Passive Acoustic Monitoring for Marine Mammals at Site E in Onslow Bay, August – December 2011

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Abstract

A High-frequency Acoustic Recording Package (HARP; Wiggins and Hildebrand 2007) was deployed between August 2011 and July 2012 in Onslow Bay at Site E in 952 m. This HARP sampled at 200 kHz for 5 minutes of every 10 minutes and recorded for 105 days between 19 August 2011 and 1 December 2011. Long-Term Spectral Averages (LTSAs) were created for three frequency bands (10 Hz – 1000 Hz, 500 Hz – 5000 Hz, and 1 kHz – 100 kHz) and scanned for marine mammal vocalizations. Calls of blue whales, fin whales, minke whales, possible sei whales, an unidentified beaked whale species, Blainville's beaked whales, Cuvier's beaked whales, Gervais' beaked whales, killer whales, *Kogia* spp., Risso's dolphins, sperm whales, and unidentified delphinids were detected in the data.

Methods

The August – December 2011 Onslow Bay Site E HARP (Onslow Bay 06E) was deployed at 33.77794^{o} N, 75.92641^{o} W on 18 August 2011 (recording started on 19 August 2011) and recovered on 13 July 2012 (recording ended on 1 December 2011). The instrument location is shown in Figure 1. Bottom depth at the deployment site was approximately 952 m. A schematic diagram of the Onslow Bay 06E HARP is shown in Figure 2.

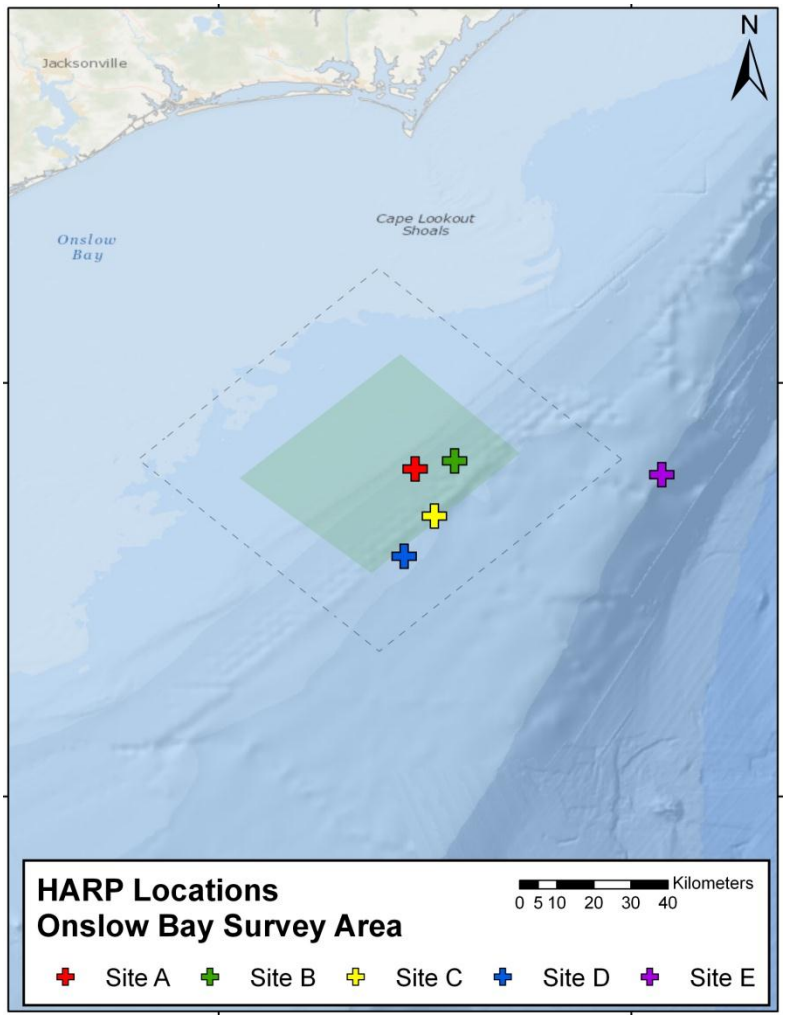

Figure 1. Location of HARP deployment sites in the Onslow Bay survey area. The location of the Onslow Bay 06E HARP is shown in purple.

