Cruise Report for R/V *Kilo Moana* KM-17-07:
ALOHA Cabled Observatory Service and RAP Tomography
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Summary

The purpose of this NSF and ONR funded cruise on the R/V *Kilo Moana* was twofold: to service the instrumentation on the ALOHA Cabled Observatory (ACO), and to collect acoustic travel time data (ship to ACO hydrophone) for the RAP (reliable acoustic path) tomography project. ACO is the deepest operating cabled observatory on the planet, at 4728 m water depth. The ACO portion was cut short near the start because of winch failure with associated ROV umbilical cable damage. The ONR portion was successful.

ALOHA Cabled Observatory

The goals of the ACO portion were to plug in standalone LIGHT4 (so CAM1 could resume operation), install basic sensor package 3 (BSP3, with OceanSonics icListen hydrophone), and to recover LIGHT1, CAM2, and BSP1 for service. The ACO portion depended on using the UH ROV *Lu'ukai*.

Just before this cruise the *Lu'ukai* was tested successfully at 430 m. At the 4700-m test site, the power and the hydraulic systems (and associated oil compensation systems) worked very well. However, the optical communications system showed marginal optical budget, but we were confident this could be improved for the subsequent ACO work. On the first dive at ACO (see a summary timeline in Table 1, and a detailed one in Appendix A), higher than expected power for the TMS (tether management system) required recovery; a blocked oil filter was replaced. On the second dive, an optical penetrator in the ROV failed at 3955 m, and communications to the TMS failed at 4642 m. When the winch was commanded to pull in, it did not. The solution was to put a stopper/grip on the wire outboard of the slack tensioner unit (STU) to take the tension and allow it to start under less load. This worked and the ROV was successfully recovered, but the optical fibers in the cable broke where the grip had been attached. This terminated the ACO operation since the winch could not be used until repaired and tested, and further, we could never reach bottom with this cable. More detail is available in separate reports. While disappointed, there was consensus that we are on the threshold of abyssal ROV operations. A replacement cable will be acquired. The next scheduled opportunity to complete this work is spring 2018.

RAP Tomography

The goal of RAP tomography is to develop the methodology to obtain sound speed (temperature) in a 60-km diameter volume around a bottom hydrophone. This has direct connections to "conventional" ocean acoustic tomography as well as seafloor "GPS-A" geodesy.

The ship track during the cruise is shown in Figure 1. Circles were run twice (5, 15, 25 km radius) and radials in the cardinal directions were run four or five times. Further, a continuous 36 hours was spent directly over the ACO hydrophone. Some 59 XBTs were deployed.

During the entire cruise within the operational area, a LFM chirp was transmitted (every 30 s, 22.5 ms duration, center frequency 4174 Hz, bandwidth 1378 Hz, and source level 260 W

acoustic, 195 dB re 1 µPa at 1 m). One reception on the ACO hydrophone is shown below (Figure 2). During daylight hours, a m-sequence pseudo-random noise signal was transmitted (3-hour interval minimum, 2-minute duration, same frequencies as LFM, 26 W acoustic, 185 dB re 1 µPa at 1 m); for these 15 transmissions, a marine mammal watch was maintained, Appendix B.

In conclusion, a wealth of data were collected for subsequent analysis.

