ADEON Sail Cruise #1
May 30, 2018 – June 3, 2018

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Sail Cruise Synopsis

The ADEON Sail Cruise of June 2018 aboard the S/V Veritas was conducted from May 30 through June 3, 2018. The boat sailed out of and returned to the pier in Norfolk VA. A towed array measurement was made around and between the Hatteras (HAT) site and the Virginia Canyon (VAC) site. The quality of the array data was excellent. Due to very low winds, there were regular times the boat needed to be under power, which contributed own-ship noise to the ambient soundscape. In spite of this low-frequency contamination, we believe the cruise was a resounding success. Both of the technical objectives of for this data set were achieved: The data will permit the determination of the bearing dependence of the sound field near the two receivers as well as between them; the array data will also provide the opportunity to estimate the sound field temporal and spatial correlation lengths (up to distance between HAT and VAC).

ADEON Sail Cruise Mission

In order to better understand the spatial structure of the soundscape field, the ADEON team proposed a set of mobile horizontal line array (HLA) measurements, to coincide with the ADEON data recovery cruises. With a mobile array system, the sound field between two moorings can be collected, and compared with the recordings at each lander. This measurement will give us an estimate of the horizontal correlation length of the ocean soundscape. This is an important scientific issue as we seek to understand the ability of a single measurement to extrapolate in space. Recordings from a towed array also provide the horizontal directionality of the sound field, an important observation space for binaural animals as well as navy sonar systems. The original plan of deploying an array from a glider was deemed too high risk, with the possibility of a forced re-routing of the research vessel to recover a drifting glider. A separate sailboat cruise was devised in place of a glider deployment. There are four planned sailboat cruises, with the objective of measuring the horizontal correlation length for several pairs of landers. The sailboat cruises are scheduled to be just before recovery cruises to help in the analysis, as lander data is returned to shore and processed shortly after the sailboat cruise data is collected.

Boat, Captain, and Crew

The sailboat was a Hunter 49. The “Veritas” has an overall length of 49’ 11”, a beam of 14’ 9”, it displaces 32813 pounds with a shoal draft of 5’ 6”. The mast height is 68.5 ft. The boat is outfitted with state of the art Garmin navigation and radar systems. The boat sleeps 4 comfortably and has 3 heads.

Captain Lillian Cardenas was chosen to captain the cruise. She has 15 years of sailing experience with an excellent safety record. Because of size constraints, there was no room for any other dedicated crew persons. Mr. Abbot (Senior Scientist) and Mr. Kmelnitsky (Senior Engineer) were chosen to assist with the sailing duties. Both have extensive sailing experience as well as experience with the science equipment. Mr. Murray (Chief Scientist) has 28 years of sea-going ocean research. Since he has no formal sailing experience, he did double duty as night cook.

Figure 1: Sailboat "Veritas"

Cruise

The ship left Virginia Beach on May 30, 2018 and arrived back on June 3, 2018. The first 18 hours were spent motoring to ADEON Point HAT. The majority of the transit to Point HAT was through shallow water, and since the acoustic array had not been tested on this boat, it was decided not to deploy the array until deeper water was reached, just before the waypoint. The array was deployed on May 31 and we sailed around Point HAT collecting data. Fighting the currents and low winds prevented an easy sail through the point, so instead we recorded data at stations 20, 15, 10, 5, 0 nautical miles from Point HAT and drifted for 30 minutes to an hour at each station.

The boat was then sailed west of Point HAT into deeper water to record the noise there. A data recording glitch forced the boat back to Point HAT to re-do the sail across the Point and out in range to 20 miles. That was successful.

During our time at Point HAT, very little shipping or biologics were observed. Sea state was 0 or 1 the entire time at that waypoint. A little rain fell and its time is noted in the log. After 20 miles, the wind died down and the current was not favorable. No headway was made for hours before it was decided to pull the array on board and motor up to near ADEON Point VAC.

Once the boat neared Point VAC, the array was redeployed and recording commenced. Low winds meant the boat did the 20, 15, 10, 5, 0 mile station drifting again. Once we were done at Point VAC (0 mile station), the boat sailed west into deep water and noise was recorded off the shelf.

