PASSIVE ACOUSTIC MONITORING FOR CETACEANS IN NAVY OPAREAS OFF THE US ATLANTIC COAST JANUARY 2013 – DECEMBER 2013

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This report forms part of a multi-institutional monitoring project intended to provide information on the species composition, population identity, density and baseline behavior of marine mammals and sea turtles present in Navy range complexes along the Atlantic coast. This program began in 2007, with baseline aerial and vessel surveys and a passive acoustic monitoring program in Onslow Bay, North Carolina and has since expanded to include study areas off Jacksonville, Florida and Cape Hatteras, North Carolina. In Onslow Bay, six years of monitoring have yielded a comprehensive picture of the density, distribution and abundance of marine mammals and sea turtles and provided new insights into residency patterns among pelagic delphinid cetaceans in this region. More than four years of monitoring in Jacksonville have provided similar information on the density and distribution of marine mammals and sea turtles in this area. In Cape Hatteras, almost three years of surveys have provided preliminary information on the complex patterns of distribution and diversity of the marine mammals and sea turtles in this highly productive area. The current report builds on this past body of work and describes passive acoustic monitoring activities that occurred at these three sites between January and December 2013.

Duke University, with assistance from the Scripps Institution of Oceanography, initiated a passive acoustic monitoring effort in 2007 in Onslow Bay, North Carolina. The program consisted of acoustic recordings made by a towed hydrophone array during vessel-based surveys as well as the deployment of autonomous bottom-mounted recorders on shelf and slope waters. In 2009 the program was expanded to include bottom-mounted recorders deployed within the Navy range complex in Jacksonville FL. Monitoring efforts were expanded again in 2012 to include Cape Hatteras, NC, where a bottom-mounted recorder was deployed along the shelf slope at a depth of approximately 950 m. The program has continued to date, primarily through the use of autonomous, bottom-mounted recorders at all three sites.

The primary objective for this ongoing passive acoustic monitoring effort is to determine patterns of occurrence and distribution of cetacean species inhabiting the continental shelf and shelf break regions. A secondary goal is to identify species-specific characteristics of the vocalizations of marine mammal species in each area and to contribute to the development of automated acoustic species classification methods. This report details passive acoustic data collection and analysis efforts during 2013 in the Cape Hatteras, Onslow Bay, and Jacksonville survey areas.

General Methodology

HARPs

Autonomous High-frequency Acoustic Recording Packages (HARPs; Wiggins and Hildebrand 2007) have been used to collect time series of acoustic data in all three survey areas. The HARP data-logging system includes a 16-bit A/D converter, a hydrophone suspended approximately 10-12 m (large mooring, see Figure 1) or approximately 22 m (small mooring, see Figure 2) above the sea floor, an acoustic release system, ballast weights, and flotation (Figures 1-2). The data-loggers are capable of sampling up to 200 kHz and can be set to record continuously or on a duty cycle to accommodate various deployment durations. These instruments combine high and low frequency hydrophone elements to detect the vocalizations of both odontocete and mysticete whales. The units sample at rates high enough to capture the echolocation clicks of most odontocetes.

Analysis

HARP data must be processed prior to analysis, including backing up the data in original format, converting data to wav format, decimating wav data by a factor of 100 to aid in baleen whale detection, and creating long-term spectral averages (LTSAs). New compression code was implemented starting in July 2010 which allowed for greater than two TB of data to be collected after the raw data were decompressed. This amount of data is impractical to analyze manually, so data are compressed for visual overview by using a *MATLAB*-based acoustic program called *Triton* (Hildebrand Lab at Scripps Institution of Oceanography, CA) to create LTSAs from the wav files, which allow for rapid review of the data. LTSAs are effectively compressed spectrograms created using the Welch algorithm (Welch 1967) by coherently averaging 500 spectra created from 2000-point, 0%-overlapped, Hann-windowed data and displaying these averaged spectra sequentially over time.

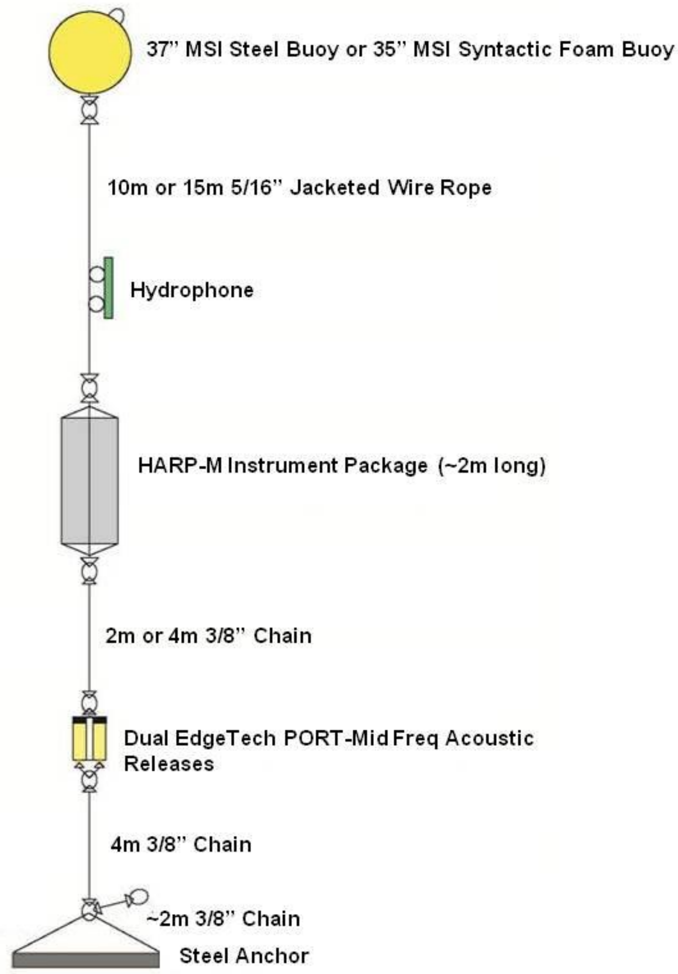

Figure 1. Schematic diagram showing details of a large mooring HARP. Note that diagram is not drawn to scale.

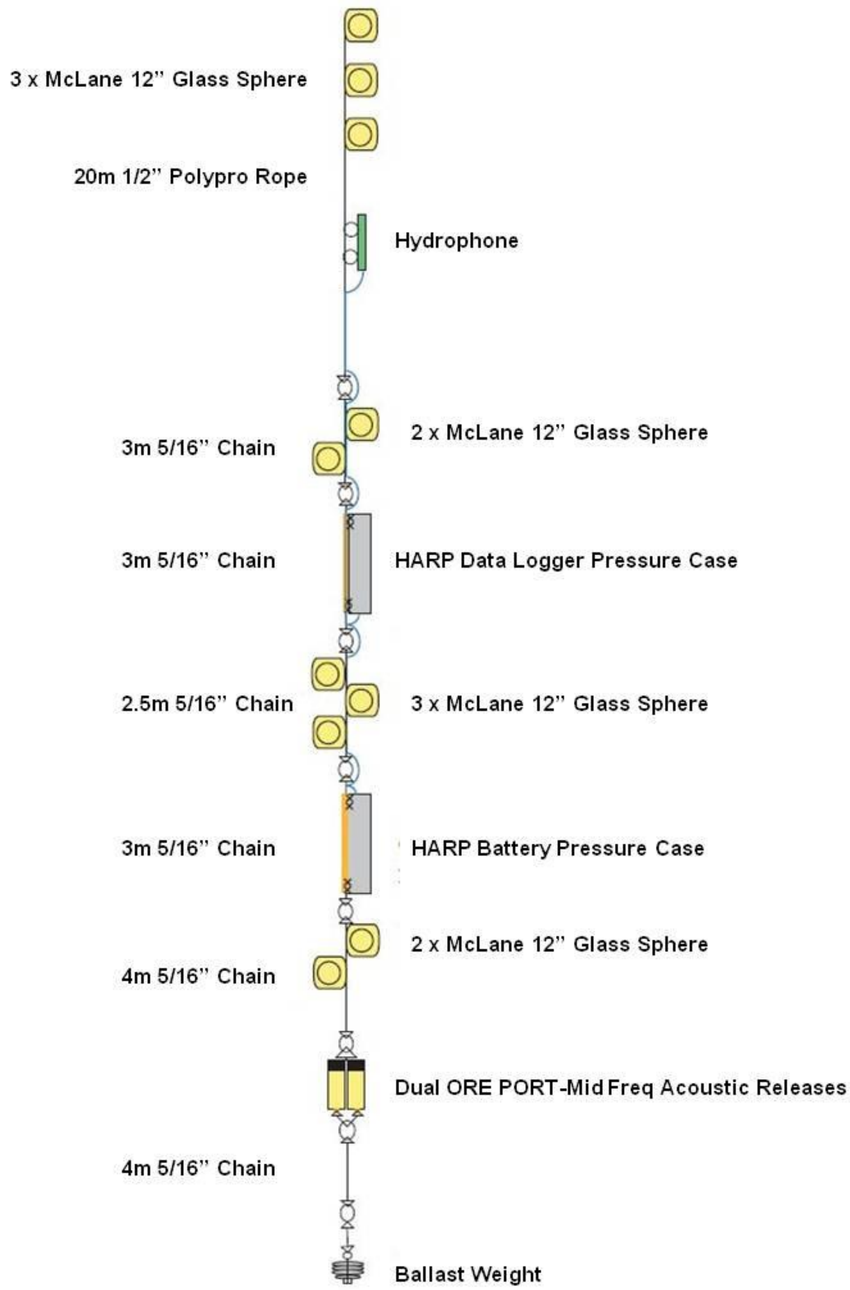

Figure 2. Schematic diagram showing details of a small mooring HARP. Note that diagram is not drawn to scale.

1. Passive Acoustic Monitoring at Cape Hatteras, NC

Methods

HARP Data Collection

The HARP initially deployed on October 9, 2012 was recovered and redeployed at a depth of 970 m at 35.34445^{o} N, 74.85210^{o} W (Site A) on May 29, 2013 (Table 1, Figure 3), yielding a deployment period of 232 days. A schematic diagram of the HARP mooring for these deployments is shown in Figure 4. This instrument is still in the field and will be recovered during spring 2014. The HARP was programmed to sample continuously at 200 kHz for both deployments. The October 2012 – May 2013 deployment provided data over 213 days (October 9, 2012 – May 9, 2013). Short-duration (0.005 s) skips in the recording occurred with increasing frequency during the last two months of this deployment, possibly due to low battery voltage. A post-processing solution has been developed to remove the skips from the recording and allow analysis of the full dataset, and data are currently being re-processed with this fix. Data logger firmware updates should minimize this issue in future deployments.

Table 1. Cape Hatteras, NC, HARP data sets analyzed and detailed in this report.

Site	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Latitude	Longitude	Depth (m)	Sampling Rate	Duty Cycle
02A	9-Oct-12	29-May-13	9-Oct-12	9-May-13	35.34060	-74.85590	970	200 kHz	continuous
03A	29-May-13	N/A	29-May13	N/A	35.34445	-74.85210	970	200 kHz	continuous

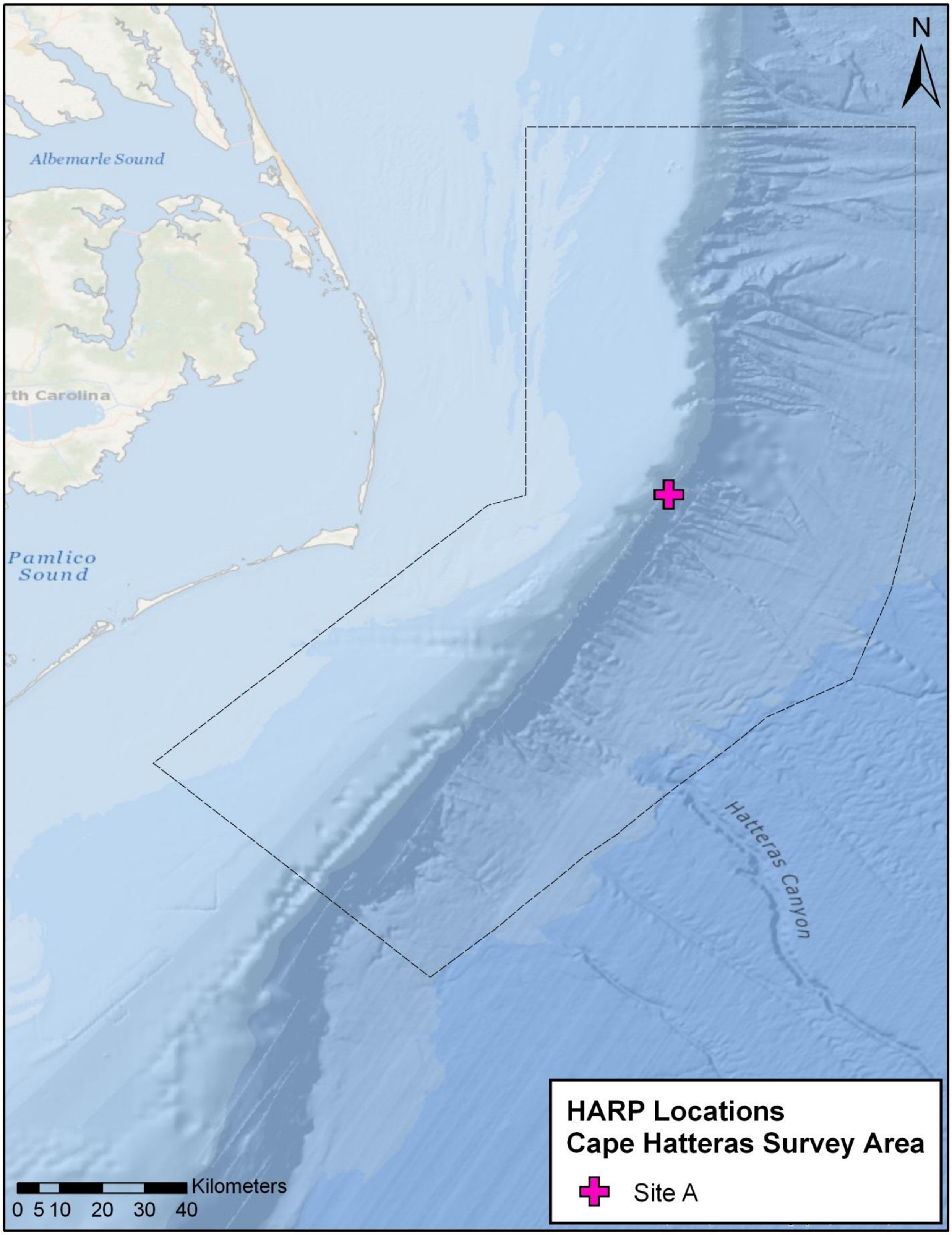

Figure 3. Location of the HARP deployment site in the Cape Hatteras survey area.

