Cruise Report for R/V *Kilo Moana* KM-23-12A,B:
ALOHA Cabled Observatory Service
and
Deep Water Sentinels Deployment
19 August – 27 August 2022

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Summary

The ALOHA Cabled Observatory 100 km north of Oahu at Station ALOHA is the deepest (4728 m) power and internet node on the planet, returning oceanographic data from the seafloor in realtime to shore. The ACO has been operational with plug-and-play capability since 6 June 2011. On this cruise we serviced the Observatory, installing a new hydrophone and removing two failed cameras.

The provision of any long-term sustainable power on the seafloor is a continuing challenge. The Naval Research Laboratory (NRL) successfully deployed three prototype Deep Water Sentinel (DWS) fuel cells that take advantage of the difference in oxygen concentration in sediment (low) and in the water above (high) to generate a small amount of electrical power mediated by microbes in the sediment, ~50 mW.

The ROV *Lu'ukai* is the *sine qua non* for performing this work. Several days were devoted to testing before the science use, as it had been out of service during Covid. It performed well.

Chronology

The schedule and tasks were as follows (see table at end for detail and times).

The ship departed the University of Hawaii Marine Center at 0800 on Saturday 19 August 2023.

Dives 1-4 – LK 177-180 – 19 August

- Four shallow ROV test dives, 430 m

Dive 5 – LK 181 – 20-21 August

- Deep ROV test dive to 4728 m at ACO
  This dive demonstrated that the following science work could be done. The oil compensation systems for the electrical system showed very little decline in capacity over time. The compass/circuit in the tether management system (TMS) failed and could not be repaired; twists in the tether were removed based on visual data.

Dive 6 – LK 182 – 22 August - ACO

- Deployed and connected Basic Sensor Package 3 (BSP3, icListen hydrophone)
- Recovered CAM1 (video camera, in place since 2011)

This icListen hydrophone has been donated to ACO by OceanSonics. Thank you!

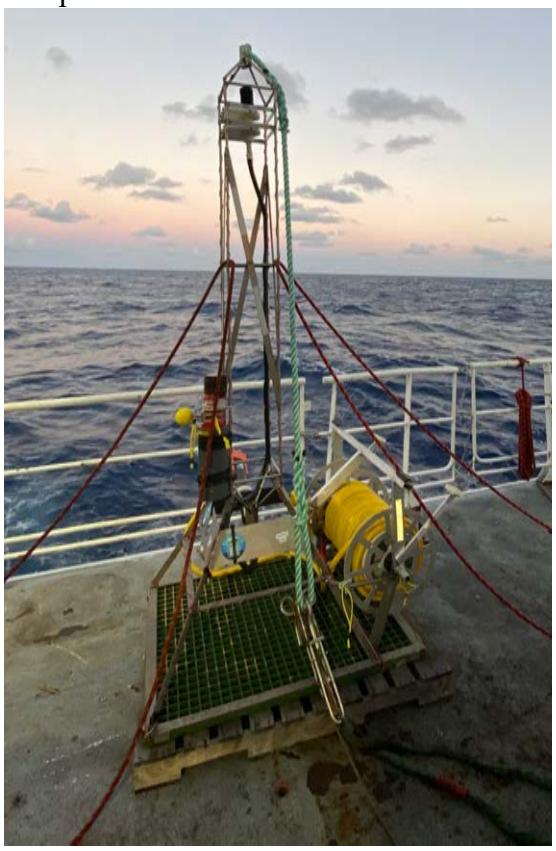
The BSP3 icListen was plugged into the Observatory OBS port E4 via a 25-m Port Extension Assembly (PEA). A parking position for future use is next to BSP3 (deployed Dive 8).

