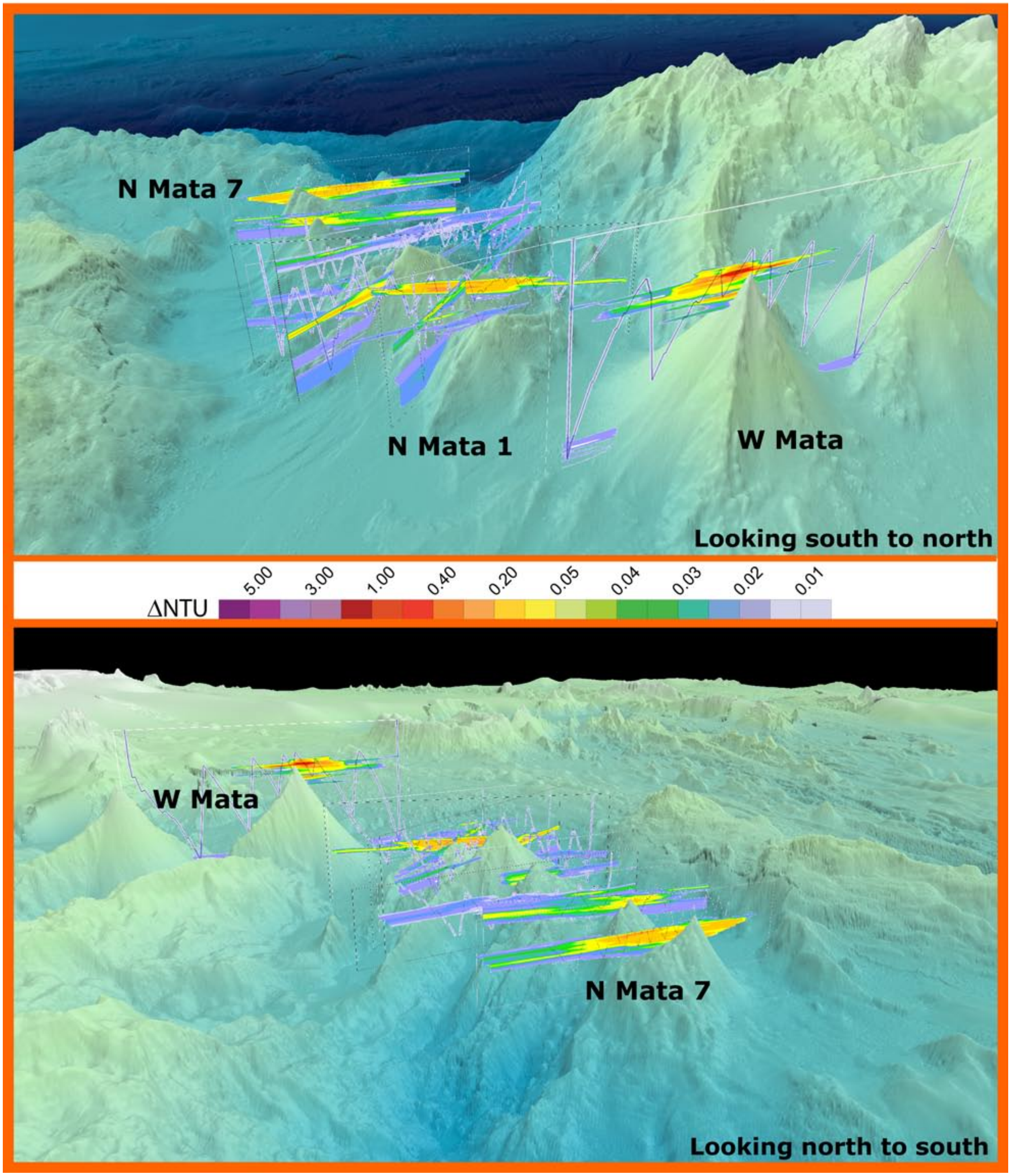
2010 NE Lau Basin
R/V *Kilo Moana* Expedition KM1008

April 28 - May 10 Apia Samoa - Apia Samoa

Chief Scientist: Joseph Resing



3-D images of the Mata volcanoes with 2-D CTD tow diagrams inserted. The CTD tow diagrams show the plumes as defined by light scattering values (DNTU). The sawtooth tow lines are the CTD track and are barely visible in these images. Image is 3 times vertically exaggerated.

Cover figure by Susan Merle and Sharon Walker.

Table of Contents

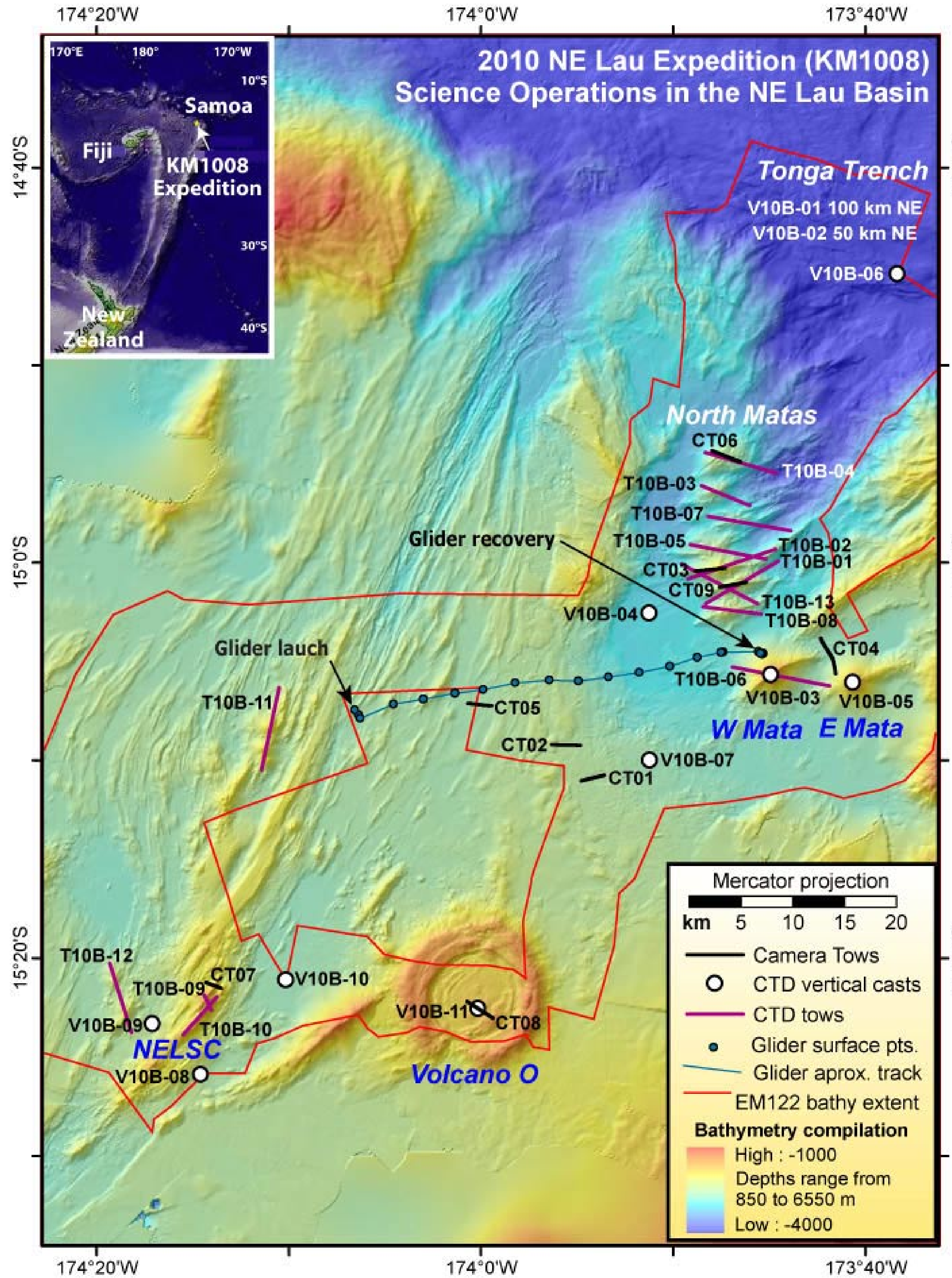


Figure 1. Science operations in the NE Lau Basin during expedition KM1008

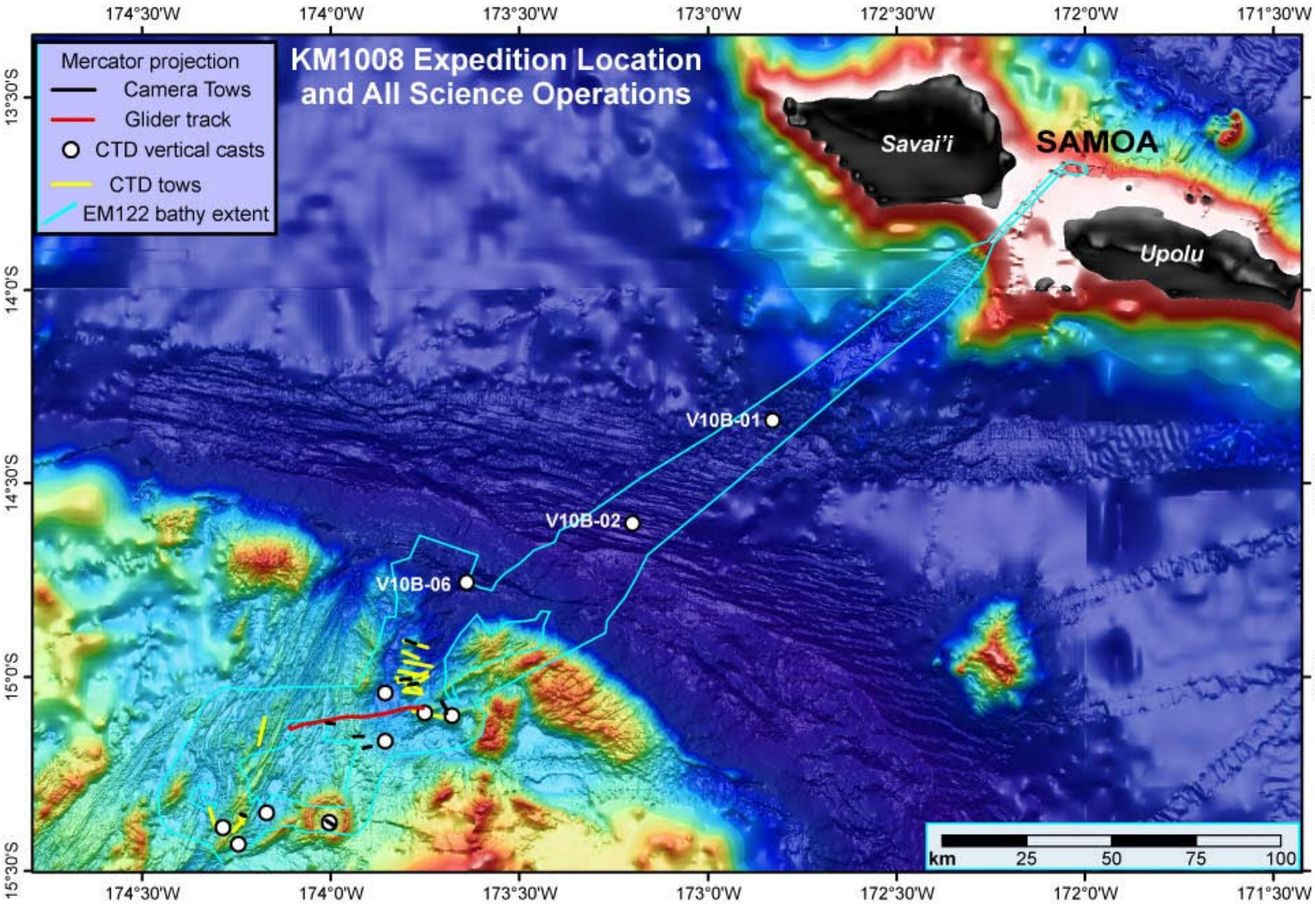


Figure 2. KM1008 expedition location and all science operations including transit and trench CTD casts.

1.0 NE Lau 2010 (KM1008) Expedition Summary

Joseph Resing, Chief Scientist

Cruise KM1008 aboard the *RV Kilo Moana* returned to the NE Lau Basin in May 2010. The NE Lau basin is the site of two previous cruises, *R/V Thompson* TN227 in November 2008 and *R/V Thompson* TN234 in May 2009. The main objective of this cruise was to continue our exploration of the region based on findings from the two previous cruises. Our previous research demonstrated that the NE Lau Basin is a "hotspot" for exploration and discovery and that there were still more findings to be made in this relatively small area. There were several features of great interest to us: the series of nine morphologically similar volcanoes beginning with E Mata running northward into the trench, the large lava flows throughout the region, deep hydrothermal plumes found near the NE Lau Spreading Center (NELSC), the large regional ^{3}HE plume present throughout the region, the hydrothermal state of the NELSC following its eruption, bathymetric anomalies north of the eruptive area on the NELSC, and the current hydrothermal state of Volcano "O", a large magmatic center. Our main operational tools were the CTD-rosette system, the Woods Hole Oceanographic Institution's TowCam (towed camera system), the ship's multibeam swath mapping system, and the ship's rock core. During the 14 days of the cruise we conducted 24 hydrocasts (13 tows and 11 verticals), nine camera tows, deployed one mooring and deployed and recovered an acoustic glider. By the end, we discovered six new hydrothermal sites and continued exploration in the time domain at five others. Between three and four days of ship time was lost due to operational problems (see operational notes section 2.2). As a result, rock coring operations and exploration of the Tofua arc did not occur.

Background

In November 2009 we discovered two active submarine eruptions in the NE Lau basin. The first eruption site was on the neovolcanic zone of the southernmost segment of the northeast Lau spreading center (NELSC) (Figure 1). Plumes characterized by high levels of light scattering, concentrations of volcanic glass shards, large temperature, pH, hydrogen and methane anomalies were detected up to 800 m above the seafloor at several locations above this ridge. Shards of volcanic glass found in samples from these plumes confirm that they arose from the quenching of molten lava by seawater. Such high-rising plumes in a well-stratified water column have been reliable indicators of massive hydrothermal discharge associated with seafloor eruptions. The second eruption was just 60 km NE of the NELSC and was named West Mata (Samoan for "Eye"). It had an intense plume rising ~175 m with some of the highest ever recorded values of ΔNTU, hydrogen (exceeding 15500 nM), δ^3He (440%), oxidation-reduction potential ("Eh") anomaly, and pH anomaly (>1.6 pH units) measured in a hydrothermal plume. Temperature anomalies >~1.5°C were measured at an altitude of ~15 m, clear evidence of buoyant fluids rising from the seafloor. The acoustic backscatter over the volcano is uniformly high indicating geologically young seafloor.

In May 2009, we returned to investigate these two eruptions with the *Jason-2* remotely operated vehicle (ROV). We conducted two dives (J2-415 & 416) at the NELSC, confirming the presence of extremely young, sediment-free, glassy lava devoid of sessile organisms. The only sign of venting was an area of dead microbial mat (material) associated with a very slight (~2°C above ambient) temperature anomaly. Adjacent older flows were clearly distinguished by their dense colonization by patchily-distributed sponges and corals. A diffuse vent in these older flows identified on video acquired by Nautilus Minerals Inc. was also revisited and several high-quality biological collections were made. We also used the Monterey Bay Aquarium Research Institute Autonomous Underwater Vehicle (AUV) *D. Allan B.* to make high-resolution maps of this ridge segment, centered on the eruption zone.

Our return to West Mata in May 2009 revealed a stunning sight on the summit of the volcano. Within a little more than an hour of reaching the bottom at W Mata on the first dive we came across an active eruption at 1205 m. We conducted five dives at W Mata and during each dive eruptive activity was observed at its summit. The eruptions were characterized by glowing molten lava, explosions, the creation of large amounts of volcanic tephra, large bubbles of magma, and the active formation of pillow lavas. Most of these phenomena were being witnessed by man for the very first time. Perhaps the most stunning observation was the formation of the large magma bubbles, which presumably arose from the expansion of magmatic and/or meteoric water vapor and other magmatic volatiles.

Based on the sampling conducted at NW Rota-1 and W Mata, active submarine volcanic eruptions produce fluids that are unlike anything found in stable hydrothermal systems. Access to active eruptions provides us with absolutely unprecedented data that can be used to understand the global impact of submarine eruptions on ocean chemistry. New fluid chemistry data shows that volcanic vents are significant sources of sulfur, aluminum, and other elements to the oceans. The unique chemistry of active volcanic sites, with extremely low pH, strong acid, high sulfur content, and high concentrations of hydrogen and other volcanic gases, creates hydrothermal habitat conditions that are in many ways the most extreme ever encountered.

Cruise Goals

The initial exploration of the northern Lau basin yielded stunning results in a short period of time. However, the 2008 and 2009 cruises also posed many unanswered questions and promised additional exciting discoveries that depend upon further exploration in the northern Lau Basin. In addition to the work on the NELSC and W Mata described above, we also conducted reconnaissance tows and casts over much of the NE Lau Basin. This work, plus data from other collaborators in the area, identified several sites with a high likelihood for the discovery and sampling of other unique hydrothermal and biological systems. Our initial exploration goals are summarized below:

East Mata. A single CTD cast in 2008 confirmed that East Mata, a smaller "twin" of West Mata lying a few kilometers to the east, is hydrothermally active. While the particle plume just above the summit was weak, concentrations of reduced chemicals (low ORP), CH_4, and especially δ^3He% were comparable to West Mata. Unlike W. Mata, acidic sulfur gasses and Hydrogen were not abundant at E. Mata indicating that E Mata was not erupting in November 2008. We revisited E. Mata to establish a time series of activity.

North Matas. The fascinating results from West and East Mata suggest that other, similar volcanoes in this area might also be active. To the northwest of West and East Mata lie a series of nine morphologically similar volcanoes we collectively refer to as the "North Matas" (Figure 3). Nautilus Minerals and Australian National University, using sensors supplied by the VENTS Program, have conducted preliminary CTD surveys around the North Matas. These surveys reveal a high regional turbidity around the N. Matas with a large particle and δ^3He plume over the largest, most northerly of these volcanoes. However, beyond ^{3}He we have not chemically characterized these plumes and could not confirm whether there was an ongoing eruption at one of these volcanoes.

Volcano "O". A massive, hydrothermally active caldera lies just ~15 km east of the NELSC. This caldera is a geological oddity, not directly associated with either a spreading ridge or the Tofua volcanic arc (Figure 1). A detailed sidescan and bathymetric survey showed that the floor of this caldera is paved with fresh sheet flows [R. Arculus, private comm.;]. A CTD tow north to south through the caldera and two vertical profiles east and west of this tow found at least five distinct plume layers indicating multiple active vent sources with at least two distinct chemistries. The plume chemistry suggests that one system is a mature high temperature hydrothermal system actively depositing sulfides while the other appears to be rich in acid magmatic volatiles. We suspect that this site is the location of frequent eruptions with a dynamic hydrothermal system.

Hydrothermal Activity on the Tofua Arc. Our exploration revealed that on the northernmost Tofua volcanic arc two relatively shallow active hydrothermal sites on Niua Volcano were identified from CTD casts. In addition, there are several sites south of Niua that have not been explored for hydrothermal activity. We were originally scheduled to visit these sites but ship problems reduced the available time.

Tafu. Evidence suggests that there is a highly active hydrothermal site on a seamount (Tafu) north of the eruptive area on the NELSC (Kim et al 2009). The venting from this site was likely masked during our survey in 2008 by the NELSC eruption.

Non-located sources. In addition to the known active sites discussed above, there are several deep plumes whose sources have yet to be determined. The first lies to the west of the NELSC, where CTD casts in 2004 and 2008 revealed a deep ΔNTU and δ^3He at ~2000 m depth, well below the ridge crest depth of 1850 m. A second plume was found between the NELSC and Volcano "O", where two casts documented light-scattering and ^{3}He maxima below 2200 m. The deep particle layers in these areas may be enhanced by ash dispersal from the 2008 NELSC eruption, but the δ^3He anomalies suggest an additional deep (~2200 m) hydrothermal source. At another site in a deep basin west of W Mata a strongly increasing ΔNTU from 2200 to 2800 m, but just a thin δ^3He anomaly near 2550 m was observed in two hydrocasts in 2008. A 2004 cast in the same area lacked the extensive ΔNTU anomalies but had the same thin δ^3He anomaly coincident with a small, thin ΔNTU layer at 2550 m. The similarity of δ^3He profiles in 2004 and 2008 suggests a plume generated by a continuing deep hydrothermal source but overlain by the deposition of volcanic ash from W Mata in 2008. These regional observations of δ^3He anomalies deeper than any explored volcano summit or ridge crest imply the existence of two or more unexpectedly deep hydrothermal sources.

Large Lava Flows. Seafloor mapping revealed young unsedimented lava flows covering large areas of seafloor around Volcano "O" and between the NELSC and the Mata volcanoes (Figure 1). We hoped to determine the chemistry and age(s) of the lava, whether they represent a source for the deep plumes and how these large outpourings of magma relate to the overall magmatic production in this region.

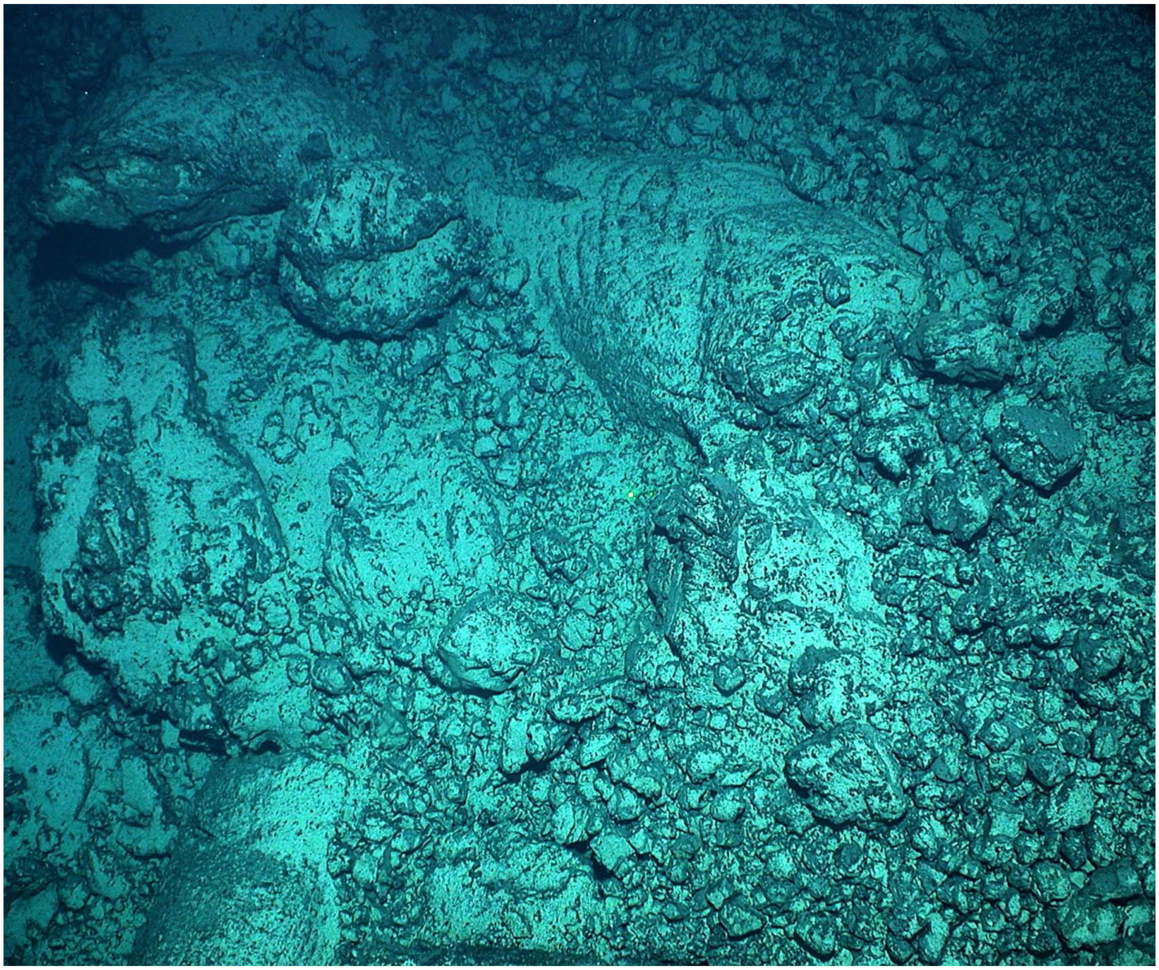
Summary and Highlights

Of the seven N Mata Volcanoes, six are hydrothermally active. The hydrothermal plumes above these volcanoes are characterized by fairly intense particle plumes with elevated methane concentrations; however the plumes appear to be relatively gas-poor, as evidenced by their small pH anomalies. The CH_4, suggests some interplay between hydrothermal fluids and the mafic to ultramafic rocks present at these volcanoes, or the interaction with hydrothermal fluids and sediments. E Mata was found to be still venting and is also CH4 rich, however it has a much larger pH anomaly. We conducted camera tows over 3 of these volcanoes and found abundant vent endemic biota and hydrothermal deposits and active venting. Our results indicate that these volcanoes are not erupting. Further chemical analysis will better help us to understand the venting taking place there.

