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Cruise Plan for USGS Field Activity 2018-051-FA: Intermediate-Period Ocean Bottom Seismometer Deployment to Record Ambient Seismic Noise on the U.S. Atlantic Margin

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U.S. Department of the Interior
U.S. Geological Survey

Contents

Overview

The objective of this cruise is to deploy six intermediate ocean-bottom seismographs (OBS) on the continental slope of the U.S. Atlantic margin in water depths of ~2000 m (
Figure 1). The deployments will take place from aboard the Research Vessel (R/V) Connecticut, sailing from and returning to Woods Hole, Massachusetts on October 16 to 19, 2018. The primary objective of the experiment is to record ambient seismic noise, which will be used to measure sediment shear wavespeeds. Sediment shear wavespeed is a proxy for shear strength, which the key parameter controlling submarine slope failures (i.e., landslides). The array will be deployed on a block of un-failed sediment on the lower slope adjacent to a recent slide scarp.

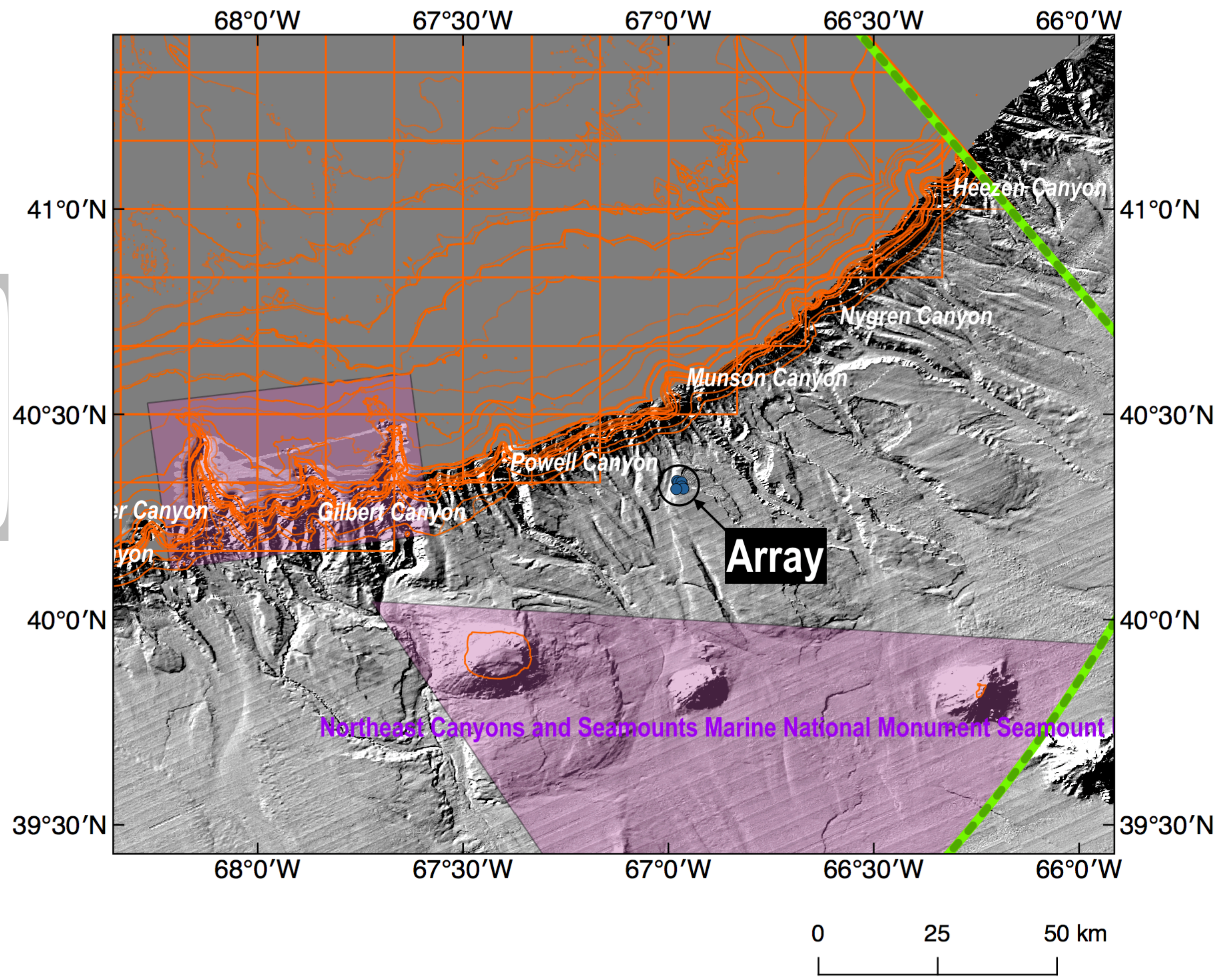


Figure 1. Map showing the location of the OBS array on the U.S. Atlantic margin. National Marine Protected Areas (NMPA) are shown in purple. Essential Fish Habitat (EFH) are shown in orange. The U.S. Exclusive Economic Zone (EEZ) is marked by the green dashed line. The array site is outside of all NMPAs and EFH and within the U.S. EEZ.

Experiment design and instrument parameters

Instrument recording specifications are listed in Table 1. See Appendix E for notes on array design considerations.

Table 1. Recording specifications for the ARRA OBS on 2018-051-FA.

Parameter	Value
Sample rate for seismometer channels	100 Hz
Sample rate for DPG channel	100 Hz

Personnel

Science Party

Nathan Miller, Chief Scientist, USGS
Wayne Baldwin, Scientist, USGS
Alan Gardner, Lead OBS engineer, WHOI
Brian Kelly, Technician, WHOI
Jared Schwartz, Technician, WHOI

Ship's Officers and Crew

R/V Connecticut will provide all ship's officers and crew.

Equipment

Broadband OBS

The six OBS to be deployed are ARRA instruments designed and built by the Woods Hole Oceanographic Institution's (WHOI) OBS Laboratory. The instruments carry a Trillium Compact intermediate-period seismometer and a Cox-Deaton-Webb Differential Pressure Gauge (DPG). Data from these sensors is recorded using a Quanterra® Q330 datalogger and Quanterra® Packet Baler 44. Timing is provided by a Symmetricom® chip-scale atomic clock. The data logger, baler, and clock are housed in one aluminum-cylindrical-pressure housing, and lithium batteries are housed in a second similar housing. Flotation is provided by syntactic foam. The complete instrument package is designed for deployments in up to 6000 m of water. See Table 2 for physical specifications and Figure 2 for a schematic of the instrument package. OBS configuration parameters for this experiment are listed in Table 1.

