reformatting, misunderstanding of fields, etc).

Days lost at sea due to weather and equipment: 2 lost days for Cyclone Hettie, but was absorbed in contingency time. Also 1-2 hours per day lost to gun repairs, but this time was also included in our contingency time. 6-8 hours lost due to inoperable winches (used a slow streamer spool instead as noted above); this was absorbed in contingency time. 4-5 days of lost seismic shooting due to missing permits performed mapping contingency instead.

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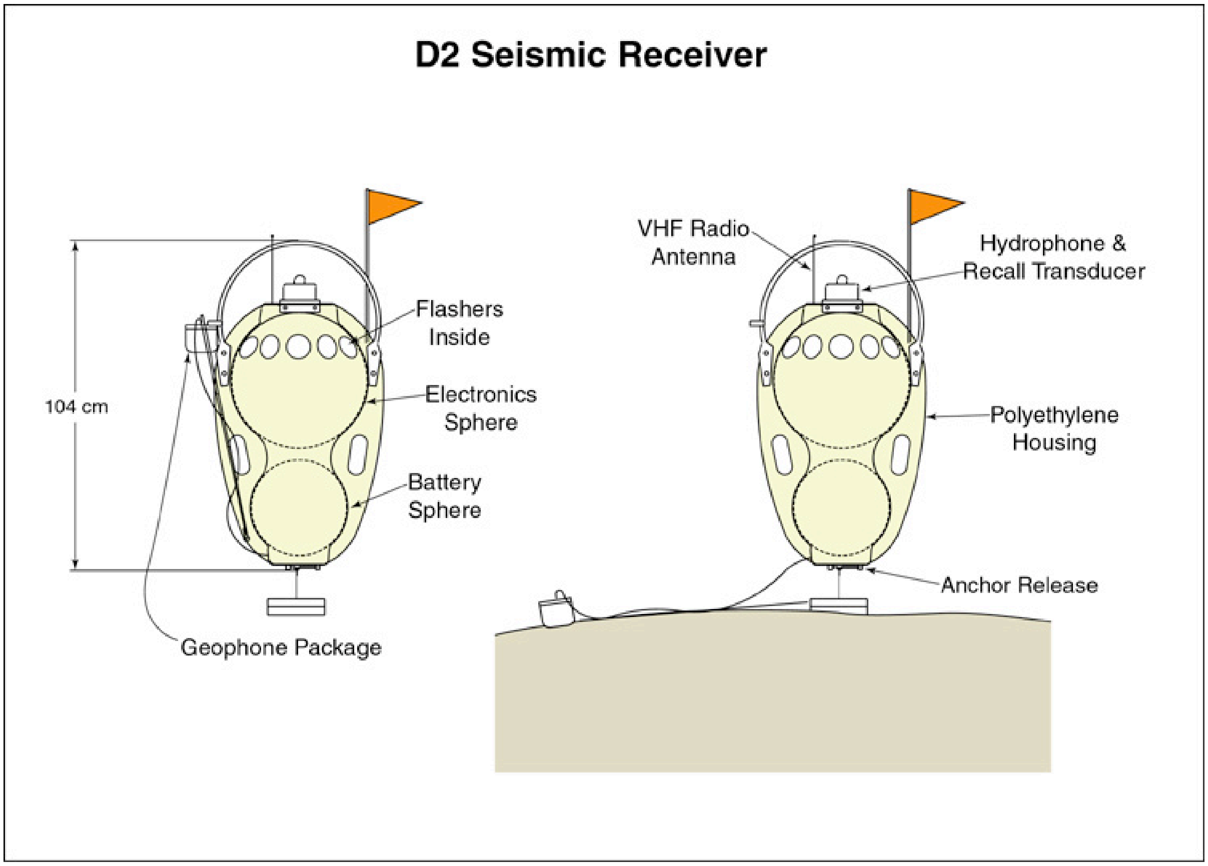
APPENDICES

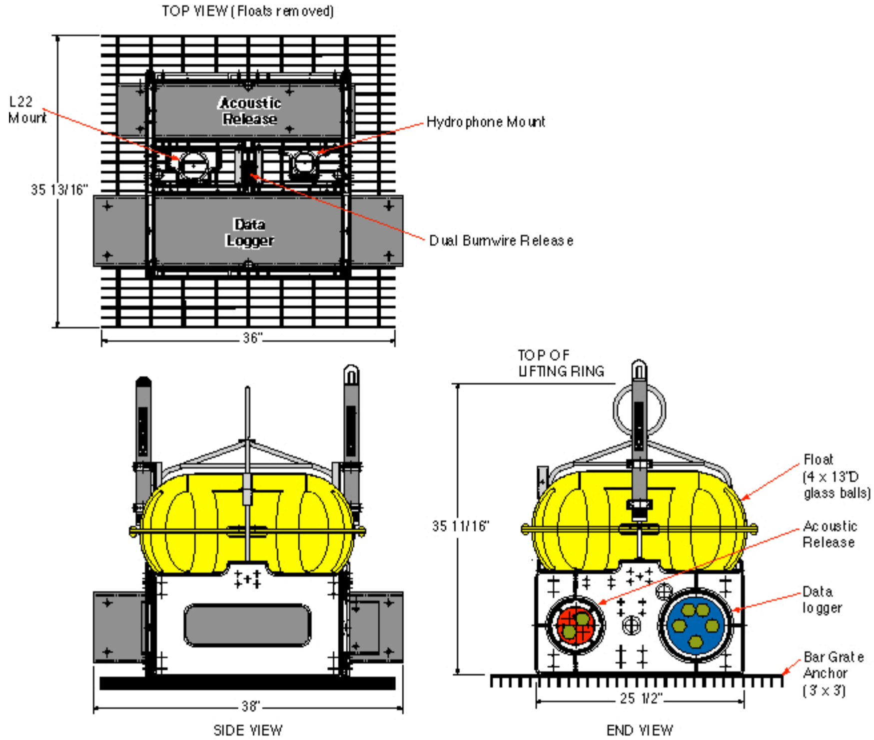
APPENDIX 1: OBS Instrument Configuration

WHOI OBS



Hydrophone: High Tech® HTI-90-U
Geophone: Geospace® 4.5 Hz GS-11D
Data Logger: Quanterra QA330 24-bit A/D. Dynamic range: 135 dB. Data compression.
Sample Rate: 200 Hz

Scripps OBS



Hydrophone: High Tech® HTI-90-U
Geophone: Mark L28 3-component geophone
Data Logger: L-Cheapo 2000 (LC2000)
Sample Rate: 200 Hz

Instrument Channels

SIO Instruments				
Channel	Description	Polarity	Output (Volts/):	Type
0	X		m/s	Mark L28
1	Y		m/s	Mark L28
2	Z		m/s	Mark L28
3	HYD		µPa	High Tech HTI-90-U
Convention for 3-comp.				

WHOI Instruments				
Channel	Description	Polarity	Output (Volts/):	Type
ELZ (1)	Vertical		m/s	Geospace 4.5 Hz GS-11D
EL1 (2)	North-South		m/s	Geospace 4.5 Hz GS-11D
EL2 (3)	East-West		m/s	Geospace 4.5 Hz GS-11D
EDH (4)	Hydrophone		µPa	High Tech HTI-90-U
Convention for 3-comp.				

- WHOI and presumably SIO instruments contain a two-ring Gimbals system that can be accidentally inverted within the sensor casing. If one ring is inverted, then the vertical component is up side down. If two rings are inverted, then the vertical is correct, but the horizontals are inverted (west becomes east and north becomes south).
- Martin R. says that SIO electronics do not invert the polarity.

Instrument Responses

Nominal Responses Type	Zeros	Poles	Corner Freq	Coil	Sensitivity	Damping
Mark L28	Two at zero	-19.79 + 20.19i -19.79 - 20.19i	4.5 Hz	120 ohms	20.4 V/m/s	0.7
Geospace 4.5 Hz GS-11D	Two at Zero	-19.792 -20.192i -19.792+20.192i	4.5 Hz	4000 ohms	32 V/m/s	0.7
High Tech HTI-90-U	0+0i -0.42553+0i	-29.5770+0i -0.36329+0i				

APPENDIX 2: WHOI OBSIP Cruise Report

L-SCAN experiment, Jan-Mar 2009
R/V Langseth

Summary:

The Ocean Bottom Seismograph (OBS) group at the Woods Hole Oceanographic Institution provided 20 “D2” instruments plus two spares (22 total) through the Ocean Bottom Seismograph Instrument Pool (OBSIP) in support of the “Lau Spreading Center Active source iNvestigation (L-SCAN). All deployments and recoveries, as well as the airgun work were handled from the R/V Langseth. Twenty-one D2 instruments were deployed initially. After shooting the airguns to these instruments, seventeen D2s were recovered. We then redeployed seventeen D2s at other sites further north. After another round of shooting, all 21 D2s on the bottom were recovered. In all there were 38 D2 deployments, and every one was successfully recovered and had recorded data over the entire deployment period.

The OBS group from Scripps Institute of Oceanography (SIO) was also present with 39 of their “L-CHEAPO” instruments. For deployments and recoveries, the OBSIP personnel were split into two 12-hour shifts, with at least one tech from each institution on each shift. This allowed for around the clock operations without regard to instrument type.