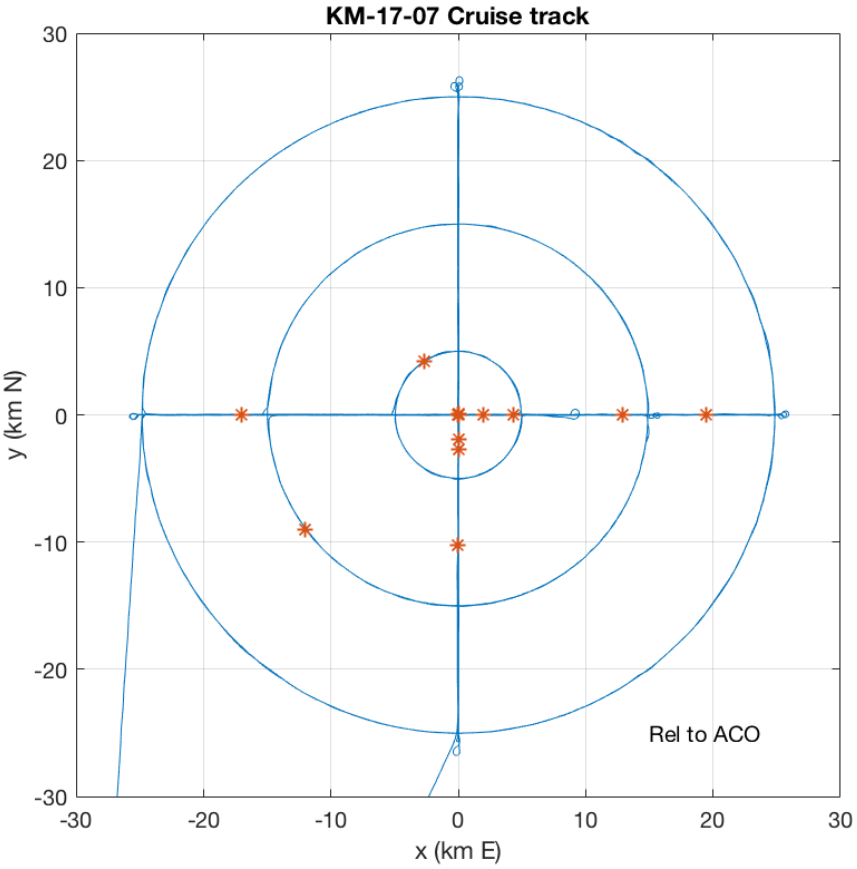

Figure 1 Cruise track. The multiple tracklines are difficult to see at this scale. Expected uncertainty is less than 10 cm rms. Stars show location of 2-munute transmissios.

	Task	Start	HST hh:mm	End
1	**Transit to Station ALOHA**	06/06 20:45	7:57	06/07 04:42
2	**RAP runs 1**	06/07 04:42	19:08	06/07 23:50
3	**ROV Dive 1 (LK-066)**	06/07 23:50	5:52	06/08 05:42
4	**RAP runs 2**	06/08 05:42	8:30	06/08 14:12
5	**ROV Dive 2 (LK-067)**	06/08 14:12	15:48	06/09 06:00
6	**RAP runs 3**	06/09 06:00	63:10	06/11 21:10
7	**Transit to Honolulu**	06/11 21:10	10:50	06/12 08:00
			131:15	

Table 1 Summary cruise tasks and times (UTC; local HST time = UTC – 10)

