Cruise Report for R/V *Kilo Moana* KM1116: ALOHA Cabled Observatory and Ka‘ena Ridge, 20 May – 7 June 2011

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Summary

The purpose of this NSF-funded cruise on the R/V *Kilo Moana* was twofold: to install the ALOHA Cabled Observatory (ACO) and survey portions of the Ka‘ena Ridge and collect rock samples.

The ACO was successfully installed. There were extreme and unexpected challenges, mainly associated with the configuration (from shore) of the sea cable, specifically having to do with the switching system in the repeaters. The ACO “saw light” during the last Jason dive, nine hours before we had to return to Honolulu. Sensors delivering data now are: camera with two lights, two hydrophones and precision pressure sensor, two acoustic Doppler profilers, a microCat temperature/conductivity sensor, and another light (on the observatory frame). The thermistor array/acoustic modem (TAAM) mooring is partially functional, with 10 thermistors recording data internally using batteries. Two other instruments have suffered ground faults/shorts to seawater: the acoustic modem (at the top of the TAAM mooring) and the ALOHA-MARS node with two CTDs and a fluorometer. In addition to much video from Jason, we obtained a complete set of digital still images of the ACO layout for a mosaic, and a video using the camera controlled from shore of Jason next to the observatory and flying away.

The Ka’ena Ridge work was very successful with four Jason dives and many rock samples collected and a number of survey lines crossing the ridge.

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1. Introduction

The purpose of this NSF-funded cruise on the R/V *Kilo Moana* was twofold:

- Install the ALOHA Cabled Observatory (ACO) and,
- Survey portions of the Ka‘ena Ridge and collect rock samples.

The remotely operated vehicle (ROV) Jason was essential to performing the required tasks.

The cruise was 18 days long, from 20 May to 7 June 2011. The ACO work was allocated 14 days, and the Ka‘ena Ridge 4 days. The ship departed Honolulu at 0800 and proceeded directly to Ka‘ena Ridge (the underwater extension of Oahu to the northwest) to conduct a combined engineering checkout and science Jason dive. Then we proceeded to Station Aloha, 100 km north, to perform the ACO work. See Figure 1-1 for a map with actual cruise lines. Table 1-1 gives coordinates of relevant points. The balance of the Ka‘ena Ridge work came mid-cruise while problems with the ACO deployment were being worked on. During pauses in the main work, some sites were visited to fill in bathymetry data gaps or to obtain data next to the WHOTS buoy.

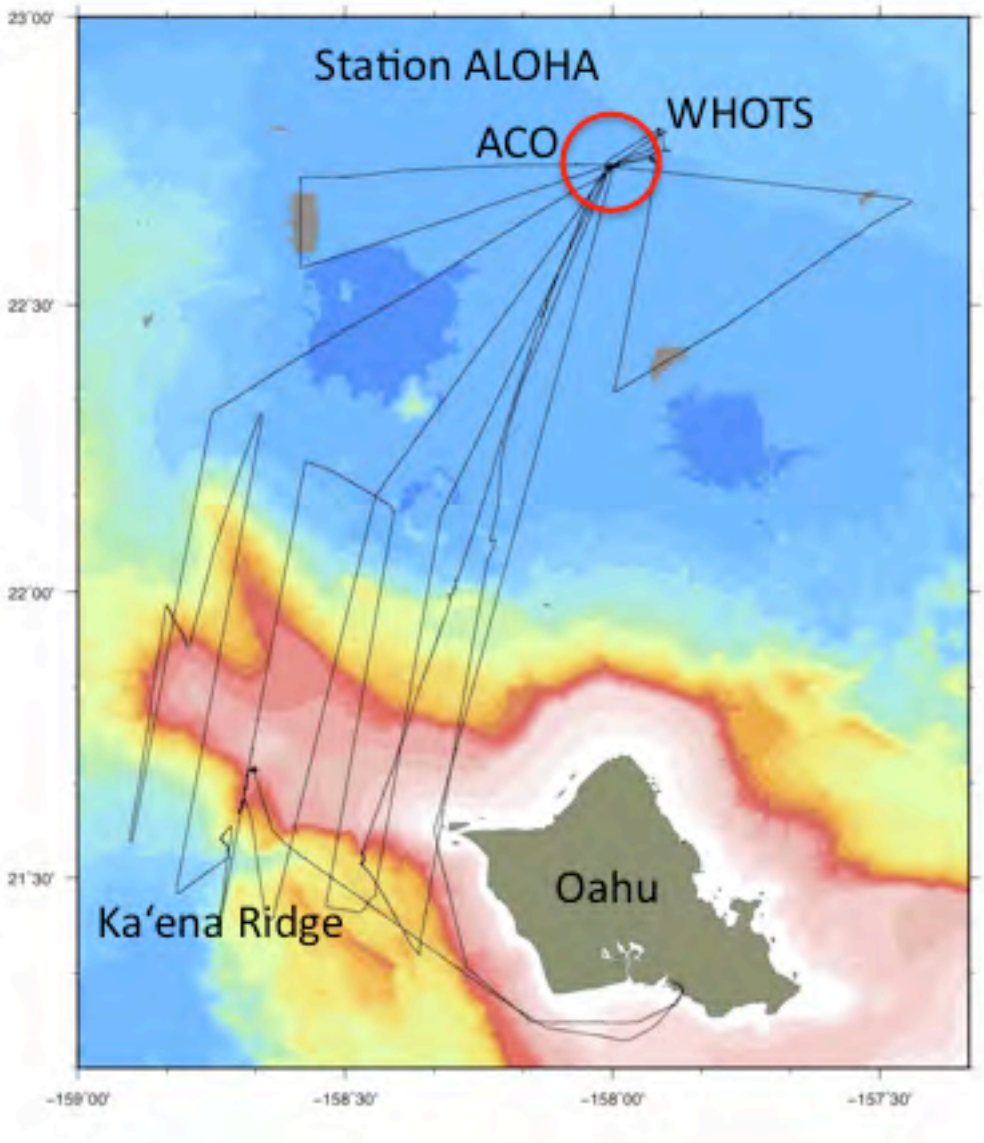

Figure 1-1 Bathymetric map of area with actual cruise lines.