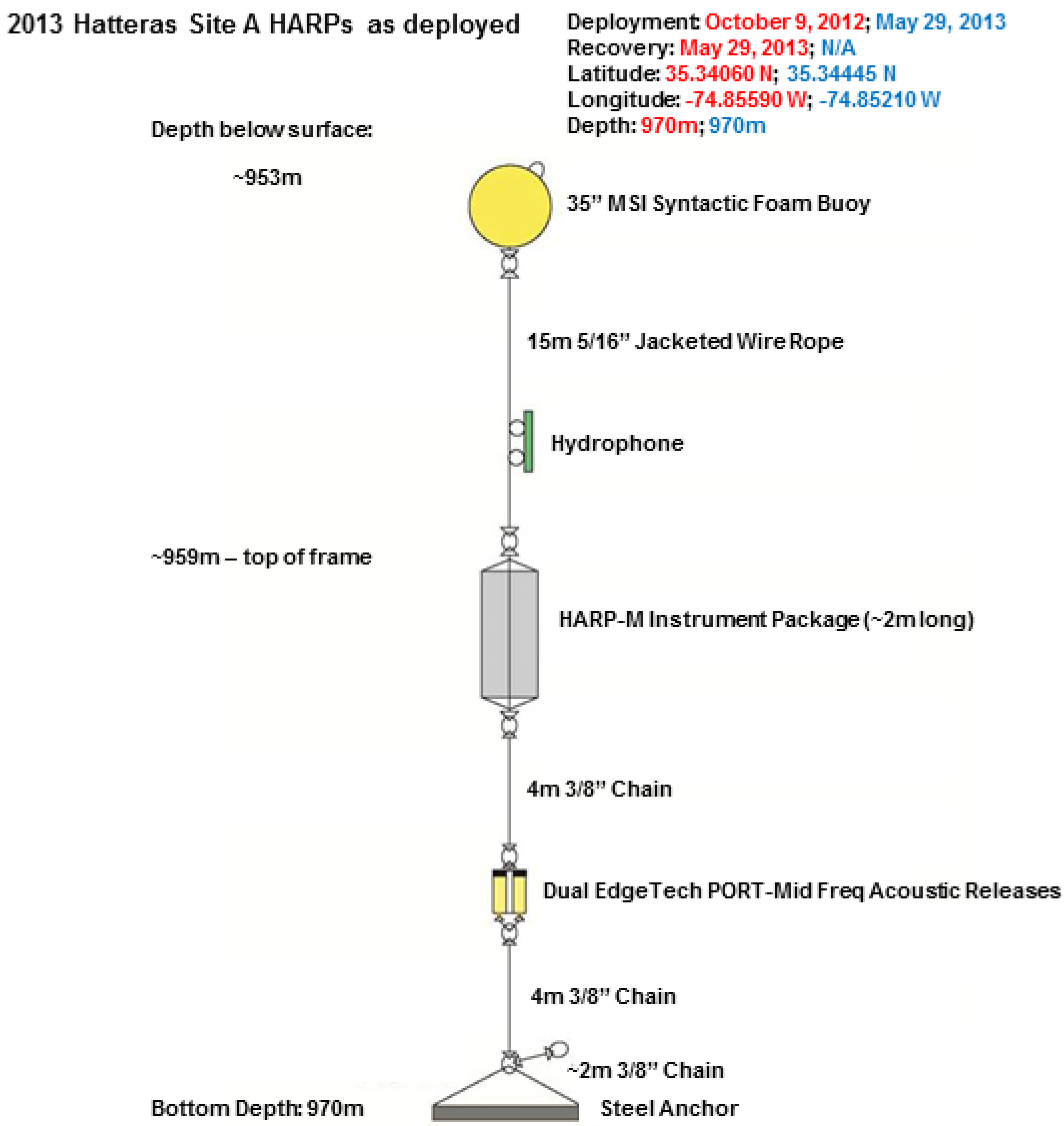

Figure 4. Schematic diagram showing details of 2013 Cape Hatteras Site A HARP deployments. Note that diagram is not drawn to scale.

Analysis

Data from the first 174 days of the 2012-2013 Site A HARP deployment (October 9, 2012 – March 31, 2013; 4161 hours of recording time) have been analyzed. The remaining data from this deployment will be analyzed after the dataset has been re-processed to eliminate the recording skips that occurred toward the end of the deployment. Recordings were manually scanned for marine mammal vocalizations using the “logger” version of *Triton* (v1.81.20121030) to view LTSAs with a frequency range of 1-100 kHz and a resolution of 5 s in time and 100 Hz in frequency. These LTSAs have been inspected for clicks of sperm and beaked whales, using corresponding waveforms and spectrograms to confirm identified vocal events. The presence of vocalizations was determined in one-minute bins. Cuvier’s beaked whale clicks were identified based on distinctive spectral characteristics apparent in the LTSAs and spectrograms. Other beaked whale click events have been designated as unidentified *Mesoplodon sp.*, and will be classified to species in further analysis.

Results

Underwater ambient noise during the 2012-2013 Site A HARP deployment is shown in Figure 5. Table 2 summarizes the occurrence of detected and identified sperm whale and beaked whale clicks for this deployment. Figures 6-8 show the temporal occurrence patterns for sperm whales, Cuvier’s beaked whales, and unidentified beaked whales (*Mesoplodon sp.*).

Sperm whales were present throughout much of the deployment, with detections on 68.6% of days analyzed, and no apparent diel pattern (Figure 6). Sperm whales occurred more frequently later (mid-November through December) than earlier in the acoustic record. In contrast, Cuvier’s beaked whale clicks occurred regularly throughout the deployment, with detections on almost all (93.4%) days (Figure 7). These click events were distributed in a remarkably uniform manner across both seasonal and diel time scales. *Mesoplodon sp.* clicks occurred relatively infrequently, with detections on only 15.6% of days analyzed. These clicks were most likely produced by

Gervais' beaked whale (*Mesoplodon europaeus*), but classification to the species level will be confirmed after further analysis.

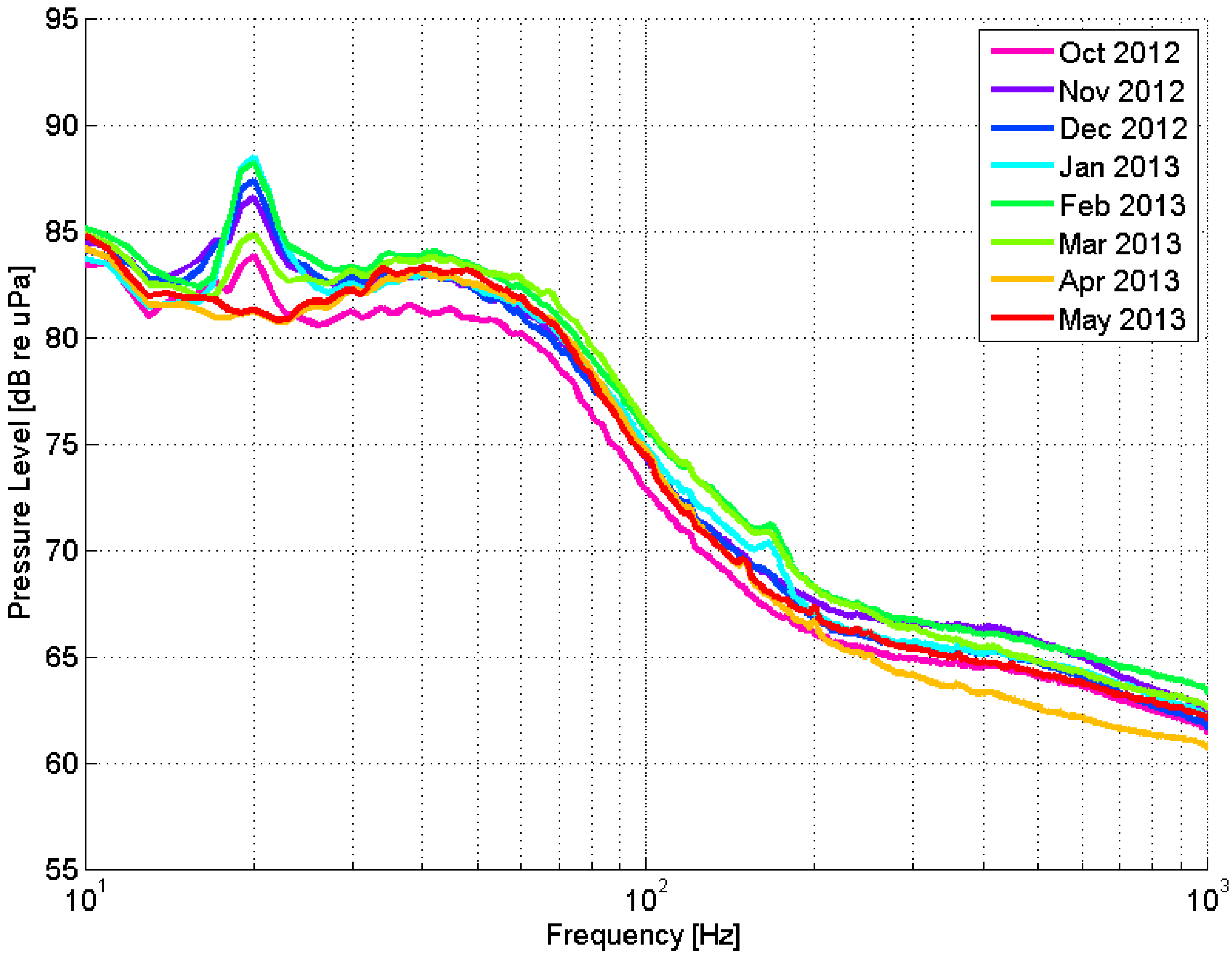

Figure 5. Monthly averages of ambient noise at Cape Hatteras Site A for October 2012 – May 2013.

Table 2. Summary of detections of sperm whales and beaked whales at Site A for October 9, 2012 – March 31, 2013.

Species	**Call type**	**Hours with vocalizations**	**Percent of total hours analyzed**	**Days with vocalizations**	**Percent of total days analyzed**
Sperm whale	clicks	391	9.3	119	68.6
Cuvier's beaked whale	clicks	196	4.7	162	93.4
Mesoplodon sp.	clicks	6.37	0.15	27	15.6

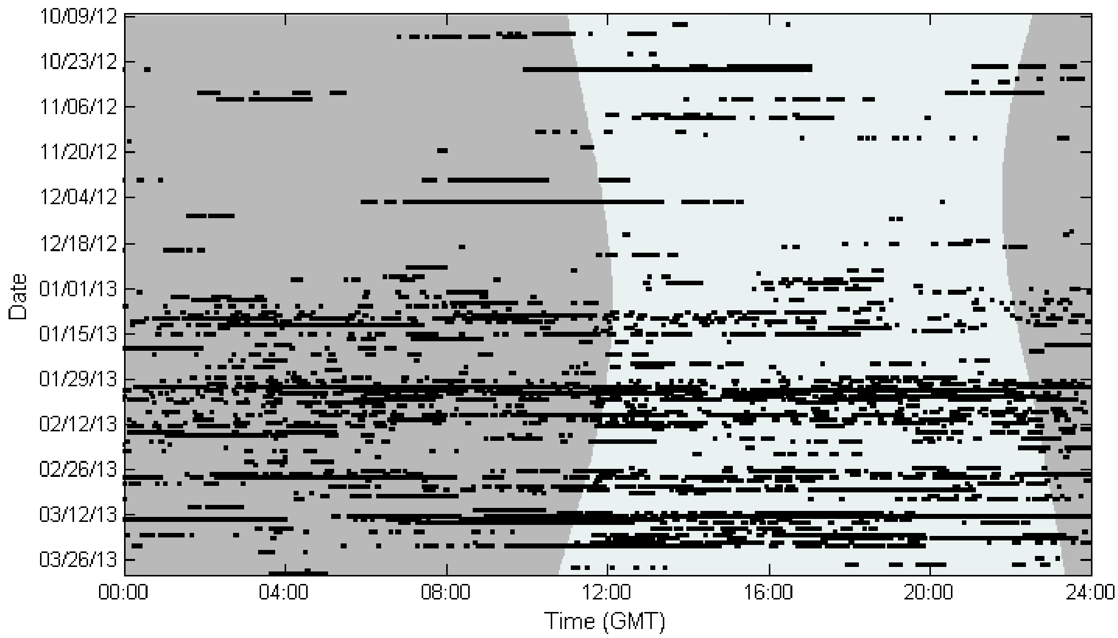

Figure 6. Sperm whale click detections (black bars) for the October 2012 – May 2013 deployment. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

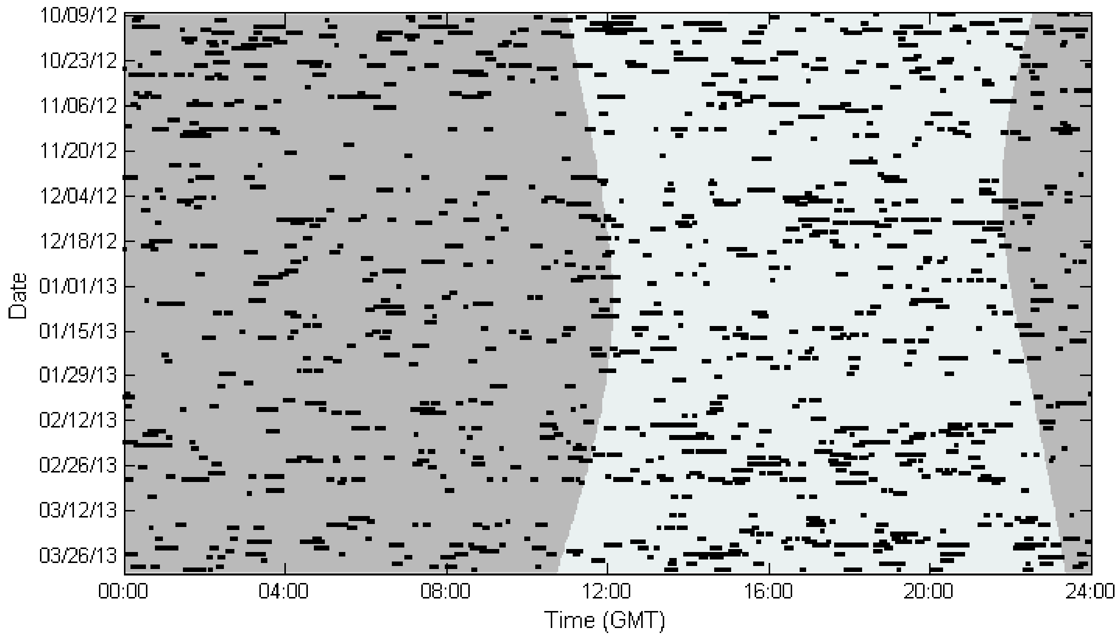

Figure 7. Cuvier's beaked whale click detections (black bars) for the October 2012 – May 2013 deployment. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

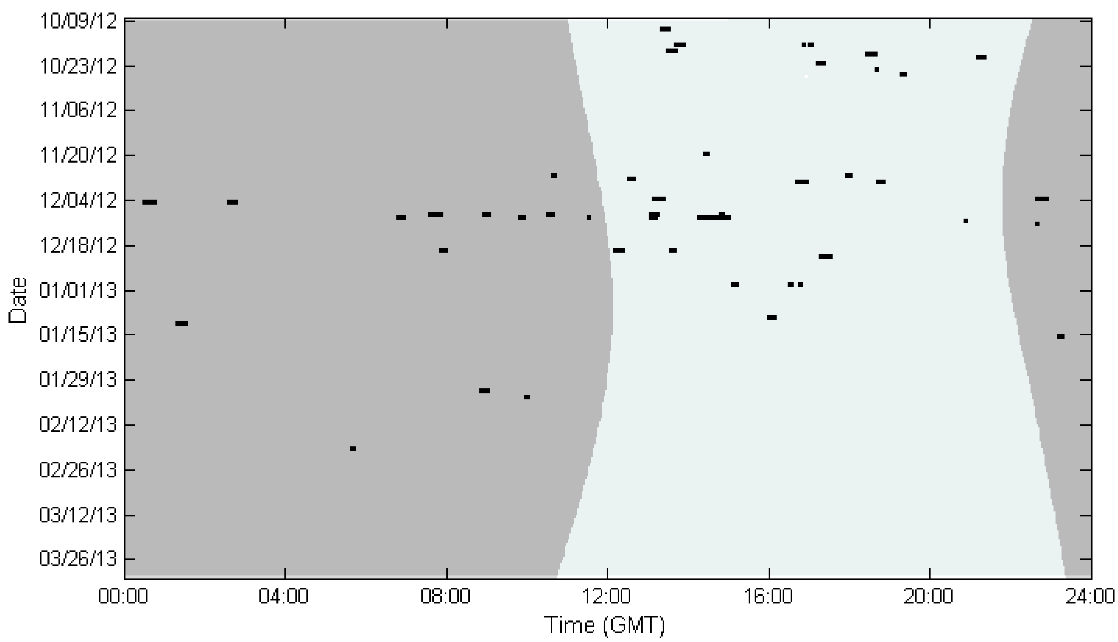

Figure 8. Unidentified beaked whale (*Mesoplodon sp.*) click detections (black bars) for the October 2012 – May 2013 deployment. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

2. Passive Acoustic Monitoring in Onslow Bay, NC

Methods

HARP Data Collection

The HARP deployed in 853 m at 33.78696 N, -75.92801 W (Site E) on October 24, 2012 was recovered on August 8, 2013 (Table 3; Figure 9). A schematic diagram of the HARP mooring for this deployment can be seen in Figure 10. This HARP sampled at 200 kHz on a duty cycle of five minutes on/five minutes off and provided data during 249 days (October 24, 2012 – June 30, 2013). Unfortunately, due to inclement weather and logistical issues, the HARP has not yet been redeployed in Onslow Bay.