Deck operations:

Deployments and recoveries went without major incident, using the A-frame and a temporary electric winch to lift the instruments over the gunwale. This worked reasonably well, and was far preferable to the HIAB crane. The only major issue was that the line jumped the sheave several times. This complicated recoveries, twice forcing D2s to be hauled up by hand, and once forcing the HIAB to be used. The winch had some minor quirks and a switch failure, but fortunately these problems did not impede the recoveries. An issue that has been noted in past cruises on the Langseth is that tag lines can become jammed in the narrow gaps along the gunwale. This did not present a major difficulty, but it did require extra care and attention. The addition of cleats along the gunwale would ease the handling of tag lines. The D2s and support equipment were housed in a 20-foot lab van stored on the main deck. This is convenient for preparing instruments and debriefing them. Unfortunately, the deck is not flat, so the van twists as it is secured, jamming the double doors shut. All operations were carried out through the side door. There are times when being able to open the rear doors would be beneficial. A GPS antenna and an Iridium satellite phone antenna were mounted to the rails on the streamer deck when the ship was in port in Astoria, Oregon. These provide signals to the interior of the van. Upon arrival in Tonga, the GPS signal was weaker in the van than when it had left Astroia. A basket of gas canisters had been secured to the rail where the GPS antenna was located. This both partially blocked the view of the sky and crushed the antenna cable. The antenna was moved over away from the basket, and the cable was re-terminated after removing the damaged section. The GPS signal improved after this.

Recoveries:

The D2s and L-CHEAPOs use the same acoustic release system, made by Edgetech/ORE, to dissolve a burnwire and drop an anchor to release the instruments. Thus both groups used the same model 8011A acoustic deck box and hull-mounted transducer to communicate with their instruments. There were no major problems with the releases. In several cases the replies from the ocean bottom were inaudible, but the instruments clearly received and responded to all commands, releasing as expected. Once the instrument had released the reply signals became clearly audible. This problem was common to both the D2s and L-CHEAPOs. This is likely a function of the makeup of the ocean floor. A few D2s needed multiple commands to be sent before they were successfully received and acknowledged. In all cases, the instruments dropped their anchors within the 15 minutes of confirming the first release command. No repeat burns were required. Spotting the instruments generally happened quickly once they were on the surface. The D2s have a very low surface profile, and thus are more difficult to spot than the L-CHEAPOs. The addition of a fluorescent orange flag to the D2s on this cruise increased their visibility significantly compared to previous cruises. The D2s are equipped with a radio beacon, to alert the bridge to their presence on the surface and ideally to allow for a Radio Direction Finder (RDF) to assist in locating the instrument. On most vessels this works well. However, on the Langseth, the RDF on the bridge was unable to detect the radio beacons until they were within about 100 meters, after they had already been spotted.

Water leak in D51:

The only major D2 instrument issue was a water leak in number D51, which was deployed at site #48 over both halves of the experiment. The main 17" glass ball, which houses essentially all the electronics, took on roughly a pint of water. The water had caused the instrument to shut down during the recovery process, so normal debrief was not possible. The ball was opened as soon as possible and all components were removed, cleaned and dried. Luckily damage was minor considering the quantity of water involved. While some neighboring components were severely corroded, the 2.5" hard drive itself was unharmed. By installing the hard drive into a spare baler, data were retrieved for the entire deployment up until the last half hour before recovery. The offset of the internal clock to UTC was not captured at recovery. The drift rate had to be inferred by comparing shots that had fallen at the same locations but at different times. Using this drift rate and the pre-deployment clock offset the data were clock corrected appropriately.

Data quality:

Data were recovered from all 38 D2 deployments, and analyzed preliminarily using Cimarron, a proprietary M-SEED viewer from Quanterra, the designer of the data loggers used in the D2s. There are no gaps in data on any of the instruments. In a few cases one of the horizontal channels of the geophone showed a low signal level compared to the other two channels on the same instrument and compared to the rest of the instruments. This is a somewhat subjective observation, and the shots are all clearly visible, so this may prove to be inconsequential. The only case where shots are not visible at all is channel EL1 on D03 deployed at site #83. The other two geophone channels and the hydrophone all look fine. See the attached spreadsheets for a summary of the performance of each channel on each deployment. A particular type of noise was observed in data from many of the instruments. This noise occurred at intervals from 1 to 8 hours (depending on the buffer size of the data logger and the amount of compression applied), each time the baler (hard drive) in the instrument turned on. It manifests as several bursts of a signal at 70Hz lasting for several seconds each over the course of a few minutes. In some cases impulses with low frequency ringing and noise spikes accompany these 70Hz bursts. These noise spikes reach amplitudes in excess of 10000 counts in a few instruments. The character of the noise for each instrument seems to be fairly consistent over the course of a deployment, although there were a few that changed over the deployment. According to personal communications with the chief scientist these noise bursts are easily distinguished from any real seismic event, and so should pose little to no problem in data processing. If necessary the times of these events can be predicted accurately for each instrument to aid processing. The attached spreadsheets also contain a brief description of the character of the baler turn-on noise. With the exception of D51 (see "Water Leak", above), data from all instruments were clock corrected using offsets obtained at the beginning and end of the deployments by comparing the time of the internal Seascan real time clocks to the internal GPS receivers of the instruments. The data were then processed into SEGY format.

Lau Basin Active Cruise, Jan-Mar 2009
Data Quality Summary, Sorted by Sensor

	LBA 1, In water				LBA 2, In water			
Sensor	Site	D#	Baler turn-on noise	Bad channels	Site	D#	Baler turn-on noise	Bad Channels
2	LBA02	D44	large	all good	LBA60	D44	small	all good
4	LBA20	D25	small	EL1 very low output, EL2 low output	LBA82	D25	small	all good
5	LBA04	D49	moderate	EL2 low, seems like a long settling period (~2 days)	LBA75	D49	moderate	all good
6	LBA48	D51	large	EL2 weird half cycle bumps ~.25sec width	Left down over both deployments			
8	LBA03	D02	small	EL2 low output?	LBA64	D32	moderate	all good
13					LBA74	D11	none	all good
14	LBA17	D39	large	all good	Left down over both deployments			
16	LBA01	D15	moderate	all good	LBA61	D15	moderate	all good
17	LBA47	D40	very large	EL2 low? (baler noise much worse at beginning than at end of deployment)	Left down over both deployments			
19					LBA80	D10	none	EL2 low output
24	LBA46	D07	large	all good (baler noise much worse at beginning than at end of deployment)	Left down over both deployments			
25	LBA21	D03	small	all good	LBA83	D03	large	EL1 no output on bottom
26	LBA18	D08	very large	all good	LBA63	D08	moderate	all good
31					LBA77	D09	moderate	all good
34	LBA29	D11	none	EL2 low output				
37	LBA28	D31	large	all good				
39	LBA19	D32	moderate	geophone channels seem somewhat noisy				
40	LBA30	D26	small	all good	LBA65	D26	small	all good
42	LBA22	D62	large	all good	LBA62	D62	large	all good
45	LBA49	D06	small	EL2 slightly low output?	LBA81	D50	large	all good (baler noise much worse at beginning than at end of deployment)
48	LBA27	D09	none	all geophone channels seem to have low output (~10k counts max amplitude shots)	LBA78	D02	small	all good
49	LBA50	D10	none	all good	LBA84	D34	small	all good
50	LBA26	D34	small	EL2 Low	LBA79	D06	large	all good
52	LBA25	D55	large	all good	LBA76	D55	small	all good
N/A		D50		Not deployed		D31		Not Deployed

APPENDIX 3: Assessment of Background Noise and Firing Interval

Shot numbers 1:120 and 121:240 in the SEGY records are fake shot numbers with times for when the airguns were no longer firing. The records occur every 60 s and the data is cut with 60 s traces, so these records constitute two x two-hour blocks of shot-free data, with the exception that in both cases the last shot of Campaigns I and II occurs only a few minutes into these two blocks. Therefore, one can examine the ring-down of the seismic source unimpeded by following shots.