During the cruise we found that W Mata continues to erupt, producing intense particle plumes with large H_2 concentrations and pH anomalies. The intensity of the eruptions interfered with the multibeam, making water column imaging difficult. To monitor the eruption we deployed an acoustic glider that recorded eruption sounds as it approached the volcano. In addition, a mooring with a hydrophone and MAPRs was deployed to continue monitoring of the eruption over the next several years.

A vertical hydrocast at a small neovolcanic cone within Volcano "O" revealed an extremely intense plume with a large decrease in pH. Decreases in pH this large are only observed in areas venting extremely large amounts of magmatic gasses. The absence of a significant H_2 anomaly indicated that it was not erupting. A camera tow revealed sulfur rich venting and fresh rock was recovered that was likely dacite. (P1 below)

The Lau basin continues to be a fruitful site for discovery and the revelation of the intensely concentrated hydrothermal activity along the Mata chain is yet another example. The conjunction of arc magmatism, back-arc spreading, and the complex tectonics of the triple junction in this region make it a very exciting location to explore. It is undoubtedly one of the most concentrated and diverse areas of submarine volcanic and hydrothermal activity found to date on Earth.



P1. The seafloor along the flanks of the central cone at Volcano O.

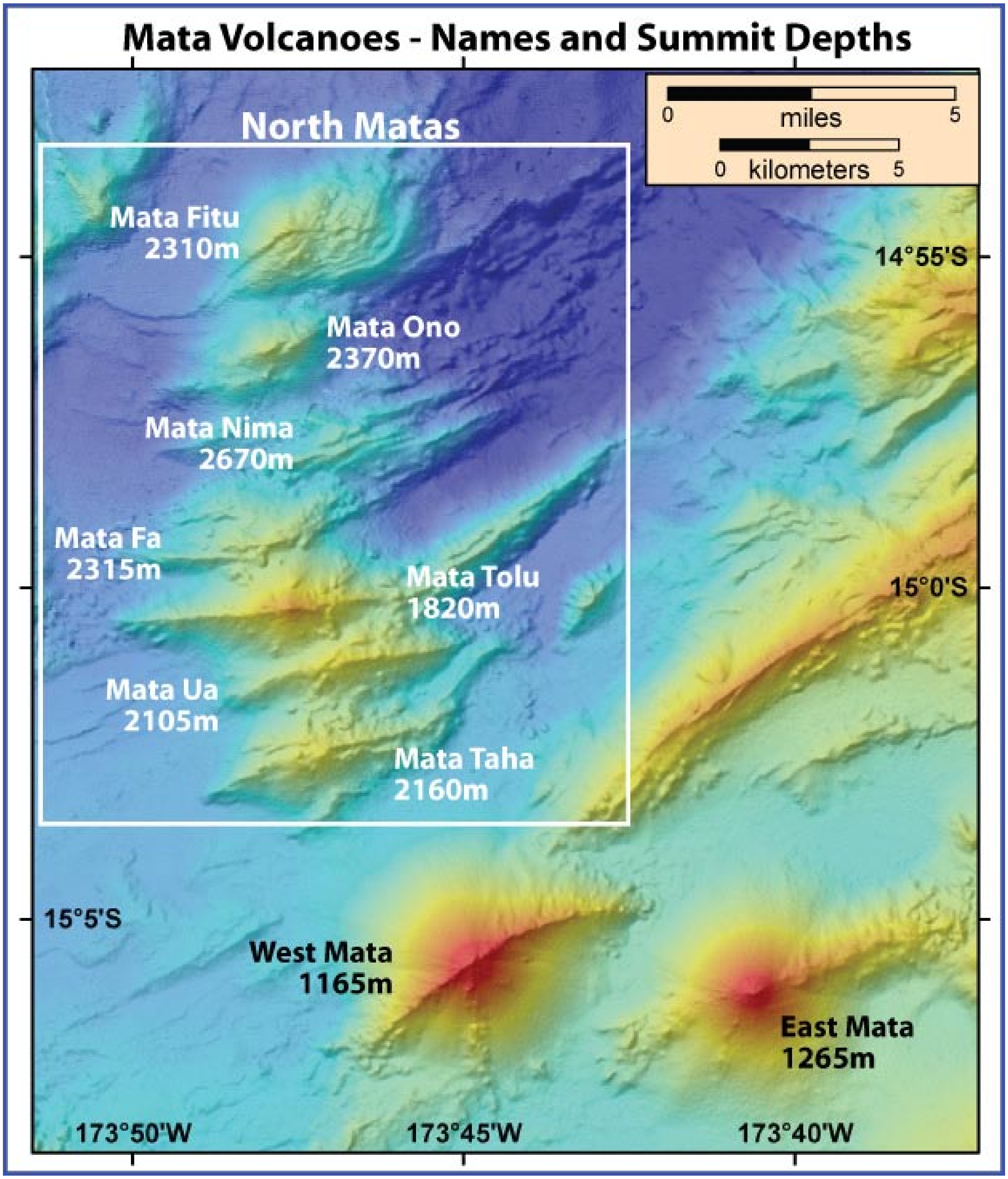


Figure 3. The Mata volcano group.

2.0 Operations

2.1 Operations Log

Highlighted cells: orange = CTD ops, green = TowCam ops, blue = mooring and glider ops.

Date (UTC)	Time (UTC)	Date (local)	Time (local)	KM1008 Science Operations	Z (m)	Latitude (S)	Longitude (W)
Apr29	0030	Apr28	1330	Depart Apia harbor, Samoa		-13.6908	-171.8022
	0132		1432	EM122. Start logging data. Line 0. North side of island heading west.	1756	-13.6908	-171.8022
	0142		1442	EM122. SOL 1. Turned on water column logging. Still N of the island.	1281	-13.6910	-171.8342
	0215		1515	Turned the bend. Now at NW part of Upolu looking for shallow water (ca. 500m) to do CTD dip test.			
	0224		1524	Stop logging water column data and bathymetry. EOL 2.	370	-13.7100	-171.9383
	0320		1620	Done with CTD test. CTD back on board.			
	0330		1630	EM122. Start logging. SOL 3.		-13.6983	-171.9583
	0422		1722	EM122. Data look bad. Logging in shallow mode.	166	-13.7433	-172.1128
	0503		1803	EM122.	116	-13.8383	-172.2100
	0620		1920	EM122. Had to stop logging.			
	0620		1920	Restarting. SOL 9. Not tracking. Data small gap.			
	0620		1920	EM122. Logging and tracking.			
	0700		2000	EM122. New sound velocity profile.	3150	-14.0883	-172.5000
	0735		2035	EM122.	3540	-14.1427	-172.5190
	0835		2135	Traffic in area of next CTD station.	3950	-14.2633	-172.7267
	0839		2139	Changing course to avoid traffic. They are not communicating. Change line. SOL 16.			
	0910		2210	EM122. Still logging. Looks OK.	4550		
	0924		2224	Slowing down for CTD station. Stop logging. EOL 17. At CTD station in trench area.	4700		
	0935		2235	CTD in the water for vertical **V10B-01** (cast #1). Lupton's Helium cast 1.	4752		
	0939		2239	Start of CTD cast.	4752	-14.3385	-172.8269
Apr29	1202	Apr29	0102	End of CTD V10B-01.			
	1203		0103	CTD back on deck.			
	1557		0657	Start of CTD vertical **V10B-02** (cast #2). Lupton's Helium cast 2.		-14.6046	-173.1992
	1652			?			
	1815		0715	End of CTD V10B-02.			
	1822		0722	EM122. SOL 26. From CTD 2 (trench) to N-Forearc feature.	6480	-14.6067	-173.2017
	1856		0756	EM122.	7104	-14.6983	-173.2583
	1921		0821	EM122. SOL 28. Not even 3x coverage.	6900		
	1954		0854	EM122. Surveying. Just climbing up from trench to forearc (line 29).	5250		

Date (UTC)	Time (UTC)	Date (local)	Time (local)	KM1008 Science Operations	Z (m)	Latitude (S)	Longitude (W)
	2019		0919	Approaching the way point for turn onto forearc. SOL 30. 4x water depth coverage at ca. 2000m. Logging **water column data** at 9.7 knots.	2100		
	2025		0925	Change course.		-14.9400	-173.4100
	2045		0945	Passing over forearc feature. Coverage > 5x water depth.	940		
	2127		1027	EM122.	1935	-15.0015	-173.5767
	2142		1042	EM122. SOL 33. Test for Gillian.			
	2205		1105	EM122. Approaching West Mata. Still logging bathymetry and water column data. Changing lines. SOL 34.	2700		
				EM122. SOL 35. Slow down to 5 knots to pass over W Mata.	2720	-15.0683	-173.7000
	2229		1129	Seeing NE rift zone.			
	2248		1148	Approaching the summit. Possibly a plume (line 36)?	1530		
				Seeing a plume? Going up > 1/2 way.	1377		
	2252		1152	Plume! Intense red spot at ca. vent level.	1345		
				EM122. Bad data for ca. 2 minutes. Lost its mind. Depth = 5131.			
	2257		1157	Still messed up data.			
	2259			Back.			
				Bad depths.			
				Looks like it is recovering…			
				EM122. Bathymetry looks good. We are past the summit. Water column data recovered. Still at line 36.	1610		
	2308		1208	Speeding back up to 10 knots. Still line 36.			
	2313		1213	EM122.	2500	-15.1100	-173.7783
				EM122. Approaching the end of this survey.			
Apr30	0003	Apr29	1300	EM122.	2511	-15.1667	-173.9033
				Approaching lava pond area for first camera tow.			
				EM122. Change lines. SOL 39. Change course for cam tow #1.			
	0010		1310	Over lava pond. Slowing down.	2490		
	0011		1311	EM122. Stop logging. End of survey.			
	0015		1315	Ready for cam tow, but now are having electrical issues.			
	0145		1445	Still not up and running with camera, so will do a vertical cast over W Mata instead. Will map again on way from cam tow 1 position (didn't happen) to V10B-03 position at W Mata summit. Will start logging when near W Mata.			
	0254		1554	EM122. SOL 40. Logging **water column data** and bathymetry. This line is heading SW to NE over the summit.	2912	-15.1267	-173.8083
	0303		1603	At the start of the SW rift zone.			
	0314		1614	Slowing down to 5 knots. Change lines. SOL 41. Coming up on summit. This will hopefully fill the gap.	2070	-15.1028	-173.7633

Date (UTC)	Time (UTC)	Date (local)	Time (local)	KM1008 Science Operations	Z (m)	Latitude (S)	Longitude (W)
				EM122. Really noisy in the water column right now.			
	0320		1620		1742		
	0322		1622	Seeing a plume ascending to ca. 500m.	1630		
				Plume here for sure.	1506		
				Position for vertical cast V10B-03 at West Mata. This spot is just west of Prometheus on the ridge between Prometheus and Hades.		-15.0944	-173.7484
	0325		1625	EM122. Bad depth.	1401		
	0325		1625	Bad depth for one ping.			
				Bad pings on and off.			
	0326		1626	Bad depth. z = 2415			
	0327		1627	Good depth.			
	0329		1629	Good depth.	1309		
	0332		1632		1427		
	0333		1633	EM122. Not logging. EOL 41 .			
				EM122. SOL 42. Logging on the "spin", just in case we get decent data. z = 7243.			
	0347		1647	EM122. EOL 42. Didn't get any decent bathymetry data near the summit. Stop logging and stop pinging.			
				Now will do the CTD.			
	0355		1655	CTD in the water for vertical **V10B-03** (cast #3) at West Mata.			
	0357		1657	Start of CTD cast.	1180 ?	-15.0945	-173.7488
	0517		1817	End of V10B-03. CTD back on board.			
				EM122. Next we will do another quick pass, perpendicular to summit this time to try to get good bathymetry data over the summit for surface difference.			
				Turning to get on line			
	0530		1830	EM122. SOL 43. Will image summit on starboard side.	1577	-15.0890	-173.7483
	0532		1832	EM122.	1267		
	0533		1833	He started turning to the SW too soon, so the data are splayed at the summit.			
				EM122. Line 43 probably OK, but pings are splayed at the summit one more time.			
				EM122. EOL 44. Stop logging until straighten this out.			
				Turning around and heading to the other side of the summit. Vents will be on the starboard side.			
	0604		1904	EM122. SOL 44. Water column data and bathymetry. Heading from south to north, perpendicular to summit. Off summit a bit to avoid bad depths.	2505	-15.1200	-173.7483
	0616		1916	EM122.	1878		
	0620		1920	Plume is there. We are still south of the summit.	1637		

Date (UTC)	Time (UTC)	Date (local)	Time (local)	KM1008 Science Operations	Z (m)	Latitude (S)	Longitude (W)
	0622		1922	Plume is very high, up to ca. 500m. Off on starboard side. We are on north side of the ridge.			
	0628		1928	EM122. EOL 44. Success!			
				Next we will try our first camera tow.			
	0851		2151	Camera in the water for cam tow (#1) **CT-01** (lava shield).		-15.1847	-173.9160
Apr30	1454	Apr30	0359	End of CT-01. Camera back on deck.		-15.1766	-173.8818
				Turn on EM122 between cam tow and CTD tow-yo (turn off during tow).		0.0000	0.0000
	1459		0359	Starting to move again after cam tow. Ca. 4 knots. Turn on EM122. SOL 45. Heading towards North Matas to do CTD tow-yo on North Mata #2 (Mata Ua).	2571	-15.1750	-173.8833
	1539		0439	Line 46. Decision from bridge: S-N tow over N Matas not possible because of current. We do SW-NE tows over N Mata 2 and 4 instead. Still heading there straight.	3014	-15.0917	-173.8300
	1605		0505	Slowing down to ca. 4.2 knots because arriving at CTD tow-yo location at N Mata 2.			
	1611		0511	Turn off EM122. EOL 47. Arrived at CTD tow-yo location at Mata Ua (second from south).	2934	-15.0341	-173.8062
	1640		0540	CTD in water for tow **T10B-01** (cast #4) at Mata Ua (#2).			
	1642		0542	Start of CTD cast.		-15.0345	-173.8053
				Winch behaving weird during tow: Slowing down on its own from time to time (from 60 to 55).			
	2128		1028	End of T10B-01. CTD back on deck.		-14.9986	-173.7425
	2135		1035	EM122. Start North Matas survey. Probably don't want to use line 48.	3128	-14.9983	-173.7433
	2201		1101	SOL 49. Turn - don't use!			
	2206		1106	EM122. Start of survey towards NNE. SOL 50.	2700	-15.0000	-173.8167
	2225		1125	EM122. North Matas survey continues. On line 50. 3x coverage.	2930	-14.9583	-173.7983
	2259		1159	SOL 52. Turn at survey point. Do not use.		-14.8642	-173.7603
	2306		1206	SOL 53. North Matas survey continues westwards.	3144	-14.8550	-173.7743
	2316		1216	SOL 54. Turn at survey point. Do not use.		-14.8558	-173.8038
	2321		1221	SOL 55. North Matas survey continues towards SSW.	3237	-14.8645	-173.8118
	2355		1255	Point on line 56, halfway between survey points.	3320	-14.9528	-173.8488
				For some reason there is no accompanying water column file with line 57.			
May01	0027	Apr30	1327	Finishing up the line at North Matas. SOL 58. Turn to CTD station. Don't use this line.	2900	-15.0385	-173.8817
	0037		1337	Stop logging. EOL 58. CTD cast next.	3083		
	0102		1402	CTD in the water for vertical **V10B-04** (cast #5) in West Mata basin (west of West Mata). Start of CTD cast.	3072	-15.0423	-173.8543

Date (UTC)	Time (UTC)	Date (local)	Time (local)	KM1008 Science Operations	Z (m)	Latitude (S)	Longitude (W)
	0322		1622	End of V10B-04. CTD back on deck.			
	0505		1805	Start of cam tow (#2) **CT-02**. Camera in water.		-15.2557	-173.9418
May01	1245	May01	0145	End of CT-02. Camera back on deck.		-15.1540	-173.9065
	1250		0150	EM122. Start survey between cam tow and cast at East Mata. SOL 59.	2553	-15.1537	-173.9048
	1301		0201	Speed of 10 knots reached. Heading ESE.		-15.1483	-173.8853
	1317		0217	SOL 61 Updated sound velocity profile. Probably do not use line 60.	2857	-15.1360	-173.8375
	1410		0310	Arriving at East Mata CTD cast site. Stop logging. EOL 62.	1323	-15.1008	-173.6778
	1421		0321	CTD in water for vertical **V10B-05** (cast #6) at East Mata.			
	1422		0322	Start of CTD cast.	1325	-15.1007	-173.6774
	1532		0432	End of V10B-05.			
	1535		0435	CTD out of water.			
	1543		0443	Leaving CTD cast site at East Mata. Turning around to start surveying the rest of East Mata. Heading for waypoint west of East Mata summit.			
	1551		0451	EM122. Start survey around East Mata. SOL 63. Heading east.	1650	-15.1023	-173.6833
	1617		0517	SOL 64. Loop-turn at waypoint. Do not use.		-15.0900	-173.6112
	1622		0522	SOL 65. East Mata survey continues southwards.	2149	-15.0900	-173.6170
	1638		0538	SOL 66. Turn at waypoint. Do not use.		-15.1347	-173.6140
	1640		0540	SOL 67. East Mata survey continues towards southwest.	2234	-15.1382	-173.6185
	1706		0606	SOL 68. Turn at waypoint. Do not use.		-15.1552	-173.6898
	1710		0610	SOL 69. SE-NW survey over West Mata.	2769	-15.1505	-173.6973
	1728		0628	SOL 70. Ask bridge to slow down to ca. 6 knots to pass over West Mata. Turn on **water column survey**.	2558	-15.1090	-173.7283
	1742		0642	Beautiful plume just north of summit! Bathymetry OK.			
	1755		0655	SOL 71. Speed up again. We passed West Mata. Water column survey still on.	2530	-15.0703	-173.7568
	1813		0713	EM122. Arriving at CTD tow-yo site for Mata Tolu (North Matas group - third from south). Stop survey. EOL 71. Turn off water column survey.	2484	-15.0318	-173.7852
	1814		0714	CTD in water for tow **T10B-02** (cast #7) at Mata Tolu. Start of CTD cast.		-15.0135	-173.8205
	2324		1224	End of T10B-02.		-14.9887	-173.7449
	2327		1227	CTD back on deck.			
May02	0041	May01	1341	Camera in the water for cam tow (#3) **CT-03** at Mata Tolu (#3).		-15.0074	-173.8165
				We seem to be ca. 200m north of where we want to be. Not sure what to do next - pull it and start again or maneuver onto line.			

Date (UTC)	Time (UTC)	Date (local)	Time (local)	KM1008 Science Operations	Z (m)	Latitude (S)	Longitude (W)
	0829		2129	End of CT-03. Camera on board.		-15.0046	-173.7897
				Next will be survey north to trench for Helium cast.			
	0902		2202	EM122. SOL 72.	2350	-14.9955	-173.7818
	1010		2310	EM122.	4420	-14.8333	-173.6817
	1044		2344	EM122. Stop logging. Finished survey. EOL 75.	4920	-14.7577	-173.6400
May02	1104	May02	0004	At CTD cast site near trench for John's Helium cast **V10B-06** (cast #8). CTD in the water.			
	1106		0006	Start of CTD cast.	4887	-14.7561	-173.6387
	1326		0226	End of V10B-06.			
	1327		0227	CTD out of water and back on board.			
				Misunderstanding with survey point: wrong value for latitude conversation. Corrected and communicated to bridge.			
	1346		0246	EM122. Start of survey. Heading west after turning around. SOL 76.	4889	-14.7560	-173.6390
	1413		0313	EM122.	4779	-14.7302	-173.7092
	1443		0343	SOL 78. Turn on survey point. Don't use.	4179	-14.7007	-173.7895
	1451		0351	SOL 79. Survey continues southwards to CTD tow site.	4204	-14.7033	-173.7830
	1526		0426	EM122. Closing the gap with available survey data. Line 80	3020	-14.8033	-173.7878
	1612		0512	EM122. Stop survey. EOL 81. Arriving at CTD tow site.	2965	-14.9290	-173.7940
	1657		0557	CTD in water for tow-yo **T10B-03** (cast #9) at Mata Ono (North Matas). Start of CTD cast.		-14.9352	-173.8087
	2024		0924	End of T10B-03.		-14.9518	-173.7672
	2030		0930	CTD out of water.			
	2047		0947	EM122. Leave for West Mata summit survey. SOL 82.	3076	-14.9533	-173.7665
	2133		1033	Called bridge to slow down to 4 knots for survey around West Mata summit. Turn on **water column survey**. SOL 84.	2206	-15.0783	-173.7553
	2140		1040	EM122. Line 84. Red spots on starboard side of water column (would be NW of summit).			
	2142		1042	Again. Same spot (ca. at halfway depth of water column).			
	2147		1047	EM122. Decrease beam angle from 65 to 50deg to get rid of artifacts in water column data. SOL 85. Plume above summit visible!			
	2153		1053	EM122. Changed now to 55deg coverage.			
	2155		1055	EM122. Line change for turn. SOL 86. Don't use.	1869		
	2207		1107	EM122. Line change after turn. SOL 87.	1803		
	2220		1120	EM122. Line 87. No plume visible on southern side of summit. Probably because of NW currents.			