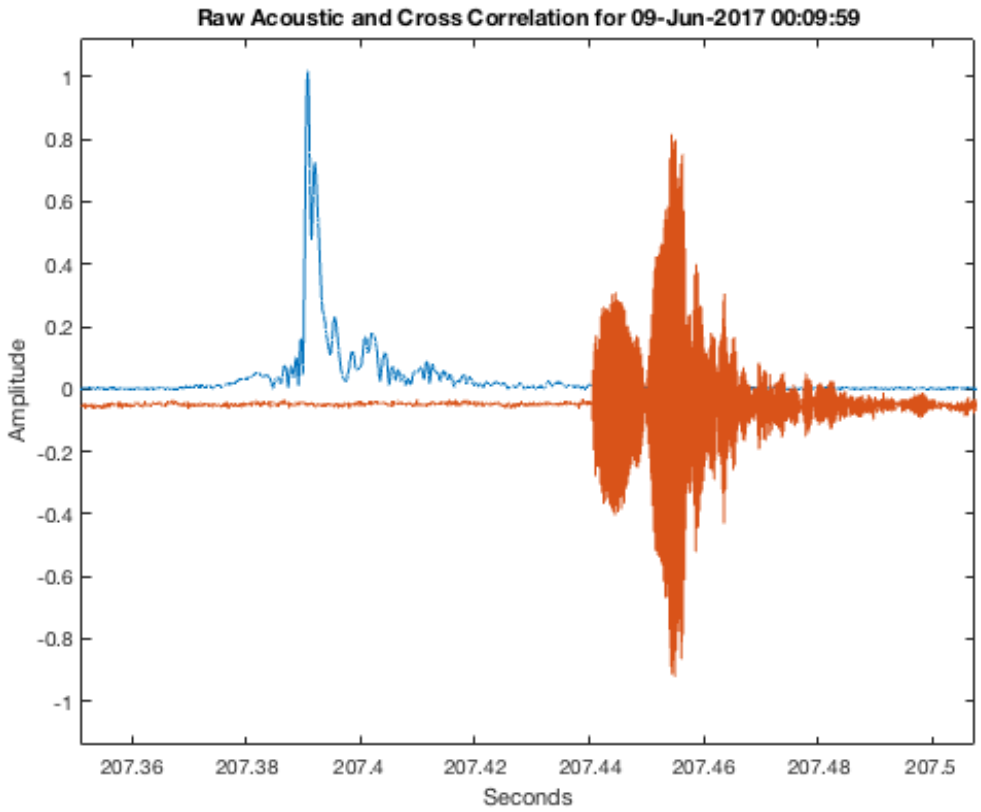

Figure 2 Sample acoustic reception of the LFM signals on the ACO hydrophone, amplitude arbitrary units. (right) Raw signal, 22.5 ms width, 50 ms advanced and shifted down 0.05 units. (left) correlation showing ~1 ms wide main peak, with bottom bounce just after.

Acknowledgments

We thank the captain and crew of the R/V *Kilo Moana* for their support during the cruise. Chief Mate Brian Wehmeyer served as captain, standing in for Gray Drewry who had taken ill on the previous cruise.

The *Lu'ukai* personnel led by Max Cremer are an excellent well integrated and cohesive team, very professionally and efficiently executing the necessary tasks.

Terry Moreau, a student intern from ENSG Geomatics, and Jessica Lotts, a recent UH journalism graduate, stood the RAP watches. Lotts also documented the cruise with a blog and video (https://jesslotts.atavist.com/rov-test-aco-cruise-)

The cruise and shore party participants are listed in Appendix C.

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Appendix A – Cruise timeline

		Task	Start	Local HST hh:mm	End
			06/06 20:45		06/15 15:00
1	**Transit to Station ALOHA**				
	1	Transit from Ko Olina to Station ALOHA	06/06 20:45	7:57	06/07 04:42
2	**RAP runs 1**				
	1	Start RAP pattern: 25 km circle, E-W, N-S lines	06/07 04:42	18:38	06/07 23:20
	2	Finish pattern at ACO	06/07 23:20	0:30	06/07 23:50
	3	Hold at ACO for ROV; continue RAP tx	06/07 23:50	0:00	06/07 23:50
3	**ROV Dive 1 (LK-066)**				
	1	At ACO completing ROV service, DP at ACO	06/07 23:50	2:50	06/08 02:40
	2	Deploy ROV. Beacon 1 on ROV, Beacon 2 on TMS. Descend 15 m/in	06/08 02:40	0:10	06/08 02:50
	3	Dive terminated at 1000 m due to high power consumption (latter - oil filter)	06/08 02:50	1:50	06/08 04:40
	4	Recover ROV	06/08 04:40	0:10	06/08 04:50
	5	Start ROV service	06/08 04:50	0:52	06/08 05:42
4	**RAP runs 2**				
	1	Start RAP pattern: 15-km circle, 5-km circle, E-W	06/08 05:42	8:30	06/08 14:12
	2	Finish pattern at ACO; continue RAP tx	06/08 14:12	0:00	06/08 14:12
5	**ROV Dive 2 (LK-067)**				
	1	At ACO completing ROV service, DP at ACO	06/08 14:12	0:20	06/08 14:32
	2	Deploy ROV. Beacon 1 on ROV, Beacon 2 on TMS. Descend 40 m/in	06/08 14:32	0:10	06/08 14:42
	3	Lost ROV telemetry at 3955 m; TMS comms at 4642 m	06/08 14:42	3:20	06/08 18:02
	4	Winch problems, at 4653 m, apply stopper/grip	06/08 18:02	1:01	06/08 19:03
	5	Recover ROV	06/08 19:03	5:14	06/09 00:17
	6	Testing	06/09 00:17	3:00	06/09 03:17
	7	Finish	06/09 03:17	2:43	06/09 06:00
6	**RAP runs 3**				
	1	Stay at ACO, RAP tx, with XBTs	06/09 06:00	20:00	06/10 02:00
	2	Run patterns, circles + radials, with	06/10 02:00	43:10	06/11 21:10