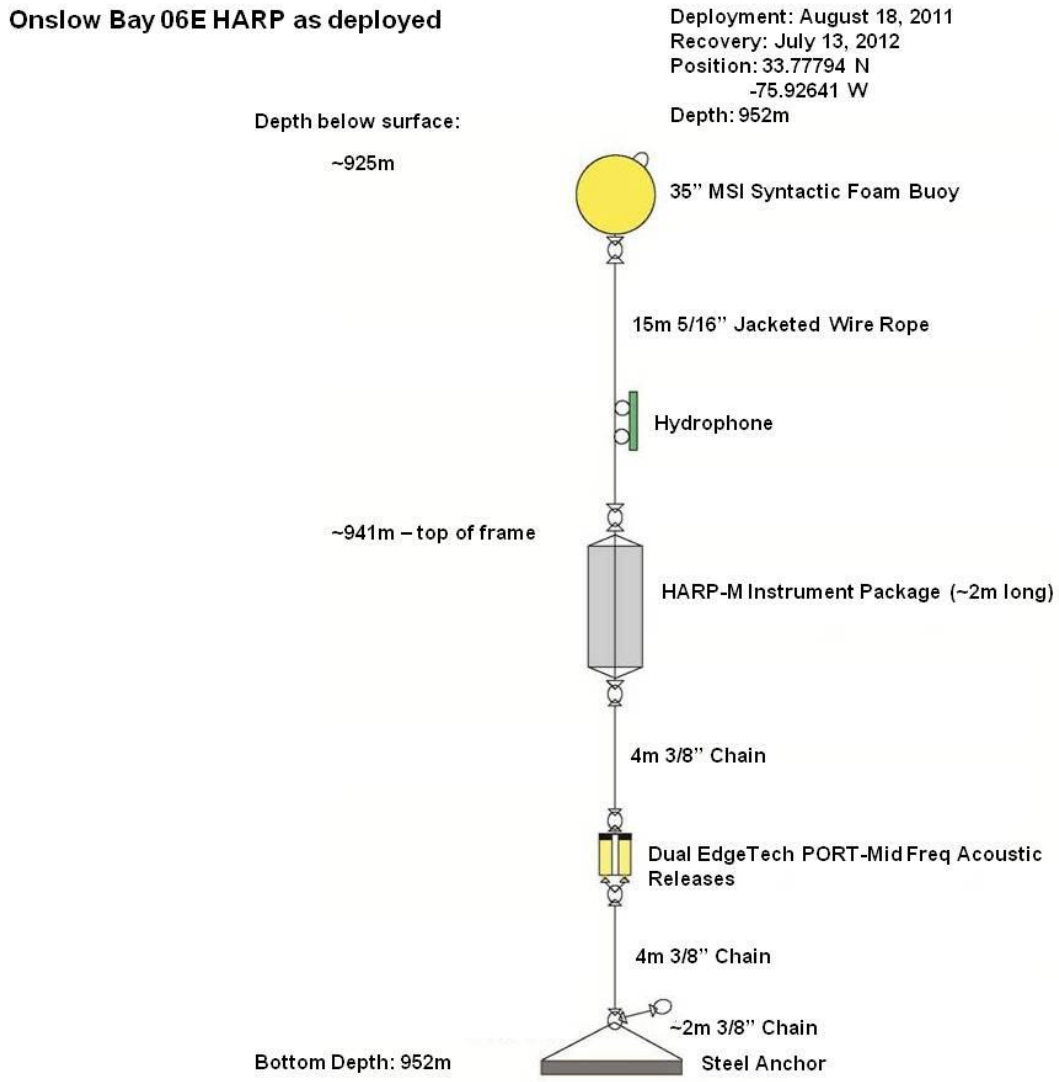

Figure 2. Schematic diagram showing details of the Onslow Bay 06E HARP. Note that diagram is not drawn to scale.

Data were acquired at a 200 kHz sampling rate for 5 minutes every 10 minutes during the Onslow Bay 06E deployment. This deployment provided a total of 1387.9 hours of data over the 105 days of recording.

The following methods are a summary of Debich *et al.* (2014). Members of the Scripps Whale Acoustics Lab manually scanned the data from the Onslow Bay 06E HARP deployment for marine mammal vocalizations and anthropogenic sounds (sonar, explosions, and shipping) using LTSAs. For effective analysis of marine mammal and anthropogenic sounds, the usable data were divided into three frequency bands ((1) low frequencies, between 10 – 1000 Hz, (2) mid frequencies, between 500 – 5000 Hz, and (3) high frequencies, between 1 – 100 kHz). The resulting LTSAs had resolutions of 5 s in time and 1 Hz in frequency (for the data decimated by a factor of 100: 10-1000 Hz band), 5 s in time and 10 Hz in frequency (for the data decimated by a factor of 20: 500-5000 Hz band), and 5 s in time and 100 Hz in frequency (for the data not decimated: 1-100 kHz). Each LTSA was analyzed for the sounds of an appropriate subset of species or sources. Blue, Bryde's, fin, minke, North Atlantic right, and sei whale sounds were classified as low frequency; humpback whale calls, North Atlantic right whale gunshot calls, shipping, explosions, and mid-frequency active sonar were classified as mid-frequency; and the remaining odontocete and sonar sounds were considered high-frequency. Low-frequency sounds were analyzed in hourly bins; mid- and high-frequency sounds were analyzed in one-minute bins. Vocalizations were assigned to species when possible. Detections of most sounds were made by manually scanning LTSAs. Humpback whale call detection effort was automated using a power-law detector (Helble *et al.* 2012). After the generalized power-law algorithm was applied, a trained analyst verified the accuracy of the detected signals. Beaked whale clicks were detected with an automated method and then assigned to species by a trained analyst, described in detail in Debich *et al.* (2014). Unidentified odontocete clicks were also assigned to spectral patterns by a trained analyst, also further described in Debich *et al.* (2014). See Debich *et al.* (2014) for a more detailed description of analysis methods for the Onslow Bay 06E data set.

Results

Table 1 summarizes the detected and identified marine mammal vocalizations for the Onslow Bay 06E HARP deployment. Figures 3-15 show the daily occurrence patterns for the different marine mammal groups (classified to species when possible). Underwater ambient noise during this deployment is shown in Figure 16. Figure 17 shows the occurrence of mid-frequency active sonar.

Blue whale calls were detected from early September through late October in 2011 (Figure 3). This timing is similar to that of other recordings at similar latitudes near the mid-Atlantic ridge (Nieukirk *et al.* 2004), as well as that seen at other Onslow Bay sites.

Fin whale 20-Hz pulses were detected from late August through November 2011, with peak calling in October (Figure 4).

Minke whale pulse trains were detected between late September and early December 2011, peaking towards the end of the deployment (Figure 5).

Downsweeps similar to those ascribed to sei whales by Baumgartner *et al.* (2008) were detected in October, November, and early December 2011 (Figure 6).