Date (UTC)	Time (UTC)	Date (local)	Time (local)	KM1008 Science Operations	Z (m)	Latitude (S)	Longitude (W)
	2222		1122	EM122. Line change for turn. SOL 88. Don't use.			
	2233		1133	EM122. Red spots on port side.			
	2235		1135	EM122. End of water column survey at West Mata. Stop logging. EOL 89.	1620	-15.0965	-173.7417
	2309		1209	Start of cam tow (#4) **CT-04** between West and East Mata on lava flow.			
May03	0709	May02	2009	End of CT-04. Camera on deck.			
				Next operations will be a CTD tow at Mata Fitu (northernmost of the North Matas). Will survey with EM122 to the site.			
	0743		2043	EM122. Logging. SOL 90.	2625	-15.0433	-173.7200
	0744		2044	EM122. Opened beams to 65/65.			
	0825		2125	EM122. Stop logging. EOL 91.	2730	-14.9193	-173.7850
	0856		2156	CTD in water for tow-yo **T10B-04** (cast #10) at Mata Fitu (northernmost North Mata).			
	0904		2204	Start of CTD cast.		-14.9068	-173.8058
May03	1313	May03	0213	End of T10B-04. CTD on deck.		-14.9246	-173.7439
	1335		0235	Leaving CTD tow site southwards towards mooring deployment site south of West Mata. Start logging EM122. SOL 92. Go at 10 knots.	3845	-14.9248	-173.7442
	1359		0259	Passing over elevated feature extending NE-wards from Mata Tolu (North Mata #3). Called bridge to speed up to 12 knots.	2801	-14.9845	-173.7438
	1427		0327	EM122. Turn on water column logging over summit of West Mata. SOL 94.	2079		
				Making a curve around summit.			
	1437		0337	Stop logging and turn off water column data. EOL 94.			
				Arriving at **mooring deployment** site south of West Mata. Deploy hydrophone and mappers.			
	1613		0513	First mapper in water.			
	1700		0600	Last mapper in water.			
				Not quite in the right place to "release" the mooring so had to transit a bit to the proper location.			
				Transit to mooring release site - where the mooring was deployed. Whole setup consists of 40" foam float ball, 1 hydrophone, 5 mappers, 1 acoustic release, 1 single RR wheel (anchor).			
	1900		0800	Mooring deployed.	2794	-15.1417	-173.7377
	1914		0814	Heading west to CTD cast site in basin southwest of West Mata. Turn on E122 logging. SOL 95.	2800	-15.1462	-173.7435
	1954		0854	Arriving at CTD cast site. Stop logging EM122. EOL 97. In basin southwest of West Mata now.	2664	-15.1663	-173.8490
	2012		0912	CTD in water for CTD vertical **V10B-07** (cast #11) in basin southwest of West Mata.			

Date (UTC)	Time (UTC)	Date (local)	Time (local)	KM1008 Science Operations	Z (m)	Latitude (S)	Longitude (W)
				Joe changed the names of the 3 northernmost Matas at this point. Have gone back and corrected the log. Log OK.			
	2014		0914	Start of CTD cast.	2661	-15.1665	-173.8539
	2213		1113	End of V10B-07.			
				EM122. SOL 97. Still at CTD site. Don't use this file?	2270		
	2250		1150	Bridge was heading the wrong direction (to an old waypoint). Circling around now and getting on the right course. SOL 98.	2750	-15.1475	-173.8467
				EM122. Stop logging. EOL 99. At camera tow site.	2625	-15.1208	-174.0063
	2351		1251	Camera in water for cam tow (#5) **CT-05** at west lava site.			
May04	0720	MAy03	2020	End of CT-05. Camera back on deck.			
				Next task tow-yo at Mata Fa (North Mata #4). Will EM122 survey on the way.			
	0754		2054	EM122. SOL 100. Steaming to next tow-yo site.	2485	-15.1117	-173.9733
	0907		2207	EM122. EOL 102. Will have to cut end of this line because did not stop logging before the ship went into a turn.	2880	-14.9848	-173.8185
				On station for CTD tow at Mata Fa.			
	0918		2218	CTD in the water for tow-yo **T10B-05** (cast #12) at Mata Fa.			
	0925		2225	Start of CTD cast.		-14.9849	-173.8187
	1314		0214	End of T10B-05.		-14.9970	-173.7531
				Going south at ca. 10 knots to CTD tow site at West Mata. No EM122 logging.			
	1400		0300	Arriving at West Mata CTD tow site.	1648	-15.0903	-173.7538
	1455		0355	CTD in water for tow-yo **T10B-06** (cast #13) at West Mata.			
	1456		0356	Start of CTD cast.	2840	-15.0881	-173.7818
	1654		0554	Small but intense plume on West Mata summit visible in water column data. Unfortunately not logged!	1180	-15.0940	-173.7485
	1656		0556	Short signal disturbance. Missing bathymetry. Not logged.			
	2024		0924	End of T10B-06. CTD on board.		-15.1041	-173.6981
				Next operation is another pass over West Mata. Hope to get good line over the volcano for surface difference.			
	2110		1010	EM122. Logging **water column data** and bathymetry over West Mata. Line from northeast to southwest over rift zone. Slightly offset from summit. SOL 103.	2737	-15.0633	-173.6883
	2135		1035	EM122. Deep mode. Data OK. Still northeast of summit. Pass over West Mata: lines 103-105 for surface difference.	1935	-15.0867	-173.7300
	2141		1041	Approaching the summit. Line 104.	1591		
	2145		1045	Seeing the plume. It's wimpy.	1380		

Date (UTC)	Time (UTC)	Date (local)	Time (local)	KM1008 Science Operations	Z (m)	Latitude (S)	Longitude (W)
	2147		1047	Plume on starboard side.	1580		
	2150		1050	Past the summit.	1775		
	2213		1113	EM122. EOL 105.	2920	-15.1255	-173.7953
	2220		1120	Next we will head north for camera tow CT-06. Not logging until we approach North Matas.			
	2256		1156	EM122. SOL 106. To fill hole west of Mata Tolu.	2850	-15.0150	-173.8117
	2330		1230	EM122. Stop logging. EOL 107.	2800	-14.9083	-173.8033
	2336		1236	At CT-06 site at Mata Fitu (northernmost Mata).			
	2348		1248	Camera in water for cam tow (#6) **CT-06** at Mata Fitu. Start tow.		-14.9058	-173.7992
May05	0754	May04	2054	End of CT-06. Camera on deck.		-14.9167	-173.7697
				Next we will do a CTD tow at Mata Nima.			
	0920		2220	CTD in the water for tow-yo **T10B-07** (cast #14) at Mata Nima. Start of CTD cast.		-14.9609	-173.8034
May05	1333	May05	0233	End of T10B-07. CTD out of water.		-14.9731	-173.7314
	1334		0234	CTD out of water.			
				Moving to CTD tow site at Mata Taha (southernmost North Mata).			
	1512		0412	CTD in water for tow-yo **T10B-08** (cast #15) at Mata Taha. Start of CTD cast.		-15.0371	-173.8077
				We are a bit north of the planned starting position. Therefore moving southeastwards first before heading east. Tow line a bit bent because of that.			
	1841		0741	End of T10B-07.		-15.0433	-173.7573
	1847		0747	CTD out of water.			
				Leaving westwards to camera tow site at the Northeast Lau Spreading Centre (NELSC).			
	1948		0848	EM122. Start survey. SOL 108.	2678	-15.0583	-173.9038
	1952		0852	Water column logging first on, now turned off.			
	2119		1019	EM122. Change of line for curve. SOL 113. Don't use line 111.		-15.0777	-174.2285
	2121		1021	EM122. Logging towards south-southwest to increase area of multi-beam survey. SOL 114.	2924	-15.0827	-174.2332
	2139		1039	Slow to 11 knots.	2500	-15.1350	-174.0900
	2205		1105		2575		
	2230		1130	EM122. Changed lines for turn to CT-07 point. SOL 117. Use part of it.			
	2243		1143	EM122. SOL 118.	2660		
	2306		1206	EM122. Stop logging. EOL 118.	2019		
	2317		1217	Camera in water for cam tow (#7) **CT-07** on the area north of Tafu (north of NELSC) where a surface differencing anomaly was mapped by Bill Chadwick.			
May06	0458	May05	1758	End of CT-07. Camera back on board.			

Date (UTC)	Time (UTC)	Date (local)	Time (local)	KM1008 Science Operations	Z (m)	Latitude (S)	Longitude (W)
	0557		1857	EM122. Start logging during transit to vertical cast in east basin (east of NELSC). SOL 119.	2030	-15.3767	-174.2300
	0623		1923	EM122. Stop logging. At CTD launch site in the basin east of NELSC.	2460	-15.4300	-174.2438
	0636		1936	CTD in water for vertical **V10B-08** (cast #16) in basin east of NELSC.			
	0639		1939	Start of CTD cast.	2475	-15.4317	-174.2431
	0832		1932	End of V10B-08.			
	0835		2135	CTD on deck.			
	0946		2246	CTD in water for vertical **V10B-09** (cast #17) in basin west of NELSC.	2294	-15.3886	-174.2848
May06	1124	May06	0024	End of V10B-09. CTD on board.			
				Leaving CTD site to multibeam line.			
	1200		0100	EM122. Start logging. SOL 120.	2027	-15.4490	-174.3080
	1251		0151	EM122. Stop logging. EOL 122.	2240	-15.3438	-174.2123
	1318		0218	Arriving at CTD tow station Tafu.			
	1334		0234	CTD in water for tow-yo **T10B-09** (cast #18) across Tafu (NELSC). Start of CTD cast.		-15.3649	-173.2398
	1518		0418	End of T10B-09. CTD back on deck.		-15.3774	-173.2338
				Another CTD tow, along the ridge of Tafu.			
	1654		0554	CTD in water for tow-yo **T10B-10** (cast #19) along Tafu (NELSC). Start of CTD cast.		-15.3979	-173.2582
	2008		0908	End of T10B-10.		-15.3659	-173.2291
	2010		0910	CTD on deck.			
	2040		0940	EM122. Start logging. SOL 122.	1970	-15.3492	-174.2327
	2122		1022	EM122. Turn off logging. EOL 123.	2548	-15.2133	-174.1077
	2134		1034	EM122. Start logging. SOL 124.	2584	-15.1897	-174.2550
	2219		1119	EM122. Stop logging. EOL 125.	2638	-15.1390	-174.1167
	2230		1130	Arriving at glider deployment site northeast of NELSC.			
	2300		1200	The glider is not communicating. Spinning the ship around to see if that helps the iridium signal.			
	2305		1205	Now we are connected.			
	2318		1218	Got the signal now.			
	2329		1229	Still communicating.			
May07	0025	May06	1325	Glider in the water!		-15.1350	-174.1049
				We're going to hand here until we decide if we can move away from the glider.			
				The plan is to head southwest for a CTD tow.			
	0140		1440	Moving now. Not mapping multibeam. We have it already.			
				Next will be CTD tow.			
	0210		1510	Circling around for tow.			
				Final route for tow: Going south to north.			

Date (UTC)	Time (UTC)	Date (local)	Time (local)	KM1008 Science Operations	Z (m)	Latitude (S)	Longitude (W)
	0236		1536	CTD in water for tow-yo **T10B-11** (cast #20) at small volcanoes north of NELSC.			
	0237		1537	Start of CTD cast.		-15.1745	-174.1905
	0636		1936	End of T10B-11. CTD on board.		-15.1055	-174.1751
				Next task is multibeam survey to the west. No previous data there.			
				Justin doing an XBT.			
	0707		2007	EM122. Start logging. Increased the angles out to 68/68.	2700	-15.0958	-174.2392
				SOL 130. Turning onto our survey line now. Check previous data and whether want to keep it.			
	0830		2130		2660	-15.2183	-174.3632
	0909		2209	EM122. End of official survey. SOL 134. Turning toward CTD tow site.	1960	-15.3200	-174.4200
	0948		2248	Speed up to ca. 11 knots.	2600	-15.3808	-174.3470
	0951		2251	EM122. Stop logging.	2165	-15.3883	-174.3100
	1045		2345	CTD in the water for tow-yo **T10B-12** (cast #21) on small volcanic (?) cones with lava flows west of NELSC.			
	1048		2348	Start of CTD cast.		-15.3381	-174.3221
May07	1412	May07	0312	End of T10B-12.		-15.3960	-174.3031
	1414		0314	CTD on board.			
				Water column logging on summit of Maka towards east-southeast due to currents and wind. At 1/4 to 1 knot.			
	1436		0336	EM122. Start logging. SOL 136.	1830	-15.4197	-174.2872
	1440		0340	Change of lines. At a speed of less than 1 knot now. SOL 137.	1721		
				We stopped because bridge thought we would do CTD.			
	1447		0347	Start moving again. Change of lines. SOL 138.	1667		
	1450		0350	Change of lines. SOL 139.			
				Line 139. Didn't see a distinct plume at northwest side of summit, but higher intensities on the sides before ca. 1507 UTC.			
	1526		0426	Change of lines. SOL 141.			
	1528		0428	Change of lines. SOL 142.			
	1530		0430	EM122. Stop logging bathymetry and water column data. EOL 142.	1633	-15.4230	-174.2817
	1614		0514	EM122. Start logging. SOL 143. Water column logging first on, then turned off. Don't use it.	2592	-15.3732	-174.2035
	1633		0533	Turn. Change of lines. SOL 144. Arriving at CTD cast site.			
	1634		0534	EM122. Stop logging. EOL 144.	2672	-15.3517	-174.1698

Date (UTC)	Time (UTC)	Date (local)	Time (local)	KM1008 Science Operations	Z (m)	Latitude (S)	Longitude (W)
	1652		0552	CTD in water for vertical **V10B-10** (cast #22). Start of CTD cast.	2673	-15.3519	-174.1692
	1843		0743	End of V10B-10. CTD on board.			
				Next operations will be multibeam survey across Volcano O and tow there.			
	1902		0802	EM122. Start logging. SOL 145.	2671	-15.3533	-174.1662
				Logging **water column data**.			
	1927		0827	Line 146. Passing southwest feature. Summit at 1247m depth. Down to ca. 2500 coverage at starboard side.	2115		
	2013		0913	Approaching the cone at Volcano O. No bubbles.			
	2020		0920	EM122. Stop logging bathymetry and water column data. EOL 147?			
	2043		0943	CTD in water for vertical **V10B-11** (cast #23) at cone in Volcano O.			
	2045		0945	Start of CTD cast.	1275	-15.3758	-174.0026
	2140		1040	EM122. Start logging **water column data** over Volcano O cone. Seeing huge plume during vertical cast.			
	2204		1104	End of V10B-11.			
	2207		1107	CTD on deck. Volcano O may be erupting!			
	2232		1132	EM122. Stopped logging of seafloor and water column data. EOL 147. Sitting in one place. Don't use this line.			
				EM122. Bubble plume survey over Volcano O cone. Logging water column data and seafloor. SOL 150. Reduced coverage to 55/55. Northwest to southeast at 1 knot.			
				Not seeing anything.			
				SOL 151. Southeast to northwest drifting backwards up the line now.			
				SOL 153. Northwest to southeast.			
May08	0011	May07	1311	EM122. Stop logging water column data and bathymetry. No bubbles.			
				Holding position until further notice.			
	0053		1353	Camera in the water for cam tow (#8) **CT-08** at Volcano O cone.		-15.3698	-174.0124
	0729		2029	End of CT-08. Camera back on deck.			
	0755		2055	Circling around to survey over the cone. Then over caldera rim. West to east. Then we will transit north to North Matas Ua (2) and Tolu (3) for CTD tow.			
	0813		2113	EM122. SOL 155. Logging water column data and bathymetry.	1618	-15.3742	-174.0072
	0838		2138	On caldera rim.	1290	-15.3767	-173.9550
				End survey across caldera. SOL 156. Turn.			

Date (UTC)	Time (UTC)	Date (local)	Time (local)	KM1008 Science Operations	Z (m)	Latitude (S)	Longitude (W)
	0845		2145	SOL 157. Heading north to North Matas for CTD tow.	2000	-15.3733	-173.9400
	0900		2200	9 knots.			
	0943		2243	Multibeaming all the way to CTD site.	2335	-15.2433	-173.9033
	1033		2333	Change of lines. SOL 161. Double coverage of basin west of West Mata.	2869	-15.1292	-173.8650
May08	1101	May08	0001	Change of lines. SOL 162. Getting close to Mata Taha (1). Filling the bathymetry data hole west of Mata Taha.	3035	-15.0653	-173.8460
	1124		0024	Change of lines. Turn. SOL 163.	2910		
	1130		0030	EM122. Stop logging. Arriving at CTD tow site at North Matas (Mata Tolu).	3008	-15.0015	-173.8280
	1155		0055	CTD in water for tow-yo **T10B-13** (cast #24).	3029		
	1158		0058	Start of CTD cast.		-15.0010	-173.8265
	1638		0538	End of T10B-13.		-15.0345	-173.7605
	1642		0542	CTD back on deck.			
	1700		0600	Heading to West Mata to do bubble plume survey. But do a detour around track of glider to avoid influence of ship on hydrophone!			
	1716		0616	EM122. Turn on logging. SOL 164.	2671	-15.0400	-173.7172
	1725		0625	Turn. Change of lines. SOL 166.	2139		
	1728		0628	After turn. SOL 166.	2514		
	1743		0643	Turn. Change of lines. SOL 167.	2399		
	1744		0644	EM122. Stop logging. EOL 167.			
	1810		0710	Arriving at summit of West Mata. Turn on logging EM122. Bathymetry and **water column logging** for bubble plume survey. SOL 168. Reduced coverage of 55/55.			
				Passing by the summit (south of it) once before getting in position for bubble survey.			
	1811		0711	Small plume visible on starboard side.			
	1812		0712	Change of lines. Turn. SOL 169.			
	1822		0722	EM122. Start bubble survey at 2 knots. Change of lines. SOL 171. Heading towards southeast. Northwest to southeast.			
	1823		0723	Subtle plume.			
	1827		0727	Cloudy plume. Then distinct plume.			
	1828		0728	Distinct plume, slightly at starboard side.			
	1829		0729	Straight plume, centered.			
	1831		0731	Straight plume, centered.			
	1832		0732	SOL 172. Stopping and drifting backwards at ca. 1 knot. Southeast to northwest.			
				Plume right at the beginning.			
	1837		0737	Small plume.			
	1839		0739	Fuzzy plume.			

Date (UTC)	Time (UTC)	Date (local)	Time (local)	KM1008 Science Operations	Z (m)	Latitude (S)	Longitude (W)
	1840		0740	Distinct plume. Almost yellow color in water column data.			
	1846		0746	Start moving forwards, but called bridge to continue drift backwards. SOL 173. Stopping. Weak fuzzy plume.			
				SOL 174. Moving backwards again. Southeast to northwest.			
	1853		0753	Straight plume.			
	1856		0756	Stopping. SOL 175.			
	1857		0757	Moving forwards again until we call bridge. SOL 176. Northwest to southeast.			
	1900		0800	Weak plume.			
	1906		0806	Stronger plume.		-15.0943	-173.7487
	1909		0809	Interrupting bubble survey. Heading to glider position. Order from Joe. Stop logging EM122. EOL 177.			
	1935		0835	Glider recovery complete. Glider and boat on board.		-15.0790	-173.7593
				Next will be camera tow. Where?			
				First go back to bubble survey on summit of West Mata and continue where we stopped.			
	1958		0858	EM122. Turn on bathymetry and **water column logging**. SOL 178. Coverage of 55/55.			
	2002		0902	Change of line. Stopping. SOL 179. Already kind of a plume. Very weak, thin but high.		-15.0925	-173.7523
				Line 179. Now moving forwards.			
				EM122. Track line not displayed anymore!			
	2008		0908	Still plume visible. On top of summit.			
				Plume disappeared now.			
	2012		0912	Stronger plume.		-15.0943	-173.7485
	2016		0916	Another straight plume. Or the same?			
	2018		0918	Intense straight plume.			
	2020		0920	Stopping. SOL 180.			
	2022		0922	SOL 181. Moving backwards. Drifting southeast to northwest.			
	2024		0924	Southeasternmost plume.			
	2030		0930	Seeing Prometheus?		-15.0951	-173.7482
						-15.0946	-173.7498
	2039		0939	Weaker plume again. Northwesternmost. Slightly on port side.		-15.0939	-173.7529
	2044		0944	Stopping. SOL 182. Heading forwards again, moving a bit more east because we drifted away too far westwards.			
	2053		0953	Line change. SOL 183. We've straightened out, are back on track. Northwest to southeast.			
	2059		0959	Little mushroom plume.			

Date (UTC)	Time (UTC)	Date (local)	Time (local)	KM1008 Science Operations	Z (m)	Latitude (S)	Longitude (W)
	2106		1006	Turning to go to camera tow site at Mata Ua (North Mata 2).			
	2108		1008	EM122. Turn off bathymetry and water column logging.			
	2145		1045	At camera tow site at Mata Ua.			
	2206		1106	Camera in water for cam tow (#9) **CT-09** at North Mata Ua.		-15.0206	-173.7928
	2219		1119	Restarting EM122 because it didn't display the depth correctly anymore. Still camera towing at Mata Ua.			
May09	0548	May08	1848	End of CT-09. Camera on board.		-15.0158	-173.7683
				We are going to stay here in one place until the engineers check one of the two engines that are still working (out of 4). If it is not good we will return to the beach.			
	0630		1930	The cruise is over! Heading back to port. Can't fix the engine (missing the right tool to take it apart).		-15.0083	-173.7874
	0653		1953	Heading back to the beach. EM122 mapping on the way. SOL 184.	2130	-15.0058	-173.7835
	0725		2025		3450	-14.9672	-173.7338
	0742		2042		3500	-14.9450	-173.7050
	0932		2232		4435	-14.8190	-173.5182
	1213	May09	0113		6645	-14.6253	-173.2342
	2138		1038	Islands of Samoa off to port and stbd	782	-13.8835	-172.2542
	2359		1259	End of survey. Just north of Upolu.	82	-13.6917	-172.0017
May10	2100	May10	1000	Pulled into Apia harbor. End of expedition.			

2.2 Notes on the Operation of the R/V *Kilo Moana* during KM1008

Joe Resing

KM1008 began with the hydrographic winch not functioning, no bow thrusters, and no ability to accomplish dredging. In addition, engine problems plaguing the previous leg cast a light pall over operations preceding our leg. The cruise departed approximately five hours late because it was believed that bad fuel may have generated the engine problems on the previous leg. As a result we had to take on fuel instead of departing. This five hour delay caused us to postpone one of the stations on our transit route so that we could undertake camera work that was scheduled to start the next day. We eventually back tracked and picked up that station, which cost us an additional four hours.

The absence of the bow thruster required that camera and CTD tows to be conducted straight into the wind or current, depending on which was dominant. The result was that only a few of the track lines taken were optimal for the operations that we intended. Eventually the ship came to the conclusion that the CTD could be towed in different orientations due to the 1-1.5 knot speed of those tows. In practice we managed to learn almost as much from the CTD operations as we would have with more optimal track lines. The camera however was unable to accomplish all that it intended. One camera tow along the NELSC needed a N-S orientation to answer an important scientific question, which could not be accomplished and was thus lost from the program.

The previous leg ended 2 or 3 days early due to the aforementioned engine problems. We agreed to finish the work from the previous leg to ensure completion of the previous leg's most compelling remaining needs. This included deploying a mooring (4hours) and deploying and recovering a glider (8 hours).

On the morning of May 7th, 2010, engine #4 failed due to valve problems and the ship was reduced to operating on 2 engines (engine #2 failed earlier in the cruise) which restricted transit speed to 8 knots. This increased transit times dramatically requiring a reevaluation of operations. On May 8th the Captain informed us that it was likely that we would be unable to continue on two engines due to unease about Engine #1. Oddly, the remaining functioning engine (#3) was a question mark at the start of the cruise because it could not be controlled from the central operating system.

The final operation was camera tow CT09 that ended on May 8th at around 1900. We then proceeded to Apia Samoa on the two remaining engines. We arrived Sunday May 9th in the late morning and waited until the morning of May 10th (Mother's Day) to return to port. A reasonable estimate of lost operations, due to all of the ship problems plus finishing off work from the previous cruise, is between three and four days of ship time.

3.0 KM1008 Expedition Participants

KM1008 Science Party. Front row left to right: Susan Hanneman, Susan Merle, Sharon Walker, Ed Baker, Gillian Grün, Richard Arculus, Peter Crowhurst. Back row left to right: Ken Rubin, Cornel de Ronde, Bob Embley, Ken Feldman, Joe Resing, Eric Olson, Nathan Buck, John Lupton, Pam Barrett, Dan Fitzgerald.