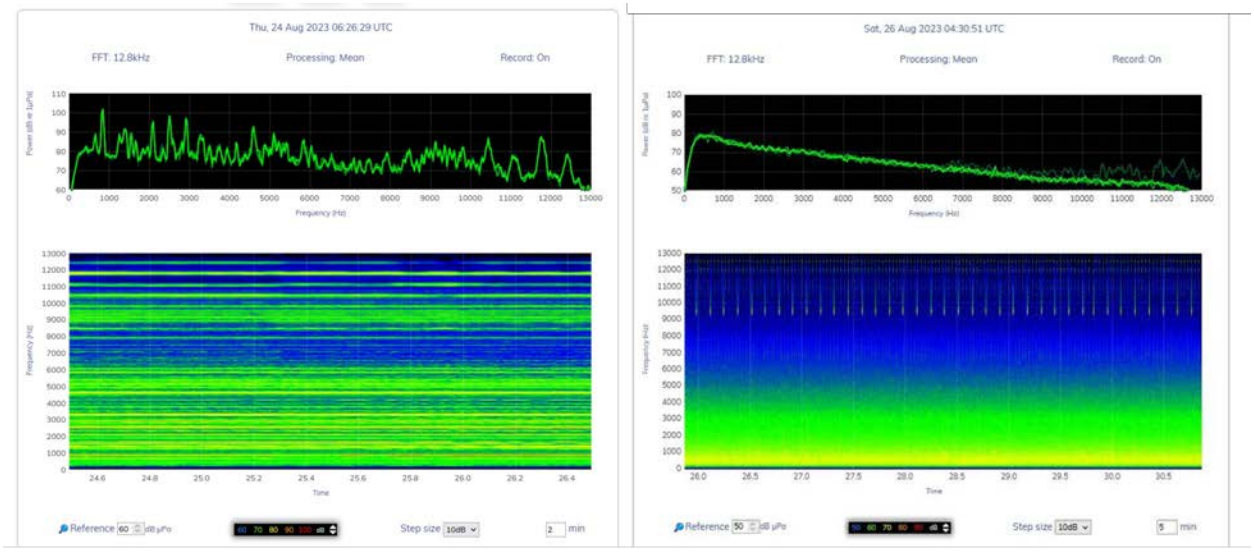
The final position of the BSP3 icListen hydrophone is approximately (to be further refined with detailed processing for the tracking data):

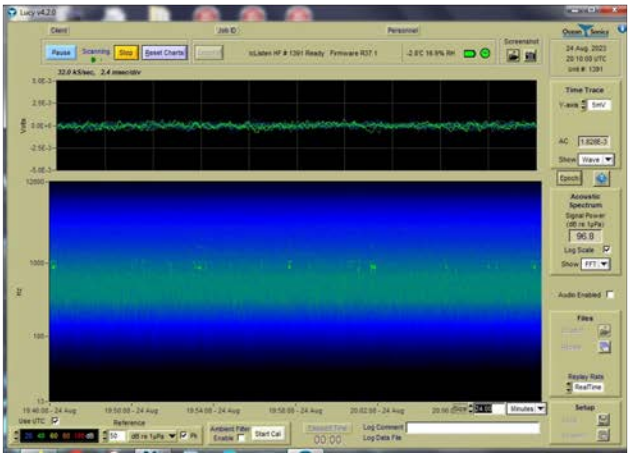
22.73879° N, 158.006161° W 22° N 44.3274’ N, 158° 0.36966’ W

The hydrophone is 2.5 m off the bottom (at 4728 m) within a flow shield consisting of a sock on a plastic frame.

See pictures below.







Shown above are spectra and spectragrams from the icListen after deployment. The first one shows data with the ROV close by. The second shows high frequency signals from the ship: a Benthos interrogator signal at 9.5 kHz being transmitted every 7 seconds, and the higher frequency signal every 2 seconds is the leakage from the 20-35 kHz ultrashort baseline tracking signals. The last figure shows what might be sperm whales at about 1 kHz (log scale). Comparisons with the other ACO HEM hydrophone show the same signals.

CAM1 had been disconnected from Port E4 prior to connecting BSP3. After the latter was connected, CAM1 was carried to the Elevator (ELEV) and connected for recovery.

