NOAA Pacific Islands Fisheries Science Center

Small Boat Mission Report

Mission Number: SB-13-16

Operator-in-Charge: Justin Nesbitt, Captain, Sea Engineering, Inc.

Chief Scientist: John Rooney

Small Boat ID/Type: M/V *Huki Pono*, 681633, 43' twin-screw workboat

Mission Title: Field Testing New Autonomous Underwater Vehicle

Mission Area: South Oahu

Mission Dates: August 14–18, 2013

1. Mission Plan

Cruise Objective: The Pacific Islands Fisheries Science Center (PIFSC) and the Woods Hole Oceanographic Institution (WHOI) conducted collaborative Autonomous Underwater Vehicle (AUV) operations off the southern coast of Oahu to field test new isobath-following and obstacle-avoidance capabilities of the SeaBED AUV. The Sea Engineering vessel M/V *Huki Pono* was chartered to perform these missions.

Cruise Operations: PIFSC, NWFSC, and WHOI AUV team personnel spent the first day of the mission testing, installing, and integrating 3 still cameras onto the AUV in preparation for a cruise in the Pacific Northwest in October. An in-water pressure test of one of the AUV's pressure canisters was also conducted, and mobilization aboard the M/V *Huki Pono* was started. Mobilizing, installation of multibeam and imaging sonars aboard the AUV and ballast testing to support isobath-following and obstacle-avoidance testing were completed shortly after noon on August 16. PIFSC and WHOI personnel got underway shortly thereafter and conducted a safety review of AUV operations aboard the M/V *Huki Pono*. Two dives were completed that afternoon southwest of the Ala Wai Boat Harbor channel (see Attachment 1, Map of dive sites) at depths within range of scuba divers. The behavior of the vehicle was evaluated, and time-series data such as the vehicle depth, current draw of each thruster, vehicle heading, etc. were downloaded and also evaluated following each dive. Based on evaluation results the AUV expert from WHOI, who wrote the source code for the SeaBED's isobathfollowing and obstacle-avoidance behavior, made changes to the vehicle's operating software. This iterative pattern of making and evaluating AUV dives, followed by changes to the AUV operating software was continued for the remaining 2 days of the survey and an additional 7 dives were performed. On the last day, however, the dive location was shifted to a site 3 nautical miles west of the Pearl Harbor channel to take advantage of a steeper slope still within range of scuba divers. During the recovery of the AUV from its third dive on August 18, the ultra-short baseline navigation system (USBL) transponder was knocked loose

during attempts to set a forward tagline on the vehicle. After vehicle recovery, scuba divers retrieved the USBL transponder. Following that additional testing was performed while the M/V *Huki Pono* was alongside the NOAA small boat piers at Ford Island. The AUV and associated equipment and supplies were demobilized off the *M*/V *Huki Pono* late in the afternoon of August 18, completing the mission.

2. Schedule

12 August AUV team personnel demobilized the AUV and ROV off the NOAA Ship *Oscar Elton Sette* following cruise SE-13-06, and ROV equipment was delivered to the Kewalo Research Facility. PIFSC AUV Team personnel moved the SeaBED to the Port Office warehouse (Bldg 184 on Ford Island) and began assembling it for SB-13-16.

13 August PIFSC, NWFSC, and WHOI personnel worked on setting up and testing cameras and integrating them onto the AUV in preparation for a NWFSC AUV cruise in October 2013. Pitting and slight water ingress into the pressure canister for the vehicle's electronics chassis and computers were discovered.

Mission Schedule:
14 August PIFSC personnel conducted an in-water test of the pressure canister for the electronics chassis and computers, with all electronics removed, at a depth of 100+ m for 20 minutes to test its watertight integrity for the upcoming mission. PIFSC, NWFSC, and WHOI personnel completed camera testing and installation aboard the AUV, and vehicle ballasting with that sensor configuration. Mobilization aboard the M/V *Huki Pono* was started.

15 August
Installation of a DeltaT multibeamn sonar and BlueView Imaging sonar on the AUV were completed. Mobilization of the AUV equipment and supplies aboard the M/V *Huki Pono* was completed.

16 August
In-water heading and depth servo tests and ballasting were conducted off the NOAA small boat piers using a forklift. The AUV was recovered aboard the M/V *Huki Pono* which got underway shortly after noon. Following a safety review of AUV deployment and recovery, the AUV was deployed offshore of Ala Wai Boat Harbor Channel and completed two dives.

