Atlantic Deepwater Ecosystem Observatory Network (ADEON)
– An Integrated System –

Post-Cruise Report for AOS Sailboat Cruise December 2020

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Overview:

The goal of ADEON is to generate multi-year measurements of the natural and human factors that describe the ecology and soundscape of the U.S. east coast Outer Continental Shelf (OCS). We aim to develop standardized tools for comparing soundscapes across regions and predictive models for the soundscape and overall ecology of the southeast OCS in water depths between 100-1000 m.

Cruise Objectives:

In order to address the 4th program objective of determining the spatial and temporal distribution of the soundscape a set of four sailboat cruises with a towed horizontal line array (HLA) were planned. The first three cruises have been completed; this report described the 4th and final cruise for ADEON. Due to COVID-19 outbreak and travel restrictions AOS had to modify some of the schedule and mission parameters for the December of 2020 research cruise, but we were still able to accomplish all research objectives.

The planned route began from the Charleston Sea Buoy. From there, we would transit to the Jacksonville mooring (JAX) where we would turn north towards the Charleston Bump (CHB), recording ambient sound for the leg from JAX-CHB. The objective was to measure ambient ocean sound at multiple ranges from each of the JAX and CHB landers, in order to examine the spatial and temporal correlation scales of the soundscape. The original plan called for two vessels, the primary sailing vessel towing a small, 7m custom made reconfigurable acoustic array developed in collaboration between AOS and SubSeaSail; and a secondary autonomous sailing vessel, the 6th generation SubSeaSail prototype equipped with a smaller version of the same reconfigurable array which was to be only 2.4m long and mounted in a fixed position approximately 2m below the surface on the hull of the semi-submersible vessel.

Inclement weather was an issue throughout the cruise and prevented multi-vessel operations, and caused the primary manned sailing vessel to have to shelter in port after only 18-hours of data collection on the second day underway. During the first day underway we experienced winds gusting to 35 kts, and seas around 8ft. The crew was fatigued; seasickness was a problem, and hypothermia was a risk. The second day the weather improved for a window long enough for us to make an 18-hour towed recording with a single phone at approximately 50m depth along a 30km transect towards the JAX mooring in a southeasterly direction. The weather forecast predicted a storm arriving on the 4th day, Friday the 4th of December, so we made the decision to transit back to Charleston to shelter from the storm for safety reasons. We took a risk and equipped the SubSeaSail with a single Cetacean Research hydrophone with onboard recorder, sampling at 96kHz; deployed the SubSeaSail in the Gulf Stream near the JAX mooring with a programmed mission to transit 128NM to the CHB mooring, then sheltered in port with the primary vessel while leaving the autonomous vessel at sea during the worst of the storm. The SubSeaSail platform performed admirably, weathered the storm and made the transit in two days. We got underway from Charleston after the storm had passed on Saturday, 05 December and rendezvoused with the SubSeaSail vessel 10km southwest of the CHB mooring at approximately 0330 local time on Sunday, 06 December. To finish the transect we conducted multiple CTD casts, with 10-minute hydrophone recordings at varying distances from the CHB

mooring, prior to having to return to port again before the weather deteriorated. We collected a total of more than 51 hours of useable single hydrophone acoustic data at varying ranges from both the JAX and CHB moorings, with accompanying CTD measurements.

Acoustic data was recorded through a combination of towing a cetacean research hydrophone and CTD from the vessel when weather permitted and by deploying an autonomous sailing platform, *SubSeaSail* with the attached cetacean phone when sea state did not permit towing.

The deliverable for each sailboat cruise is a cruise test plan, a post-cruise report and the binary data in post-processed form. The raw data will be provided to UNH for archiving.

Vessel:

The recordings gathered during the December 2020 ADEON Sail Cruise came from a cetacean research phone with an attached CTD. Recordings were made from the primary manned monohull sailing platform, the Catalina 445 *Avalon,* and from a deployed autonomous sailing vessel*, SubSeaSail.* Each vessel is pictured below in Figure 1. Acoustic recording devices and the *SubSeaSail* were stored on deck during transit and deployed from the Starboard rear of the *Avalon*.

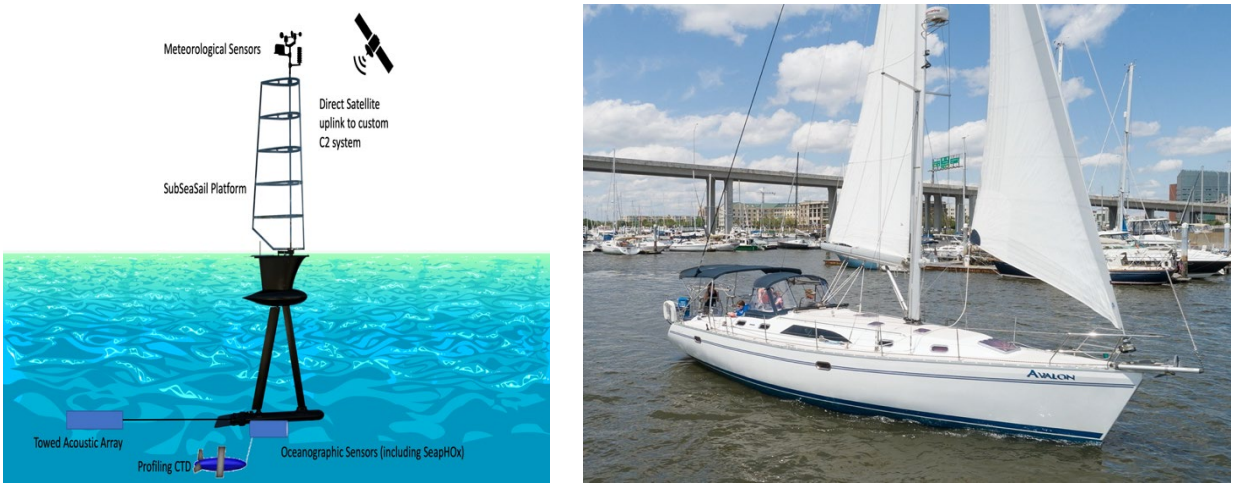

Figure 1. SubSeaSail (Left) Charleston Sailing School, Catalina 445, Avalon (Right).