Table 2. WHOI ARRA broadband OBS physical specifications

Characteristic	**Value**

Characteristic	Value
Total weight in air (Deployment)	544 kg (1,200 lb)
Total weight in air (Recovery)	454 kg (1,000 lb)
Length	0.81 m (32”) without sensor deployment arm 1.62 m (64”) with sensor deployment arm
Width	1.32 m (52”)
Height	0.78 m (31”) without lifting bail 1.14 m (45”) with lifting bail
Strobe	Yes
Radio-direction finding (RDF)	Yes
Flag	Yes

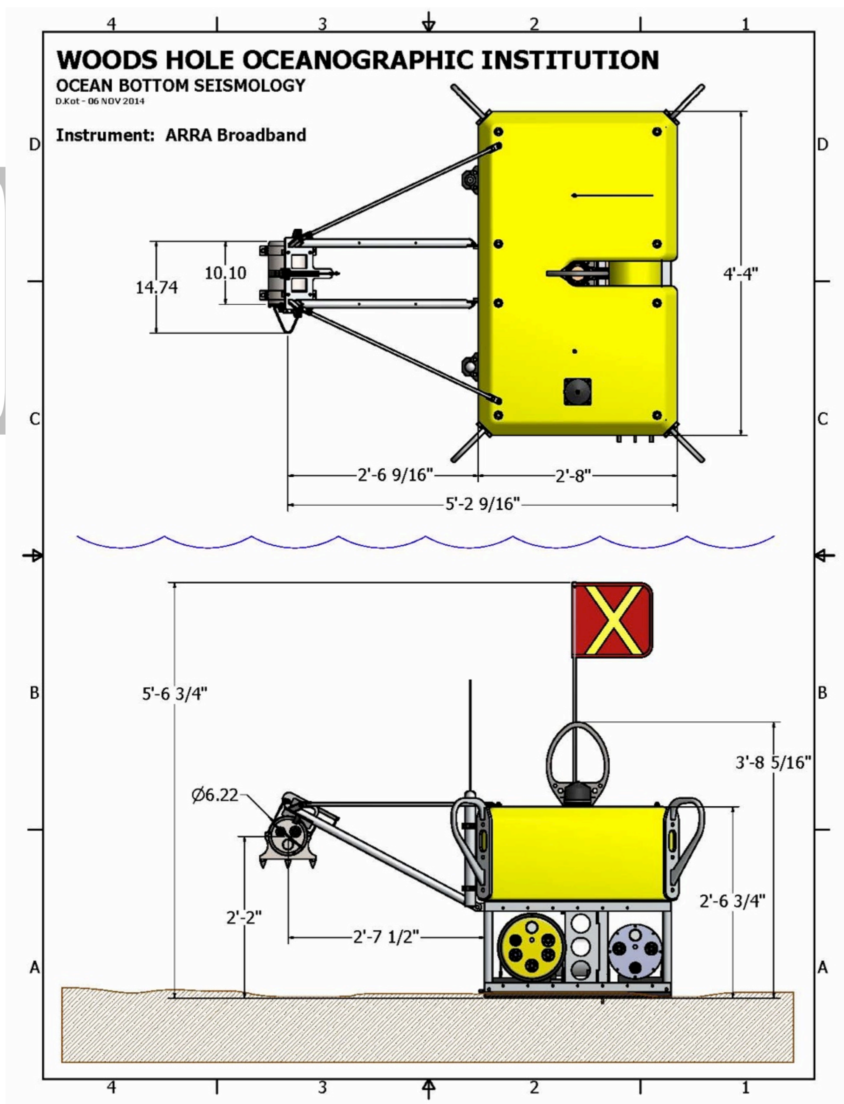


Figure 2. Top (above) and side (below) view of the WHOI ARRA OBS.

Ship

The six OBS deployments will be made from the R/V Connecticut (Table 3, Figure 3).

Figure 3. R/V Connecticut after recent lengthening to 27 m (90 ft). Image from https://www.marinetechnologynews.com/news/lengthened-research-vessel-556363.

Table 3. General specifications of R/V Connecticut.

Characteristic	Value
Length overall	27 m (90 ft)
Beam	8 m (26 ft)
Cruising speed	16.6 km/hr (9 kts)
Berthing	10 – 12 science berths, 5 – 6 crew berths
Work deck area	58 m^2 (625 ft^2)
Dry lab area	18 m^2 (200 ft^2)
Deck crane SWL	4400 kg (9700 lbs) at 4.6 m (15 ft) extension; 2200 kg (5000 lbs) at 7 m
A-frame SWL	7200 kg (16000 lbs)
Wet lab area	18 m^2 (200 ft^2)
Sonar well	0.51 m (20 in.) diameter well pipe located amidships with access to dry lab

Lab space

Computer equipment will be set up in the ship's dry lab. Equipment will consist mainly of laptop computers and a ~2x2x2 ft lab rack. Cabling will connect the computers to the OBS while on deck. An acoustic deck box will also be set up in the dry lab and connected either to a well-mount transducer (preferred option) or to a transducer that will be deployed over the side only when the ship is stationary (back-up option).

An XBT system will also be set up in the dry lab. This system will include a second lab-rack computer and an XBT launcher cable running to the ship's rail.

Deck space

The six OBS will be staged and as ready for deployment as possible prior to departing the dock. Each instrument will require ~6 x 6 ft of deck space. There will also be one wire basket and other support gear on deck.

Berthing

The ship will provide berthing for up to 6 science party members. All members of the science party are male.

Lifting capability for loading and deploying OBS

The OBS weigh 1,200 lbs each with anchors attached. The OBS will be loaded onto the ship using the ship's deck crane, which has a safe-working load (SWL) of 9,700 lbs at 15' and 5,000 lbs at 23' extension.

OBS deployments can take place using the ship's deck crane or the A-frame. The A-frame has a 16,000 SWL. A decision about which to use will be made by the ship's crew in consultation with the OBS technicians.

Hull-mount transducer

Acoustic communications between the OBS and the ship will be made using an Edgetech 8011A/M deck box and a transducer. The transducer will either be mounted in the ship's sonar well (preffered option) or deployed over the side (back-up option). If the over-the-side option is used, the transducer will be hand deployed/recovered and will only be in the water while the ship is stationary. The WHOI OBS group will provide two transducers so that either option could be used as needed.