2010 Participating Scientists and Affiliations

Joseph Resing - Chief Scientist, University of Washington
Richard Arculus - Australian National University
Edward Baker - NOAA Pacific Marine Environmental Lab
Pamela Barrett - University of Washington grad student
Nathan Buck - University of Washington
Peter Crowhurst - Nautilus Minerals
Cornel de Ronde - Institute of Geological and Nuclear Sciences
Robert Embley - NOAA Pacific Marine Environmental Lab
Kenneth Feldman - Independent contractor with Woods Hole
Gillian Grün - Institute of Geological and Nuclear Sciences grad student
Susan Hanneman - Independent contractor with NOAA PMEL
John Lupton - NOAA Pacific Marine Environmental Laboratory
Susan Merle - Oregon State University
Eric Olson - University of Washington
Kenneth Rubin - University of Hawaii
Sharon Walker - NOAA Pacific Marine Environmental Laboratory

R/V Kilo Moana Crew

Richard Meyer - Captain
Eric Schoenbnerg - Chief Mate
Christian Berg-Hansen - 2nd Mate
James Scancella - 3rd Mate
Stephen Graves - Q Med
Robert McDonough - Q Med
Craig Harvey - AB
Thomas Perry - AB
Roger Rios - AB
David Spurgin - AB
Lawson Worrell - AB
Frank Zellin - AB
Joachim Heise - Chief Engineer
David Roddy - 1st Asst. Engineer
William Kane - 2nd Asst. Engineer
Travis Souza - 3rd Asst. Engineer
Shawn Lindenmuth - Steward
Donnie Cabanizas - Cook
Karsten Murray - Steward Asst.
Dan Fitzgerald - Scientific Marine Technician
Justin Smith - Scientific Marine Technician

4.0 CTD Operations

Edward Baker, Joseph Resing, John Lupton, Cornel de Ronde, Richard Arculus, Sharon Walker, Nathan Buck, Eric Olsen, Pam Barrett

The primary objectives of the CTD operations were to conduct vertical casts and tows to explore for new hydrothermal sites, acquire discrete water samples for chemical analyses, and compare measurements acquired during this cruise with those from the earlier cruises in this area (November 2008, May 2009). A total of 24 CTD casts (11 vertical casts and 13 tows) were completed; see figure 1 for CTD cast locations. Study areas included the Tonga Trench (3 casts), the north Mata volcanoes (8 tows), W and E Mata (1 tow, 2 casts), volcano "O" (1 cast), the NELSC (2 tows), and various sites in the N Lau Basin (2 tows, 5 casts). Sensors on the CTD included the standard hydrographic sensors (conductivity, temperature, and pressure) as well as optical backscattering, oxidation-reduction potential (ORP), and an altimeter. A total of 1959 water samples were taken for the following analyses: helium (387 samples), methane and hydrogen (393), H_2S (45), pH (404), dissolved inorganic carbon (115), total dissolvable metals (392), dissolved metals (92), particulate bulk chemistry (XRF) (94), and particle morphology/type (SEM) (37). Some water samples were analyzed at sea, while others need to be analyzed in laboratories on shore.

North Matas

Seven small volcanoes are found along 173°47'W between 15°2' and 14°55'S (Figure 3). None is as large or shallow as W or E Mata, but most share with those volcanoes a characteristic ridge running SW-NE through the summit. Remarkably, our CTD results indicate the six of these seven volcanoes are hydrothermally active (Figures 4-8). Only at Mata Nima (5), barely identifiable as a volcano, did we detect no clear evidence of hydrothermal emissions. Plumes over these volcanoes ranged over 800 m of depth, from 1800 to 2600 m. The most intense ΔNTU anomalies (>0.2) were detected at Mata 2 and Mata 7. Especially large ORP anomalies were present at Mata 2 and Mata 4, though this observation may not be directly related to source strength because the ORP intensity is a strong function of distance from the source. ΔNTU values >0.1 at all volcanoes except Mata 5 and Mata 4 imply that the sources are high temperature (black smokers) and/or rich in particulate S.

West Mata and East Mata

Casts over these volcanoes confirm that both are still active, with plume characteristics similar to those seen in November 2008 and May 2009. In fact, the plume at W Mata is ~100 m higher than seen in 2008, implying that the buoyancy flux has increased because of increases in the heat and/or volume flux from the vents.

Northeast Lau Spreading Center

Tows over the NELSC examined the 2008 eruption zone on the ridge and the volcano Tafu at the northern end of the ridge segment. ΔNTU and ORP anomalies were detected at the south end of the eruptive zone, indicating that some venting is still present there (Figure 10). Casts at and near Tafu in 2008 were inconclusive regarding present day venting there. In 2010 we conducted another tow over

Tafu, finding no ORP anomalies but a weak ΔNTU (<~0.02) plume surrounding the summit, centered ~50 m below the peak. Chemical analyses of the samples will be required to determine if Tafu may be active.

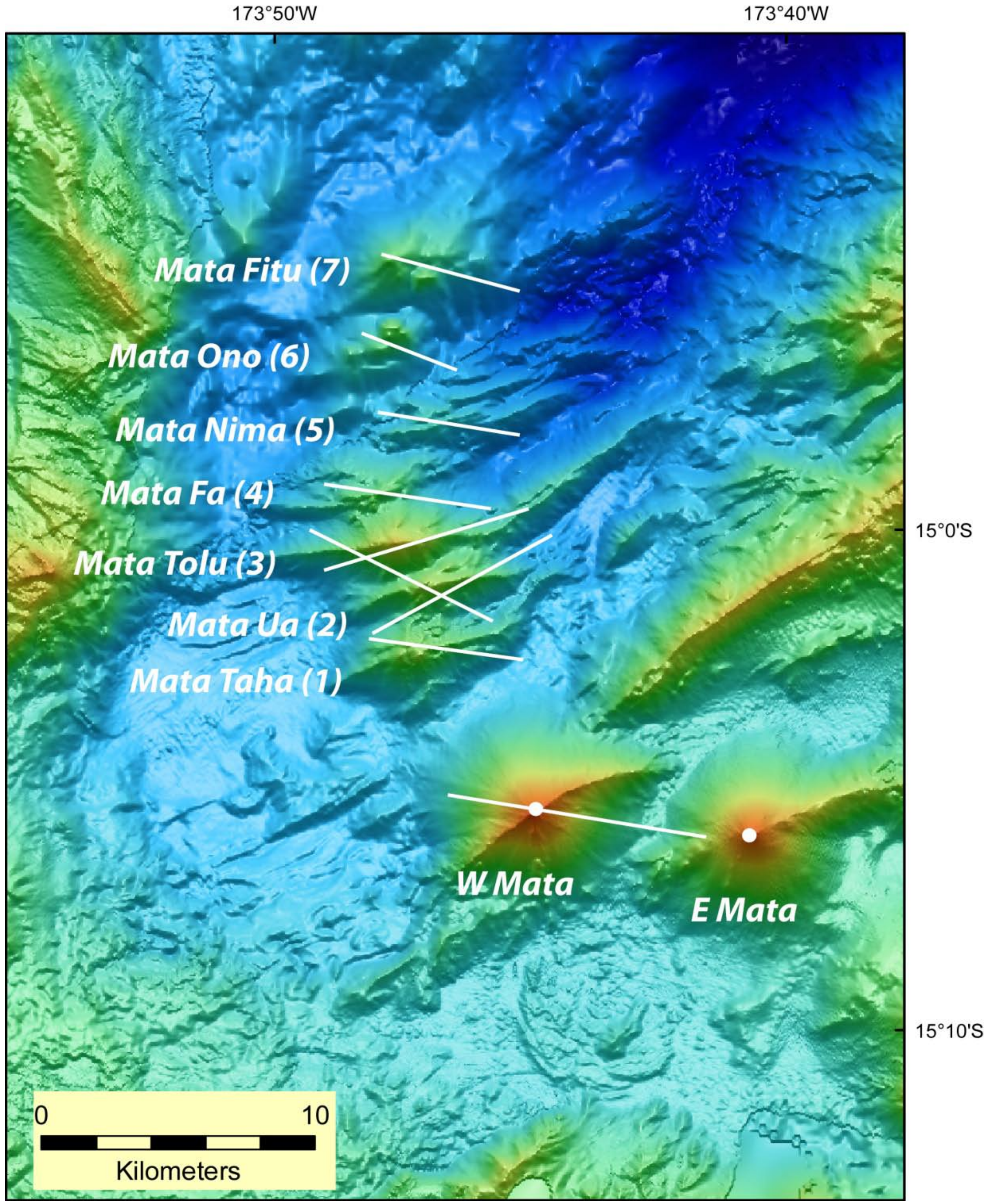


Figure 4. The Mata volcanoes in the N Lau Basin. White lines and dots show locations of tows and casts from the 2010 cruise.

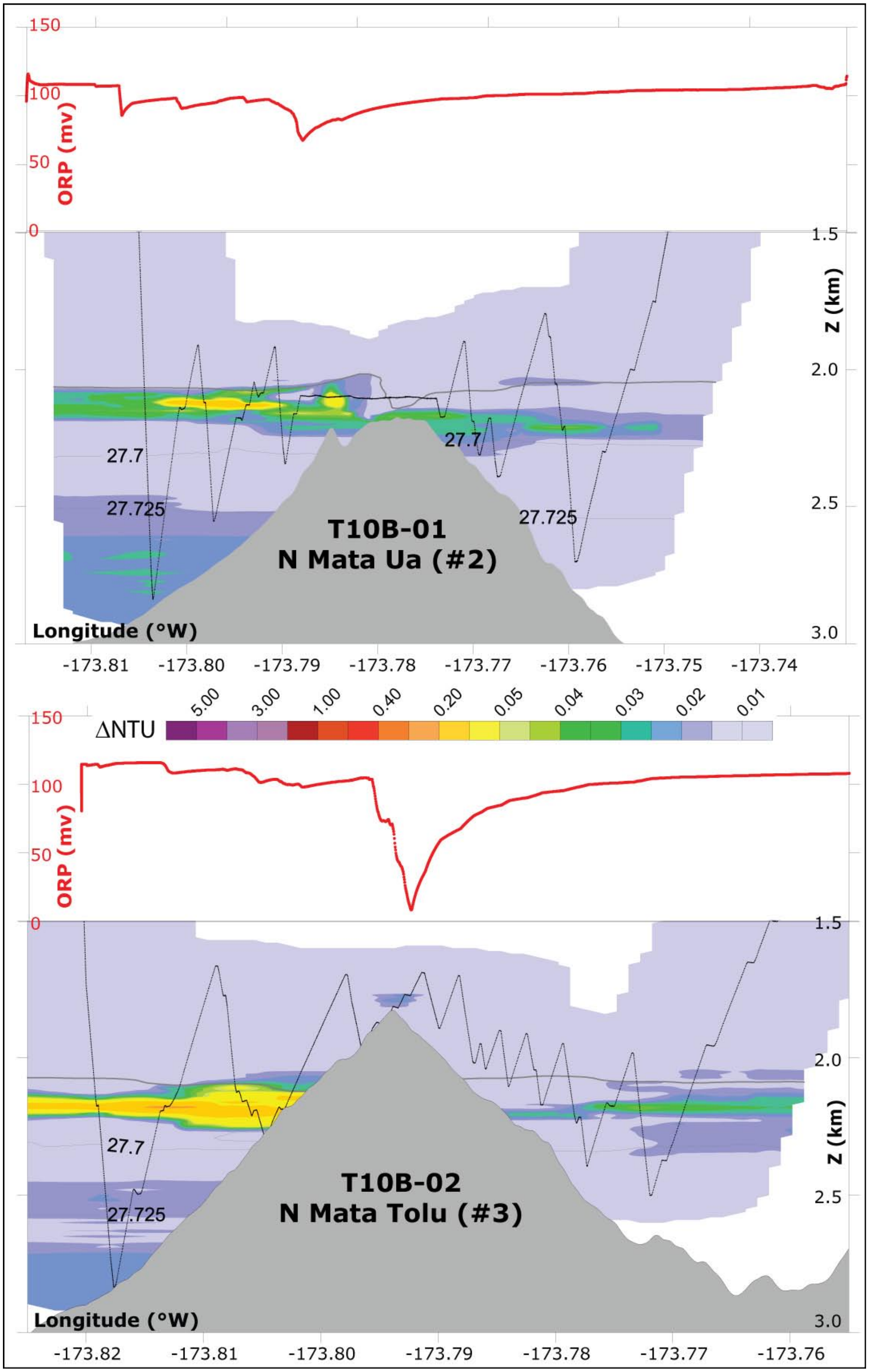


Figure 5. CTD tows from N Mata 2 and 3. Top panel in each shows ORP profile; negative values indicate higher concentration of reduced species. Bottom panel in each shows the plume as defined by light scattering values (ΔNTU, scale bar for both tows). Sawtooth grey lines are the CTD track.

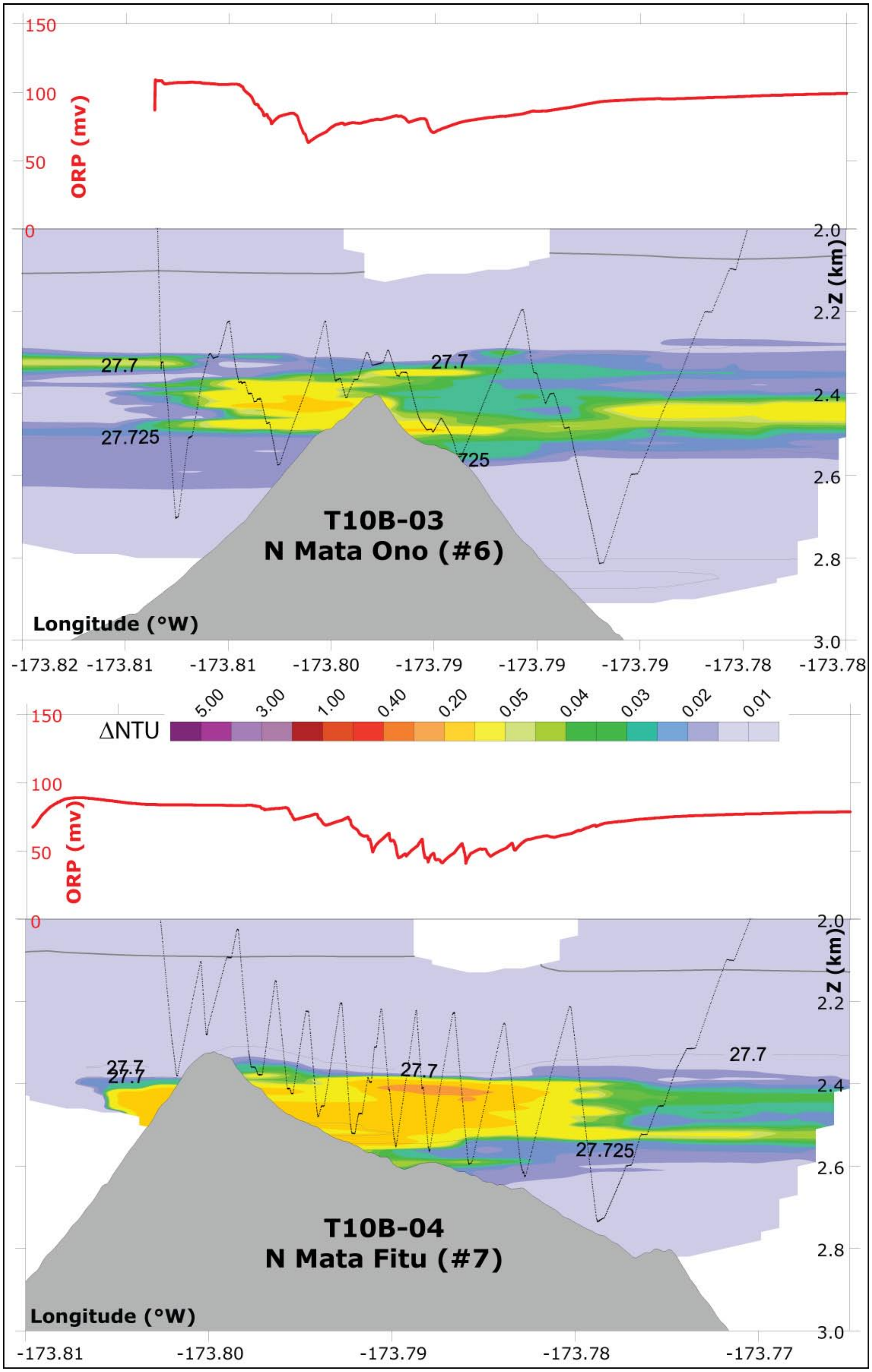


Figure 6. CTD tows from N Mata 6 and 7. Top panel in each shows ORP profile; negative values indicate higher concentration of reduced species. Bottom panel in each shows the plume as defined by light scattering values (ΔNTU, scale bar for both tows). Sawtooth grey lines are the CTD track.

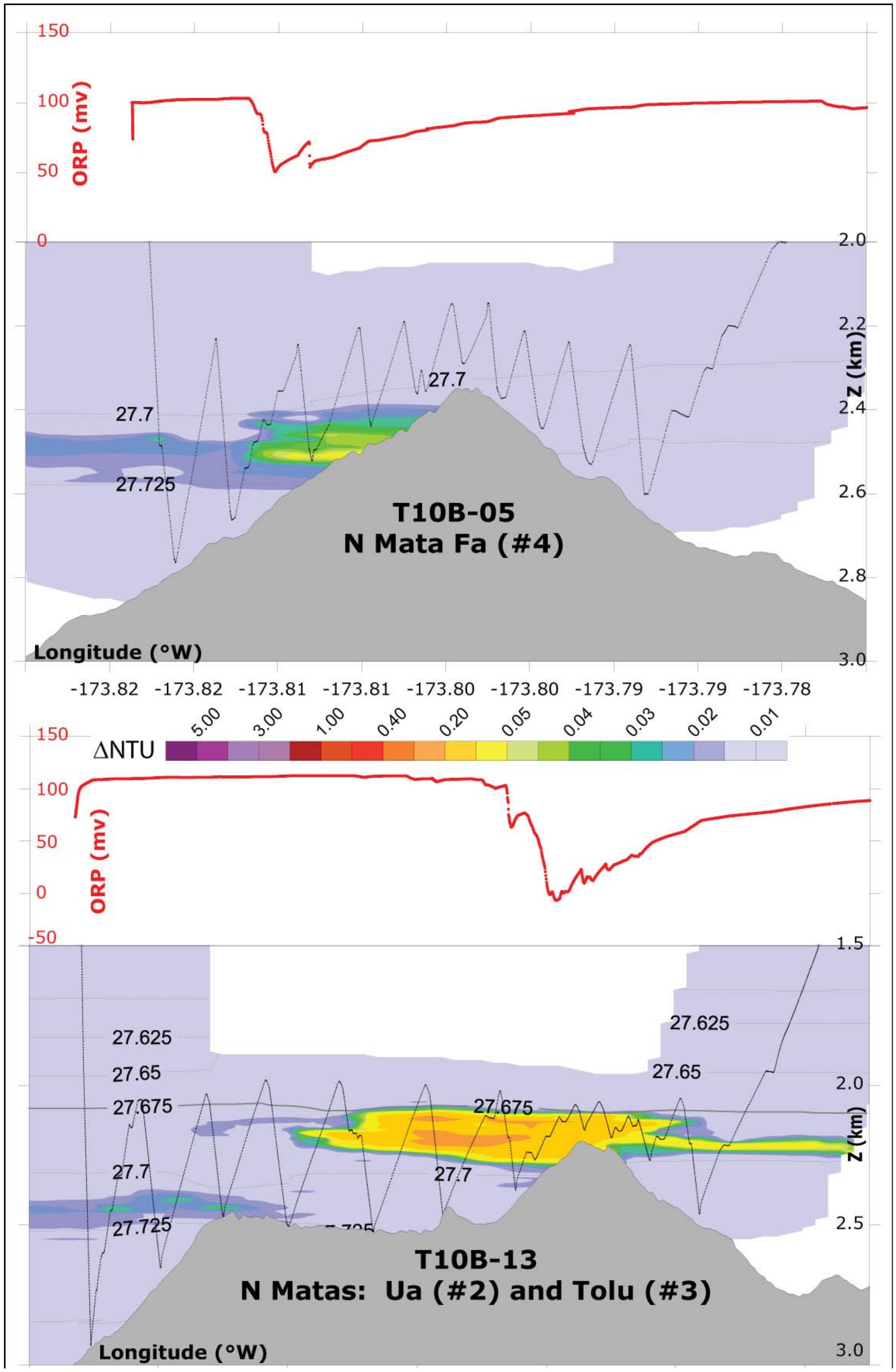


Figure 7. CTD tows over N Mata 4, 3 and 2. Top panel in each shows ORP profile; negative values indicate higher concentration of reduced species. Bottom panel in each shows the plume as defined by light scattering values (ΔNTU, scale bar for both tows). Sawtooth grey lines are the CTD track. Note that the depth and ORP scales are not identical for all panels.

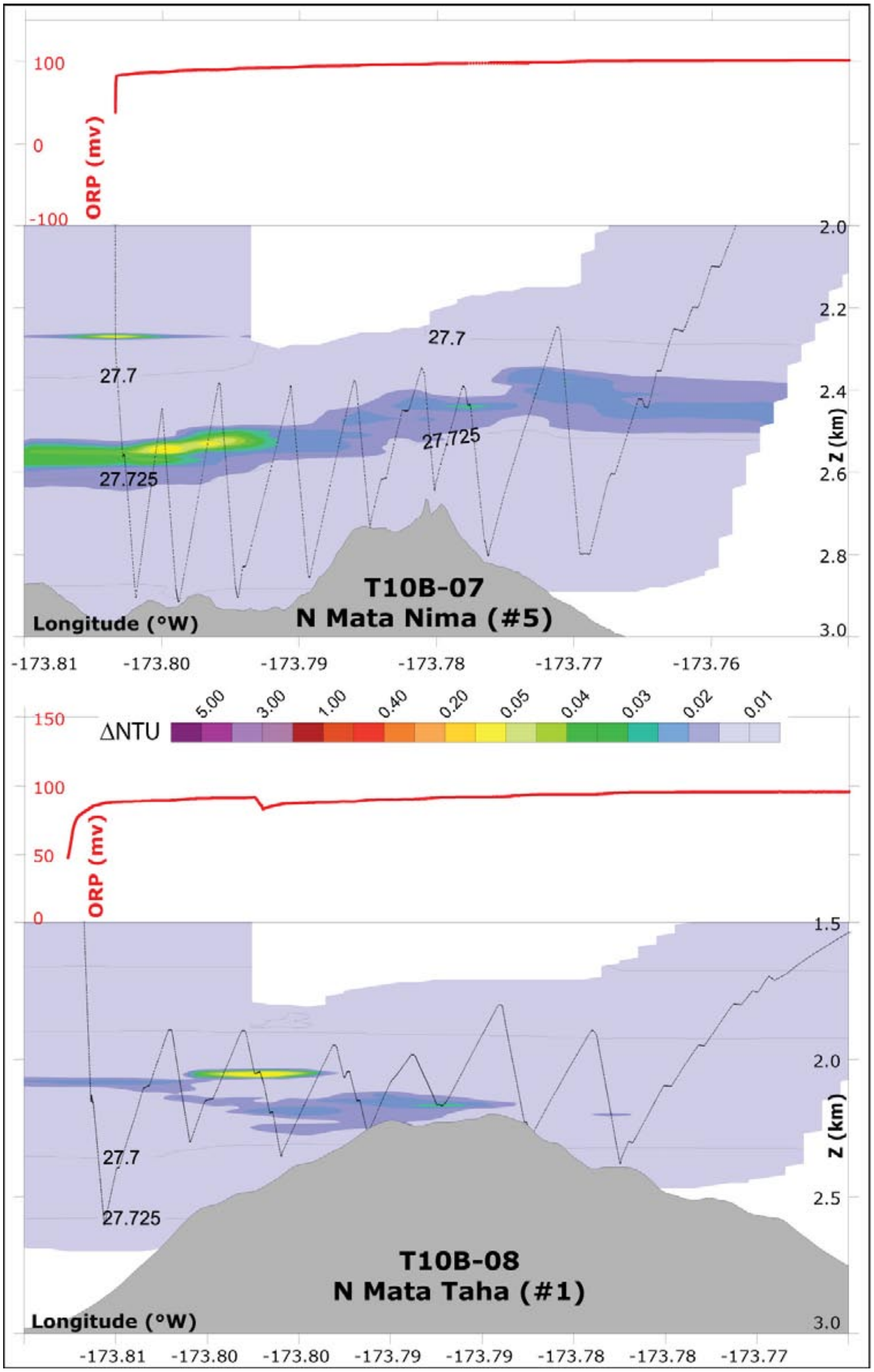


Figure 8. CTD tows from N Mata 5 and 1. See figure 7 for explanation. Although there is a ΔNTU plume over Mata 5, the absence of any ORP anomaly and the fact that the plume horizons match those seen at Mata 4 and Mata 6 implies that Mata 5 is inactive. Note that the depth and ORP scales are not identical for all panels.