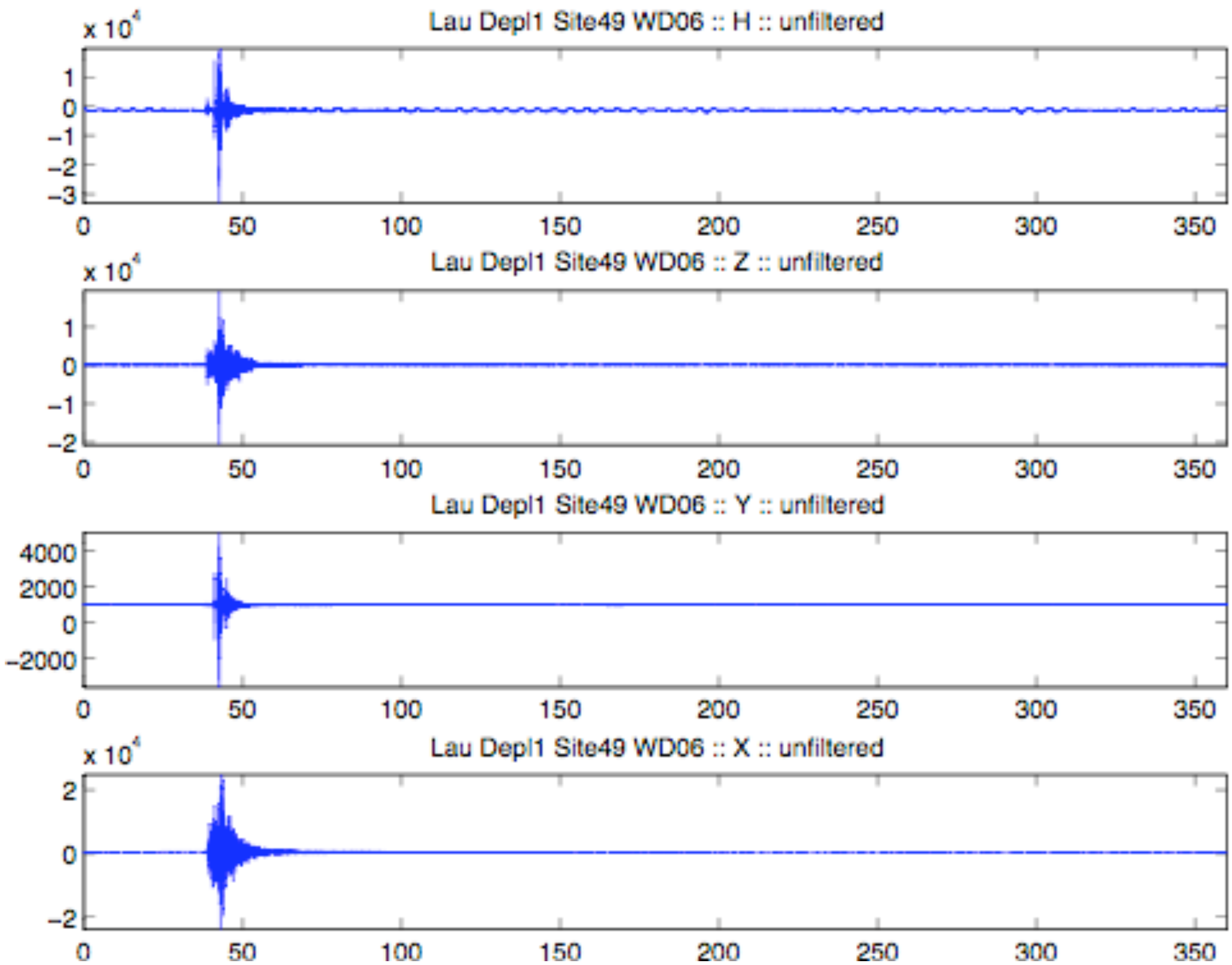


Figure. Station 49 (deployment 1). Last shot. Station is located ~8km from the shot.

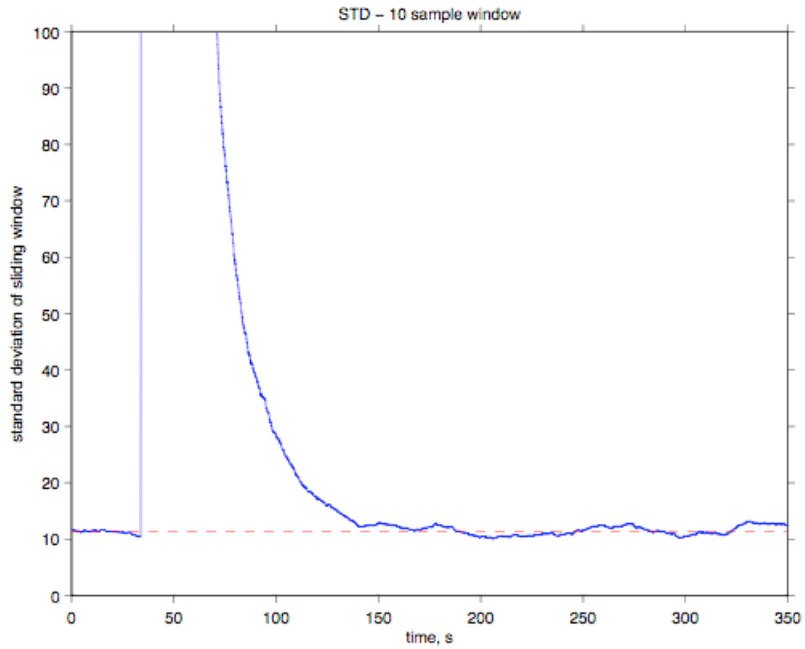


Figure. Station 49 (deployment 1). RMS amplitude (RMS of 10 point window) of last shot. Station is located ~8km from the shot.

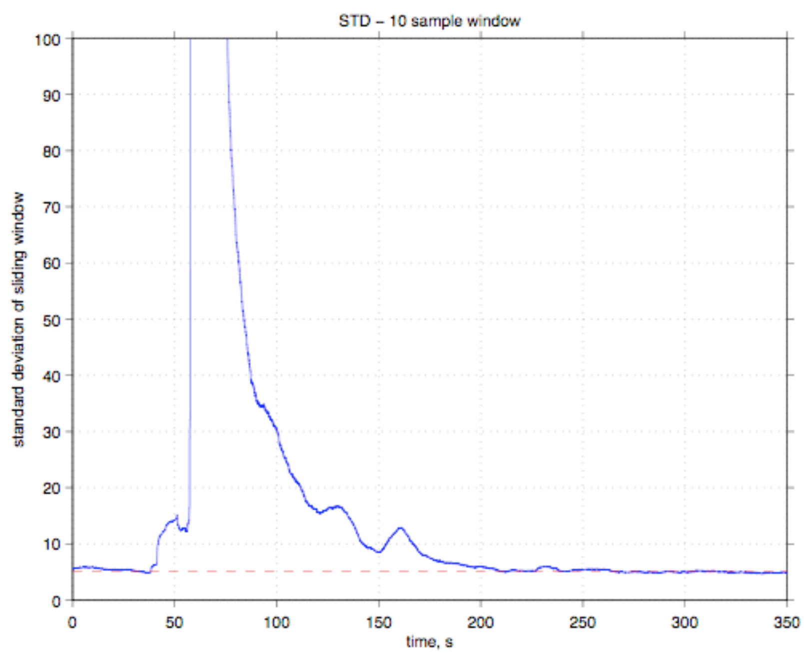


Figure. Station 04 (deployment 1). RMS amplitude (RMS of 10 point window) of last shot. Station is located ~38km from the shot.

For a station located 8 km from the source, the time for the shot noise to dissipate is ~140 s after the first arrival. For a station located 38 km from the source, the time for energy dissipation is ~180 s after the first arrival. For stations >38 km from the source, one should consider 210 s shot intervals or larger.

APPENDIX 4: Marine Mammal Observation Summary

No marine mammals (or turtles) observed during the airgun operations. One green turtle sited during post-seismic mapping phase (March 3). Small pod of pilot whales spotted on transit to port. Preliminary search for large baleen whale calls in the OBS data returned nothing.

APPENDIX 5: OBS Deployment & Logging Protocol

MGL0903
A Johnson

15 minutes before arrival
Bridge → M-Lab, M-Deck: “15 minutes from drop site XX”

~1200 m before arrival, bridge slows
Bridge slows to 3 knots
Bridge → M-Lab, M-Deck: “1200 m to drop point, slowing to 3 knots”

ELOG: Make an elog entry when the ship begins to slow for deployment:
Type: OBS Deploy: Approach
Subject: Approaching site XX

50m before drop point
Bridge → M-Lab, M-Deck: “50m to drop point, slowing to 0 knots

M-Lab → M-Deck: “release instrument”
or
M-Lab → M-Deck: “release when ready”

Type: OBS Deploy: Drop
Subject: Released OBS XX
Entry (edit in later if unavailable at drop)
Serial: XXXXX
Release ID: XXXXX

OBS Lab done with release testing
OBS Lab → Main Lab: “Done with release test, ready to transit to next site”
Main Lab → Bridge: “Done with release test, ready to transit to next site”

ELOG: Make an entry when the ship starts for the next point:
Type: OBS Deploy: Acoustics OK/Transit to next
Subject: Acoustics OK

APPENDIX 6: OBS Deploy Log Keeping

MGL0903
2009-01-25

Five items should be logged for each deployment:

Arrival on site, ie, when the ship slows and begins approach.
Release of instrument
Multibeam secured
End of acoustic tests, begin transit to next
Multibeam pinging and logging

When	Type	Subject	Text
Arrival on site, ie, when the ship slows and begins approach.	OBS_Deploy:Approach	OBS XX approach	
Release of instrument	OBS_Deploy:Released	OBS XX deployed	SOI/WHO

			Lat: XX XX.XXX Long: XXX XX.XXX Depth: XXXX m
Turn multibeam off	Multibeam	Multibeam secured	Secured for acoustics ops
End of acoustic tests, begin transit to next	OBS_Deploy:Disabled	Transit to next	Acoustics OK
Turn multibeam on	Multibeam	Multibeam pinging and logging	

Additional comments on speed or meters to/from site may be useful. Note also anything anomalous or unusual.

APPENDIX 7: Line Change Orders

MGL0903 Line Change Orders, v 1.0
2009-01-30
A. Johnson

Bridge should notify 30 mins before wheel over point. Alert Watch Leader at this time.
Bridge will also notify before turn begins.

Coming off line

In Spectra, find the Line Control windows on the lower left screen. Watch the helmsman display on the left side of the lower right screen.

Watch the Velocity Along Track (VA) on the spectra display. Once VA drops below three you must end the line and either begin the next or switch to internal cycle.

If guns are pulled early for maintenance, or the source is otherwise degraded, log a separate LGSP entry in ELOG:

Type	LGSP
Subject	<linename> LGSP XXXX
Text	Why no longer good (eg. “Air leack S4, picking up for repair”)

Note EOL in ELOG:

Type	EOL
Subject	EOL <linename> SP XXXX
Text	

After disabling shooting, go to the Digishot system and switch to internal triggers. Set the shot cycle to 20s. Enable the spare guns (one at a time). NOTE THE DIGISHOT GUN CONFIG BEFOREHAND.

Nav Logs
- Update and close out the Nav Line Log.
- Update and sabve the Nav Sequence Log.
- Create and fill out a new Nav Line Log for the next line.