	Latitude deg	N minutes	Longitude deg	W minutes	Incremental distance (nmi)
UHMC, Snug Harbor	21	18.937	157	53.186	
Honolulu WP1	21	16	157	54	
Barbers Point WP	21	16	158	9	14
Ka‘ena Ridge Dive1	21	37.052	158	41.875	37
ACO Cable Termination	22	44.324	158	0.372	78
Station ALOHA	22	45	158	0	1

Table 1-1 Coordinates of waypoints and stations

This report is divided into two parts, the ACO installation effort and the Ka‘ena Ridge work. Appendix 1 has the more detailed cruise time line with significant events. Appendix B has more detailed information on the rock samples.

The ACO portion of the cruise used 10 Jason dives (J2-552 – J-555, J2-558 – J2-559, J2-561 – J2-564). The Ka‘ena Ridge portion of the cruise used 4 Jason dives (J2-551, J2-556, J2-557, J2-560). There were two weather days, where anomalously high trade winds prevented work.

Please reference the cruise plan dated 15 May 2011. Additional information can be found at the ALOHA Observatory web site (http://www.soest.hawaii.edu/ALOHA) and the project wiki (http://www.soest.hawaii.edu/acowiki/index.php/Main_Page). Also, sometime soon, the Jason data (video and other) will be posted on the “Jason Virtual Van” (http://4dgeo.whoi.edu/jason).

2. ALOHA Cabled Observatory Installation

Upon arrival at the ACO site, a survey dive (J2-552, ACO Dive 1) was conducted to locate the cable termination and replace the homer beacon. The termination frame was moved several meters north to clear a cable wuzzle. The next five ACO dives were related to trying to debug fiber connections with changes being made to the fiber configuration in the JBOX. Because we (finally) felt the problem lay in the sea cable and could only be fixed on shore (with possibly a configuration change in the JBOX), we decided to install all the subsea components while the shore personnel continued to work on sea cable configuration.

On Friday 3 June, the TAAM mooring was deployed, after reconfiguring the cables and connections just above the anchor, so that the IMM unit would fit below the A-frame with the releases and anchor. The mooring landed in the desired location about 50 m WNW of the JBOX location. Later the same day, the observatory (OBS) was deployed successfully, but the dive had to be aborted when the lowering bridle was caught in Jason thrusters. After a 45-minute turn-around, Jason redeployed (ACO Dive 8) to move and connect the AMM secondary node, move and connect the camera (CAM), and connect the TAAM. Regarding the latter, the acoustic modem seafloor cable was connected first. Then we returned to the mooring, and before attempting to deploy the IMM seafloor cable, we inspected the lower part of the mooring. At this time we found the IMM-seafloor connector had pulled out. The 10 thermistors are internally recording on battery power. During this time, the JBOX was tested (negative) and the ODI T101 test connector mounted on Jason with a feed to the ship was mated to the sea cable to provide further diagnostic data.

The results from the latter indicated a clear light path, but the JBOX had to be recovered (Dive 9), reconfigured and redeployed (Dive 10). This time it worked. At 0905 6 June HST, we received notification that Ethernet was functional; hydrophone signals sounding like Jason could be heard

at UH. Then the subsea connections were reconfigured to connect the JBOX to the OBS. This worked. At 1047 6 June HST, sensor data started flowing, Figure 2-1.

A multitude of factors caused the problems with the sea cable/fiber configuration. There was a basic error in fiber assignments between the sea cable and the ODI connector. A new software program (PALMS) was being used to check the status of the sea cable (repeater settings, received light power at each repeater, laser output bias current, light path routings, etc.). This program had been checked out and used on other systems (by Mark Tremblay, our ex-AT&T consultant, who flew out from New Jersey when we started having problems). With our system there were problems, partly associated with the RS-232 computer interfaces and variability therein. Part way through the evolution, it was discovered that fiber pair 3 (fibers 3 and 4) were reversed on the back of the Terminal Transmission Equipment (TTE). This combined with the RS232 problems conspired to initially partially scramble the switching matrix within the repeaters, so that light took unknown paths. It was only after this error was found, and the delays in the RS232 were understood, that the shore personnel were able to slowly re-configure the system. With the results of the various JBOX and test connector configurations, a final fiber configuration was arrived at and implemented in the final JBOX deployment. As a side benefit one fiber pair that had previously thought to be broken was found to be working (available for future expansion).