Crew:

Captain: Kevin Klinges (Charleston Sailing School)
Chief Scientist: Chris Verlinden (AOS)
Technologist: Gerald Burkett (AOS)
Computer Scientist: Tessa Munoz (AOS)
AOS Technologist Interns: Julian Blanco & Joseph Munoz

Figure 2. December 2020 Experiment team

Crewmembers manned a 24-hour watch rotation in 3 to 6-hour durations. On watch, members safely navigated the vessel and maintained operational status of the scientific equipment.

Navigation & Schedule:

The original cruise test plan is shown in Figure 2.

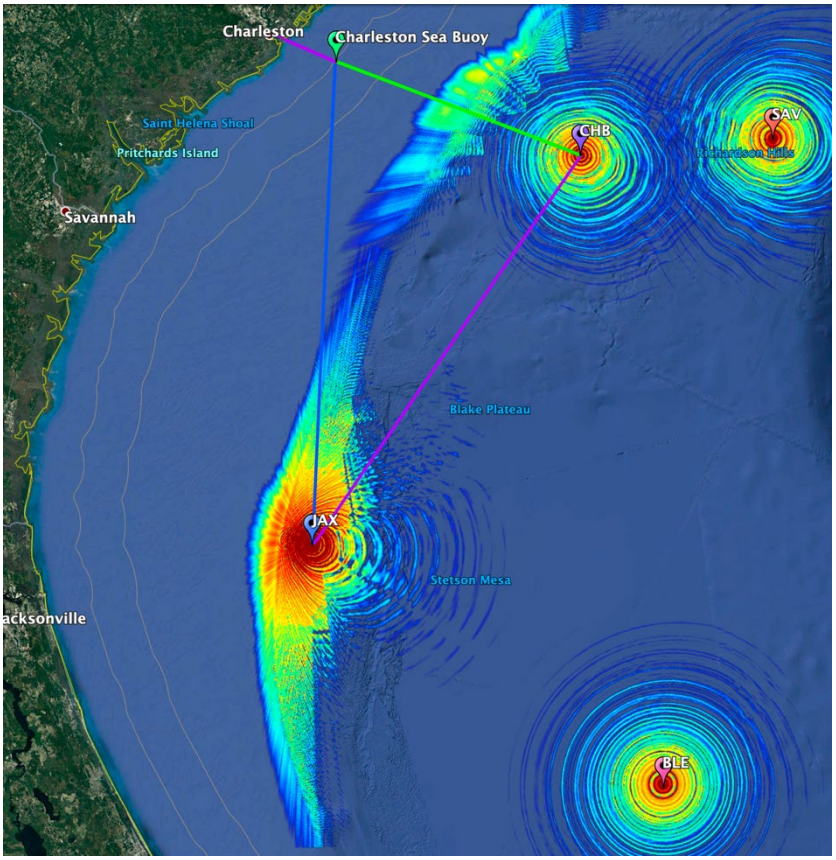

Figure 3. December 2020 Experiment Plan

Final execution of the experiment deviated in that the vessel had to return to Charleston on Thursday December 3rd to escape a storm for which the *SubSeaSail* was then deployed with the cetacean research phone to conduct the transit to CHB. After the storm, the vessel left Charleston on Saturday December 5th to retrieve the SubSeaSail. After retrieval, the vessel completed transit to CHB then had to turn back to Charleston early due to foul weather. The vessel's actual experimental track-line is shown below in Figure 4.