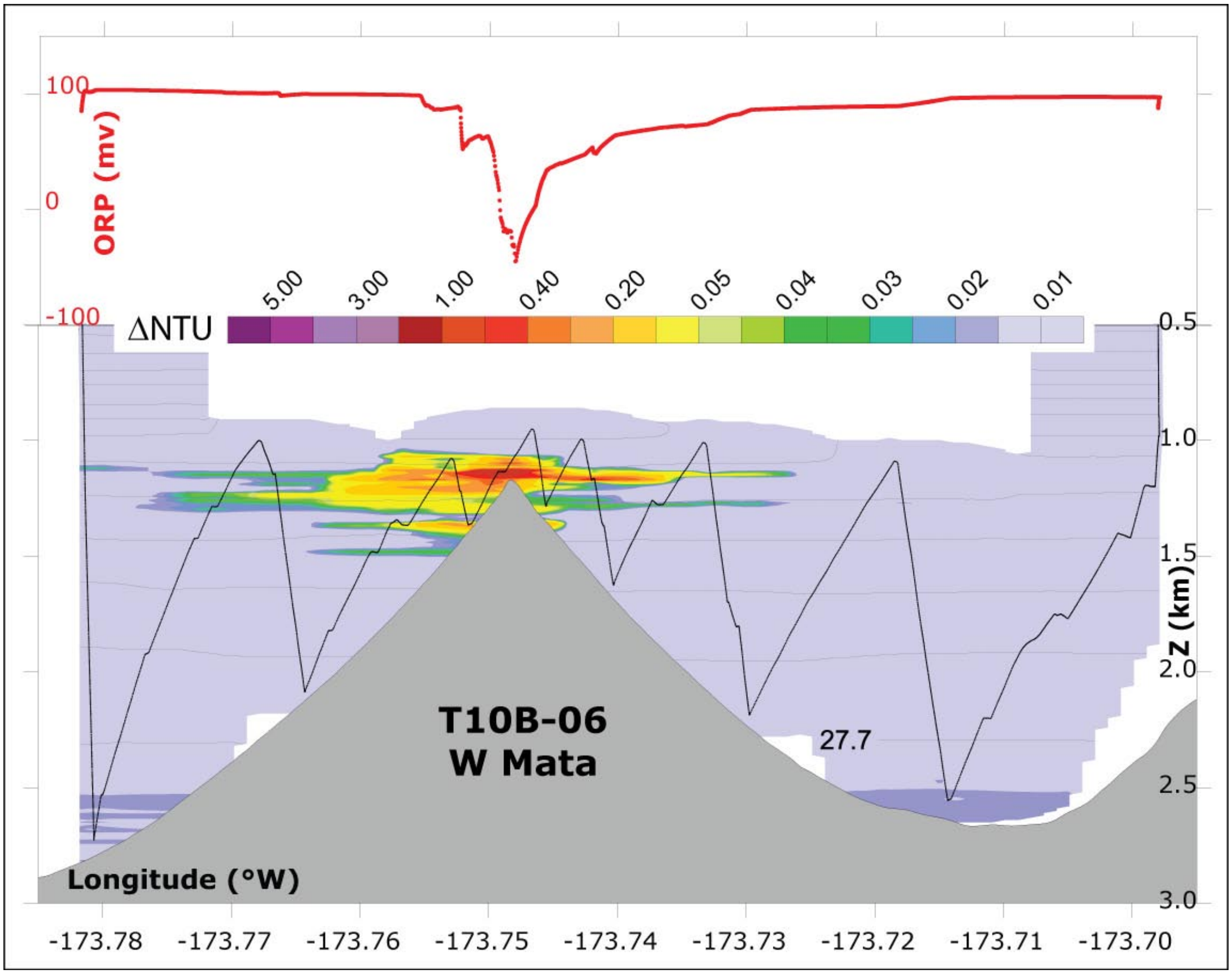


Figure 9. CTD tow over West Mata. Top panel in shows ORP profile; negative values indicate higher concentration of reduced species. Bottom panel shows the plume as defined by light scattering values (ΔNTU). Sawtooth grey lines are the CTD track.

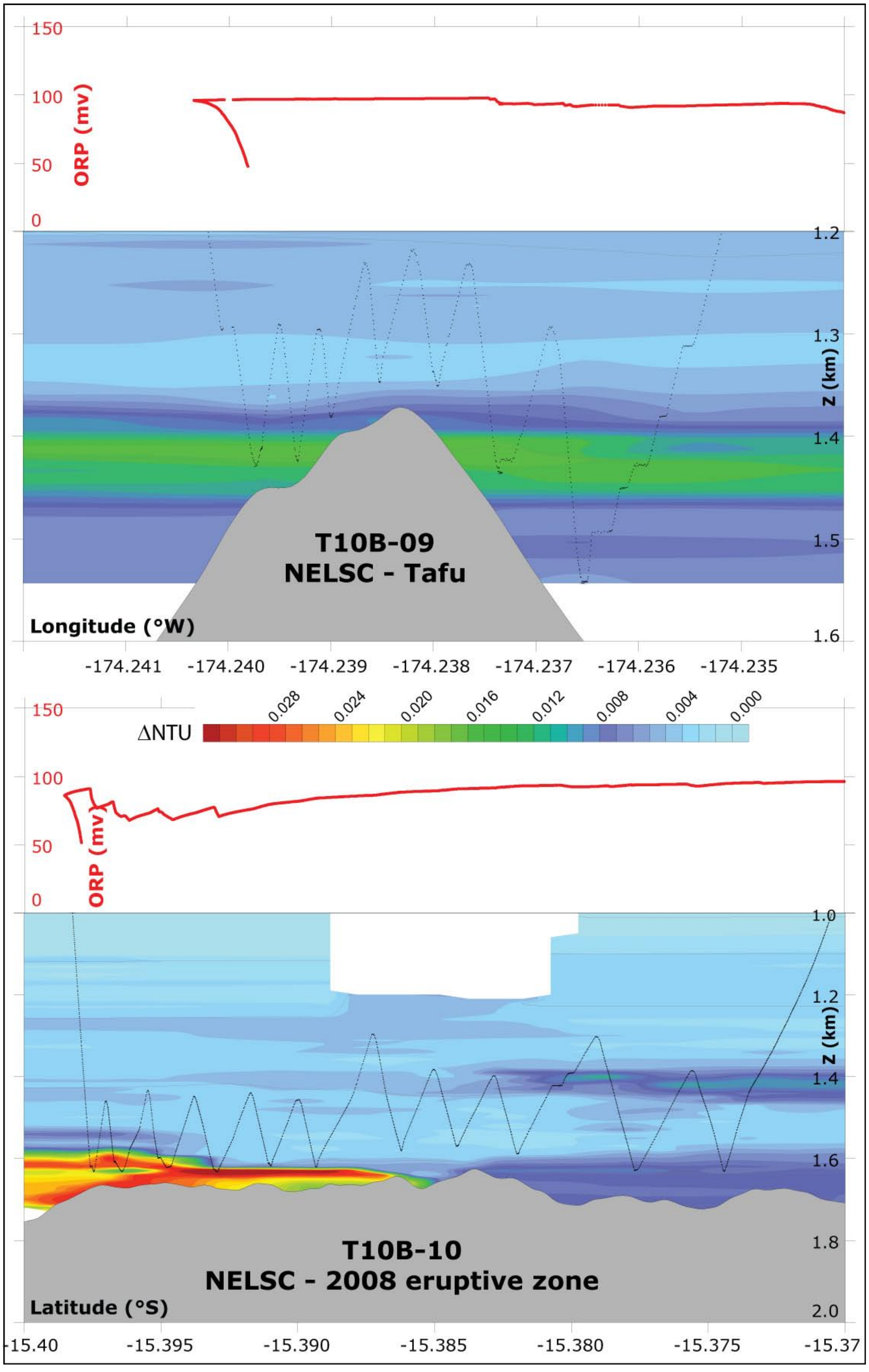


Figure 10. NELSC area tows (Tafu and NELSC). Top panel in each shows ORP profile. Bottom panel in each shows the plume as defined by light scattering values (ΔNTU, scale bar for both tows). Sawtooth grey lines are the CTD track. The depth scales are not identical for all panels. Bottom figure: CTD tow along the NELSC. Weak plumes are apparent at the south end of the 2008 eruptive zone. Note: This NTU scale differs from the scale used on the Mata figures.

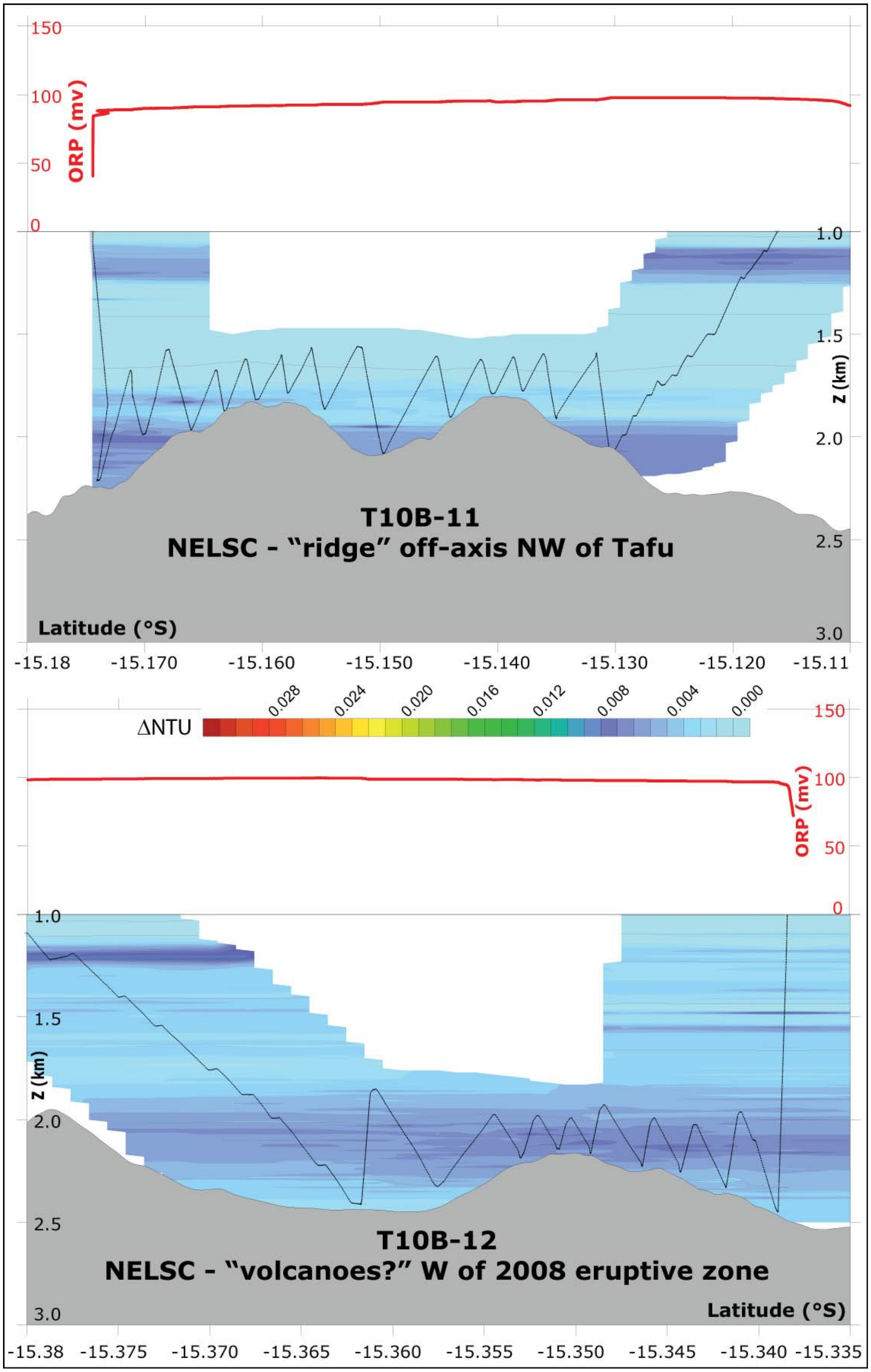


Figure 11. NELSC vicinity tows. Top panel in each shows ORP profile. Bottom panel in each shows the plume as defined by light scattering values (ΔNTU, scale bar for both tows). Sawtooth grey lines are the CTD track. Note that the depth scales are not identical for all panels. Note: This NTU scale differs from the scale used on the Mata figures.

Table 1. CTD Sample Types and Numbers

Sample type	*Abbreviation*	*# of samples*	*Responsible PI*
Helium isotope analysis	*3He*	*387*	*John Lupton, NOAA PMEL, Newport OR*
Methane and hydrogen	*CH4, H2*	*393*	*Marv Lilley, UW, Seattle WA*
pH (acidity)	*pH*	*404*	*Joseph Resing, NOAA PMEL Seattle WA / UW*
Dissolved inorganic carbon	*DIC*	*115*	*Joseph Resing*
Total dissolvable trace metals	*TDMe*	*392*	*Joseph Resing*
Dissolved trace metals	*DMe*	*92*	*Joseph Resing*
Particulate bulk chemistry	*XRF*	*94*	*Joseph Resing*
Particle morphology and type	*SEM*	*37*	*Joseph Resing*

Total samples: 1959

Table 2. CTD Casts, NE Lau 2010 - Expedition KM1008

Sharon Walker

CAST	Statn	Start date	Start time	End date	End time	Z	3He	H2 & CH4	H2S	PH	DIC	TDMe	DMe	XRF	SEM	Comments	Latitude	Longitude
0	test					500										test cast - all bottles tripped (some wanted for general seawater supply) - cast to ~500m, altimeter seemed OK		
1	V10B -01	4/29	0939	4/29	1202	4752	21	21		19	13	19		1		Lupton Helium cast near trench - cast went to only 3000m	-14.338533	-172.826867
2	V10B -02	4/29	1557	4/29	1815	> 3000	20	20		20	10			1		Lupton Helium cast #2 near trench - cast went to only 3000m	-14.604550	-173.199150
3	V10B -03	4/30	0357	4/30	0517	1180 (??)	9	10		18	5	20	5	5	2	W Mata summit - bottom depth uncertain as EM120 was having problems over eruptive vents	-15.094500	-173.748817
4	T10B -01 (start)	4/30	1642														-15.034500	-173.805317
	T10B -01 (end)			4/30	2128		17	21	8	17	5	21	7	7	3	tow over N Mata #2 (N Mata Ua)	-14.998633	-173.742533
5	V10B -04	5/1	0102	5/1	0322	3072	17	21		21	3	21	3	3	2	basin west of N Matas	-15.042317	-173.854300
6	V10B -05	5/1	1422	5/1	1532	1325	10	10	4	18	4	10	4	4	1	E Mata - summit (same place as V09B-24)	-15.100733	-173.677433
7	T10B -02 (start)	5/1	1814														-15.013467	-173.820450
	T10B -02 (end)			5/1	2324		16	21	7	21	10	21	7	7	2	tow over N Mata #3 (N Mata Tolu)	-14.988700	-173.744883
8	V10B -06	5/2	1106	5/2	1326	4887	20	20		20		20	1	1	1	Lupton Helium cast #3 in trench - cast went to only 3000m	-14.756083	-173.638733

9	T10B -03 (start)	5/2	1657														-14.935167	-173.808683
	T10B -03 (end)			5/2	2024		21	21		21	8	21	8	8	2	tow over N Mata #6 (N Mata Ono)	-14.951817	-173.767167
10	T10B -04 (start)	5/3	0904														-14.906767	-173.805767
	T10B -04 (end)			5/3	1313		21	21		21	6	21	6	6	1	tow over N Mata #7 (N Mata Fitu)	-14.924583	-173.743917
11	V10B -07	5/3	2014	5/3	2213	2661	20	21		21		21	3	3	3	basin west of W Mata	-15.166500	-173.853867
12	T10B -05 (start)	5/4	0925														-14.984900	-173.818683
	T10B -05 (end)			5/4	1314		19	19		21	4	21	4	4	2	tow over N Mata #4 (N Mata Fa)	-14.997000	-173.753083
13	T10B -06 (start)	5/4	1456														-15.088050	-173.781783
	T10B -06 (end)			5/4	2019		21	21	8	21	15	21	7	7	5	W. Mata	-15.104050	-173.698050
14	T10B -07 (start)	5/5	0920														-14.960900	-173.803433
	T10B -07 (end)			5/5	1333		21	21		18		11	1	1		tow over N Mata #5 (N Mata Nima)	-14.973050	-173.731417
15	T10B -08 (start)	5/5	1512														-15.037067	-173.807667
	T10B -08 (end)			5/5	1841		16	20	2		3	20	3	3	1	tow over N Mata #1 (N Mata Taha)	-15.043333	-173.757333
16	V10B -08	5/6	0639	5/6	0832	2475	16	8		18		15	4	4	2	NELSC - basin east of ridge (near V08C-17)	-15.431700	-174.243067
17	V10B -09	5/6	0946	5/6	1124	2294	12	8		8		8	1	1		NELSC - basin west of ridge (near V08C-15)	-15.388617	-174.284767
18	T10B -09 (start)	5/6	1334														-15.364883	-174.239817
	T10B -09 (end)			5/6	1518		11	11		11		11	3	3		NELSC - tow over Tafu	-15.377400	-174.233783
19	T10B -10 (start)	5/6	1654														-15.397917	-174.258217
	T10B -10 (end)			5/6	2008		8	8		8	4	8	4	4	1	NELSC - tow over 2008 eruptive zone	-15.365917	-174.229133
20	T10B -11 (start)	5/7	0237														-15.174450	-174.190517
	T10B -11 (end)			5/7	0636		14	12		13		12	2	2		off-axis "ridge" west of NELSC north of Tafu	-15.105450	-174.175133
21	T10B -12 (start)	5/7	1048														-15.338067	-174.322133
	T10B -12 (end)			5/7	1412		9	9		11		7	2	2		off-axis volcanoes west of NELSC 2008 eruptive zone	-15.396033	-174.303117
22	V10B -10	5/7	1652	5/7	1843	2673	16	17		16		21	2	2	2	basin E of NELSC	-15.351850	-174.169217
23	V10B -11	5/7	2045	5/7	2204	1275	11	11	8	21	16	21	8	8	3	Volcano O	-15.375767	-174.002583
24	T10B -13 (start)	5/8	1158														-15.000983	-173.826517
	T10B -13 (end)			5/8	1638		21	21	8	21	9	21	7	7	4	tow over N Mata #2 (Ua) and #3 (Tolu) (~2500m contour of #3 west flank then over cone on S side of #2)	-15.034450	-173.760483

5.0 Chemistry Summary

Joe Resing, with helium data additions by John Lupton

During CTD casts and tows, discrete samples were collected in Niskin bottles and were subsampled for chemical analysis to be conducted at sea (H_2, CH_4, H_2S, and pH) and ashore (^3He, Total CO_2, alkalinity, particulate matter composition, and dissolved and total dissolvable Fe, Mn, and Al). Samples for helium isotopes were sealed into copper tubing at sea by cold-welding the copper using a special hydraulic press. The dissolved gases in these samples will be analyzed for $^3He/^4He$ ratio and helium concentration in the Newport, Oregon mass spectrometer laboratory. At shore analyses are not complete. The at sea analyses are summarized here. The most notable features of the at sea chemistry is the elevated CH_4 concentrations in all of the plumes above Northern Matas and at E Mata, the extremely elevated H_2 at W Mata, and the elevated H2S and large pH anomaly at Volcano "O". The at sea results are summarized below. (Refer to figures 1, 2, and 4 for cast locations. Refer to figures 5 - 11 for tow plots.)

Northern Matas

Mata Taha (1). Hydrocast T10B08 exhibited a moderate plume intensity along most of the tow line ranging from 2100 to 2300m depth. A smaller more intense plume was centered around 2100m. The pH anomalies were relatively (0.011 pH units) small with moderate to high CH_4 concentrations with CH_4 = 40nM in the intense plume and 30 nM in the rest of the plumes.

Mata Ua (2). Hydrocast T10B01 exhibited an intense plume at 2100m that was rich in CH_4 (>160nM) with a relatively small decrease in pH (~0.04 pH units). The particle anomaly exceeded 0.1NTU which is usually indicative of plumes rich in elemental sulfur versus Fe. This is supported by the relatively small amount of burnt orange color on the filters. Hydrocast T10B13 also crossed Ua and an intense plume was found with the very high CH_4 concentrations (>250nM).

Mata Tolu (3). Hydrocast T10B02 exhibited a large particulate anomaly at ~ 2200m with a moderately low pH anomaly (0.04 pH units) and very high CH_4 = 140nM. An intense ORP signal at 1800m lacked a large particle signal but contained 80nM CH_4.

Mata Fa (4). Hydrocast T10B05 exhibited a moderate particle plume at ~ 2400-2550m depth. It had moderately elevated CH_4 (~45nM) and a small pH anomaly (0.012 pH units). The ratio of CH_4 to LSS fell on the same trend as the other Matas.

Mata Nima (5). Hydrocast T10B07 exhibited a relatively weak plume from 2400-2600m that was 200m above the summit of Nima. This depth is coincident with the intense plumes coming from Mata Ono and Fitu, one of is the likely source of the plume observed during this tow. CH_4 reached 17nM and a pH anomaly of ~.01 was observed.

Mata Ono (6). T10B03 exhibited an intense particle plume with moderately high CH_4 (45nM) and a relatively small pH anomaly (~0.018 pH units).

Mata Fitu (7). Hydrocast TB1004 exhibited a very intense plume between ~ 2400 and ~ 2500m and LSS signals were well in excess of 0.2 NTU. CH_4 was extremely high (291 nM) with a moderate pH anomaly (~ 0.04 pH units)

West Mata

Casts V10B03 and T10B06 were conducted above West Mata Volcano. The plumes encountered during these casts were less intense than the plumes above W Mata in 2008. H_2 and pH anomalies were only 20 to 33% of their 2008 levels. H_2 values were still very high with the highest concentration reaching 4.8 uM, which supports the acoustic observations that the eruption was still taking place during these hydrocasts.

East Mata

Cast V10B05. This cast was placed in the same location as cast V08C34 conducted in 2008. The profiles for both casts were similar in shape with increasing signal with depth. CH_4 concentrations reached 80nM in 2010 versus 127nm in 2008, while the pH anomaly in 2010 was 0.1 versus 0.2 in 2008.

Volcano "O"

V10B11. This hydrocast was conducted above a small cone that was young in appearance. The light scatter plume was at full scale and the ORP signal was negative. This plume had only moderately low CH_4 and hydrogen but had among the largest pH anomalies ever seen. pH anomalies of this magnitude are most commonly observed at volcanoes emitting both sulfur based acids and CO_2. The low pH suggests that an eruption was not ongoing.

NELSC

Hydrocasts T10B09 and T10B10 were conducted on or near the NELSC to reexamine the plume above the 2008 eruptive area and to examine the relationship between the hydrothermal plume at Tafu with the plumes found previously above the eruptive area of the NELSC. A very weak plume was identified above Tafu during T10B09 with 1nM and 0.006 pH unit anomalies in CH_4 and pH respectively. A low intensity plume near the seafloor was found in the southern area of the 2008 eruption. CH_4 was low and the pH anomaly was ~0.004 pH units.