	XBTs, end S			
7	**Transit to Honolulu**			
1	Transit	06/11 21:10	9:00	06/12 06:10
2	Holding off Honolulu for entry	06/12 06:10	0:50	06/12 07:00
3	Arrive	06/12 07:00	1:00	06/12 08:00
		06/06 20:45	**131.3**	**06/12 08:00**
			5.47	

	Start	**Duration**	**End**
Dive 1	06/08 02:50	2:00	06/08 04:50
Dive 2	06/08 14:42	9:35	06/09 00:17
Dive time total		**11:35**	

ROV Dive 1 (LK-066)	5:52
ROV Dive 2 (LK-067)	15:48
ROV Total	**21:40**

RAP runs 1	19:08
RAP runs 2	8:30
RAP runs 3	63:10
RAP total	**90:48**

ACO Dives + RAP runs	112:28
Transits	18:47
Total time	**131:15**

Appendix B – Transmission Log

KM17-07 Acoustic transmission log
Chief Scientist - Bruce Howe
7-15 June 2017

	UTC Date Time	HST Date Time	lat deg	lat min	lon deg	lon min	Signal	Duration minute	Level dB	Comments	Observer
1	06/08/17 03:06	06/07/17 17:06	22	44.301	-157	57.81	Mseq	2	185	Nothing Spotted	JL
2	06/08/17 18:39	06/08/17 08:39	22	39.475	-158	7.413	Mseq	2	185	Nothing Spotted	JL
3	06/08/17 18:45	06/08/17 08:45	22	39.475	-158	7.413	Mseq	2	185	accidental tx	JL
4	06/08/17 21:47	06/08/17 11:47	22	44.32	-157	52.825	Mseq	2	185	Nothing Spotted	JL
5	06/09/17 00:48	06/08/17 14:48	22	44.306	-158	0.367	Mseq	2	185	Nothing Spotted	JL
6	06/09/17 03:57	06/08/17 17:57	22	43.303	-158	0.348	Mseq	2	185	Nothing Spotted	JL
7	06/09/17 19:28	06/09/17 09:28	22	44.319	-158	0.385	Mseq	2	185	Nothing Spotted	JL
8	06/09/17 22:29	06/09/17 12:29	22	44.362	-158	0.354	Mseq	2	185	Nothing Spotted	JL
9	06/10/17 01:30	06/09/17 15:30	22	44.326	-158	0.394	Mseq	2	185	Nothing Spotted	JL
10	06/10/17 19:30	06/10/17 09:30	22	44.327	-157	59.215	Mseq	2	185	Nothing Spotted	JL
11	06/10/17 22:33	06/10/17 12:33	22	42.85	-158	0.367	Mseq	2	185	Nothing Spotted	JL
12	06/11/17 01:33	06/10/17 15:33	22	38.786	-158	0.375	Mseq	2	185	Nothing Spotted	JL
13	06/11/17 19:35	06/11/17 09:35	22	46.601	-158	1.951	Mseq	2	185	Nothing Spotted	JL
14	06/11/17 22:38	06/11/17 12:38	22	44.34	-157	48.98	Mseq	2	185	Nothing Spotted	JL
15	06/12/17 02:27	06/11/17 16:27	22	44.322	-158	10.327	Mseq	2	185	Nothing Spotted	JL

Appendix C – Cruise and Shore Party Participants

Name	Position	Email	Phone
Cruise Participants			
UH/ACO			
Bruce Howe	Chief Scientist	bhowe@hawaii.edu	Cell: 808-469-0553 Off: 808-956-0466 Hm: 808-888-0665
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Karynne Morgan	Project Asst	karynnem@hawaii.edu	808-956-6036
Kellie Terada	Project Asst	kterada@hawaii.edu	808-956-4101
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Makaha Cable Station – AT&T		GCSO_Makaha@att.com	808-696-4224
Ed Ecalavea	Manager	ee1786@att.com	671-727-8062
UH/Marine Center			
Alan Hilton	Marine Superintendent	marsup@soest.hawaii.edu	Off: 808-842-9814 Cell: 808-818-5178
Brian Wehmeyer	Master R/V *Kilo Moana*	master@km.soest.hawaii.edu	