ADEON 5 Final Recovery
Cruise Report
AR049 – R/V Armstrong
4 – 21 Dec 2020
Woods Hole, MA to Woods Hole, MA

Photo credit: Jennifer Miksis-Olds

ADEON: Chief Scientist Jennifer Miksis-Olds, Joseph Warren, Anthony Lyons, Carmen Lawrence, Brandyn Lucca, Hannah Blair, Grant Milne

ROV JASON: Expedition Leader Ben Tradd, Korey Verhein, Chris Lathan, Stefano Suman, Jim Varnum, Fred Denton, Hugh Popenoe

Cruise Summary

The objectives for this cruise were to recover bottom landers at six sites (Figure 1) along the shelf break (depths ranging from 200 – 900 m roughly), collect CTD/XBT profiles to characterize hydrographic conditions at the sites, conduct net sampling to collect biological specimens at each site, and conduct fine-scale (roughly 10 km by 10 km) multi-frequency acoustic surveys at each site (Figure 2). Lander recovery was only planned at 6 of the 7 ADEON sites because the VAC lander was trawled up prematurely by a fisherman in July 2020. We were able to successfully recover all of the landers deployed during ADEON Cruise 4 AR049 and an additional JAX lander that was deployed in 2018 (Table 1). ROV Jason was used to recover the landers at the WIL site and the JAX site. The WIL lander did not surface after the acoustic releases were tripped even though the acoustic releases were communicating fine with the ship. ROV Jason dove and video revealed that the WIL lander was buried in sediment, likely a result from a passing hurricane. Jason shook the lander free, and it surfaced under its own buoyancy. The Jason dive at JAX showed the disabled lander from 2018 did indeed release, but the release line got caught within the lander. Jason cut the line, and the lander surfaced under its own floatation. On our return leg to Woods Hole, we made a slight detour to run a reciprocal cruise track line from the HAT site to port in support of testing of a new gravimeter on board. We appreciate the excellent work of the ROV Jason team, ship's Captain, and crew (in all aspects on the boat). With their help we were able to accomplish all cruise objectives.

COVID Impacts

The ship was late leaving the dock by one day due to COVID related concerns. The delay was to allow for the final return of test results for a potential COVID interaction of one of the ship crew. This delay also coincided with a weather delay due to an offshore storm. ADEON had 3 weather days built into the schedule, so all objectives were still able to be met even with the initial delay.

COVID restrictions also reduced the number of people ADEON could bring to sea from 12-14 to 7. As a result, there were not enough people to support a full daily rotation of marine mammal observations. The RV Armstrong bridge crew were ADEON partners in this endeavor and called down to the main lab when marine mammals were sighted. An ADEON team member was then able to capture this info on the marine mammal data sheets.

Table 1. Summary of sampling that occurred at each site location during the AR049 research cruise.

Site	Lander Recovered	CTD/XBT casts	Ring net tows	IKMT net tows	Finescale Acoustic Survey	ROV Jason Dives	Fish specimens preserved
Jason Eng. Site		1		1		1	
HAT	Yes	1	1	1	1		Yes
WIL	Yes	1	1	1	1	1	Yes
SAV	Yes	1	1	1	1		Yes
BLE	Yes	1	1	1	1	3	Yes
JAX	Yes	1	1	1	1	1	Yes
CHB	Yes	1	1	1			Yes
Cruise Total	6 / 6	7	6	7	5	6	6ss

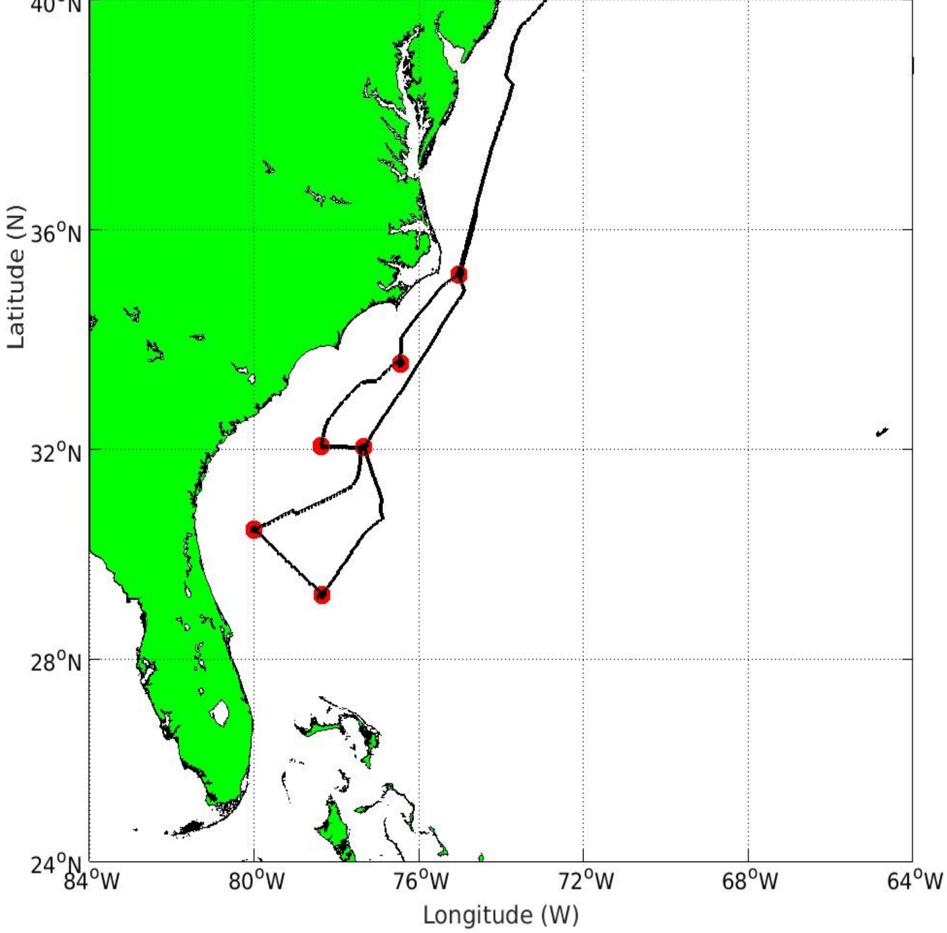

Figure 1. Cruise track for R/V Armstrong Cruise #AR049 from 4 – 21 Dec 2020. Site locations are highlighted by red circles.