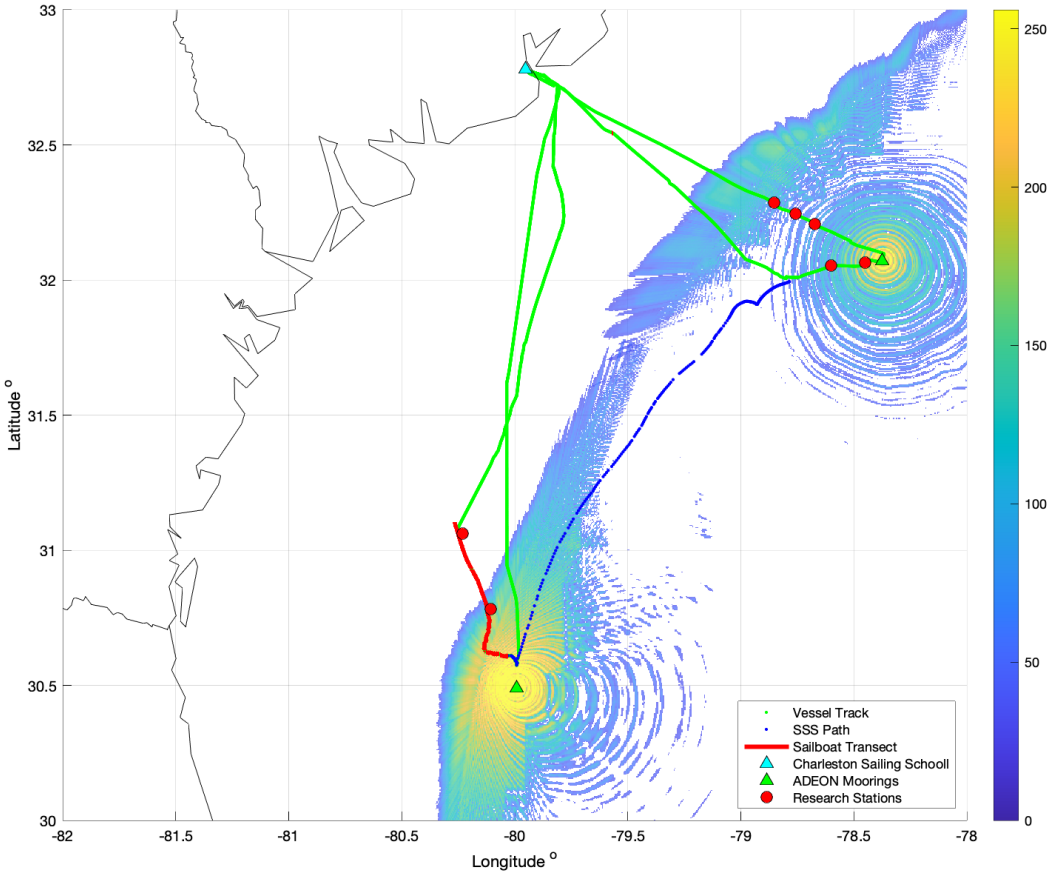

Figure 4. December 2020 Experiment vessel track and sample stations

Data Collection:

Whenever environmental conditions allowed, all attempts were made to collect data. Conditions that specifically prevented array deployment or necessitated its recovery included sea state, onset of nighttime, and wind speed or direction. Most often during the week heavy winds (in excess of 20kts) or wind directions unfavorable for sailing were the cause of not deploying devices. Table 1 describes collection events in detail.

Table 1. Experimental recording times.

Date	Time (GMT)	Event	Elapsed time deployed (hh:mm)
2-Dec	2140	Cetacean/CTD towed	02:45
3-Dec	0205	Cetacean/CTD recovered	////
3-Dec	0220	Cetacean/CTD deployed	18:10
4-Dec	2030	Cetacean/CTD recovered	////
4-Dec	2230	Deployed SubSeaSail with attached Cetacean	34:00
6-Dec	0830	SubSea Sail/Cetacean recovered	////
6-Dec	0957	CTD cast	00:51
6-Dec	1048	CTD recovered	////
7-Dec	0144	CTD/Aquarian deployed at CHB	00:41
7-Dec	0225-0227	Recovered CTD/Aquarian	////
7-Dec	1541	Deployed CTD/Aquarian	00:14
	1555	Recovered CTD/Aquarian	////
7-Dec	1722	Deployed Cetacean/CTD/Aquarian	00:22
7-Dec	1754	Cetacean/CTD/Aquarian recovered	////
7-Dec	1838-1839	Cetacean/CTD/Aquarian deployed	00:16
7-Dec	1855	Cetacean/CTD/Aquarian recovered	////
7-Dec	1954	Cetacean/Aquarian/CTD deployed	00:13
7-Dec	2007	Cetacean/CTD/Aquarian recovered	////
	Total Time Deployed:		Approx [51:32]

CTD Casts:

Cast and towed CTD's were conducted through the duration of the experiment. The maximum depth of the CTD casts varies because some of the tows were conducted without stopping the vessel. Figure # and Figure # below display the salinity and temperature data respectively from the casts conducted throughout the cruise. CTD casts were conducted using an RBR Concerto CTD logger. The logger was lashed to a 400ft line and 30 pounds of diving weights. Deployment and recovery were assisted using the ships onboard power winch.

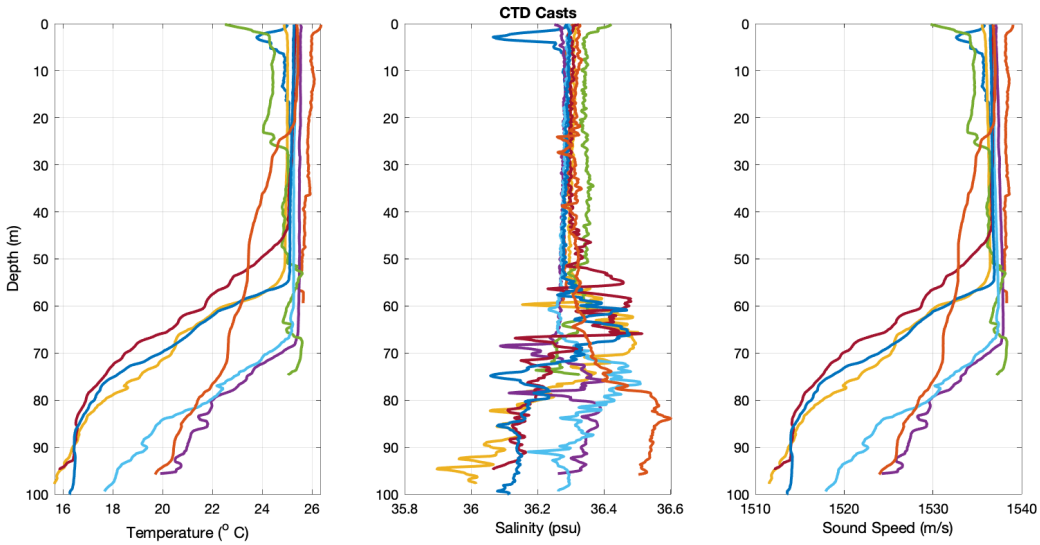

Figure 5. December 2020 Experiment CTD temperature, salinity, and sound speed profiles.