The wind picked up after that and the boat was able to sail from North of Point VAC thru the waypoint and 20 miles South. We decide to sail South just off the shelf in deeper water, since on the way up from Point HAT, we were on the shelf on the shallow side.

At Point VAC there were plenty of ships, biologics, and rain. Sea state was still around 0 or 1 most of the time with one night being choppy (sea state 2 or 3). The Veritas sailed south until the winds died down. The captain suggested we head back to port, since our fuel was running a bit low. The boat used more fuel than was estimated due to the low winds and the necessity to motor to waypoints.

The ambient noise collection required minimal ship noise, so the engines and generators were run only when needed. Even the flow noise across the towed acoustic array needed to be minimized, so the ship speed was kept below 5 knots when possible. Because of the electronic nature of the data recording equipment, laptops were used to record the data. By minimizing the laptop's power, hours of continuous recording was possible.

GPS

GPS recording was done using a portable (USB) Garmin antenna connected to a Windows laptop. The ASCII NMEA stream was captured and saved in a terminal window. The GPS data logs the data record about once a second. Unfortunately, it was determined after the test, that the laptop, when running on battery, suspends itself after a few minutes of inactivity from the keyboard or mouse. When the computer is woken up, the GPS logging would continue. Every few hours, the crew would check the laptop – waking it up, and it looked like it was logging the data continuously. But there are gaps, sometimes hours long, in the GPS data logged by the laptop.

Luckily, the captain logged the ship GPS from which the GPS for most of the sail cruise was obtained from the vessel Navionics GPS feed.

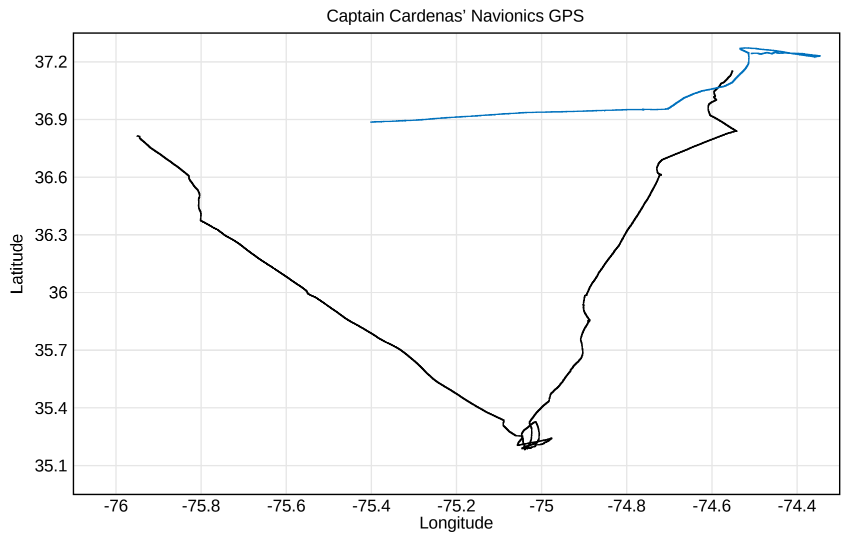

Figure 2: GPS positions of Veritas showing the array tow path between HAT and VAC (black line) and the time after the array was recovered at VAC during the return leg (blue).

CTD

OASIS supplied a Richard Brancker Research Concerto CTD to conduct the Temperature / Salinity vs Depth measurements. Because the sailboat was not a true research vessel, there was little room for a good deployment / recovery system for the CTD. The CTD was deployed by hanging it over the side and letting it soak for 5 minutes. It was then lowered by hand to depth (estimated by the crew). An electric winch was used to bring it up, while a crew member coiled the rope neatly for the next deployment. For this cruise, the rope was only 400 ft. While under sail, the CTD did not have sufficient weight to sink properly, and some CTD casts showed a very shallow maximum depth.

Because of the deployment / recovery scheme, all three OASIS crew needed to be present for each CTD cast. Further, since the acoustic array was being towed behind the boat, sometimes a CTD cast would not be done for fear of it being tangled with the array. In all, 7 CTDs were conducted.

The CTDs show a good contrast in water properties from the ADEON Point HAT site and the ADEON Point VAC site. The downcast data matched with the upcast data, so the water properties that were measured can be assumed to be correct. Analysis will compare the CTD data with historical (World Ocean Atlas) data as well as downloaded HYCOM / NCOM data for the dates of the cruise.