Basins and Sources East and West of the NELSC

Hydrocasts T10B11, T10B12, V10B08, V10B09, and V10B10 were conducted to relocate deep plumes found previously in the region and to identify any possible sources for these plumes. T10B11 was placed on an off axis ridge. This tow exhibited small hints of a plume with excess CH_4 from 1700-1800m. T10B12 towed across two neovolcanic features west of the NELSC eruptive area. No plume was apparent and no chemical anomalies were obvious. V10B08 was conducted west of the Maka hydrothermal area within 10km of V08C17. No plume was observed. V10 B09 was conducted within 4km of V08C15. A small particle plume was observed, however chemical anomalies were ambiguous. V10B10 reoccupied V08C28. Plumes were observed from 1200 to1400 m without clear chemical anomalies, suggesting volcanic glass from W Mata. A deeper plume centered from 1900 to 2300m had no CH_4 anomaly but a weak but resolved pH anomaly (0.004). One sample at 2640m had elevated CH_4 (7.4 nM) and H2 (8.3 nM) with no corresponding particle or ORP signals.

Regional ^{3}He plume.

Vertical casts V10B01, V10B02, and V10B06 were conducted above the trench to help delineate the regional ^{3}He plume. V10B01 exhibited a weak LSS plume over the range ~1550 to ~1950m, however there are no apparent anomalies in H_2, CH_4, or pH. Cast V10B02 had two very small particle anomalies that appear to coincide with two very small CH_4 anomalies. No pH changes were apparent. V10B06 was within ~20km of the northernmost Mata and had a broad plume with a small LSS signal that corresponds with a low intensity CH_4 plume.

Basin Casts

Two vertical casts, V10B04 and V10B07, into the basin west and south of the Mata volcanoes revealed deep particle plumes. V04, in the Basin southwest of the Northern Matas, revealed two LSS plumes, one at 1900m and the other from ~2500m to 2950m. The 1950m plume had no corresponding chemical anomalies, while the deeper plume exhibited enrichments in CH_4 and pH anomaly. V07, SW of W Mata, also had two particle plumes, one at 1100m and deep plume from ~2500m to 2631 (bottom at 2661). The shallow plume appears to be from W. Mata and has a significant pH anomaly. The deeper plume also has a single point pH anomaly. Measurements of Mn and He isotopes will be essential to determine if the deep plumes found here are of hydrothermal origin or from W. Mata debris flows.

6.0 Towed Camera and Seafloor Sampling Operations

Bob Embley and Ken Rubin

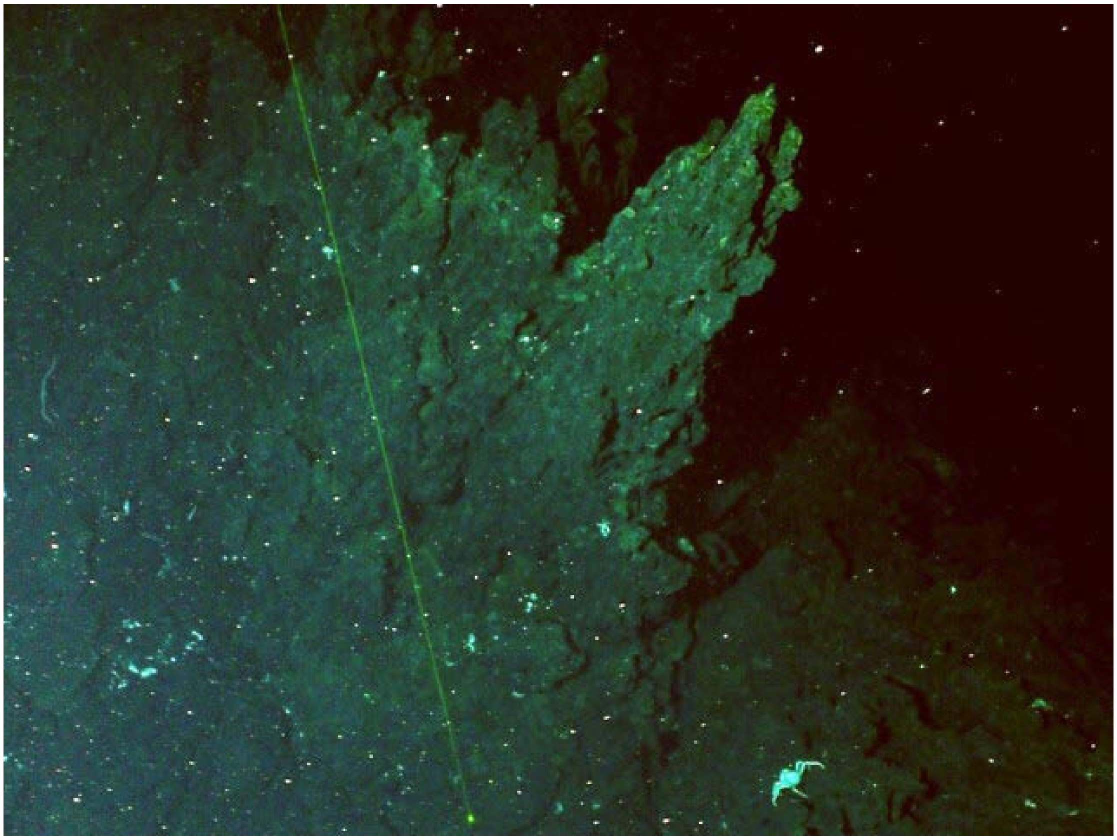
Nine deployments of the WHOI TowCam system were made during the expedition at predetermined targets in and around the Mata seamount group, the NESLC, plus a target at volcano O to investigate the source of unusual water column signatures found the night before by the CTD team (Figure 1). Although the original plan was to operate the TowCam from the CTD cable with the capability to view images of the sea floor in real time, the failure of the new CTD winch on *Kilo Moana* in March 2010 forced us to use the 0.68" fiber optic cable, alternating with the CTD operations. The CTD winch failure also forced cancellation of the dredging program. The lack of dynamic positioning (due to failure of the bow thruster on the March leg) constrained us to tow almost directly into the prevailing wind (E-NE). Fortunately, most of the geologic structures of interest (with exception of NELSC) were oriented in an approximate E-NE trend or could be towed in multiple directions (e.g., conical shaped). The camera was lowered to within ~5 meters of the seafloor and slowly towed (~0.25 knots) over features of interest. The system was "flown" by the camera operator (K. Feldman) using a winch joystick in the lower lab on *Kilo Moana*. An altimeter provided real-time monitoring of the height above the seafloor which was adjusted constantly as the camera moved over the topography. A SeaBird CTD on the camera sled provided real-time records of pressure depth, conductivity, temperature and optical backscatter. The ORP (oxidation-reduction potential) sensor attached to the CTD failed during the first dive, but an internally recording MAPR instrument was also attached to the camera system to provide ORP data. Images were downloaded from the digital camera after recovery of the TowCam and examined the following day.

A set of rechargeable batteries powered the camera, strobes, CTD and a Laser scaling system. Tows 1, 2, 4 and 5 (Table 3) targeted large lava flows (P2, Figures 12, 13, 15, 16) identified on multibeam data collected in November 2008. Tow 2 also went up the NW flank of East Mata volcano to ground truth the variable acoustic backscatter patterns caused by different age volcaniclastic flows. Tows 3, 6 and 9 (Figures 14, 17, 20) were made over Mata Tolu, Mata Fitu and Mata Ua to characterize their geology and hydrothermal activity (all three were active (P3-P5)). Tow 7 (Figure 18) discovered another young lava flow (P6) on the north rift of Tafu volcano that had been identified by differencing the 2008 EM300 multibeam data with an EM120 data set collected by scientists at the Korean Ocean Research and Development Institute (KORDI) in 2006. In response to the discovery of a very intense sulfur-rich plume over the dacite cone in the SE corner of Volcano O, Tow 8 (Figure 19) found concentrated venting of sulfur near its summit at ~1280 m (P7).

The TowCam program on the *Kilo Moana* was very successful although we did lose the final camera tow due to the failure of an engine that shortened the cruise by 1+ day. The loss of the sampling program was also unfortunate. However, we did "collect" some small samples of rock on the camera frame during infrequent bottom contacts (Table 4) which will be analyzed at the University of Hawaii. Also, we are scheduled for a 4 day dredging program on *Kilo Moana* in December 2010, which should allow us to complete our objectives for the NE Lau in 2010.

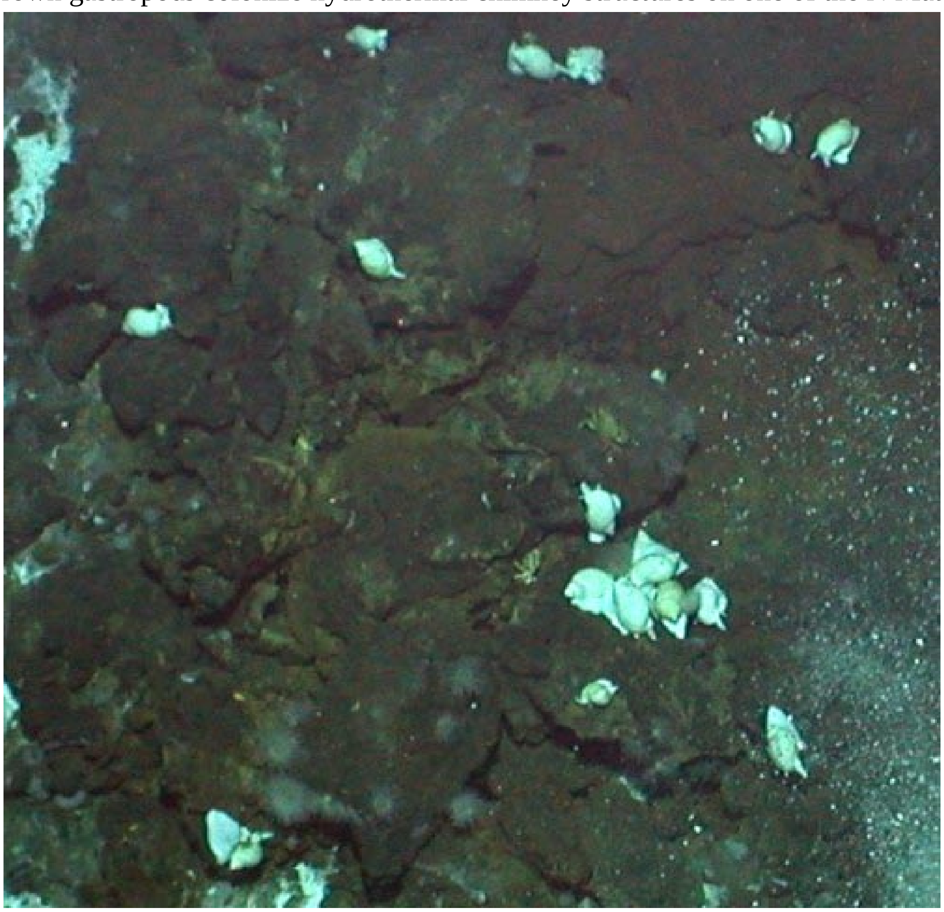
Seafloor images from the TowCam

P2. CT02 large lava flow.

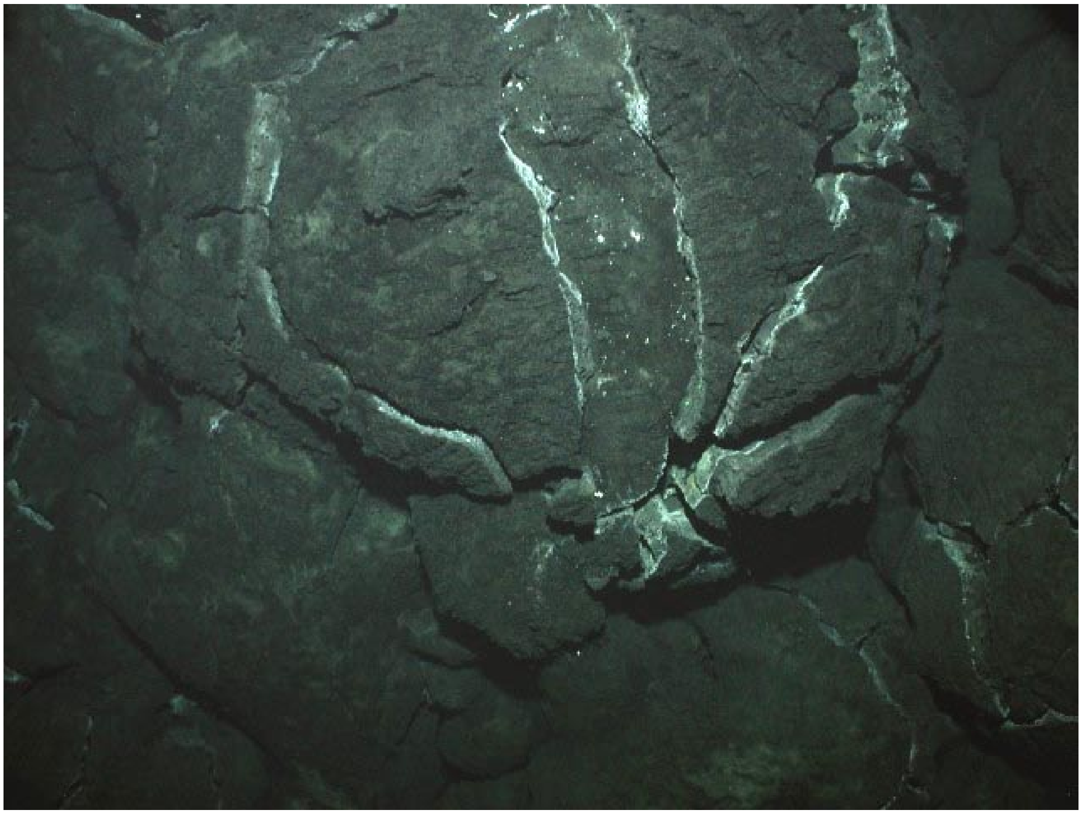


P3. Chimneys on one of the northern Matas

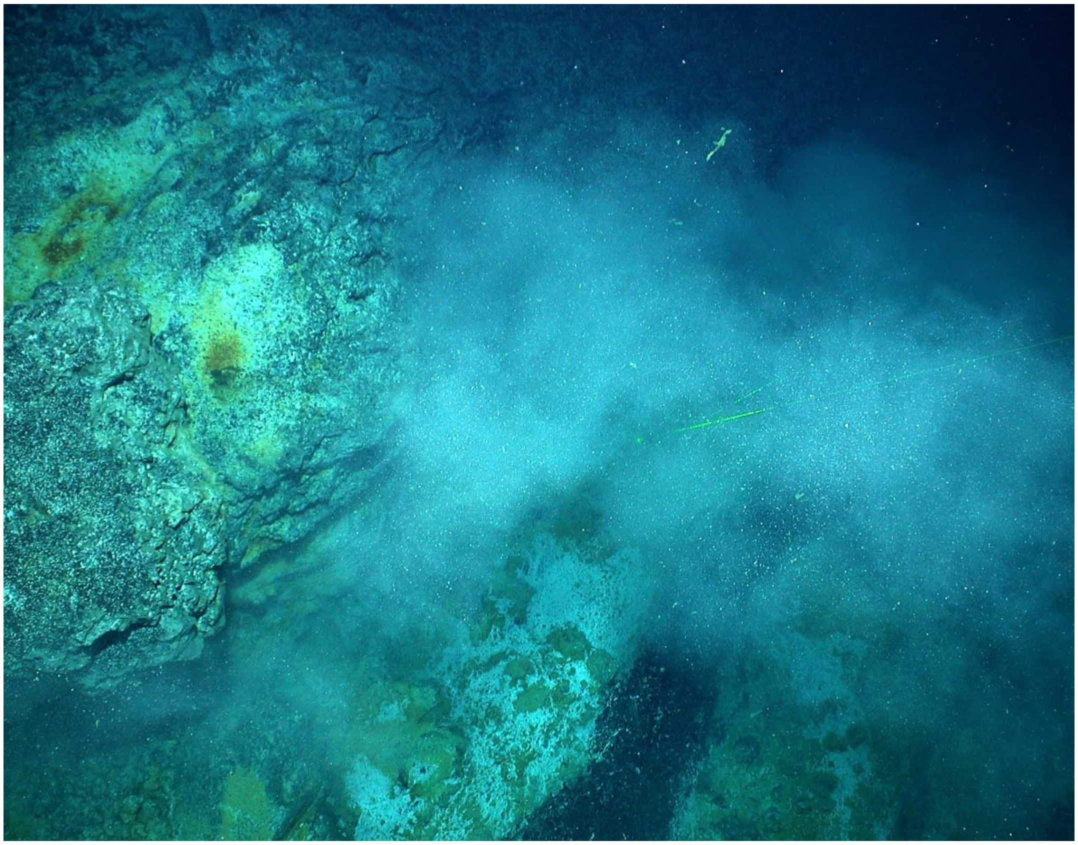
P4. Large brown gastropods colonize hydrothermal chimney structures on one of the N Mata volcanoes.



P5. Crabs, *Phymorhychus* gastropods (large white snails) and small actinarian anemones populate a volcanic substrate with active diffuse hydrothermal venting.



P6. Young, fresh pillow lava in a newly discovered lava flow erupted near Tafu volcano on the NELSC. The white deposits on the surfaces of the cracks usually only lasts for a few years after eruption.



P7. Elemental sulfur deposits on the summit of the central cone at Volcano O.

Table 3. TowCam operation statistics

Camera Tow #	JD	Date	Start bottom time (UTC)	End bottom time (UTC)	Total bottom time (hrs)	Area	Depth range (m)	latitude at tow center	longitude at tow center	Nav setbacks
CT01	120	April 30	09:57 1st flash	13:45	3.8	Lava pond	2502 - 2528	-15.181447	-173.903021	233m
CT02	121	May 1	06:15 1st flash	11:39	5.4	Large lava flow	2347 - 2520	-15.153504	-173.926353	160m
CT03	122	May 2	01:55 1st flash	07:37	5.7	Mata Tolu (#3)	1834 - 2431	-15.005557	-173.800681	150m
CT04	123	May 3	00:15 1st flash	06:00	5.25	Between W and E Mata on lava flow	2247 - 2702	-15.079480	-173.695972	00:15-03:15 140m. 03:15-04:30 280m. 04:30-06:00 180m.
CT05	124	May 4	01:05 1st flash	05:54	4.82	NW lava flow	2580 - 2630	-15.119614	-174.001750	140m
CT06	125	May 5	01:00 turbidity spike	06:30	5.5	Mata Fitu (#7)	2402 - 2731	-14.910094	-173.787712	130m
CT07	126	May 6	00:29	04:00	3.52	N/NE Tafu	1710 - 2019	-15.356029	-174.232647	75m
CT08	128	May 8	01:55	06:45	4.83	Volcano O center cone	1267 - 1747	-15.376710	-174.001136	75m
CT09	129 and 130	May 9 and 10	23:15	04:45	5.5	Mata Ua (#2)	2114 - 2329	-15.018258	-173.780682	90m
Total bottom time: 44.32 hours										

Table 4. Samples recovered from the Towcam after dives

sample number	Location	Date (GMT)	approx mass	pieces or rock?	disposition at end of cruise
CT03-1	Mata Tolu	5/2/2010	15-20 gms	pieces	in hawaii
CT05-1	Mata Fitu	5/3 to 5/4/2010	1-2 gm	pieces	in hawaii
CT07-1	NELSC N of Tafu	5/5 to 5/6/2010	25 gm	pieces	in hawaii
CT08-1	volcano O central cone	5/5 to 5/6/2010	500 gm	rock	in hawaii
CT08-2	volcano O central cone	5/5 to 5/6/2010	200 gm	rock	in hawaii
CT08-3	volcano O central cone	5/5 to 5/6/2010	200 gm	rock	in hawaii
CT08-4	volcano O central cone	5/5 to 5/6/2010	150 gm	rock	in hawaii
CT08-5	volcano O central cone	5/5 to 5/6/2010	200 gm	rock	in hawaii
CT08-6	volcan O central cone	5/5 to 5/6/2010	20 mg	rock	in hawaii
CT08-7	volcano O central cone	5/5 to 5/6/2010	10gm	pieces	in hawaii
CT09-1	Matua Ua	5/7 to 5/8/2010	50 mg	pieces	in hawaii

6.1 Maps of TowCam Dive Tracks

Susan Merle

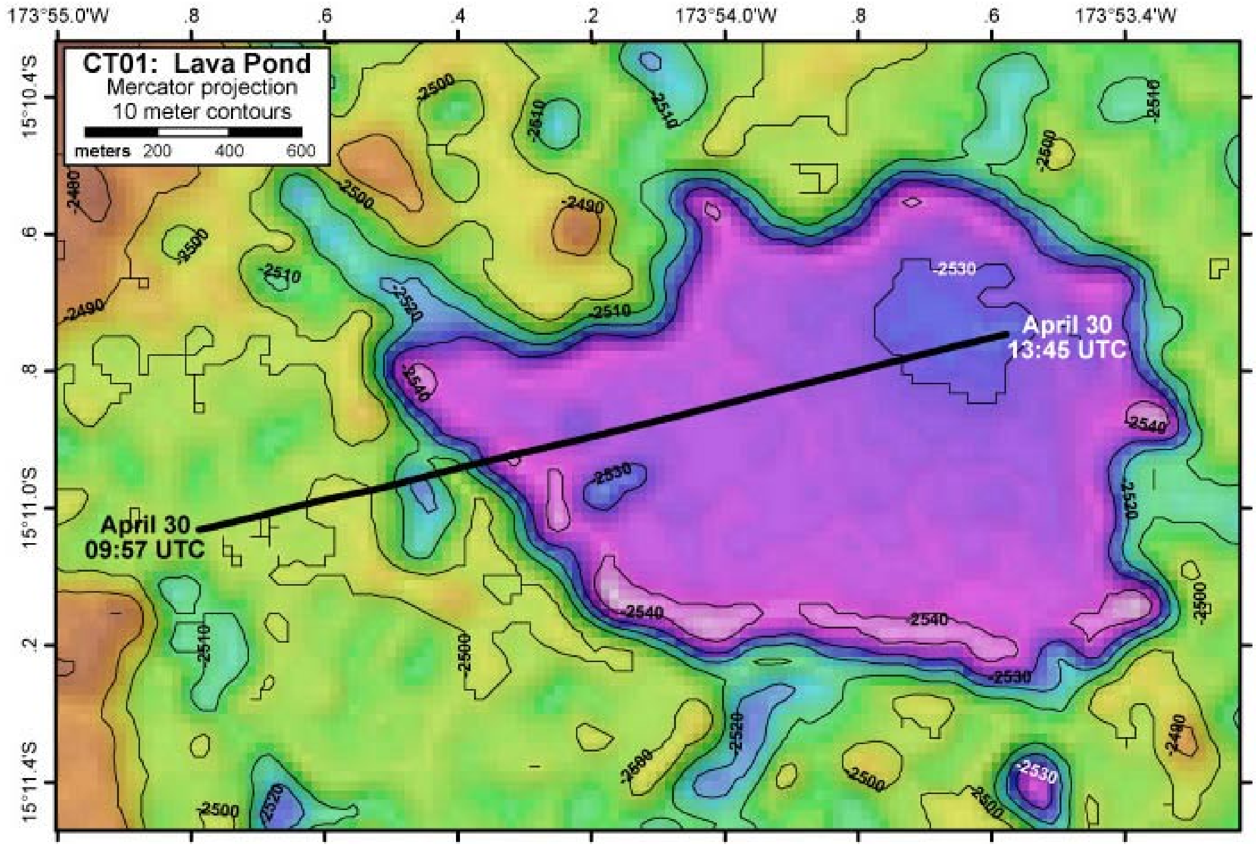


Figure 12. CT01 lava pond dive track.

