Passive Acoustic Monitoring for Marine Mammals at Site D in Jacksonville, FL, August 2014 – May 2015

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Individual technical reports of other HARP deployments are available at: http://www.navymarinespeciesmonitoring.us/reading-room/

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Abstract

A High-frequency Acoustic Recording Package (HARP; Wiggins and Hildebrand 2007) was deployed between August 2014 and July 2015 in the Jacksonville, FL, survey area at Site D in 806 m. This HARP sampled continuously at 200 kHz and recorded for 279 days between 23 August 2014 and 29 May 2015. The data were divided into three frequency bands (10 Hz – 1000 Hz, 500 Hz – 5000 Hz, and 1 kHz – 100 kHz) and scanned manually for marine mammal vocalizations using Long-Term Spectral Averages (LTSAs) and automated computer algorithm detection when possible. Vocalizations of fin whales, minke whales, sei whales, *Kogia* spp., Risso's dolphins, sperm whales, Blainville's beaked whales, Gervais' beaked whales, and unidentified delphinids were detected in the data.

Methods

The August 2014 – July 2015 Jacksonville Site D HARP (Jacksonville 11D) was deployed at 30.15060^{o} N, 79.77005^{o} W on 23 August 2014 (recording started on 23 August 2014) and recovered on 2 July 2015 (recording ended on 29 May 2015). The instrument location is shown in Figure 1. Bottom depth at the deployment site was approximately 806 m. A schematic diagram of the Jacksonville 11D HARP is shown in Figure 2.

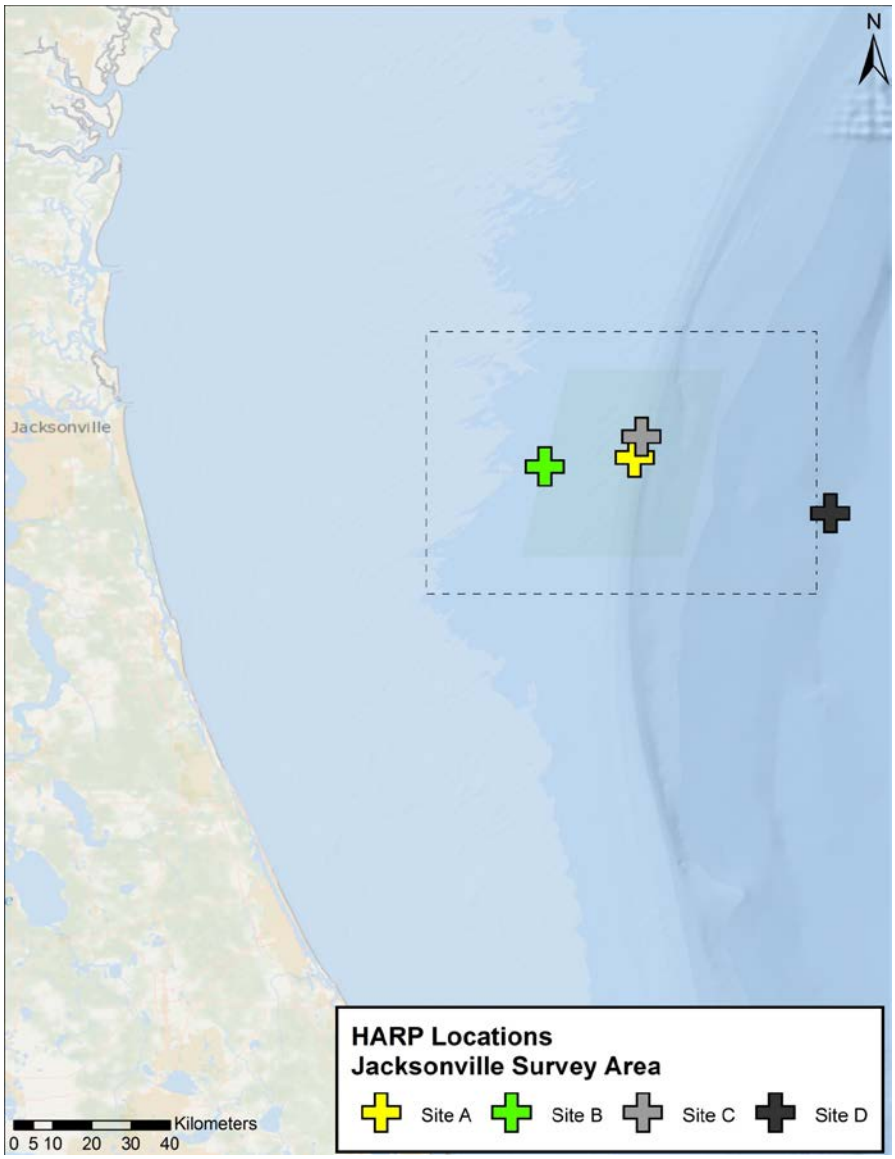

Figure 1. Location of HARP deployment sites in the Jacksonville survey area. The location of the Jacksonville 11D HARP is shown in black.