Sensors delivering data now are: camera with two lights (CAM), two hydrophones and precision pressure sensor (HEM), two acoustic Doppler profilers, a temperature/conductivity sensor, and another light (on the observatory frame connected to the μSEM). The thermistor array/acoustic modem (TAAM) mooring is partially functional, with the 10 thermistor recording data internally using batteries. Two other instruments have suffered ground faults/shorts to seawater: the acoustic modem (at the top of the TAAM mooring) and the ALOHA-MARS node with two CTDs and a fluorometer. In addition to much video data from Jason, we obtained a complete set of digital still images of the ACO layout for a mosaic, and a video using the camera controlled from shore of Jason next to the observatory and flying away. Versions of the latter are available on the project web site. The first still image the ship received from shore is shown in Figure 2-2. The final seafloor configuration is shown in Figures 2-3 and 2-4.

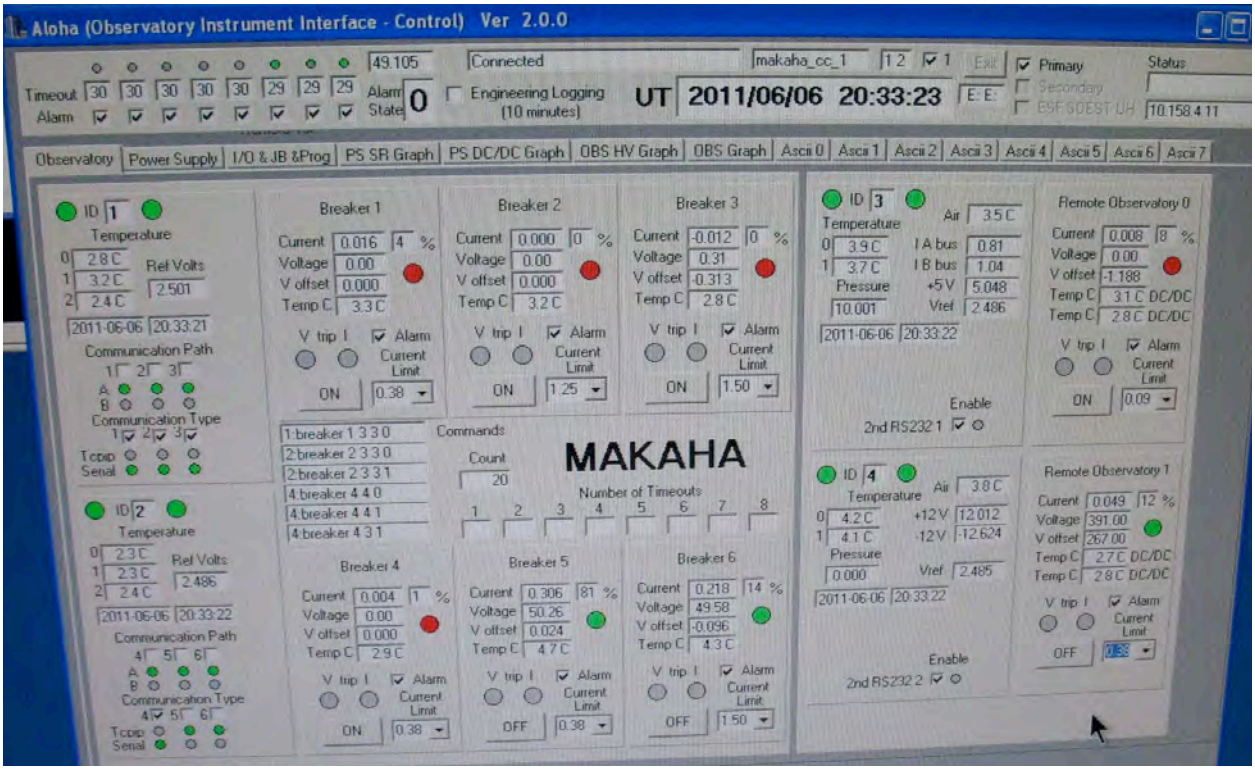

Figure 2-1 "First light" screen shot showing the HEM, µSEM, and AMM on.

Figure 2-2 First camera image sent from shore to the ship.