Acoustic Data:

During this cruise, we recorded over 51 hours of usable acoustic data from a Cetacean Research hydrophone, sampling at 96 kHz. This included a 23-hour south-southeasterly tow towards the JAX mooring at approximately 50m depth; a 34-hour surface transect between JAX and CHB using the same hydrophone; and 7 "research stations" where one or more 10-minute recordings were made at various depths. The data from the 23-hour tow is described below.

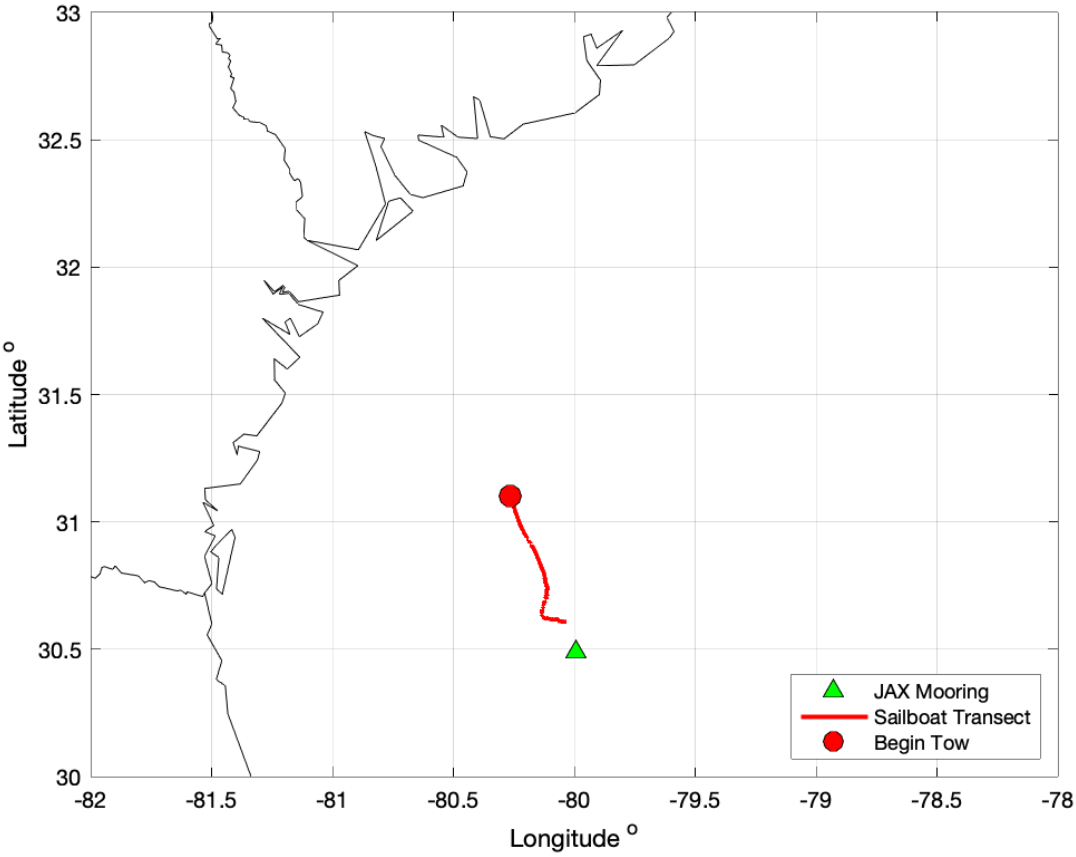

Figure 6. Map of 23-hour hydrophone tow towards JAX mooring

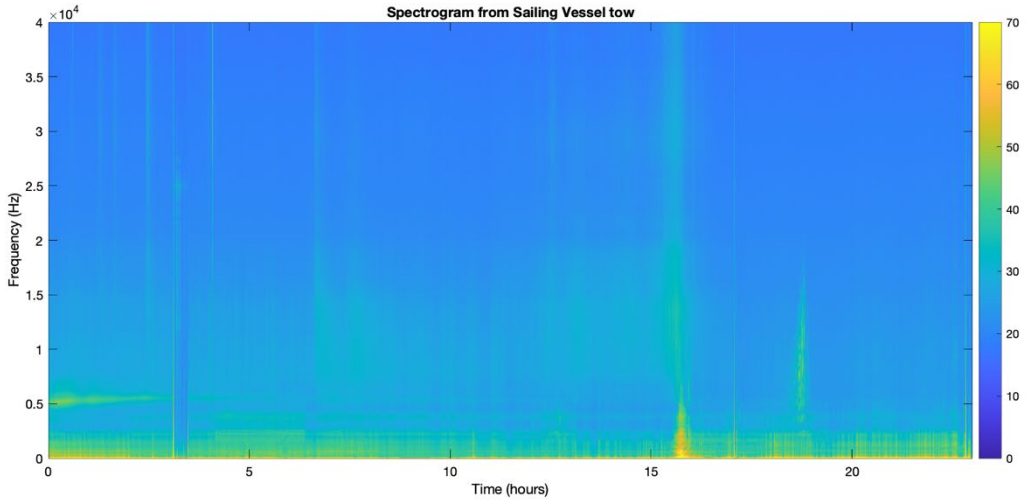

Figure 7. Spectrogram of data from 23-hour hydrophone tow towards JAX mooring

In order to examine the spatial correlation scales of the ambient noise field, we first calculate the range of every point along the tow to the beginning point of the tow.