Radio-direction finding (RDF)

The WHOI OBS group will supply a hand-held radio-direction finding (RDF) receiver for use as needed on recoveries.

Navigation data

R/V Connecticut will provide access to GPS NMEA strings.

XBT system

USGS will provide an expendable bathy-thermograph (XBT) system for measuring water-column sound speeds for use in the acoustic surveys.

Hazardous materials

The WHOI OBS group will bring the following hazardous materials on board:

1. Primary Lithium Metal Batteries contained in equipment
2. Alkaline Batteries contained in equipment
3. Denatured Alcohol
4. Paint Thinner
5. Silicon Lubricant (aerosol), 3M

Material-safety data sheets (MSDS) will be provided to the ship's officers upon arrival.

Plans and Procedures

Deployments

The planned drop sites for the OBS are listed in Table 4. Sites were chosen using recent multibeam bathymetry data gridded to 100 m resolution from Andrews et al. [2016]. All sites are shallower than the maximum 6000 m depth rating of the OBS, and no point deeper than 6000 m is known to exist within a radius equal to the water depth of each site. Following deployment, an acoustic survey will be conducted using four locations at a distance of one-half the water depth from the drop location. Detailed maps are included in Appendix A, and Appendix B lists all waypoints, including survey points.

Table 4. OBS deployment sites

Point	Longitude	Latitude	Water depth (m)[1]
AN1	W 66° 58.8862'	N 40° 19.0440'	2046
AN2	W 66° 57.8371'	N 40° 19.1156'	2035
AN3	W 66° 58.1189'	N 40° 19.4561'	2006
AN4	W 66° 58.1210'	N 40° 20.0583'	1983
AN5	W 66° 58.5887'	N 40° 20.0237'	1984

AN6	W 66° 58.7769'	N 40° 20.2506'	1975

[1]Water depths from Andrews et al. [2016].

The final deployment procedure, including crane operations and communications between the bridge and deck, will be worked out between the WHOI Technicians and the ship's officers and crew. The WHOI group typically uses a brailer release and two to three taglines to secure and stabilize the instruments during hoisting. The WHOI group will supply the brailer releases and taglines. Detailed below is what a typical deployment looks like.

1. *OBS is staged (craned) at the deployment area.
2. *OBS is assembled (weather dependent).
3. *Complete preliminary check out procedures and acoustic checkout.
4. Arrive at Site Location. Check water depth.
5. Connect seismic senor to OBS.
6. Complete final check out procedures.
7. Crane OBS over the side.
8. Release at surface
9. Confirm touchdown (stay on station until confirmation that OBS has reached the seafloor)
10. Complete acoustic survey. For each of four survey locations:
    a. **Transit to survey point
    b. **Record acoustic range to instrument
11. Disable instrument
12. Transit to next site and repeat

*Steps 1-3 can occur prior to arriving at the site location, depending on weather conditions.
**If well-mounted transducer is used, acoustic survey can occur underway. If over-the-side transducer is used, the ship will stop and hold station at each survey location.

This is a brief overview. The order of the steps may vary due to weather. In good weather, many preparations can be completed while underway.

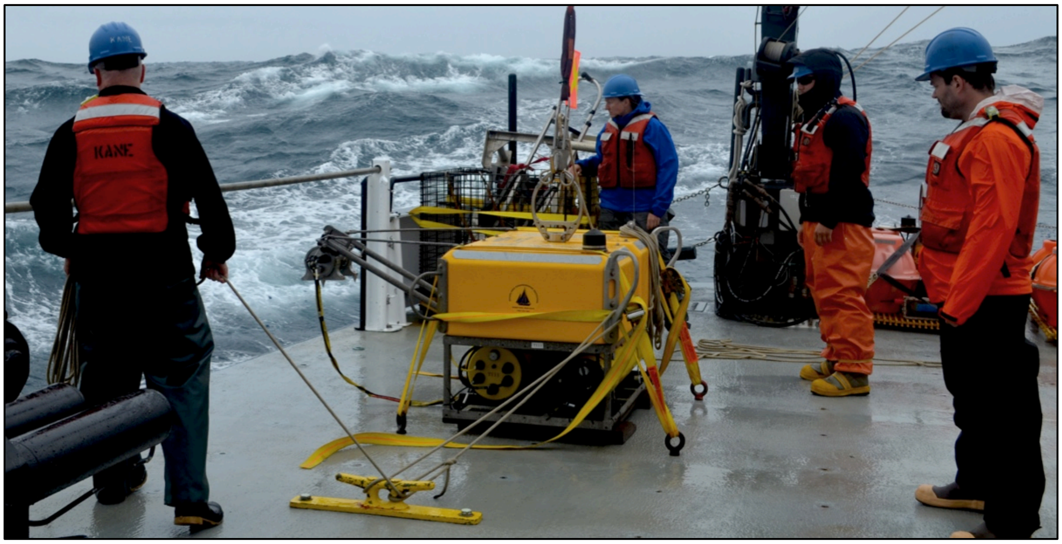


Figure 4. WHOI ARRA OBS readied for deployment.

Recovery

There are no recoveries planned for this cruise. The WHOI OBS team will, however, have recovery poles, hooks, and related equipment for recovering instruments, in case a recovery is required. A recovery would proceed as follows:

1. Locate the instrument using:
    a. Visual (Day-time - Flag / Night-time - Flasher and Solas Approved Retroreflective Tape)
    b. Radio (RDF)
2. Bring ship alongside instrument
3. Hook the OBS and attach lifting line and taglines
4. Lift instrument out of the water
    a. NOTE: Sensor may be hanging ~5' below the OBS frame.
5. Land on deck and secure