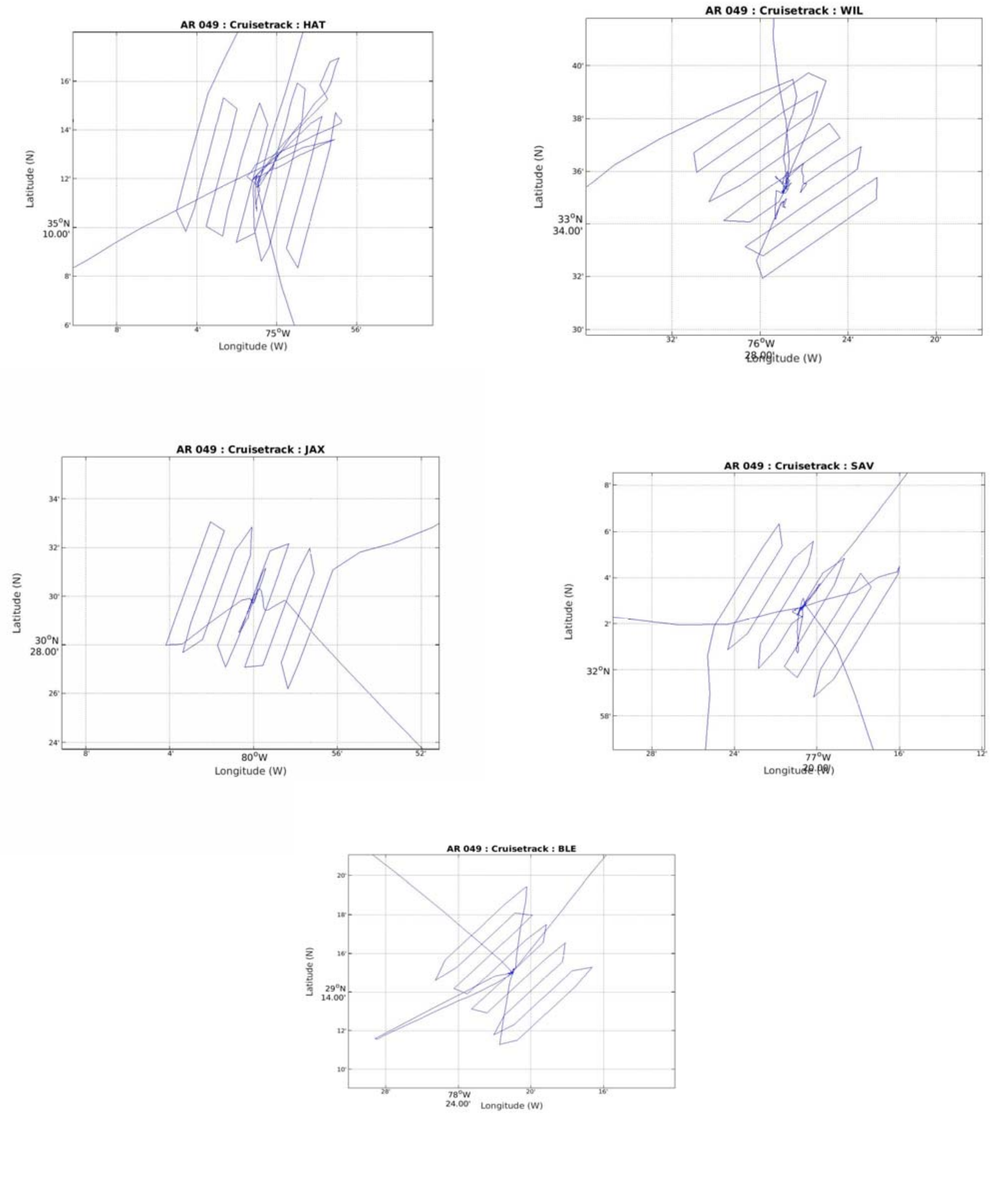

Figure 2. Cruise track for the ship at each site during R/V Armstrong Cruise AR049.

Lander Retrieval – Carmen Lawrence

At each of the six sites, landers were successfully recovered. Upon arrival to each station, the lander was first communicated with via the acoustic releases and range was established. If the range was acceptable, the landers were released from the anchor. Once the lander was spotted on the surface, the vessel approached the lander on the starboard side and was hooked via a snap hook line that led into the J-frame. The lander was then brought on board over the starboard side and secured for transit.

At WIL, communication with the acoustic releases on the lander was established. However, the lander did not surface despite the release being confirmed by both acoustic releases. The JASON ROV was deployed the following day, and it was found that the lander was buried. The JASON crew used the manipulator arms to lift the lander from the sediment and the lander surfaced on its own (Figure 3). The ship's small boat was then deployed to secure the lander until it could be recovered by the vessel.

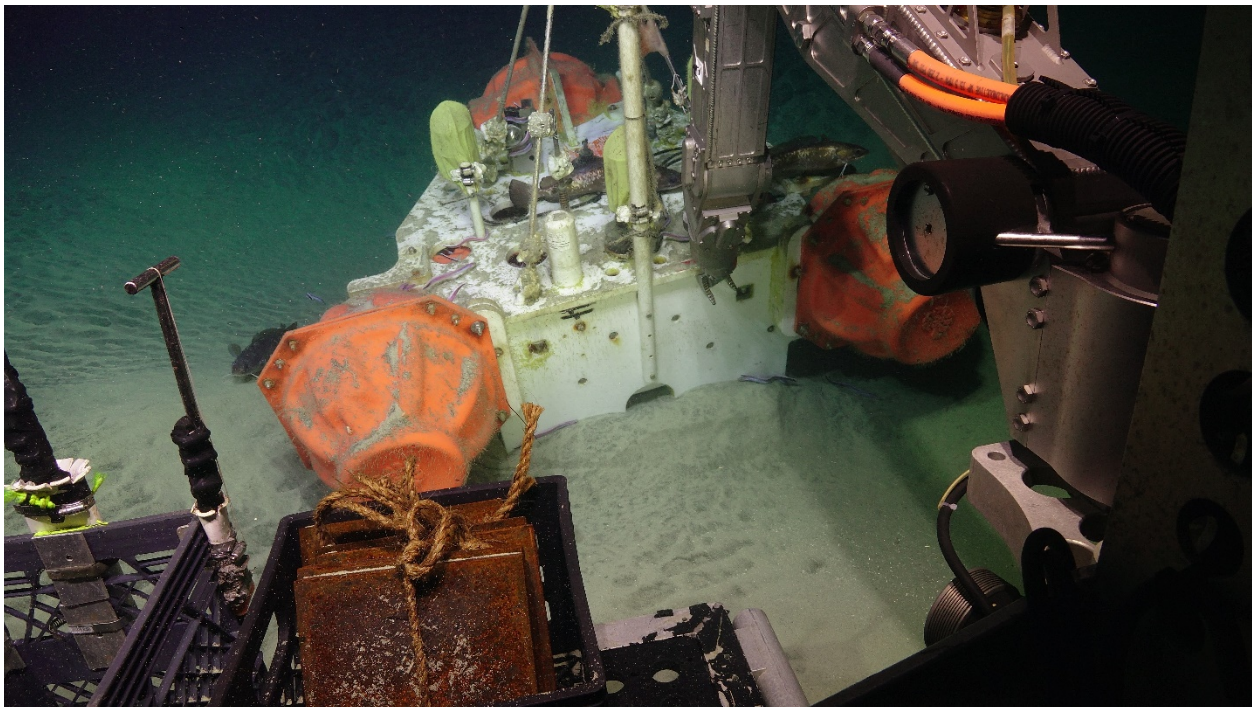

Figure 3. Image captured from the ROV Jason cameras. The manipulator are is prying the buried WIL lander from the sediment. (Photo credit: ROV Jason footage provided to Jennifer Miksis-Olds)

At JAX, communications were established with acoustic release from the lander deployed during ADEON 3, which was not recovered during the ADEON 4 cruise. As with the previous cruise, only one of the acoustic releases was responsive. The JASON ROV was again deployed to recover this lander. The acoustic release line connecting the anchor appeared to have caught within the structure of the lander, preventing it from fully releasing from the anchor, as the second acoustic release was not responsive and did not release (Figure 4). The JASON crew used the ROV's manipulator arm with a small knife to sever the acoustic release line and the lander floated to the surface. The lander was recovered once it was spotted on the surface and JASON remained deployed during this time.