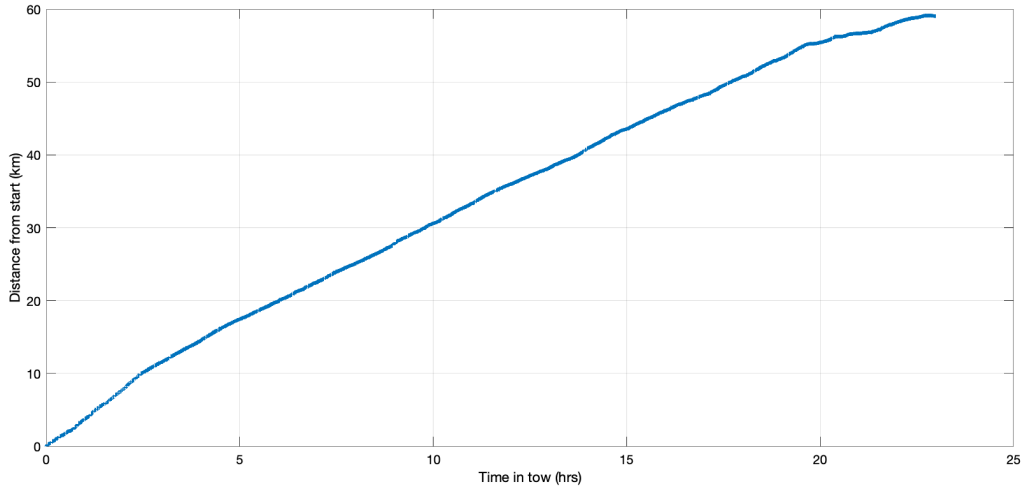

Figure 8. Distance from starting point during the 23-hour hydrophone tow towards JAX mooring

One way to describe spatial correlation scales of a soundscape is to plot the correlation coefficient of the noise spectra as a function of distance. Figure 9 shows this relationship during the 23-hour horizontal tow.

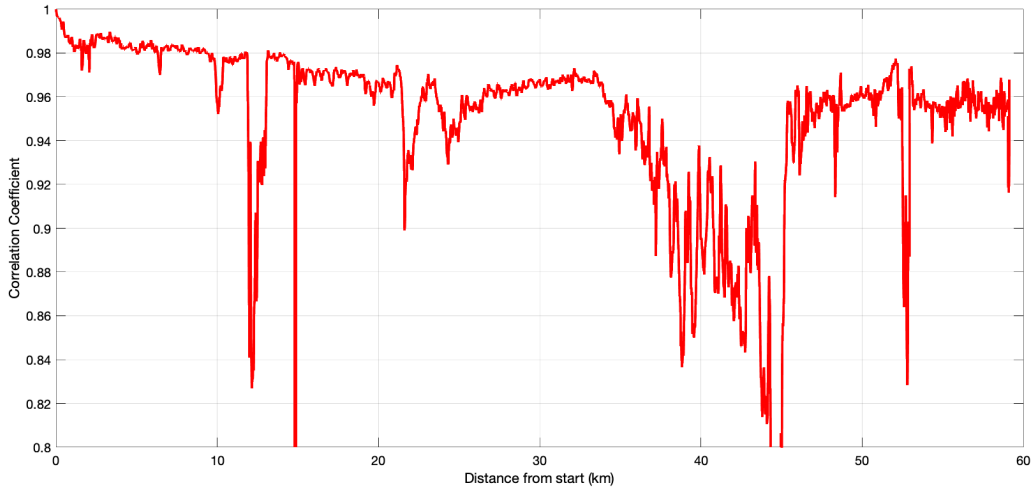

Figure 9. Correlation coefficient of acoustic spectra along 23-hour hydrophone tow towards JAX mooring

This same method can be used to examine temporal correlation scales at a single point. In the future we will use this method to analyze the rest of the data collected during this, and other ADEON cruises, compare the lander data to itself over time, and compare lander data to towed data.

Daily Operations Summary

All times in Local/GMT

Monday 30NOV2020

Local/GMT

- 0800/1300: Departure from Clarksburg, MD making way to Charleston, SC
- 1800/2300: Arrived in Charleston, SC

On Sunday, Nov 29th the crew loaded up a trailer with all the required equipment for transit to South Carolina on the morning of Monday Nov 30th. The crew drove to SC and stayed the night in a hotel near the marina.

Tuesday 01DEC2020 - Wednesday 02DEC2020

Local/GMT

- 1715/2215: Underway from Charleston Sailing School
- 1906/0006: Exiting traffic separation scheme IVO Charleston Harbor
- 1906/0006: Turned Motor off and began sailing; turned south towards JAX

Tuesday morning the crew met with the captain of the Avalon, Kevin Klinges. We spent the day loading equipment onto the boat, adjusting the initial cruise plan based on weather forecasts and going over cruise safety. Deployment was planned for 1700 so we could arrive at the JAX waypoint during a period of mild weather. As shown in Figure 11 below, weather conditions of 15 knot winds on average (gusting to 35 kts) and average wave height of 1.8 meters shown in Figure 12 made the transit out to Jacksonville buoy difficult for the crew, but we arrived at the destination without issues during transit. The crew set up scheduled shifts and prepared the recording devices, so they were ready to deploy once we arrived at the station.

