Passive Acoustic Monitoring for Marine Mammals off Virginia, North Carolina, and Florida Using High-frequency Acoustic Recording Packages: 2015 Annual Report

Submitted to:

Naval Facilities Engineering Command Atlantic under Contract No. N62470-15-D-3011, Task Order 51 and Contract No. N2470-15-D-8006, Task Order 06, issued to HDR, Inc.

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February 2016

Suggested Citation:

Hodge, L., J. Stanistreet, and A. Read. 2016. *Annual Report 2015: Passive Acoustic Monitoring for Marine Mammals off Virginia, North Carolina, and Florida Using High-frequency Acoustic Recording Packages. Draft Report*. Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command Atlantic, Norfolk, Virginia, under Contract Nos. N62470-15-D-3011, Task Order 51 and N2470-15-D-8006, Task Order 06 issued to HDR, Inc., Virginia Beach, Virginia. February 2016.

Individual technical reports and detailed analyses of HARP deployments are available through the Navy's Marine Species Monitoring Program web portal PAM Deployment Explorer and Reading Room.

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High-frequency Acoustic Recording Package. Photo by Scripps Institution of Oceanography (accessed at http://www.nefsc.noaa.gov/psb/acoustics/psbAcousticsMigration.html)

This project is funded by US Fleet Forces Command and managed by Naval Facilities Engineering Command Atlantic as part of the US Navy's marine species monitoring program.

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Acronyms and Abbreviations

HARP	High-frequency Acoustic Recording Package
Hz	Hertz
kHz	kilohertz
LTSA	long-term spectral average
m	meter(s)
ms	millisecond(s)
µs	microsecond(s)
s	second(s)
USWTR	Undersea Warfare Training Range

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1. Executive Summary

The U.S. Navy has been using High-frequency Acoustic Recording Packages (HARPs) to conduct passive acoustic monitoring in waters offshore of Virginia, North Carolina, and Florida to determine patterns of occurrence and distribution of cetacean species and anthropogenic sounds since 2007. The datasets discussed in this report came from six HARP deployments: one near Norfolk Canyon, Virginia (982 m depth) between June 2014 and April 2015; three off Cape Hatteras, North Carolina (850-970 m depth) between October 2012 and April 2015; and two off Jacksonville, Florida (88-94 m depth) between May 2013 and August 2014.

Each HARP dataset was manually scanned for marine mammal vocalizations and anthropogenic sounds using long-term spectral averages (LTSAs) and in some cases, automated detection algorithms. The effective frequency range of the HARP data (10 Hz–100 kHz) was divided into three parts for analysis: 10–1,000 Hz, 10–5,000 Hz, and 1–100 kHz.

Six baleen whale species were detected: blue whales, fin whales, minke whales, sei whales, North Atlantic right whales, and humpback whales. Fin, minke, and humpback whales were detected at all three sites. Fin whale calls showed peaks in occurrence during the winter months. Similarly, minke whale pulse trains showed a strong seasonal pattern in Cape Hatteras and Jacksonville. Humpback whale calls were detected in much lower numbers than these other two species at the Norfolk Canyon and Cape Hatteras sites, although there was a peak in occurrence in March 2013 at Cape Hatteras. There were more consistent humpback whale detections at the Jacksonville site, with detections between February and June. Blue and sei whales were detected at both Norfolk Canyon and Cape Hatteras but not Jacksonville. Blue whale calls were very rarely detected at Norfolk Canyon but were commonly detected at Cape Hatteras, with peaks in occurrence in October and November. Peaks in detections of sei whale calls occurred in December and April at the Norfolk Canyon site and between December and March at the Cape Hatteras site. North Atlantic right whale up-calls were detected only at Cape Hatteras and only for a few days; the timing coincided with the migration of this species in the spring and fall. An additional low-frequency sound, the 5-pulse signal, which may be produced by a baleen whale, was detected from February to September 2014 at the Jacksonville site.

Echolocation clicks from six known odontocete species were detected: *Kogia* spp., Risso's dolphins, sperm whales, Cuvier's beaked whales, Gervais' beaked whales, and Blainville's beaked whales. The only identified clicks detected at all three sites were those of Risso's dolphins, and they occurred in low numbers. No other clicks could be identified to species at the Jacksonville site. Blainville's beaked whale clicks were only detected at the Cape Hatteras site, and there were only a few detections of these clicks during each of the three deployments at that site. All other click types that could be identified to species, as well as echolocation clicks possibly produced by Sowerby's beaked whale, were detected at both Norfolk Canyon and Cape Hatteras. *Kogia* spp. clicks were detected throughout all of the recordings from these two locations as were sperm whale clicks, with the latter showing peaks in occurrence in February and summer months. Cuvier's beaked whale clicks were the most abundant beaked whale click type found at Cape Hatteras, with increases in detections between September and December at that site. These clicks were also found at Norfolk Canyon, with detections mainly occurring between the end of December and March. Gervais' beaked whale clicks were detected mainly between November and March and between June and July at both sites. The possible Sowerby's beaked whale clicks were only detected on one day at Cape Hatteras but were the most common beaked whale click type found at Norfolk Canyon, with peaks in occurrence between December and March. Finally, odontocete clicks and whistles that could not be assigned to species were detected throughout all recordings.

Anthropogenic sounds were also detected at all sites. Included in this report are mid-frequency active sonar, low-frequency active sonar greater than 500 Hz, and airgun detections. Mid-frequency active sonar was detected throughout all recordings reported here, with the fewest number of detections at Cape Hatteras. Low-frequency active sonar greater than 500 Hz was detected infrequently only at Norfolk Canyon. Airguns were detected throughout the recordings made at Norfolk Canyon and Cape Hatteras, with peaks in detections in June 2013 and between June and October 2014.

2. Introduction and Background

In October 2005, the U.S. Department of the Navy proposed the installation of an Undersea Warfare Training Range (USWTR) in Onslow Bay off the coast of North Carolina for the purpose of anti-submarine warfare training using mid-frequency tactical sonar (1-10 kilohertz [kHz]). As part of a multi-institutional monitoring plan for Onslow Bay, an acoustic monitoring effort, funded by the U.S. Atlantic Fleet, was initiated in 2007 by Duke University with assistance from Scripps Institution of Oceanography. In 2008, the preferred site for the USWTR was changed to Jacksonville, Florida. While acoustic monitoring continued in Onslow Bay, it also began in Jacksonville in 2009, once again led by Duke University with assistance from Scripps Institution of Oceanography. In broad support of Atlantic Fleet Training and Testing, acoustic monitoring later expanded to an area off Cape Hatteras, North Carolina (2012), and near Norfolk Canyon, Virginia (2014).. During 2015, passive acoustic data were collected in the Jacksonville, Cape Hatteras, and Norfolk Canyon areas using autonomous bottom-mounted recorders. The primary objectives of the passive acoustic monitoring program are to:

1) Determine the patterns of *occurrence* at each monitoring site;

2) Compare patterns of occurrence to better understand distributional patterns; and

3) Document species-specific characteristics of the vocalizations of marine mammal species in each area.

3. General Methods

This section includes general methods consistent for all HARP deployments and data analyses. Differences in analysis methods and specific details for individual HARPs are discussed in sections 3, 4, and 5.

3.1 Bottom-mounted Recorders

To collect time-series of acoustic data in all three survey areas, autonomous High-frequency Acoustic Recording Packages (HARPs; Wiggins and Hildebrand 2007) were utilized. The HARP data-logging system includes a 16-bit analog-to-digital converter; a hydrophone suspended approximately 10–12 meters (m) (large mooring, see **Figure 1**), approximately 22 m (small mooring, see **Figure 2**), or approximately 20 m (compact small mooring, see **Figure 3**) above the seafloor; an acoustic release system; ballast weights; and flotation (**Figures 1 through 3**). 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 variable deployment durations. These instruments combine high- and low-frequency hydrophone elements to detect the vocalizations of both odontocete and mysticete cetaceans. The units sample at rates high enough to capture the clicks of many odontocetes.

3.2 Data Analysis

HARP data require processing prior to analysis, including backing up 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 over two terabytes of data to be collected after the raw data were decompressed. This amount of data is impractical to analyze manually, so data were compressed for visual overview by using a *MATLAB*-based acoustic analysis program called *Triton* (Hildebrand Lab at Scripps Institution of Oceanography, La Jolla, California) to create LTSAs from the .wav files, which allowed 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 percent-overlapped, Hann-windowed data and displaying these averaged spectra sequentially over time.

Each HARP dataset was manually scanned for marine mammal vocalizations and anthropogenic sounds using the “logger” version of *Triton* (Hildebrand Lab at Scripps Institution of Oceanography, La Jolla, California). Automated computer algorithm detectors were also used to analyze the data. The effective frequency range of the HARP data (10 Hz–100 kHz) was divided into three parts for analysis: 10–1,000 Hz, 10–5,000 Hz, and 1–100 kHz. The resulting resolutions of the LTSAs were:

- Low-frequency LTSA (LF-LTSA), for the data decimated by a factor of 100: 5 s in time and 1 Hz in frequency (10–1,000 Hz band),
- Mid-frequency LTSA (MF-LTSA), for the data decimated by a factor of 20: 5 s in time and 10 Hz in frequency (10–5,000 Hz band), and
- High-frequency LTSA (HF-LTSA), for the data not decimated: 5 s in time and 100 Hz in frequency (1-100 kHz band).

The LF-LTSAs were inspected for sounds produced by blue (*Balaenoptera musculus*), fin (*Balaenoptera physalus*), sei (*Balaenoptera borealis*), Bryde’s (*Balaenoptera edeni*), minke (*Balaenoptera acutorostrata*), and North Atlantic right whales (*Eubalaena glacialis*), as well as the 5-pulse signal previously found during deployments off of Jacksonville, Florida (Debich et al. 2013). The MF-LTSAs were inspected for humpback whale (*Megaptera novaeangliae*) calls, killer whale

(*Orcinus orca*) tonal and pulsed calls (for JAX datasets only), shipping, explosions, airguns (for Norfolk Canyon and Cape Hatteras datasets only), underwater communications, low-frequency active sonar above 500 Hz (for Norfolk Canyon and Cape Hatteras datasets only), and mid-frequency active sonar. The remaining odontocete sounds were inspected for using the non-decimated LTSAs. Low-frequency sounds were analyzed in hourly bins; mid- and high-frequency sounds were analyzed in 1-minute bins. Vocalizations were assigned to species when possible. For North Atlantic right whale calls, the data were only examined for up-calls. Information on the detections of shipping, explosions, and underwater communications is not reported here but can be found in Debich et al. (2015) and Debich et al. (in prep).

Detections of most sounds were made by manually scanning LTSAs. However, automated detectors were used for some calls, including humpback whale calls and beaked whale echolocation signals. For the Norfolk Canyon and Cape Hatteras datasets described in Sections 3 and 4, detectors were also used to detect fin whale 20-Hz calls, *Kogia* spp. clicks, and delphinid echolocation clicks.

For all datasets, 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. No effort was made to separate song and non-song calls.

For the Norfolk Canyon and Cape Hatteras datasets, fin whale 20-Hz calls were detected using an energy detection method, which used a difference in acoustic energy between signal and noise, calculated from a 5-s LTSA with 1-Hz resolution. The frequency at 22 Hz was used as the signal frequency, while noise was calculated as the average energy between 10 and 34 Hz. The resulting ratio is termed the fin whale acoustic index and is reported as a daily average. All calculations were performed on a dB scale.

Three steps were involved in the classification of *Kogia* spp. clicks for the Norfolk Canyon and Cape Hatteras datasets. First, the clicks with energy between 70 and 100 Hz and without energy in lower frequency bands were identified. Then, an expert system classified these clicks based on spectral characteristics, and finally an analyst verified all echolocation click bouts manually as *Kogia* spp. clicks.

For the Norfolk Canyon and Cape Hatteras datasets, delphinid echolocation clicks were detected using a modified version of a Teager energy detector (Soldevilla et al. 2008, Roch et al. 2011). Events were reviewed manually to remove false detections. LTSAs were then manually examined to identify reoccurring echolocation click types. Clicks were manually classified into separate click types based on characteristics such as inter-click interval, spectral peaks/troughs, and peak frequency. Classification was carried out by comparison to species-specific spectral characteristics from HARP recordings in the Gulf of Mexico (Frasier 2015). See Debich et al. (in prep) for a more detailed description of the above analysis methods.

Beaked whale echolocation signals were detected with an automated method for all sites; however, an additional step was implemented for the Norfolk Canyon and Cape Hatteras datasets. For all sites, the detection of these signals began with the same initial automated detection steps described in detail in Debich et al. (2014) to find 75-s recording segments containing potential beaked whale frequency modulated pulses. 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 (Debich et al. 2014). For the Norfolk Canyon and Cape Hatteras datasets, additional criteria based on the shape and duration of the signal envelope were then applied to reduce the high number of false detections of non-beaked whale clicks. All detected signals with a signal envelope increasing after 20 sample points, and remaining above a 50 percent energy threshold for at least 19 sample points but no greater than 70 sample points were kept; signals not meeting these criteria were removed from analysis. The remaining detections were grouped into detection events, with detections separated by no more than 5 minutes considered to be a single event. For all sites, a final computer-assisted manual classification step was implemented where each detected event was given a species label by a trained analyst, and any remaining false detections were rejected (as in Baumann-Pickering et al. 2013). The additional step described above for the Norfolk Canyon and Cape Hatteras datasets resulted in significantly more detections of beaked whales than manual LTSA analysis, due to the ability to detect faint, barely visible beaked whale clicks as well as beaked whale clicks mixed in with echolocation from other odontocete species.