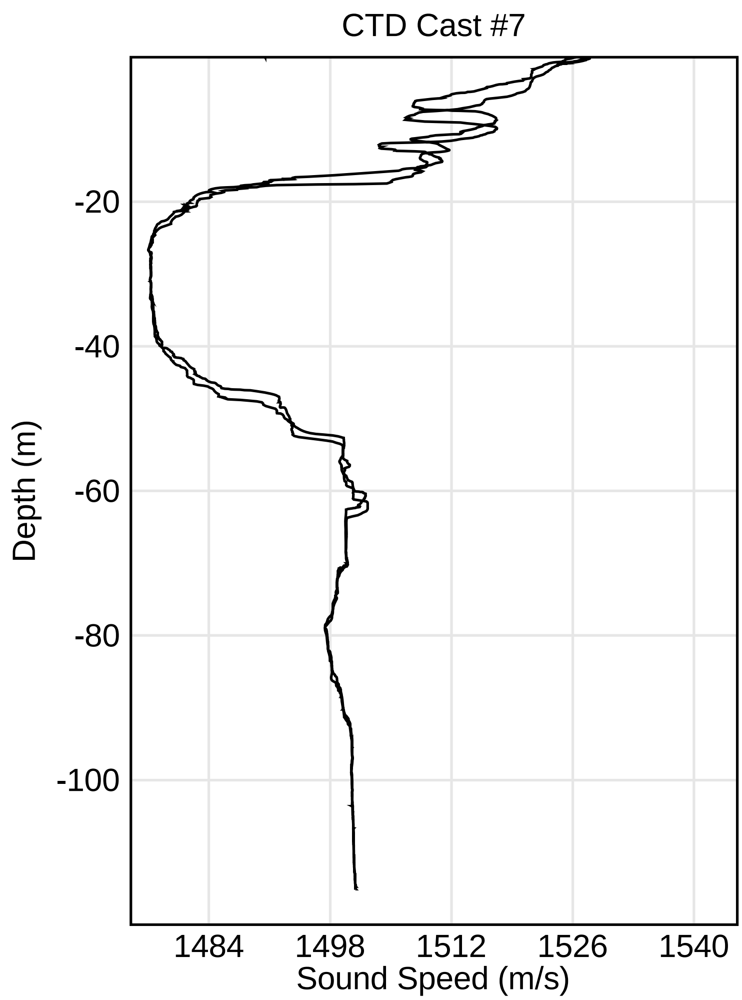

Figure 3: CTD Cast Number 7 (near Point VAC). Both the downcast and upcast data is plotted

For future sail cruises, a better CTD deployment system should be used, including heavier weights and a spool for the rope.

<u>Acoustic Data</u>

The acoustic data was collected using OASIS' OTA3 array. The OTA3 array is a horizontally towed array of 16 acoustic elements and 2 non-acoustic sensors (not functional this trip). Each hydrophone samples at 3125 Hz but low passed filtered at 1000Hz. The data has variable gain and is digitized using a 16 bit A/D converter. The array is thin and light, easily deployable, and uses very little power (< 2 watts). The array is cut for 1000Hz (total length is about 11m), uses a 10 m leader cable, and was attached to the boat with another 75 m tow cable that included fairing to reduce strum. The array was also harnessed to the stern using 2 bungee cords to reduce the effects of heave. By sailing under 5 knots, water flow noise across the elements was be minimized.

The data coming up from the array were broadcast via UDP to a Linux laptop. The raw data packets that were received from the array were packaged into 1 minute binary files and stored onto the laptop file system.

Over 48 hours of good data were recorded. Figure 4 shows the data continuity. The small gaps were because of various recording glitches. The first glitches were due to the Linux laptop being suspended when the laptop was on battery power, this was quickly diagnosed and corrected. Another data gap was when the battery of the laptop died. The big gap was during the transit from ADEON Point HAT to ADEON Point VAC. There was no wind to sail efficiently, so the array was recovered and the boat was motored up to ADEON Point VAC, where the array was redeployed.