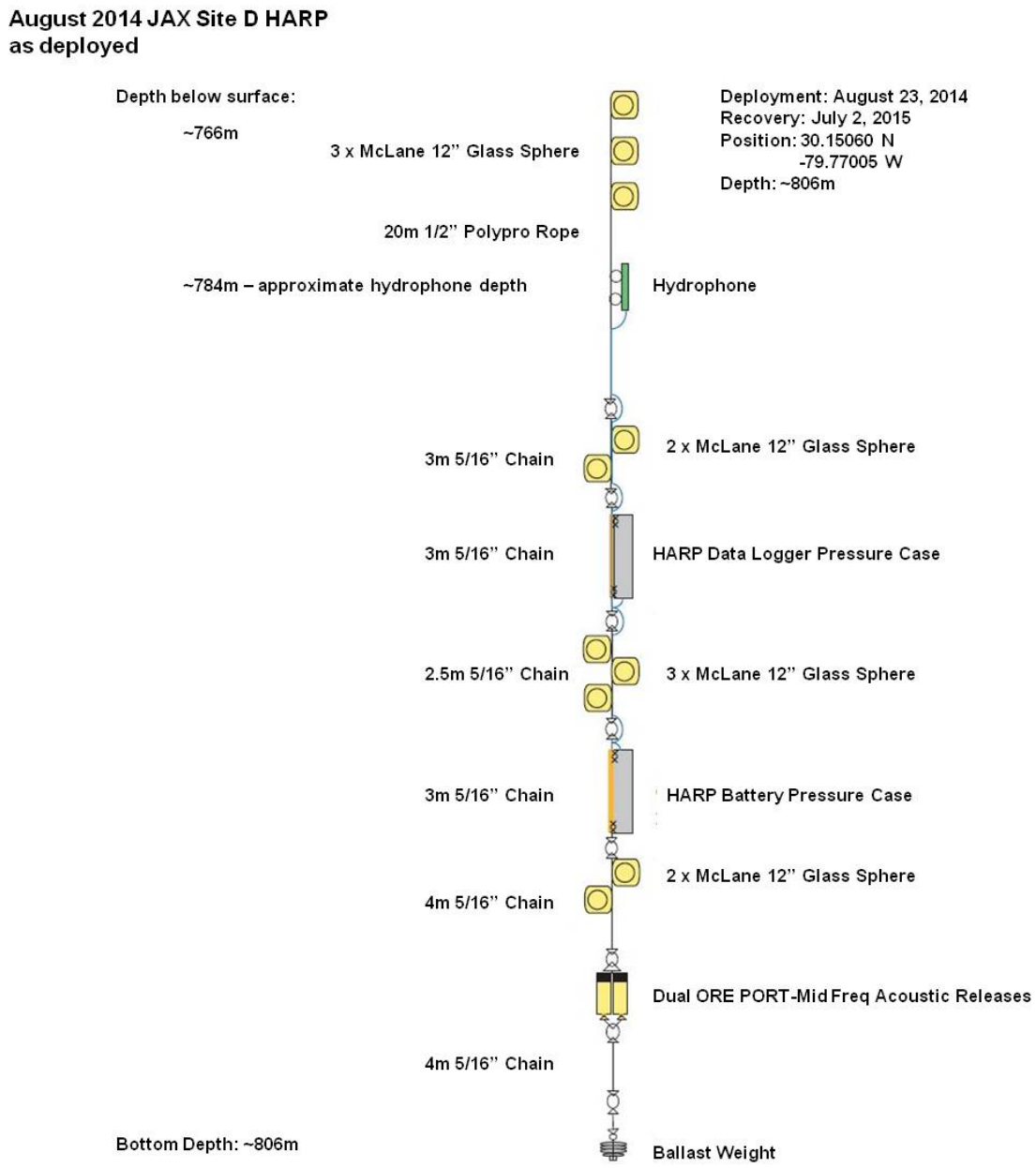

Figure 2. Schematic diagram showing details of the Jacksonville 11D HARP. Note that diagram is not drawn to scale.

Data were acquired continuously at a 200 kHz sampling rate during the Jacksonville 11D deployment. This deployment provided a total of 6,697 hours of data over the 279 days of recording.

The following methods are a summary from Frasier *et al.* (2016). Members of the Scripps Whale Acoustics Lab manually scanned the data from the Jacksonville 11D HARP deployment for marine mammal vocalizations and anthropogenic sounds (shipping, sonar) using LTSAs. Automated computer algorithm detectors were also used to analyze the data. Personnel at Scripps Institution of Oceanography analyzed the data for all marine mammal vocalizations except for beaked whales. J.E. Stanistreet performed the analysis for beaked whales; these methods will be discussed later.

Prior to manual review of the data, LTSAs were made for three frequency bands: (1) 10 – 1000 Hz (with resolutions of 5 s in time and 1 Hz in frequency), (2) 10 – 5000 Hz (with resolutions of 5 s in time and 10 Hz in frequency), and (3) 1 – 100 kHz (with resolutions of 5 s in time and 100 Hz in frequency). For effective analysis of marine mammal and anthropogenic sounds, analysts scanned three frequency bands: (1) low-frequency, between 10-300 Hz, (2) mid-frequency, between 10-5000 Hz, and (3) high-frequency, between 1-100 kHz. Each band was analyzed for the sounds of an appropriate subset of species or sources. Blue, fin, sei, Bryde's, minke, and North Atlantic right whales as well as the 5-pulse signal were classified as low-frequency; humpback whales, killer whale tonal and pulsed calls, shipping, explosions, underwater communications, and mid-frequency active sonar were classified as mid-frequency; and the remaining odontocete and sonar sounds were considered high-frequency.

Detections of most sounds were made by manually scanning LTSAs. However, detectors were used for some calls, including humpback whale calls, delphinid clicks, and beaked whale

echolocation signals. Humpback whale call detection effort was automated using a power-law detector (Helble *et al.* 2012).

Delphinid clicks were detected automatically using an energy detector with a minimum received level threshold of 120 dB_{pp} re: 1 µPa (Roch *et al.* 2011, Frasier 2015). An analyst manually reviewed LTSAs and mean spectra for all detected bouts (defined as periods of clicking separated by at least 15 minutes) and removed false positives. Detections were divided into successive five-minute windows, and dominant click types were identified automatically within each window. An automated clustering algorithm was then used to identify recurring click types (Frasier *et al.* in prep), which were used as templates and attributed to a specific species if known (e.g., Risso's dolphins) or assigned a number if species was unknown. Click types within each five-minute window that matched a template were classified by the matched template. Click types that did not match a template were labeled as unknown.

Beaked whale echolocation signals were detected using an automated method and then assigned to species by a trained analyst (JES), as detailed in Debich *et al.* (2015). A Teager Kaiser energy detector (Roch *et al.* 2011) was used to find echolocation signals, and criteria based on peak and center frequency, duration, and sweep rate were used to discriminate between delphinid and beaked whale signals. After this, a computer-assisted manual classification step was performed where each detected event containing potential beaked whale signals was given a species label by a trained analyst, and any remaining false detections were rejected (as in Baumann-Pickering *et al.* 2013).