17 August M/V *Huki Pono* got underway at approximately 1000 and proceeded to offshore of the Kewalo Basin – Waikiki area. Four AUV dives were conducted, with changes to the vehicle's operating software being made after each dive.

18 August M/V *Huki Pono* got underway at approximately 0900 and proceeded to a site 3 nautical miles west of the Pearl Harbor channel. Two AUV dives were conducted with changes being made to the vehicle's operating software after each. Following the second dive the UBSL transponder was knocked loose during the recovery process. The transponder was recovered by divers and the M/V *Huki Pono* returned to Ford Island. Vehicle behavior analysis continued while the M/V *Huki Pono* was tied up at the pier for another 2 hours until

the WHOI person onboard needed to leave to catch his flight. The AUV and related equipment were demobilized from the M/V *Huki Pono.*

3. Field Party

Name	Role	Dates	Organization
John Rooney	Chief Scientist/Diver	08/14-08/18	JIMAR
Jeremy Taylor	AUV Operator	08/14-08/18	JIMAR
Frances Lichowski	AUV Deck Assistance/Diver	08/14-08/18	JIMAR
Elizabeth Clarke	NWFSC AUV PI	08/14	NOAA
Gabriel Cohen	Student Assistant	08/14-08/18	NOAA
Clay Kunz	WHOI/SeaBED Tech. Representative	08/14-08/18	WHOI

4. Results

The following were accomplished during the mission:

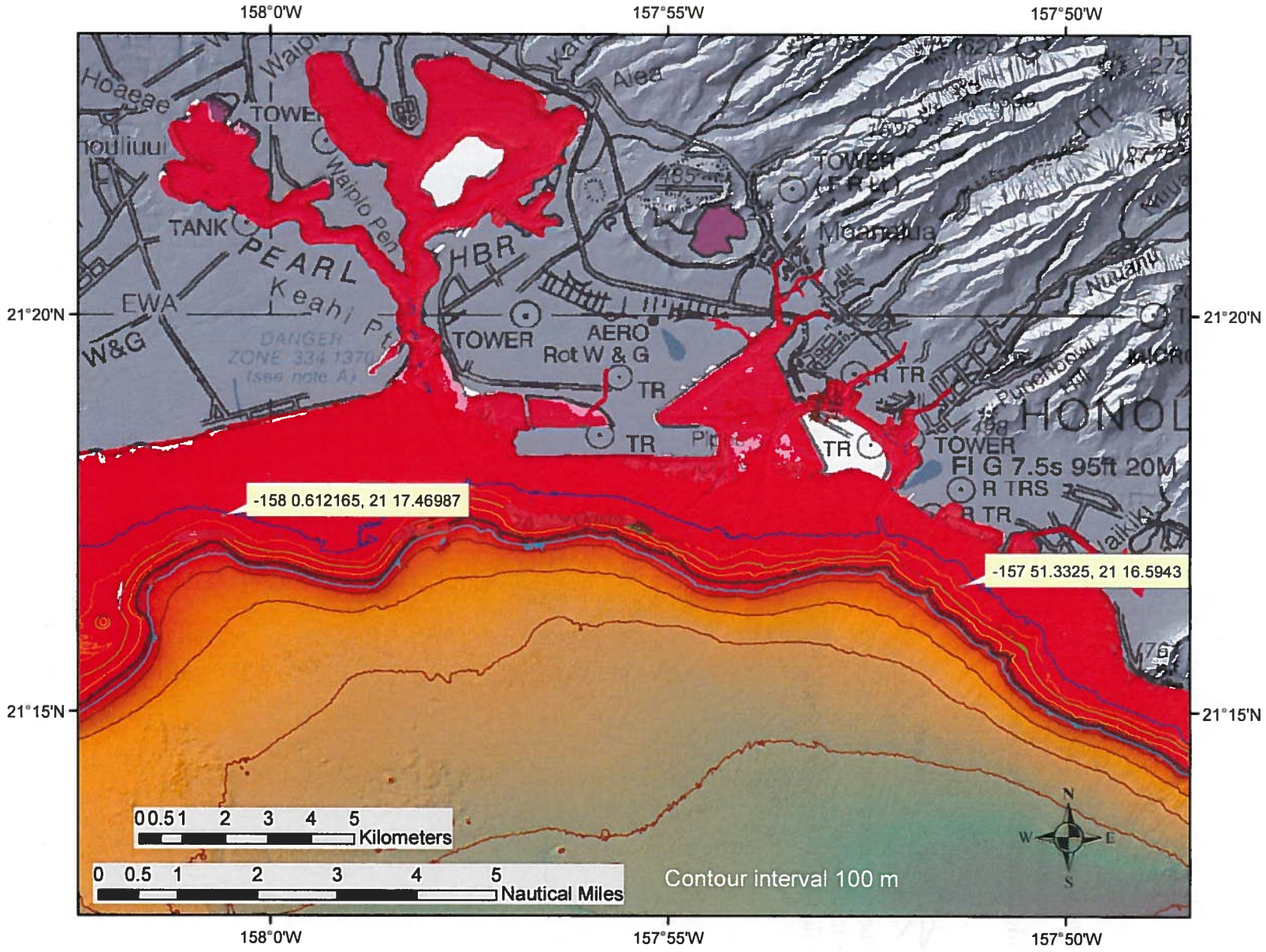
- Installation and testing of 3 still cameras on the new PIFSC/NWFSC SeaBED Class AUV were completed. Numerous modifications were made to the vehicle to mount the cameras and to the onboard software to operate them.
- A total of 8 AUV dives were completed, with changes to the vehicle's software made after each, gradually working through problems. By the end of the mission the vehicle was able to demonstrate the ability to drive from shallower water to a deeper depth, turn in the specified direction, and follow the prescribed isobath.
- Iterative adjustments were made to thruster settings to optimize settings for forward motion and turning rates. It was concluded that different settings will be required for terrain of different steepness and rugosity.
- While recovering the AUV during its last open-water dive, the USBL transponder was knocked loose while attempting to route a tagline on the AUV's forward bale. The tagline was eventually installed and the AUV was successfully brought aboard without damage, and divers were able to recover the USBL transponder. These circumstances highlight a relatively-easy-to-address weakness in the installation of the UBSL transponder and once demonstrated the value of conducting testing within scuba diver depths and having a dive plan, divers, and equipment on hand.
- Problems with the output of the DeltaT multibeam echosounder precluded that instrument from being used for vehicle guidance. WHOI personnel will contact Imagenex Corporation to address these problems. As an alternative, the port-side beam from the Doppler Velocity Log on the AUV was used as one of the primary sensors for isobath following. While viable in the terrain where testing occurred, and valuable for testing changes to the vehicle's operating software, this instrument will not be useable for this purpose in steeper terrain.
- Isobath following took precedence over obstacle avoidance testing during this mission. Gentle-to-moderately-sloping terrain was deliberately selected for AUV dives. As a