Table 3. Onslow Bay, NC, HARP data sets analyzed and detailed in this report.

Site	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Latitude	Longitude	Depth (m)	Sampling Rate	Duty Cycle
06E	18-Aug-11	13-Jul-12	19-Aug-11	1-Dec-11	33.77794	-75.92641	952	200 kHz	5 min on / 5 min off
07E	13-Jul-12	24-Oct-12	14-Jul-12	2-Oct-12	33.78666	-75.92915	914	200 kHz	5 min on / 5 min off
08E	24-Oct-12	8-Aug-13	24-Oct-12	30-Jun-13	33.78696	-75.92801	853	200 kHz	5 min on / 5 min off

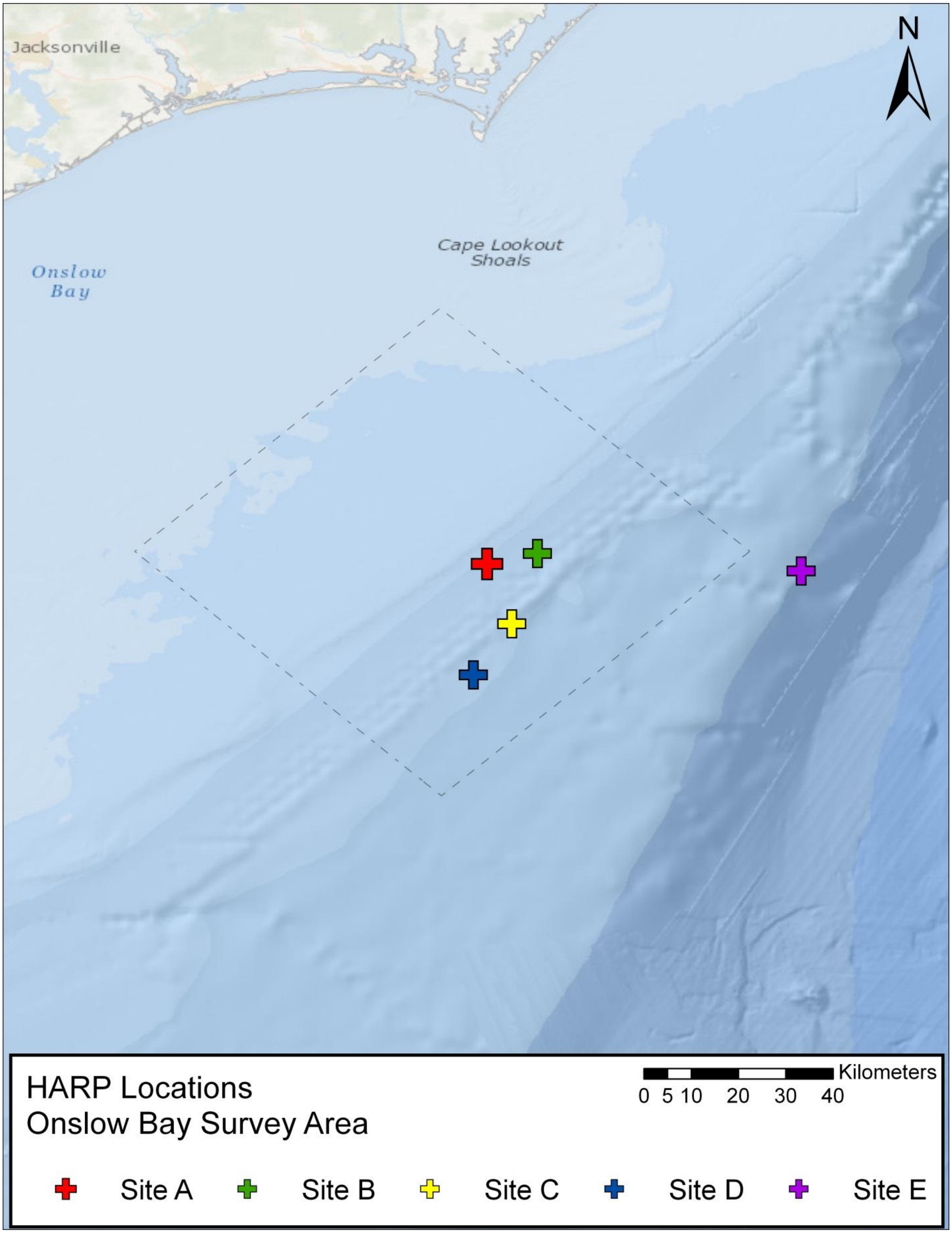

Figure 9. Location of HARP deployment sites in the Onslow Bay survey area.

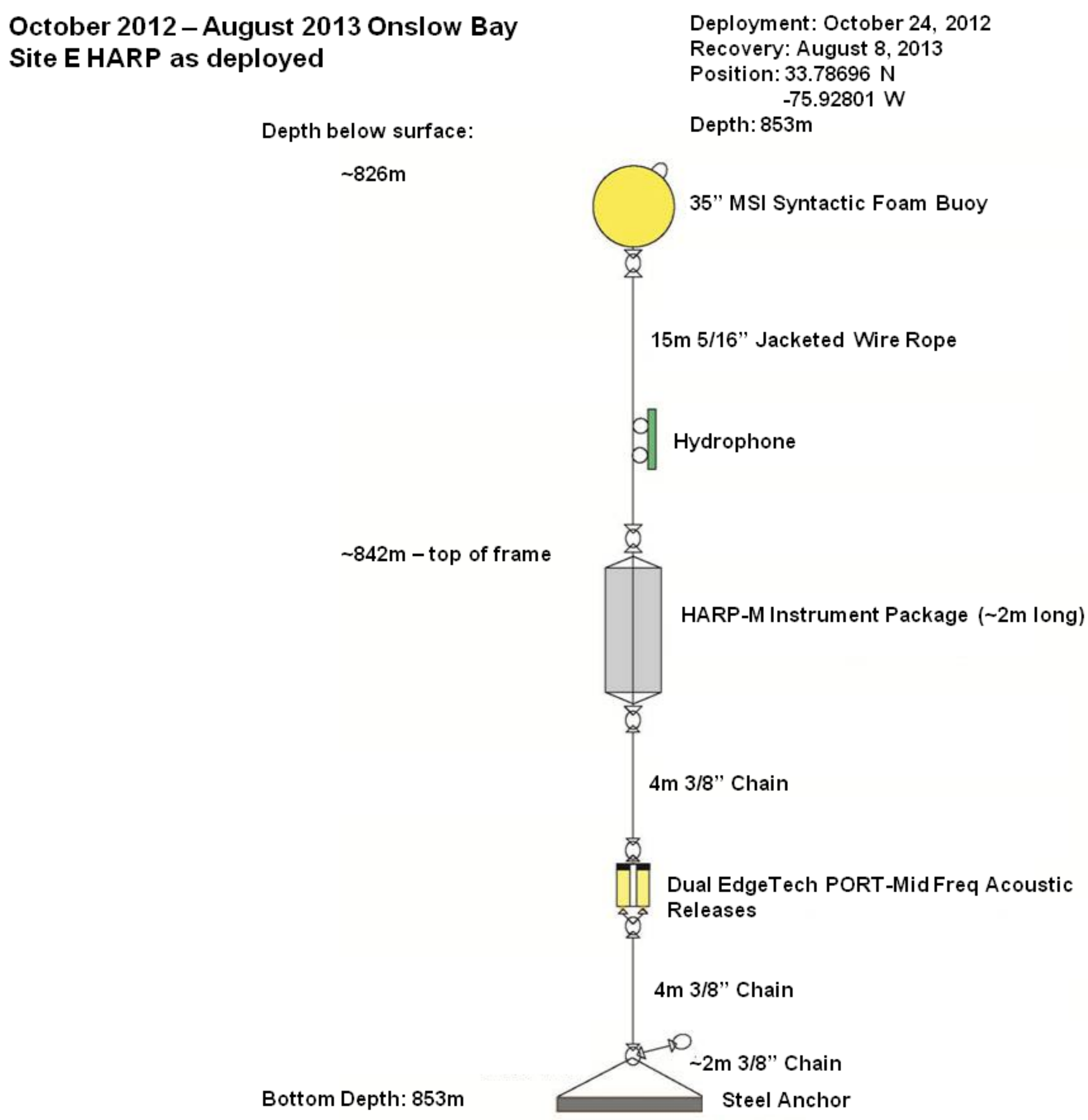

Figure 10. Schematic diagram showing details of the Site E Onslow Bay HARP deployment between October 2012 and August 2013. Note that diagram is not drawn to scale.

<u>Analysis</u>

Data from the most recent Site E HARP deployment (October 2012 – August 2013) have not yet been analyzed. The data from the August 2011 – July 2012 Site E HARP deployment (depth: 952 m; location: 33.77794 N, -75.92641 W; recording period: August 19 – December 1, 2011;

amount of data: 1387.9 hrs during 105 days; Figure 9) and the July – October 2012 Site E HARP deployment (depth: 914 m; location: 33.78666 N, -75.92915 W; recording period: July 14 – October 2, 2012; amount of data: 1054.6 hrs during 81 days; Figure 9) were manually scanned for marine mammal vocalizations using the "logger" version of *Triton*. 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. Detection of humpback whale calls was automated using a power-law detector (Helble *et al.* 2012), after which 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, as described in detail in Debich *et al.* (2014) (Appendix I). Unidentified odontocete clicks were also assigned to spectral patterns by a trained analyst, further described in Debich *et al.* (2014). Manual scanning was used to detect mid-frequency active sonar, followed by the use of a custom developed software routine which detected individual pings and calculated peak-to-peak received sound pressure levels, as described in Debich *et al.* (2014). Please see Appendix I (Debich *et al.* 2014) for a more detailed description of analysis methods for data sets from Site E.

Results

The following is a summary of the analysis performed by Debich *et al.* (2014) at Scripps Institution of Oceanography. The full analysis report is found in Appendix I.

Underwater ambient noise during the two deployments is shown in Figures 11 and 12. Tables 4 and 5 summarize the detected and identified marine mammal vocalizations for the August – December 2011 Site E HARP data set and for the July – October 2012 Site E HARP data set, respectively. Figures 13-25 show the daily occurrence patterns for the different marine mammal groups (classified to species when possible). Figure 26 shows the occurrence of mid-frequency active sonar. More details on the calculated peak-to-peak received sound pressure levels of the mid-frequency active sonar can be found in Appendix I.

Blue whale calls were detected from early September through late October in 2011 (Figure 13a) and from late August through late September in 2012 (Figure 13b). This timing is consistent with other recordings at similar latitudes near the mid-Atlantic ridge (Nieukirk *et al.* 2004), as well as acoustic records from other Onslow Bay sites (Hodge, *In Preparation*).

Fin whale 20-Hz pulses were detected from late August through November 2011, with peak calling in October (Figure 14). No fin whale 20-Hz pulses were detected between July and October 2012.

Minke whale pulse trains were detected at between late September and early December 2011, peaking towards the end of the deployment (Figure 15). No minke whales were recorded at this site between July and October 2012.

Downsweeps, similar to those ascribed to sei whales by Baumgartner *et al.* (2008), were detected in October, November, and early December 2011 (Figure 16). No downsweeps were detected between July and October 2012.

Odontocete vocalizations at Site E included echolocation clicks and frequency-modulated whistles (Figures 17-25). Most of these detections were assigned to the unidentified odontocete category (Figure 17), with clicks being divided into four main groups when possible based on spectral patterns. Unidentified odontocete whistles <5 kHz, possibly related to killer whale occurrence, were detected in both 2011 and 2012 (see Appendix I for more details). There was a peak in these <5 kHz whistle detections in mid-November 2011, but no obvious peak in 2012.

Several click detections were assigned to beaked whales. There were a few detections of an unfamiliar click type assigned to an unidentified beaked whale species (BW38) in 2011, but no detections in 2012 (Figure 18). Blainville’s beaked whale (*Mesoplodon densirostris*) clicks were detected in both 2011 and 2012 (Figure 19). Similarly, Cuvier’s beaked whale clicks were detected in both 2011 and 2012 (Figure 20). There was a slight peak in Cuvier's click detections in November 2011. There were significantly more detections of Gervais' beaked whale than any other beaked whale. Detections for this species peaked in November 2011 and in mid- to late September in 2012 (Figure 21). Other detected odontocete clicks included killer whales, which were detected in late November 2011 (Figure 22). No killer whale clicks were recorded in 2012. Finally, *Kogia* spp. (Figure 23), Risso's dolphins (*Grampus griseus*) (Figure 24), and sperm whales (Figure 25) were detected in both the August – December 2011 and July – October 2012 deployments. *Kogia* spp. clicks peaked in late November 2011.

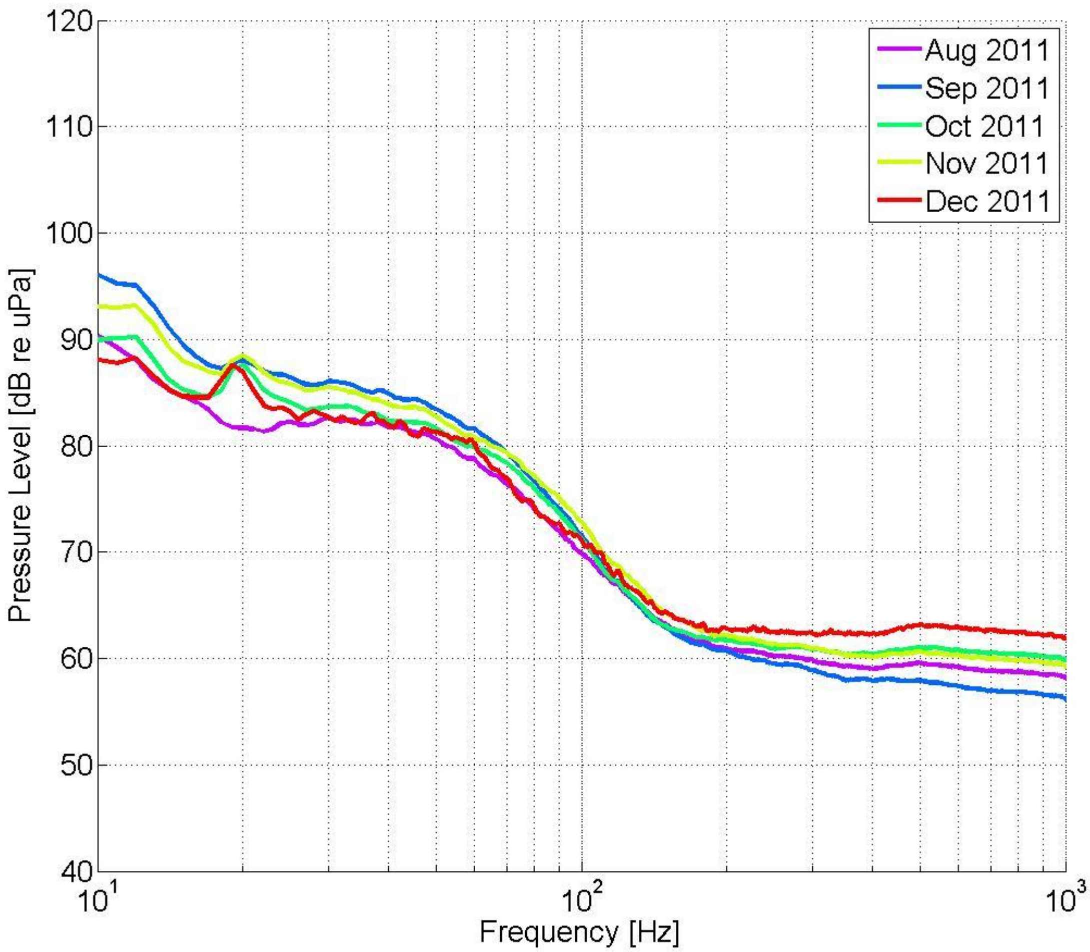

Figure 11. Monthly averages of ambient noise at Site E for August – December 2011.