Detected odontocete vocalizations included clicks and whistles (Figures 7-15). Most of these detections were assigned to the unidentified odontocete category (Figure 7), with clicks being divided into four main groups when possible based on spectral patterns. The unidentified odontocete vocalization category also included unidentified odontocete whistles <5 kHz, possibly related to killer whale occurrence, with a peak in mid-November (see Debich *et al.* 2014 for more details). Several click detections were assigned to beaked whales. There were a few detections assigned to an unidentified beaked whale click type (BW38) (Figure 8). Blainville's beaked whale clicks were also detected (Figure 9), as were Cuvier's beaked whale clicks (Figure 10). For Cuvier's beaked whale clicks, there was a slight peak in November 2011. There were significantly more Gervais' beaked whale detections than any other beaked whale. Detections for this species peaked in November 2011 at Site E (Figure 11). Other detected odontocete vocalizations included killer whale clicks, which were detected in late November 2011 (Figure 12). *Kogia* spp. (Figure 13), Risso's dolphins (Figure 14), and sperm whales (Figure 15) were also all detected in the August – December 2011 deployment at Site E. *Kogia* spp. clicks peaked in late November 2011.

Table 1. Summary of detections of marine mammal vocalizations at Site E for August – December 2011. * For mysticetes, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in hourly bins; for odontocetes, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in minute bins.

Species	**Call type**	**Total duration of vocalizations (hours)***	**Percent of recording duration***	**Days with vocalizations**	**Percent of recording days**
Blue whale	A and B calls	12	0.48	7	6.67
Fin whale	20 Hz	190	7.64	43	40.95
Minke whale	pulse train (slow-down, speed-up, regular)	250	10.06	33	31.43
Possible sei whale	downsweep	15	0.60	7	6.67
Unidentified odontocete	clicks, whistles	169.63	12.22	99	94.29
Unidentified beaked whale (BW38)	clicks	0.75	0.05	4	3.81
Blainville's beaked whale	clicks	3.53	0.25	10	9.52
Cuvier's beaked whale	clicks	2.65	0.19	5	4.76
Gervais' beaked whale	clicks	225.12	16.22	104	99.05
Killer whale	clicks	0.38	0.03	2	1.90
Kogia spp.	clicks	2.33	0.17	23	21.90
Risso's dolphin	clicks	3.27	0.24	1	0.95
Sperm whale	clicks	140.18	10.10	46	43.81

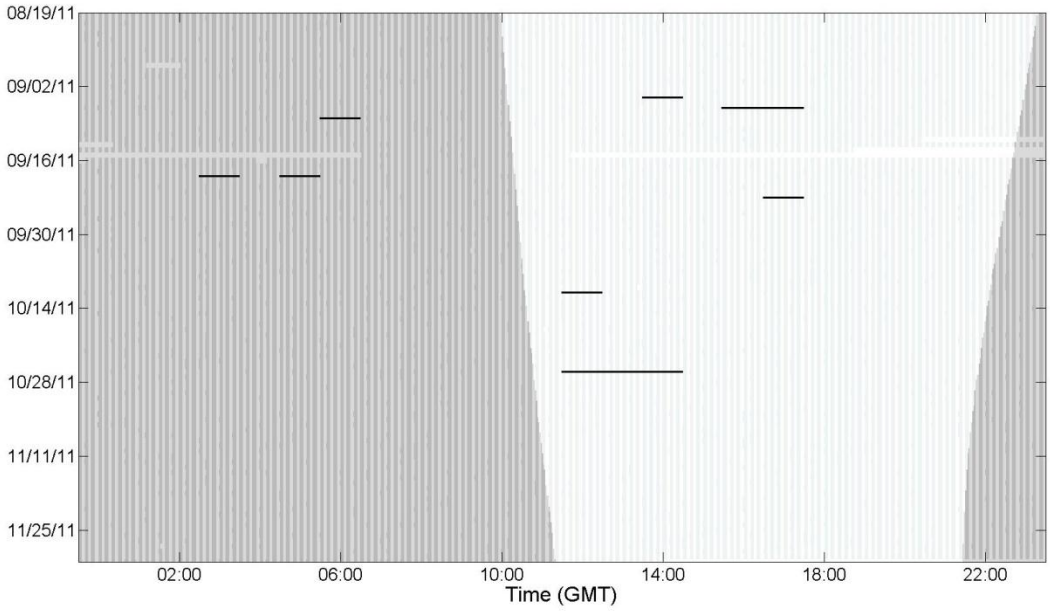

Figure 3. Blue whale Type A and B call detections (black bars) in hourly bins for the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort, including times when masking may have occurred (shown in one-minute bins).

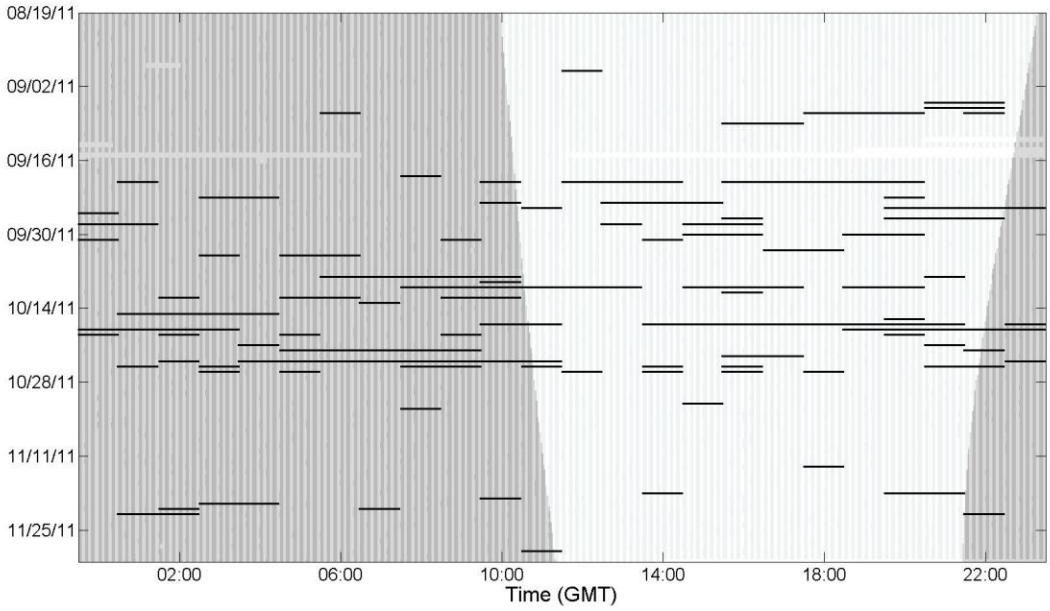

Figure 4. Fin whale 20-Hz pulse detections (black bars) in hourly bins for the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort, including times when masking may have occurred (shown in one-minute bins).