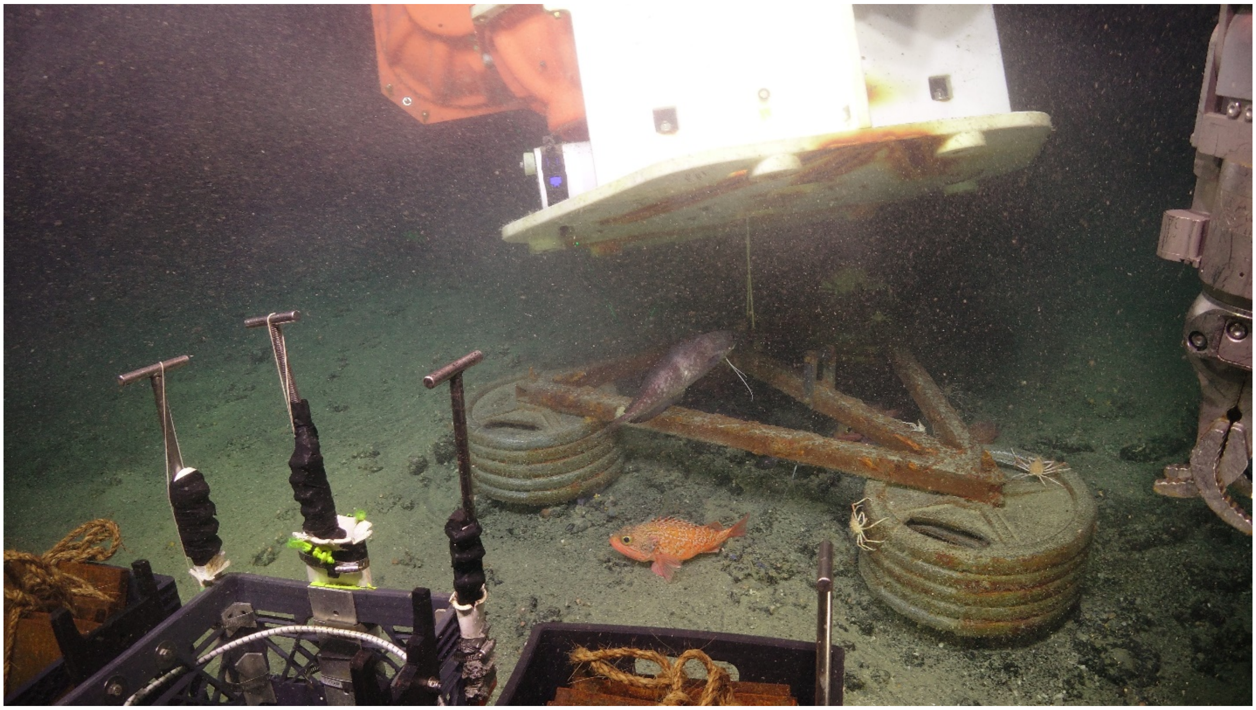

Figure 4. Image captured from the ROV Jason cameras. The JAX lander released but the relaaease line got caught up in the lander structure preventing it from surfacing. (Photo credit: ROV Jason footage provided to Jennifer Miksis-Olds)

Multiple Frequency Acoustic Echosounder Data – Joseph Warren

The RV Armstrong's EK80 system (Figure 5) was run continuously during the cruise with the 18 and 38 kHz transducers in narrowband (due to ship constraints) and the 70, 120, and 200 kHz transducers operating in broadband mode. Pulse lengths were 1024 microseconds and ping rate was set to maximum, except when in shallow (< 150 m) water or when sea state (and thus data quality) were poor. Ping rate was then set to 0.2 to 1 Hz.