Observer Logs
- Update and close out the Observer Line Log.
- Update and save the B15 Log.
- Create and fill out a new Observers Line Log for the next line.

Update the Line Board

Prepare the Spectra Line Control Node
- Select the next line (right-click on the line name).
- **Update sequence number** (right next to line name). Sequence numbers should always increment when changing lines.
- **Update shot number**: first shot should be sequence x 1000 + 21.
- eg. for sequence 7 first shot should be 7021.
- make sure 20 run-in and 0 run-out shots are configured
- Make sure shot type is **DAlong Track**.
- Make sure interval is **500 meters**
- Make sure the line is going in the right direction. Reverse line if necessary.
- Make sure beneath the ENABLED/DISABLED button "**Online and Approach**" is selected.

Prepare the shotlog
- Switch to the NavLog workspace on spectra1
- Close the nav log.
- Click 'setup' and select the new line.

When coming on to line

Turn off the spare guns in Digishot.

As the ship approaches the line, watch the velocity along track. Velocity along track (VA) should be 3.0 knots or better before enabling.

Prepare Digishot
- Set Digishot for external triggers.
- Set Digishot to shooting mode.

Enable shooting in Spectra

Note approach in ELOG

Type	SOL
Subject	SOL <linename> FSP XXXX
Text	FSP XXXX

If not the same as SOL, note FGSP in ELOG:

Type	FGSP
Subject	<linename> FGSP XXXX
Text	FGSP XXXX

Update and save the Nav and Observer logs, and the B15.

APPENDIX 8: Local and Global Earthquakes Occurring during the OBS experiment

```
FILE CREATED:  Wed Mar  4 02:42:50 2009
 Global Search   Earthquakes=       12
 Catalog Used: PDE
 Date Range:   2009/01/24   to    2009/02/28
 Magnitude Range:   6.0  -  10.0
 Data Selection: Preliminary Data Only

 CAT   YEAR  MO DA  ORIG TIME   LAT  LON  DEP  MAGNITUDE
 PDE-Q  2009  01 24 012839.35       -28.25 -176.70  10  6.0
 PDE-Q  2009  02 02 175321.77       -13.58  -76.53  21  6.0
 PDE-Q  2009  02 09 140902.93        -6.57  -81.12  15  6.0
 PDE-Q  2009  02 11 173450.66         3.90  126.40  20  7.2
 PDE-Q  2009  02 11 182511.60         4.03  126.78  35  6.0
 PDE-Q  2009  02 12 034939.73         3.93  126.40  26  6.0
 PDE-Q  2009  02 12 131507.43         4.05  126.57  35  6.3
 PDE-Q  2009  02 15 100449.30        -5.87  -80.91  21  6.1
 PDE-Q  2009  02 17 033054.45       -30.82 -178.64  13  6.0
 PDE-Q  2009  02 18 215345.23       -27.44 -176.33  25  6.9
 PDE-Q  2009  02 22 174522.53         3.68  126.56  32  6.0
```

PDE-Q 2009 02 28 143305.42 -60.47 -24.75 10 6.3

FILE CREATED: Wed Mar 4 02:51:28 2009
Geographic Grid Search   Earthquakes= 3
Latitude: 14.000S - 24.000S
Longitude: 180.000E - 175.000E
Catalog Used: PDE
Date Range: 2009/01/24 to 2009/02/28
Data Selection: Preliminary Data Only

CAT	YEAR	MO	DA	ORIG TIME	LAT	LON	DEP	MAGNITUDE
PDE-Q	2009	01	27	005458.44	-17.69	176.00	35	4.9
PDE-Q	2009	02	04	031426.39	-23.88	179.76	533	4.6
PDE-Q	2009	02	11	135243.80	-16.21	178.32	21	5.7

FILE CREATED: Wed Mar 4 02:55:18 2009
Geographic Grid Search   Earthquakes= 24
Latitude: 14.000S - 24.000S
Longitude: 170.000W - 180.000W
Catalog Used: PDE
Date Range: 2009/01/24 to 2009/02/28
Data Selection: Preliminary Data Only

CAT	YEAR	MO	DA	ORIG TIME	LAT	LON	DEP	MAGNITUDE
PDE-Q	2009	01	24	090158.05	-19.58	-179.11	671	5.2
PDE-Q	2009	01	24	175820.96	-21.06	-178.05	487	4.2
PDE-Q	2009	01	25	111816.46	-18.42	-174.48	42	4.6
PDE-Q	2009	01	26	115439.62	-17.80	-178.59	579	5.8
PDE-Q	2009	01	27	062913	-17.84	-178.68	601	5.9
PDE-Q	2009	01	28	123942.83	-16.97	-172.07	10	5.5
PDE-Q	2009	01	28	224757.27	-17.62	-178.47	537	4.7
PDE-Q	2009	01	30	033735.16	-15.05	-174.85	35	4.3
PDE-Q	2009	01	30	034710.93	-15.39	-174.47	10	5.7
PDE-Q	2009	02	01	203136.07	-16.96	-179.15	504	
PDE-Q	2009	02	02	144357.81	-21.79	-179.43	590	4.8
PDE-Q	2009	02	03	043837.38	-18.03	-178.21	597	4.4
PDE-Q	2009	02	05	035558.73	-16.64	-173.76	94	4.8
PDE-Q	2009	02	07	215156.44	-20.54	-178.21	543	5.2
PDE-Q	2009	02	08	094544.29	-16.38	-173.25	10	4.6
PDE-Q	2009	02	10	041013.47	-22.65	-175.41	41	4.1
PDE-Q	2009	02	11	093104.47	-20.78	-177.33	10	5.5
PDE-Q	2009	02	12	040545.64	-20.55	-177.64	473	
PDE-Q	2009	02	15	011807.74	-16.62	-173.17	53	4.8
PDE-Q	2009	02	20	014618.16	-18.32	-178.76	515	5.6
PDE-Q	2009	02	22	090050.02	-15.72	-178.39	438	4.6
PDE-Q	2009	02	23	194922.86	-18.75	-174.80	202	4.8
PDE-Q	2009	02	27	022924.99	-22.35	-175.44	35	4.9
PDE-Q	2009	02	28	071759.01	-20.16	-173.13	35	4.6

APPENDIX 9: Gravity Reduction Information


```
RV Langseth Gravity Tie Form

CruiseID PRE MGL0902 POST MGL0903
Date 20-21 Jan 09
Port Nuka 'alofa
Operator Ted Koczynski

Pier side Reading #1 (outbound)
Ship's position (CNav)
LAT 21d08.15155'South LONG 175d10.77727'West ALT 58.31 meters (SeaPath)

Shipboard BGM reading 24850(raw counts) Height of Pier over Main Deck .60 meters
Portable GPS Time TIME 21:35 start,21:55 end
Portable GPS Position LAT LONG ALT Non operating
L&R Readings     Reading1 2510.10
                 Reading2 2510.02
                 Reading3 2509.61
                 Reading4 2510.11
                 Reading5 2509.69
                 Reading6 2510.13
                 Reading7 2510.09
                 Ave. 2510.75 Discarding outliers

Tie Point
Tie Point Description (see relevant documentation/maps/pictures attached) Fua Amotu
Airport Main Terminal on front walkway at road,
Right terminal end= measurement 1, left end= measurement 2, Center= measurement 3
Portable GPS Time TIME 23:07 start, 23:45 end.
Portable GPS Position LAT LONG ALT Non Operating.
L&R Readings     Measurement1          Measurement2          Measurement3
                 Reading1 2509.70      Reading1 2509.83      Reading1 2509.72
                 Reading2 2509.85      Reading2 2509.76      Reading2 2509.78
                 Reading3 2509.84      Reading3 2509.76      Reading3 2509.80
                 Reading4 2509.78
                 Reading5 2509.80 Note: So little change noted in readings that all
                 readings will be averaged for the Tie Value.
                 Average= 2509.785, Hi and Lo tossed out.


Pier side L&R reading #2 (inbound)

Shipboard BGM reading ~24750(raw counts) Height of Pier over Main Deck -.30 meters
Portable GPS Time TIME 0126 21 Jan 2009 UTC
Portable GPS Position LAT LONG ALT Non operational
L&R Readings     Reading1 2510.21
                 Reading2 2510.04
                 Reading3 2510.26
                 Reading4 2510.25
                 Reading5 2510.21
                 Average  2510.223, Hi and Lo tossed out.

Notes: Info on Old airfield is lost, nobody remembers where the old buildings were.
I made 3 measurements at the new terminal. I also checked with the Tongan Land
Survey Department for any info on gravity ties. They had no knowledge of any
gravity stations. Further checks with the Tongan Geological Survey were fruitless.
Giving the topography here I would take the Airport values as extremely close to
previous values.
Comparing notes from the R/V Ewings Gravity Tie value dated 10/70, that was
978871.23, mGal, minus the Tie value that was dated July 1973 that has a value of
```

Page 1

978857.49 or a -13.71 mGal difference, indicating the 1970 value was Potsdam referenced.