Explosions were also detected automatically, using a matched filter detector described in further detail in Frasier *et al.* (2016). See Frasier *et al.* (2016) for a more detailed description of analysis methods.

Low-frequency sounds were analyzed in hourly bins; mid- and high-frequency vocalizations were analyzed in one-minute (odontocete whistles, sperm whale clicks, *Kogia* spp. clicks, beaked whale clicks) or five-minute (delphinid clicks) bins. Vocalizations were assigned to species when possible.

Results

Table 1 summarizes the detected and identified marine mammal vocalizations for the Jacksonville 11D HARP deployment. Figures 3-12 show the daily occurrence patterns for the different marine mammal groups (classified to species when possible). Figure 13 shows the occurrence of mid-frequency active sonar. Figure 14 shows the occurrence of high-frequency active sonar. Underwater ambient noise during this deployment is shown in Figure 15. These results are a summary of Frasier *et al.* (2016) as well as a summary of the work performed by J.E. Stanistreet on beaked whales.

Fin whale 20-Hz pulses were detected between January and March 2015 (Figure 3). Minke whale pulse trains were detected first in October 2014, with detections ramping up to almost continuous (on an hourly basis) in December and remaining at elevated levels through March 2015 (Figure 4). Minke whale pulse trains started decreasing in April and were not detected

after early May 2015 (Figure 4). Sei whale downsweeps were detected between November 2014 and January 2015, with a peak in detections in January (Figure 5).

Detected odontocete vocalizations included clicks and whistles (Figures 6-12). Many detections were assigned to the unidentified odontocete category (Figures 6-7), with clicks being divided into three main groups based on spectral patterns (see Frasier *et al.* (2016) for more details). *Kogia* spp. clicks were detected throughout the recording period, with highest numbers of detections occurring between October 2014 and April 2015 (Figure 8). Risso's dolphin clicks were detected in low numbers between August 2014 and April 2015 and in higher numbers in late April through May 2015, with detections primarily at night (Figure 9). Sperm whale clicks were detected intermittently between August 2014 and May 2015 (Figure 10). Blainville's beaked whales were detected on only two days – once in November and once in January (Figure 11). Gervais' beaked whales were detected on four days during this deployment (Figure 12).

Table 1. Summary of detections of marine mammal vocalizations at Jacksonville Site D for August 2014 – May 2015 (Jacksonville 11D).

Species	**Call type**	**Total duration of vocalizations (hours)**	**Percent of recording duration**	**Days with vocalizations**	**Percent of recording days**
Fin whale[a]	20 Hz	76	1.1	13	4.6
Minke whale[a]	pulse train (slow-down, speed-up, regular)	3654	54.6	184	65.7
Sei whale[a]	song or non-song (not separated)	88	1.3	17	6.1
Unidentified odontocete[b]	clicks	382.2	5.7	218	77.9
Unidentified odontocete[c]	whistles	423.3	6.3	181	64.6
Kogia spp.[c]	clicks	10.5	0.2	80	28.6
Risso's dolphin[b]	clicks	93.3	1.4	131	46.8
Sperm whale[c]	clicks	28.6	0.4	11	3.9
Blainville's beaked whale[c]	clicks	0.7	0.01	2	0.7
Gervais' beaked[c]	clicks	2.2	0.03	4	1.4

[a]Analyzed in hourly bins.
[b]Analyzed in five-minute bins.
[c]Analyzed in one-minute bins.

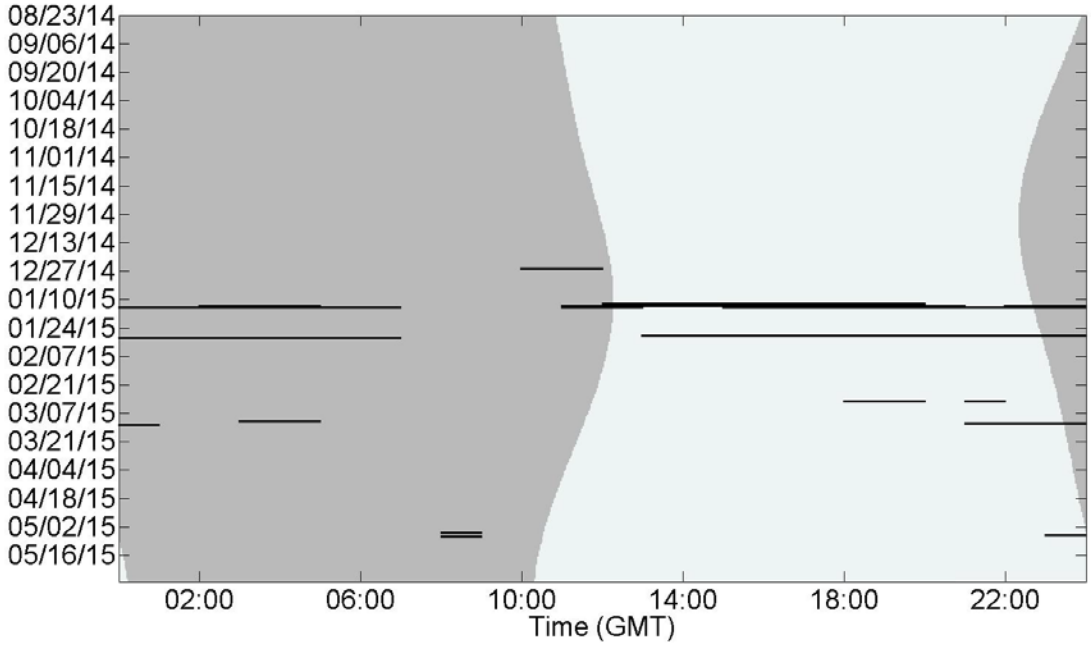

Figure 3. Fin whale 20-Hz pulse detections (black bars) in hourly bins within the Jacksonville 11D deployment. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