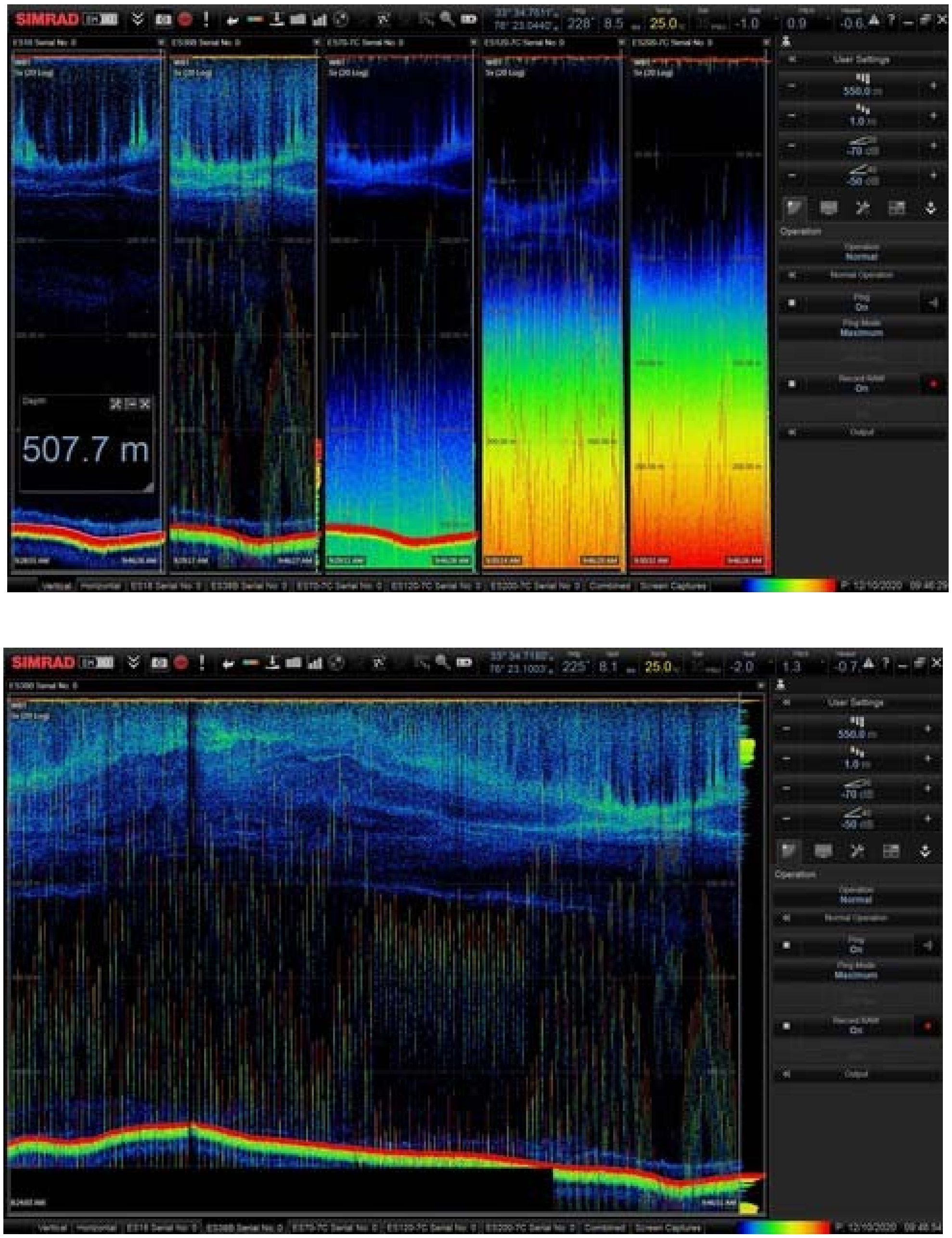

Figure 5. Example echograms from the ship's EK80 showing epiplagic scattering layers (top) as well as internal waves (bottom) which were commonly observed during the cruise as the ship transited across the continental shelf. These data are from the WIL fine-scale acoustic survey.

At each survey site except for CHB (due to time constraints) and VAC (due to the lander there being previously trawled up), a fine-scale acoustic grid (Figure 6) was conducted at a speed of 8 kn. Survey lines were adjusted for the direction of the sea state.

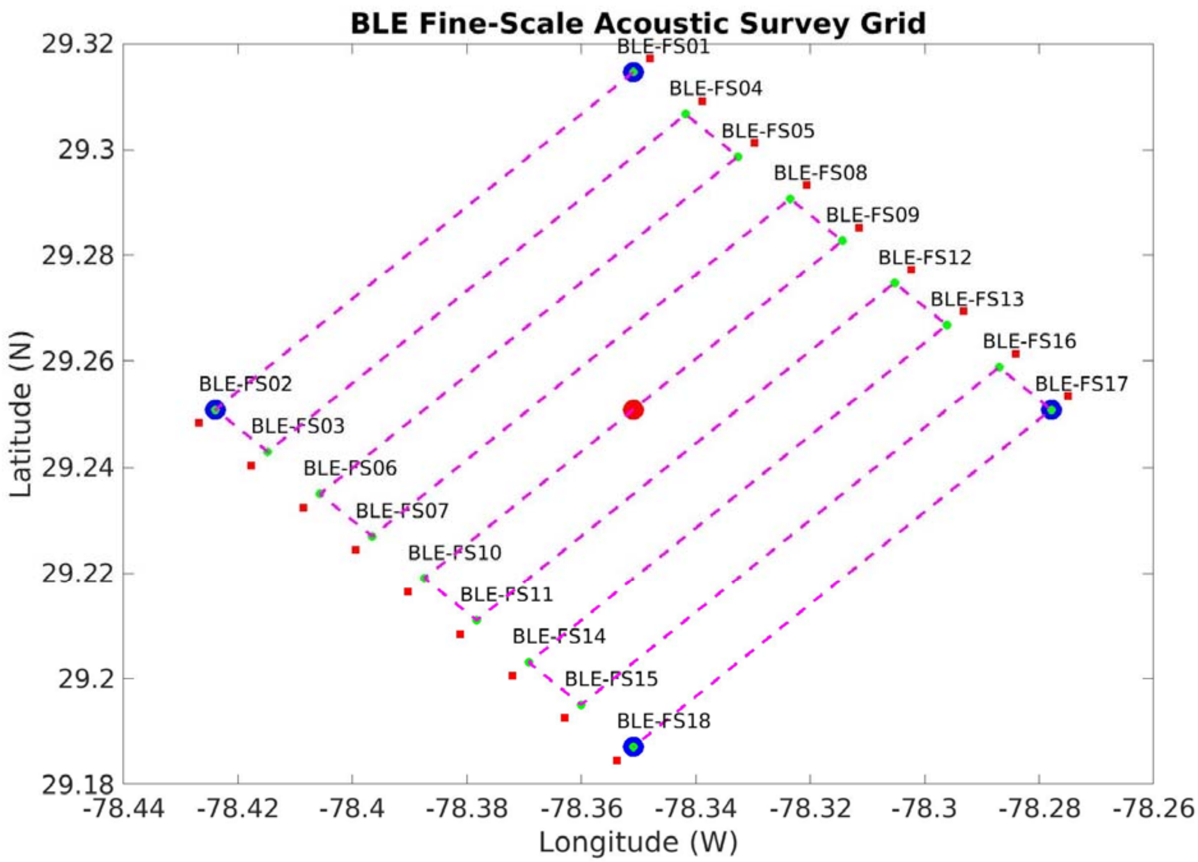

Figure 6. The grid acoustically surveyed at the BLE site. The red dot at the center represents the location of the bottom lander. The survey grid covers an area roughly 10 km by 10 km.

Net tow sampling – Joseph Warren

Biological specimens were collected at each site (except for VAC) using two different nets. A 60 cm diameter, ring-net BONGO pair (one with 1000 um mesh, the other with 333 um mesh) was deployed at each site (roughly at the lander location) with a vertical cast to 100 m (Figure 7). Actual net depths may be slightly less than the wire out due to surface currents causing the tow wire to be slightly off-vertical. Zooplankton and larval nekton collected in the ring net were preserved in buffered formalin solution for post-cruise identification and enumeration. Unique or interesting specimens from these tows were occasionally photographed or preserved individually.

Figure 7. Bongo net being rinsed after the tow by graduate students Hannah Blair (standing) and Brandyn Lucca (kneeling) on deck (left) and the cod ends showing the catch (right). Photo credit: Joe Warren

A larger net (5 m2 Isaacs-Kidd Midwater Trawl) was also deployed at each site (Figure 8), typically multiple times per site. One tow was done at the lander location and was targeted to sample the scattering layers observed in the water column on the ship's echosounder. One additional tow was conducted opportunistically to sample mesopelagic fauna at the site of JASON's deep (3000 m) engineering dive. For all (but the deepest, JSN site) IKMT tows a temperature-depth sensor was placed on the net to measure the path of the net (Figure 9). This is in addition to the USBL beacon that was put on the trawl wire just above the net which recorded (and provided real-time data) on net depth during the tow.