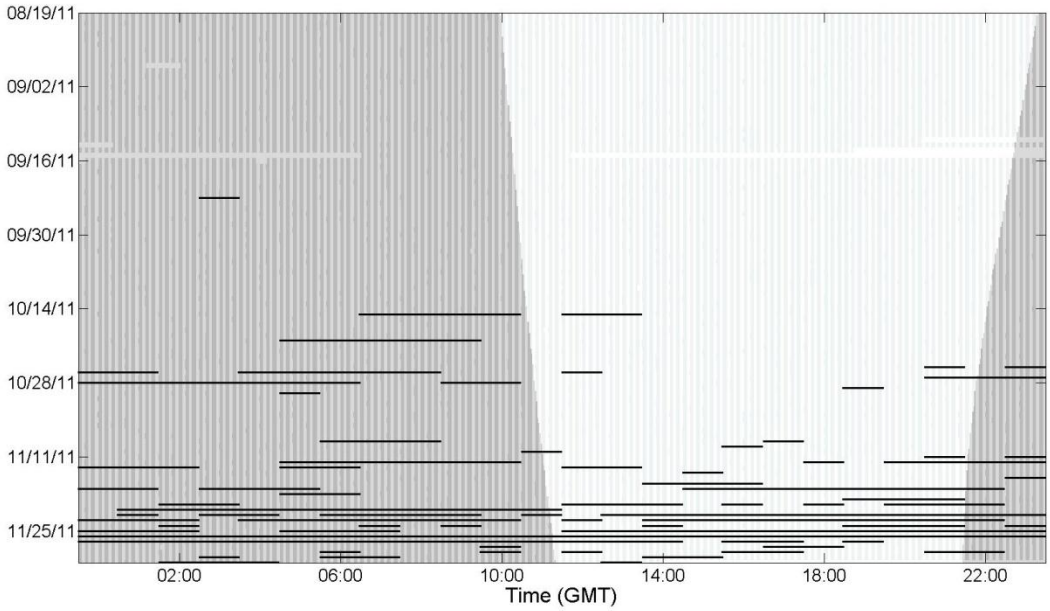

Figure 5. Minke whale detections (black bars) in hourly bins for the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval

Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort, including times when masking may have occurred (shown in one-minute bins).

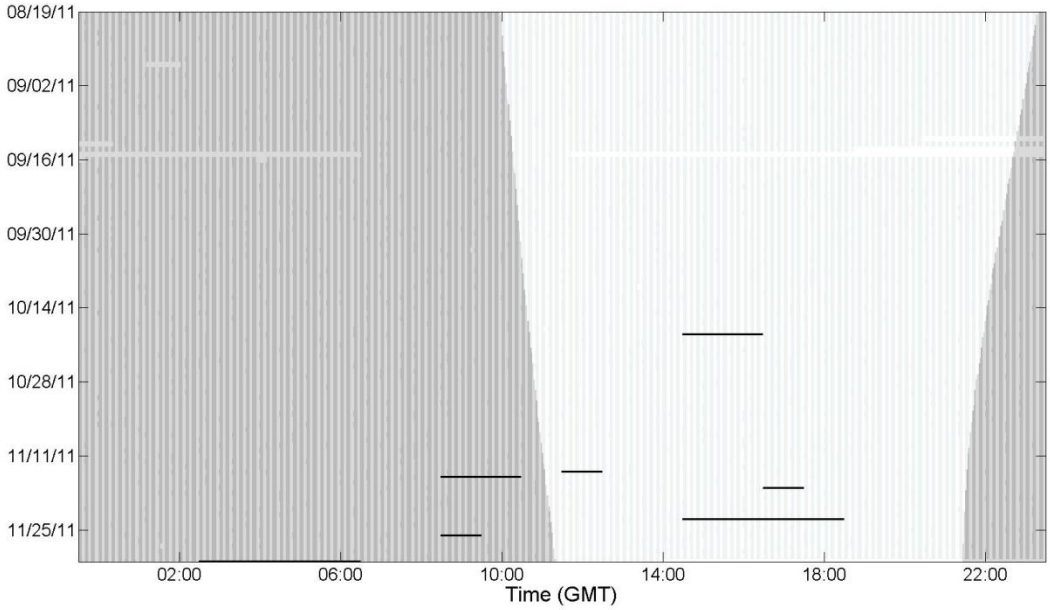

Figure 6. Downweep detections (black bars) in hourly bins that may be produced by sei whales (Baumgartner *et al.* 2008) for the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort, including times when masking may have occurred (shown in one-minute bins).