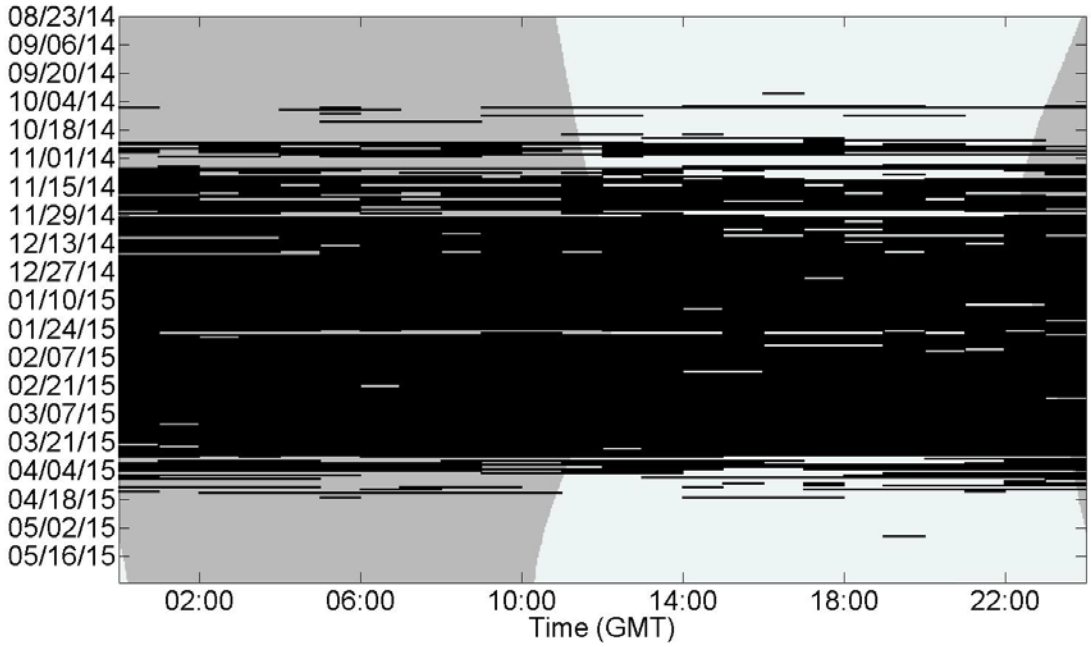

Figure 4. Minke whale pulse train detections (black bars) in hourly bins within the Jacksonville 11D deployment. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

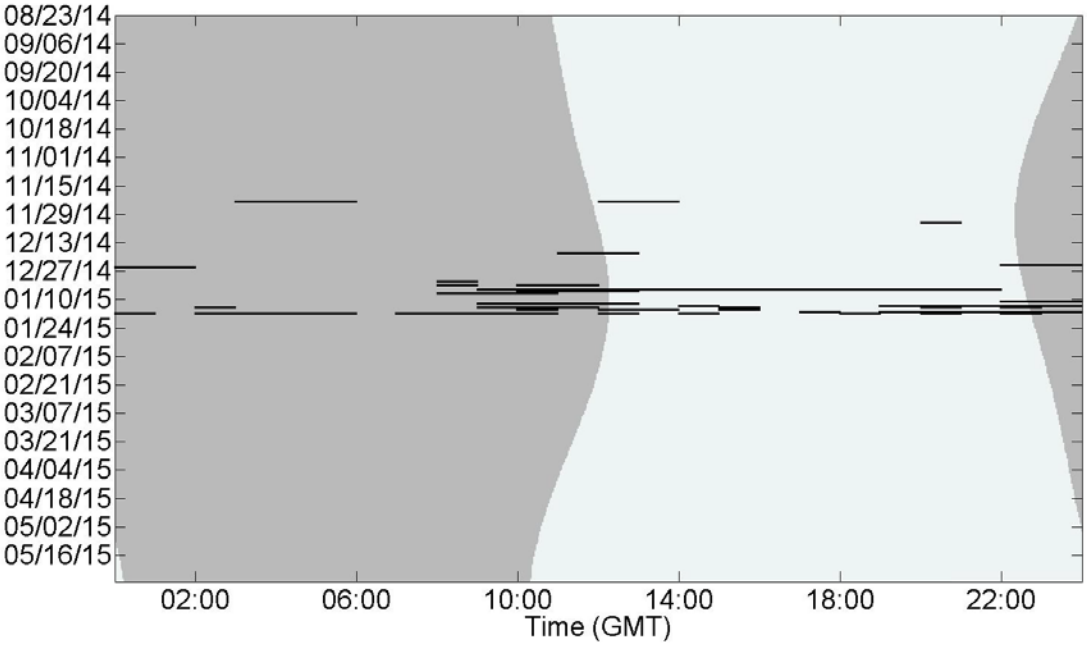

Figure 5. Sei whale downsweep detections (black bars) in hourly bins within the Jacksonville 11D deployment. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