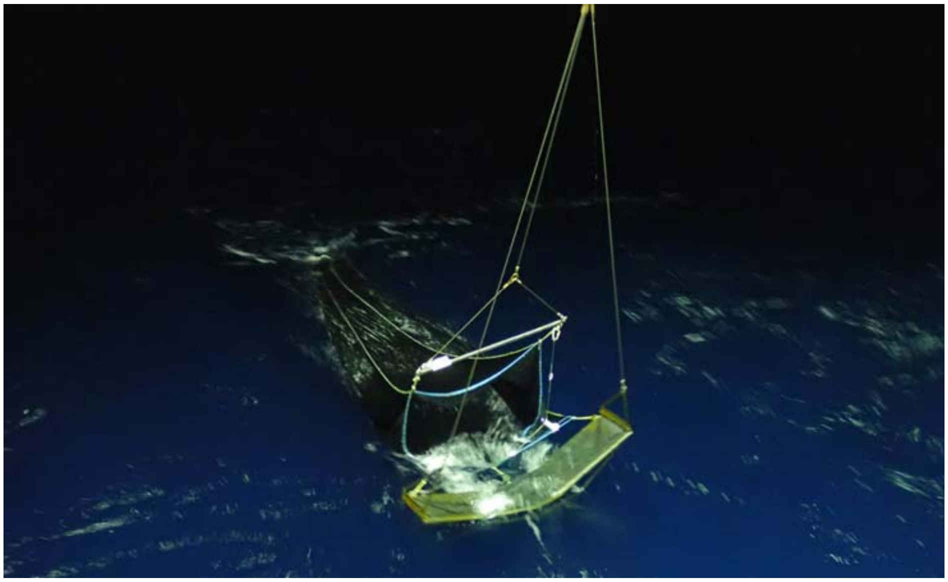

Figure 8. The Isaacs Kidd Midwater Trawl being recovered. Wire-out speeds were 10 – 30 meters per second, and haul-back speeds were 10 to 30 meters per second. Tow depths ranged from 300 m to 1200 m. Photo credit: Joe Warren

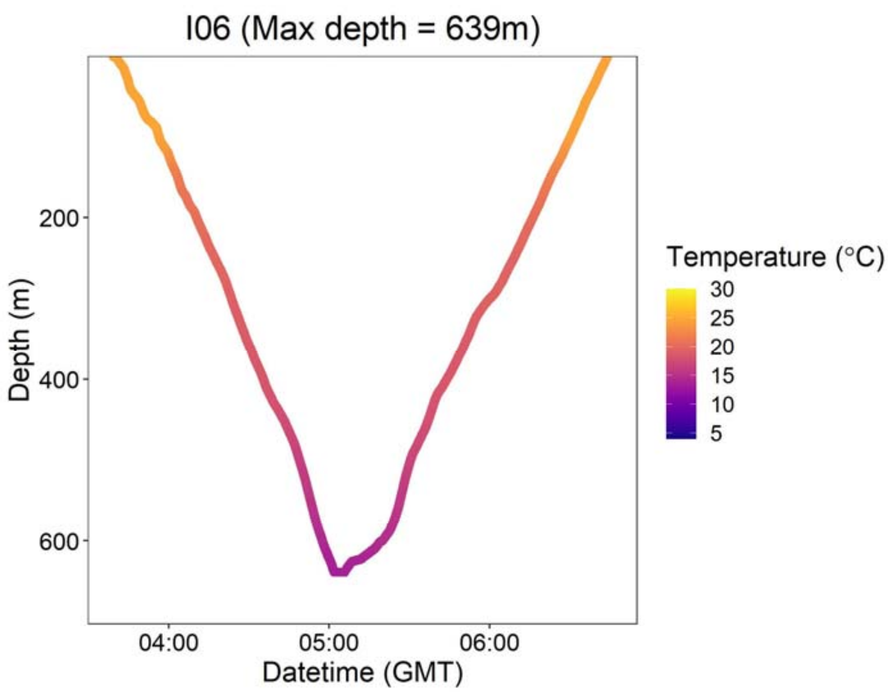

Figure 9. A sample IKMT net depth and temperature tow profile (I-06) conducted on 15 December 2020 at the BLE station. Color of the line represents the temperature recorded from the temperature-depth sensor attached to the net.

Animals from these net tows were preserved in formalin solution for post-cruise identification and enumeration. Selected individual animals were removed (noted on the tow data sheet) for photography (Figure 10).

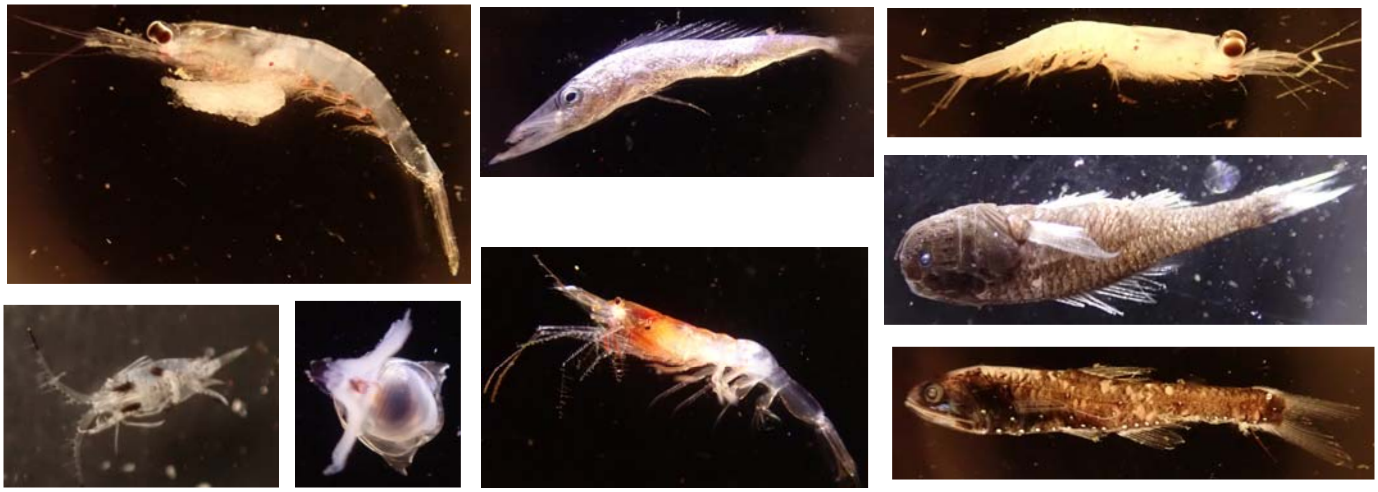

Figure 10. Some of the animals collected by net tows during the AR049 cruise. Photo credits: Joe Warren

Organism Target Strength and Sound Speed Measurements - Brandyn Lucca

Ex situ target strength (TS) – the logarithmic measure of the acoustic cross-section of a backscattering target – measurements were made on individuals from several taxonomic groups collected from net tows. These estimates provide valuable acoustic data that can be used to improve quantitative estimates of abundance and biomass by validating theoretical acoustic TS models. Benchmarking these models and assessing how they perform with empirical measurements is an important step for determining the most appropriate scattering model for converting acoustic backscatter data into units useful for ecologists and fishery managers, such as numeric abundance and biomass. All TS experiments were conducted in a 44 gallon aquarium with two broadband urethane transducers mounted at the top and aimed downwards (Figure 11). Additional experiments were conducted to measure the sound speed contrast of animals relative to ambient seawater (h) (Table 2). For the TS experiments, animals were tethered with monofilament and weighted down to limit movement due to ship motion. These transducers pinged at both discrete narrowband frequencies (38, 50, 120, 150, and 200 kHz) as well as broadband sweeps (35-73 and 130-210 kHz). The transducer system was calibrated using direct-path measurements as well as those of a tethered 38.1 mm tungsten carbide sphere.