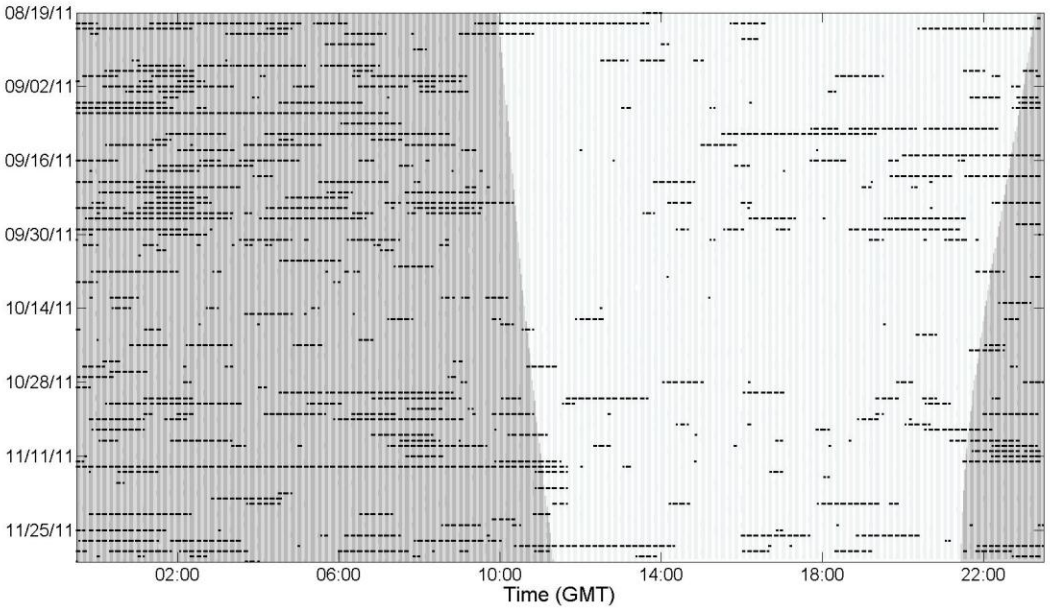

Figure 7. Unidentified odontocete vocalization detections (black bars) for the August – December 2011 Site E data set. These detections also include clicks that were assigned to four spectral patterns based on spectral features. See Debich et al. (2014) for more details. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

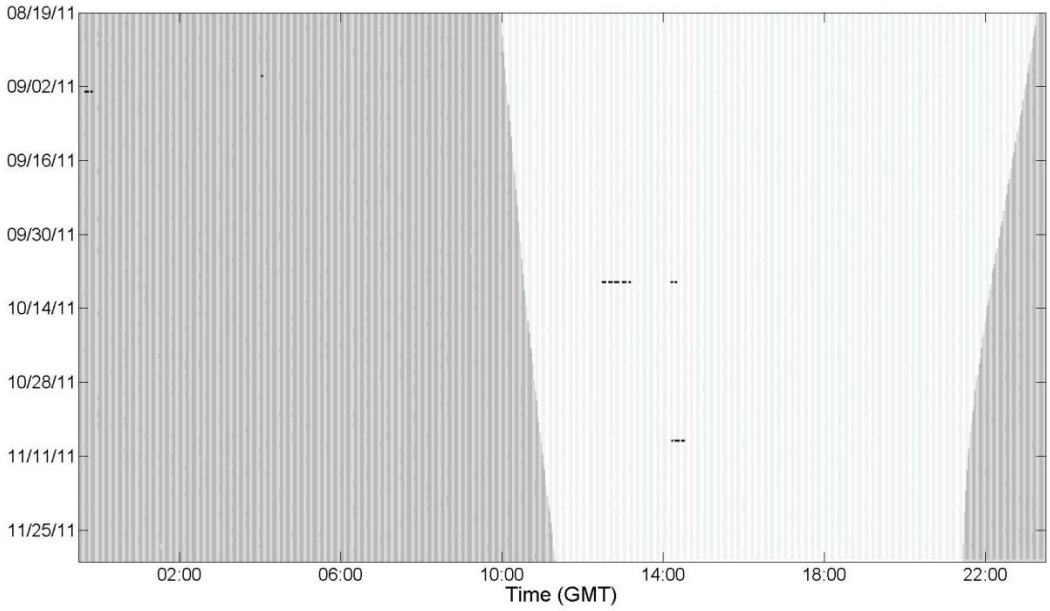

Figure 8. Unidentified beaked whale (BW38) click detections (black bars) for the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

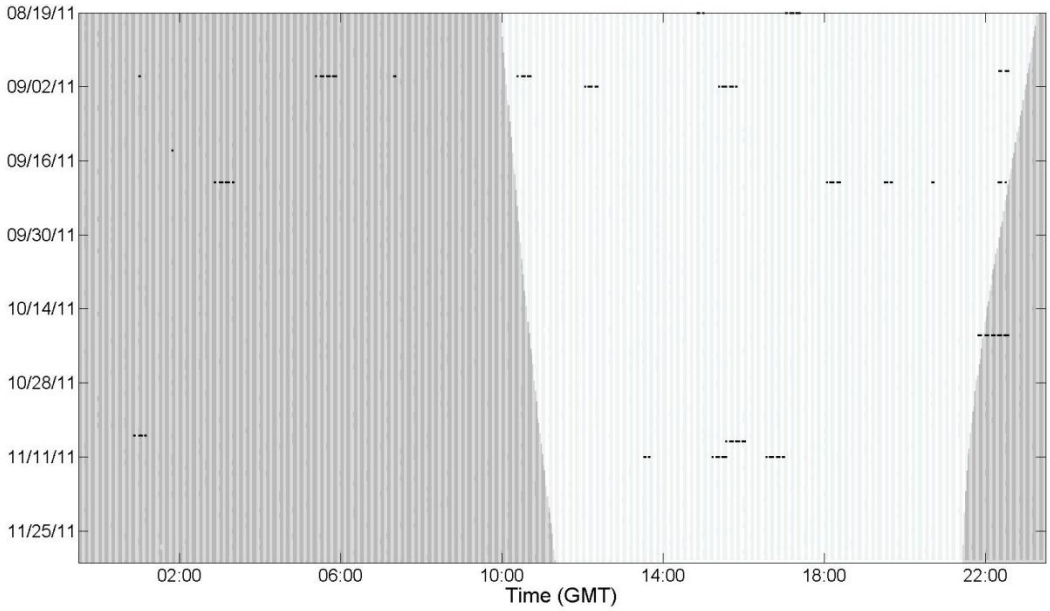

Figure 9. Blainville's beaked whale click detections (black bars) for the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