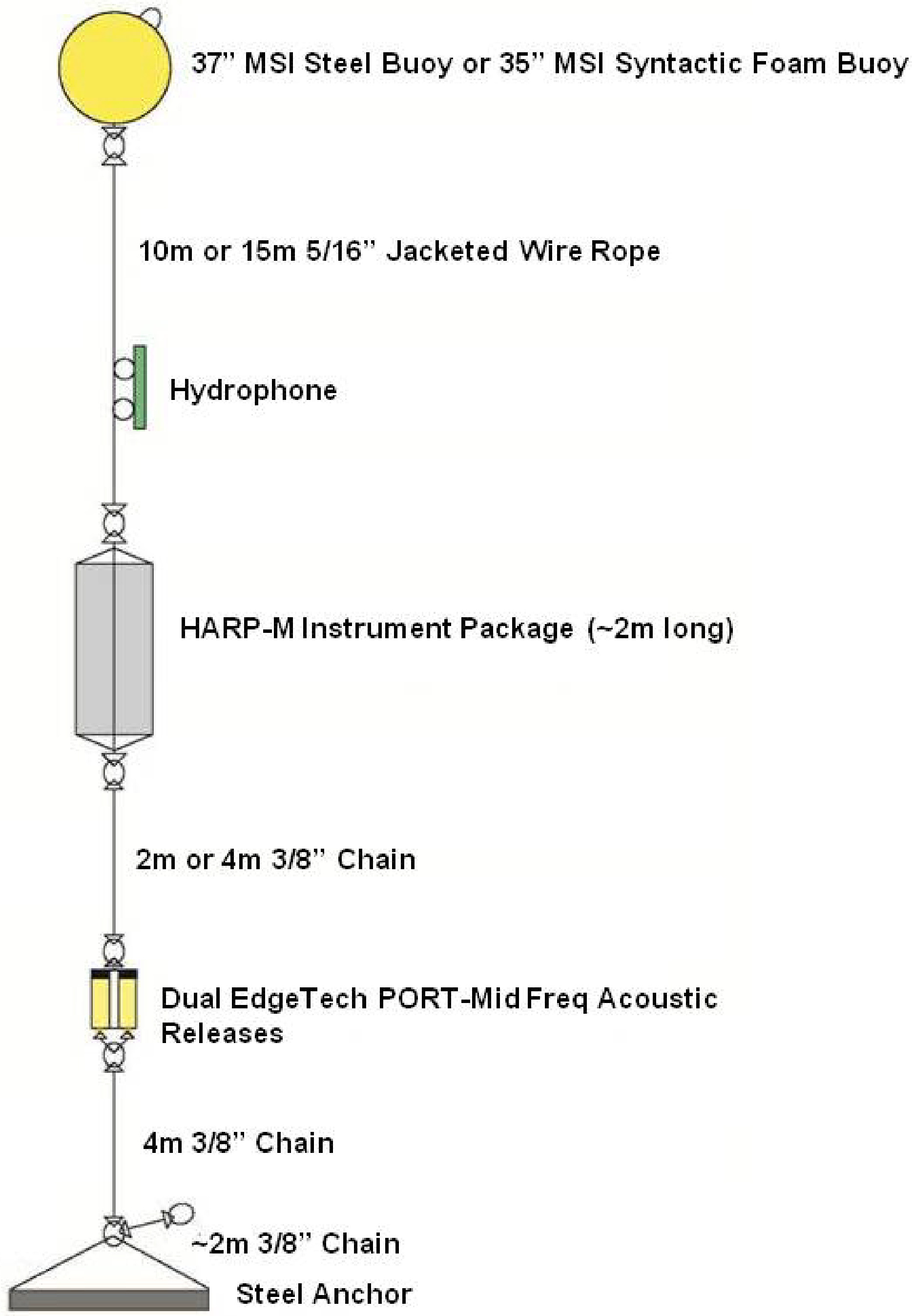

Figure 1. Schematic diagram showing details of a large mooring HARP. Note that diagram is not drawn to scale.

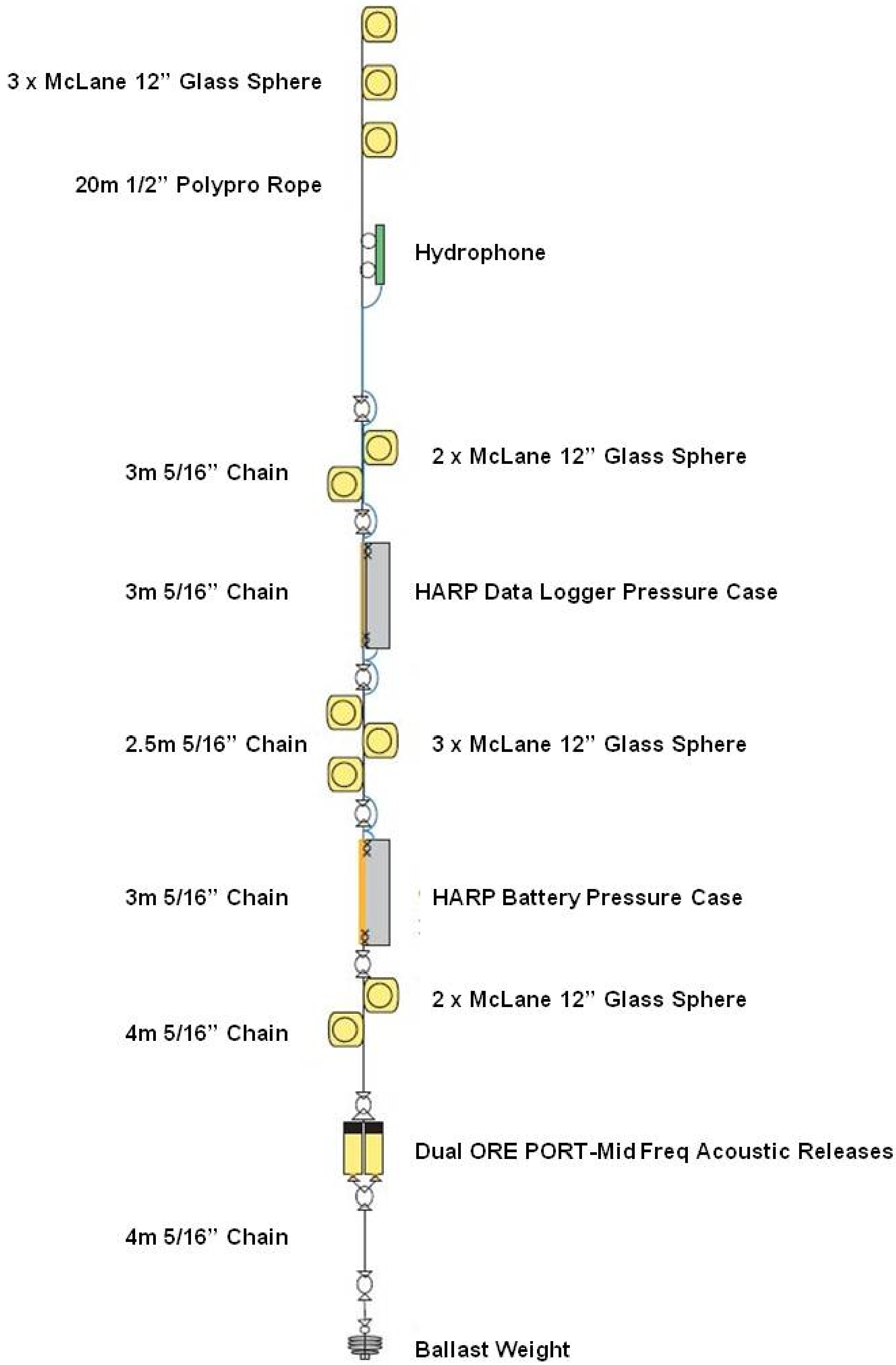

Figure 2. Schematic diagram showing details of a small mooring HARP. Note that diagram is not drawn to scale.

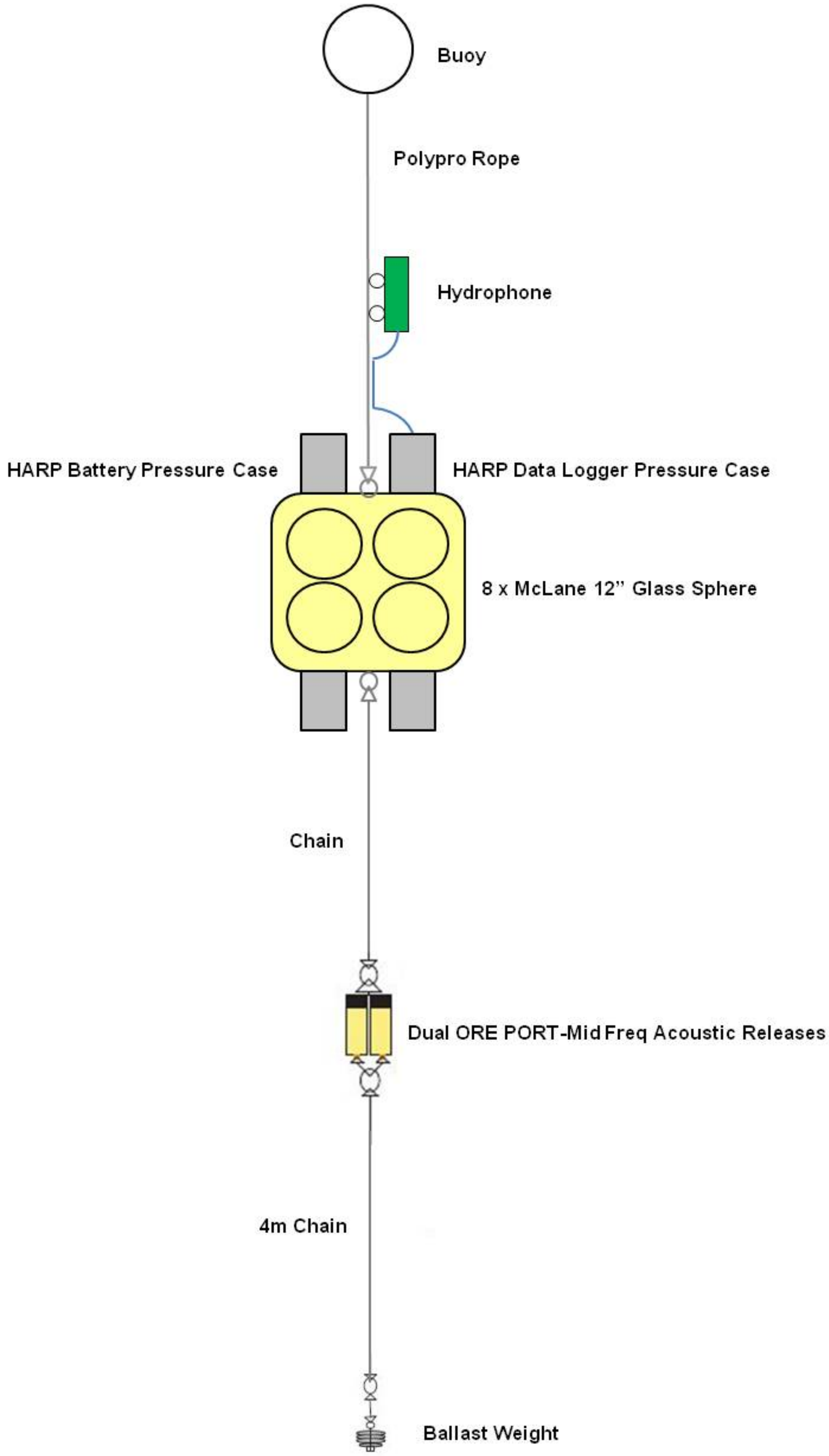

Figure 3. Schematic diagram showing details of a compact small mooring HARP. Note that diagram is not drawn to scale.

3.3 Summary of Deployments

A total of 31 HARP deployments have been made to date since 2007: 10 in Onslow Bay, 15 in Jacksonville, five in Cape Hatteras, and in Norfolk Canyon (**Table 1**). There were two occasions during which two HARPs were recording concurrently at different sites in Onslow Bay, and there were five occasions during which two HARPs were recording concurrently at different sites in Jacksonville (**Table 1**). **Table 1** includes location, depth, deployment and retrieval dates, recording dates, information on duty cycle, mooring type, status of analysis, and type of reports written, if any. All HARPs sampled at 200 kHz.

Individual technical reports and detailed analyses of all HARP deployments are available through the Navy's Marine Species Monitoring Program web portal PAM Deployment Explorer and Reading Room

Table 1. Details of all HARP deployments in Jacksonville, Onslow Bay, Hatteras, and Norfolk Canyon.

Location	Deployment ID	Latitude (N)	Longitude (W)	Depth (m)	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Duty Cycle (min on/off)	Mooring Type	Status of Analysis	Report Available
JAX												
JAX A	JAX01A	30.2771	80.1258	82	30MAR09	16SEP09	02APR09	25MAY09	5/10	large	HF	Yes - T
JAX B	JAX01B	30.2582	80.4282	37	30MAR09	16SEP09	02APR09	05SEP09	5/10	large	HF, M	Yes - T
JAX A	JAX02A	30.2805	80.2160	83	16SEP09	21FEB10	16SEP09	15DEC09	5/10	large	HF, M	Yes - T
JAX B	JAX02B	30.2582	80.4280	39	23SEP09	21FEB10	No data	No data	5/10	large	N/A	No – no data
JAX A	JAX03A	30.2811	80.2153	89	21FEB10	26AUG10	22FEB10	30JUL10	5/10	large	HF, M	Yes - T
JAX B	JAX04B	30.2591	80.4256	38	09MAR10	26AUG10	09MAR10	19AUG10	5/10	large	HF, M	Yes - T, D
JAX A	JAX05A	30.2681	80.2089	91	26AUG10	01FEB11	26AUG10	25JAN11	5/10	large	HF, LF	Yes - T, D
JAX B	JAX05B	30.2570	80.4326	37	26AUG10	01FEB11	27AUG10	01FEB11	5/10	large	HF, LF	Yes - T, D
JAX A	JAX06A	30.2781	80.2208	91	01FEB11	14JUL11	01FEB11	14JUL11	5/10	large	HF, LF	Yes - T, D
JAX B	JAX06B	30.2576	80.4278	37	02FEB11	14JUL11	02FEB11	14JUL11	5/10	large	HF, LF	Yes - T, D
JAX A	JAX08A	30.2850	80.2214	91	24JAN12	abandoned	27JAN12	unknown	continuous	large	abandoned	No – no data
JAX C	JAX09C	30.3328	80.2007	94	12MAY13	17FEB14	13MAY13	20JUN13	continuous	large	HF, LF	Yes - T, D
JAX C	JAX10C	30.3264	80.2049	88	17FEB14	23AUG14	17FEB14	23AUG14	continuous	small	HF, LF	Yes - T, D
JAX D	JAX11D	30.1506	79.7700	806	23AUG14	02JUL15	23AUG14	22MAY15	continuous	small	IP	No
JAX D	JAX12D	30.1489	79.7711	800	02JUL15	N/A	02JUL15	N/A	continuous	small	N/A	N/A
ONSLOW												
Onslow Bay A	USWTR01A	33.7913	76.5238	162	09OCT07	27MAY08	10OCT07	16JAN08	5/5*	large	HF, LF	Yes - T
Onslow Bay B	USWTR02B	33.8110	76.4282	232	30MAY08	24NOV08	30MAY08	10SEP08	5/5	large	HF, LF	Yes - T
Onslow Bay A	USWTR03A	33.7895	76.5192	174	24APR09	16SEP09	24APR09	09AUG09	5/5	large	HF, LF	Yes - T
Onslow Bay A	USWTR04A	33.7873	76.5240	171	08NOV09	19JUN10	08NOV09	24FEB10	5/10	large	HF, LF	Yes - T
Onslow Bay C	USWTR04C	33.6778	76.4768	335	08NOV09	19JUN10	08NOV09	20APR10	5/10	large	HF, LF	Yes - T
Onslow Bay A	USWTR05A	33.7931	76.5162	171	29JUL10	10JUN11	30JUL10	03MAR11	5/5	large	HF, LF	Yes - T
Onslow Bay D	USWTR05D	33.5806	76.5501	338	29JUL10	10JUN11	30JUL10	24FEB11	5/5	large	HF, LF	Yes - T
Onslow Bay E	USWTR06E	33.7779	75.9264	952	18AUG11	13JUL12	19AUG11	01DEC11	5/5	large	HF, LF	Yes - T, D
Onslow Bay E	USWTR07E	33.7866	75.9291	914	13JUL12	24OCT12	14JUL12	02OCT12	5/5	large	HF, LF	Yes - T, D
Onslow Bay E	USWTR08E	33.7869	75.9280	853	24OCT12	08AUG13	24OCT12	30JUN13	5/5	large	HF, LF	Yes - T