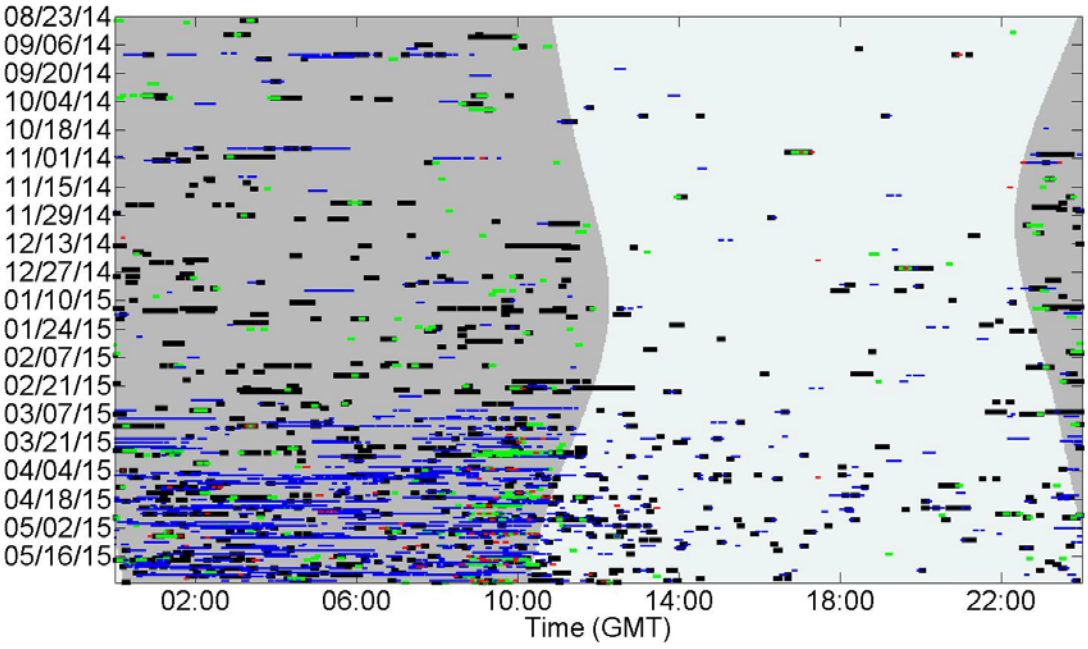

Figure 6. Unidentified odontocete click detections in five-minute bins within the Jacksonville 11D deployment. Black, green, and blue bars are clicks assigned to different click types; red bars are clicks not assigned to a click type. Dark gray shading indicates periods of darkness,

determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). For more information on click types and which species may produce them, see Frasier *et al.* (2016).

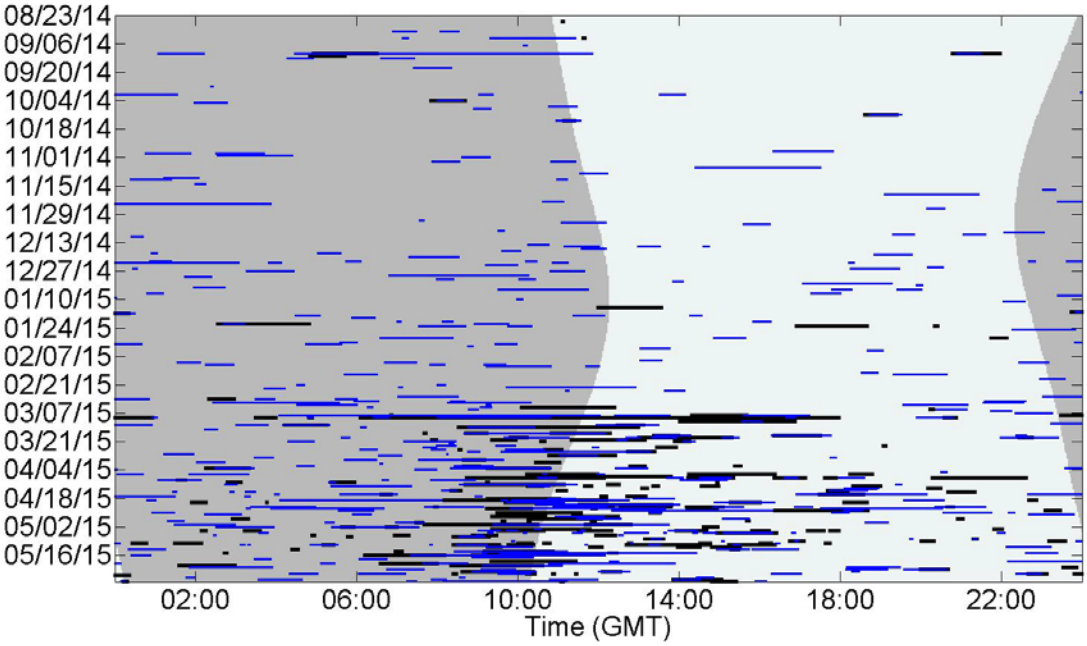

Figure 6. Unidentified odontocete whistle detections (black bars are whistles less than 5 kHz and blue bars are all other whistles) in one-minute bins within the Jacksonville 11D deployment. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

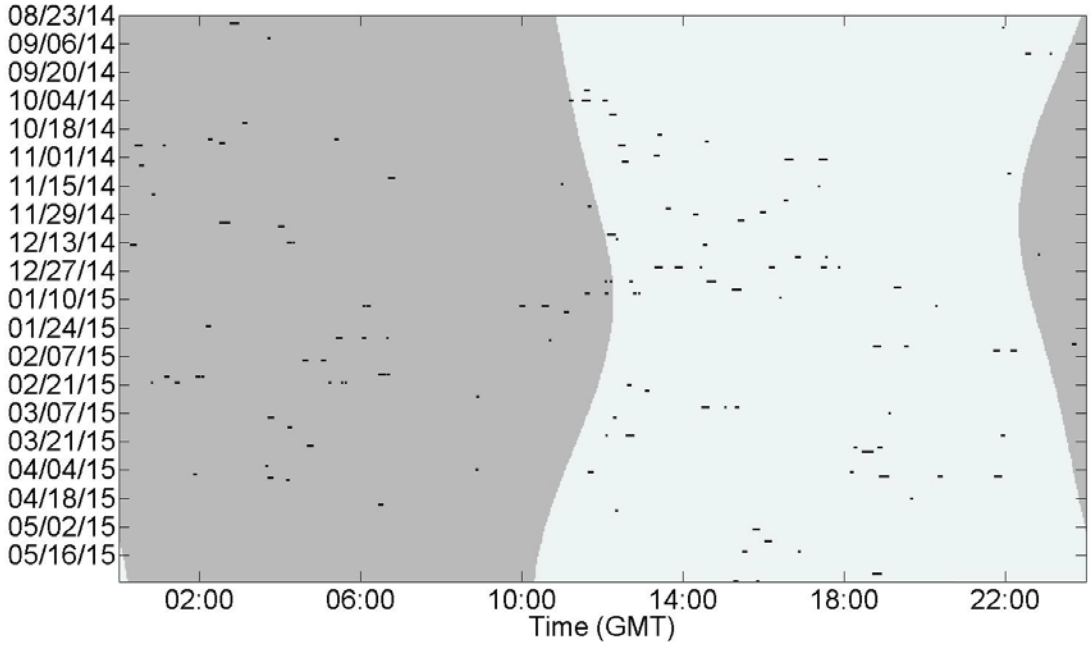

Figure 8. *Kogia* spp. click detections (black bars) in one-minute bins within the Jacksonville 11D deployment. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