1. Height of pier over main deck should be entered in meters.
Use a negative value to indicate pier is below main deck.
Form v1.1 20080818 ;)

X

GRAVITY BASE STATION

LATITUDE: 21°14.0'S (1)	STATION DESIGNATION: FUA AMOTU
LONGITUDE: 175°07.5'W (1)	
ELEVATION: 32 METERS (1)	COUNTRY/STATE: Tonga Islands TN

REFERENCE CODE NUMBERS	
DoD 3771-1	
IGB 41415A	
WA 7023	

ADOPTED GRAVITY VALUE: g= 978 857.49 mgals

ESTIMATED ACCURACY	DATE (MONTH/YEAR)
± mgals	July 1973

DESCRIPTION AND/OR SKETCH

Airport, on ground at entrance to NAC hut. (1) (2)

REFERENCE SOURCE

(1) 02320 (2) 00916

AC FORM APR 70 8342/ GD-11 PREVIOUS EDITIONS WILL BE USED

tedski

From: jns007@aol.com
Sent: Tuesday, July 31, 2007 1:39 PM
To: jrc@ldeo.columbia.edu; johnd@ldeo.columbia.edu; wsager@rv-revelle.ucsd.edu
Cc: stennett@ldeo.columbia.edu; tedski@ldeo.columbia.edu
Subject: Re: gravity processing

Hi Jim,

My memory is that, at one time, the filtering was done for 180 data points, (3 minutes), because the original Bell-supplied software used this interval. This left some noise in the data, so the system guys ran it through another filter, of the same type, but somewhat longer. I think this is the second step to which you refer. Later they realized that they could do the same thing with a single, longer, filter.

Regards,
Joe

-----Original Message-----
From: James R. Cochran <jrc@ldeo.columbia.edu>
To: jns007@aol.com; johnd@ldeo.columbia.edu; wsager@rv-revelle.ucsd.edu
Cc: stennett@ldeo.columbia.edu; tedski@ldeo.columbia.edu
Sent: Mon, 30 Jul 2007 1:27 pm
Subject: Re: gravity processing

Hi Joe

I thought there was a later step where we ran it through another filter to take out residual noise with amplitudes of 2-5 mGal and wavelengths of a few km. Am I misremembering?

Jim

At 1:02 PM -0400 7/30/07, jns007@aol.com wrote:

> The original Bell software used Gaussian smoothing, and I believe that Lamont still uses this. A filter length of 200 to 600 data points is typical. Other weighted filters may be OK. I once, in ignorance, used division by increasing powers of two, and that seemed to work.
>
> Regards,
> Joe
>
> -----Original Message-----

From: James R. Cochran <jrc@ldeo.columbia.edu>
To: John Diebold <johnd@ldeo.columbia.edu>; William Sager <wsager@rv-revelle.ucsd.edu>
Cc: stennett@ldeo.columbia.edu; tedski@ldeo.columbia.edu
Sent: Mon, 30 Jul 2007 10:36 am
Subject: Re: gravity processing

Will

Raw gravimeter output is completely unusable - but I am sure the gravimeter software applies a three minute or five minute low pass filter to it. We found that there is still some several mGal short wavelength noise after that and now also apply an optimized low pass filter that Chris Small developed during a cruise we were on back in the 90s. I will CC a couple of our Science Officers in the Marine Office to see if they can help and maybe send you some software. If not, I will dig around, but I haven't done any hands-on processing at this level since I was trying to run a BGM3 in Alvin 6 or 7 years ago

Joe and Teddy - Can either of you help Will with this?
Thanks

Jim

At 10:07 AM -0400 7/30/07, John Diebold wrote:
>Will;
>
>All i know is that we normally apply a long filter - Jim Cochran is >the resident
>expert.
>
>John
>
>
>On Jul 30, 2007, at 4:04 AM, William Sager wrote:
>
>>Dear John,
>>
>>I am out on the Revelle where we have been collecting geophysical >>data and dredges from the Ninteyeast Ridge for the last month. One >>of the pieces of equipment is a Bell gravimeter. Scripps doesn't >>usually run a gravimeter and this one was borrowed from the Navy at >>my request. The trouble is that the Scripps techs don't really >>know what to do with the raw gravimeter data. I have never before >>gotten involved in the raw data processing myself. So I am writing >>to ask if you can give me a Lamont contact who knows about the >>steps of processing the output from one of these gravimeters. I >>figure LDEO has been collecting such data for years, so you guys >>would be the ones to ask. The raw gravimeter output looks very >>noisy, so there must be some filtering as well as Eotvos >>corrections to be made. If you can, please tell me who to write.
>>
>>Thanks
>>Will

-- ______________

James R. Cochran
Doherty Senior Research Scientist
Lamont Doherty Earth Observatory
Palisades, NY 10964

LOCKHEED MARTIN
Lockheed Martin
2221 Niagara Falls Blvd., Niagara Falls, NY 14304

DATA SHEET 1
BGM-3 SENSOR CALIBRATION USING AN ULTRADEX DIVIDING HEAD

S/N 213 **, P/N 6109-300503-1**

DATE 3/30/04 **TIME** 1300 **CALIBRATED BY** DR STUBBS

TREND = ________ **MGAL/DAY**

(1) Output Pulses/400 Sync pulses at 0° 2507784 pulses

(2) Output Pulses/400 Sync pulses at 20° 1347620 pulses

(3) Output Pulses/400 Sync pulses at 340° 1347645 pulses

(4) (1) ÷ 100 = 25077.84 PPS

(5) (2) ÷ 100 = 13476.20 PPS

(6) (3) ÷ 100 = 13476.45 PPS

(7) ½[(5)+ (6)] = 13476.325 PPS

(8) {[(4) - (7)] x10^{-6}}/(1-cos(20°)) = 0.192373058 PPS/micro g

(9) 0.980375*/(8) = 5.0962178 mgal/PPS **Scale Factor** *(Spec: 4.0 to 6.0 mgal/PPS)*

(10) (4) x (9) x 10^{-3} = 127.8021 gals

(11) 980.375** - (10) = 852.5729 gals

(12) **CALIB** output pulses/400 sync pulses = 2500288 pulses

(13) **TEST** output pulses/400 sync pulses = 2500000 pulses

(14) **CALIB** equivalent = [(12) x (9)] ÷ 100,000 = 127.4201 gals

(15) **TEST** equivalent = [(13) x (9)] ÷ 100,000 = 127.4054 gals

(16) (11) x 1000 = 852572.9 mgals **Bias** *(Spec: (17) to (18))*

(17) 1000(977-25 x (9)) = 849594.6 mgals (lower limit)

(18) 1000(983-25 x (9)) = 855594.6 mgals (upper limit)

*local gravity at Wheatfield (980.375 gals) ÷ 1000. Value must be changed if Calibration is done elsewhere.
**local gravity at Wheatfield (980.375 gals). Value must be changed if Calibration is done elsewhere.

LOCKHEED MARTIN
Lockheed Martin
2221 Niagara Falls Blvd., Niagara Falls, NY 14304

DOC. NO. 6109-928094
ISSUE : B
DATE : 5/00
PAGE : 5

Eli
FYI.
Ted

DATA SHEET 1
BGM-3 SENSOR CALIBRATION USING AN ULTRADEX DIVIDING HEAD

S/N 213, P/N 6109-300503-1

DATE 3/30/04 TIME 1300 CALIBRATED BY DR STUBBS

TREND = ________ MGAL/DAY

(1) Output Pulses/400 Sync pulses at 0° 2507784 pulses

(2) Output Pulses/400 Sync pulses at 20° 1347620 pulses

(3) Output Pulses/400 Sync pulses at 340° 1347645 pulses

(4) (1) ÷ 100 = 25077.84 PPS

(5) (2) ÷ 100 = 13476.20 PPS

(6) (3) ÷ 100 = 13476.45 PPS

(7) ½[(5)+ (6)] = 13476.325 PPS

(8) {[(4) - (7)] x10^{-6}}/(1-cos(20°)) = 0.192373058 PPS/micro g

(9) 0.980375*/(8) = 5.0962178 mgal/PPS **Scale Factor** *(Spec: 4.0 to 6.0 mgal/PPS)*

(10) (4) x (9) x 10^{-3} = 127.8021 gals

(11) 980.375** - (10) = 852.5729 gals

(12) **CALIB** output pulses/400 sync pulses = 2500288 pulses

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(15) **TEST** equivalent = [(13) x (9)] ÷ 100,000 = 127.4054 gals

(16) (11) x 1000 = 852572.9 mgals **Bias** *(Spec: (17) to (18))*

(17) 1000(977-25 x (9)) = 849594.6 mgals (lower limit)