Location	Deployment ID	Latitude (N)	Longitude (W)	Depth (m)	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Duty Cycle (min on/off)	Mooring Type	Status of Analysis	Report Available
CAPE HATTERAS												
Cape Hatteras A	HAT01A	35.3405	74.8576	950	15MAR12	09OCT12	15MAR12	11APR12	continuous	large	HF, LF	Yes - T
Cape Hatteras A	HAT02A	35.3406	74.8559	970	09OCT12	29MAY13	09OCT12	09MAY13	continuous	large	IP	No
Cape Hatteras A	HAT03A	35.3444	74.8521	970	29MAY13	08MAY14	29MAY13	15MAR14	continuous	large	IP	No
Cape Hatteras A	HAT04A	35.3467	74.8480	850	08MAY14	06APR15	9MAY14	11DEC14**	continuous	large	IP	No
Cape Hatteras A	HAT05A	35.3421	74.8572	980	06APR15	N/A	07APR15	N/A	continuous	csm	N/A	N/A
NORFOLK CANYON												
Norfolk Canyon A	NFC01A	37.1662	74.4669	982	19JUN14	07APR15	19JUN14	05APR15	continuous	csm	IP	No

Notes: All HARPs sampled at 200 kHz. For Mooring Type: csm = compact small mooring. For Status of Analysis: HF = high-frequency (> 1 kHz) analysis completed; LF = low-frequency (< 1 kHz) analysis completed; M = LF analysis completed only for minke whales; IP = analysis in progress; N/A = not applicable - data are not yet available for analysis. For Report Available: 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. ** = represents end of normal recording – there were four more files on four different days between 26DEC14 and 15JAN15 (skipping caused by disk error issue).

4. Norfolk Canyon

4.1 Methods

Data Collection

The compact small mooring design HARP that was deployed off the coast of Virginia near Norfolk Canyon at a depth of 982 m at 37.16623° N, 74.46692° W (Norfolk Canyon Site A) on 19 June 2014, was recovered on 7 April 2015 (**Table 2**, **Figure 4**). A schematic diagram of the HARP mooring for this deployment is shown in **Figure 5**. The HARP sampled continuously at 200 kHz.

Table 2. Norfolk Canyon HARP data set detailed in this report.

Site	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Latitude (N)	Longitude (W)	Depth (m)	Sampling Rate	Duty Cycle
01A	19-Jun-14	7-Apr-15	19-Jun-14	5-Apr-15	37.1662	74.4669	982	200 kHz	continuous

Data Analysis

The June 2014–April 2015 Norfolk Canyon Site A deployment yielded 6951 hours of recording time over 290 days of recording (**Table 2**). The data have been analyzed for marine mammal and anthropogenic sounds (minus odontocete whistles) and will be reported here as a summary of Debich et al. (in prep), with beaked whale analysis performed by J.E. Stanistreet. Odontocete whistle analysis of this dataset is ongoing and will be reported on during the next annual report.

Data Quality

Highly stereotyped broadband digital errors (‘glitches’) were found in the June 2014–April 2015 Norfolk Canyon dataset. These glitches were short in duration (between 100 microseconds [µs] and 10 milliseconds [ms]) and started in the second half of the dataset, increasing in occurrence once they appeared. It is believed that the glitches do not significantly impact the resulting data analysis.

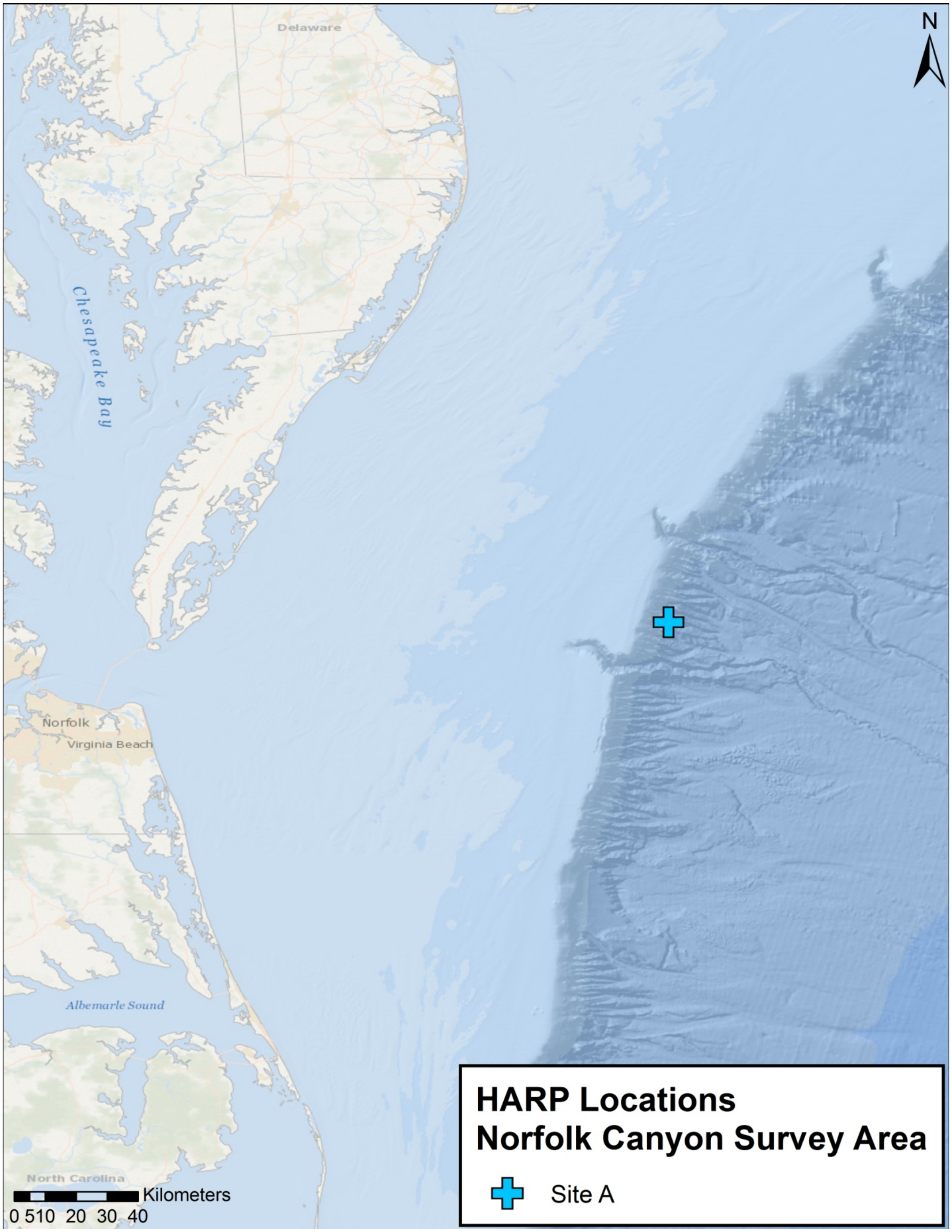

Figure 4. Location of the HARP deployment sitenear Norfolk Canyon.

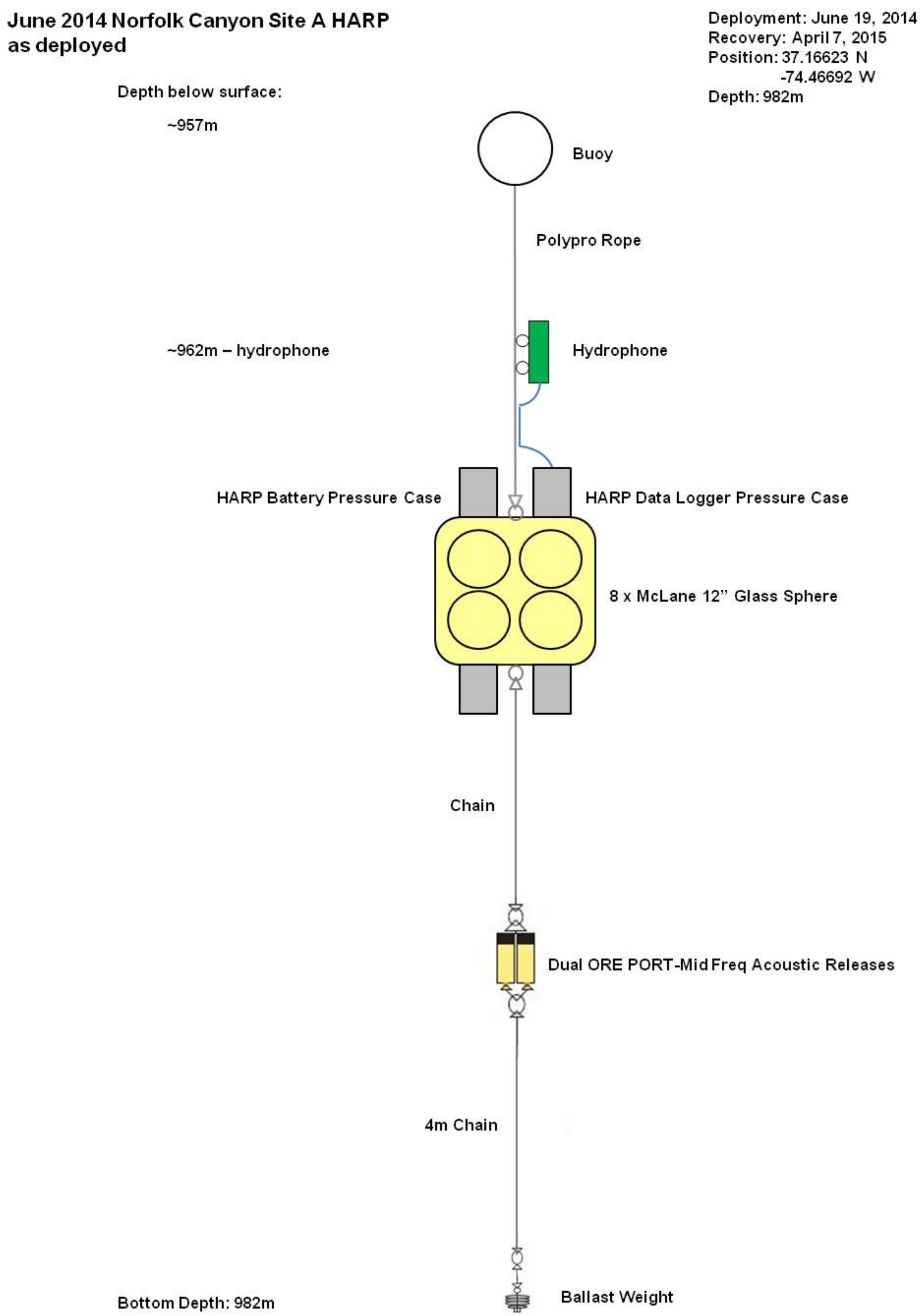

Figure 5. Schematic diagram showing details of the 2014-2015 Norfolk Canyon Site A HARP deployment. Note that diagram is not drawn to scale.

4.2 Results

Underwater ambient noise during the June 2014–April 2015 Norfolk Canyon Site A dataset is shown in **Figure 6**. **Table 3** summarizes the detected and identified marine mammal vocalizations during this deployment**. Figures 7-19** show the daily occurrence patterns for the marine mammals detected in this dataset. **Figure 20** shows the occurrence of mid-frequency active sonar. **Figure 21** shows the occurrence of low-frequency active sonar. **Figure 22** shows the occurrence of airguns.