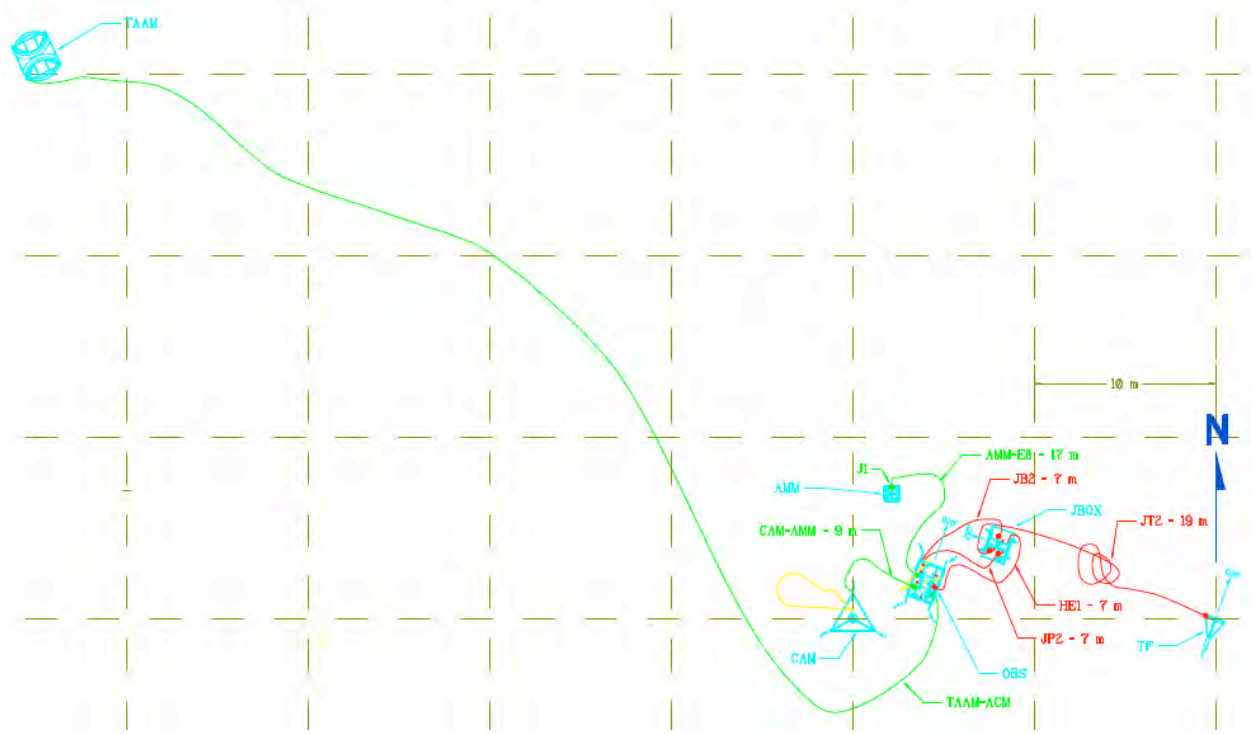

Figure 2-3 ACO bottom configuration – 1

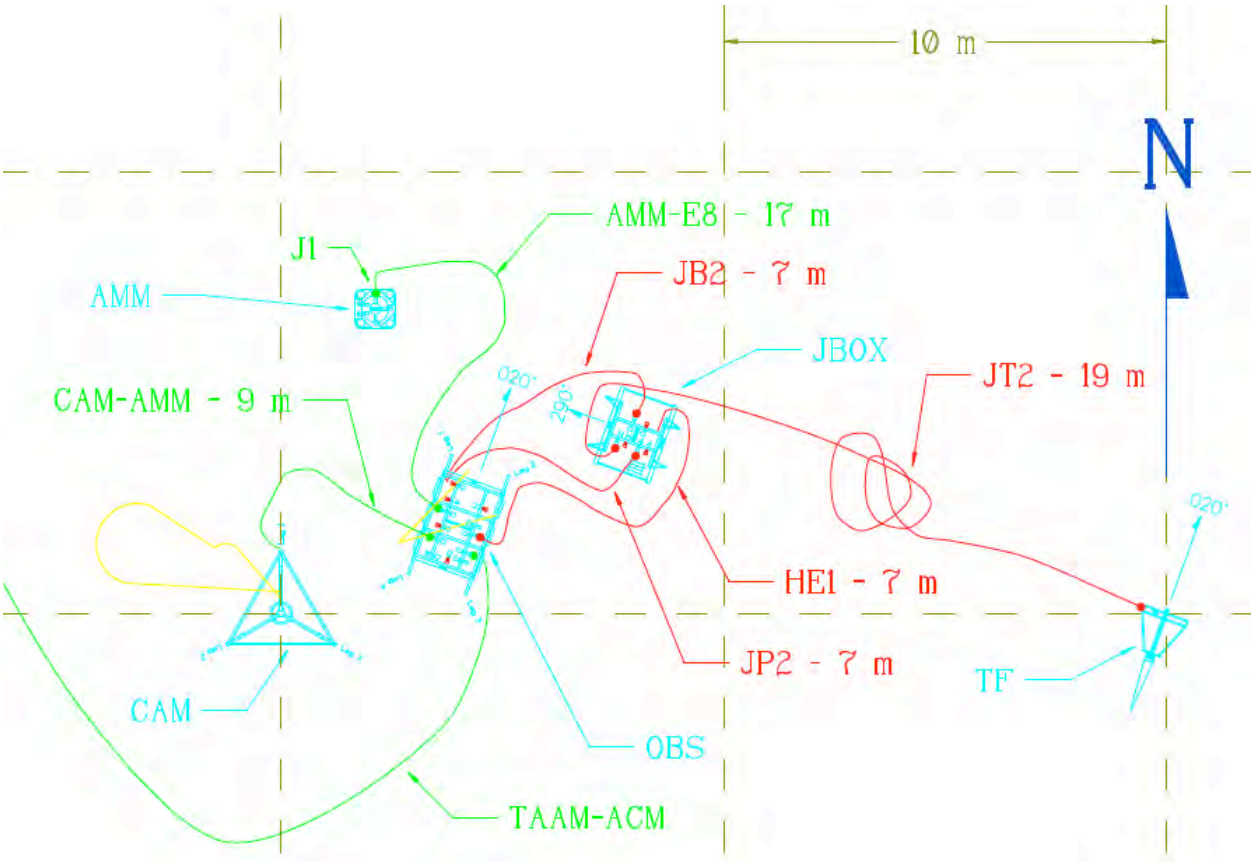

Figure 2-4 ACO bottom configuration – 2

3. Ka‘ena Ridge

Geological investigations of Kaʻena Ridge during R/V Kilo Moana cruise KM1116 included four dives of ROV Jason and seven survey lines crossing the ridge axis, along which gravity and magnetics data were collected. The locations of the four Jason dives (J2-551, J2-556, J2-557, and J2-560) and survey lines A-G are shown on Figure 3-1. This shows the locations of samples collected during four dives of ROV Jason (blue circles). A towed magnetometer was deployed during the survey lines. Gravity and multi-beam bathymetric data were collected along these lines, as well as for all other transits shown in Figure 1-1. Information on the 53 samples collected during the Jason dives is given in Appendix B. The data collected are intended to elucidate the number of different volcanic sequences present along Kaʻena Ridge. On-shore laboratory studies will determine the chemical composition and age of the collected samples. Gravity and magnetics data will be used to clarify the sub-surface structure of the ridge.