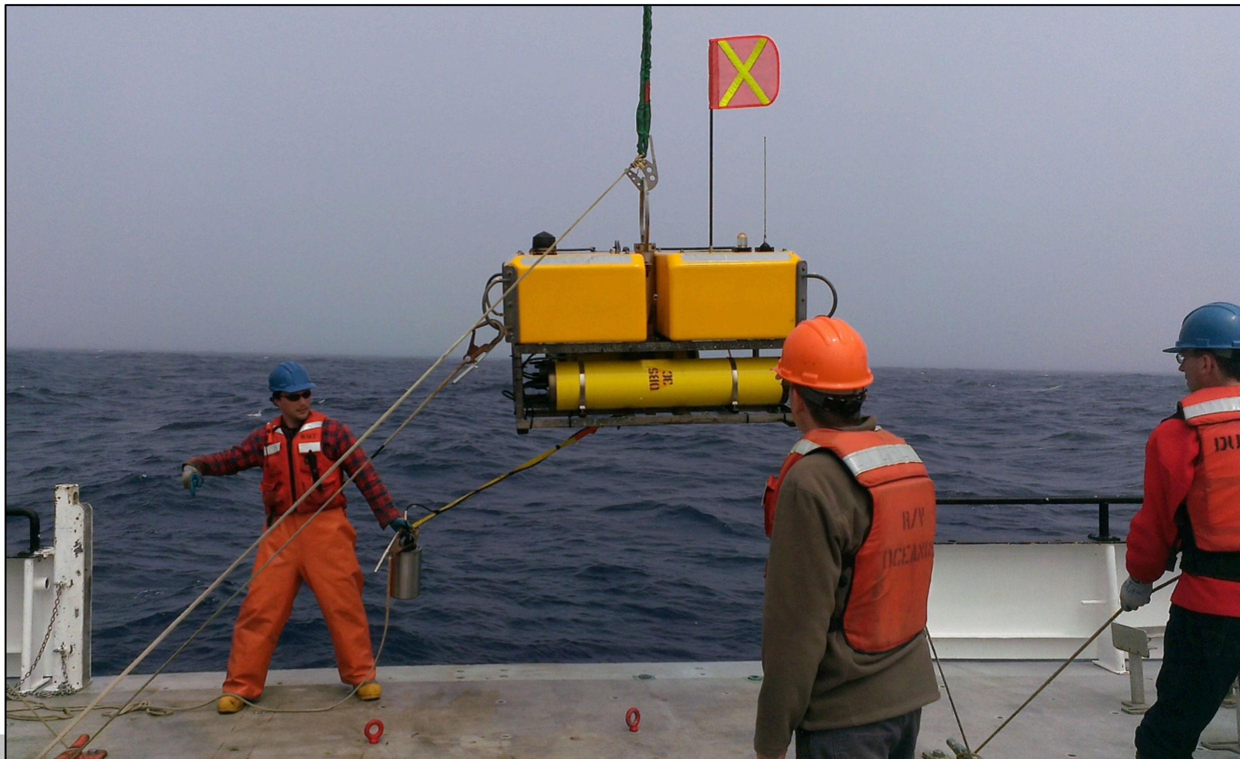


Figure 5. Recovery of a WHOI ARRA OBS.

Cruise timetable

A general cruise timetable is given in

Table 5, and a detailed nominal timetable including all waypoints is included in Appendix C. These timetables were developed assuming a 9 kt ship speed over ground, 1.5 hours for onsite-preparation and deployment of each OBS, a 48 m/min descent rate for the OBS, and 15 min onsite time for each acoustic survey location.

Table 5. Summary of the cruise timetable.

Date(s)	Activity
2018-10-16 14:00	Mobilize at Iselin Dock, Woods Hole Oceanographic Institution
2018-10-16 20:00	Depart Woods Hole
2018-10-17 to 2018-10-18	Deploy and survey OBS
2018-10-19	Arrive Woods Hole and demobilize

Regulatory compliance

National Environmental Protection Act

A USGS National Environmental Protection Act (NEPA) compliance checklist was performed approved for this experiment (Appendix D).

National Security/Department of Defense oversight

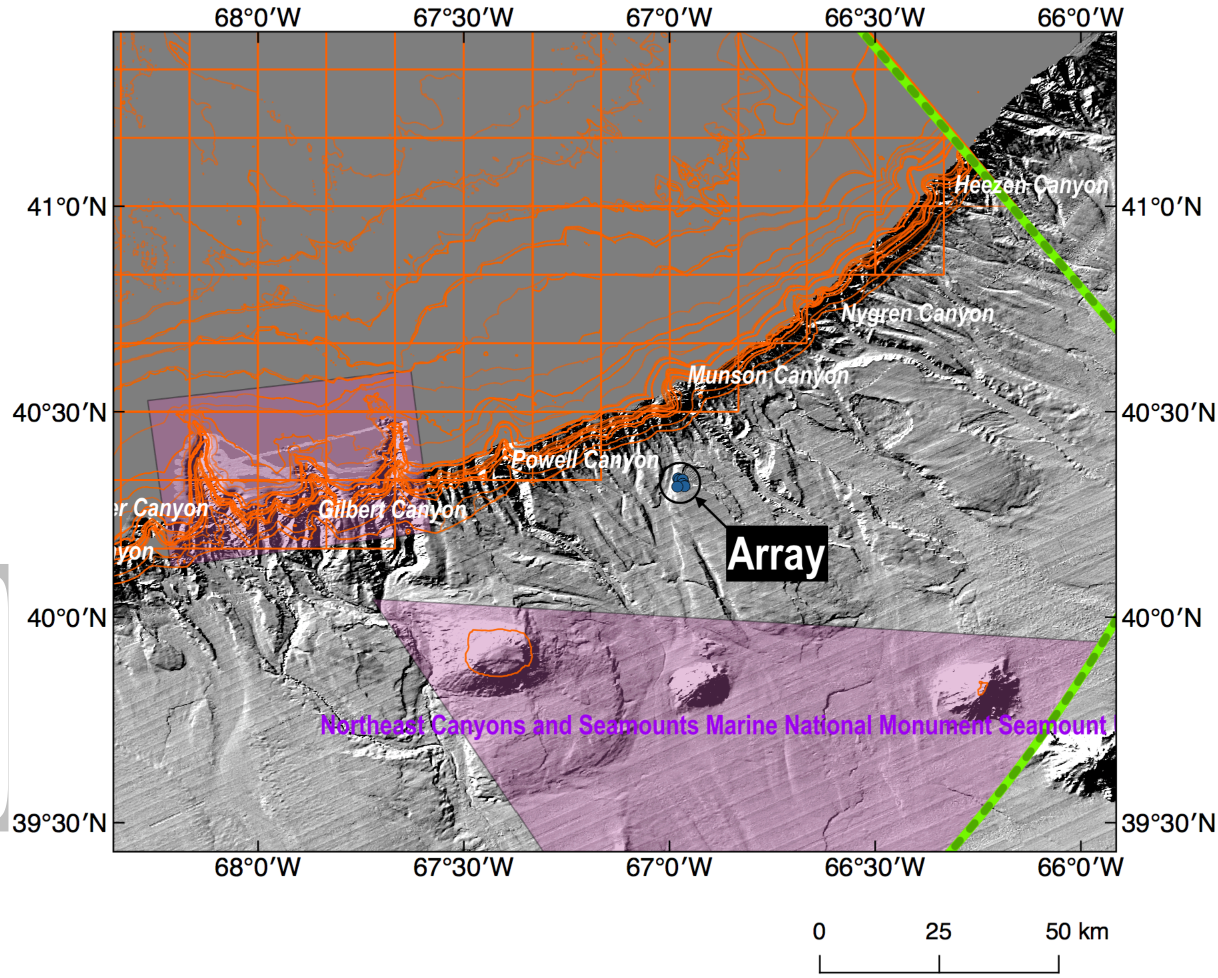
The U.S. Navy was notified of the deployment location, planned experiment duration, and instrument specifications. Contact John Collins, director WHOI Ocean Bottom Seismograph Laboratory, for more information.