Figure 11. All TS and h measurements were conducted in the wet lab using a power amplifier, match transformer, digitizing oscilloscope, signal generator, and a laptop (top-left). Sound speed contrast (h) experiments were performed in a plastic bin so the brass 192 kHz transducers could remain submerged (top-right). TS measurements were made in a 44 gallon aquarium using urethane broadband transducers (bottom-left) on tethered animals such as the hatchetfish (bottom-right).

A total 452 animals were photographed to measure body morphometry (Figure 12), with many being frozen for their respective mass (g) to be measured post-cruise on land. Of these 452, 36 were used for *ex situ* TS experiments that comprised 1 squid, 2 krill, 3 shrimp, and 26 fish (Table 3).

Figure 12. A variety of mesopelagic animals were collected and used for tethered TS measurements, including hatchetfish (Sternoptyx sp., top-left), bristlemouths (Cyclothone braueri, top-right), shrimp (Jancinella spiniculata, bottom-left), and other mesopelagic organisms (e.g., Pollichtys mauli, bottom-right). The smallest increment on the scalebars for all images displayed is 1 mm.

Table 2. Summary of h experiments conducted during the cruise.

Tow ID	**Species**	**Common Name**	***n***
I-01	*Eusergestes arcticus*	Arctic red prawn	2
I-01	*Nematoscelis gracilis*	Krill	1

Table 3. Number of individual animals of each species that had their TS measured for the various narrow- and broadband frequencies.

Taxa	**35-73 kHz**	**38 kHz**	**50 kHz**	**130-210 kHz**	**120 kHz**	**150 kHz**	**200 kHz**
Cephalopoda	1	1	1	1	1	1	1
Cyclothone braueri	7	7	7	8	8	8	8
Cyclothone spp.	3	3	3	6	6	6	6
Decapterus kurroides	1	1	1	1	1	1	1
Euphauisiacea	2	2	2	2	2	2	2
Eusergestes arcticus	2	2	2	2	2	2	2
Gonostomatidae	2	2	2	3	3	3	3
Jancinella spiniculata	1	1	1	1	1	1	1
Melamphaidae	2	2	2	2	2	2	2
Myctophidae	4	4	4	4	4	4	4
Pollichtys mauli	4	4	4	4	4	4	4
Selar crumenophthalmus	1	1	1	1	1	1	1
Sternoptyx sp.	1	1	1	1	1	1	1
Total	31	31	31	36	36	36	36

Organism Density Contrast Measurements - Hannah Blair

The density contrast (*g*) of an organism relative to the surrounding seawater is an important acoustic material property. Density contrast values are inputs to acoustic scattering models, which allow for estimating zooplankton abundances from active acoustic data. Shipboard density contrast measurements were conducted on zooplankton that composed a large proportion of the net contents for each net tow. Measurements were conducted as soon after tows were completed as was feasible, and no longer than 24 hours after a tow.

Measurements were conducted using the titration technique. In this method, animals are placed in a beaker with a known volume of seawater. Known volumes of a solution of 50:50 or 25:75 seawater to glycerin are added until the animal floats up at neutral buoyancy, indicating that the animal's density matches that of the solution. Following each density measurement, all measured animals were photographed with a ruler to acquire animal lengths (Figure 13). Each animal was then frozen so that their masses may be measured after the cruise.

Density measurements were made on a total of 191 animals (Figure 14). Taxa measured included decapod shrimp (*Eusergestida* spp., *Jancinella* spp., *Sergia* spp., etc.), euphausiids (krill; *Nematoscelis* spp., *Nematobranchion* spp., *Thysanopoda* spp., and *Stylocheiron* spp.), myctophid fish, gonostomatid fish, *Cyclothone* spp. fish, and elopomorph fish larvae (leptocephali).

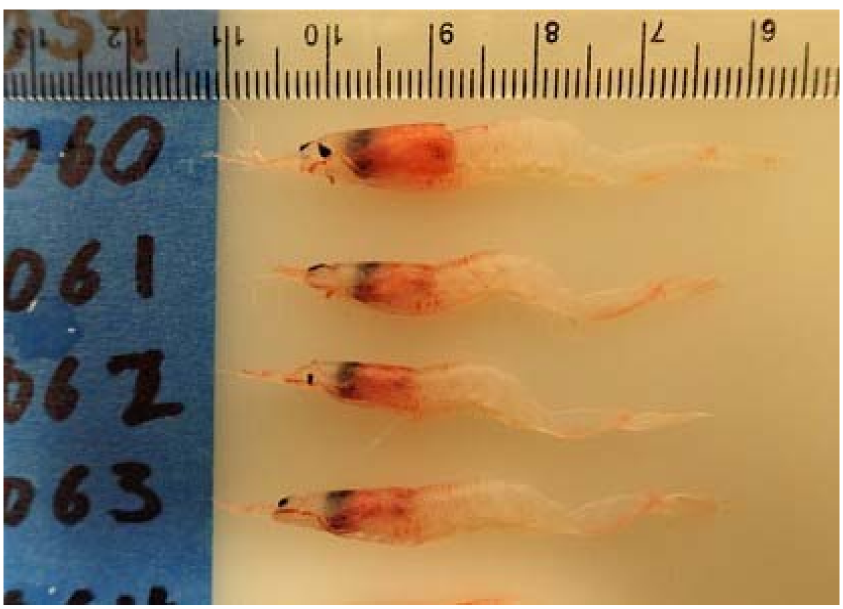

Figure 13. Individual animals are numbered and photographed after being measured for g. These data allow for animal length, morphology, taxa or other parameters to be compared with the measured g values.