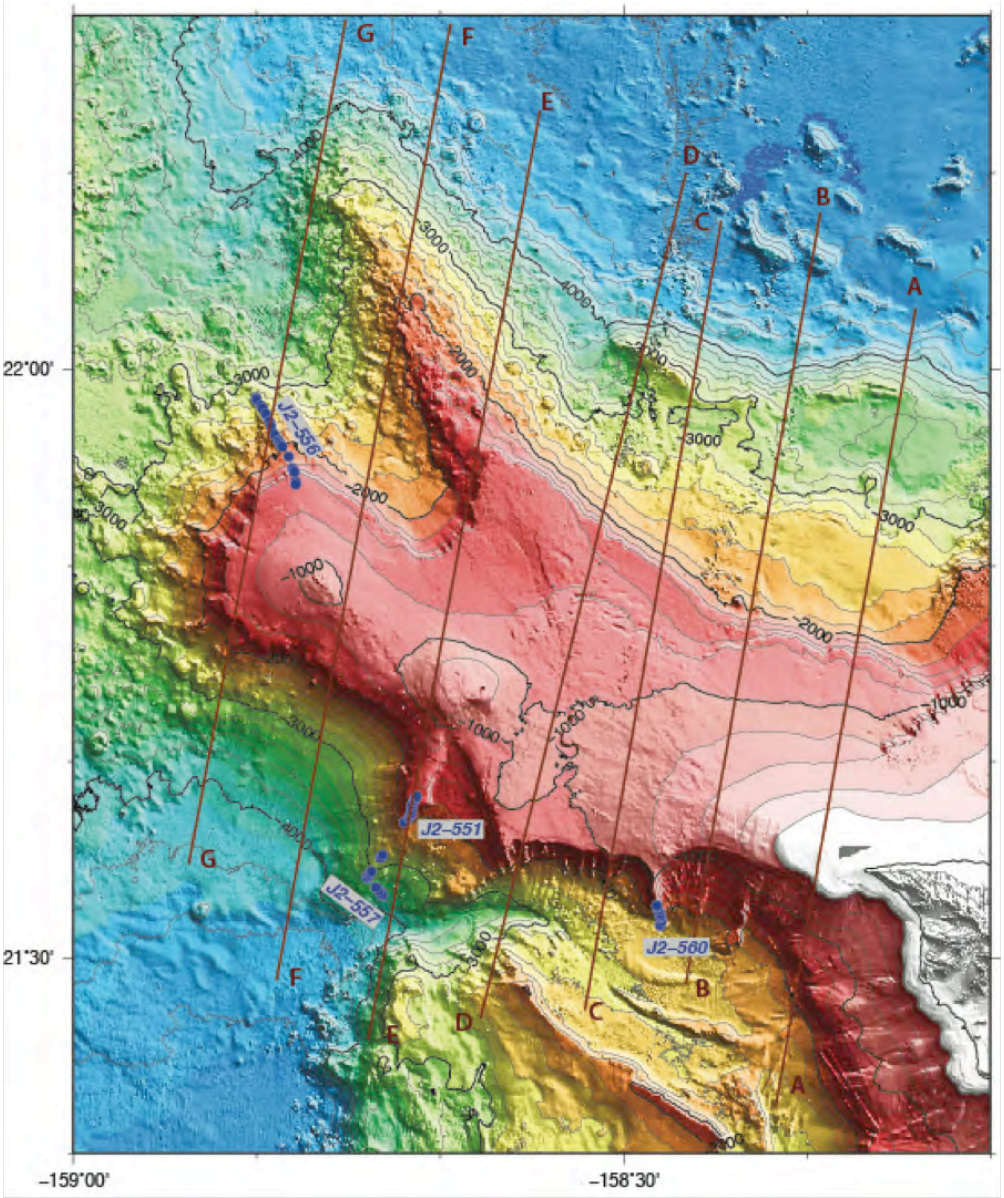

Figure 3-1 Bathymetry of Ka‘ena Ridge showing Jason dives and survey lines.

Acknowledgments

The success of this cruise is largely due to the outstanding performance and professionalism of the WHOI Jason team, led by Matthew Heintz. Because of the ACO problems, there were more dives than expected and some of these were more arduous bounce dives, especially in the final days of the cruise. The Jason team helped develop and integrated the test connector into their system so we could "talk" to shore from the ship, thereby providing critical information to diagnose the cable problems. Capability such as this will be of great benefit for future cabled observatory operations.

The captain and crew of the R/V *Kilo Moana* supported us in every way possible. Capt. Rick Meyer always found ways to buoy our spirits. Chief Mate Eric Schoenberg always made sure the deck operations were conducted safely; he found the solution to the "over boarding block problem." Vic Polidoro and Trevor Young from OTG provided all possible assistance. Vic ran all the science deck operations efficiently and safely at all times of day and night.