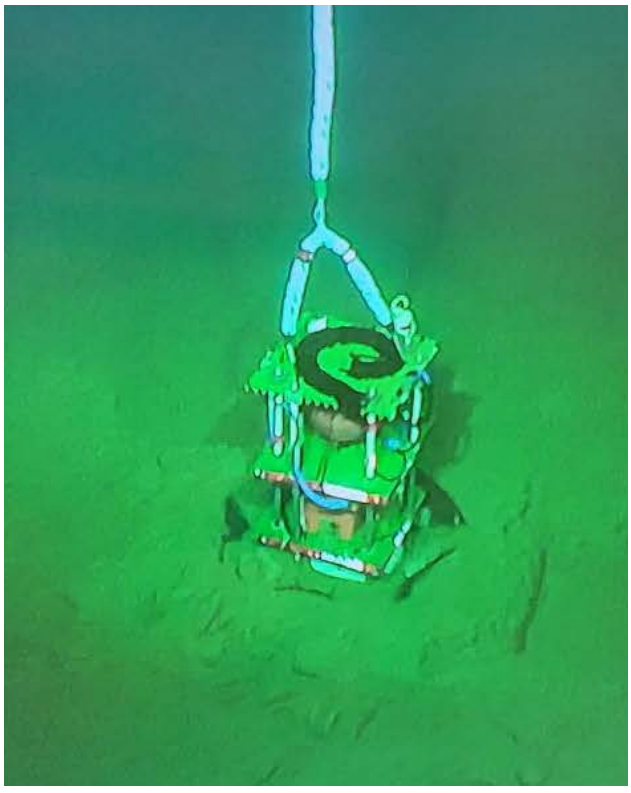
The ROV was deployed at 08/23 06:16 HST, reached bottom and undocked at 08/23 10:48 and completed trimming at 08/23 11:46. The ROV was recovered on deck 08/24 00:18. ELEV+CAM1 was released acoustically at 08/24 03:58 and recovered 08/24 06:26. Total ROV time in the water was 18:02, and bottom time was 11:05. There were no issues with the ROV. However, as we have often experienced in the past, it takes many minutes for sediment to clear after any interaction with the bottom, slowing the entire operation.

Dive 7 – 23 August - DWS

- Deployed three Deep Water Sentinel (DWS) Fuel Cell packages.
- Take sediment cores and water samples

All three Deep Water Sentinel landers initiated taking measurements at 19:30 UTC on August 24, 2023. Shortly thereafter they were free-fall deployed by dropping them over the side using the ship's crane and a quick release. This was done in sequence and the ship was moved one ship length (~60 m) in-between each drop. The lander that was dropped first ended up on the seafloor (4730 m depth) about 70 m away from the others, but the second and third landers ended up only about 5 m away from each other. The ROV inspection of the landers on the bottom showed that all three landed correctly, but that the rubber skirt had become rigid at these temperatures and pressures and was non-functional as a secondary seal. The first ROV effort involved moving Lander B about 70 m to the NNE to separate it from Lander C. The ROV removed the drop drogue chutes and released some bricks that were staged on the landers. The bricks were ineffective at holding the rubber skirt down, so the ROV was used to plow sediment under and around the skirt to create an embankment of sediment around the lander and seal in the anode. The bricks were also a useful tool for the ROV to use to push sediment under the rubber and fill in gaps. The plow procedure was then repeated for Landers C and A.

The very first task before the landers were moved was to collect water samples to establish the a priori water state. After the three landers were sealed by ROV plowing, the ROV took four sediment push cores. Then each lander was inspected after the sediment plumes had time to settle away. Landers C and B looked completely sealed around all sides. Lander A revealed one remaining gap, so the ROV was used to plow at that location and seal the gap. The figure below shows the final state of Lander B.



Lander B on the bottom after plowing.

Final locations of the landers:

Lander	Latitude (° N)	Longitude (° W)
A	22.7066309	157.9290466
B	22.7078386	157.9284050
C	22.7073117	157.9287957

The ROV mission was completed at 16:25 UTC August 25, 2023 and the ROV was recovered at 19:25 UTC.

Dive 7 – LK 184 – 25-26 August - ACO

- Recover CAM2

CAM2 was successfully recovered.

However, upon seeing it for the first time (figure below), it was clear the glass sphere had imploded, just leaving a few plastic and metal chips below. It appears the nearby lights and hydrophone on the frame survived; the frame itself was only slightly damaged where the equatorial ring connected.

It was originally intended to perform tests of the prototype ACO Port Test Tool (PTT) on this dive; however, it was found during the descent not to be working; further, it was determined the acoustic releases were inoperable (both ACO science faults). The decision was made to just recover CAM2, and to cut the anchor line on the ELEV with the ROV.