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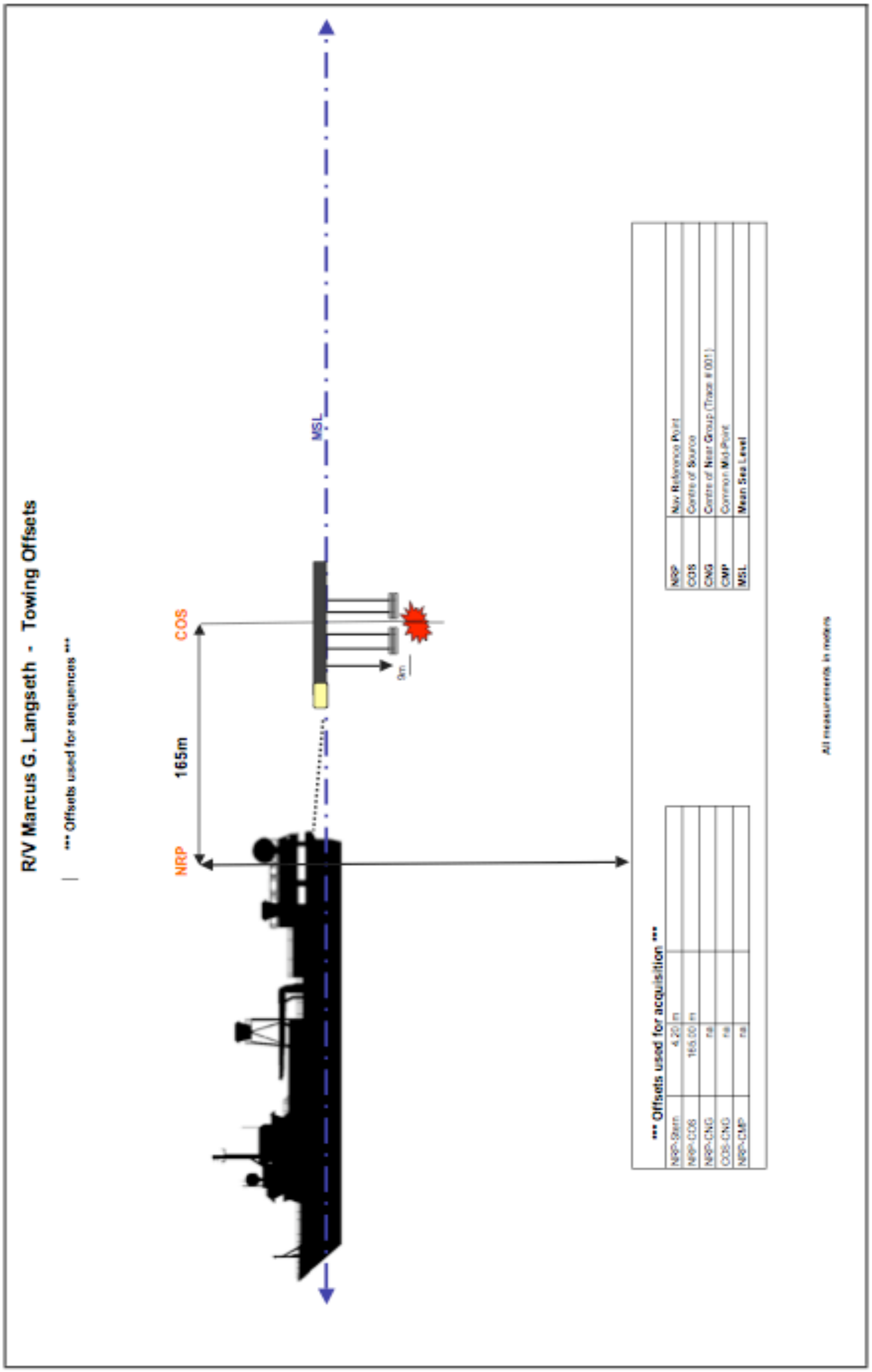
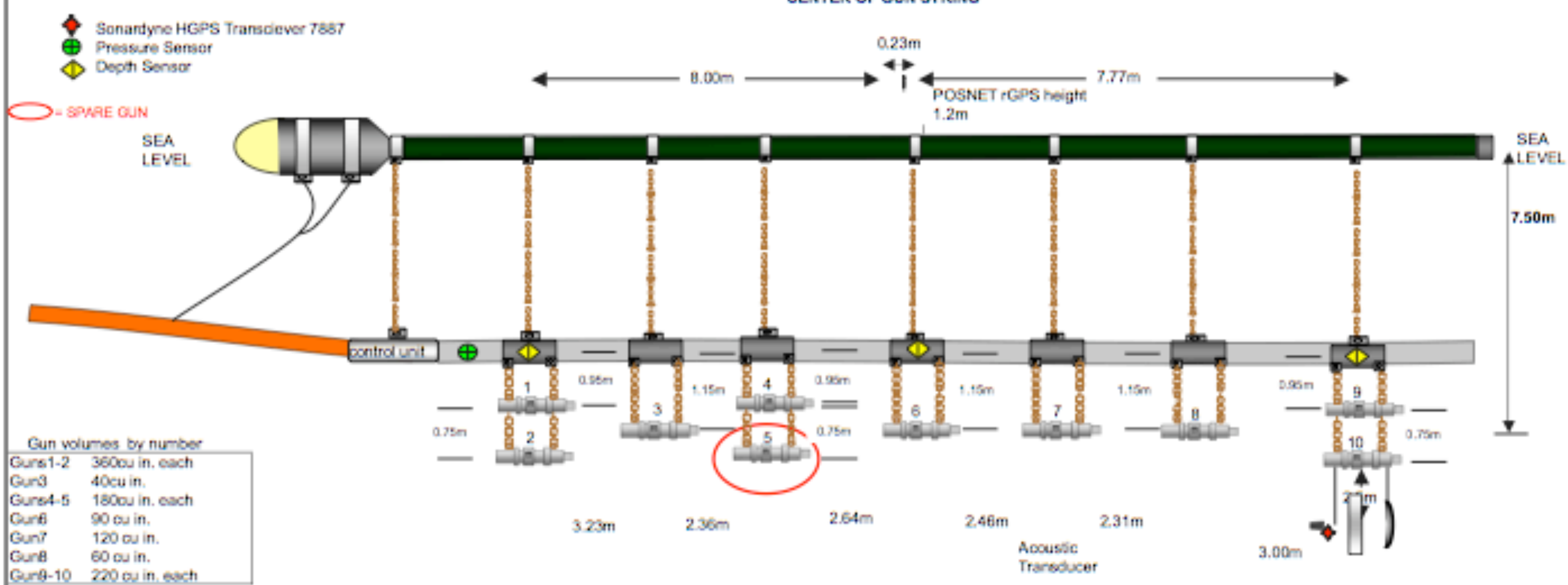
*local gravity at Wheatfield (980.375 gals) ÷ 1000. Value must be changed if Calibration is done elsewhere.
**local gravity at Wheatfield (980.375 gals). Value must be changed if Calibration is done elsewhere.

APPENDIX 10: Towing Configurations



R/V Marcus G. Langseth - Gun Array Offsets



Gun volumes by number

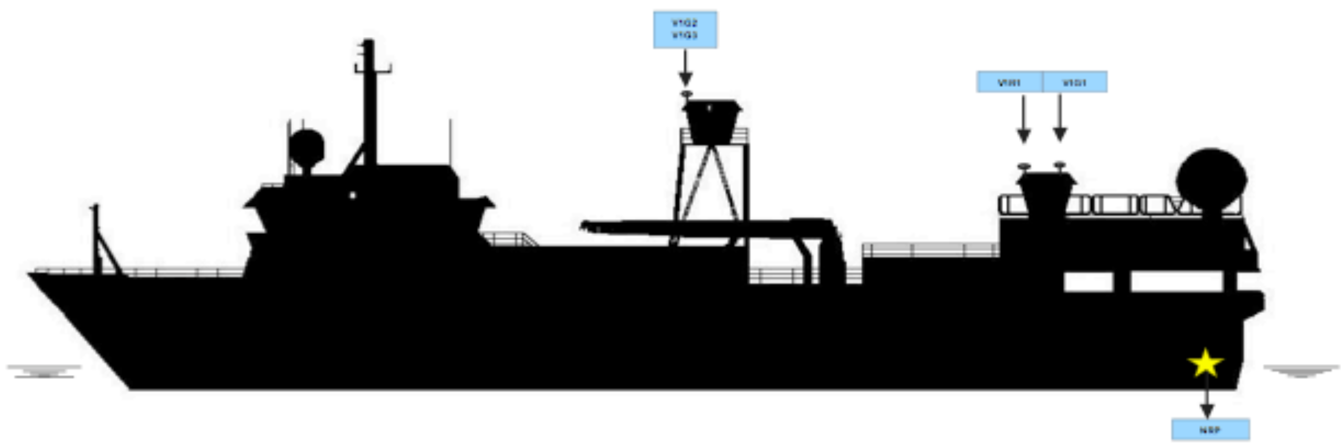
Guns1-2	360cu in. each
Gun3	40cu in.
Guns4-5	180cu in. each
Gun6	90 cu in.
Gun7	120 cu in.
Gun8	60 cu in.
Gun9-10	220 cu in. each

Array total volume (without spares) is 6600 cubic inches.
String 1 has guns 9 & 10 in a horizontal cluster; Strings 2, 3, 4, have all clusters hanging vertically.
Gun clusters have 0.75m between guns and hang 0.95m from center of hanger

Total volume per string (without spare) 1650 cubic inches.
Cluster Guns are 1m apart. **NOTE: drawing not to scale**
Single guns hang from hanger 1.15m

All measurements in meters

All gun volumes, numbering, locations, and offsets approved by chief gunner Tom Spoto.