On shore, Mark Tremblay and Dave Harris were called in on an emergency basis and near-miraculously solved the cable problems. On campus, Jim Jolly and Jim Babinec as well as Fernando Santiago-Mandujano, Brian Chee and Joseph Gum assisted them. We are glad and very relieved that Jim Jolly is doing fine now after suffering a heart attack during this operation, and greatly appreciate his essential contributions to the success of the ACO.

The willingness of AT&T to accommodate this activity within their Makaha cable station and their support of the ACO project is much appreciated.

Appendix A – Timeline

KM1116: ACO - Ka'ena Ridge Timeline

Local times * Personnel required at Makaha Cable Station

Day	Start	Hours	End	Task
Friday	05/20 08:00	6.5	05/20 14:30	Transit Honolulu – Ka'ena Dive 1
	05/20 14:30	1.0	05/20 15:30	Lower USBL pole
	05/20 15:30	4.0	05/20 19:30	Test and drop transponder
	05/20 19:30	6.5	05/21 02:00	Survey transponder for USBL cal
Saturday	05/21 02:00	1.5	05/21 03:30	Release and recover transponder
	05/21 03:30	4.0	05/21 07:30	Transit (with pole down) to dive site
	05/21 07:30	1.0	05/21 08:30	Launch Jason
	05/21 08:30	12.0	05/21 20:30	***J2-551*** - Ka'ena Dive 1 – **Engineering + Science**
	05/21 20:30	2.0	05/21 22:30	Transit to start Line D; Service
	05/21 22:30	4.0	05/22 02:30	Transit Line D 42 nmi
Sunday	05/22 02:30	4.0	05/22 06:30	Transit end of Line D to ACO 45 nmi
	05/22 06:30	1.0	05/22 07:30	Lower USBL pole
	05/22 07:30	1.0	05/22 08:30	Deploy Jason, Medea
	05/22 08:30	2.5	05/22 11:00	***J2-552*** - ACO Dive 1 - descend
	05/22 11:00	4.0	05/22 15:00	ACO Dive 1 – **survey**
	05/22 15:00	2.5	05/22 17:30	ACO Dive 1 – ascend, recover
	05/22 17:30	7.5	05/23 01:00	Service; free fall CAM at 20:40
Monday	05/23 01:00	1.0	05/23 02:00	Deploy JBOX, then Jason, Medea
	05/23 02:00	3.0	05/23 05:00	***J2-553*** - ACO Dive 2 – descend
	05/23 05:00	13.5	05/23 18:30	*ACO Dive 2 – **JBOX position/connect/test;** move camera, TF homer beacon; inspect PMI grip
	05/23 18:30	2.5	05/23 21:00	ACO Dive 2 – ascend, recover
	05/23 21:00	15.0	05/24 12:00	Service, Bathymetry survey, WHOTS inspection
Tuesday	05/24 12:00	0.5	05/24 12:30	Deploy Jason, Medea
	05/24 12:30	2.5	05/24 15:00	***J2-554*** - ACO Dive 3 - descend
	05/24 15:00	4.0	05/24 19:00	ACO Dive 3 - **Recover JBOX**, beacons on camera; survey cable to south
	05/24 19:00	3.5	05/24 22:30	ACO Dive 3 – ascend, recover
	05/24 22:30	9.5	05/25 08:00	Service, fix JBOX, bathymetry survey
Wednesday	05/25 08:00	1.0	05/25 09:00	Deploy JBOX, then Jason, Medea

	05/25 09:00	2.5	05/25 11:30	***J2-555*** - ACO Dive 4 – descend
	05/25 11:30	7.0	05/25 18:30	*ACO Dive 4 – **JBOX position/connect/test**
	05/25 18:30	2.5	05/25 21:00	ACO Dive 4 – ascend, recover
	05/25 21:00	13.5	05/26 10:30	Service, Transit ACO to Ka'ena Dive 2/Track TBD
Thursday	05/26 10:30	22.5	05/27 09:00	***J2-556*** - Ka'ena Dive 2 **- Survey and sample**
Friday	05/27 09:00	7.5	05/27 16:30	Service and transit, survey line F
	05/27 16:30	18.5	05/28 11:00	**J2-557** - Ka'ena Dive 3 **- Survey and sample**
Saturday	05/28 11:00	17.0	05/29 04:00	Service and transit, survey lines E, C & B, transit to ACO
Sunday	05/29 04:00	24.0	05/30 04:00	**Weather day - stand off WHOTS Buoy**
Monday	05/30 04:00	0.5	05/30 04:30	Deploy Jason, Medea
	05/30 04:30	2.5	05/30 07:00	***J2-558*** - ACO Dive 5 - descend
	05/30 07:00	6.5	05/30 13:30	*ACO Dive 5 - **Recover JBOX with umbilical**
	05/30 13:30	3.0	05/30 16:30	ACO Dive 5 – ascend, recover
	05/30 16:30	11.5	05/31 04:00	Service, fix JBOX
Tuesday	05/31 04:00	1.0	05/31 05:00	Deploy JBOX, then Jason, Medea
	05/31 05:00	2.5	05/31 07:30	***J2-559*** - ACO Dive 6 – descend
	05/31 07:30	10.0	05/31 17:30	*ACO Dive 6 – **JBOX position/connect/test, survey cable**
	05/31 17:30	2.5	05/31 20:00	ACO Dive 6 – ascend, recover
	05/31 20:00	12.0	06/01 08:00	Service, free fall AMM
Wednesday	06/01 08:00	3.5	06/01 11:30	**Weather - transit to Ka'ena**
	06/01 11:30	6.0	06/01 17:30	Survey Line A
	06/01 17:30	12.5	06/02 06:00	***J2-560*** - Ka'ena Dive 4 **- Survey and sample**
Thursday	06/02 06:00	7.0	06/02 13:00	Transit to ACO, Service, terminate 0.681, prep deck
	06/02 13:00	18.0	06/03 07:00	**Weather - at ACO, WHOTS**
Friday	06/03 07:00	3.5	06/03 10:30	Deploy TAAM on 0.681 - weather dependent
	06/03 10:30	1.5	06/03 12:00	Lower TAAM
	06/03 12:00	1.0	06/03 13:00	**Navigate/release TAAM**
	06/03 13:00	2.0	06/03 15:00	Recover wire, position OBS on deck
	06/03 15:00	1.0	06/03 16:00	Service; terminate 0.681 wire
	06/03 16:00	1.0	06/03 17:00	Deploy OBS, Jason, Medea
	06/03 17:00	3.0	06/03 20:00	***J2-561*** - ACO Dive 7 – descend
	06/03 20:00	4.0	06/04 00:00	ACO Dive 7 – **Deploy OBS, Abort - line foul**
Saturday	06/04 00:00	3.0	06/04 03:00	ACO Dive 7 – ascend, recover
	06/04 03:00	0.8	06/04 03:45	Service
	06/04 03:45	0.3	06/04 04:00	Deploy Jason, Medea