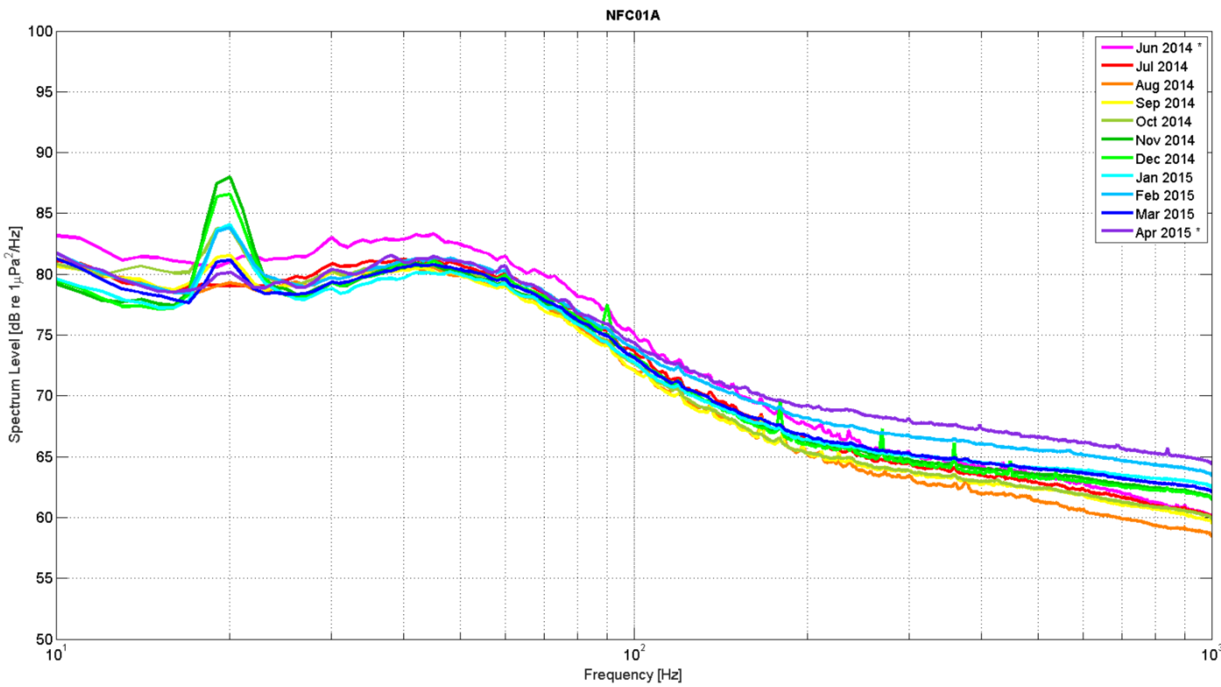

Figure 6. Monthly averages of ambient noise at Norfolk Canyon Site A for June 2014–April 2015. Months with an asterisk (*) are partial recording periods. Figure from Debich et al. (in prep).

Table 3. Summary of detections of marine mammal vocalizations at Norfolk Canyon Site A for June 2014–April 2015. Fin whale 20-Hz pulses are not included as they were reported as an acoustic index and not logged with a start and end time for individual detection events. *For all mysticetes except humpback whales, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in hourly bins; for humpback whales and 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 total recording days
Blue whale	A and B calls	3	0.04	2	0.7
Fin whale	40 Hz	50	0.7	26	8.9
Minke whale	pulse train (slow-down, speed-up, regular)	23	0.3	11	3.8
Sei whale	downsweep	152	2.2	59	20.3
Humpback whale	variable	0.03	0.0005	2	0.7
Unidentified odontocete	clicks	1058.7	15.2	282	96.9
Kogia spp.	clicks	1.7	0.02	59	20.3
Risso's dolphin	clicks	12.0	0.2	15	5.2
Sperm whale	clicks	787.5	11.3	160	55.0
Cuvier's beaked whale	clicks	16.8	0.2	59	20.3
Gervais' beaked whale	clicks	9.5	0.1	43	14.8
Possible Sowerby's beaked whale	clicks	19.1	0.3	103	35.4

Mysticete detections included blue whales, fin whales, minke whales, sei whales, and humpback whales. Blue whale calls were detected only on two days (**Figure 7**). Fin whale 20-Hz pulses (as measured by the acoustic index) were detected throughout the deployment, with a peak in calling in December (**Figure 8**). Fin whale 40-Hz calls were detected in low numbers, with peaks in hourly call detections between November and December (**Figure 9**). Compared to the Cape Hatteras and Onslow Bay HARP deployment sites during the winter, very few minke whale pulse trains were detected at Norfolk Canyon, as seen in **Figure 10**. Sei whale downsweeps were detected mainly between November and April, with peaks in occurrence in December 2014 and April 2015 (**Figure 11**). Humpback whale calls were detected only on two days during this deployment, once in August and once in November (**Figure 12**).

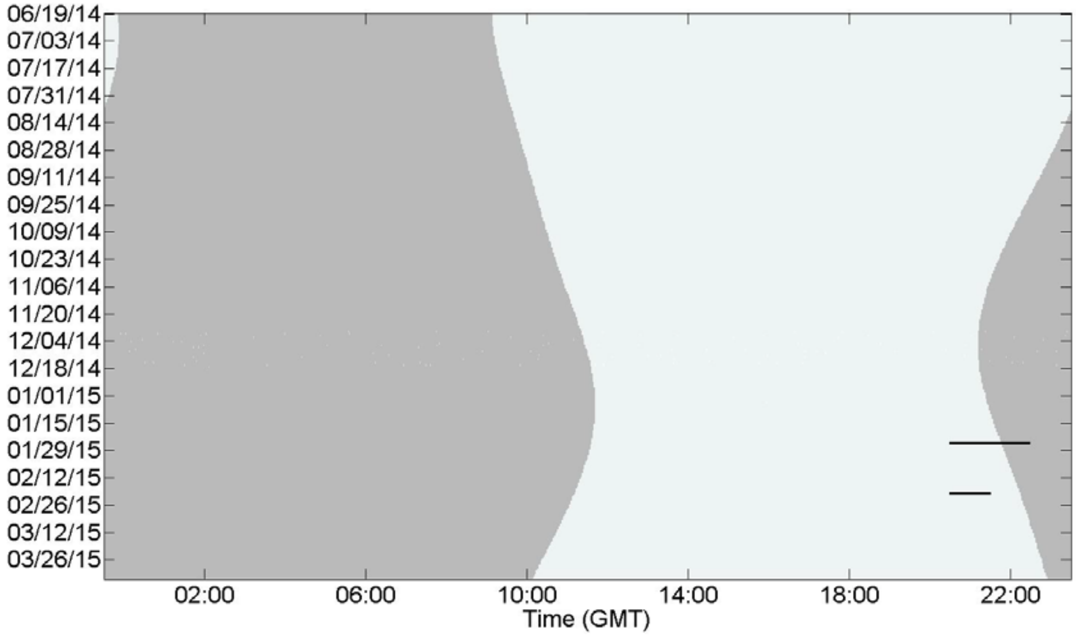

Figure 7. Blue whale call detections (black bars) in hourly bins within the June 2014–April 2015 Norfolk Canyon Site A dataset. Vertical gray shading here and in all subsequent figures of the same type indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

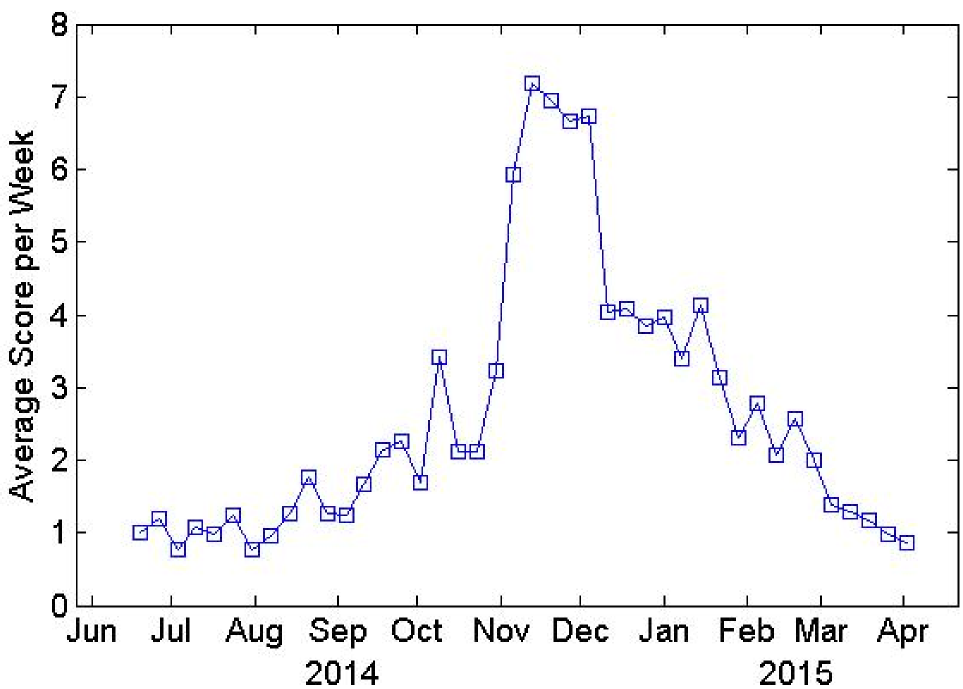

Figure 8. Weekly value of fin whale 20-Hz call acoustic index for the June 2014–April 2015 Norfolk Canyon Site A dataset.

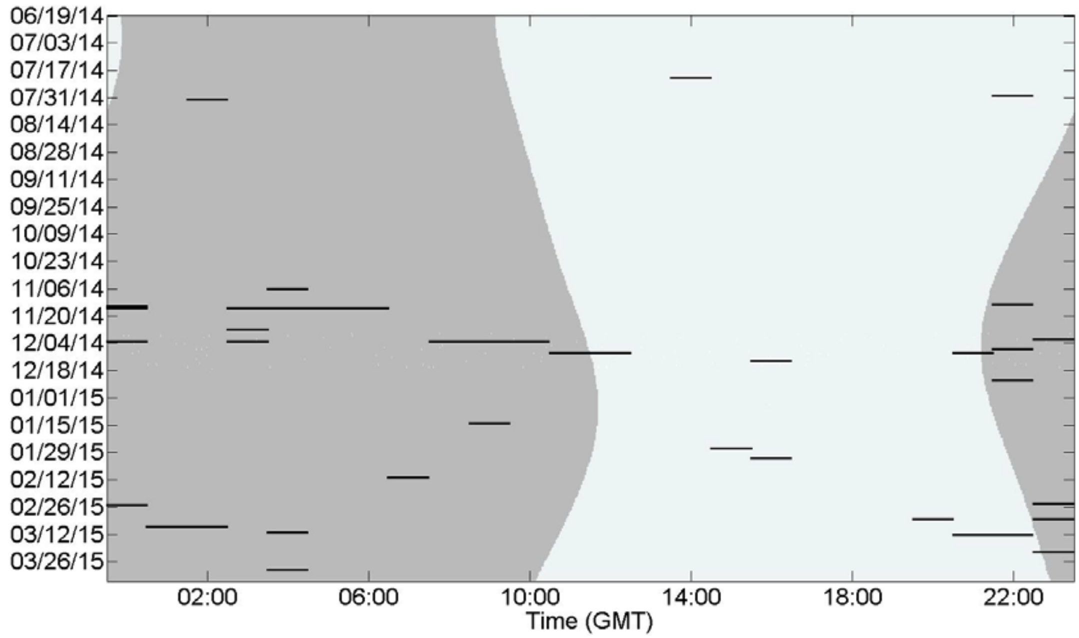

Figure 9. Fin whale 40-Hz call detections (black bars) in hourly bins within the June 2014–April 2015 Norfolk Canyon Site A dataset.

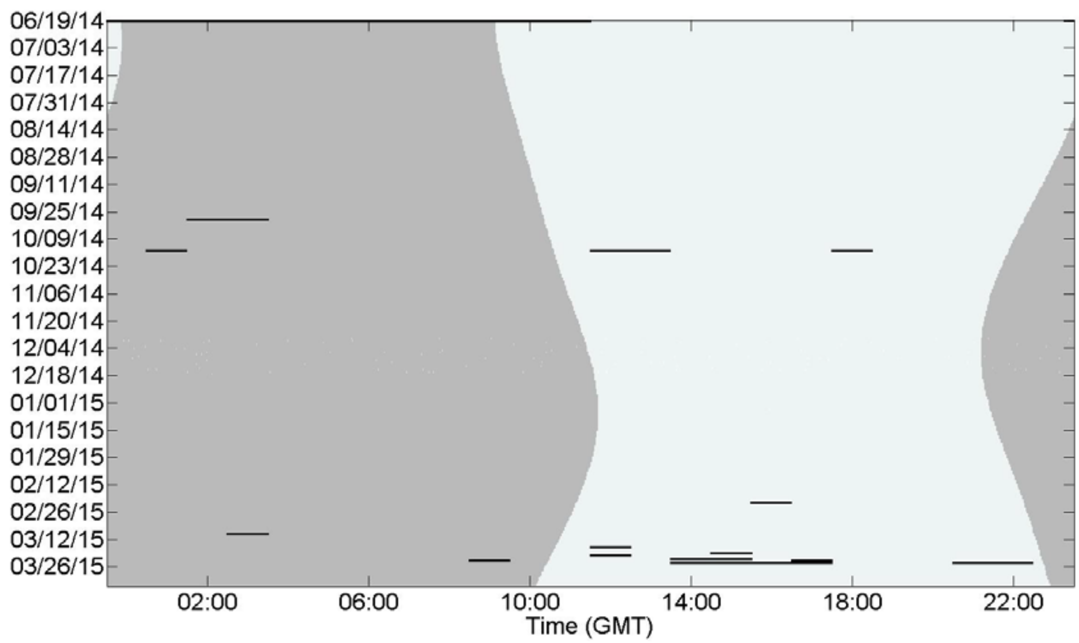

Figure 10. Minke whale pulse train detections (black bars) in hourly bins within the June 2014–April 2015 Norfolk Canyon Site A dataset.

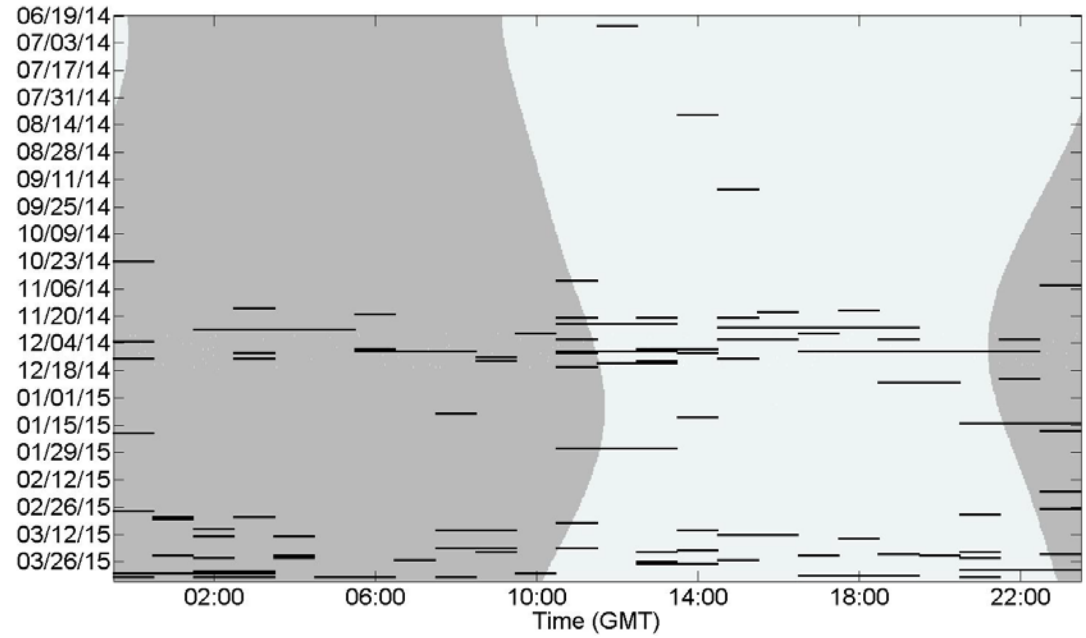

Figure 11. Sei whale downsweep detections (black bars) in hourly bins within the June 2014–April 2015 Norfolk Canyon Site A dataset.