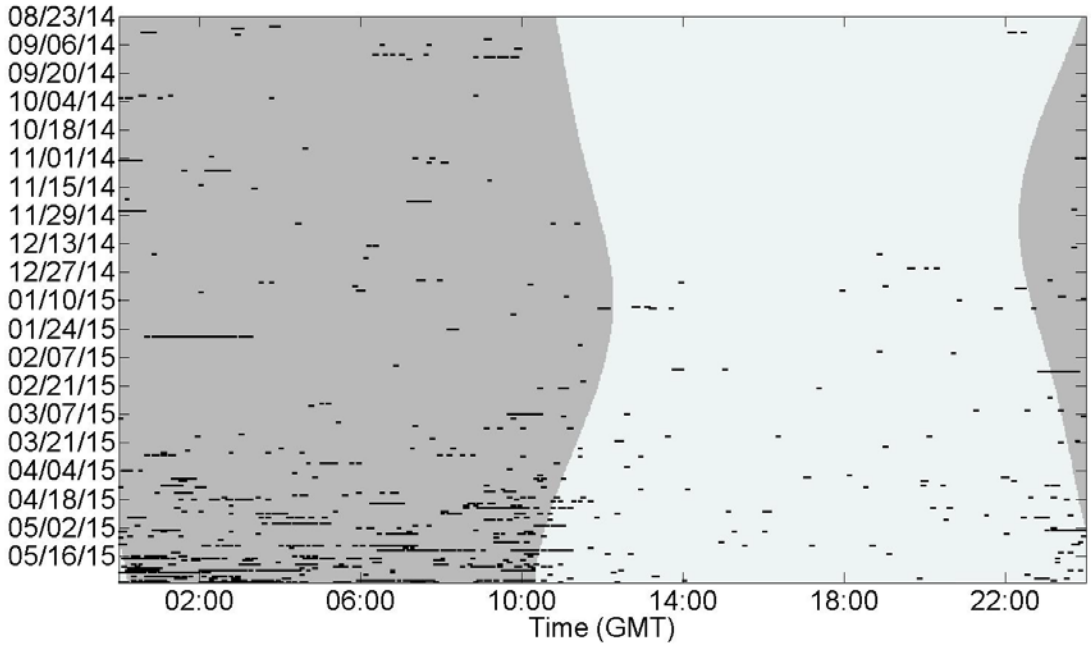

Figure 9. Risso's dolphin click detections (black bars) in five-minute bins within the Jacksonville 11D deployment. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

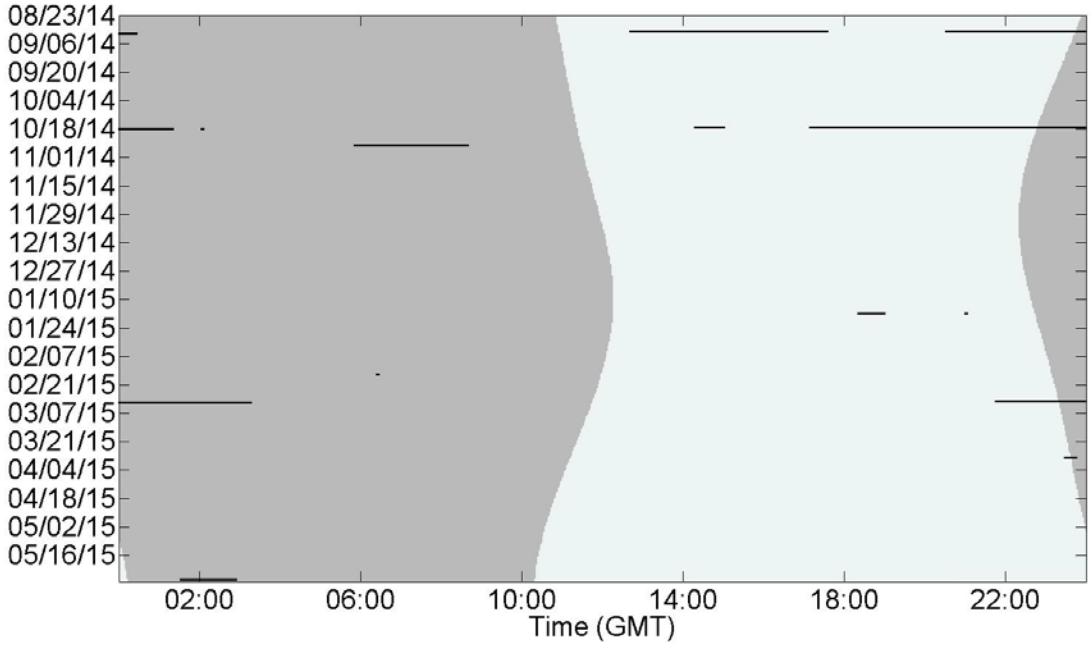

Figure 10. Sperm whale click detections (black bars) in one-minute bins within the Jacksonville 11D deployment. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