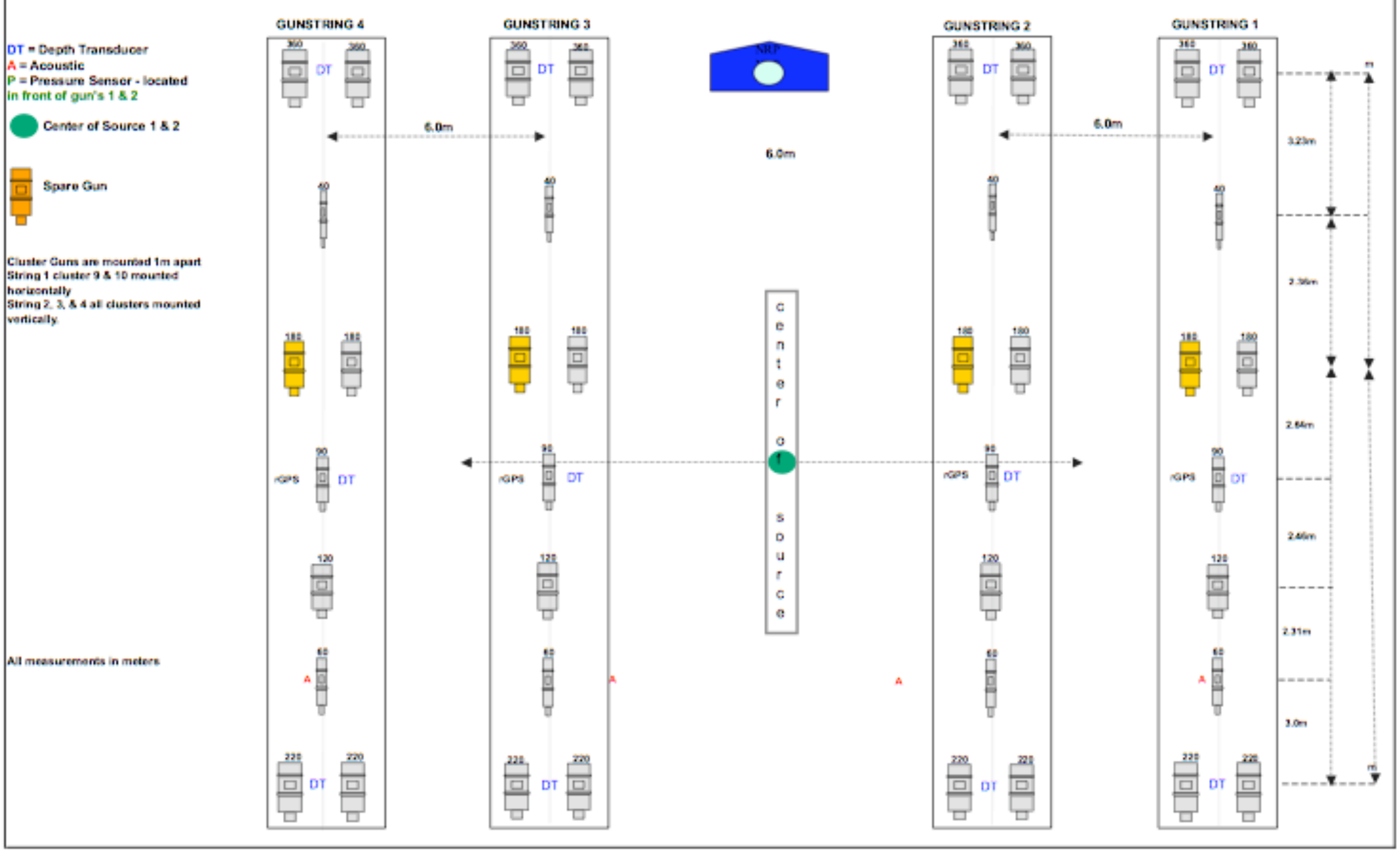


Note: All Echosounders are used in Spectra with 6.6m ship's draft correction applied.

All measurements in meters

		FORE/AFT (Y)	STBD/PORT (X)	UP/DOWN (Z)
NRP	NAVIGATION REFERENCE POINT	0.00	0.00	0.00
V1G1	C-Nav	4.87	8.06	14.50
V1G2	SeaPath 200	1.50	25.30	16.90
V1G3	Pos MV	8.50	22.30	16.90
V1G4	PosNet	4.87	10.45	14.50
V1R1	PosNet	4.87	10.45	14.50
EM120	Multibeam	49.70	8.50	-6.60

r/v Marcus G. Langseth - Gun Configuration



APPENDIX 11: XBT Drops

Sheet2

MGL0903 XBT Launch Log

David Ng, LDEO, MGL0903

Date yyyy-mm-dd	Launch Time UTC	Seq. #	Latitude	Longitude	Probe Type	Export Salinity Value (ppt)	SURFACE SV m/s	6m SV m/s	Last **Good** Depth m	Water Temp (C) at LGD	Sound Velocity at LGD
2001-03-15	21:22:47	292	09 11.3736 N	104 07.03027 W	T-5	35.0	1539.31		290.9	10.91	1497.85
2009-01-25	06:38:50	2	20 28.16077 S	176 02.21289 W	T-5	35.0	1541.07		1830.5 m	2.52	1490.64
2009-01-26	01:12:26	3	20 38.26782 S	176 10.17969 W	T-5	35.0	1541.28		2193.5	2.51	1596.88
2009-01-28	06:25:50	4	20 11.11S	176 03.44 W	T-5	35.0					
2009-01-30	21:58:57	5	20 33.09741 S	176 13.82812 W	T-5	35.0	1540.43		285 m	19.6	1525.09
2009-01-31	22:06:00	6	20 32.98132 S	176 14.42969 W	T-5	35.0	1539.63		134.5	23.07	1531.87
2009-01-31	05:46:00	7	20 35.625 S	176 12.718 W	T-5	35.0	1540.9		2201	2.56	1497.08
2009-02-01	04:15:00	8	20 41.17419 S	176 07.88672 W	T-5	35.0	1541.87		?	?	?
2009-02-02	03:57:00	9	20 47.11035 S	176 13.10742 W	T-5	35.0	1542.55	1542.32	2170	2.49	1496.25
2009-02-04	00:38:00	10	20 41.20642 S	175 59.375 W	T-5	35.0	1541.09	1541.13	2190 m	3.22	1499.34
2009-02-05	05:25:46	11	20 54.53979 S	176 9.33984 W	T-5	35.0	1541.95	1541.88	2181.8	2.55	1496.69
2009-02-06	06:01:06	12	21 5.2793 S	176 15.8872 W	T-5	35.0	1541.36	1541.99	1150.3	7.83	1500.79
2009-02-07	06:49:48	13	20 59.24487 S	176 17.41602 W	T-5	35.0	1544.24	1541.33	2159.1	2.33	1495.39
2009-02-08	05:14:23	14	20 26.6272 S	176 14.26758 W	T-5	35.0	1542.19	1543.2	2177.4	2.44	1496.1
2009-02-09	05:42:29	15	21 03.1191 S	176 26.50586W	T-5	35.0	1542.74		2156.8	2.41	1495.64
2009-02-10	03:29:00	16	20 49.6599 S	176 023.3125 W	T-5	35.0	1544.96	1542.5	2151.8	2.37	1495.38
2009-02-11	06:20:00	17	na	na	T-5	35.0	na	na	0 meters	na	na
2009-02-11	21:13:00	18	20 57.8728 S	176 03.4589 W	T-5	35.0	1543.68	1544.14	2178	2.41	1496.01
2009-02-12	06:09:00	19	20 07.701 S	176 02.701 W	T-5	35.0	1543.74	1543.61	2159	2.44	1495.82
2009-02-13	05:15:00	20	20 13.81726 S	175 53.42969 W	T-5	35.0	1544.17	1543.76	2155.7	2.43	1495.74
2009-02-14	06:37:45	21	20 19.57495 S	176 0.56641 W	T-5	35.0	1543.51	1543.77	2179.6	2.36	1495.83
2009-02-14	22:45;56	22	20 17.130 S	176 7.38281 W	T-5	35.0	1544.29	1543.72	2159.6	2.37	1495.75
2009-02-18	04:26:56	23	19 56.03308 S	176 13.70312 W	T-5	35.0	1544.49	1544.91	2184.1	2.3	1495.66
2009-02-19	09:00:00	24	20 16.11707 S	176 25.70508 W	T-5	35.0	1543.73	1544.04	2139? m	2.42?	1495
2009-02-24	15:34:00	25	20 07.31641 S	175 45.02539 W	T-5	35.0	1542.46	1542.65	2160	2.38	1495.59
2009-02-25	14:40:02	26	20 23.09839 S	176 18.05859 W	T-5	35.0	1542.02	1542.84	2157	2.39	1495.58
2009-02-25	20:59:32	27	20 05.08813 S	176 15.79297 W	T-5	35.0	1542.61	1543.16	2165.74	2.4	1495.73
2009-02-27	20:59:32	28	20 12.20264 S	176 12.4707W	T-5	35.0	1542.64	1542.7	2184.6	2..32	1495.74
2009-02-27	22:12:03	29	20 29.24426 S	176 10.95898 W	T-5	35.0	1542.85	1542.73	2164.6	2.39	1495.71
2009-02-28	10:56:48	30	19 59.35583 S	176 34.09766 W	T-5	35.0	1542.38	1543.31	2037	2.4	1493.57
2009-02-28	18:02:59	31	20 02.92578 S	176 48.27344 W	T-5	35.0	1542.47	1542.93	1852.4	2.58	1491.26
2009-03-01	04:36:12	32	20 29.39087 S	176 52.81621 W	T-7	35.0	1543.19	1543.5	900	4.94	1485.28
2009-03-01	13:15:08	33	21 43.51196 S	177 16.98828 W	T-7	35.0	1541.55	1542.05	901.9	4.91	1485.22
2009-03-01	13:23:07	34	21 44.13916 S	177 15.73242 W	T-7	35.0	1540.32	1542.01	760.1	5.78	1486.35
2009-03-02	02:45:27	35	21 01.6044 S	178.20.000 W	T-7	35.0	1542.59	1542.57	760.1	5.47	1485.13
2009-03-03	19:18:56	36	20 36.31665 S	176 56.66211 W	T-7	35.0	1541.79	1542.18	757	5.78	1486.37
2009-03-04	23:59:43	37	20 26.65869 S	176 55.72266 W	T-5	35.0	1542.07	1542.6	2181.3	2.32	1495.68
2009-03-06	22:34:20	38	19 44.52563 S	178 38.75586 W	T-7	35.0	1543.29	1544.23	860.5	4.86	1484.3

APPENDIX 12: Clearances

NOV-17-2008 13:31 OES/OA/MLP P.01

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Bureau of Oceans and International Environmental and Scientific Affairs
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Washington, D.C. 20520
P (202) 647-0238 F (202) 647-1106

FACSIMILE TRANSMITTAL SHEET

TO:	Jeff Rupert Lamont-Doherty Earth Observatory (845) 359-6817	**RE:**	R/V MARCUS G. LANGSETH 1/14/2009 - 3/3/2009 State File: 2008-083
FROM:	Liz Tirpak/ R Barnes tirpakej@state.gov	**DATE:**	Monday, November 17, 2008 Total pages: 4

We have just received the following approval(s) for the above-referenced research cruise:

Coastal State	*Diplomatic Note*	*Approval Date*
Tonga	MFA Diplomatic Note No. F-7/2/3	11/12/2008

Please notify the Chief Scientist of the following obligations to the clearance-granting coastal state(s):

SUBMIT PCR FORM TO THE STATE DEPARTMENT NO LATER THAN 30 DAYS AFTER THE END DATE OF THE CRUISE: the form is available at http://www.state.gov/www/global/oes/oceans/ntrvo66.html. On this form, the Chief Scientist reports when the cruise data will be forwarded to the Department of State for distribution to the clearance-granting coastal states.