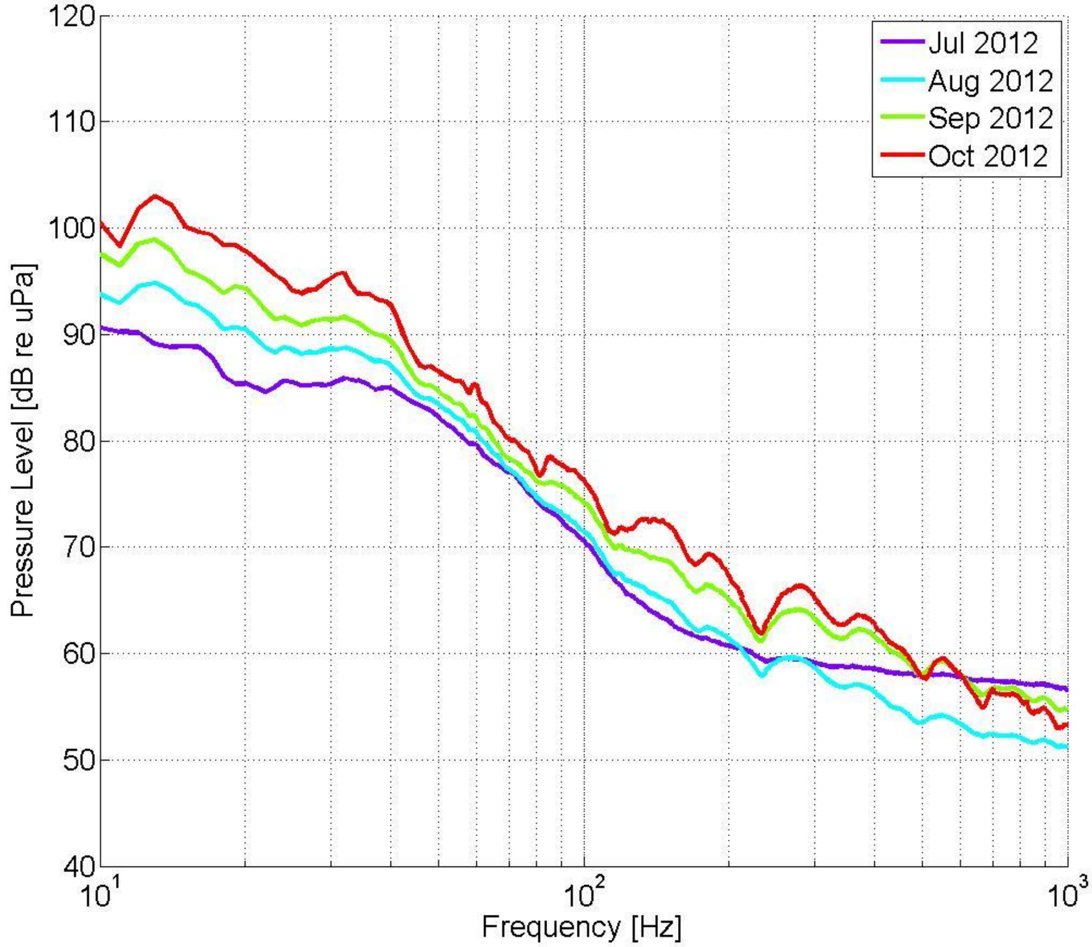

Figure 12. Monthly averages of ambient noise at Site E for July – October 2012.

Table 4. 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

Table 5. Summary of detections of marine mammal vocalizations at Site E for July – October 2012. * 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	3	0.18	2	2.47
Unidentified odontocete	clicks, whistles	119.25	11.31	64	79.01
Blainville's beaked whale	clicks	0.93	0.09	2	2.47
Cuvier's beaked whale	clicks	0.87	0.08	3	3.70
Gervais' beaked whale	clicks	175.45	16.64	77	95.06
Kogia spp.	clicks	0.48	0.05	7	8.64
Risso's dolphin	clicks	12.38	1.17	10	12.35
Sperm whale	clicks	72.73	6.90	32	39.51

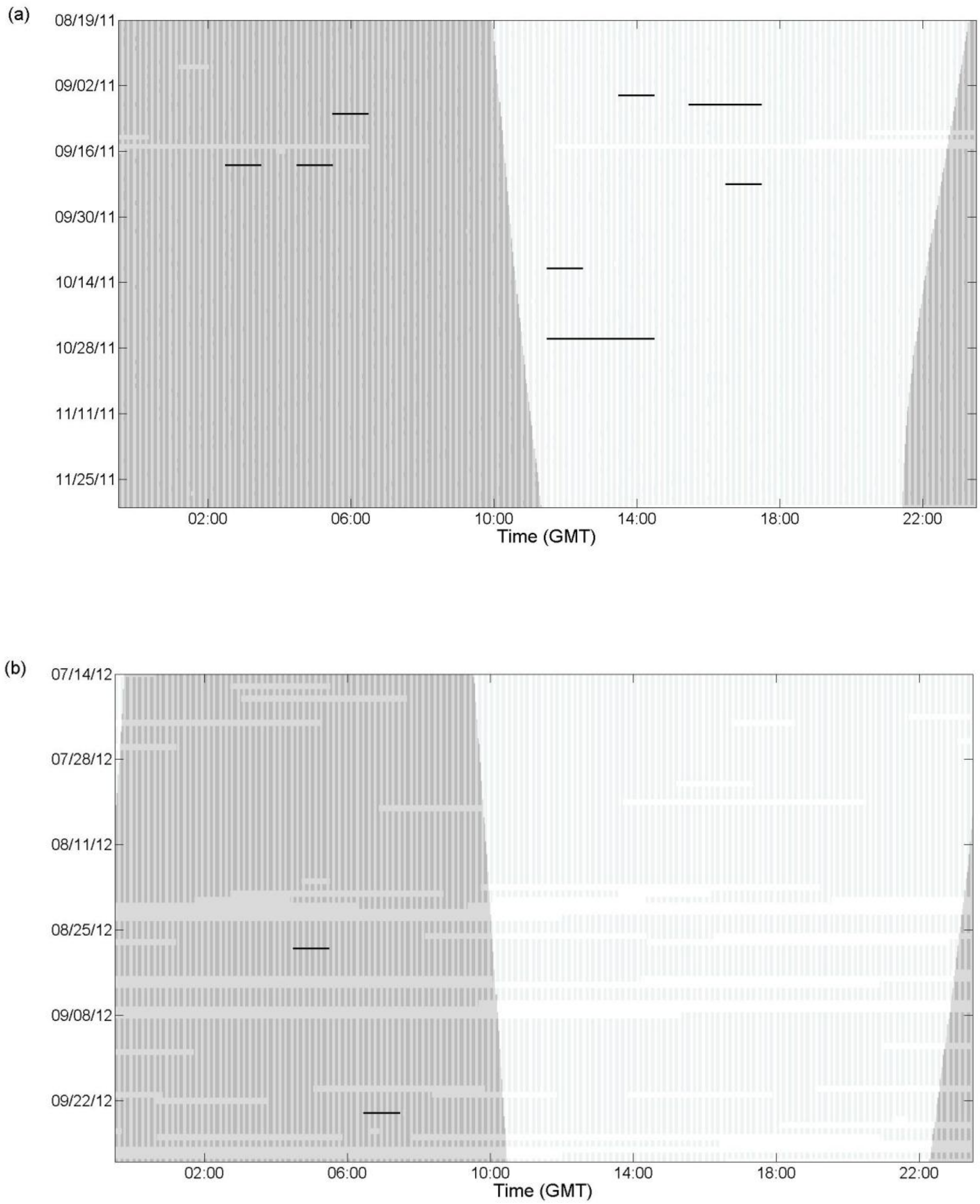

Figure 13. Blue whale Type A and B call detections (black bars) in hourly bins for the (a) August – December 2011 Site E data set and (b) July – October 2012 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort, including times when masking may have occurred (shown in one-minute bins).

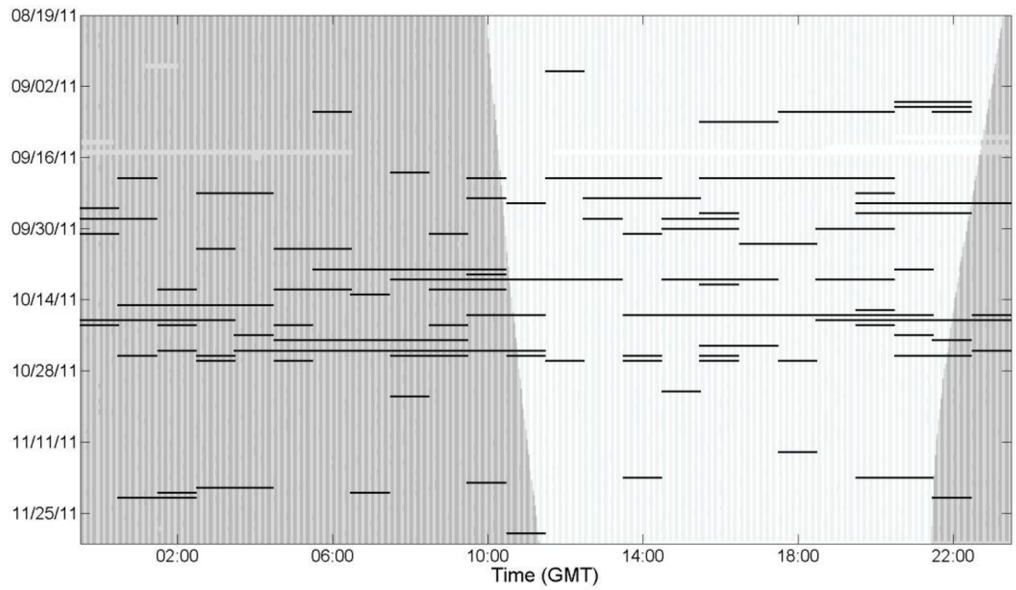

Figure 14. Fin whale 20-Hz pulse detections (black bars) in hourly bins for the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort, including times when masking may have occurred (shown in one-minute bins). No fin whale 20-Hz pulses were detected between July and October 2012 at Site E.

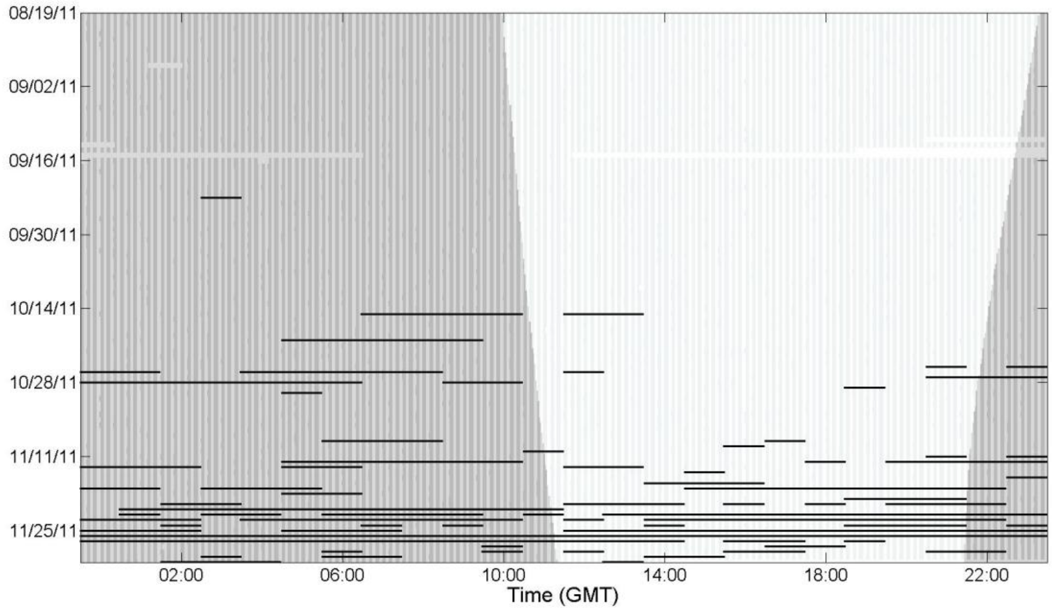

Figure 15. Minke whale detections (black bars) in hourly bins for the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort, including times when masking may have occurred (shown in one-minute bins). No minke whale pulse trains were detected between July and October 2012 at Site E.

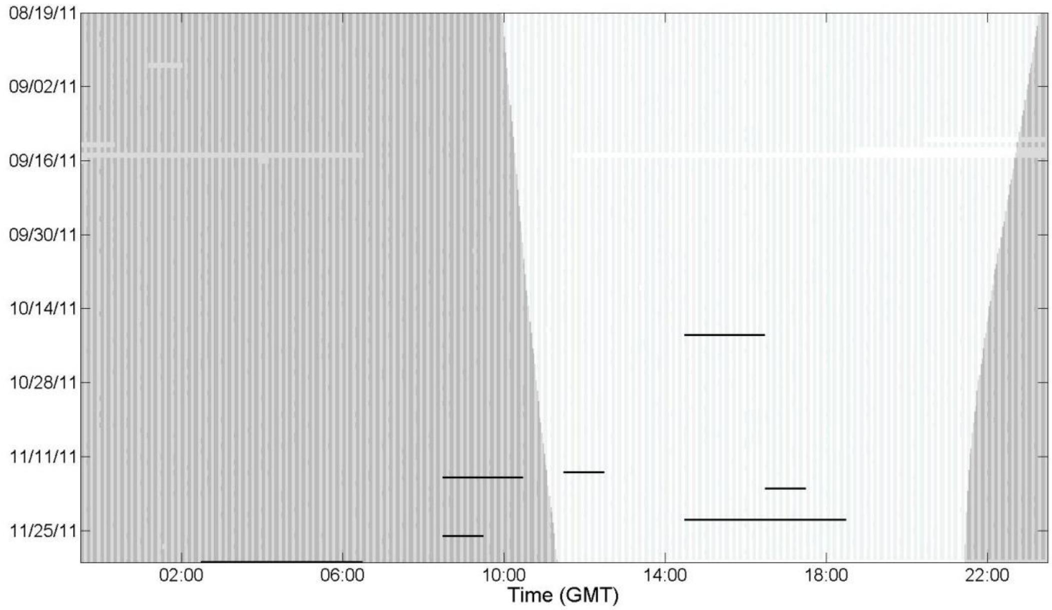

Figure 16. Downweep detections (black bars) in hourly bins that may be produced by sei whales (Baumgartner *et al.* 2008) for the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort, including times when masking may have occurred (shown in one-minute bins). No downsweep detections occurred between July and October 2012 at Site E.