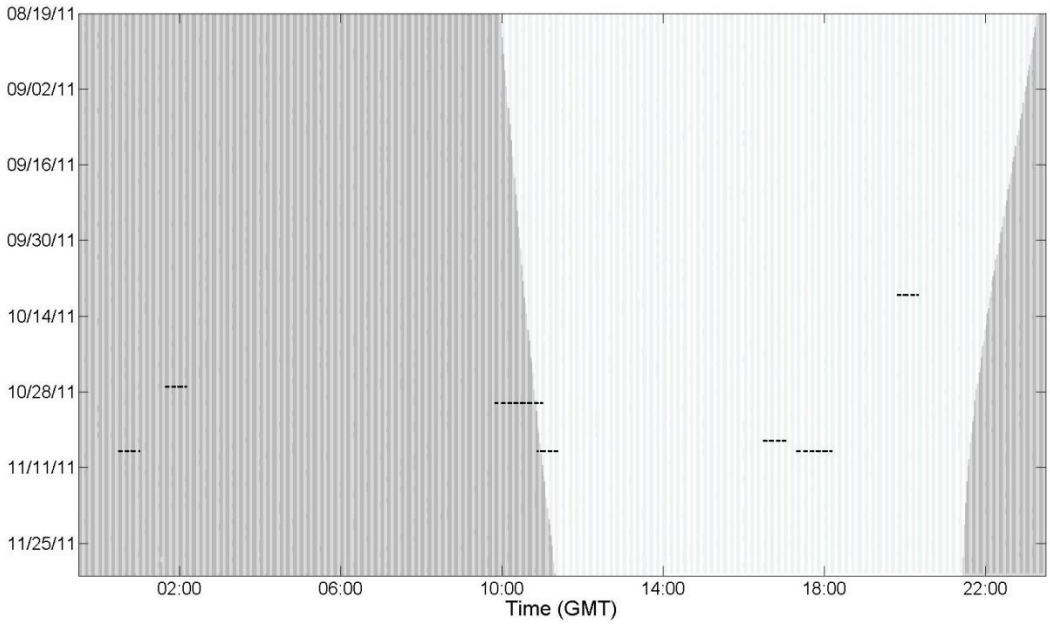

Figure 10. Cuvier's beaked whale click detections (black bars) for the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

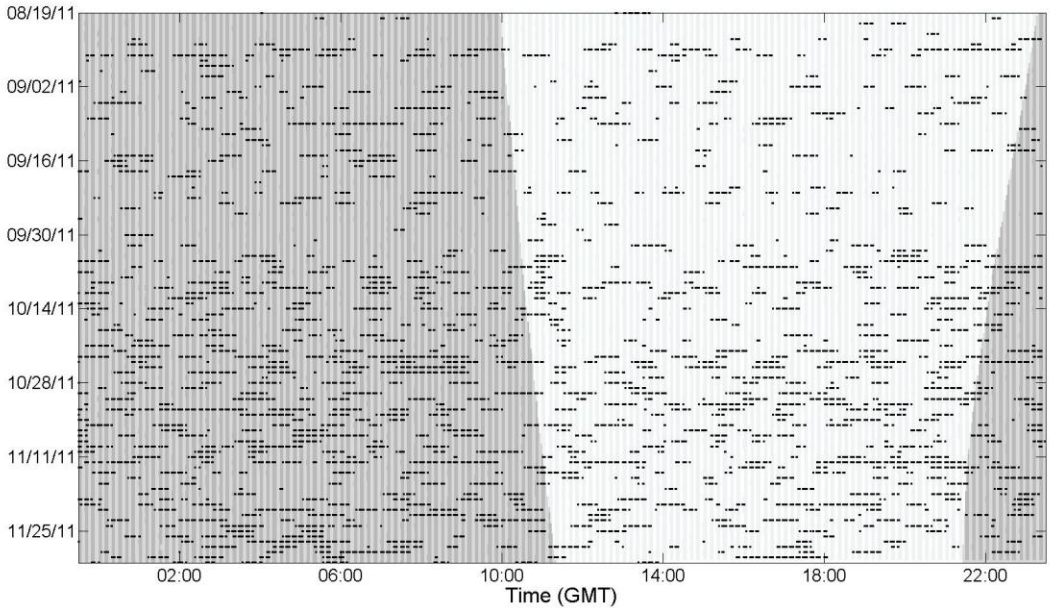

Figure 11. Gervais' beaked whale click detections (black bars) for the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

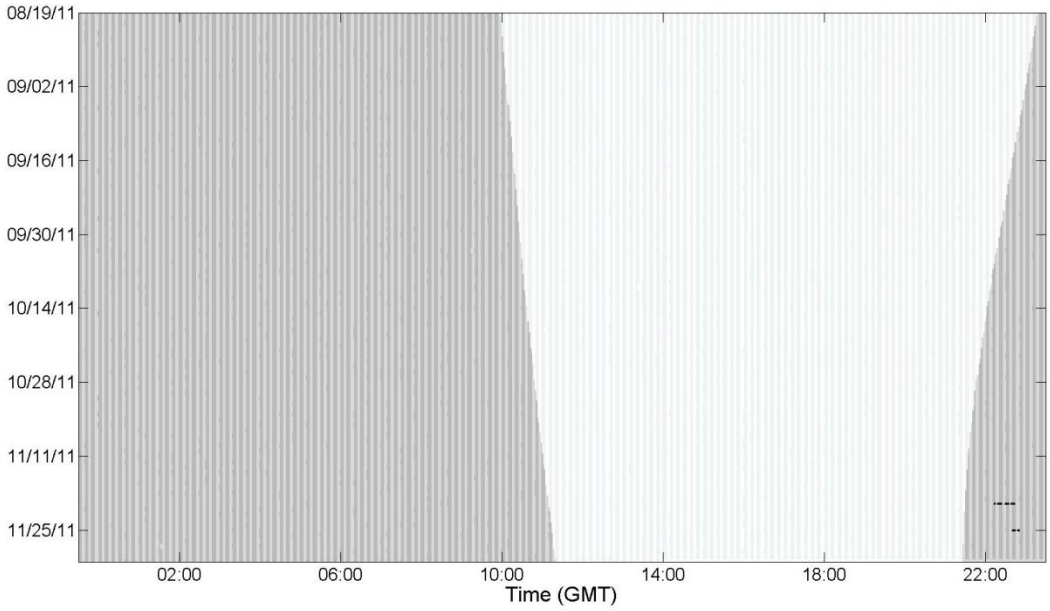

Figure 12. Killer whale click detections (black bars) for the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