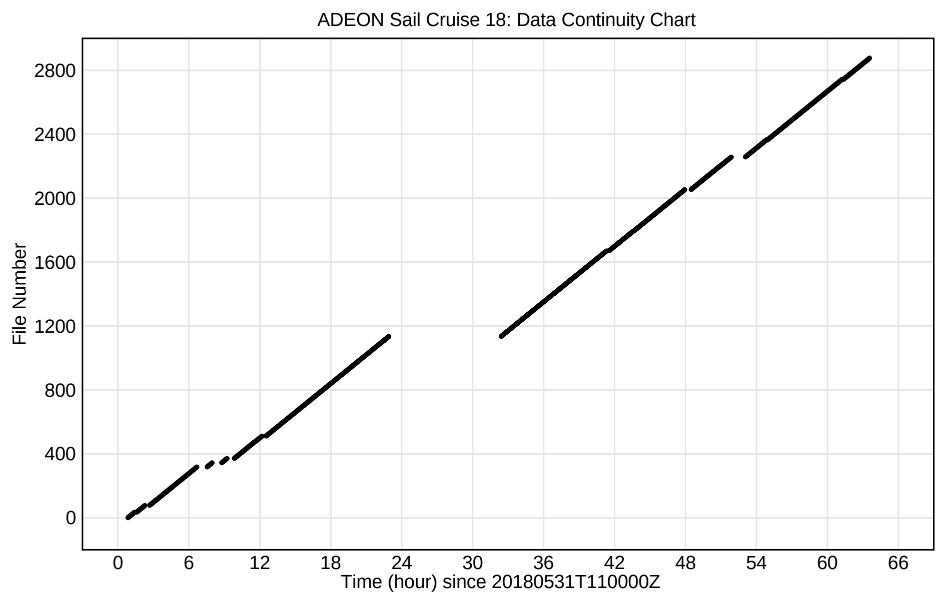

Figure 4: Acoustic data continuity

Figure 5 shows a 1 hour spectrogram of a single element. The first half hour the ship was running its engine and generator. The second half hour they were off. The units of the plot are dB re $1\mu Pa^2/Hz$.

Figure 6 shows a bearing time record (BTR) for one hour of data processed using the 950 to 1000Hz bands. No array element localization was done, the array was assumed to be straight.

Both Figures 5 and 6 show that the initial looks at the data show a very clean, usable data set, with little flow noise or any contamination (besides the engines and generator when they were on).