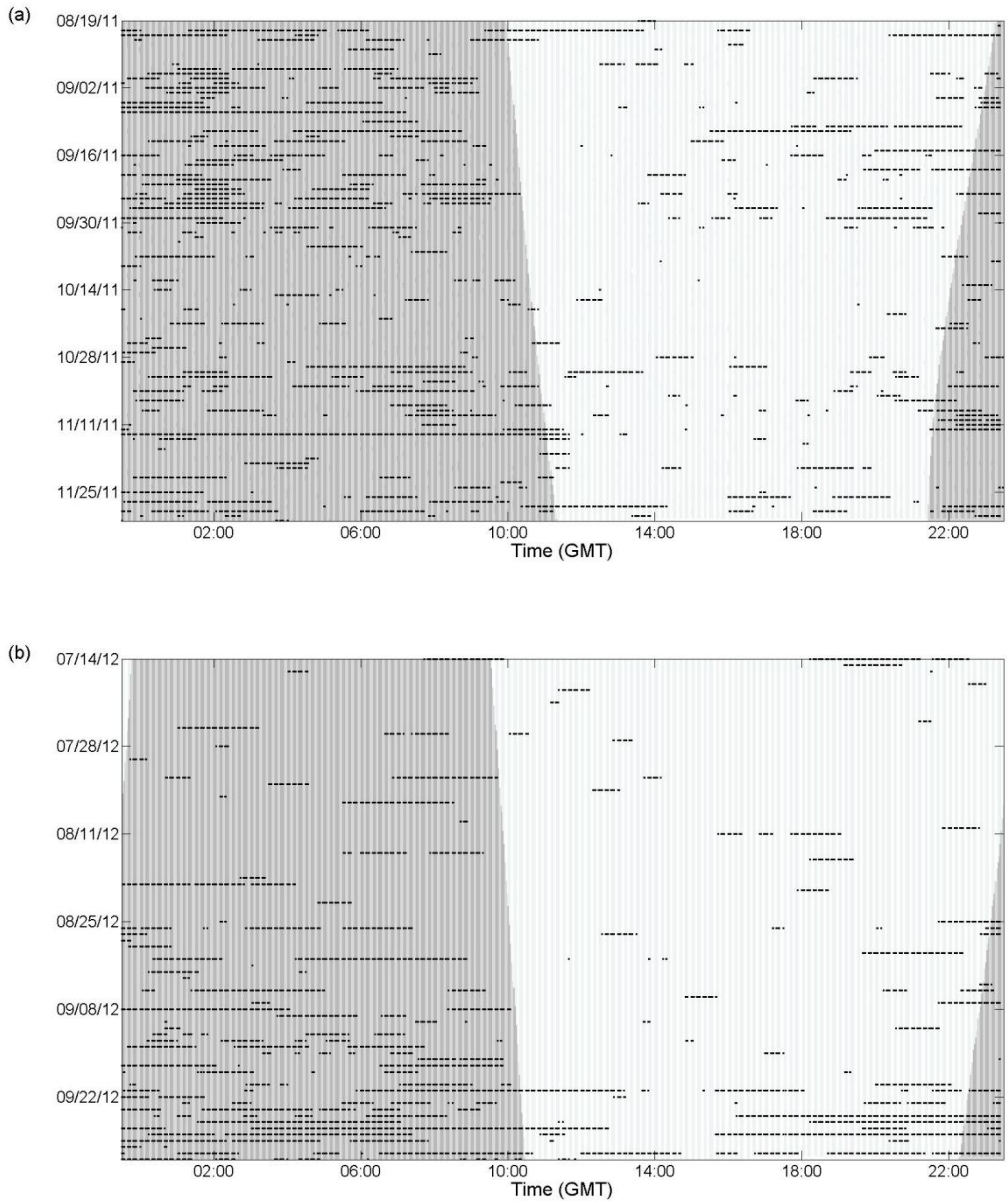

Figure 17. Unidentified odontocete vocalization detections (black bars) for the (a) August – December 2011 Site E data set and (b) July – October 2012 Site E data set. These detections also include clicks that were assigned to four spectral patterns based on spectral features. See Appendix I for more 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.

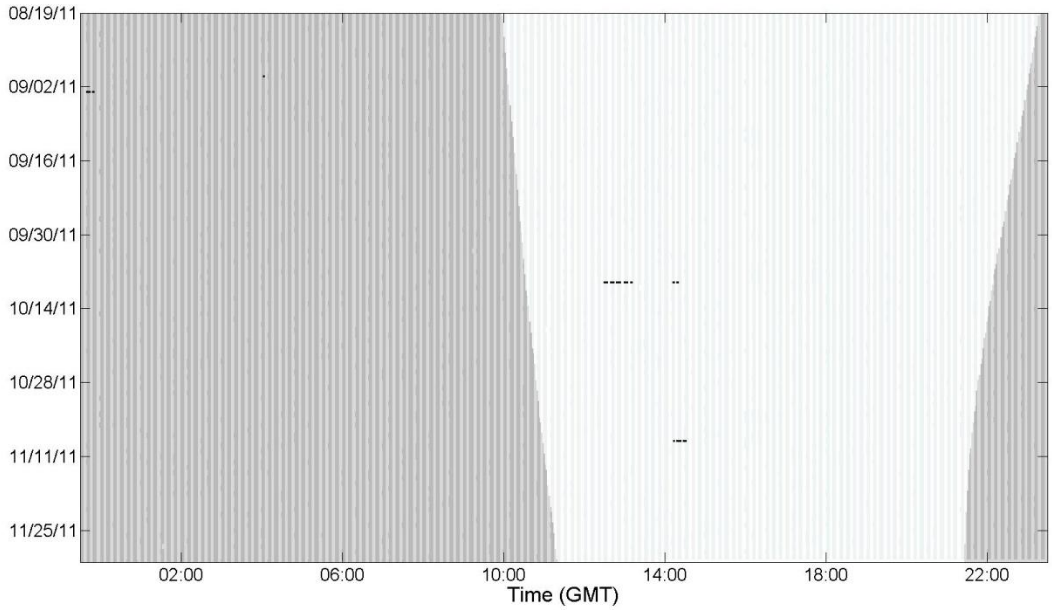

Figure 18. Unidentified beaked whale (BW38) click detections (black bars) for the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort. No BW38 clicks were detected between July and October 2012 at Site E.

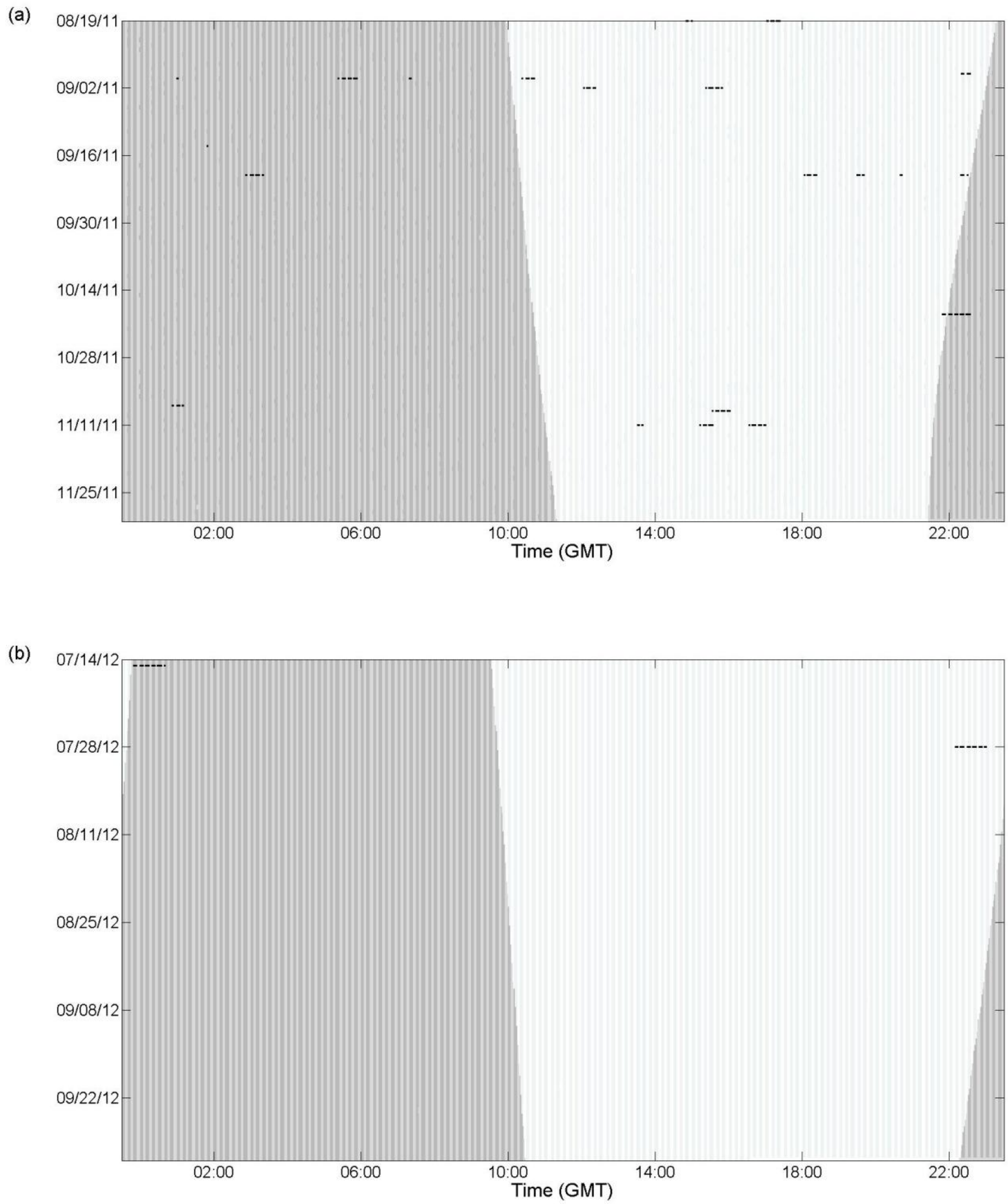

Figure 19. Blainville's beaked whale click detections (black bars) for the (a) August – December 2011 Site E data set and (b) July – October 2012 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

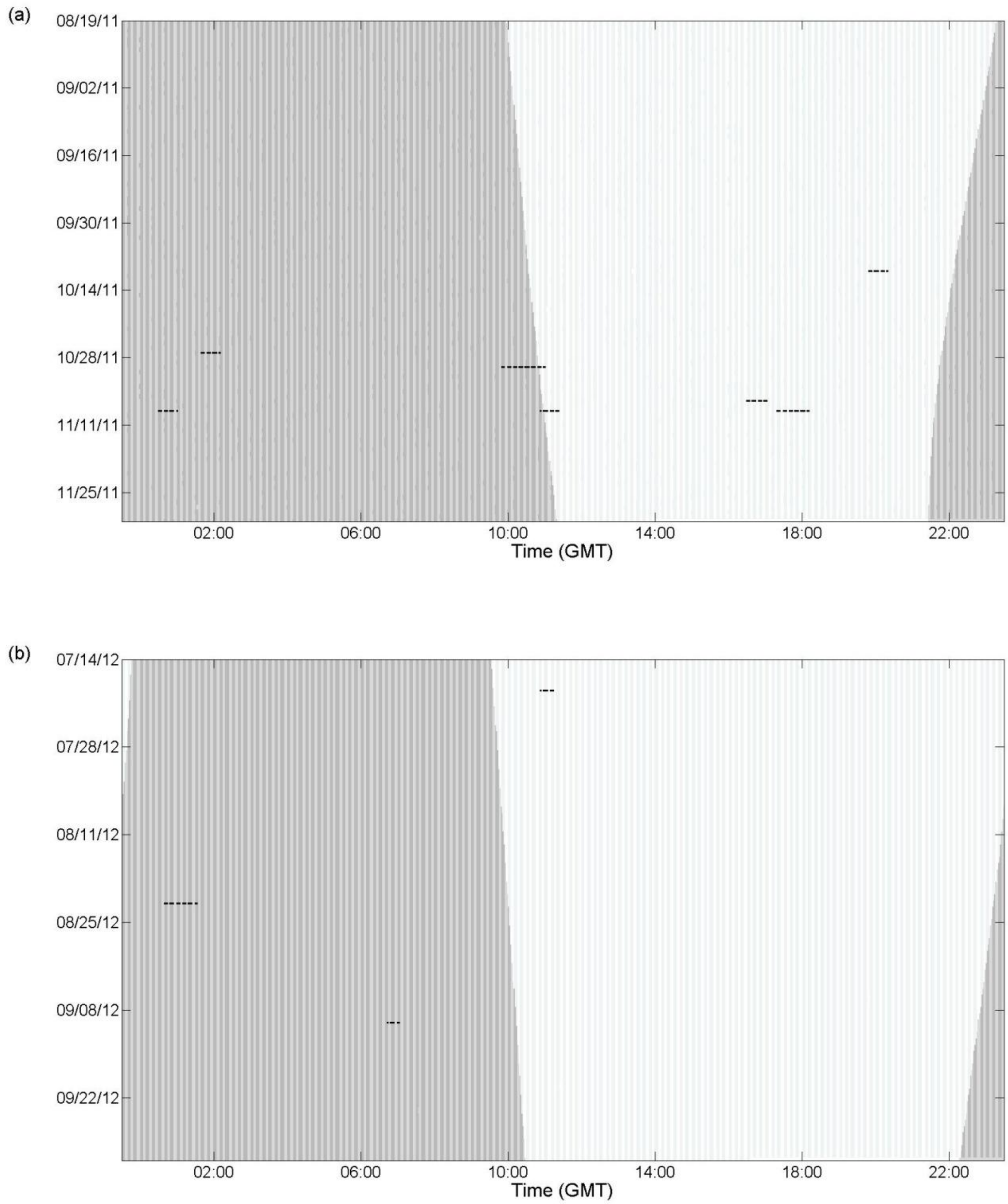

Figure 20. Cuvier's beaked whale click detections (black bars) for the (a) August – December 2011 Site E data set and (b) July – October 2012 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

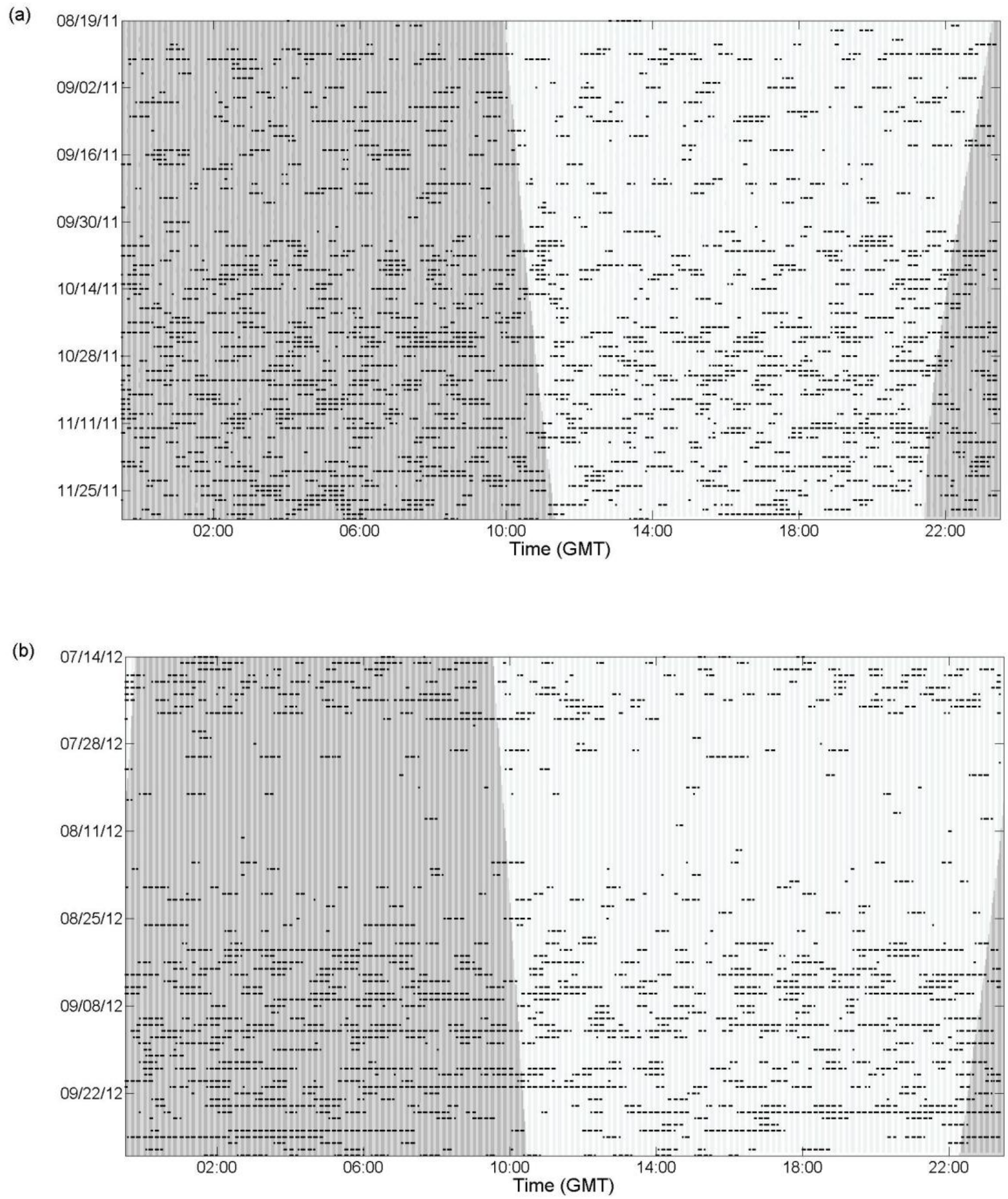

Figure 21. Gervais' beaked whale click detections (black bars) for the (a) August – December 2011 Site E data set and (b) July – October 2012 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