Wednesday 02DEC2020 – Thursday 03DEC2020

Local/GMT:

- 1630/2130: Initial cast of CTD and Cetacean phone
- 1640/2140: Secondary cast of CTD and Cetacean phone with more weight
- 1652/2152: Engine started for maneuver
- 1707/2207: Engine turned off
- 2000/0100: Blue Robotics tube leak tested with LRA
- 2105/0205: Castaway CTD and Cetacean retrieved
- 2120/0220: Castaway CTD and Cetacean sent out with more weight. Data retrieved from Castaway CTD, Cetacean phone leak checked and set out without downloading data.
- 2155/0255: Engaged vessel engine

As shown in Figure 12, average wave height for December 2nd and 3rd was around 1.8 meters with the average wind speed at around 10.5 knots. Before arrival to the JAX buoy, the crew began measurements. Using the CTD and Cetacean phone weighted with 30 pounds and 100

meters of line. The crew attempted to deploy a towed array, but the sea state caused the array to be buffeted in the surface waves, even at the greatest achievable depth. Additionally, deploying and recovering the large, cumbersome and heavy array on the moving vessel raised safety concerns. For data quality and safety, the crew decided to only use the Cetacean phone for the remainder of the recordings.

Thurs 03DEC2020 – Friday 04DEC2020

Local/GMT

- 0004/0504: Turned off vessel engine
- 0852/1352: Tanker passed 1nm in front of vessel
- 0907/1407: Generator turned on
- 1007/1507: Cetacean recovered to verify recording
- 1009/1509: Cetacean placed back in water
- 1220/1720: Turned off vessel engine
- 1530/2030: Cetacean and CTD retrieved
- 1730/2230: SubSeaSail Launched with Cetacean research hydrophone
- 1740/2240: SubSeaSail Rerouted to Charleston

The crew continued to sail and collect recordings with the CTD and Cetacean device for majority of Thursday, December 3rd. Reviewing the weather forecasts, it was decided that we needed to return to Charleston to wait out a building storm. Since the sea state did not permit us to remain out, the crew outfitted the autonomous sailing platform, SubSea Sail, with the Cetacean device, set up its transit to the Charleston buoy and deployed it when we needed to depart the research area for port, so it could continue to record data during the storm. The recording schedule is also shown above in Table 1.

Friday 04DEC2020

Local/GMT

- 1400/1900: Docked back in Charleston until storm passes.

As shown in Figure 12, Friday December 4th had average wave height of 1.8 meters and winds averaging 10 knots, Figure 11 at the location of the NDBC buoy, but closer to Charleston, the marina weather station recorded average wind speeds of 20kt, with gusts to 40 kts. The crew stayed on the boat, docked in the marina for the night while monitoring the SubSea Sail's location.

Saturday 05DEC2020

Local/GMT

- 1447/1947: Engine started
- 1500/2000: Shove off from dock
- 1511/2011: Refuel
- 1520/2020: Transiting to SubSeaSail coordinates for retrieval

In the morning of Saturday December 6th, the crew reviewed the forecasts and adjusted the cruise plan. There was a small window for us to transit out to retrieve the SubSeaSail and collect recordings from CHB and then make way back to the marina before poor sea states returned. The crew followed the storm out that evening and adjusted mission waypoint coordinates for the SubSeaSail to intersect our transit to CHB.

Sunday 06DEC2020 – Mon 07DEC2020

Local/GMT

- 0330/0830: Recovered SubSeaSail. The sail was not intact but retrieved data recordings for the duration of deployment.
- 0457/0957: Deployed CTD 32°02'.978, 078°36'.577
- 0503/1003: Assembly reached 300' depth
- 0548/1048: Recovered CTD
- 0722/1222: Deployed again near St16: 32°03.558, 078°27.185
- 0742/1242: pull up 32°03.98 078°27.026
- 0755/1255: on board Cetacean recording stopped 32°04.463, 078°26.794
- 0844/0144: Deployed Cetacean at CHB 34°04.450, 78°22.382
- 0854/0144: Deployed Aquarian hydrophone at 4m depth with 45° angle 32°04.770 078°22.276 45db gain 3ft seas 3.5 second roll period
- 0925/0225: Recovered Cetacean: 32°05'.6, 78°22'.112
- 0927/0227: Recovered Aquarian 32°05.752, 078°22'.063
- 1041/1541: Deployed Cetacean 32°08.357 78°37.756
- 1045/1545: Recovered cetacean 32°08.573 078°30.864
- 1055/1555: Recovered AQ 32°08.583 78°30.868
- Note: Cetacean data corrupted, so some data from the above research station was not recovered.
- 1222/1722: Deployed Aquarian/Cetacean/CTD 32°12.201, 078°40.246
- 1224/1724: begin calibration test
- 1227/1727: Cetacean research at 100 meters line out; 32 12.302; 078 40.268 begin 10-minute recording
- 1240/1740: began raising CR phone to approx. 7 meters
- 1248/1748: began active source calibrations
- 1253/1753: active source calibrations terminated
- 1254/1754: Recovered Aquarian/Cetacean/CTD
- 1338/1838: Deployed Aquarian 32°14.516 078°45.375
- 1339/1839: Deployed Cetacean/CTD 32°14.531 078°45.374
- 1355/1855: Recovered Aquarian/Cetacean/CTD 32°14.653 078°45.378
- 1454/1954: Deployed Aquarian/Cetacean/CTD 32°3217.155 078°51.214
- 1456/1956: Cetacean and CTD at 100 meters line out
- 1507/2007: Recovered Aquarian/Cetacean/CTD 32°17.180 078°51.264
- 1508/2008: Made way back to Charleston due to weather.