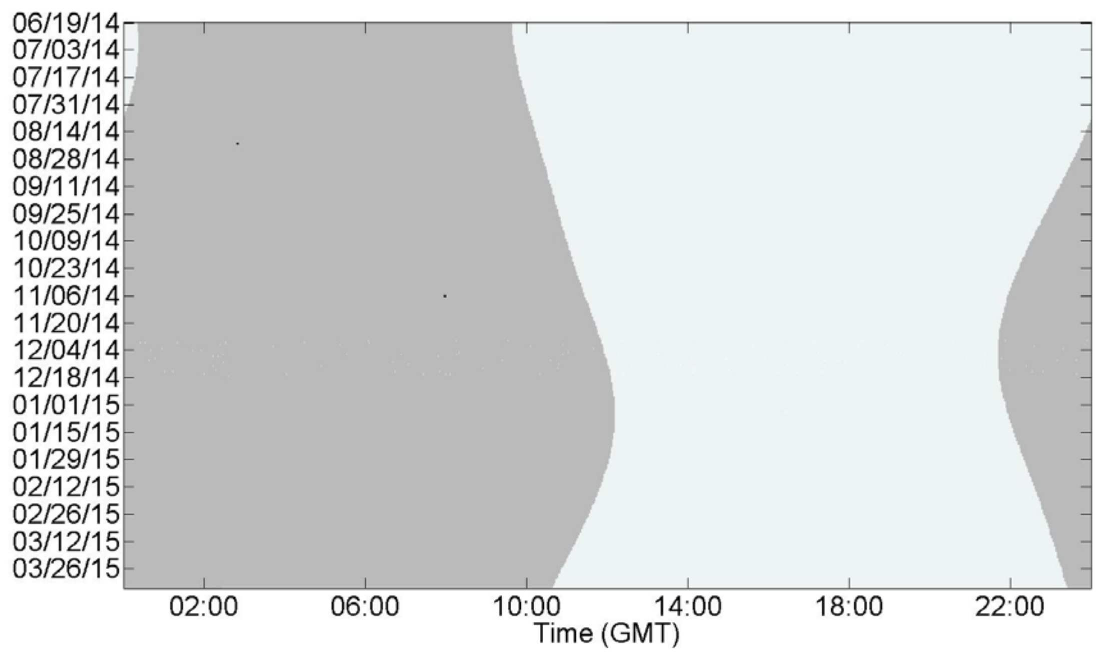

Figure 12. Humpback whale call detections (black bars) in one-minute bins within the June 2014–April 2015 Norfolk Canyon Site A dataset.

Detected odontocetes included unidentified odontocetes, *Kogia* spp., Risso's dolphins (*Grampus griseus*), sperm whales (*Physeter macrocephalus*), Cuvier's beaked whales (*Ziphius cavirostris*), Gervais' beaked whales (*Mesoplodon europaeus*), and possible Sowerby's beaked whales (*Mesoplodon bidens*). Most of the odontocete detections were assigned to the unidentified odontocete category, with the unidentified clicks being divided into five main groups based on spectral patterns (**Figure 13**). Altogether, these unidentified clicks were present nearly continuously throughout the deployment. For more details on each of the five groups of clicks and which species may have produced them, see Debich et al. (in prep). Clicks produced by *Kogia* spp. were also detected throughout the deployment, but in very low numbers (**Figure 14**). Risso's dolphin clicks were detected in the months of August, September, January, and March, with a peak in detections in September (**Figure 15**). Sperm whales were detected throughout the deployment during both day and night, with peaks in click detections in August 2014 and April 2015 (**Figure 16**). There were also several click detections that were assigned to beaked whales. Cuvier's beaked whale clicks occurred during this deployment, with detections mainly between the end of December and March (**Figure 17**). Gervais' beaked whale clicks were also detected, with most detections between the end of November and mid-February (**Figure 18**). Finally, most beaked whale detections were a higher-frequency click type, possibly from Sowerby's beaked whale. These detections occurred throughout the deployment, with peaks between December and March (**Figure 19**).

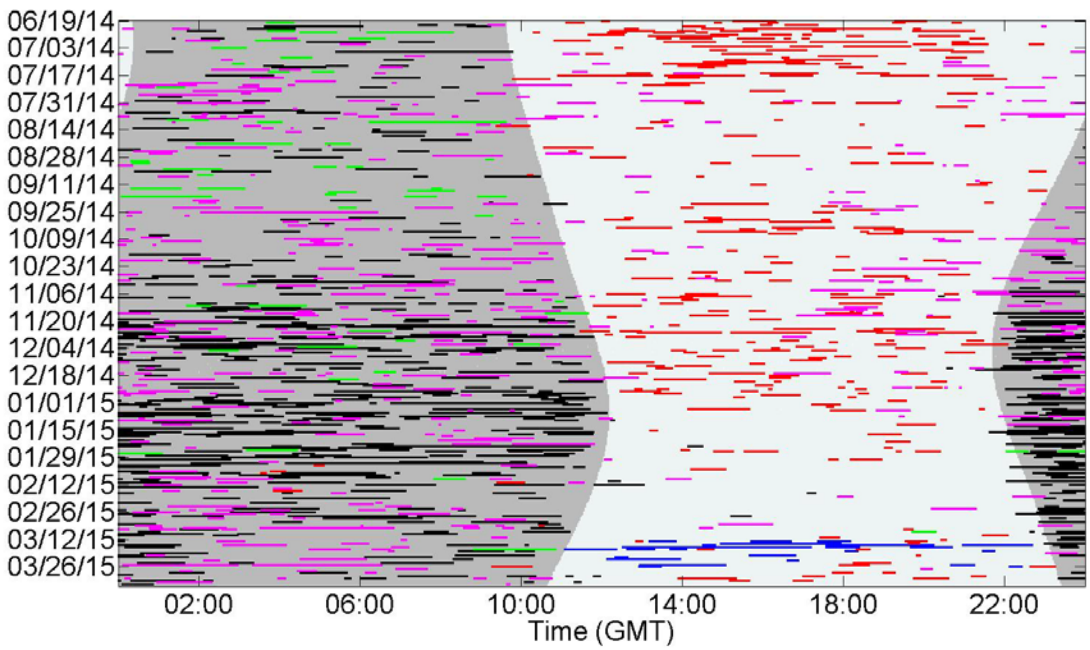

Figure 13. Unidentified odontocete click detections (different colored horizontal bars represent the different groups clicks were divided into) in one-minute bins within the June 2014–April 2015 Norfolk Canyon Site A dataset.

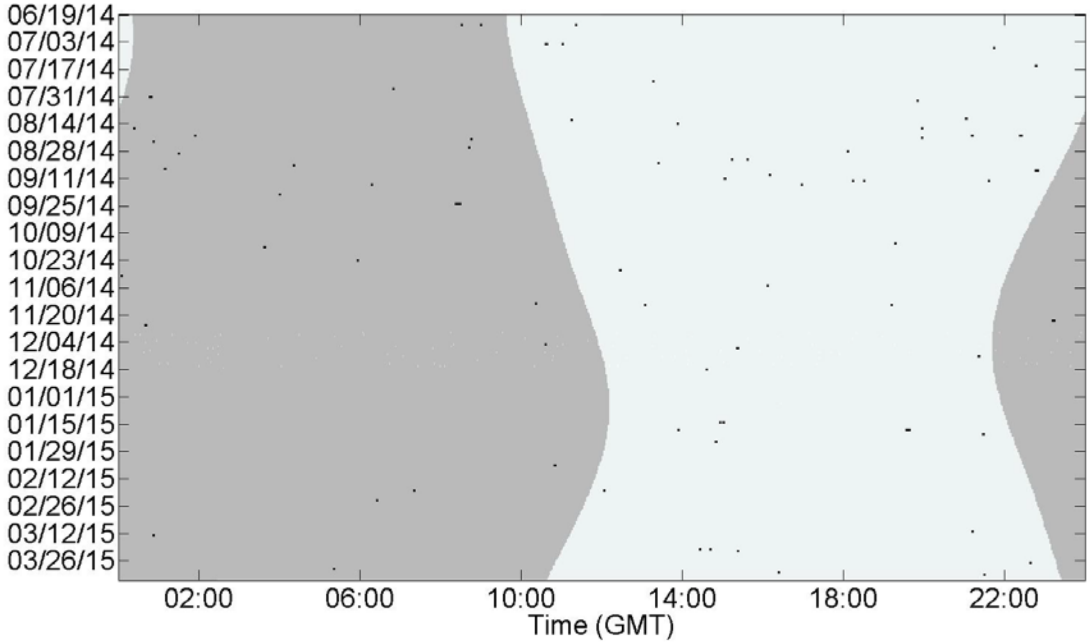

Figure 14. *Kogia* spp. click detections (black bars) in one-minute bins within the June 2014–April 2015 Norfolk Canyon Site A dataset.

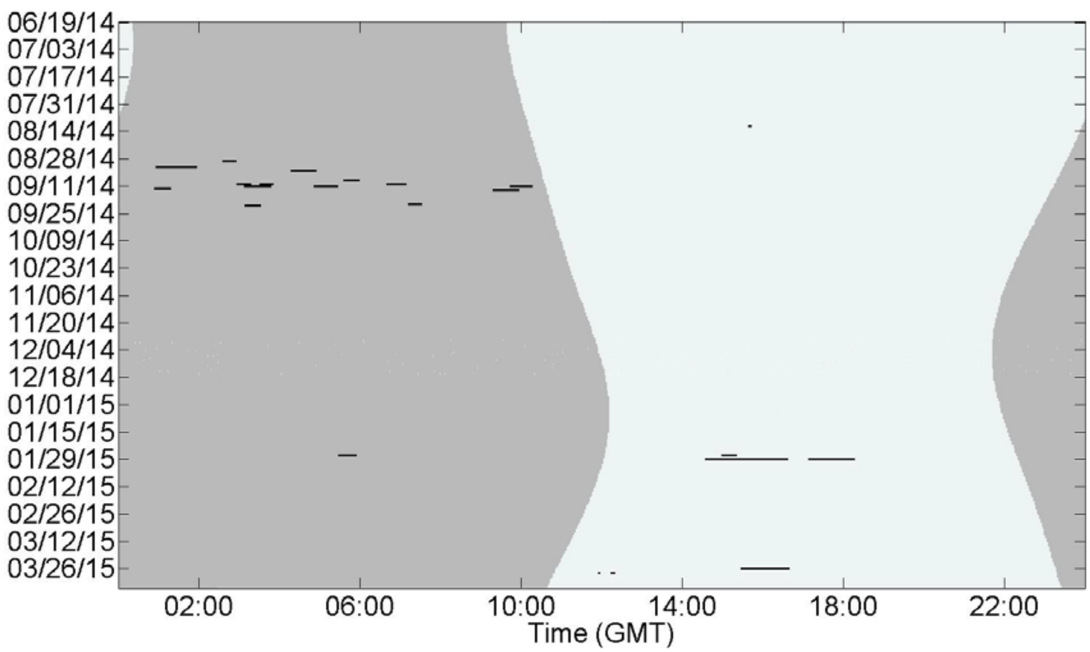

Figure 15. Risso's dolphin click detections (black bars) in one-minute bins within the June 2014–April 2015 Norfolk Canyon Site A dataset.

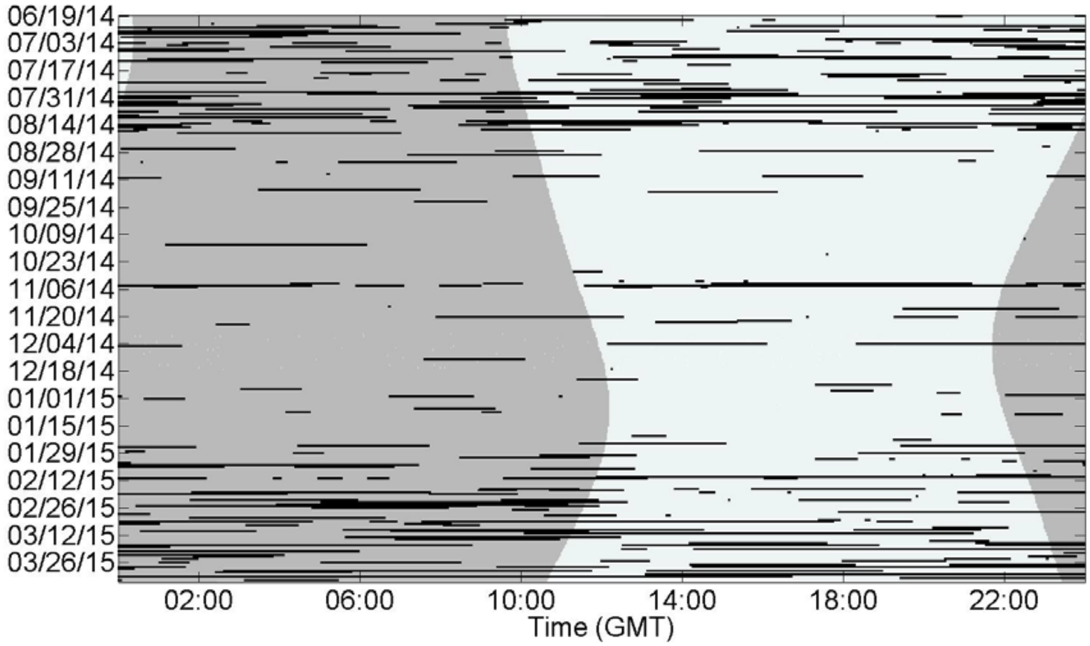

Figure 16. Sperm whale click detections (black bars) in one-minute bins within the June 2014–April 2015 Norfolk Canyon Site A dataset.