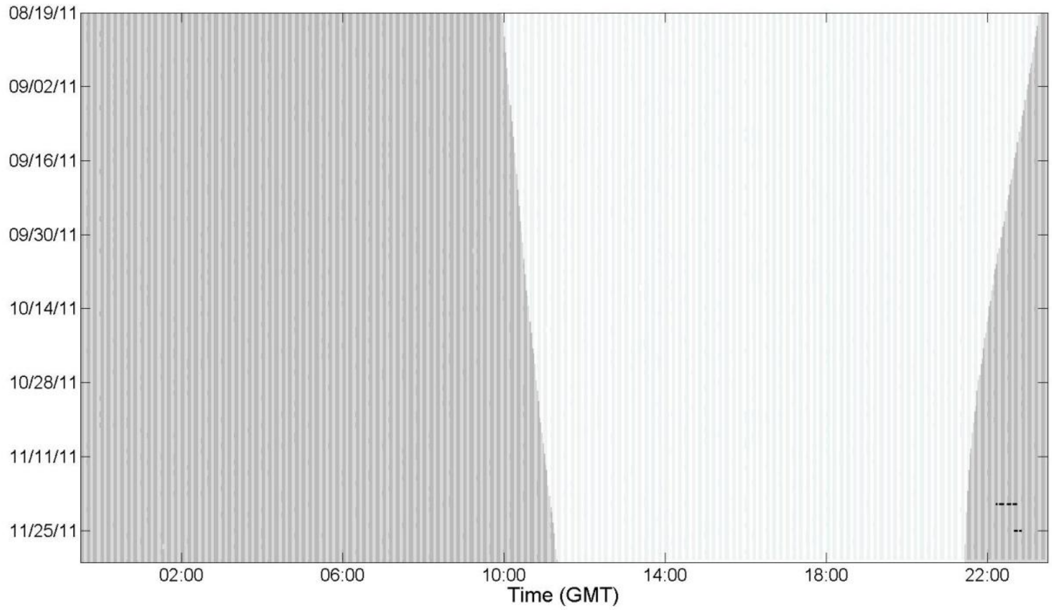

Figure 22. Killer whale click detections (black bars) for the August – December 2011 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort. No killer whale clicks were detected between July and October 2012 at Site E.

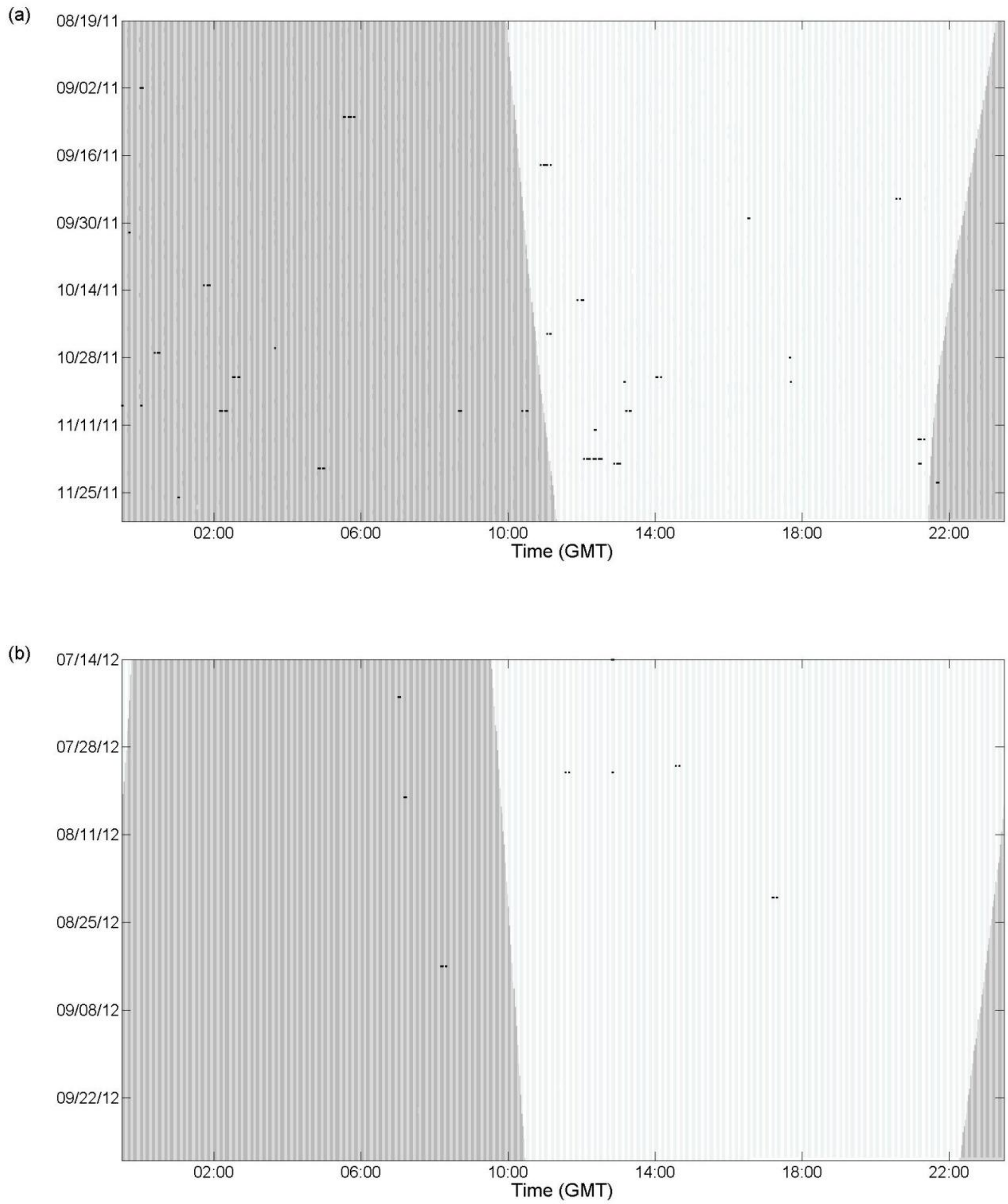

Figure 23. Kogia spp. click detections (black bars) for the (a) August – December 2011 Site E data set and (b) July – October 2012 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

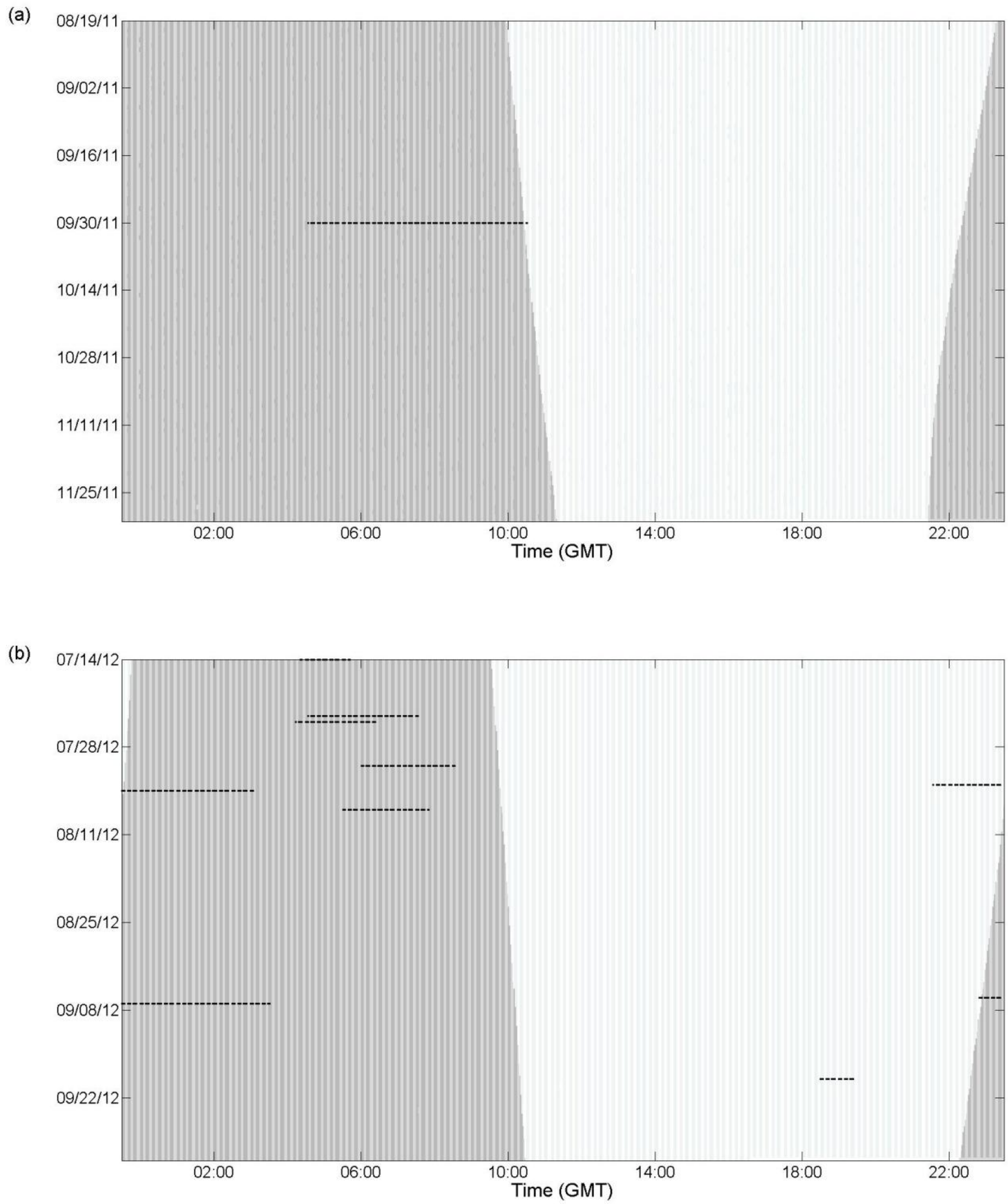

Figure 24. Risso's dolphin click detections (black bars) for the (a) August – December 2011 Site E data set and (b) July – October 2012 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

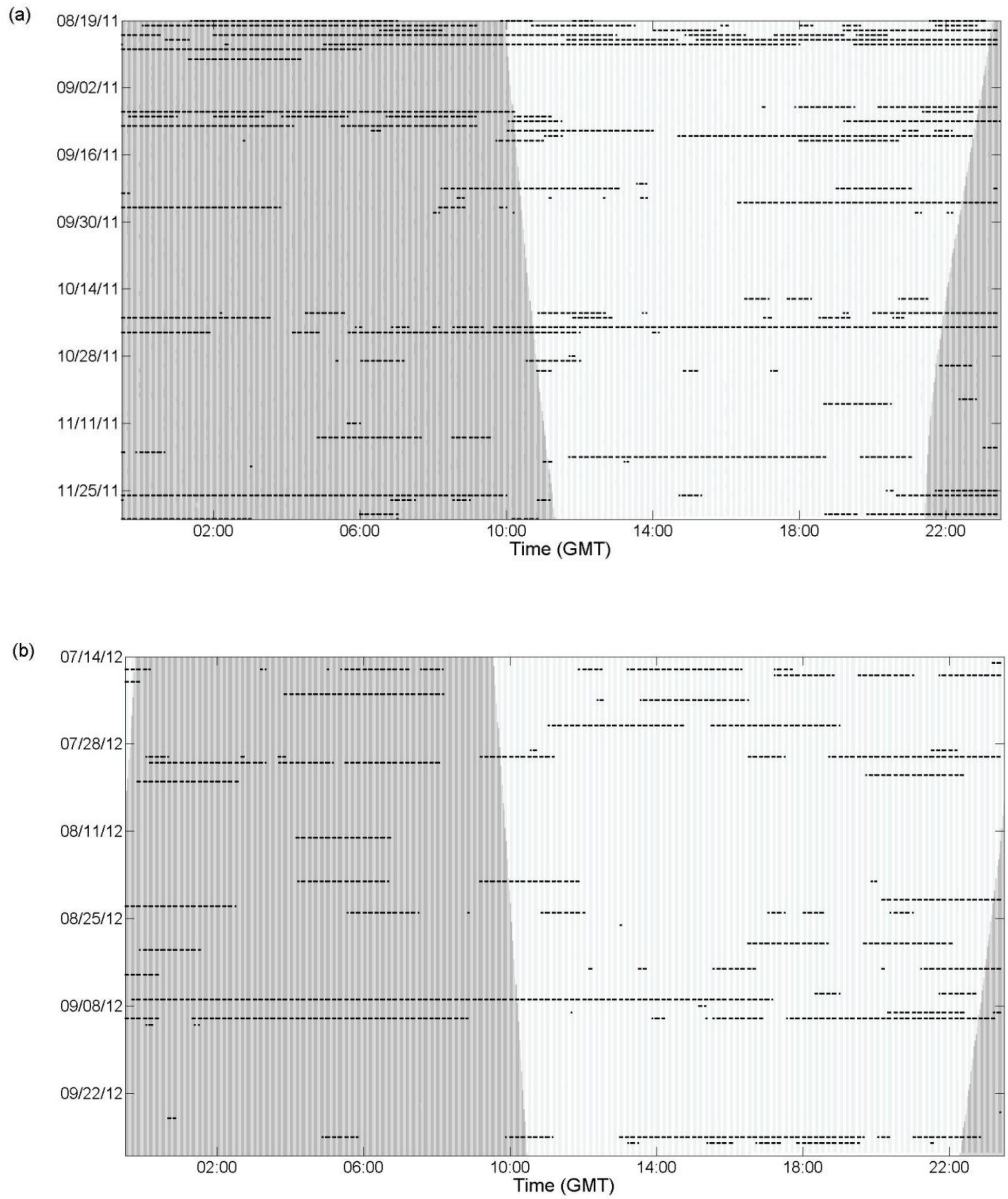

Figure 25. Sperm whale click detections (black bars) for the (a) August – December 2011 Site E data set and (b) July – October 2012 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