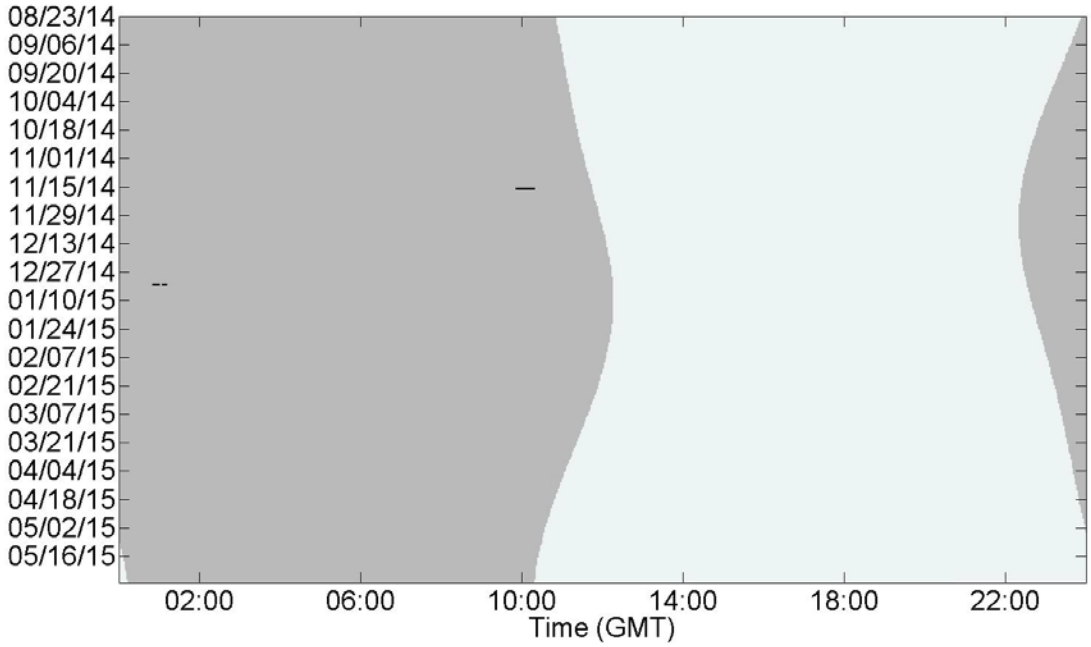

Figure 11. Blainville's beaked whale click detections (black bars) in one-minute bins within the Jacksonville 11D deployment. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

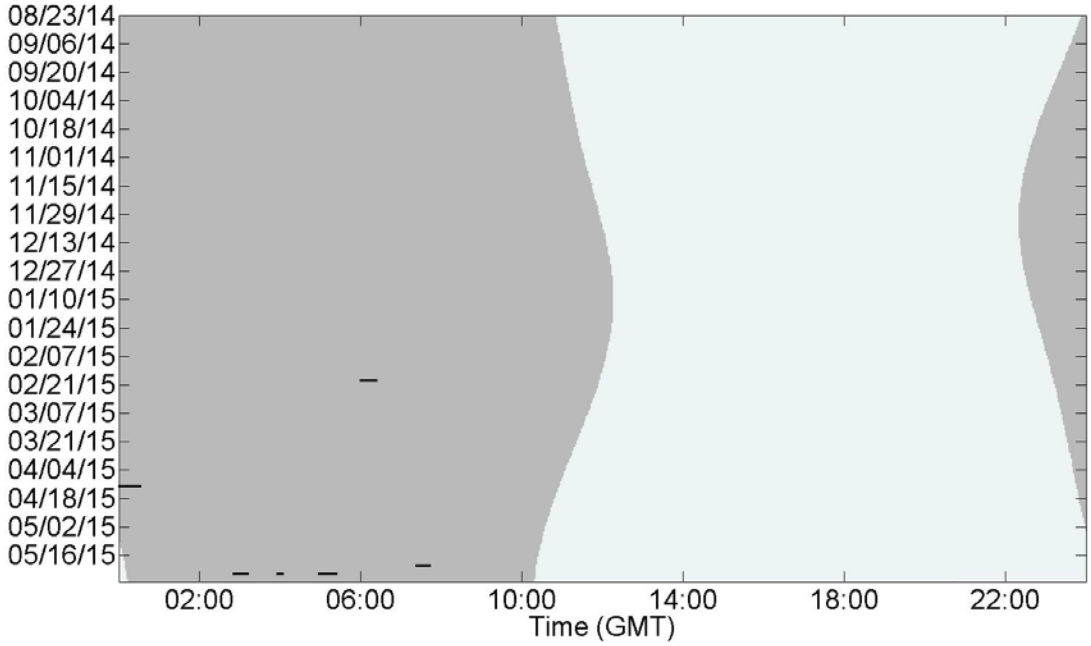

Figure 12. Gervais' beaked whale click detections (black bars) in one-minute bins within the Jacksonville 11D deployment. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