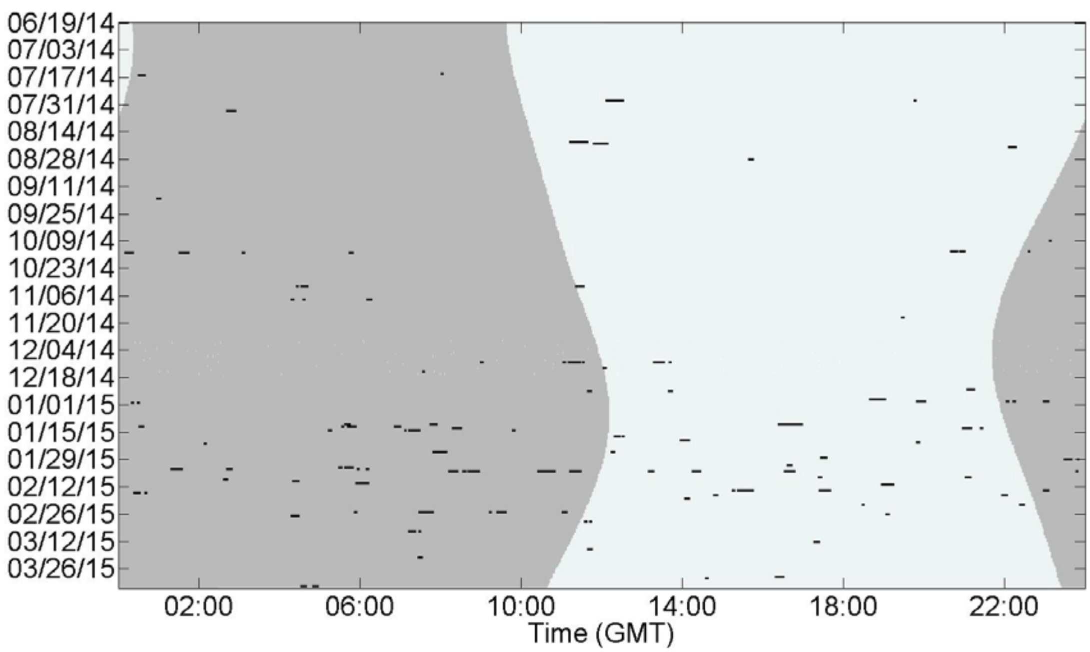

Figure 17. Cuvier's beaked whale click detections (black bars) in one-minute bins within the June 2014–April 2015 Norfolk Canyon Site A dataset.

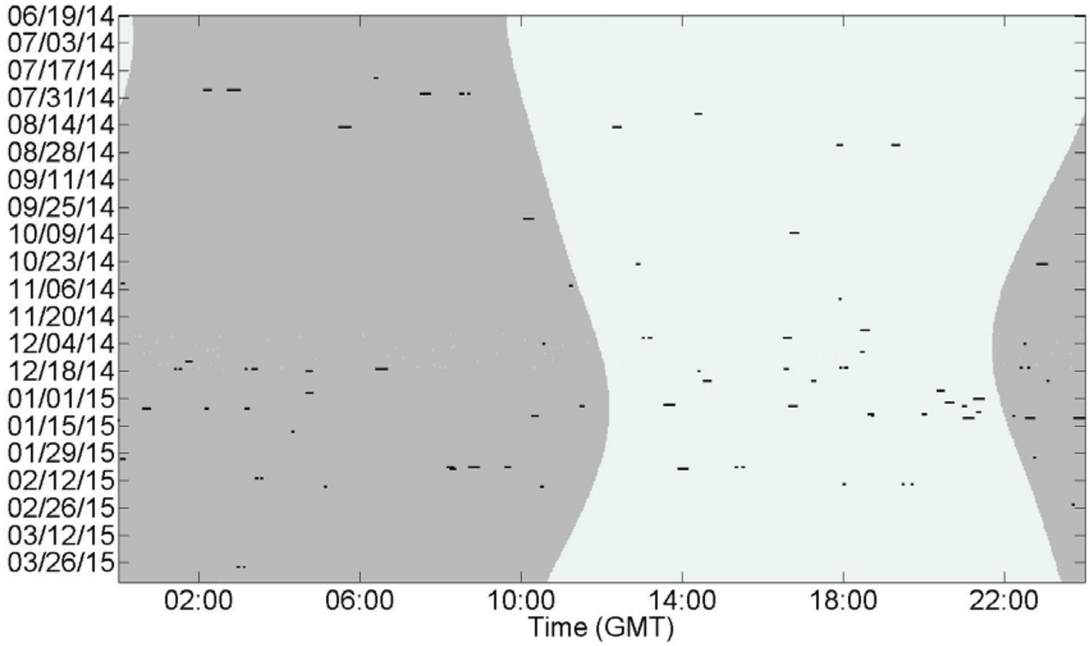

Figure 18. Gervais' beaked whale click detections (black bars) in one-minute bins within the June 2014–April 2015 Norfolk Canyon Site A dataset.

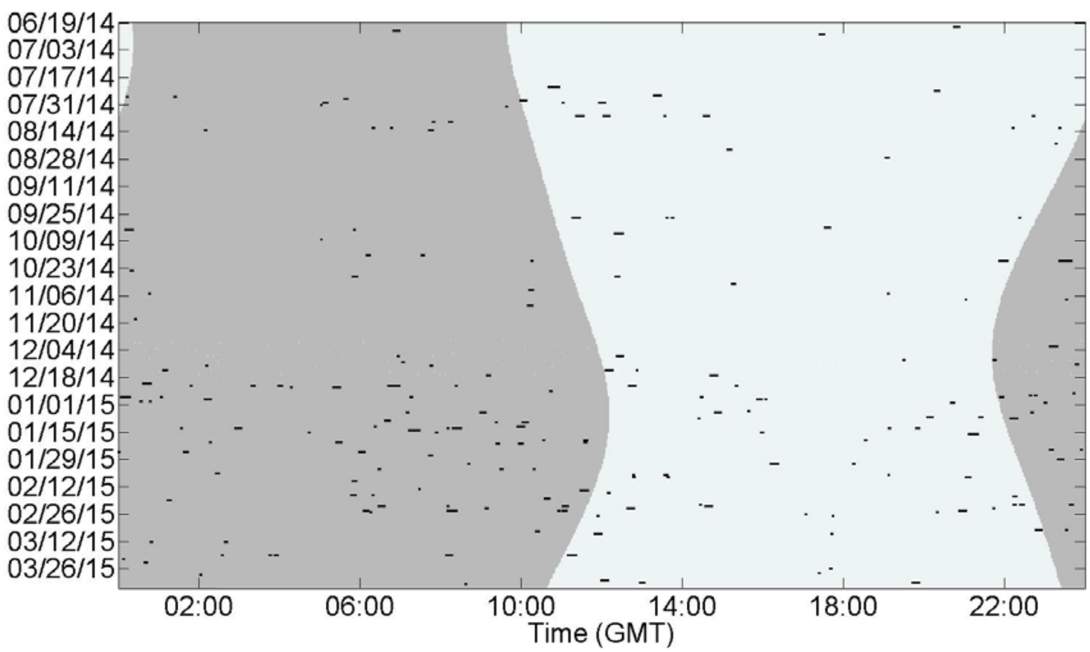

Figure 19. Possible Sowerby's beaked whale click detections (black bars) in one-minute bins within the June 2014–April 2015 Norfolk Canyon Site A dataset.

Mid-frequency active sonar was detected throughout the deployment, with most detections occurring during night (**Figure 20**). Low-frequency active sonar was detected sporadically, with most detections occurring during the day (**Figure 21**). Airguns were detected mainly between June 2014 and January 2015 during both day and night, with a peak in detections in October 2014 (**Figure 22**).

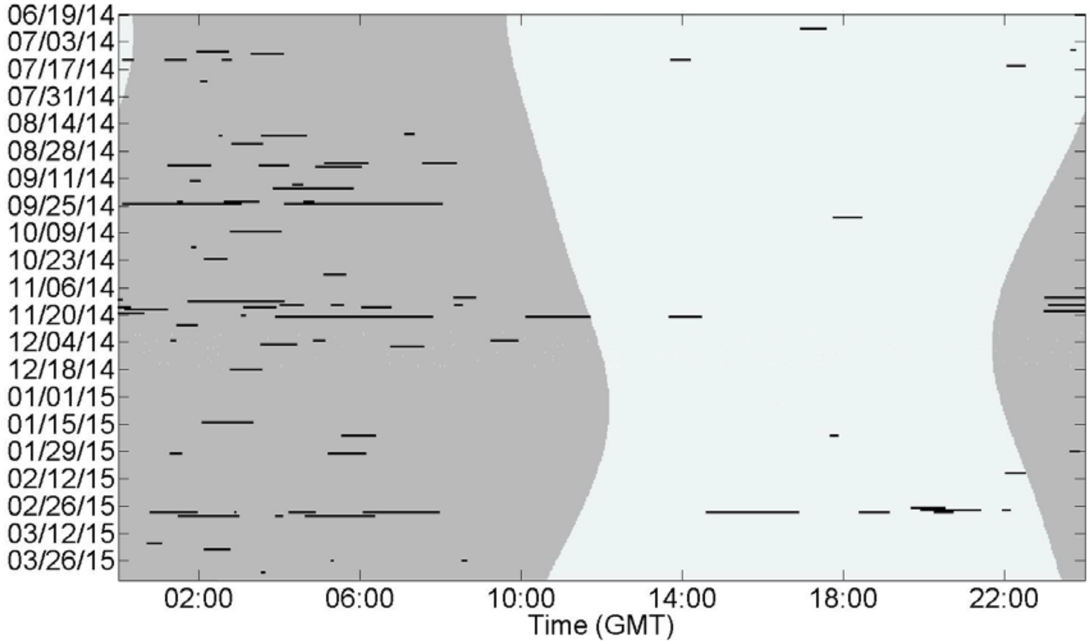

Figure 20. Mid-frequency active sonar (black bars) detected within the June 2014–April 2015 Norfolk Canyon Site A dataset.

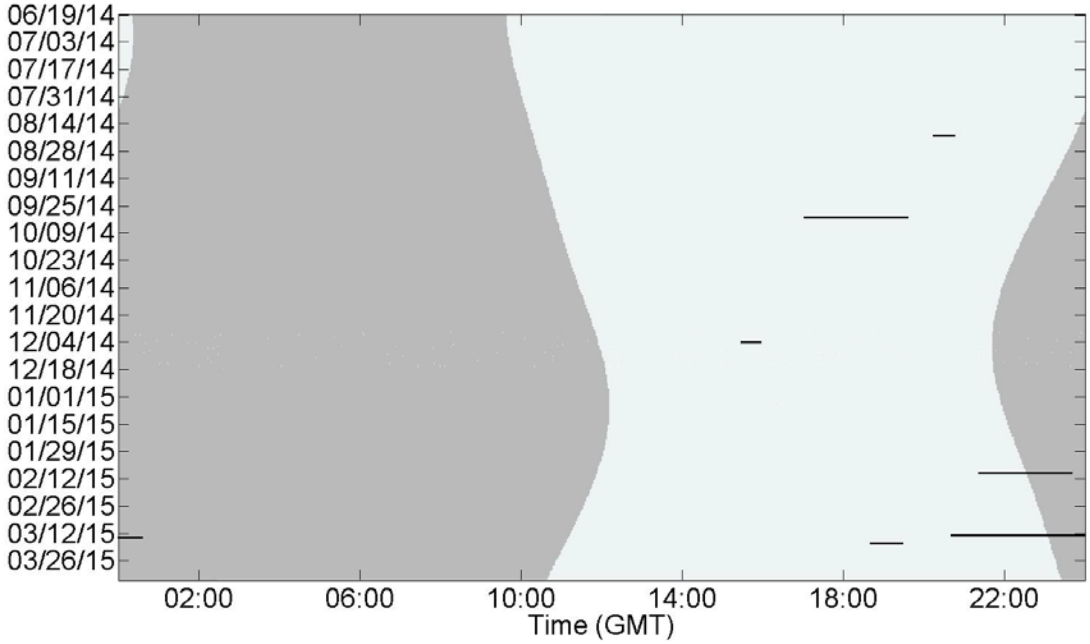

Figure 21. Low-frequency active sonar (black bars) detected within the June 2014–April 2015 Norfolk Canyon Site A dataset.

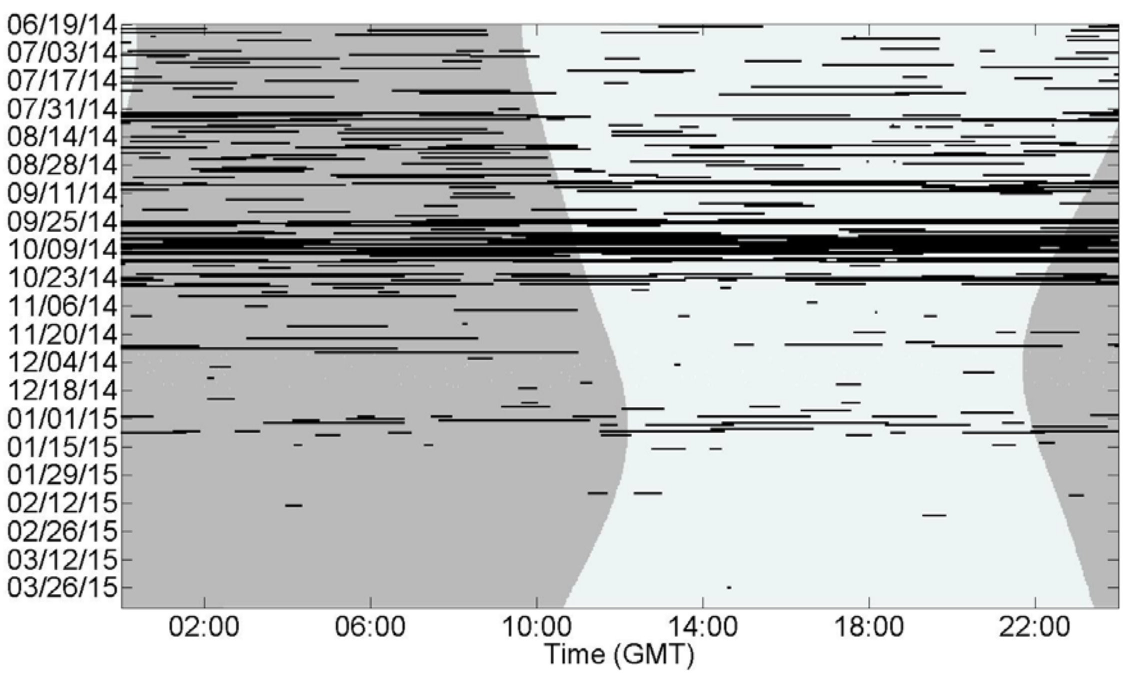

Figure 22. Airgun detections (black bars) within the June 2014–April 2015 Norfolk Canyon Site A dataset.