	06/04 04:00	2.0	06/04 06:00	***J2-562*** - ACO Dive 8 – descend
	06/04 06:00	2.8	06/04 08:45	ACO Dive 8 – **AMM - find, move to OBS**
	06/04 08:45	3.8	06/04 12:30	*ACO Dive 8 – **Connect OBS to JBOX; test (fails)**
	06/04 12:30	0.5	06/04 13:00	ACO Dive 8 – **AMM - connect to OBS**
	06/04 13:00	1.0	06/04 14:00	ACO Dive 8 – **Move and connect CAM to AMM**
	06/04 14:00	2.0	06/04 16:00	ACO Dive 8 – **Move to TAAM, pull AcModem cable, connect to OBS**
	06/04 16:00	1.8	06/04 17:45	ACO Dive 8 – **Inspect TAAM IMM - damaged connector**
	06/04 17:45	4.0	06/04 21:45	*ACO Dive 8 – **Test JBOX, T101 connector**
	06/04 21:45	2.5	06/05 00:15	ACO Dive 8 – ascend, recover
Sunday	06/05 00:15	2.3	06/05 02:30	Jason and Medea service
	06/05 02:30	0.5	06/05 03:00	Deploy Jason, Medea
	06/05 03:00	2.5	06/05 05:30	***J2-563*** - ACO Dive 9 - descend
	06/05 05:30	0.8	06/05 06:15	ACO Dive 9 - locate
	06/05 06:15	0.8	06/05 07:00	ACO Dive 9 - **disconnect JB2, transfer to parking on OBS**
	06/05 07:00	0.5	06/05 07:30	ACO Dive 9 - **disconnect HE1 from OBS, coil on JBOX**
	06/05 07:30	0.5	06/05 08:00	ACO Dive 9 - **disconnect JP2, transfer to parking on OBS**
	06/05 08:00	1.0	06/05 09:00	ACO Dive 9 - **move JT2/G2 to parking on OBS**
	06/05 09:00	3.3	06/05 12:15	ACO Dive 9 - **rig JBOX for recovery**
	06/05 12:15	3.0	06/05 15:15	ACO Dive 9 - ascend, recover
	06/05 15:15	0.5	06/05 15:45	recover Jason, Medea, JB on deck
	06/05 15:45	5.0	06/05 20:45	Open JB, reconfigure/test, close JB; service Jason/Medea
	06/05 20:45	0.8	06/05 21:30	Deploy JB, Jason, Medea
	06/05 21:30	1.8	06/05 23:15	descend
	06/05 23:15	2.3	06/06 01:30	***J2-564*** - ACO Dive 10 - **Position JBOX**
Monday	06/06 01:30	0.2	06/06 01:42	ACO Dive 10 - **Move JT2/G2 from OBS parking to JBOX and connect**
	06/06 01:42	0.2	06/06 01:54	ACO Dive 10 - **Move JP2 from parking on OBS to parking on JBOX**
	06/06 01:54	0.2	06/06 02:06	ACO Dive 10 - **Move JB2 from parking on OBS to parking on JBOX**
	06/06 02:06	1.0	06/06 03:06	ACO Dive 10 - **Housekeeping (ADCP bucket, CTD, light, photo, bridle)**
	06/06 03:06	2.0	06/06 05:06	ACO Dive 10 - **Mosaic**

	06/06 05:06	3.5	06/06 08:36	ACO Dive 10 - **Standby for cable station to open/personnel**
	06/06 08:36	1.0	06/06 09:36	*ACO Dive 10 - **test JBOX - Ethernet!**
	06/06 09:36	0.3	06/06 09:54	ACO Dive 10 - **at JBOX Connect JP2 to JP1**
	06/06 09:54	0.3	06/06 10:12	ACO Dive 10 - **at JBOX Connect JB2 to JB1**
	06/06 10:12	0.3	06/06 10:30	ACO Dive 10 - **Move HE1 to OBS E5**
	06/06 10:30	3.5	06/06 14:00	*ACO Dive 10 - **Testing - OBS works! cleanup**
	06/06 14:00	1.3	06/06 15:15	ACO Dive 10 - **Camera op - Jason and OBS**
	06/06 15:15	2.5	06/06 17:45	ACO Dive 10 - ascend and recover
	06/06 17:45	0.3	06/06 18:00	secure gear on deck
	06/06 18:00	14.0	06/07 08:00	underway for Honolulu
		432.0	hours	NB - TAAM can be deployed any time, initially runs autonomously
		18.0	days	NB - TAAM deployment more weather dependent