References

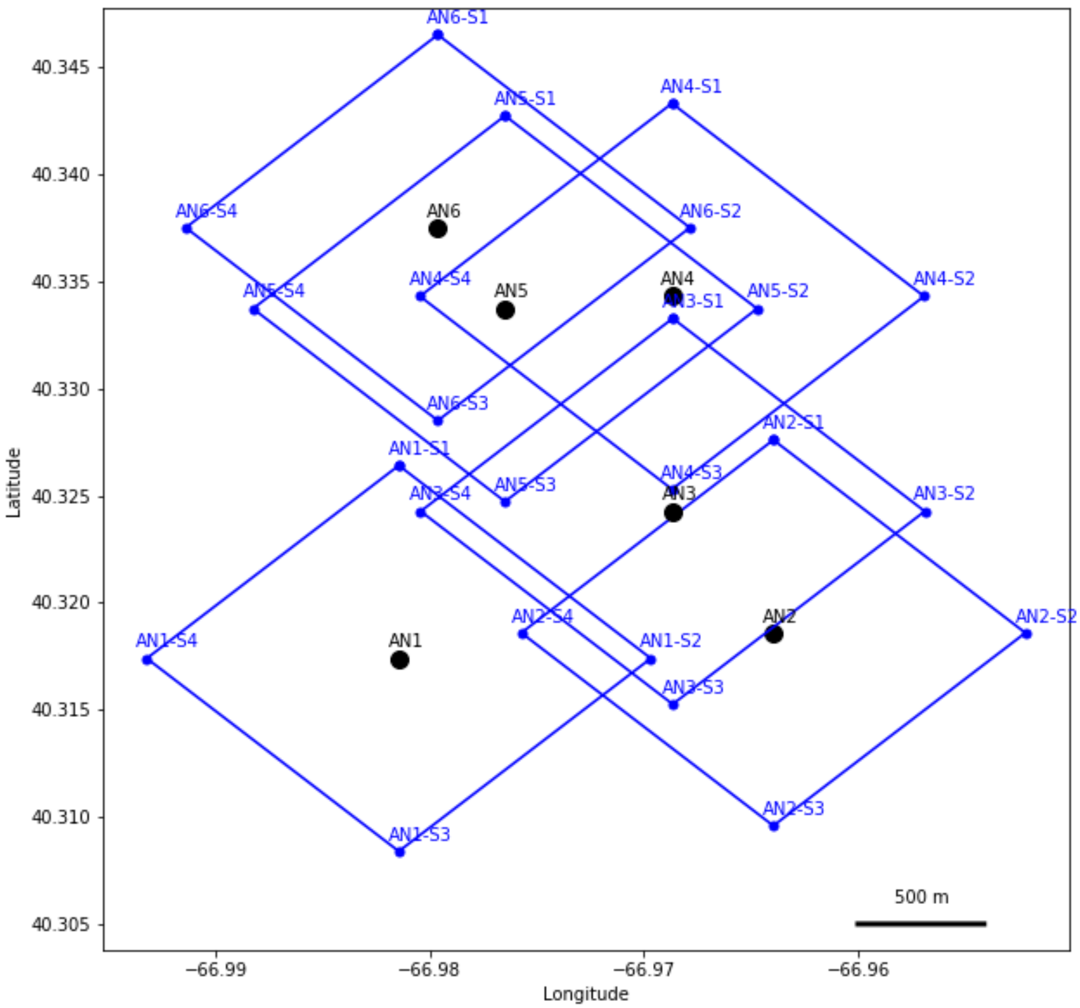
Andrews, B.D., Chaytor, J.D., ten Brink, U.S., Brothers, D.S., Gardner, J.V., Lobecker, E.A., and Calder, B.R., 2016, Bathymetric terrain model of the Atlantic margin for marine geological investigations (ver. 2.0, May 2016): U.S. Geological Survey Open-File Report 2012–1266, 19 p., 1 pl., http://dx.doi.org/10.3133/ofr20121266.

Appendix A: Deployment plan maps

Overview



Waypoint map



Black circles are deployment locations. Blue circles are points for the acoustic surveys.

Appendix B: Waypoints

Point	Longitude	Latitude	Water depth (m)
AN1	W 66° 58.8862'	N 40° 19.0440'	2046
AN2	W 66° 57.8371'	N 40° 19.1156'	2035
AN3	W 66° 58.1189'	N 40° 19.4561'	2006
AN4	W 66° 58.1210'	N 40° 20.0583'	1983
AN5	W 66° 58.5887'	N 40° 20.0237'	1984
AN6	W 66° 58.7769'	N 40° 20.2506'	1975
AN6-S1	W 66° 58.7769'	N 40° 20.7909'	
AN6-S2	W 66° 58.0708'	N 40° 20.2505'	
AN6-S3	W 66° 58.7769'	N 40° 19.7102'	
AN6-S4	W 66° 59.4830'	N 40° 20.2505'	
AN5-S1	W 66° 58.5887'	N 40° 20.5640'	
AN5-S2	W 66° 57.8826'	N 40° 20.0237'	
AN5-S3	W 66° 58.5887'	N 40° 19.4833'	
AN5-S4	W 66° 59.2947'	N 40° 20.0237'	
AN4-S1	W 66° 58.1210'	N 40° 20.5987'	
AN4-S2	W 66° 57.4149'	N 40° 20.0583'	
AN4-S3	W 66° 58.1210'	N 40° 19.5180'	
AN4-S4	W 66° 58.8271'	N 40° 20.0583'	
AN3-S1	W 66° 58.1189'	N 40° 19.9965'	
AN3-S2	W 66° 57.4130'	N 40° 19.4561'	
AN3-S3	W 66° 58.1189'	N 40° 18.9158'	
AN3-S4	W 66° 58.8249'	N 40° 19.4561'	
AN2-S1	W 66° 57.8371'	N 40° 19.6560'	
AN2-S2	W 66° 57.1311'	N 40° 19.1156'	
AN2-S3	W 66° 57.8371'	N 40° 18.5753'	
AN2-S4	W 66° 58.5430'	N 40° 19.1156'	
AN1-S1	W 66° 58.8862'	N 40° 19.5844'	
AN1-S2	W 66° 58.1803'	N 40° 19.0440'	
AN1-S3	W 66° 58.8862'	N 40° 18.5037'	
AN1-S4	W 66° 59.5921'	N 40° 19.0440'	