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5. Cape Hatteras

5.1 Methods

Data Collection

During this reporting period the large mooring HARP deployed on 8 May 2014 at 35.34677^o N, 74.84805^o W off the coast of Cape Hatteras, NC (Site A) in approximately 850 m was retrieved on 6 April 2015 (**Table 4, Figure 23**), yielding a deployment period of 334 days. A compact small mooring HARP was deployed that same day at the same site (35.34218^o N, 74.85726^o W) in approximately 980 m (**Table 4, Figure 23**). Schematic diagrams of the HARP moorings for these deployments are shown in **Figures 24 and 25**. This instrument is still in the field and is expected to be recovered during early 2016. The HARP was programmed to sample continuously at 200 kHz for both deployments.

Table 4. Cape Hatteras, HARP data sets analyzed and detailed in this report.

Site	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Latitude (N)	Longitude (W)	Depth (m)	Sampling Rate	Duty Cycle
02A	9-Oct-12	29-May-13	9-Oct-12	9-May-13	35.3406	74.8559	970	200 kHz	continuous
03A	29-May-13	8-May-14	29-May13	15-Mar-14	35.3444	74.8521	970	200 kHz	continuous
04A	8-May-14	6-Apr-15	9-May-14	11-Dec-14	35.3467	74.8480	850	200 kHz	continuous
05A	6-Apr-15	N/A	7-Apr-15	N/A	35.3421	74.8572	980	200 kHz	continuous

Data Analysis

Three datasets from deployments at Cape Hatteras Site A have been analyzed for marine mammal and anthropogenic sounds and will be reported here as a summary of Debich et al. (in prep), with beaked whale analysis performed by J.E. Stanistreet. These datasets include the dataset from the October 2012–May 2013 deployment that yielded 5093 hours of recording time over 212 days, the dataset from the May 2013–May 2014 deployment that yielded 6965 hours of recording time over 290 days, and the dataset from the May 2014–April 2015 deployment that yielded 5207 hours of recording time over 217 days. Odontocete whistle analysis of these datasets is ongoing and will be reported on during the next annual report.

Data Quality

Highly stereotyped broadband digital errors (‘glitches’) were found in the October 2012–May 2013 and the May 2013–March 2014 Cape Hatteras datasets. These glitches were short in duration (between 100 μs and 10 ms) and started in the second half of both datasets, increasing in occurrence once they appeared. To repair the glitches, the data were overwritten using a detector calibrated to the observed amplitude and duration of the glitches. This process does not overwrite any real broadband signals in the data. It is believed that neither the glitches nor the repair process significantly impacted the resulting data analysis.

For the May–December 2014 Cape Hatteras dataset, normal recording ended on December 11, 2014. After that date, disk error issues caused skipping in the data. These disk error issues resulted in only four more 75-s files written on four different days between 26 December 2014 and 15 January 2015. These data were not analyzed.

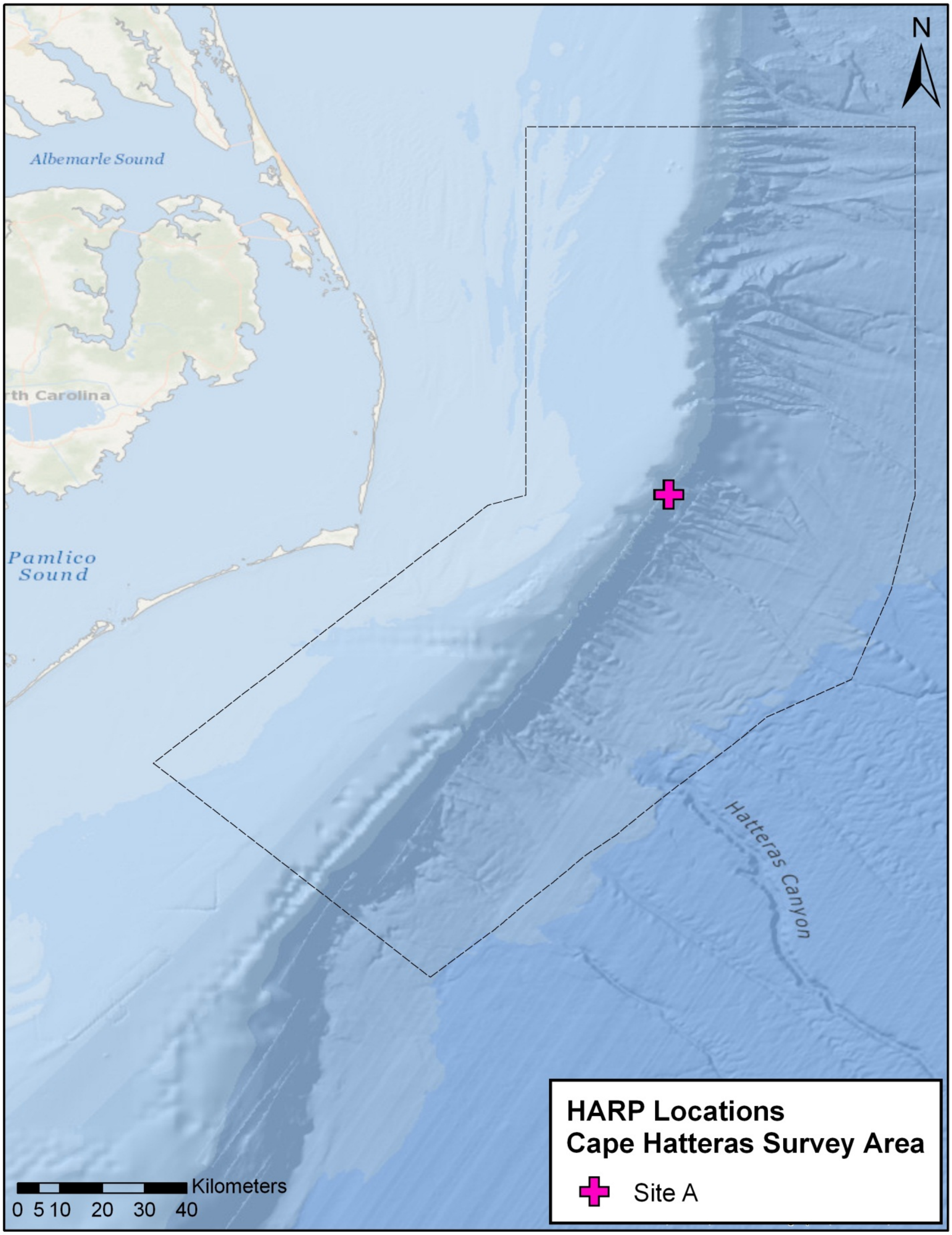

Figure 23. Location of the HARP deployment site in the Cape Hatteras study area.

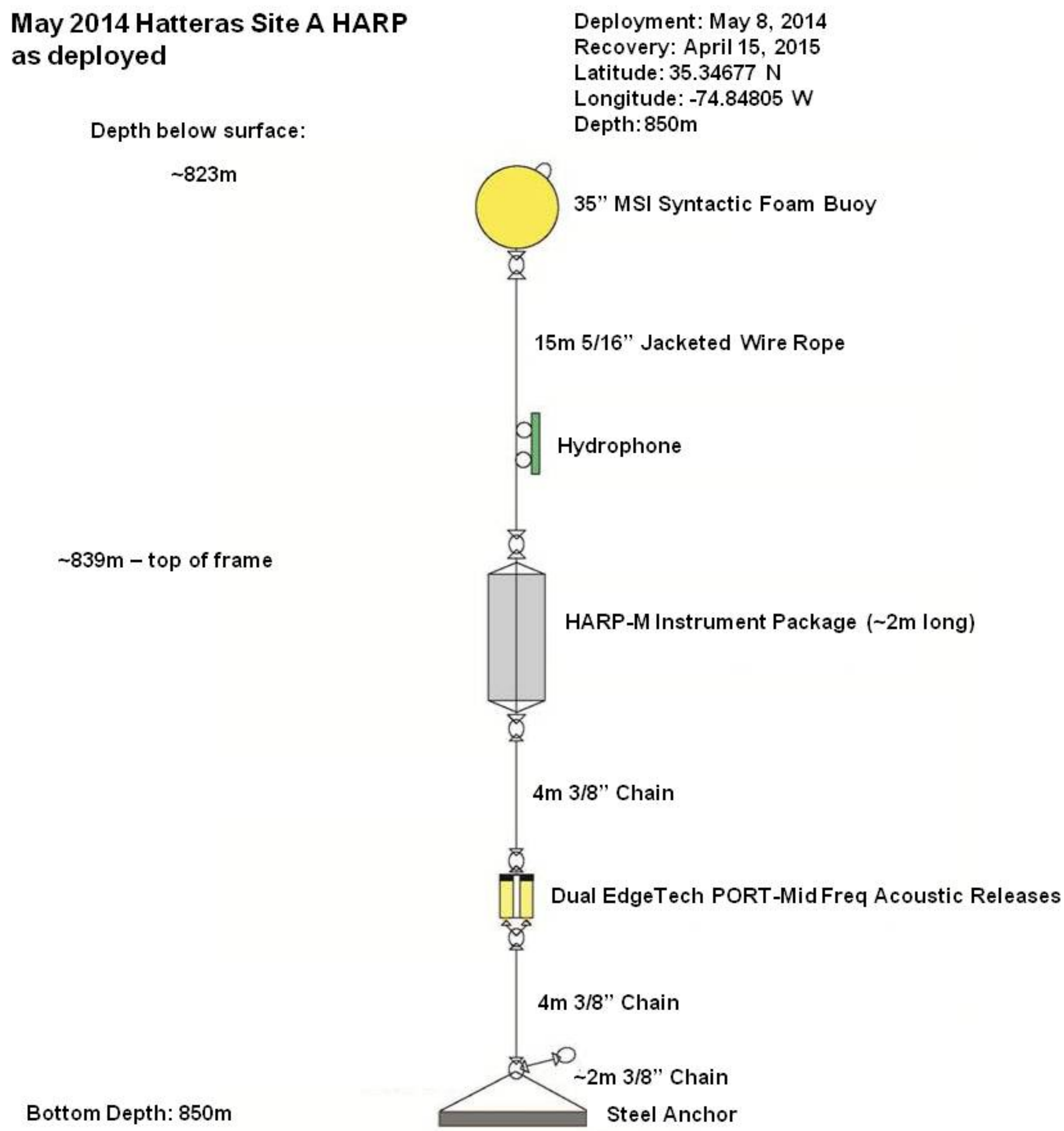

Figure 24. Schematic diagram showing details of the May 2014 Cape Hatteras Site A HARP deployment. Note that diagram is not drawn to scale.

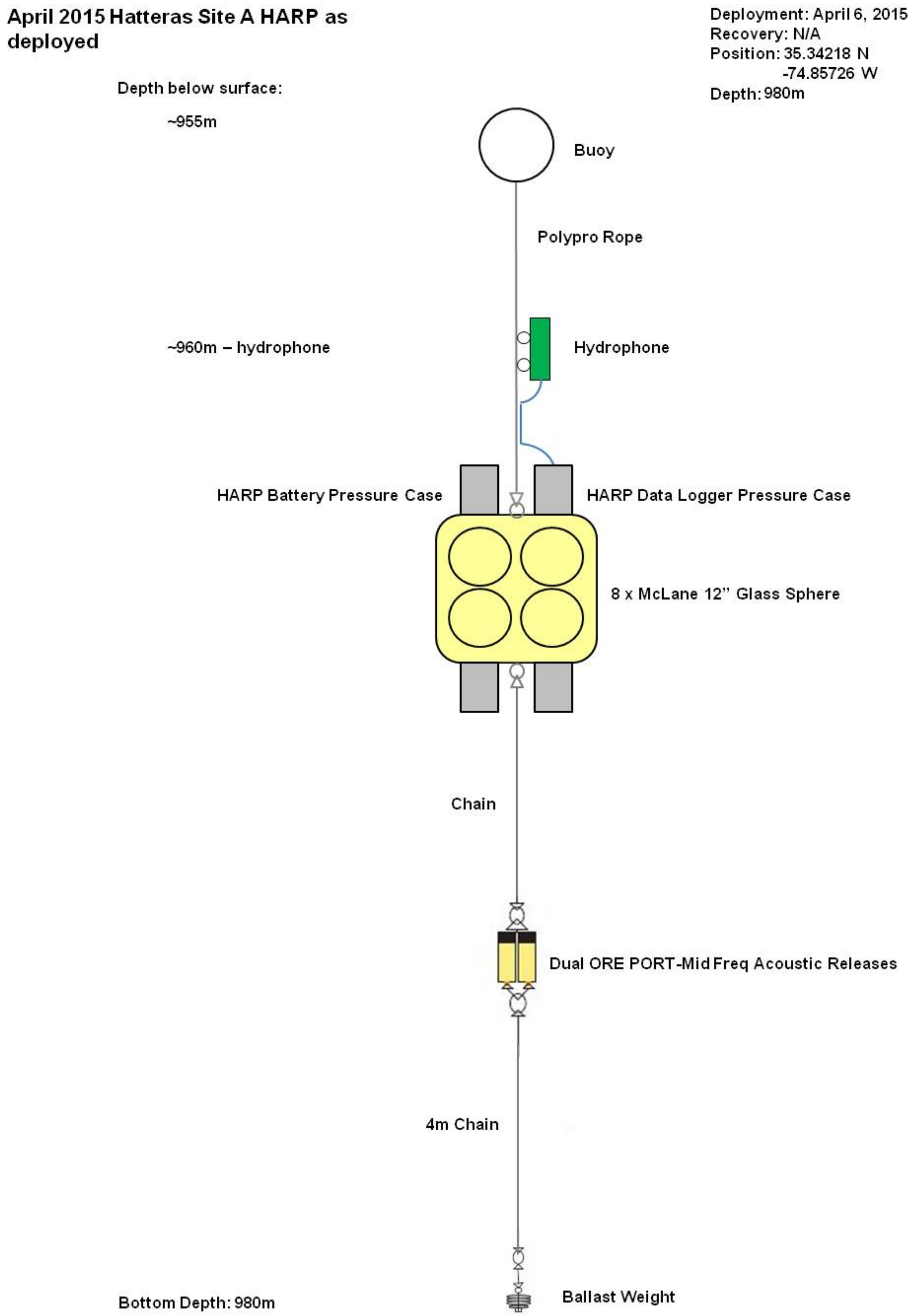

Figure 25. Schematic diagram showing details of the April 2015 Cape Hatteras Site A HARP deployment. Note that diagram is not drawn to scale.