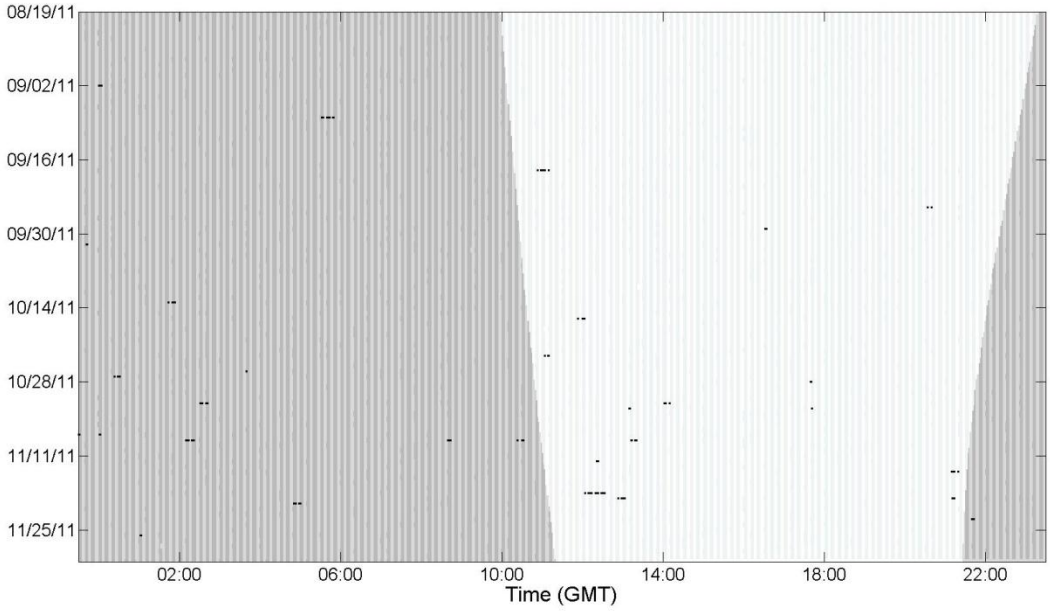

Figure 13. *Kogia* spp. click detections (black bars) for the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

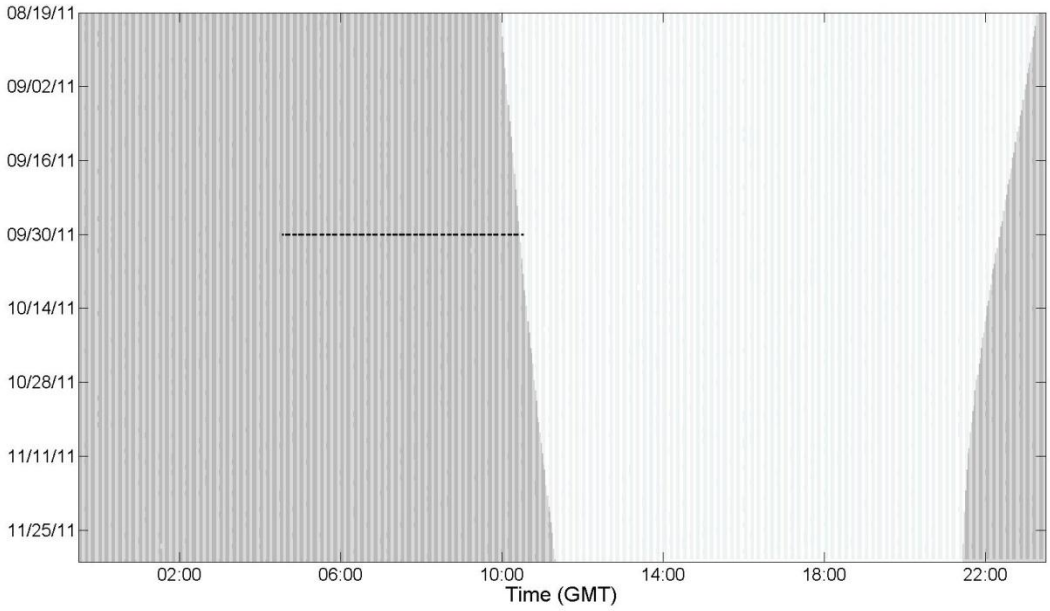

Figure 14. Risso's dolphin click detections (black bars) for the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