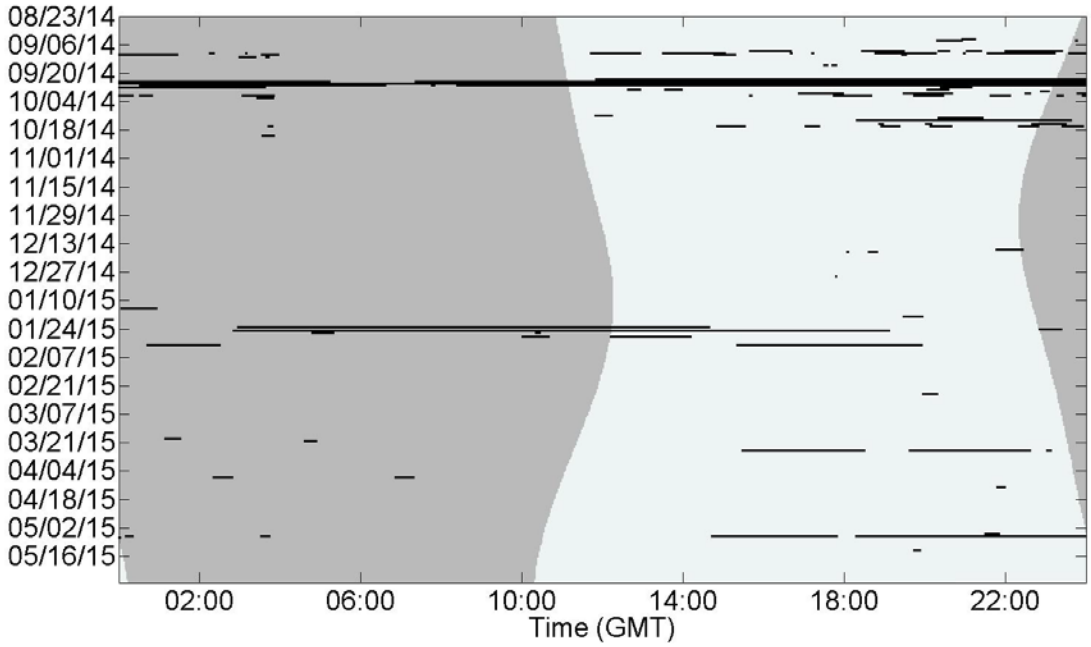

Figure 13. Mid-frequency active sonar (black bars) detected during the Jacksonville 11D deployment. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

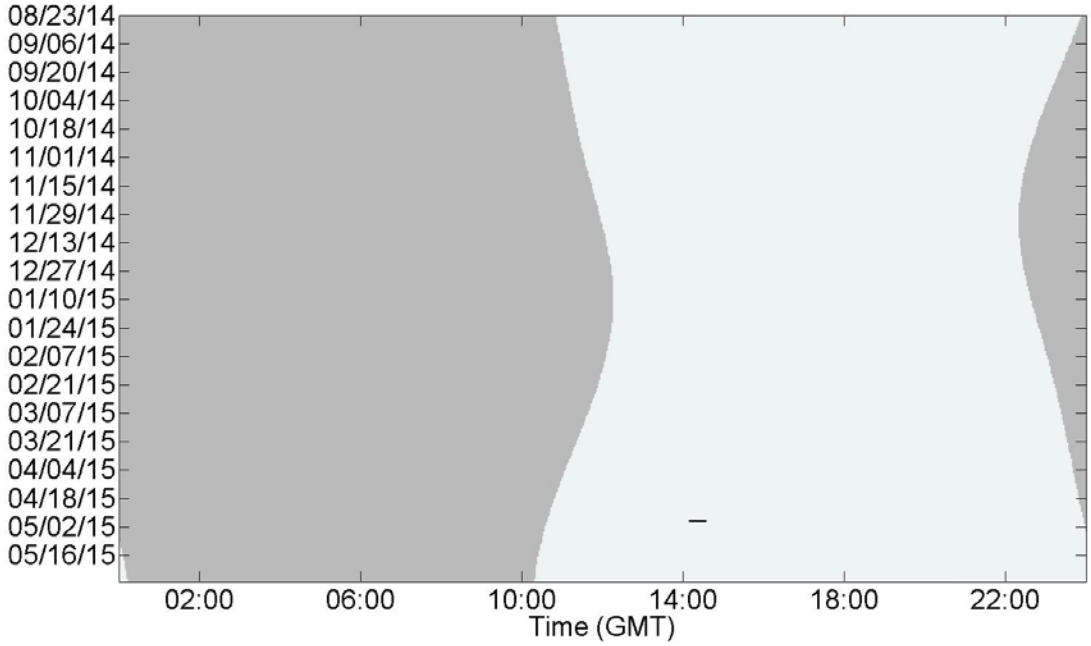

Figure 14. High-frequency active sonar (black bars) detected during the Jacksonville 11D deployment. Dark gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

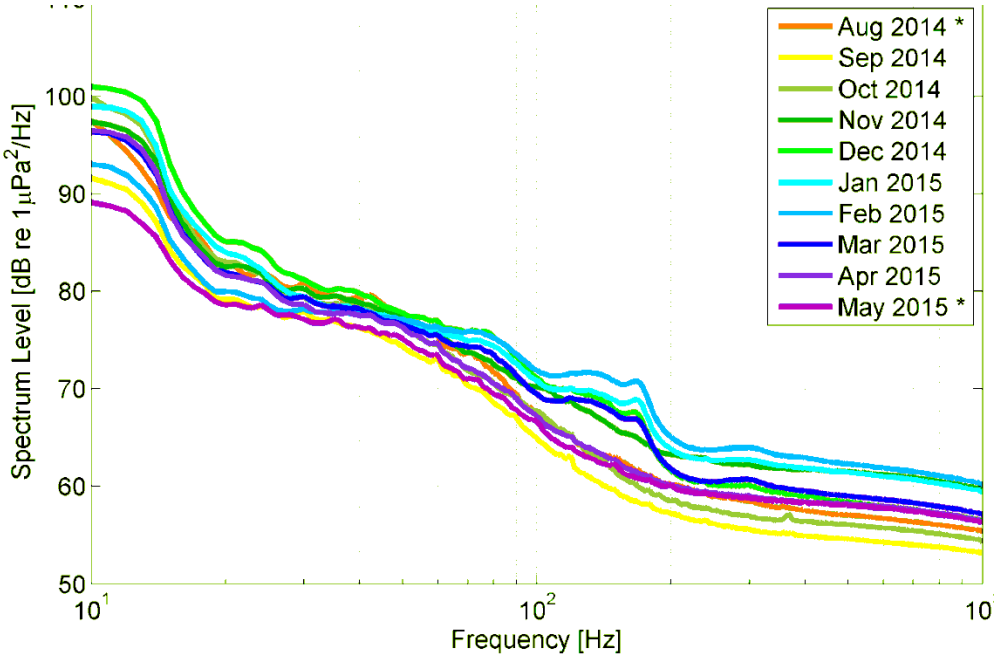

Figure 15. Monthly averages of ambient noise at Jacksonville, FL, Site D for August 2014 – May 2015. Months with an asterisk (*) are partial recording periods. Figure from Frasier *et al.* (2016).

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