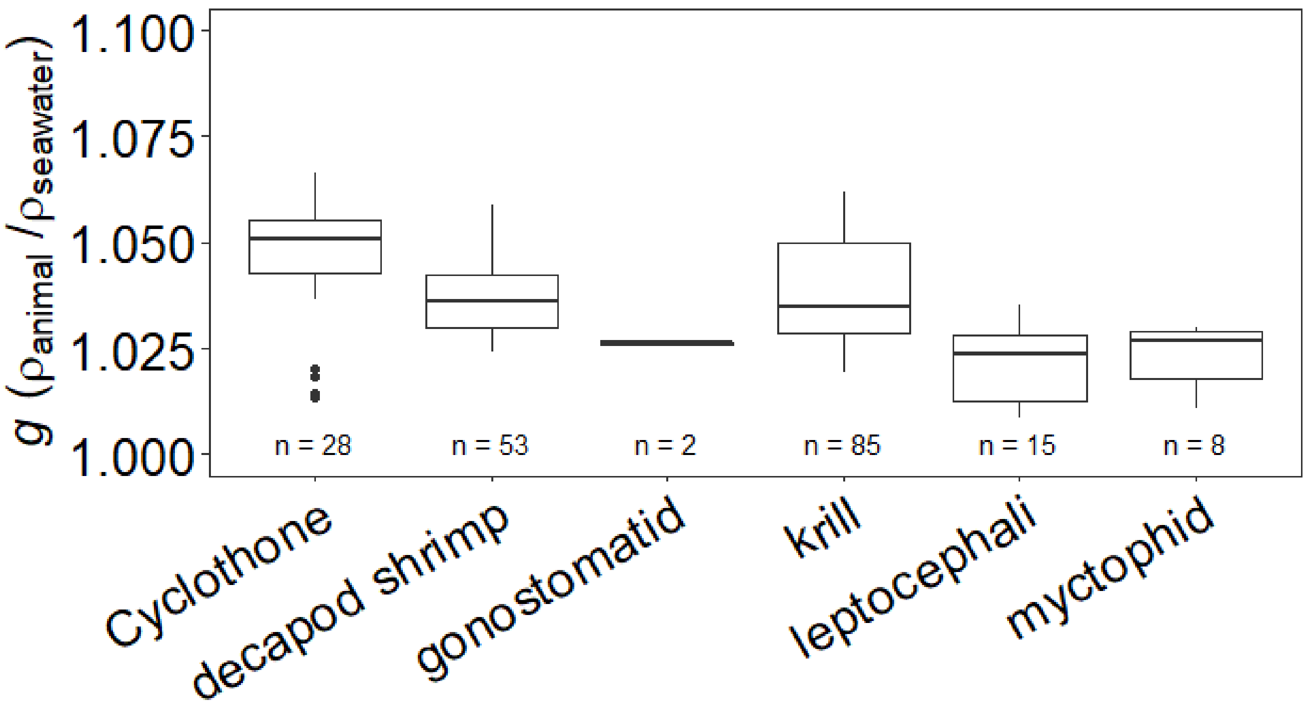

Figure 14. Density contrast measurements showed variation both within and among different animal taxa. A total of 191 g-measurements were made during cruise AR049. Krill, fish (especially Cyclothone spp.), and shrimp made up a large proportion of the Isaacs Kidd Midwater Trawl (IKMT) samples, and were therefore targeted for g-measurements. Material properties of Cyclothone spp. fish were of particular interest for this cruise. All krill were identified to genus, and most also to species.

AEON (Acoustic Environmental Observation Network) – Jennifer Miksis-Olds

Landers were successfully re-deployed at the ADEON HAT and WIL sites for an additional year under an ONR funded project called AEON (Table 4). A third site was targeted for redeployment, but the deployment was not successful and the lander surfaced within 2 hours of deployment. Satellite beacon messages were received, and the lander was recovered 176 miles north of the deployment site on the cruise track back to port.

Table 4. Table: Lander deployment locations, depth and estimated bottom locations

Site	Deployment Location		Drop Date	Time (UTC)	Estimated Location		Depth (m)
	Latitude	Longitude			Latitude	Longitude	
HAT	35 12.0150 N	075 01.1370 W	2020 Dec 03	18:59	35 12.0602 N	075 01.1300 W	296
WIL	33 35.7900 N	076 26.9040 W	2020 Dec 03	20:54	33 35.8797 N	076 26.8641 W	450

ROV Jason Engineering Dives – Ben Tradd

ONR funds supported ROV Jason to take part in the ADEON AR049 cruise with the objective of recovering the 2018 JAX lander. Having Jason onboard also allowed ADEON to recover the WIL when it did not surface after confirming the acoustic release command. The WIL lander was discovered to be covered in sediment which prevented it from floating to the surface (Figure 16). Jason was able to shake the lander free. At JAX, it was discovered that the lander did release, but the release line got caught within the lander (Figure 16). Jason was able to cut through the release line, and the lander floated to the surface under its own buoyancy. Both landers were recovered in good working order with a full suite of data,

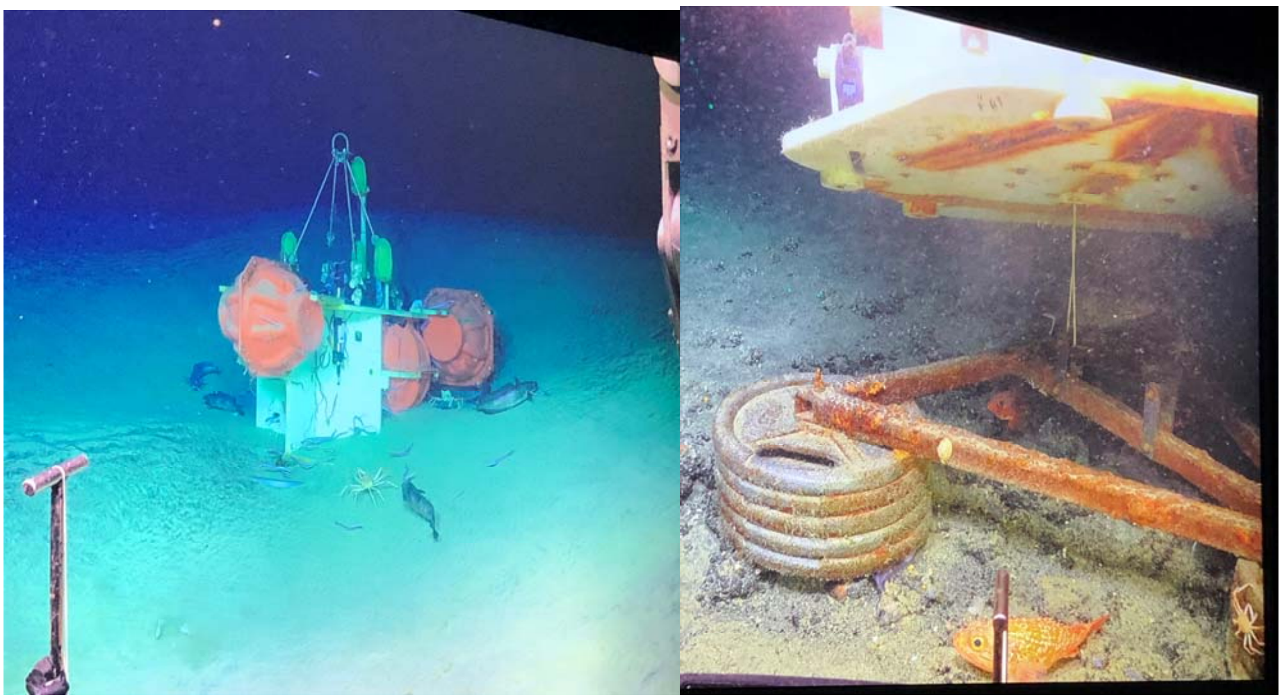

Figure 16. Left – ADEON WIL lander buried in sediment which prevented surfacing despite successful release. Right – ADEON JAX 2018 lander showing caught release line that prevented surfacing. Both photos taken from cameras mounted on ROV Jason (Photo credit: Jennifer Miksis-Olds).

Two days of the cruise were devoted to ROV Jason engineering dives (Figure 17). The two days of Jason operations were supported by NSF funds.