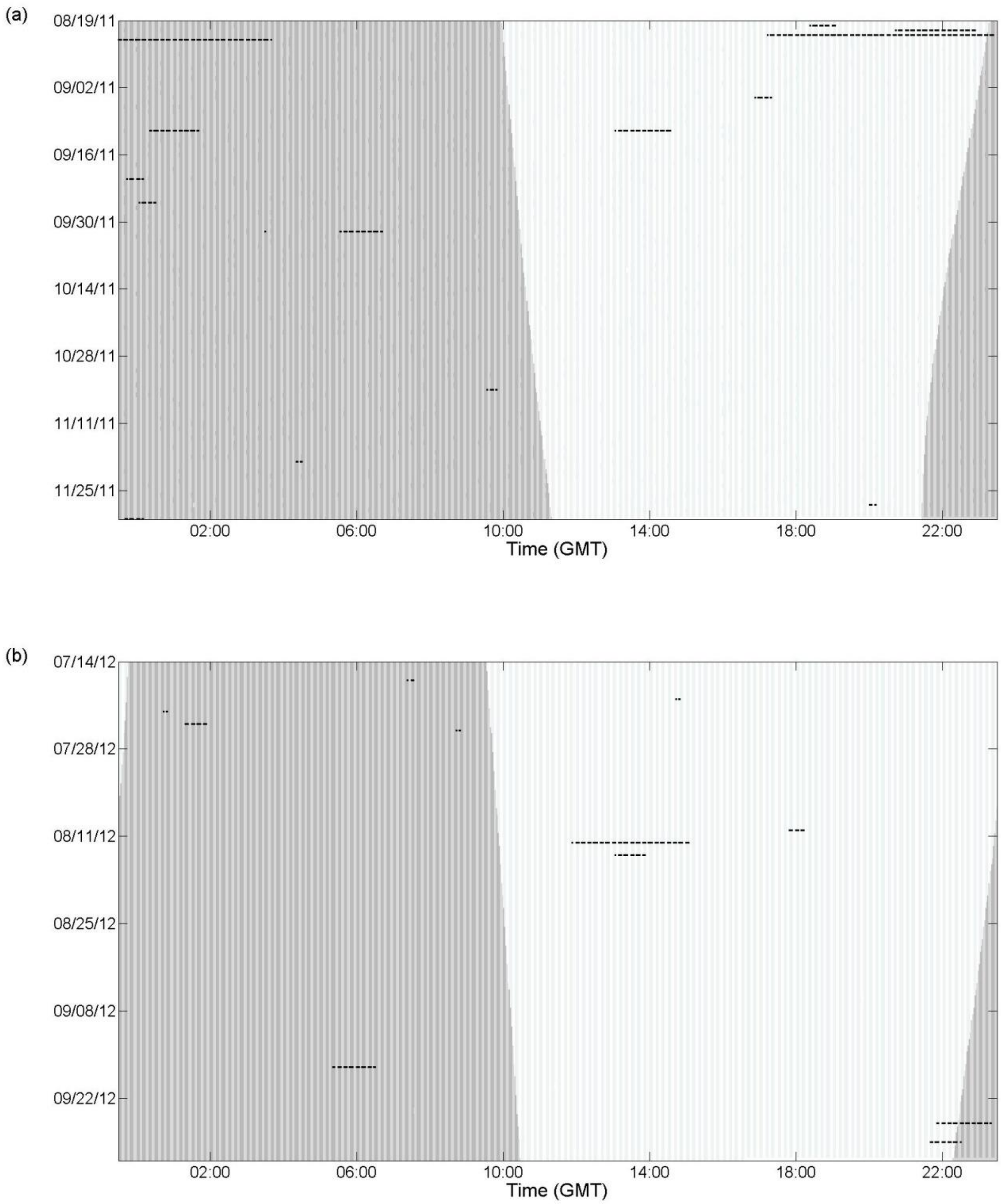

Figure 26. Mid-frequency active sonar (black bars) detected during the (a) August – December 2011 Site E data set and (b) July – October 2012 Site E data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

3. Passive Acoustic Monitoring in Jacksonville, FL

Methods

HARP Data Collection

The HARP deployed in 94 m at 30.33287 N, -80.20071 W (Site C) on May 12, 2013 was recovered on February 17, 2014 (Table 6; Figure 27). The deployment period was 282 days. A new HARP, with a smaller mooring design, was deployed in 88 m at 30.32643 N, -80.20493 W (Site C) on February 17, 2014 (Table 6; Figure 27). Both HARPs were set to sample continuously at 200 kHz. Schematic diagrams of the HARP moorings for these deployments can be seen in Figures 28 and 29. The switch to a smaller mooring was made to allow for greater flexibility in terms of boat scheduling and weather windows during retrievals and deployments, as the smaller design can be handled from smaller vessels (such as the SAFE boat recently purchased by the Duke Marine Lab) and in less optimal sea state conditions. The ability to use smaller vessels will allow HARP deployments and retrievals to occur during short weather windows, as these boats can operate at much faster running speeds than other vessels.

Table 6. Jacksonville, FL, HARP data sets analyzed and detailed in this report.

Site	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Latitude	Longitude	Depth (m)	Sampling Rate	Duty Cycle
4B	9-Mar-10	26-Aug-10	9-Mar-10	19-Aug-10	30.2592	-80.4257	40	200 kHz	5 min on / 10 min off
9C	12-May-13	17-Feb-14	13-May-13	20-Jun-13	30.33287	-80.20071	94	200 kHz	continuous
10C	17-Feb-14	N/A	17-Feb-14	N/A	30.32643	-80.20493	88	200 kHz	continuous

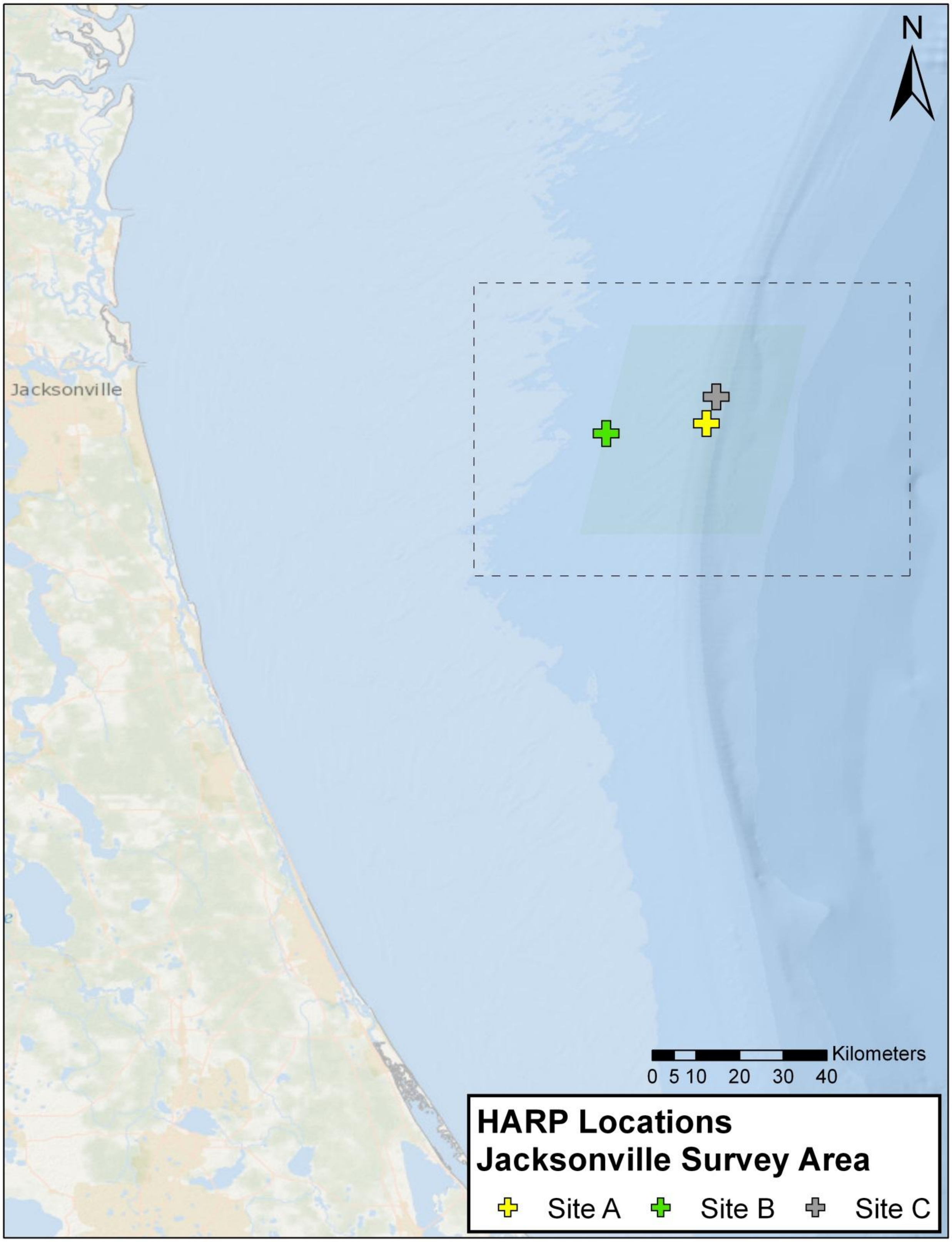

Figure 27. Location of HARP deployment sites in the Jacksonville, Florida survey area.

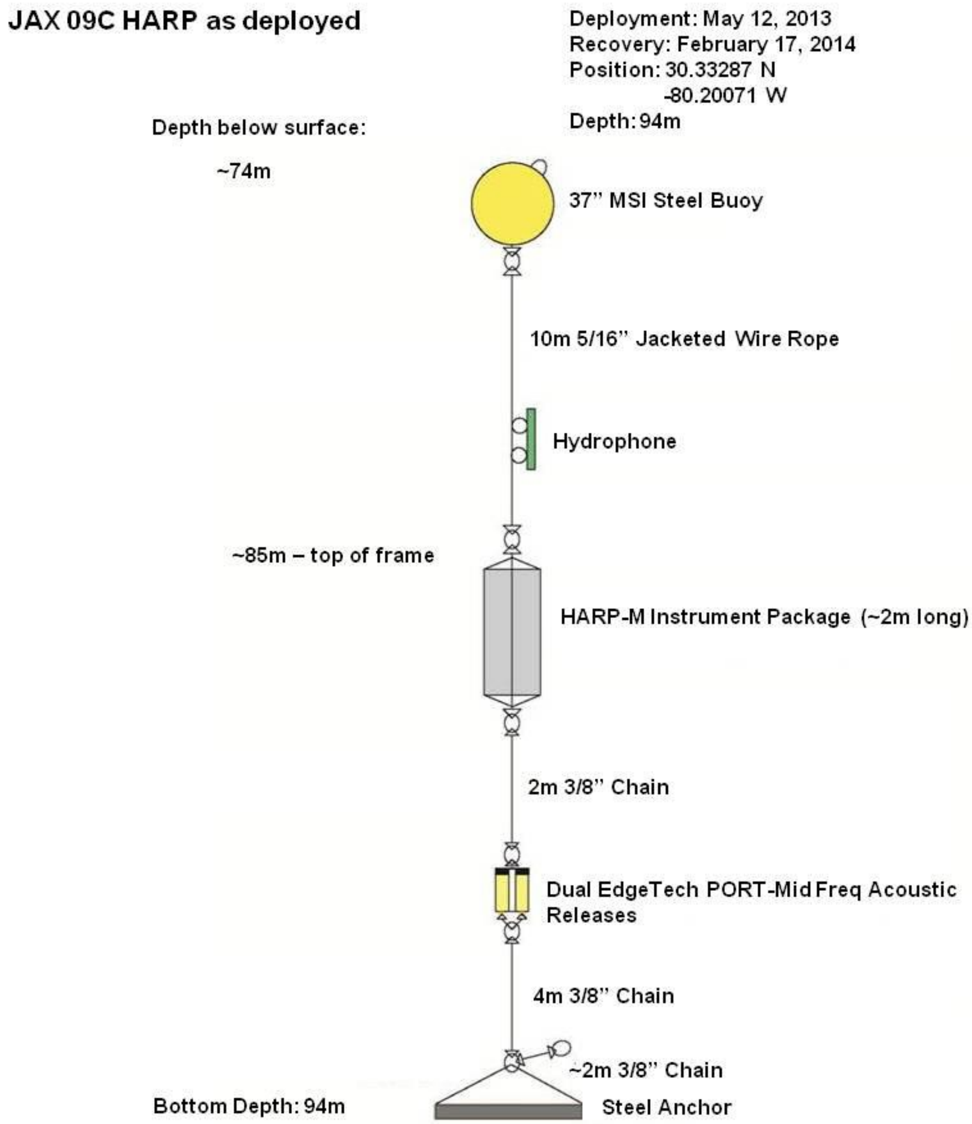

Figure 28. Schematic diagram showing details of the Site C Onslow Bay HARP deployment (large mooring) between May 2013 and February 2014. Note that diagram is not drawn to scale.

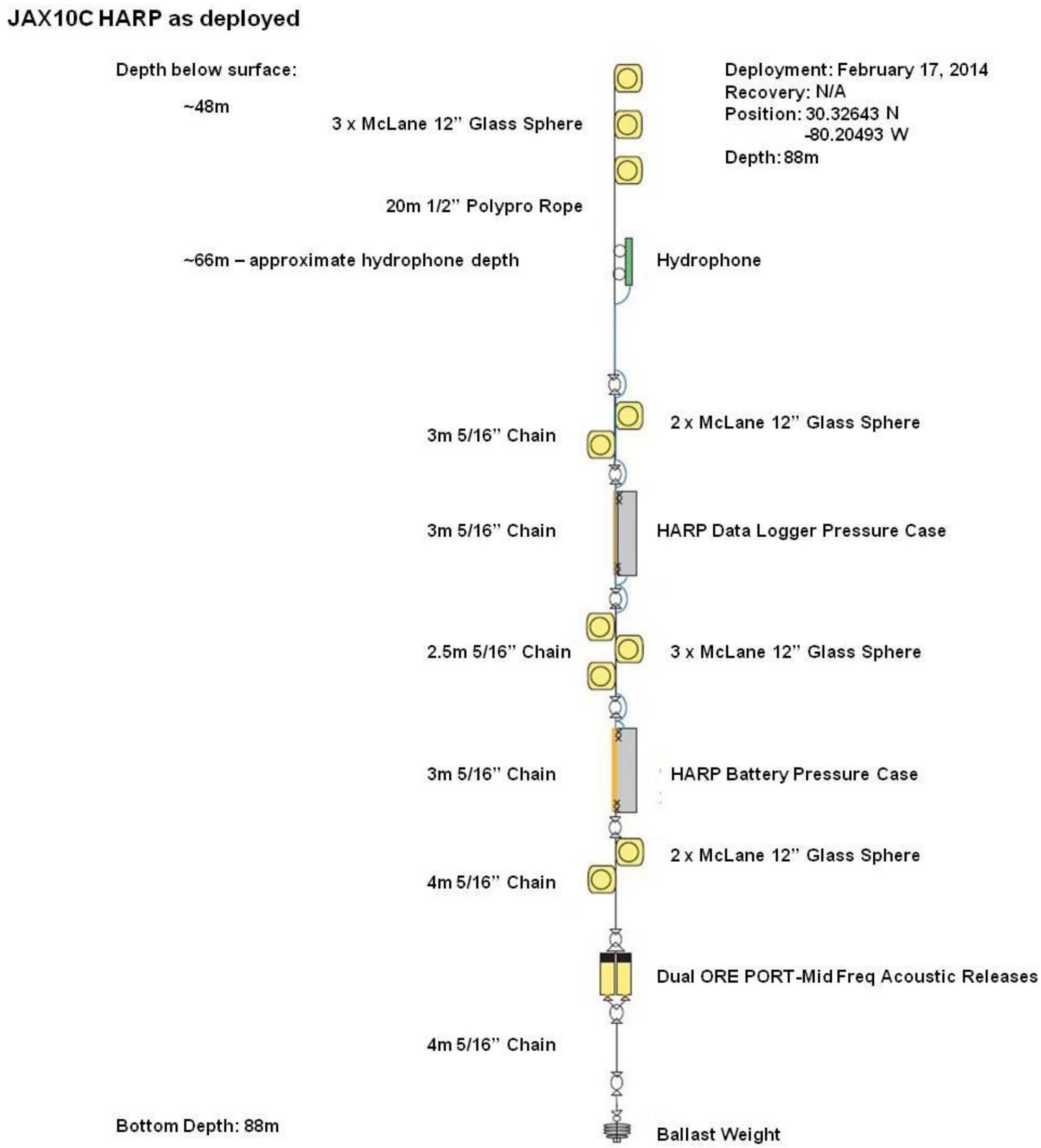

Figure 29. Schematic diagram showing details of the Site C Onslow Bay HARP deployment (small mooring) made in February 2014. Note that diagram is not drawn to scale.