The crew was able to recover the SubSeaSail the morning of Monday December 7th. It had a missing sail, but the Cetacean device was still attached, and data was recovered. The crew took a

short opportunity to rest while transiting to CHB. Near arrival to CHB, the recording devices were prepared, and samples collected by the CTD, Cetacean and/or an Aquarian research phone. Additional recordings and accompanying CTD casts were done at CHB and along the leg while transiting back to Charleston while time permitted. Some of the recordings from the Cetacean device were corrupted and not able to be used, but at most of the locations we were able to obtain recordings with the Aquarian phone. The recording schedule for all files that were not corrupted are included in Table 1 above. Monday evening the crew collected all recording devices and made transit back to Charleston marina on both engine and sails.

Tues DEC082020

Local/GMT

- 0200/0700: Docked back at Charleston Sailing School Marina
- 1200/1700: Departed for Clarksburg, MD

On Tuesday morning, the crew arrived back at the Charleston marina where they slept on the boat, debriefed with the captain, downloaded all the data, packed up the trailer with all the equipment and departed back to Maryland.

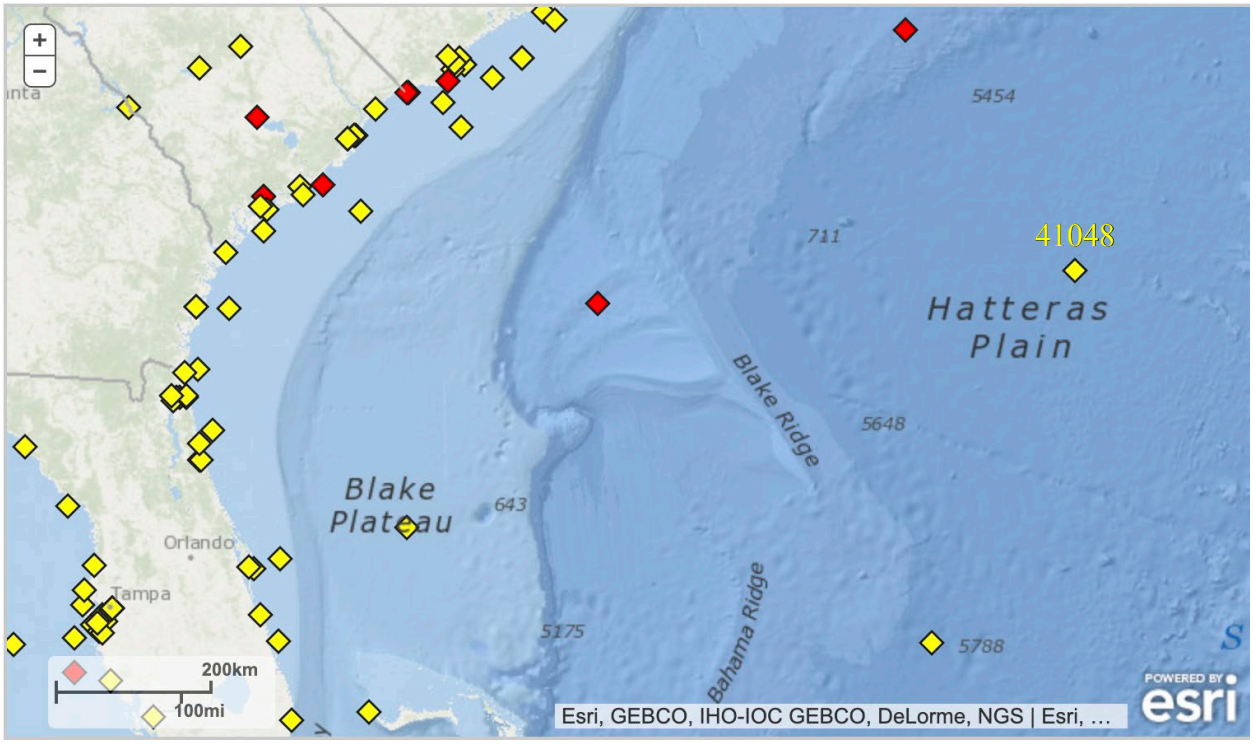

Figure 10: Map of NDBC buoys IVO the experiment area; figures 11 and 12 come from NOAA station 41048.