<u>*Dive 1 (12/15/2020)*</u>:
-Tested the new Nortech doppler. very good results, seems like a quality unit
-**Completed Phins integration with frankly amazing results.** We were able to hold an absolutely rock solid position with nothing but USBL data and Phins. I think this is going to be a revolutionary addition to our closed loop control that will enable us to manipulate things (like OOI mid water moorings) in auto XY. Really impressive stuff.

<u>*Dive 2 (12/15/2020)*</u>:
-Tested the new RDI doppler with good results, had bottom lock at 370 meters which was impressive.

-Tested new motor pod with the new connector whips, no grounds throughout the dive.
- Also did a bit of pilot training on this dive.

Dive 3 (12/16/2020):
- Installed new thruster motor on aft lateral position. Checked out good on all deck tests and is currently being used subsea
- Additional testing of RDI doppler
- Pilot training
-Testing of ships "vehicle follow" DP mode.
-Testing of new Alvin USBL beacons
- .842 Cable lubrication

Figure 17. ROV Jason returning to the deck of the R/V Armstrong after its final engineering dive to 3000 m . (Photo credit: Jennifer Miksis-Olds)

Gravity Data Acquisition and testing of new WHOI-SSSG/PFPE DgS AT1M marine gravimeter alongside BGM3 gravimeter – Dr. Danial Fornari

The WHOI Shipboard Scientific Services Group's (SSSG) Potential Field Pool Equipment (PFPE) Facility was funded by NSF (OCE2015229) in early 2020 to acquire a new marine gravimeter to test its capabilities and data resolution in comparison to the ITAR-regulated BGM3 gravimeters that have been used for decades for US academic marine gravity data acquisition. PFPE took delivery of the new DgS AT1 marine gravimeter (sn017) in July 2020. PFPE assembled and commenced testing of the new DgS gravimeter in the PFPE gravity lab in the Smith building at WHOI during July through November.

In mid-November, the DgS system was installed on RV *Armstrong* in the transceiver room next to the BGM3 gravimeter sensor. Excellent comparison data were acquired with both systems during dock testing for 2.5 weeks. This confirmed the functionality of the new system and correspondence of the data with the BGM3 S220 system that was running concurrently.

The at-sea testing of the new DgS AT1-sn017 gravimeter with the BGM3 S220 was conducted on RV *Armstrong* on cruise AR49, down the east-coast of the US (Figure 1). The cruise commenced on Dec. 4, with both gravimeters producing excellent results based on near real-time analysis of data from files being sent to shore via the sat. comms. system by the WHOI SSSG (Figure 18). Note that a portion of the return transit from offshore Cape Hatteras back to Woods Hole was on a reciprocal trackline in order to more precisely compare the accuracy and precision of data from both gravimeters. Analysis of the gravity data to date have been collaborative between PFPE team members (primarily M. Tivey, M. Tominaga and D. Fornari) and Dr. Daniel Scheirer of USGS Menlo Park, a long-time collaborator with Fornari and user of PFPE marine gravimeters for oceanographic research.

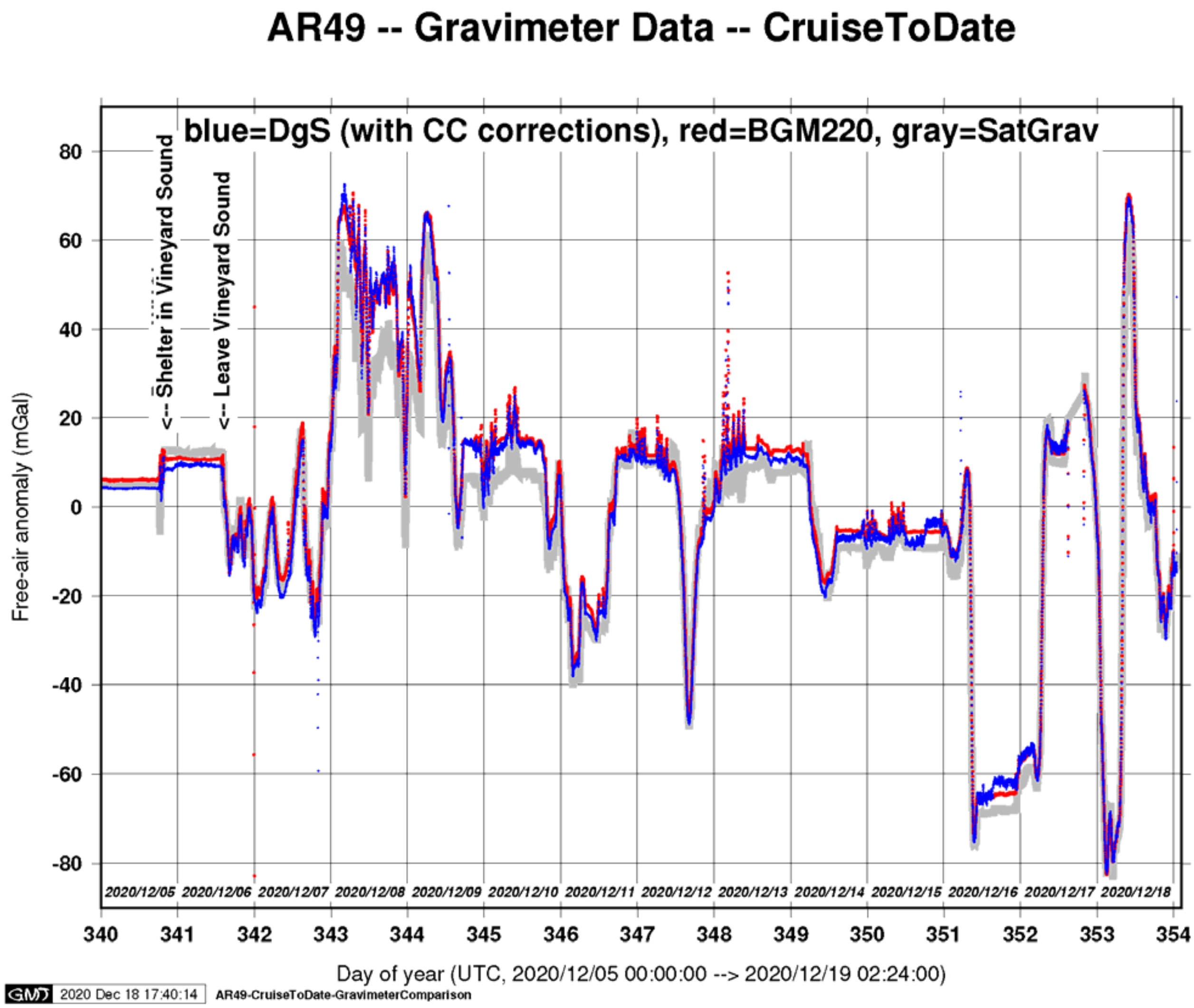

Figure 18. Plot of preliminary DgS and BGM3 processed free-air gravity data collected on AR49 cruise to Dec. 18, 2020. (plot by Dr. D. Scheirer – USGS).