SUBMIT CRUISE DATA TO THE STATE DEPARTMENT: the Chief Scientist must provide the appropriate number of copies and translations of the data for each clearance granting coastal state. See Notices to Research Vessel Operators on the web to determine country-specific reporting requirements. All materials can be mailed to my attention at the address listed above.

If the Chief Scientist cannot supply the data to the Department of State prior to the deadlines indicated in their PCR Form (due to sampling error, cancelled cruise, or other condition), you must notify our office with a formal letter of explanation. If you need an extension of time for submitting data, please request an extension in writing and indicate your revised due date. Should I fail to receive a request for extension, I will contact you by fax at the end of each month to let you know which scientists you will need to encourage.

Do not hesitate to contact me if you have any questions or modifications to this clearance.

F.7/8/3

The Ministry of Foreign Affairs of the Kingdom of Tonga presents its compliments to the Embassy of the United States of America and has the honour to refer to the Diplomatic Note. No. 27 dated 21st August 2008 requesting Clearance for the R/V MARCUS G LANGSETH to conduct marine scientific research within Tongan Waters.

The Ministry has further the honour to inform the latter and submit herewith a copy of the approval from His Majesty's Cabinet Decision on 29th October 2008 that have granted clearance for the R/V MARCUS G LANGSETH to conduct Marine Research in Tongan Waters during the period 14th January 2009 – 03rd March 2009:-

The Ministry of Foreign Affairs of the Kingdom of Tonga avails itself of this opportunity to renew to the Embassy of the United States of America the assurances of its highest consideration.

Embassy of the United States of America
SUVA

12th November 2008

MINISTRY OF FOREIGN AFFAIRS

2/21?

No.1140

P.-11a

MEMORANDUM

29th October 2008

To: *Hon. Cabinet Members*
Secretary for Finance and Planning
Secretary for Foreign Affairs
Secretary for Lands, Survey & Natural Resources and Environment
Private Secretary to His Majesty

Sonata

3/11

With reference to *Re: Seeking Permission for Research Vessel (R/V) Marcus G Lengseth Vessel to conduct Marine Scientific Survey under the National Jurisdiction of the Kingdom of Tonga.*

(LSR 10/1 V2)

I have the honour to inform you that His Majesty's Cabinet Decision on 29th October 2008 was as follows:-

Recommendations are approved, as amended, i.e.:

> *That the request from the National Science Foundation to conduct marine scientific research in Tongan waters by the Research Vessel Marcus G Lengseth from 14th January 2009 – 03rd March 2009 be approved.*
>
> *That the result of the survey be submitted to the Ministry of Lands, Survey & Natural Resources and Environment in two stages as follows:*
>
> *I. A preliminary report at the end of the research survey;*
> *II. Final report when data analysis and result is completed.*

FOREIGN MINISTRY
03 NOV 2008
REGISTRY OFFICE

-2

1140. cont.

3. That a staff from the Ministry of Lands, Survey & Natural Resources and Environment participates (subject to space availability) in the research survey and all the expenses incurred be borne by the National Science Foundation.

4. That the participant from Tonga submits a cruise report to the Secretary for Lands, Survey & Natural Resources and Environment no later than one month after his arrival in Tonga.

5. That the Ministry of Foreign Affairs convey the terms and condition of the Cabinet Decision to the Embassy of the United States in Suva, Fiji.

MINISTRY FOR FOREIGN AFFAIRS, INTERNATIONAL CO-OPERATION AND CIVIL AVIATION

Phone: (679) 330 9645
Fax : (679) 330 1741

Levels 8 & 9 Suvavou House, Victoria Parade
P.O. Box 2220 Government Building
Suva, Fiji Islands

Web site: http://www.foreignaffairs.gov.fj
E-mail: foreignaffairs@govnet.gov.fj

Note No. 838/08

The Ministry of Foreign Affairs, International Cooperation and Civil Aviation of the Government of The Republic of the Fiji Islands presents its compliments to the Embassy of the United States of America and has the honour to refer to the latter's Note No. 149 of 14th November, 2008 in regards to request diplomatic clearance of "Marcus G. Langseth", a United States flagged vessel owned by the United States National Science Foundation to conduct marine scientific research with the Fiji Exclusive Economic Zone (EEZ).

The Ministry of Foreign Affairs, International Cooperation and Civil Aviation has the honour to advice that diplomatic clearance has been granted to the aforementioned vessel to conduct marine scientific research with the Fiji Exclusive Economic Zone (EEZ) between 14th January to 28th February, 2009.

The Ministry of Foreign Affairs, International Cooperation and Civil Aviation of the Government of The Republic of the Fiji Islands avails itself of this opportunity to renew to the Embassy of the United States of America the assurances of its highest consideration.

Embassy of the United States of America
Loftus Street
Suva.

17 December, 2008

REPUBLIC OF THE FIJI ISLANDS

United States Department of State
Bureau of Oceans and International Environmental and Scientific Affairs
2201 C Street NW, Room 5805
Washington, D.C. 20520
P (202) 647-0238 F (202) 647-1106

FACSIMILE TRANSMITTAL SHEET

TO:	Jeff Rupert Lamont-Doherty Earth Observatory (845) 359-6817	**RE:**	R/V MARCUS G. LANGSETH 1/11/2009 - 3/11/2009 State File: 2008-083
FROM:	Liz Tirpak | KBarnes tirpakej@state.gov	**DATE:**	Thursday, January 22, 2009 Total pages: 2

We have just received the following approval(s) for the above-referenced research cruise:

Coastal State	*Diplomatic Note*	*Approval Date*
Tonga	MFA Diplomatic Note No. 22/09 ~~MFA Diplomatic Note No. 22/09~~	01/17/2009

Please notify the Chief Scientist of the following obligations to the clearance-granting coastal state(s):

SUBMIT PCR FORM TO THE STATE DEPARTMENT NO LATER THAN 30 DAYS AFTER THE END DATE OF THE CRUISE: the form is available at http://www.state.gov/www/global/oes/oceans/ntrvo66.html. On this form, the Chief Scientist reports when the cruise data will be forwarded to the Department of State for distribution to the clearance-granting coastal states.

SUBMIT CRUISE DATA TO THE STATE DEPARTMENT: the Chief Scientist must provide the appropriate number of copies and translations of the data for each clearance granting coastal state. See Notices to Research Vessel Operators on the web to determine country-specific reporting requirements. All materials can be mailed to my attention at the address listed above.

If the Chief Scientist cannot supply the data to the Department of State prior to the deadlines indicated in their PCR Form (due to sampling error, cancelled cruise, or other condition), you must notify our office with a formal letter of explanation. If you need an extension of time for submitting data, please request an extension in writing and indicate your revised due date. Should I fail to receive a request for extension, I will contact you by fax at the end of each month to let you know which scientists you will need to encourage.

Do not hesitate to contact me if you have any questions or modifications to this clearance.

MINISTRY FOR FOREIGN AFFAIRS, INTERNATIONAL CO-OPERATION AND CIVIL AVIATION

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Levels 8 & 9 Suvavou House, Victoria Parade
P.O. Box 2220 Government Building
Suva, Fiji Islands

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E-mail: foreignaffairs@govnet.gov.fj

<u>Note No. 22/09</u>

The Ministry of Foreign Affairs, International Cooperation and Civil Aviation of the Government of The Republic of the Fiji Islands presents its compliments to the Embassy of the United States of America and has the honour to refer to the latter's Note No. 3 of 9th January, 2009 in regards to request amendments of dates for diplomatic clearance of "Marcus G. Langseth", a United States flagged vessel owned by the United States National Science Foundation to conduct marine scientific research with the Fiji Exclusive Economic Zone (EEZ).

The Ministry of Foreign Affairs, International Cooperation and Civil Aviation has the honour to advice that diplomatic clearance has been granted to the aforementioned vessel to conduct marine scientific research with the Fiji Exclusive Economic Zone (EEZ) between 11th January to 11th March, 2009 and also to call at the port of Suva from 8th to 11th March, 2009.

The Ministry of Foreign Affairs, International Cooperation and Civil Aviation of the Government of The Republic of the Fiji Islands avails itself of this opportunity to renew to the Embassy of the United States of America the assurances of its highest consideration.

Embassy of the United States of America
Loftus Street
Suva.

17 January, 2009

TOTAL P.02