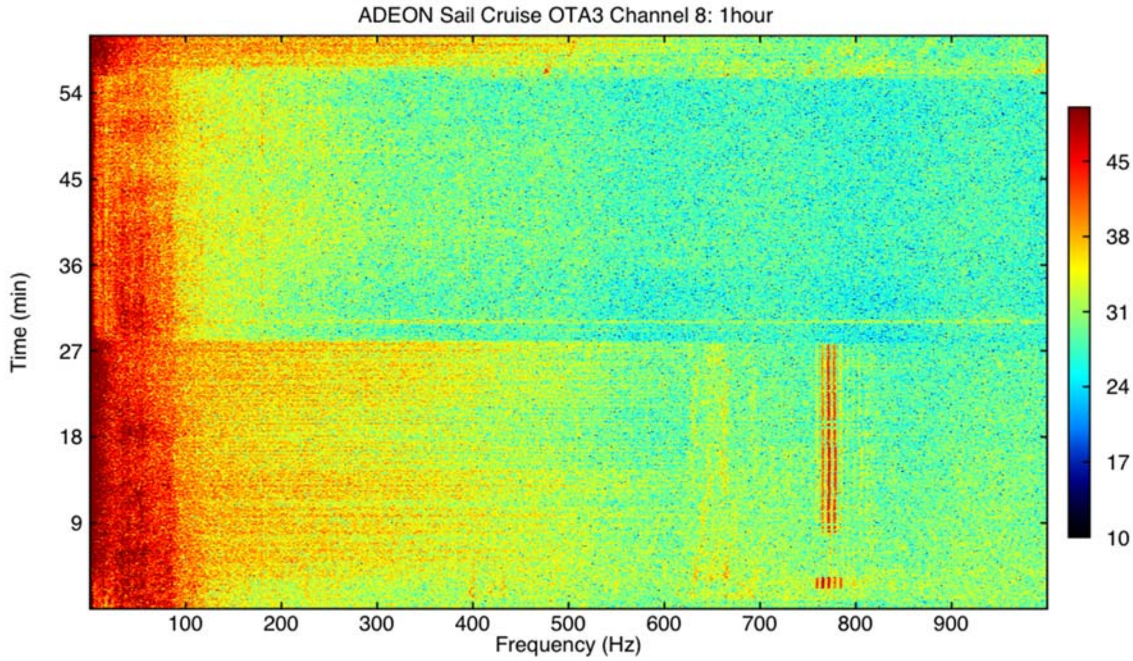

Figure 5: One hour, single element spectrogram

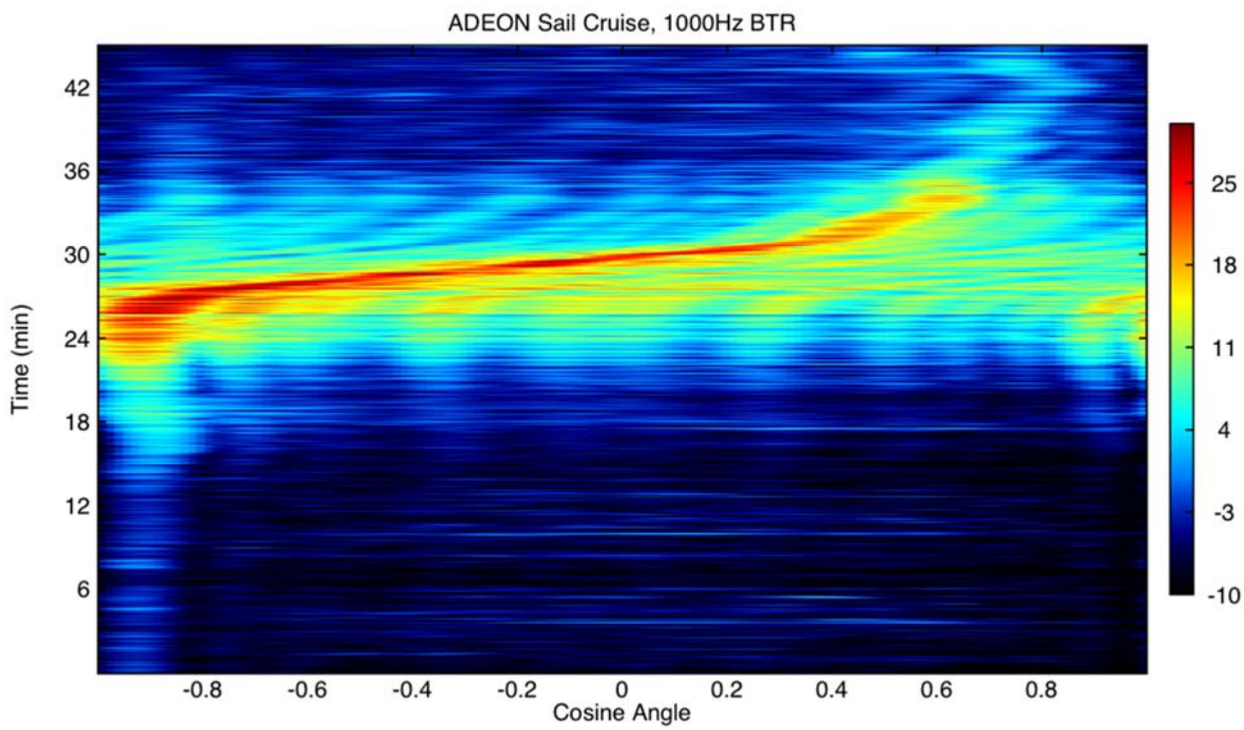

Figure 6: One hour 1000Hz Bearing Time Record (BTR) during a Container ship closest point of approach

Lessons Learned

Lessons learned include:

1) The need to bring (or confirm the need for) a battery back-up power for the recording computer while the ship is under sail. When the engines of the vessel are shut off for reduced own-ship noise, the ships power is minimal.
2) A crew of 4 was the minimum required and although successful made for a very strenuous schedule, limiting the number of days at sea. For longer legs, a larger crew and boat may be helpful.