<u>Analysis</u>

Acoustic records from the March – August 2010 Site B HARP deployment (Figure 27, Table 6) were manually scanned for baleen whale vocalizations and mid-frequency active sonar using

LTSAs. Analysis of high-frequency marine mammal calls in these records has been reported previously and therefore is not discussed here. For effective analysis of the low-frequency marine mammal sounds and mid-frequency active sonar, data were divided into two frequency bands: (1) low frequencies, between 10 – 1000 Hz; and (2) mid frequencies, between 500 – 5000 Hz. 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) and 5 s in time and 10 Hz in frequency (for the data decimated by a factor of 20: 500-5000 Hz band). All data were analyzed by visually scanning the LTSAs in appropriate frequency bands or by running automatic detectors. Each LTSA was analyzed for the sounds of an appropriate subset of species or sources. Blue, fin, Bryde's, minke, North Atlantic right, and sei whale sounds, and an unknown sound found during earlier JAX data analysis (the "5pulse" sound), were classified as low frequency; humpback whale and mid-frequency active sonar sounds were classified as mid-frequency. When a sound of interest was identified in the LTSA, the corresponding waveform or spectrogram was examined to further classify particular sounds to species or source. Acoustic classification was carried out either by comparison to species-specific spectral characteristics or by analysis of the time and frequency character of individual sounds. Humpback whale calls were identified using a power-law detector (Helble *et al.* 2012), followed by manual verification by a trained analyst. Manual scanning was used to detect mid-frequency active sonar, followed by the use of a custom software routine which detected individual pings and calculated peak-to-peak received sound pressure levels, described in further detail in Johnson *et al.* (2014). See Appendix II (Johnson *et al.* 2014) for a more detailed description of analysis methods.

Results

The following is a summary of the analysis performed by Johnson *et al.* (2014) at Scripps Institution of Oceanography. The full analysis report is found in Appendix II.

Underwater ambient noise during the March – August 2010 deployment at Site B is shown in Figure 30. High ambient noise levels, caused by instrument strumming and fluid flow at the hydrophone, were prevalent during this deployment and decreased the ability to detect low-frequency sounds. Table 7 summarizes the detected and identified mysticete vocalizations (consisting of only one species – the humpback whale) for this deployment. Figure 31 shows the daily occurrence patterns for humpback whales. Figure 32 shows the occurrence of mid-frequency active sonar. More details on the calculated peak-to-peak received sound pressure levels of the mid-frequency active sonar can be found in Appendix II.

Humpback whale vocalizations (not song) were detected during two days, March 11 and 12, 2010 (Figure 31). There were no instances of humpback whale song detected.

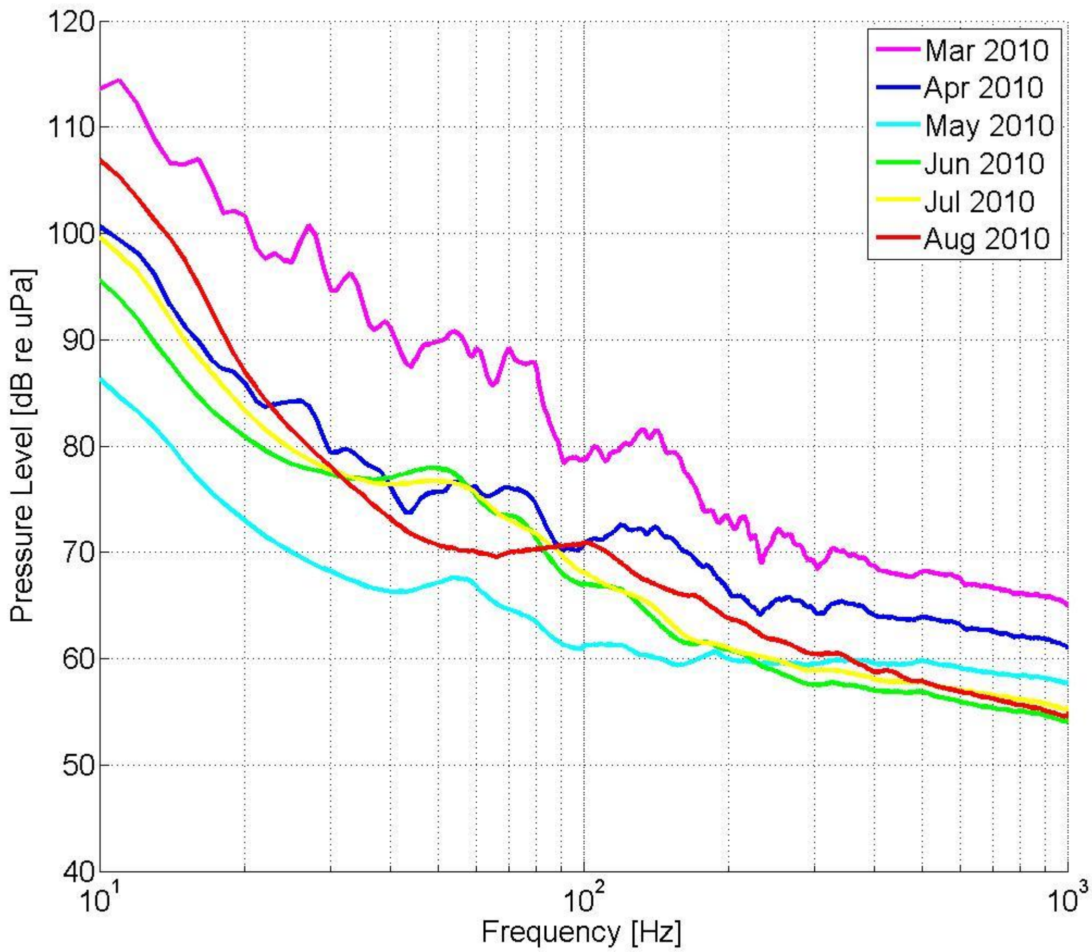

Figure 30. Monthly averages of ambient noise at Site B for March – August 2010.

Table 7. Summary of detections of mysticete vocalizations at Site B for March – August 2010.

Species	**Call type**	**Total duration of vocalizations (hours)**	**Percent of recording duration**	**Days with vocalizations**	**Percent of recording days**
Humpback whale	non-song	1.67	0.12	2	1.22

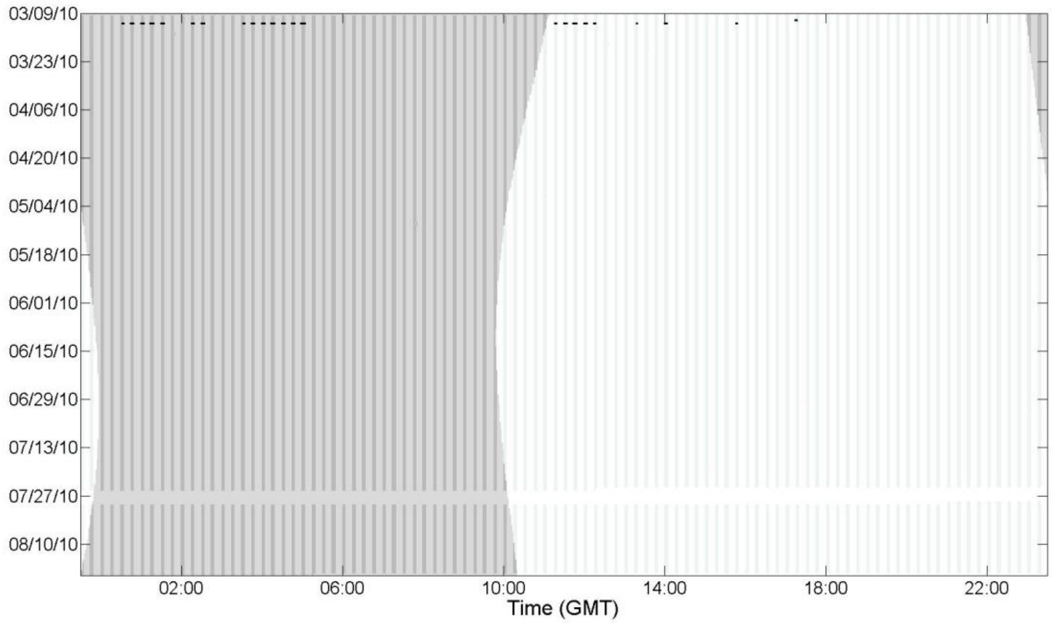

Figure 31. Humpback whale detections (black bars) for the March – August 2010 Site B data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

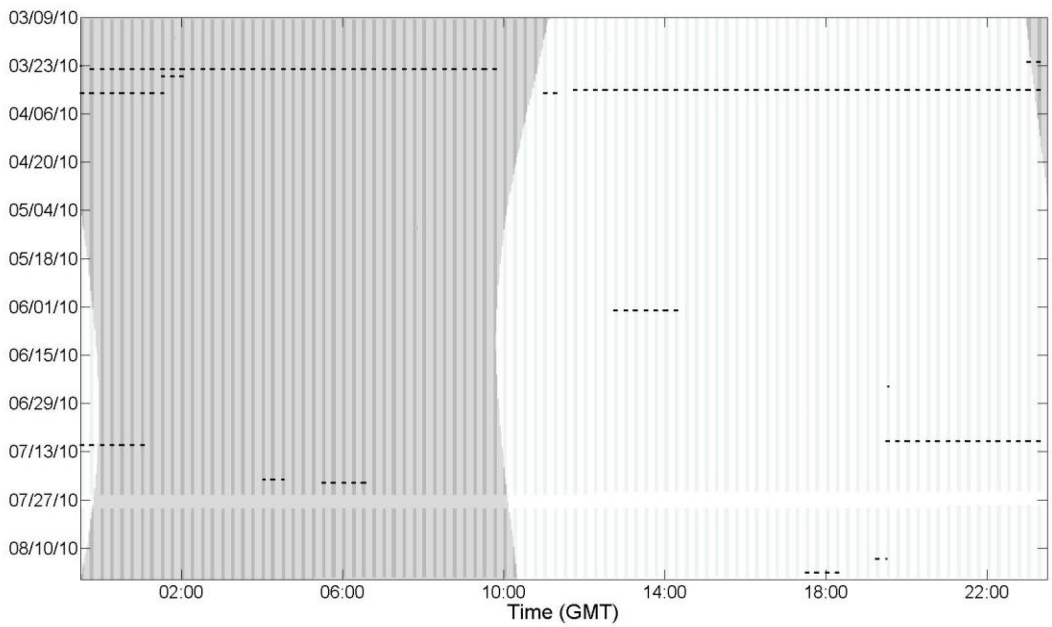

Figure 32. Mid-frequency active sonar (black bars) detected during the March – August 2010 Site B data set. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). Lighter shading indicates recording/analysis effort.

4. Current and Anticipated Analyses for 2014

Cape Hatteras

To date, the dataset from the Hatteras 02A deployment has been analyzed for beaked whales and sperm whales only. The Scripps Institution of Oceanography will complete analysis of this dataset over the next year. A detailed and technical report will be provided once the analysis is complete.

Onslow Bay

The dataset from the Onslow Bay 05D deployment (July 2010 – June 2011) is currently being analyzed. Disks 1-12 (out of 16 total) have been analyzed for high frequency odontocete vocalizations and sonar; disks 1-8 have been analyzed for low frequency mysticete vocalizations. The analysis for this dataset will be completed within the upcoming year. It is also anticipated that the dataset from the Onslow Bay 08E deployment (October 2012 – August 2013) will be analyzed over the next year. Technical reports for these datasets will be provided once the analyses are complete.

Jacksonville

The dataset from the recently recovered Jacksonville 09C deployment (May 2013 – February 2014) will be analyzed by Scripps Institution of Oceanography over the next year. A detailed and technical report will be provided once the analysis of this dataset is complete.

Summary of Deployments

The following is a table of all HARP deployments in Hatteras, Onslow Bay, and Jacksonville to date. The table includes information on: location; depth; deployment and retrieval dates; recording dates; ; duty cycle; status of analysis; and reports. All HARPs sampled at 200 kHz.

Location	Deployment ID	Latitude	Longitude	Depth (m)	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Duty Cycle (minutes on/off)	Status of Analysis	Report of Details?
JAX											
JAX A	JAX01A	30.2771	-80.1258	82	30MAR09	16SEP09	02APR09	25MAY09	5/10	HF	No
JAX B	JAX01B	30.2582	-80.4282	37	30MAR09	16SEP09	02APR09	05SEP09	5/10	HF, LF	No
JAX A	JAX02A	30.28052	-80.21603	83	16SEP09	21FEB09	16SEP09	15DEC09	5/10	HF, LF	No
JAX B	JAX02B	30.25820	-80.42800	39	23SEP09	21FEB09	No data	No data	5/10	N/A	No – no data
JAX A	JAX03A	30.28111	-80.21530	89	21FEB10	26AUG10	22FEB10	30JUL10	5/10	HF, M	No
JAX B	JAX04B	30.25919	-80.42566	38	09MAR10	26AUG10	09MAR10	19AUG10	5/10	HF, LF	No
JAX A	JAX05A	30.26819	-80.20894	91	26AUG10	01FEB11	26AUG10	25JAN11	5/10	HF, LF	Yes – T, D
JAX B	JAX05B	30.25708	-80.43269	37	26AUG10	01FEB11	27AUG10	01FEB11	5/10	HF, LF	Yes – T, D
JAX A	JAX06A	30.27818	-80.22085	91	01FEB11	14JUL11	01FEB11	14JUL11	5/10	HF, LF	Yes – T, D
JAX B	JAX06B	30.25768	-80.42781	37	02FEB11	14JUL11	02FEB11	14JUL11	5/10	HF, LF	Yes – T, D
JAX A	JAX08A	30.28501	-80.22141	91	24JAN12	abandoned	27JAN12	unknown	continuous	abandoned	No – no data
JAX C	JAX09C	30.33287	-80.20071	94	12MAY13	17FEB14	13MAY13	20JUN13	continuous	N/A	N/A
JAX C	JAX10C	30.32643	-80.20493	88	17FEB14	N/A	17FEB14	N/A	continuous	N/A	N/A
ONSLOW											
Onslow Bay A	USWTR01A	33.79138	-76.52382	162	09OCT07	27MAY08	10OCT07	16JAN08	5/5*	HF, LF	Yes – T
Onslow Bay B	USWTR02B	33.81107	-76.42829	232	30MAY08	24NOV08	30MAY08	10SEP08	5/5	HF, LF	Yes – T
Onslow Bay A	USWTR03A	33.78951	-76.51920	174	24APR09	16SEP09	24APR09	09AUG09	5/5	HF, LF	Yes – T
Onslow Bay A	USWTR04A	33.78733	-76.52409	171	08NOV09	19JUN10	08NOV09	24FEB10	5/10	HF, LF	Yes – T
Onslow Bay C	USWTR04C	33.67784	-76.47689	335	08NOV09	19JUN10	08NOV09	20APR10	5/10	HF, LF	Yes – T
Onslow Bay A	USWTR05A	33.79316	-76.51620	171	29JUL10	10JUN11	30JUL10	03MAR11	5/5	HF, LF	Yes – T
Onslow Bay D	USWTR05D	33.58065	-76.55015	338	29JUL10	10JUN11	30JUL10	24FEB11	5/5	IP, F	No
Onslow Bay E	USWTR06E	33.77794	-75.92641	952	18AUG11	13JUL12	19AUG11	01DEC11	5/5	HF, LF	Yes – T, D
Onslow Bay E	USWTR07E	33.78666	-75.92915	914	13JUL12	24OCT12	14JUL12	02OCT12	5/5	HF, LF	Yes – T, D
Onslow Bay E	USWTR08E	33.78696	-75.92801	853	24OCT12	08AUG13	24OCT12	30JUN13	5/5	NS	No
CAPE HATTERAS											
Cape Hatteras A	Hatteras01A	35.34054	-74.85761	950	15MAR12	09OCT12	15MAR12	11APR12	continuous	HF, LF	Yes – T
Cape Hatteras A	Hatteras02A	35.3406	-74.85590	970	09OCT12	29MAY13	09OCT12	09MAY13	continuous	IP	No
Cape Hatteras A	Hatteras03A	35.34445	-74.8521	970	29MAY13	N/A	29MAY13	N/A	continuous	N/A	N/A

Notes: For Status of Analysis: HF = high-frequency (odontocete, > 1 kHz) analysis completed; LF = low-frequency (mysticete, < 1 kHz) analysis completed; F = low-frequency analysis completed only for fin whale 20-Hz pulses; M = low-frequency analysis completed only for minke whale pulse trains; IP = analysis in progress; N/A = not applicable, because data is not yet available for analysis; NS = analysis not started, but data is available for analysis. For Report of Details?: T = technical report; D = detailed report; N/A = not applicable, because HARP is still in the field. Key: JAX = Jacksonville Range Complex; m = meter(s); USWTR=Undersea Warfare Training Range. * = represents the initial duty cycle, but instrument recorded continuously starting 01 January 2008.

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