Appendix C: Nominal timetable

Activity	Start Point	End Point	Dist. (km)	Depth (m)	Duration (hr) Transit	Ops	Descent	Total	Time Start	End
MOB	Port	Port	0.00	0	0.000	6.000	0.000	6.000	2015-10-16 14:00	2015-10-16 20:00
Transit	Port	AN1	335.00	0	20.098	0.000	0.000	20.098	2015-10-16 20:00	2015-10-17 16:05
Deploy	AN1	AN1	0.00	2046	0.000	1.500	0.710	2.210	2015-10-17 16:05	2015-10-17 18:18
Transit	AN1	AN2	1.49	0	0.090	0.000	0.000	0.090	2015-10-17 18:18	2015-10-17 18:23
Deploy	AN2	AN2	0.00	2035	0.000	1.500	0.707	2.207	2015-10-17 18:23	2015-10-17 20:36
Transit	AN2	AN3	0.75	0	0.045	0.000	0.000	0.045	2015-10-17 20:36	2015-10-17 20:38
Deploy	AN3	AN3	0.00	2006	0.000	1.500	0.697	2.197	2015-10-17 20:38	2015-10-17 22:50
Transit	AN3	AN4	1.11	0	0.067	0.000	0.000	0.067	2015-10-17 22:50	2015-10-17 22:54
Deploy	AN4	AN4	0.00	1983	0.000	1.500	0.689	2.189	2015-10-17 22:54	2015-10-18 01:06
Transit	AN4	AN5	0.67	0	0.040	0.000	0.000	0.040	2015-10-18 01:06	2015-10-18 01:08
Deploy	AN5	AN5	0.00	1984	0.000	1.500	0.689	2.189	2015-10-18 01:08	2015-10-18 03:19
Transit	AN5	AN6	0.50	0	0.030	0.000	0.000	0.030	2015-10-18 03:19	2015-10-18 03:21
Deploy	AN6	AN6	0.00	1975	0.000	1.500	0.686	2.186	2015-10-18 03:21	2015-10-18 05:32
Transit	AN6	AN6-S1	1.00	0	0.060	0.000	0.000	0.060	2015-10-18 05:32	2015-10-18 05:36
Survey	AN6-S1	AN6-S1	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 05:36	2015-10-18 05:51
Transit	AN6-S1	AN6-S2	1.41	0	0.085	0.000	0.000	0.085	2015-10-18 05:51	2015-10-18 05:56
Survey	AN6-S2	AN6-S2	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 05:56	2015-10-18 06:11
Transit	AN6-S2	AN6-S3	0.00	0	0.000	0.000	0.000	0.000	2015-10-18 06:11	2015-10-18 06:11
Survey	AN6-S3	AN6-S3	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 06:11	2015-10-18 06:26
Transit	AN6-S3	AN6-S4	1.41	0	0.085	0.000	0.000	0.085	2015-10-18 06:26	2015-10-18 06:31
Survey	AN6-S4	AN6-S4	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 06:31	2015-10-18 06:46
Transit	AN6-S4	AN5-S1	1.60	0	0.096	0.000	0.000	0.096	2015-10-18 06:46	2015-10-18 06:52
Survey	AN5-S1	AN5-S1	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 06:52	2015-10-18 07:07
Transit	AN5-S1	AN5-S2	1.41	0	0.085	0.000	0.000	0.085	2015-10-18 07:07	2015-10-18 07:12
Survey	AN5-S2	AN5-S2	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 07:12	2015-10-18 07:27
Transit	AN5-S2	AN5-S3	1.41	0	0.085	0.000	0.000	0.085	2015-10-18 07:27	2015-10-18 07:32
Survey	AN5-S3	AN5-S3	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 07:32	2015-10-18 07:47
Transit	AN5-S3	AN5-S4	0.94	0	0.056	0.000	0.000	0.056	2015-10-18 07:47	2015-10-18 07:50
Survey	AN5-S4	AN5-S4	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 07:50	2015-10-18 08:05
Transit	AN5-S4	AN4-S1	1.89	0	0.113	0.000	0.000	0.113	2015-10-18 08:05	2015-10-18 08:12
Survey	AN4-S1	AN4-S1	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 08:12	2015-10-18 08:27
Transit	AN4-S1	AN4-S2	1.41	0	0.085	0.000	0.000	0.085	2015-10-18 08:27	2015-10-18 08:32
Survey	AN4-S2	AN4-S2	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 08:32	2015-10-18 08:47
Transit	AN4-S2	AN4-S3	1.41	0	0.085	0.000	0.000	0.085	2015-10-18 08:47	2015-10-18 08:52
Survey	AN4-S3	AN4-S3	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 08:52	2015-10-18 09:07
Transit	AN4-S3	AN4-S4	0.65	0	0.039	0.000	0.000	0.039	2015-10-18 09:07	2015-10-18 09:10
Survey	AN4-S4	AN4-S4	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 09:10	2015-10-18 09:25
Transit	AN4-S4	AN3-S1	1.07	0	0.064	0.000	0.000	0.064	2015-10-18 09:25	2015-10-18 09:29
Survey	AN3-S1	AN3-S1	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 09:29	2015-10-18 09:44
Transit	AN3-S1	AN3-S2	1.41	0	0.085	0.000	0.000	0.085	2015-10-18 09:44	2015-10-18 09:49
Survey	AN3-S2	AN3-S2	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 09:49	2015-10-18 10:04
Transit	AN3-S2	AN3-S3	1.41	0	0.085	0.000	0.000	0.085	2015-10-18 10:04	2015-10-18 10:09
Survey	AN3-S3	AN3-S3	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 10:09	2015-10-18 10:24
Transit	AN3-S3	AN3-S4	0.48	0	0.029	0.000	0.000	0.029	2015-10-18 10:24	2015-10-18 10:25
Survey	AN3-S4	AN3-S4	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 10:25	2015-10-18 10:40
Transit	AN3-S4	AN2-S1	1.33	0	0.080	0.000	0.000	0.080	2015-10-18 10:40	2015-10-18 10:45
Survey	AN2-S1	AN2-S1	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 10:45	2015-10-18 11:00
Transit	AN2-S1	AN2-S2	1.41	0	0.085	0.000	0.000	0.085	2015-10-18 11:00	2015-10-18 11:05
Survey	AN2-S2	AN2-S2	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 11:05	2015-10-18 11:20
Transit	AN2-S2	AN2-S3	1.41	0	0.085	0.000	0.000	0.085	2015-10-18 11:20	2015-10-18 11:25
Survey	AN2-S3	AN2-S3	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 11:25	2015-10-18 11:40
Transit	AN2-S3	AN2-S4	1.15	0	0.069	0.000	0.000	0.069	2015-10-18 11:40	2015-10-18 11:45
Survey	AN2-S4	AN2-S4	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 11:45	2015-10-18 12:00
Transit	AN2-S4	AN1-S1	0.28	0	0.017	0.000	0.000	0.017	2015-10-18 12:00	2015-10-18 12:01
Survey	AN1-S1	AN1-S1	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 12:01	2015-10-18 12:16
Transit	AN1-S1	AN1-S2	1.41	0	0.085	0.000	0.000	0.085	2015-10-18 12:16	2015-10-18 12:21
Survey	AN1-S2	AN1-S2	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 12:21	2015-10-18 12:36
Transit	AN1-S2	AN1-S3	1.41	0	0.085	0.000	0.000	0.085	2015-10-18 12:36	2015-10-18 12:41
Survey	AN1-S3	AN1-S3	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 12:41	2015-10-18 12:56
Transit	AN1-S3	AN1-S4	1.69	0	0.101	0.000	0.000	0.101	2015-10-18 12:56	2015-10-18 13:02
Survey	AN1-S4	AN1-S4	0.00	0	0.000	0.250	0.000	0.250	2015-10-18 13:02	2015-10-18 13:17
Transit	AN1-S4	Port	335.00	0	20.098	0.000	0.000	20.098	2015-10-18 13:17	2015-10-19 09:23
DEMOB	Port	Port	0.00	0	0.000	6.000	0.000	6.000	2015-10-19 09:23	2015-10-19 15:23