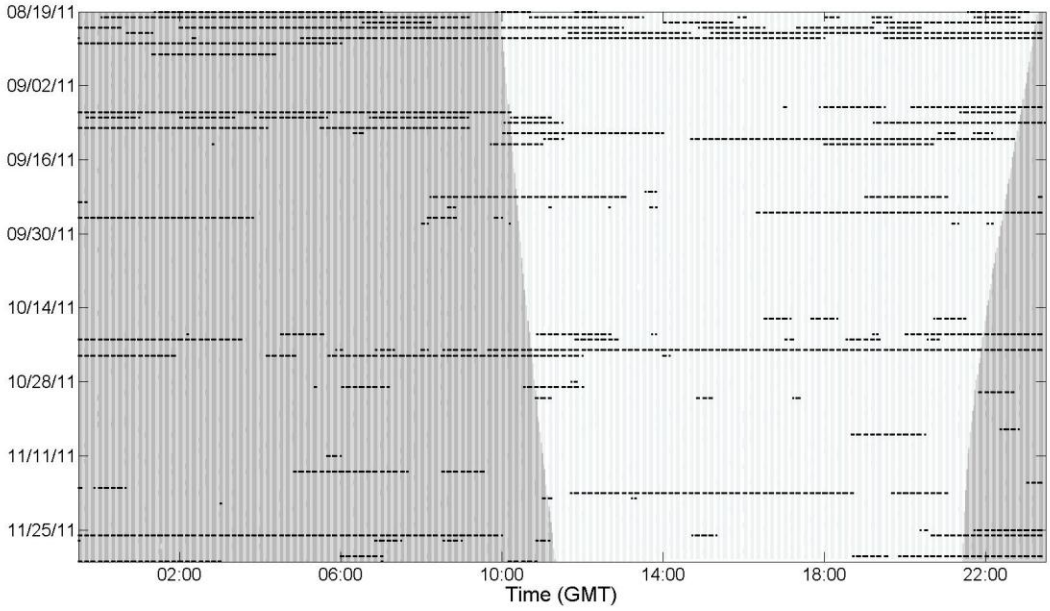

Figure 15. Sperm whale click detections (black bars) for the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

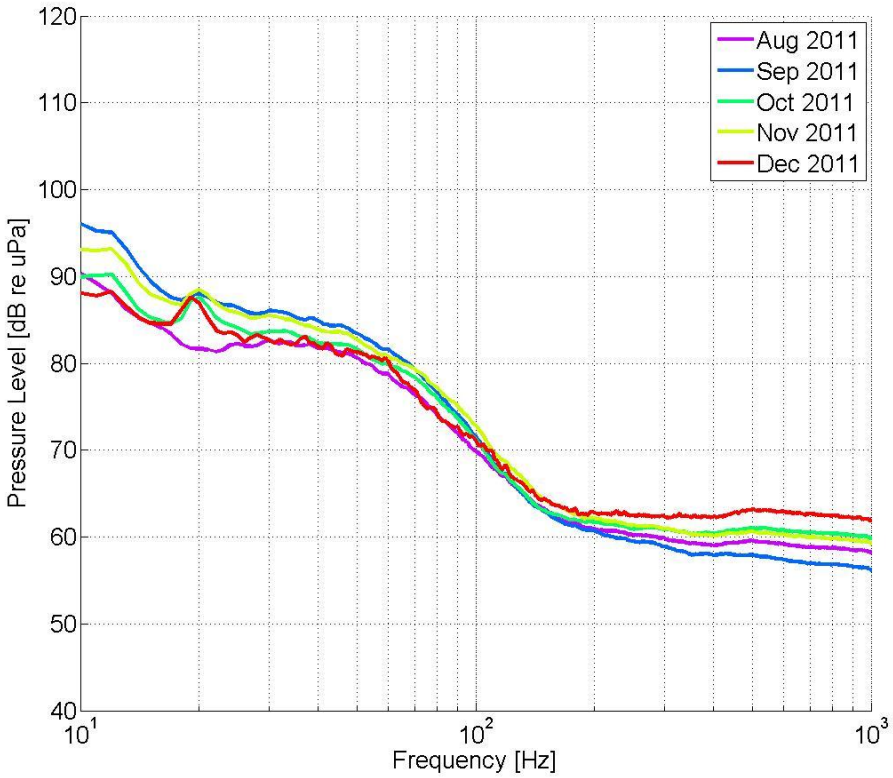

Figure 16. Monthly averages of ambient noise at Onslow Bay Site E for August – December 2011.

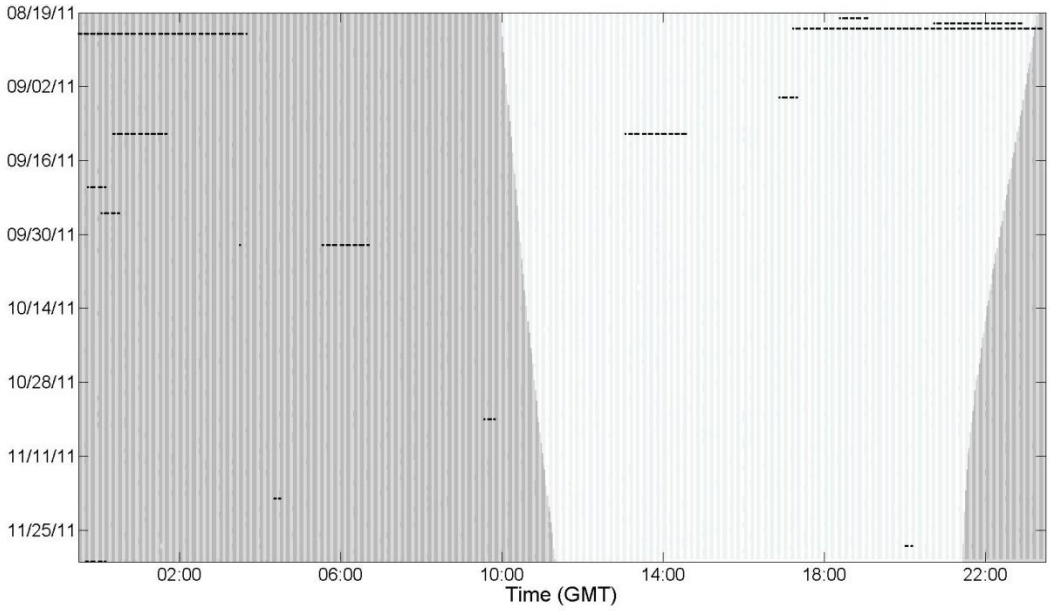

Figure 17. Mid-frequency active sonar (black bars) detected during the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

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