Appendix B – Rock samples

Dive # Sample #	Latitude (deg min N)	Longitude (deg min W)	Depth (m)	Description
Dive J2-551				
J2-551-1	20° 36.00’	158° 44.00’	1912	Hyaloclastic breccia
J2-551-2	21° 36.25’	158° 43.77’	1876	Basalt
J2-551-3	21° 36.29’	158° 43.74’	1857	Basalt
J2-551-4a	21° 36.39’	158° 43.65’	1775	Hyaloclastite
J2-551-4b	21° 36.39’	158° 43.65’	1775	Basalt fragment surrounded by hyaloclastite
J2-551-5	21° 36.51’	158° 43.62’	1698	Hyaloclastic breccia
J2-551-6	21° 37.54’	158° 41.57’	1616	Hyaloclastite
J2-551-7	21° 37.70’	158° 41.55’	1552	Hyaloclastite
J2-551-8	21° 37.85’	158° 41.50’	1507	Basalt
J2-551-9	21° 38.02’	158° 41.42’	1476	Hyaloclastite
J2-551-10	21° 38.06’	158.41.41’	1470	Hyaloclastic breccia
J2-551-11	21° 38.21’	158° 41.32’	1450	Massive basalt
J2-551-12	21° 38.24’	158° 41.30’	1448	Hyaloclastic breccia
Dive J2-556				
J2-556-1	21° 58.60’	158° 50.00’	2699	Pillow basalt
J2-556-2	21° 58.46’	158° 50.00’	2698	Pillow basalt
J2-556-3	21° 58.20’	158° 49.80’	2628	Pillow basalt
J2-556-4	21° 58.00’	158° 49.70’	2528	Pillow basalt
J2-556-5	21° 57.80’	158° 49.50’	2455	Pillow basalt
J2-556-6	21° 57.40’	158° 49.33’	2256	Pillow basalt
J2-556-7	21° 57.10’	158° 49.20’	2153	Pillow basalt
J2-556-8	21° 56.68’	158° 49.04’	2109	Pillow basalt
J2-556-9	21° 56.43’	158° 48.84’	1972	Pillow basalt
J2-556-10	21° 56.27’	158° 48.77’	1890	Pillow basalt
J2-556-11	21° 56.15’	158° 48.68’	1933	Pillow basalt
J2-556-12	21° 56.10’	158° 49.60’	1946	Hyaloclastite
J2-556-13	21° 55.58’	158° 48.26’	1912	Hyaloclastite
J2-556-14	21° 55.00’	158° 48.00’	1640	Hyaloclastite
J2-556-15	21° 54.88’	158° 47.99’	1534	Hyaloclastite
J2-556-16	21.54.76’	158° 47.95’	1379	Hyaloclastite
J2-556-17	21° 54.40’	158° 47.90’	1325	Possibly ‘a‘ā
J2-556-18	21° 54.20’	158° 47.90’	1310	Hyaloclastite
Dive J2-557				
J2-557-1	21° 33.20’	158° 43.13’	3702	Mudstone

J2-557-2	21° 33.26’	158° 43.19’	3666	Olivine basalt
J2-557-3	21° 33.42’	158° 43.35’	3569	Pillow basalt
J2-557-4	21° 33.57’	158° 42.51’	3413	Olivine basalt
J2-557-5	21° 34.02’	158° 43.94’	3228	Pillow basalt
J2-557-6	21° 34.12’	158° 43.99’	3172	Mudstone
J2-557-7	21° 34.20’	158° 43.92’	3116	Pillow basalt
J2-557-8	21° 34.30’	158° 43.84’	3035	Hyaloclastic mudstone
J2-557-9	21° 34.41’	158° 43.77’	2966	Pillow basalt
J2-557-10	21° 35.11’	158° 43.27’	2770	Mudstone
J2-557-11	21° 35.24’	158° 43.13’	2680	Olivine basalt
Dive J2-560				
J2-560-1a	21° 31.62’	158° 28.02’	2551	Olivine basalt
J2-560-1b	21° 31.62’	158° 28.02’	2551	Breccia
J2-560-2	21° 31.72’	158° 28.01’	2418	Nested breccias
J2-560-3	21° 31.87’	158° 27.93’	2244	Siltstone
J2-560-4	21° 23.05’	158° 27.96’	2128	Spongy Pāhoehoe
J2-560-5	21° 32.11’	158° 27.98’	2076	Olivine basalt
J2-560-6	21° 32.11’	158° 27.99’	2064	Olivine basalt
J2-560-7	21° 32.16’	158° 28.01’	1954	Basalt
J2-560-8	21° 32.29’	158° 28.06’	1834	Olivine basalt
J2-560-9	21° 32.44’	158° 28.10’	1759	Olivine basalt
J2-560-10	21° 32.57’	158° 28.15’	1644	Aphyric basalt
J2-560-11	21° 32.63’	158° 28.17’	1576	Vesicular basalt
J2-560-12	21° 32.67’	158° 28.18’	1535	Vesicular basalt