Appendix D: {NEPA compliance}

Appendix E: Experiment and array design notes

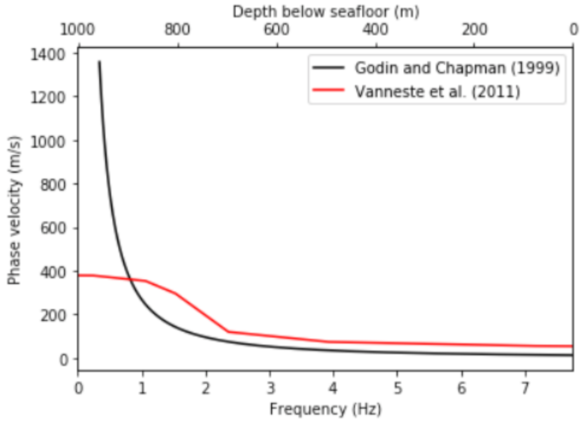


Figure E-1. Examples of velocity dispersion in marine sediments.

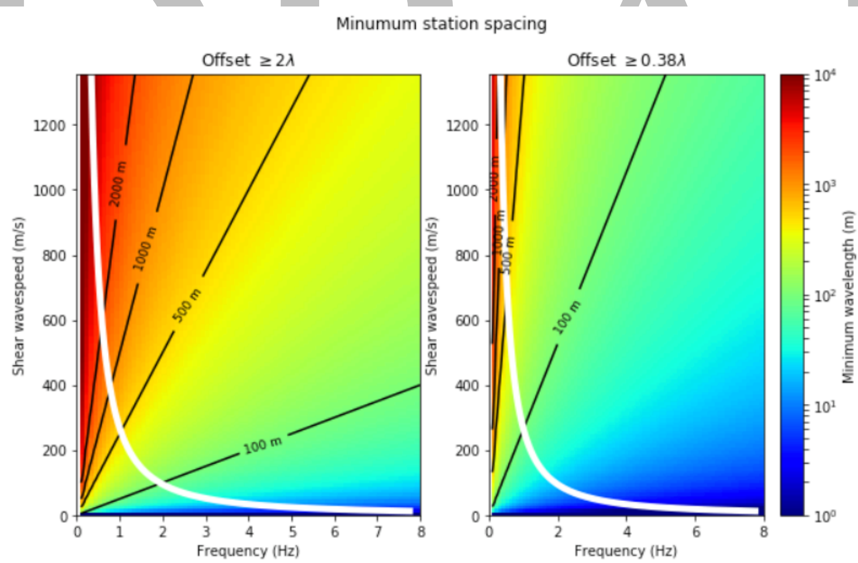


Figure E-2. Minimum instrument spacing needed to retrieve noise correlation functions from (left) time-domain cross correlation or (right) frequency-domain cross correlation (i.e., cross spectra).