result, there were no obstacles detected by the BlueView sonar that were close enough to initiate avoidance behavior. Additionally, avoidance behavior was programmed to have the AUV climb over obstacles. While more useful in many scenarios, for isobath following it would be advantageous for the AUV to be able to turn away from the obstacle and maneuver around it while still maintaining its prescribed depth and this topic is under discussions with WHOI.

- Definitive progress was made on isobath following during SB-13-16. Use of the M/V *Huki Pono* to conduct brief AUV dives followed by modifications to the AUV's operating software proved to be an effective way to field test and adjust AUV behavior. Additional testing and development of isobaths-following and obstacle-avoidance capabilities is strongly recommended.
- This was the first AUV mission using a small boat in Hawaii that was based in Pearl Harbor. CDR Kamphaus, Commanding Officer of the Marine Operations Center—Pacific Islands, was approached about use of the NOAA small boat piers as well as warehouse space in Building 184. CDR Kamphaus' support and assistance, and that of his Operations Officer, LTJG Anthony Imberi, were very helpful and instrumental in the mission's success. The assistance of Ryan Nichols, who served as the mission's Vessel Operations Coordinator (VOC) in the evenings and weekend, is also acknowledged and appreciated.

5. Attachments

Attachment 1: Map of overall survey area and specific survey sites.



Map 1. Map of south central Oahu coastal waters. Starting locations for AUV dives during SB-13-16 shown, using the standard ArcGIS format of longitude, latitude in degrees and decimal minutes.

6. Approvals

5/29/2014

John Rooney, Ph.D.
Chief Scientist
Pacific Islands Fisheries Science Center

Date

5/29/2014

Samuel G. Pooley, Ph.D.
Science Director
Pacific Islands Fisheries Science Center

Date