The image below shows the memorial plaque for Fred Duennebier, that serves as a parking position, now at the end of the PEA from Secondary Node 1 (SN1) Port J2, for the flying connector.

Dive 8 – LK 185 – 26 August - ACO

- Test prototype Port Test Tool

This dive was aborted early on due to high attenuation on the TMS optical fiber.

Concluding Remarks

New instruments were successfully deployed by ROV *Lu'ukai.*

For ACO, a new icListen hydrophone was installed. It has a flatter response to higher frequency than the present HEM one, and it is mounted we think better in a frame higher up off the bottom with a flow shield. It is aligned (nominally) with respect to the HEM to have a long baseline perpendicular to the bearing to the Kauai Beacon. CAM1 and CAM2 were recovered. We were not able to test the ACO Port Test Tool.

For the Deep Water Sentinel project, three bottom landers were deployed. While the bottom rubber "skirt" deformed due to temperature and pressure and could not form a good seal, the ROV was able to plow sediment against the landers to make an effective barrier between the electrode on the base of the lander and the free water.

ROV *Lu'ukai* performed well, especially considering that it had been out of service for the last 2 years with little maintenance. Extra days were included in this cruise to test and fix problems. These were essential. The crew, led by team leader Blue Eisen, was exceptional, professional, and worked long hours to keep the operation going (even though short one pilot/engineer).

We had six graduate students on board from the Ocean and Resources Engineering Department of the University of Hawaii at Manoa, all getting their sea legs, helping with the icListen and elevator. See the group photo below.

Lastly, the R/V *Kilo Moana* performed very well. The captain, crew, and marine technicians were uniformly helpful, engaged, and cheerful, being an integral part of the overall mission.

ALOHA Cabled Observatory – Deep Water Sentinel Cruise
R/V *Kilo Moana*
19-27 August 2023

Summary Timetable

ACO + DWS Cruise, 19 - 27 August 2023 KM-2312A,B

Bruce Howe, Jeff Book

	Task	Start (HST (UTC-10))	Elapsed	End
1	Transit to test site - Test Dives 1-4, LK 177-180	08/19 08:00	56:10	08/21 16:10
2	Transit to Station ALOHA	08/21 16:10	10:50	08/22 03:00
3	Turn around the ROV	08/22 03:00	4:37	08/22 07:37
4	ROV Test Dive 5 LK-181	08/22 07:37	10:08	08/22 17:45
5	Turn around the ROV	08/22 17:45	0:30	08/22 18:15
6	ACO Casius survey	08/22 18:15	9:35	08/23 03:50
7	Deploy ACO BSP3 and ROV, ACO Dive 1, LK-182	08/23 03:50	10:05	08/23 13:55
8	Disconnect CAM1 and move away	08/23 13:55	1:01	08/23 14:56
9	Move and connect BSP3	08/23 14:56	4:47	08/23 19:43
10	Rig CAM1 to ELEV for recovery	08/23 19:43	1:44	08/23 21:27
11	Recover ELEV+CAM1 and ROV	08/23 21:27	10:35	08/24 08:02
12	NRL Work - Prep ROV	08/24 08:02	1:24	08/24 09:26
13	NRL - Deploy DWS	08/24 09:26	1:09	08/24 10:35
14	Deploy ROV, DWS Dive 1, LK-183	08/24 10:35	4:02	08/24 14:37
15	Adjust DWS units	08/24 14:37	15:48	08/25 06:25
16	Conduct CTD search survey	08/25 06:25	0:00	08/25 06:25
17	Recover ROV	08/25 06:25	3:00	08/25 09:25
18	Service ROV, Deploy ELEV	08/25 09:25	7:30	08/25 16:55
19	ACO Dive 2, LK-184, CAM2 Recovery	08/25 16:55	5:47	08/25 22:42
20	CAM2 recovery	08/25 22:42	7:54	08/26 06:36
21	Recover ROV and ELEV+CAM2	08/26 06:36	6:15	08/26 12:51
22	ACO Dive 4, LK-185, Port Test Tool	08/26 12:51	0:54	08/26 13:45
23	Transit from ACO to Honolulu	08/26 13:45	19:55	08/27 09:40
			193:40	