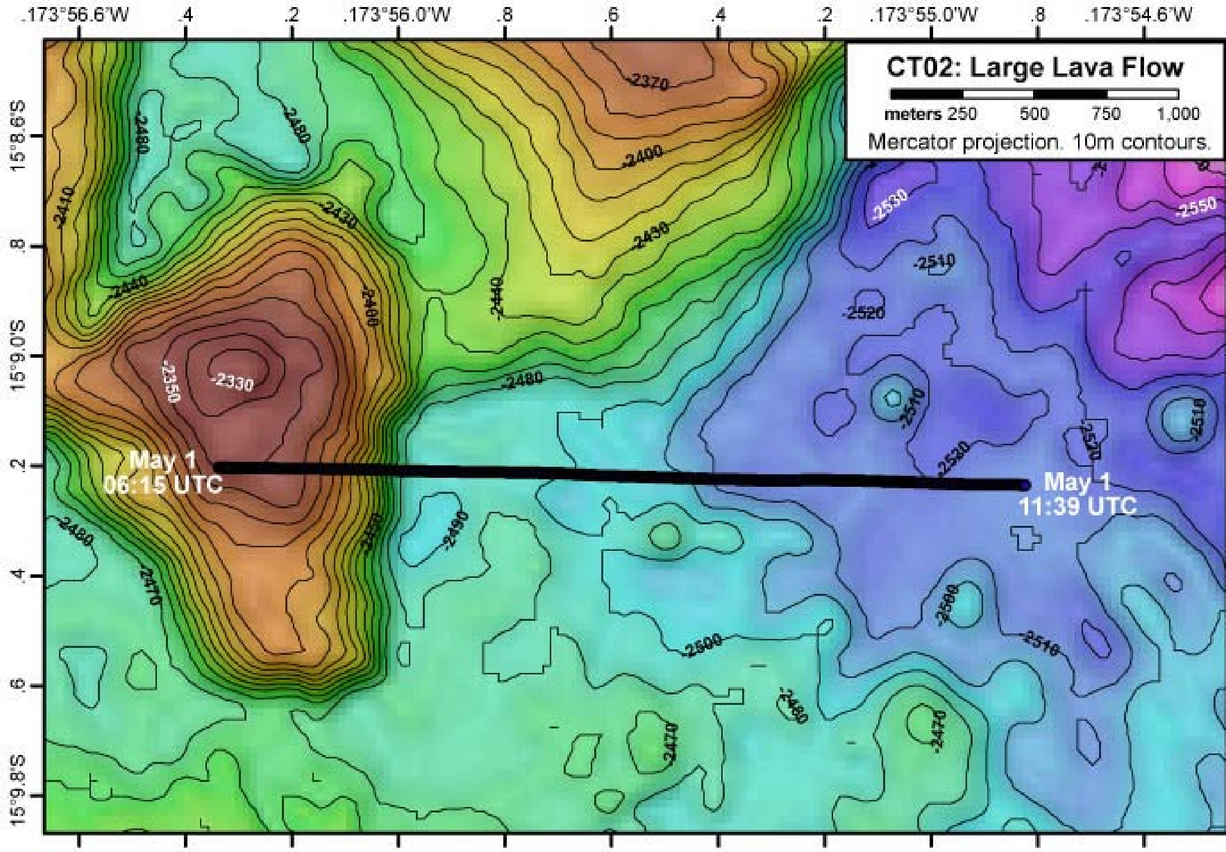


Figure 13. CT02 large lava flow dive track.

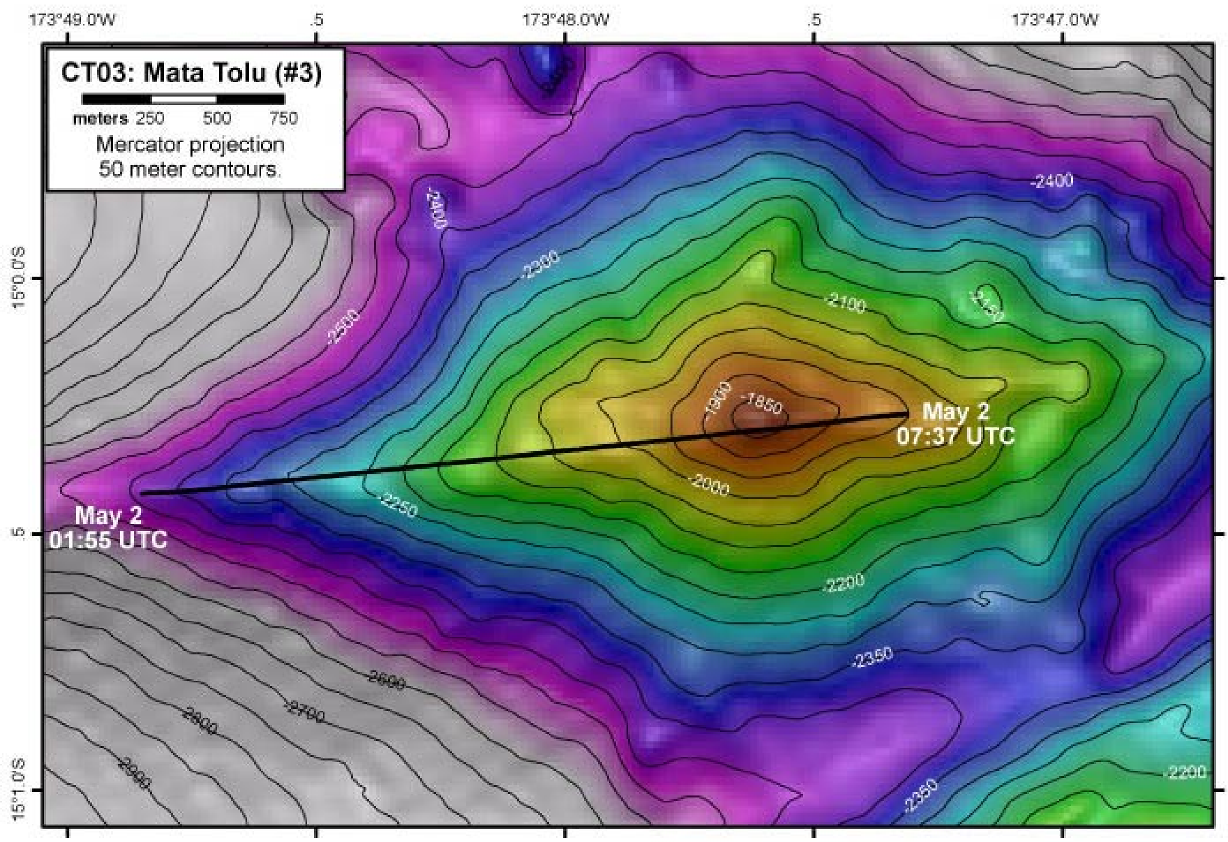


Figure 14. CT03 Mata Tolu (3) dive track.

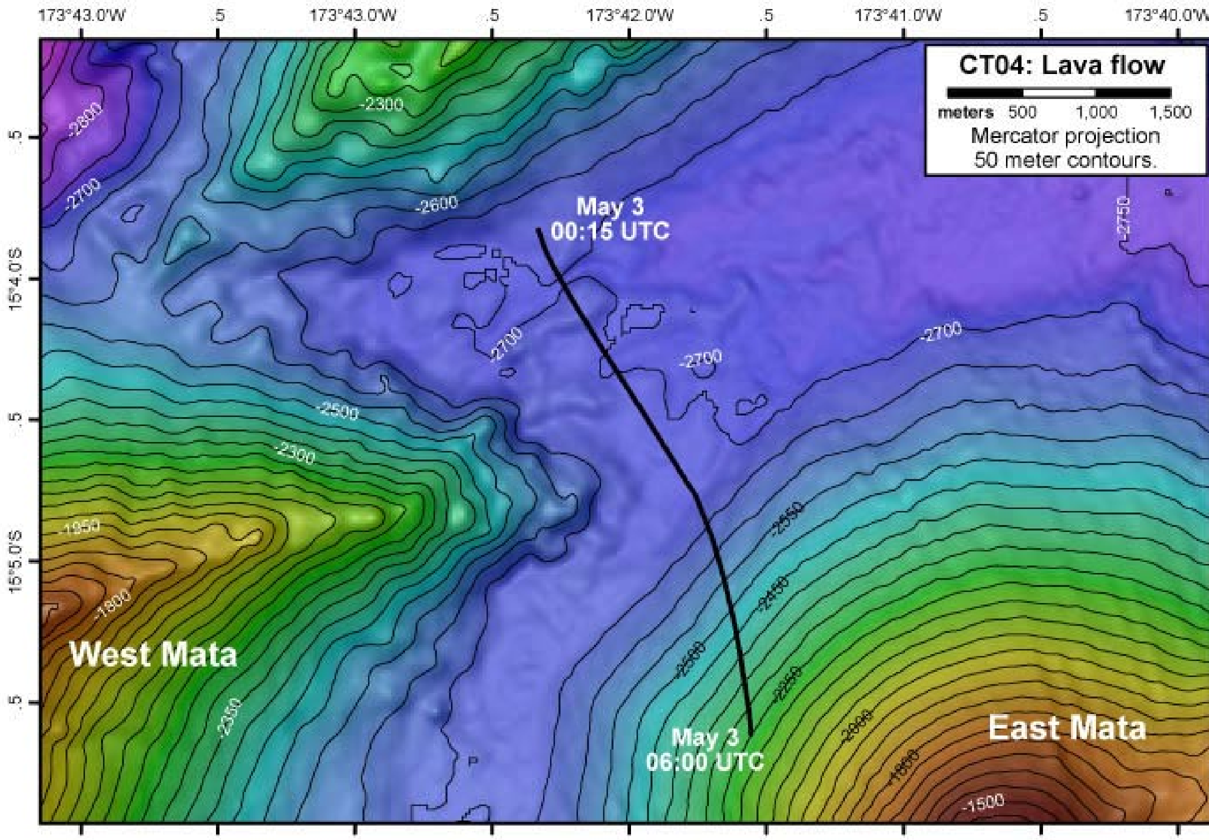


Figure 15. CT04 lava flow between W and E Mata dive track.

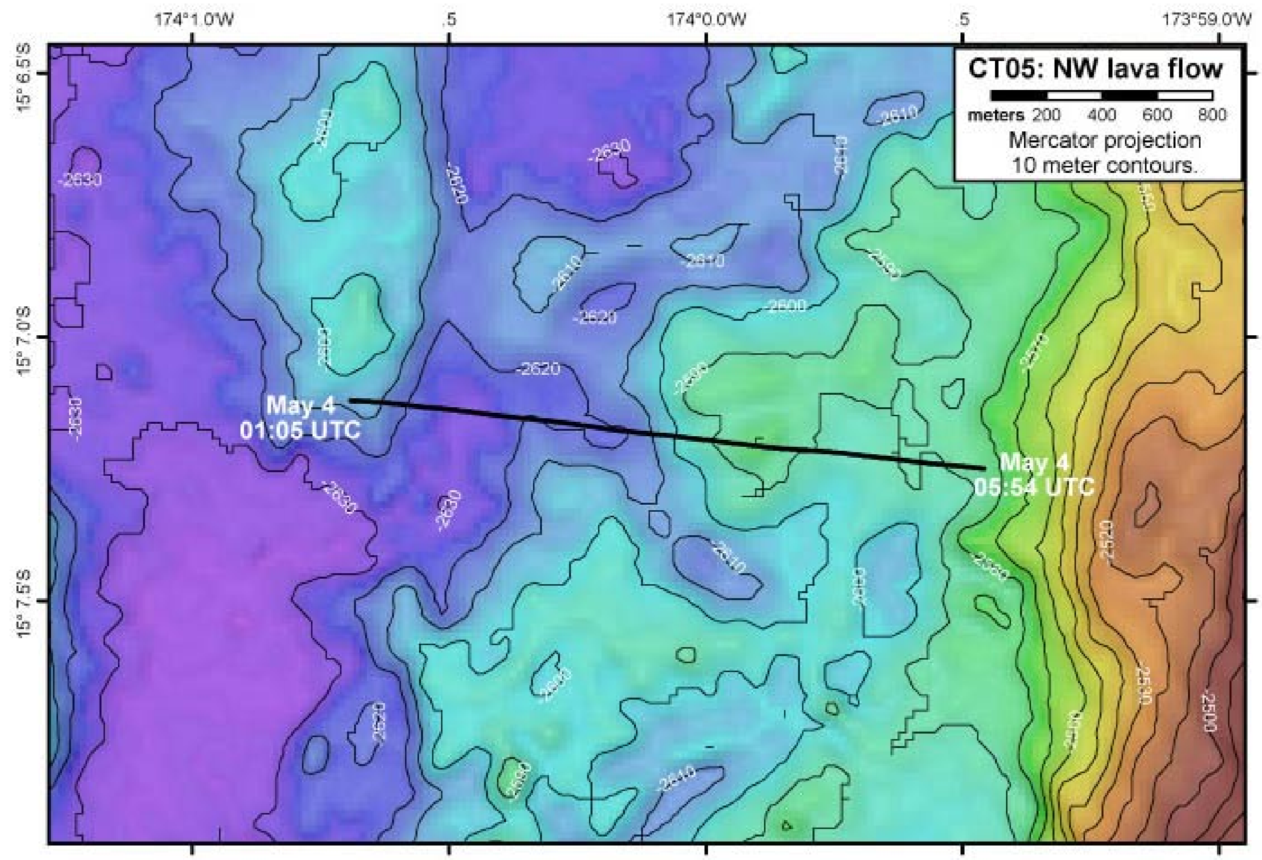


Figure 16. CT05 NW lava flow dive track.

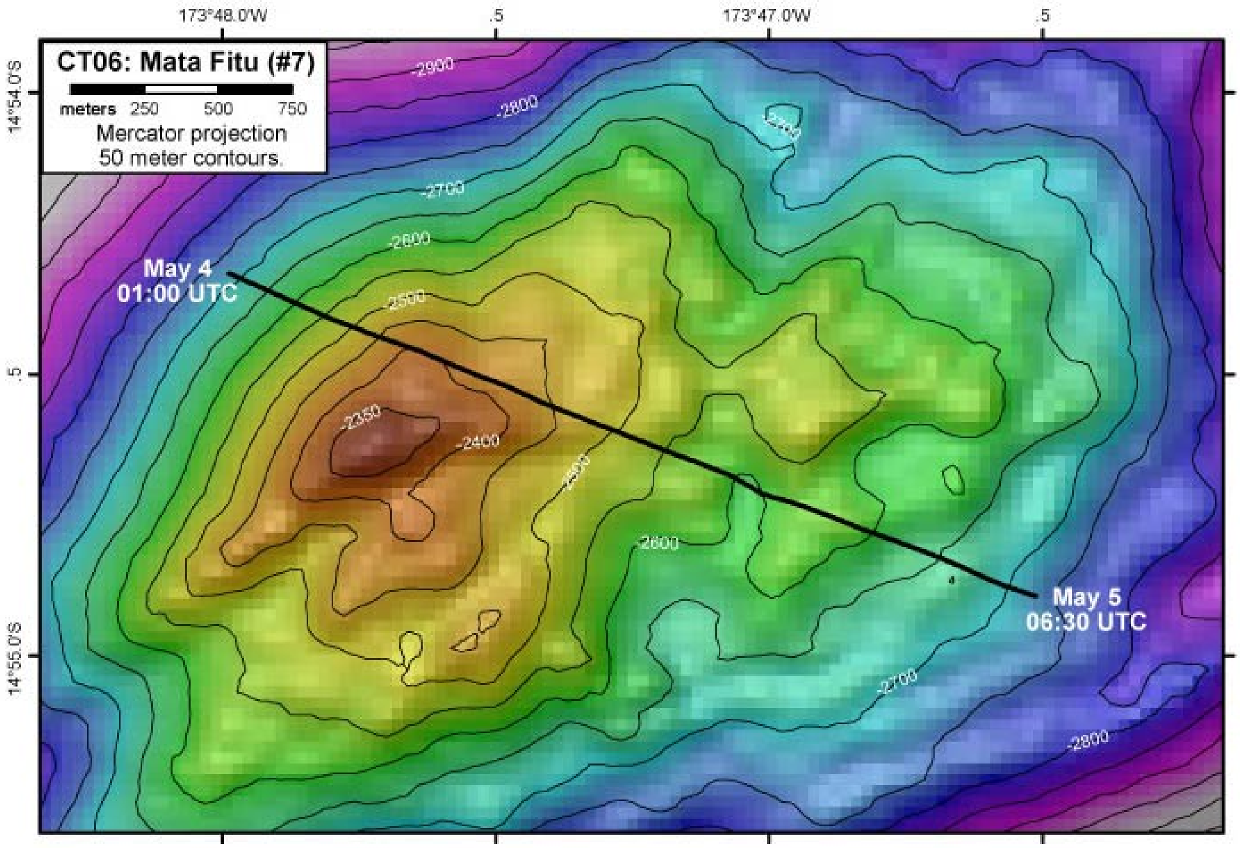


Figure 17. CT06 Mata Fitu (7) dive track.

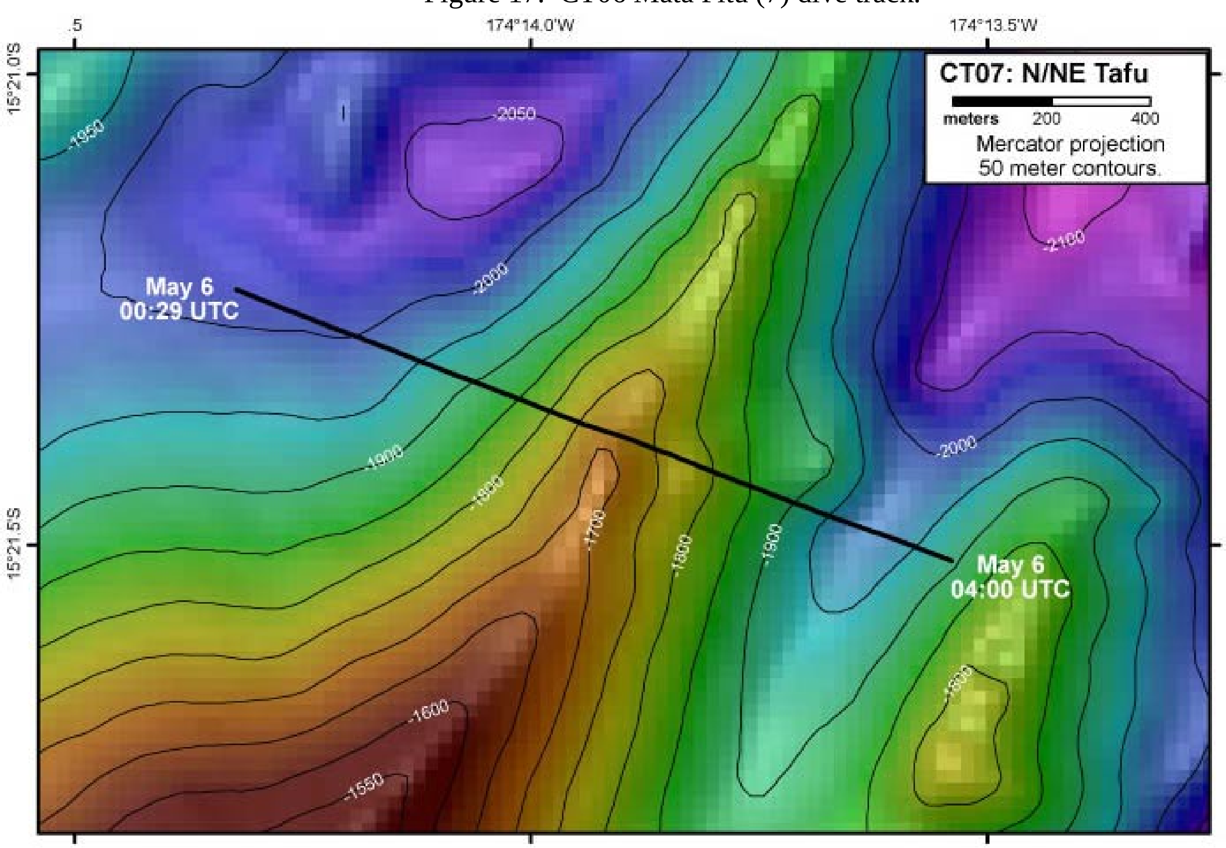


Figure 18. CT07 N/NE Tafu dive track.

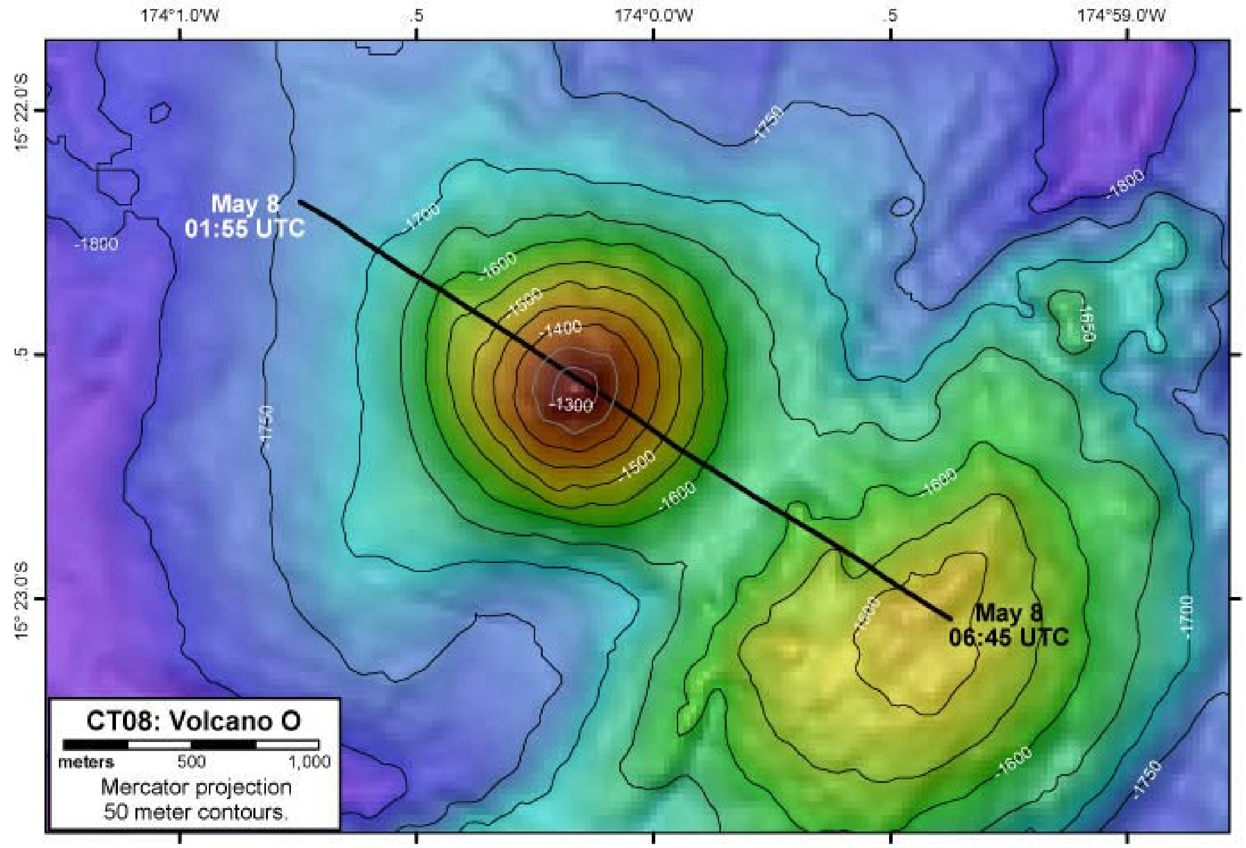


Figure 19. CT08 Volcano O cone dive track.