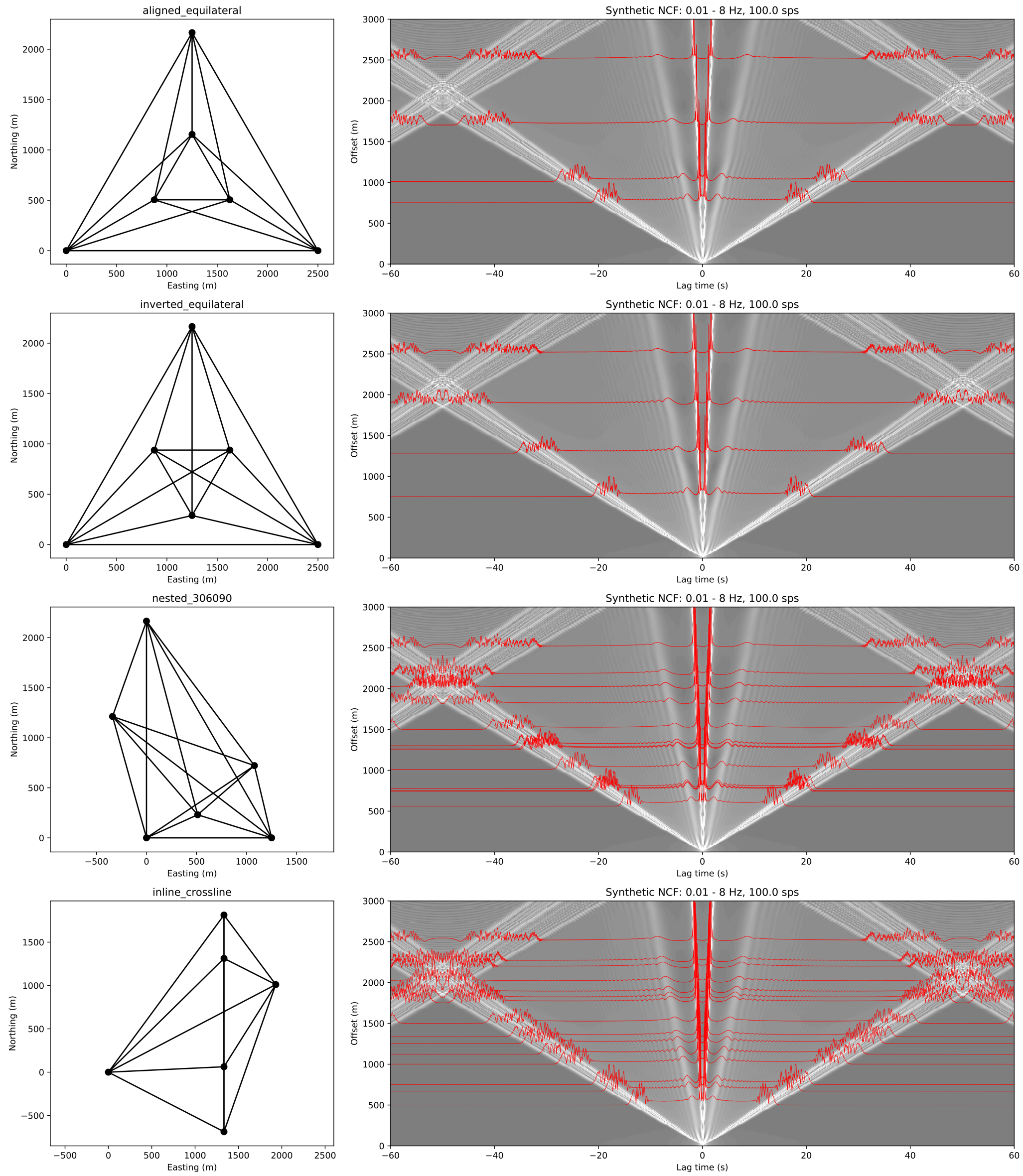


Figure E-3. Synthetic noise correlations functions for different array geometries. The array design on the bottom row was chosen for this experiment as a balance between providing a range of unique offsets and tolerance to instrument failure.

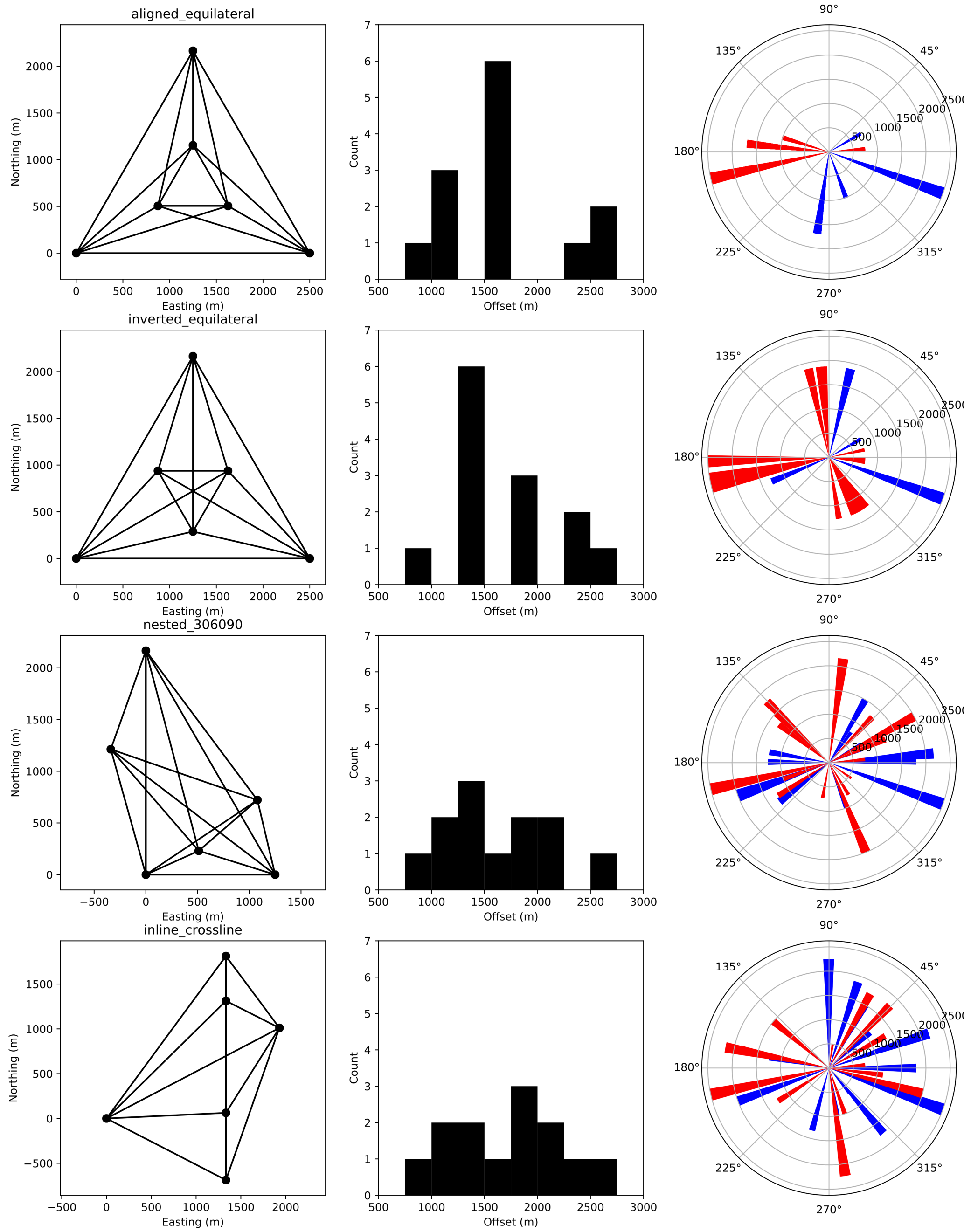


Figure E-4. Offset and azimuth distribution for different array geometries.