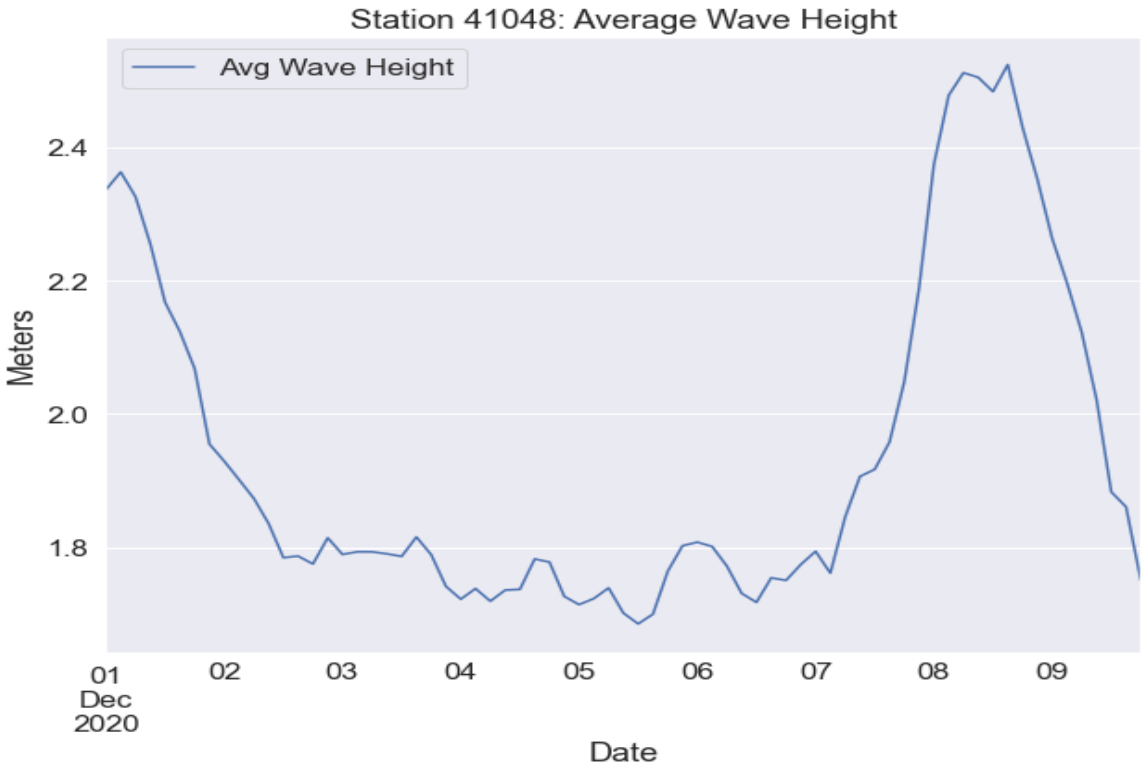

Figure 11: Average Wave Height for the duration of cruise recordings from NOAA station 41048.

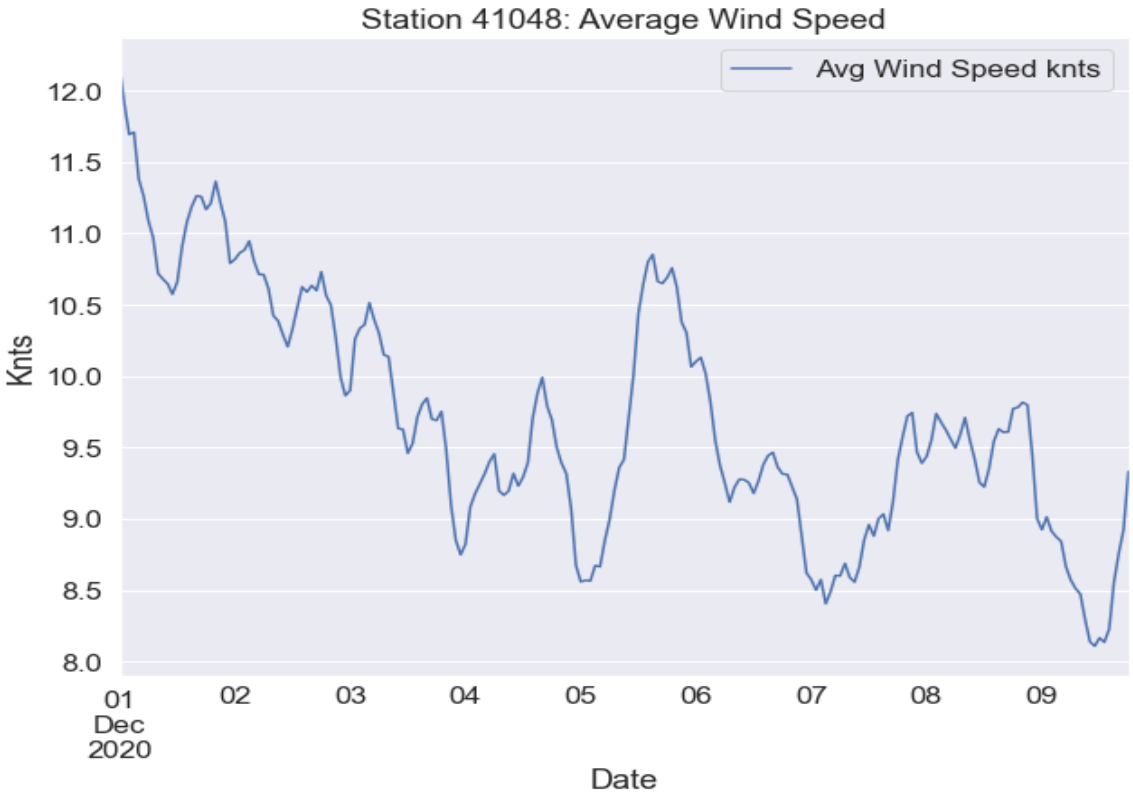

Figure 12: Average wind speed for the duration of cruise recordings from NOAA station 41048.