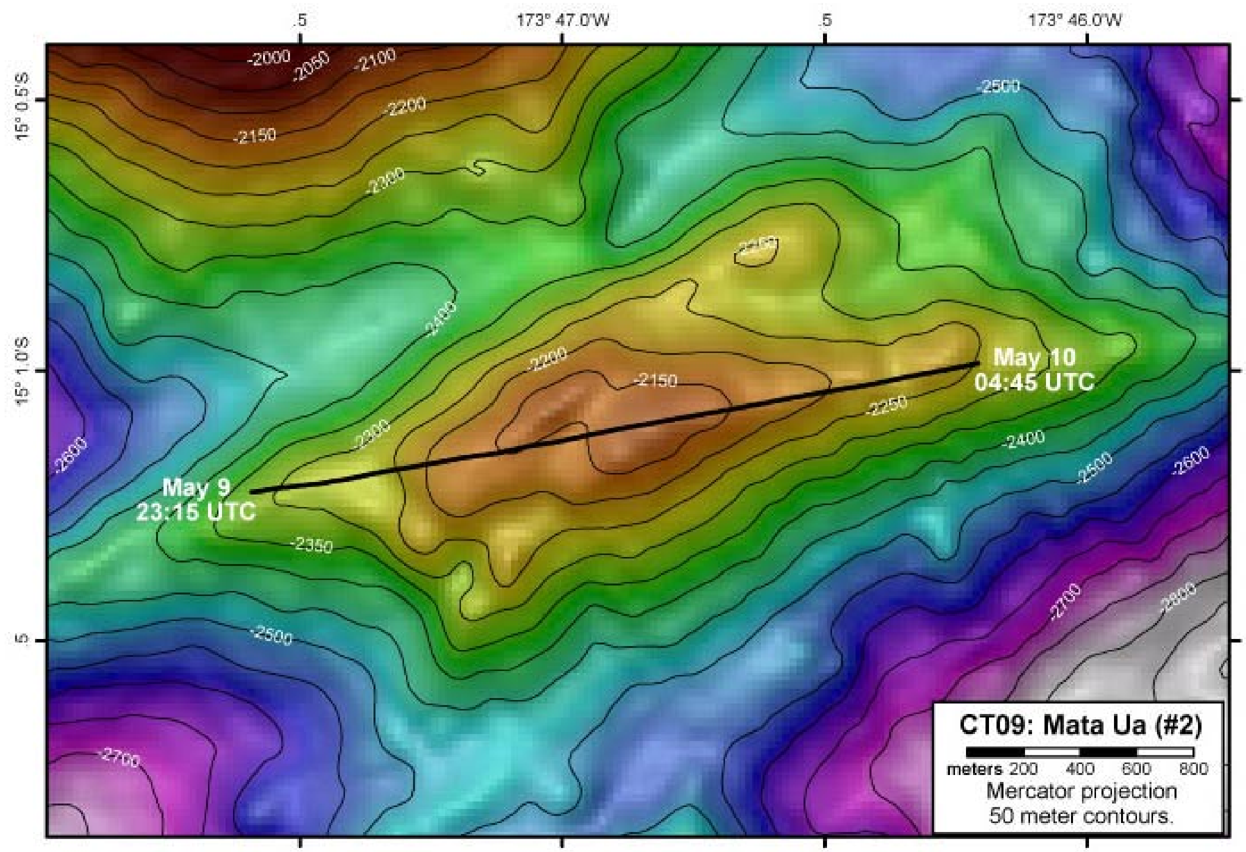


Figure 20. CT09 Mata Ua (2) dive track.

7.0 ADCP Data

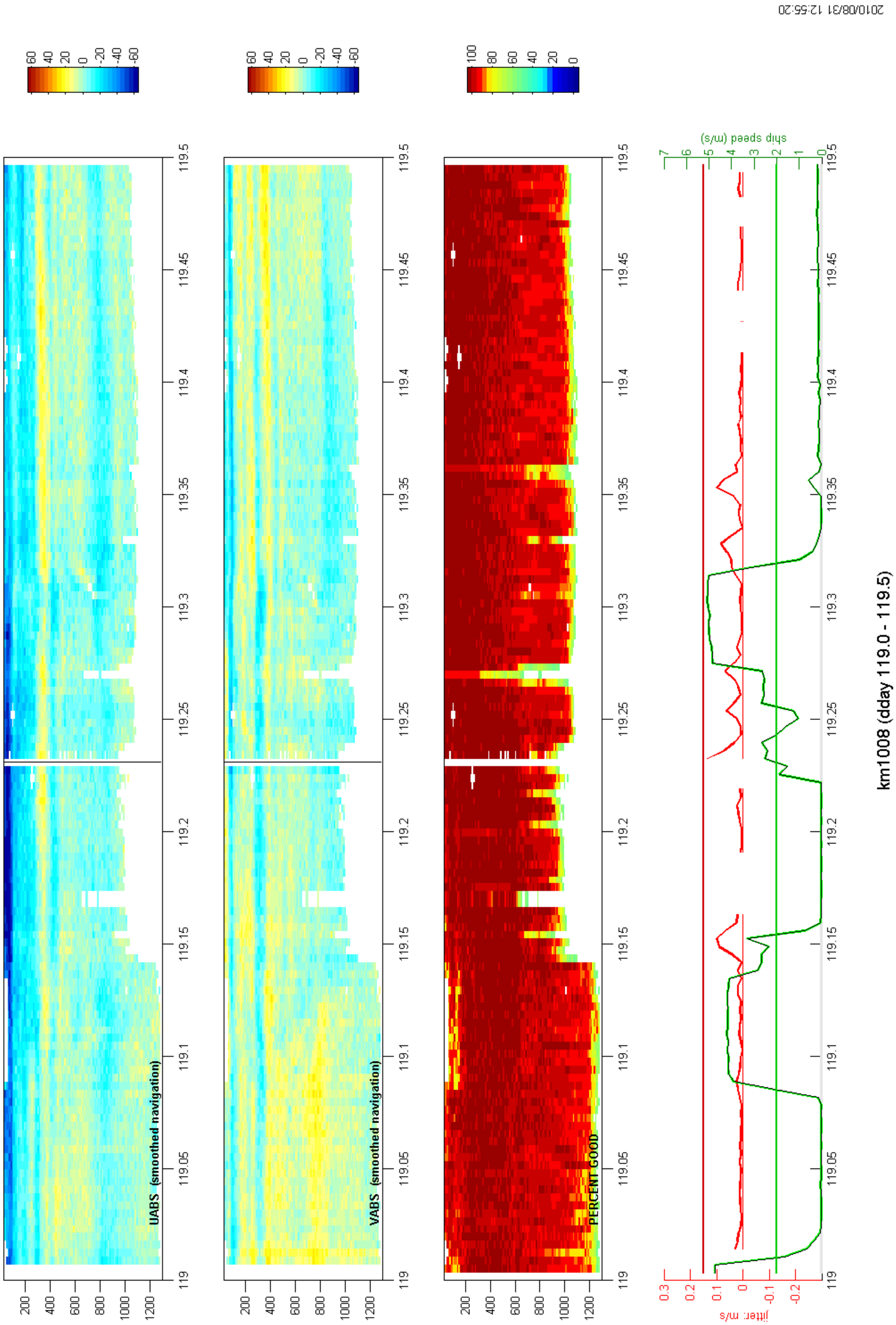
Nathan Buck

Acoustic doppler current profiling data was collected to provide current vector measurements to be used with continuous and discrete CTD data for flux calculations. The *Kilo Moana* is equipped with a RDI 38KHz "Ocean Surveyor" ADCP which was operated in both narrowband and broadband modes. Current data were collected for the duration of the cruise using UHDAS (University of Hawaii data acquisition system). UHDAS is a suite of programs and processing tools developed by the University Hawaii which performs at sea data acquisition, processing and monitoring. Post processing was done using a CODAS database (Common Ocean Data Access System) in conjunction with Gautoedit, which is collection of Matlab programs for extracting and displaying velocity and other ancillary data and is also provided by the University of Hawaii.

Further details concerning ocean currents data can be found at the Joint Archive for Shipboard ADCP (http://ilikai.soest.hawaii.edu/sadcp/) which "is responsible for the acquisition, review, documentation, archival and distribution of shipboard ADCP sets."

Both broadband and narrow narrowband data were processed to 5 minute averages. Broadband profiles reached a depth of 1000m; Narrowband profiles reached a depth of 1250m. Final processed outputs are written as Matlab files and provide time, x, y, z, u and v. All times are in UTC and the decimal day is a zero-based value (Noon on January 1 UTC is 0.5, not 1.5)

See figures 21 and 22 below.



km1008 (dday 119.0 - 119.5)
UABS (smoothed navigation)
VABS (smoothed navigation)
PERCENT GOOD
jitter: m/s
ship speed (m/s)
2010/08/31 12:55:20

Previous page:
Figure 21. Panel Plots for narrowband data produced by Gautoedit displaying absolute u and v velocities as well as PG (or 'Percent Good,' the number of accepted pings for a given ensemble) and Ship speed.

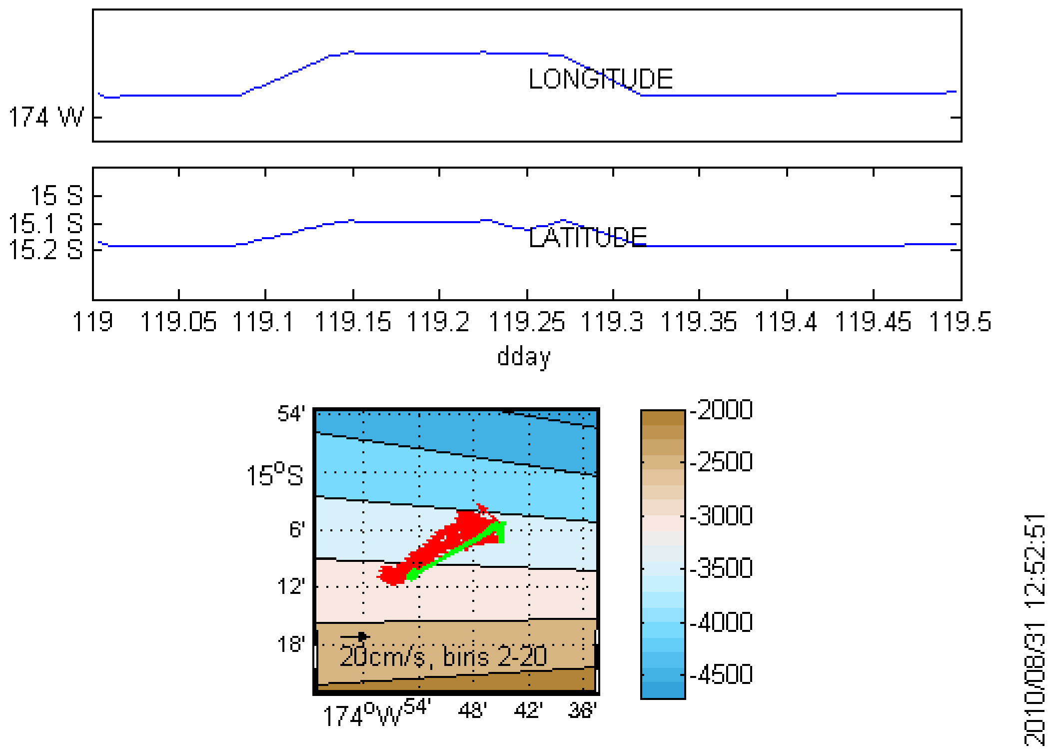


Figure 22. Panel Plots for narrowband data produced by Gautoedit displaying latitude and longitude as well as the ships course in Cartesian coordinates overlaid with vector plots for the average current between 450 and 500 meters.

8.0 Acoustic Glider Operations

Modified from web entry: http://laueruptions.blogspot.com/2010/05/acoustic-glider.html

Scientists and engineers from NOAA/ Pacific Marine Environmental Laboratory's Vents Program and Oregon State University successfully flew an ocean glider for hunting underwater volcanic plumes and eruptions in the NE Lau. The team of scientists and ship's complement on the R/V *Kilo Moana* deployed and recovered the glider while 5000 miles away a team of engineers on shore controlled the glider 24 hours a day during this two-day mission. The ocean glider "flys" by controlling its buoyancy with respect to surrounding seawater and repeating dives and ascents between the surface and 950 meter depths at 3-3.5 hour intervals. The ocean glider can go up and down in the water column by use of a pump pushing oil in and out of its internal oil reservoir to an external bladder in the nose cone and converting the resulting vertical motion to horizontal momentum through its wings. During each surfacing, the glider calls in via satellite to a shore side team and transmits data from its latest dive and ascent. The lack of a physical propulsion system allows for "quiet" operation of the glider, enabling high quality sound recordings of nearby erupting volcanic vents. In addition to the hydrophone used for recording volcano sounds, the glider is equipped with instruments able to detect temperature, conductivity and turbidity anomalies associated with hydrothermal and eruptive plumes.

The glider performed flawlessly during the mission. Ironically the only problems arose because of the delicate nature of the technology and communications issues. A two day window of calm seas was critical because the glider had to be recovered carefully by small boat and towed carefully over to the ship and hooked onto a lifting line. Choosing the launch time required constant coordination between the shore and ocean teams over a week period. Also, during the pre-dive diagnostics prior to deployment of the glider, satellite communication between the glider and the PMEL shore station was less than ideal and attributed to interference from the steel structure of the ship. However, once deployed in the water, we experienced very few satellite communication issues. The *Kilo Moana's* e-mail service was excellent and helped tremendously in coordinating the operations between the ship and shore teams.

During this mission, engineers at PMEL in Seattle and Newport worked together to monitor the progress of the glider and report its position and status to ship board personnel around the clock. Over the two-day mission, the glider travelled roughly 50km from north of the Northeast Lau Spreading Center (NELSC) to the volcanic cone at West Mata where it was met by the ship and recovered. Despite working upstream against a surface current of 30-40cm/sec, the glider made good forward progress averaging 30cm/sec headway toward its waypoints. T he glider's navigation was amazingly accurate during a nearly flawless flight. Currently, data from the mission are being analyzed and we expect that it will reveal new insight of the plumes near the West Mata area as well as the acoustic signature unique to active seafloor volcanism.

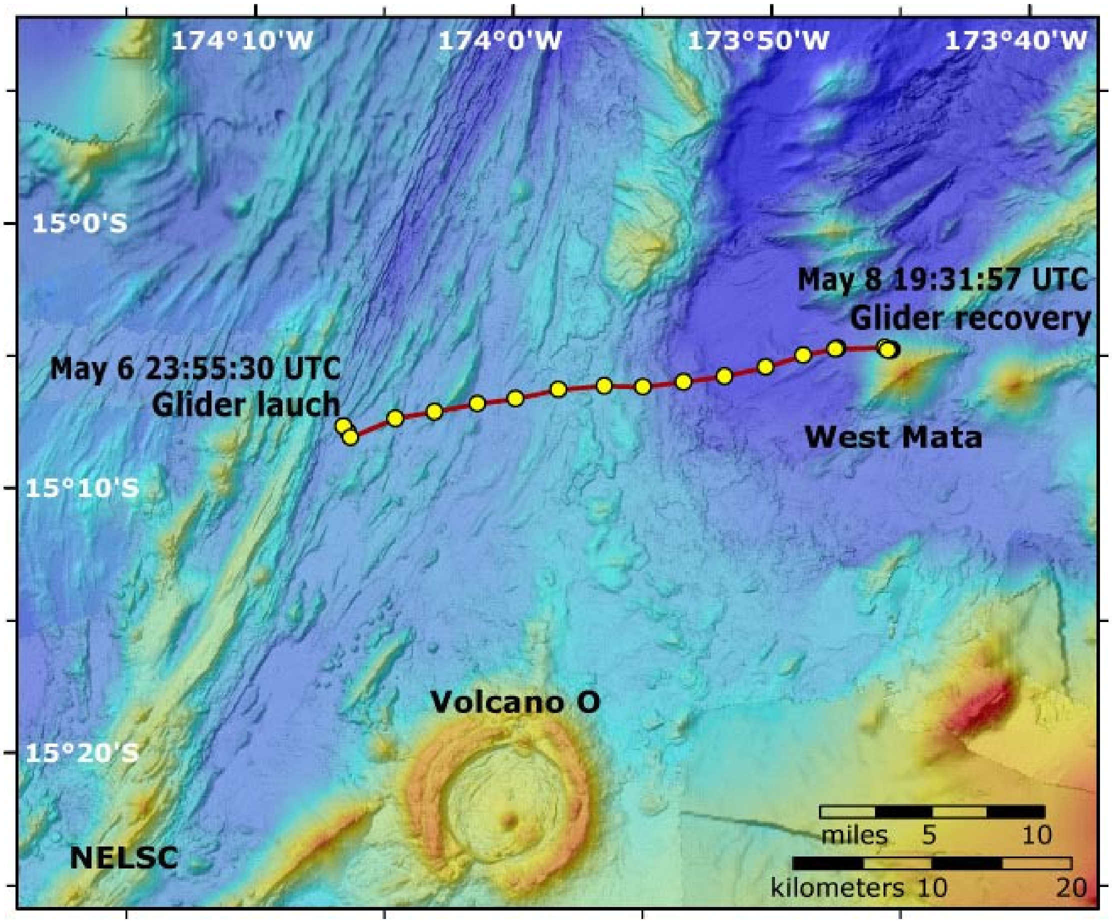


Figure 23. The glider path from launch to recovery. The yellow points are positions when the glider surfaced.

Recovering the glider using the ship's Zodiac.

9.0 Mapping the Seafloor and Water Column

Susan Merle

EM122 multibeam system on the Kilo Moana

The new EM122 12 kHz multibeam system on the R/V *Kilo Moana* has the capability of mapping the water column as well as the seafloor. Kongsberg, the company who manufactures the systems, reports in their maintenance manual that compared with the EM120 the EM122 has up to 4 times the resolution in terms of sounding density. The EM122 has a possible 432 beams per ping. An EM120 system has 191 beams per ping. The EM122 system on the *Kilo Moana* uses the same 1x2 degree transducers as the EM120, but with new electronics and software.

The SIS (Seafloor Information System) on the *Kilo Moana* allows the user to set operating parameters and to monitor data logging. Bathymetry, backscatter and water column data can be displayed in real-time. Bathymetric displays include 2D and 3D geographical displays of the data, as well as a waterfall display of consecutive pings, a quality display of the current ping including how the beams were formed, etc. Other real-time parameters that are displayed by the system and recorded by a watchstander at a regular interval include: UTC time, seafloor depth, latitude and longitude, heading, ship speed, and swath coverage. The water column display can image biomass and other acoustic reflectors present between the seafloor and sea surface. Gas bubbles from plumes above NW Rota-1 were easily visualized on the previous expedition to NW Rota-1 in the Marianas, and 3D plume objects were successfully created using the Fledermaus 3D midwater software.

Mapping operations on KM1008

Most of the seafloor mapping accomplished on the 2010 expedition was opportunistic, surveying the seafloor when there was sufficient time to gather new multibeam data without compromising other operations. (Figure 1). New bathymetry data were added to the west of our EM300 coverage in this area, as well as mapping the four northern Matas at higher resolution than was previously available. Bathymetry data were also collected on the transit to and from Samoa. Several areas were re-surveyed for surface differencing, including the NELSC, Volcano O and West Mata (Figure 24). More than 7000 square kilometers of seafloor was mapped on the expedition, >4000 km^2 in the operations area and 3000 km^2 transiting from Samoa and back (Figures 1 and 2).

The water column data were noisy, exhibiting sector artifacts that made the plumes at the summit of West Mata volcano appear to extend to the surface along sector edges. These errors were probably due to increased noise due to engine problems that the *Kilo Moana* was experiencing. Realistic plumes above West Mata were also observed on the water column display, but 3D depictions of those plumes could not be created, probably because there is not as much gas in the plume above West Mata as there is above NW Rota-1 in the Marianas, where successful 3D objects of the plume were created on the previous expedition (KM1005).

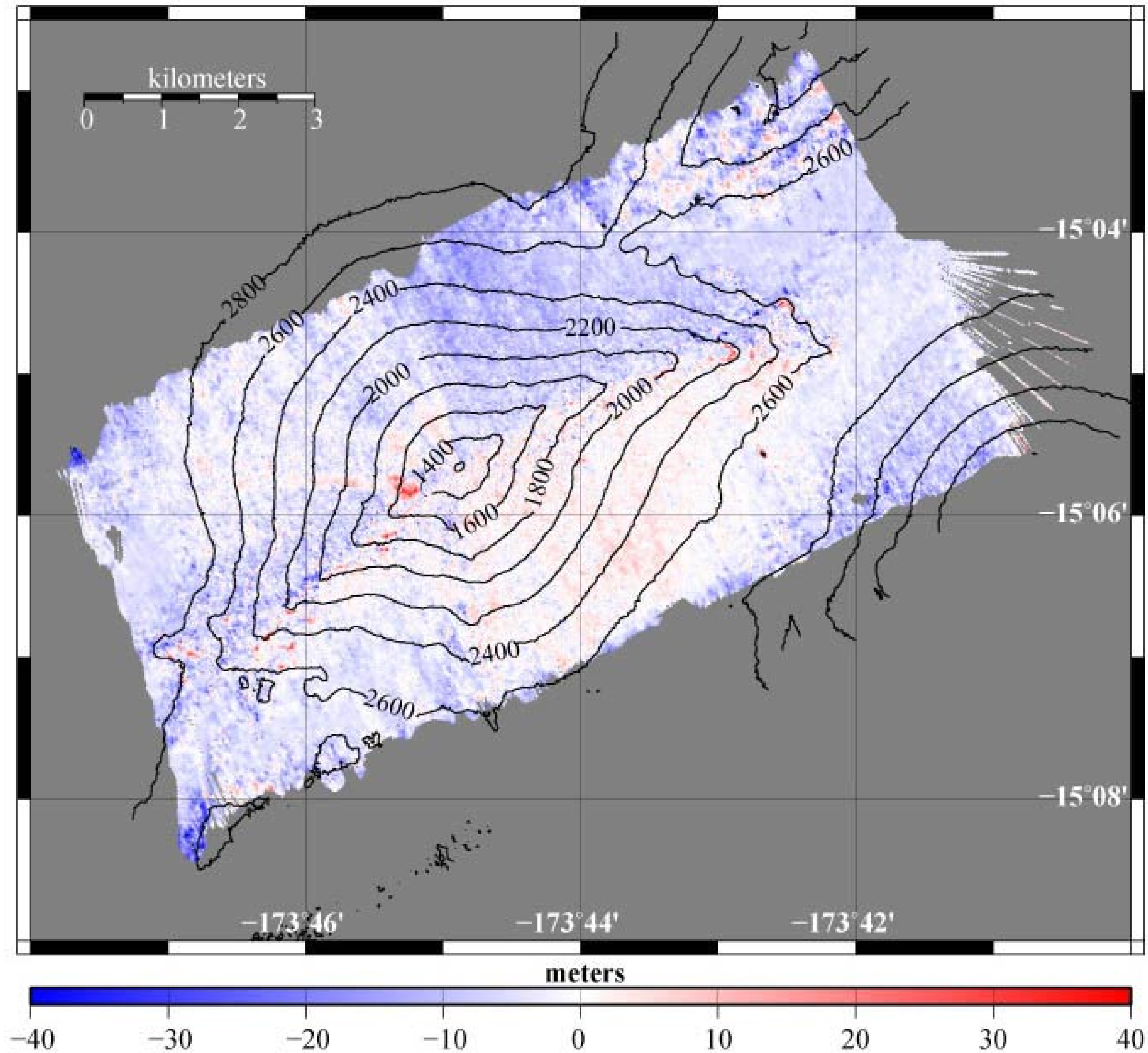


Figure 24. West Mata 2009 (EM300) - 2010 (EM122) bathymetry depth difference in meters. 200 meter contours are the 2010 EM122 data.

10.0 Mooring Deployment

Events	Z (m)	lat deg	lat min	long deg	long min	Latitude	Longitude
Mooring deployed.	2794	-15	8.50	-173	44.26	-15.1417	-173.7377

A mooring with a hydrophone and MAPRs attached was deployed to continue monitoring of the eruption over the next several years.