5.2 Results

These results, except for the beaked whale analysis which was performed by J.E. Stanistreet, are a summary of Debich et al. (prep). Monthly averages of underwater ambient noise during the three Cape Hatteras Site A datasets described here (the October 2012–May 2013 dataset, the May 2013–March 2014 dataset, and the May–December 2014 dataset) are shown in **Figure 26**. **Tables 5 through 7** summarize the detected and identified marine mammal vocalizations during these three datasets**. Figures 27 through 41** show the daily occurrence patterns for the different marine mammal groups (classified to species when possible) at Cape Hatteras Site A during the three deployment periods. **Figure 42** shows the occurrence of mid-frequency active sonar. **Figure 43** shows the occurrence of airguns.

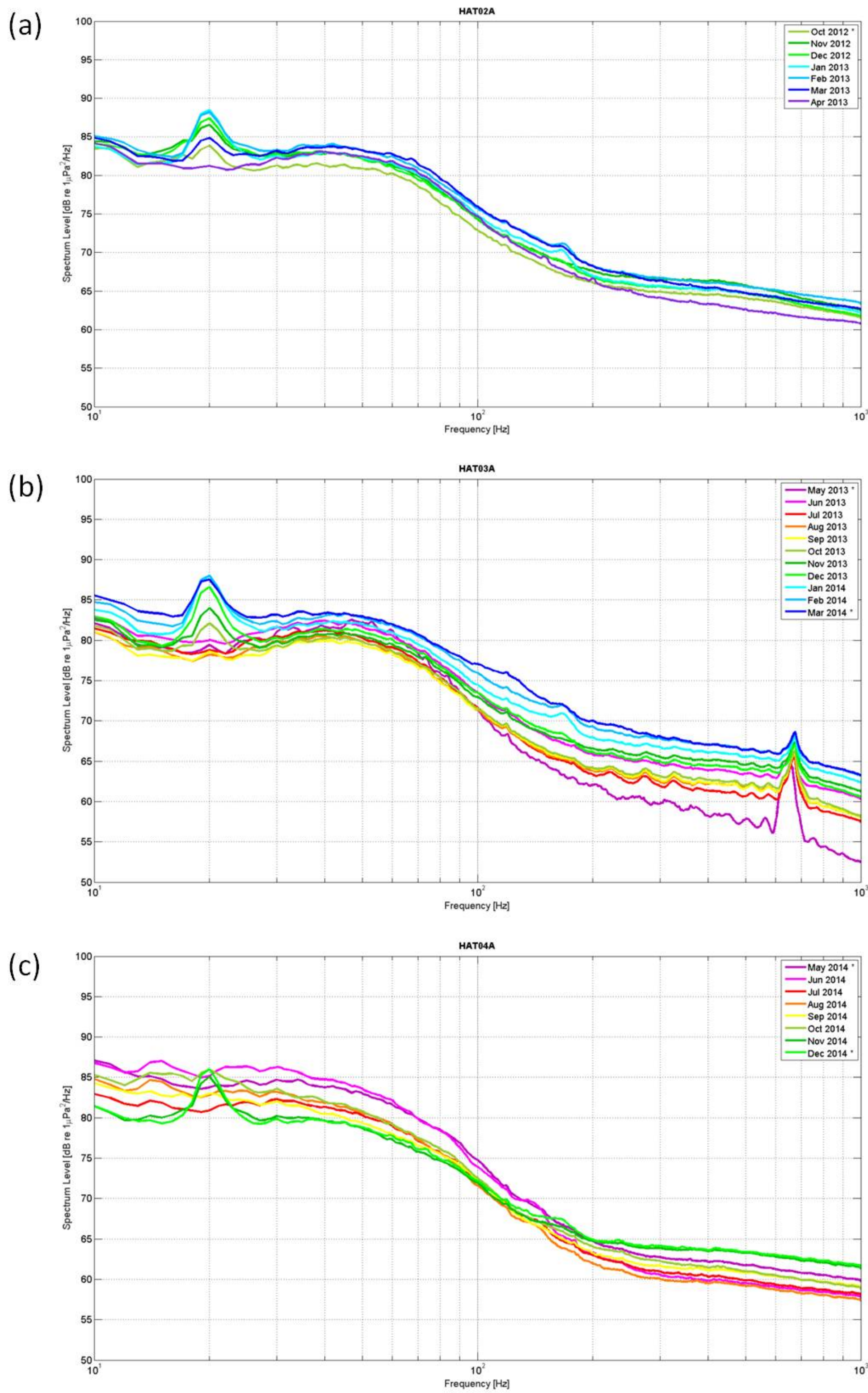

Figure 26. Monthly averages of ambient noise at Cape Hatteras Site A for (a) October 2012–May 2013, (b) May 2013–March 2014, and (c) May–December 2014. Months with an asterisk (*) are partial recording periods. Figure from Debich et al. (in prep).

Table 5. Summary of detections of marine mammal vocalizations at Cape Hatteras Site A for October 2012–May 2013. Fin whale 20-Hz pulses are not included as they were reported as an acoustic index and not logged with a start and end time for individual detection events. *For all mysticetes except humpback whales, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in hourly bins; for humpback whales and 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 total recording days
Blue whale	A and B calls	157	3.1	42	19.7
Fin whale	40 Hz	37	0.7	16	7.5
Minke whale	pulse train (slow-down, speed-up, regular)	1880	36.9	128	60.1
Sei whale	downsweep	214	4.2	57	26.8
North Atlantic right whale	up-call	7	0.1	2	0.9
Humpback whale	variable	17.9	0.4	25	11.7
Unidentified odontocete	clicks	3072.8	60.3	213	100
Kogia spp.	clicks	2.6	0.05	37	17.4
Risso’s dolphin	clicks	0.02	0.0003	1	0.5
Sperm whale	clicks	818.3	16.1	150	70.4
Cuvier’s beaked whale	clicks	334.9	6.6	206	96.7
Gervais’ beaked whale	clicks	13.0	0.3	42	19.7
Blainville’s beaked whale	clicks	0.07	0.001	1	0.47

Table 6. Summary of detections of marine mammal vocalizations at Cape Hatteras Site A for May 2013–March 2014. Fin whale 20-Hz pulses are not included as they were reported as an acoustic index and not logged with a start and end time to individual detection events. *For all mysticetes except humpback whales, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in hourly bins; for humpback whales and 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 total recording days
Blue whale	A and B calls	26	0.4	16	5.5
Fin whale	40 Hz	8	0.1	5	1.7
Minke whale	pulse train (slow-down, speed-up, regular)	1781	25.7	121	41.6
Sei whale	downsweep	113	1.6	37	12.7
North Atlantic right whale	up-call	1	0.01	1	0.3
Humpback whale	variable	0.3	0.005	2	0.7
Unidentified odontocete	clicks	2351.8	33.9	286	98.3
Kogia spp.	clicks	3.9	0.06	67	23.0
Risso's dolphin	clicks	2.9	0.04	3	1.0
Sperm whale	clicks	1330.7	19.2	196	67.4
Cuvier's beaked whale	clicks	446.0	6.4	272	93.5
Gervais' beaked whale	clicks	42.8	0.6	121	41.6
Blainville's beaked whale	clicks	0.5	0.007	4	1.4
Possible Sowerby's beaked whale	clicks	0.1	0.001	1	0.3

Table 7. Summary of detections of marine mammal vocalizations at Cape Hatteras Site A for May–December 2014. Fin whale 20-Hz pulses are not included as they were reported as an acoustic index and not logged with a start and end time to individual detection events. *For all mysticetes except humpback whales, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in hourly bins; for humpback whales and 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 total recording days
Blue whale	A and B calls	22	0.4	4	1.8
Minke whale	pulse train (slow-down, speed-up, regular)	237	4.6	35	16.1
Sei whale	downsweep	15	0.3	7	3.2
North Atlantic right whale	up-call	2	0.04	1	0.5
Humpback whale	variable	0.5	0.009	5	2.3
Unidentified odontocete	clicks	1122.6	21.6	210	96.8
Kogia spp.	clicks	1.9	0.04	39	18.0
Risso's dolphin	clicks	5.9	0.1	5	2.3
Sperm whale	clicks	571.4	11.0	97	44.7
Cuvier's beaked whale	clicks	231.2	4.4	210	96.8
Gervais' beaked whale	clicks	29.2	0.6	87	40.1
Blainville's beaked whale	clicks	0.1	0.002	2	0.9

Mysticete detections included blue whales, fin whales, minke whales, sei whales, North Atlantic right whales, and humpback whales. Blue whales were present primarily in October and November, but continued to be detected through April (**Figure 27**). Fin whale 20-Hz pulses (as measured by the acoustic index) were detected throughout the deployment, with peaks in calling in December and January (**Figure 28**). Fin whale 40-Hz calls were detected in low numbers throughout the October 2012–May 2013 and May 2013–March 2014 datasets (**Figure 29**). There were no fin whale 40-Hz calls detected in the May–December 2014 dataset. Minke whale pulse trains showed a strong seasonal pattern, with a peak in detections between December and February (**Figure 30**). Sei whale downsweeps were detected throughout the deployment, with peaks in occurrence between December and March (**Figure 31**). North Atlantic right whale up-calls were detected on only a few days at Cape Hatteras Site A (**Figure 32**). The timing coincides with the migration of this species in the spring and fall. Humpback whale calls were detected in low numbers during these deployments, with a peak in occurrence in March 2013 (**Figure 33**).

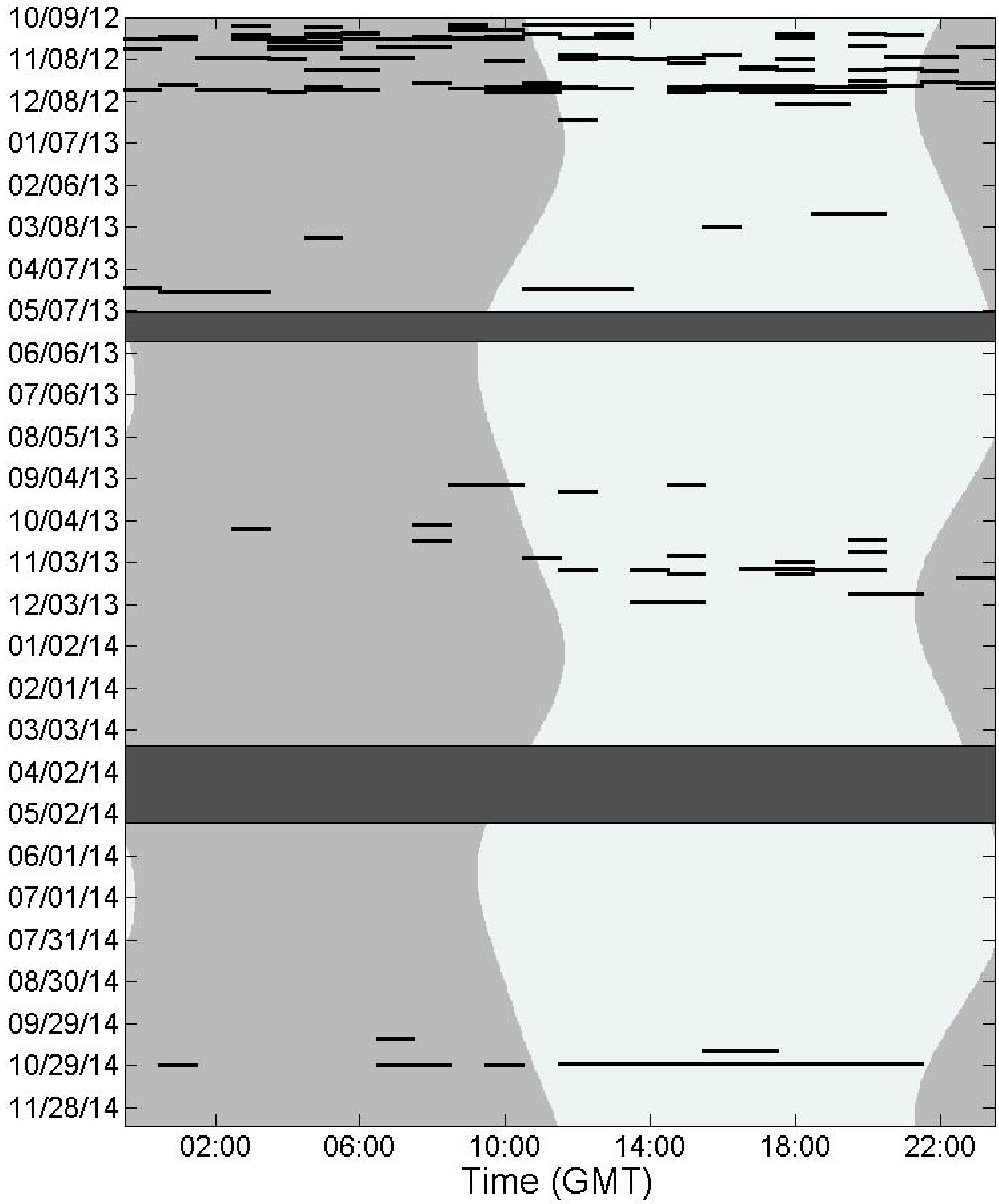

Figure 27. Blue whale call detections (black bars) in hourly bins within the October 2012–May 2013, May 2013–March 2014, and May–December 2014 Cape Hatteras Site A datasets. For this figure and all subsequent figures of the same type, vertical gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil), and horizontal dark gray shading indicates absence of acoustic data.

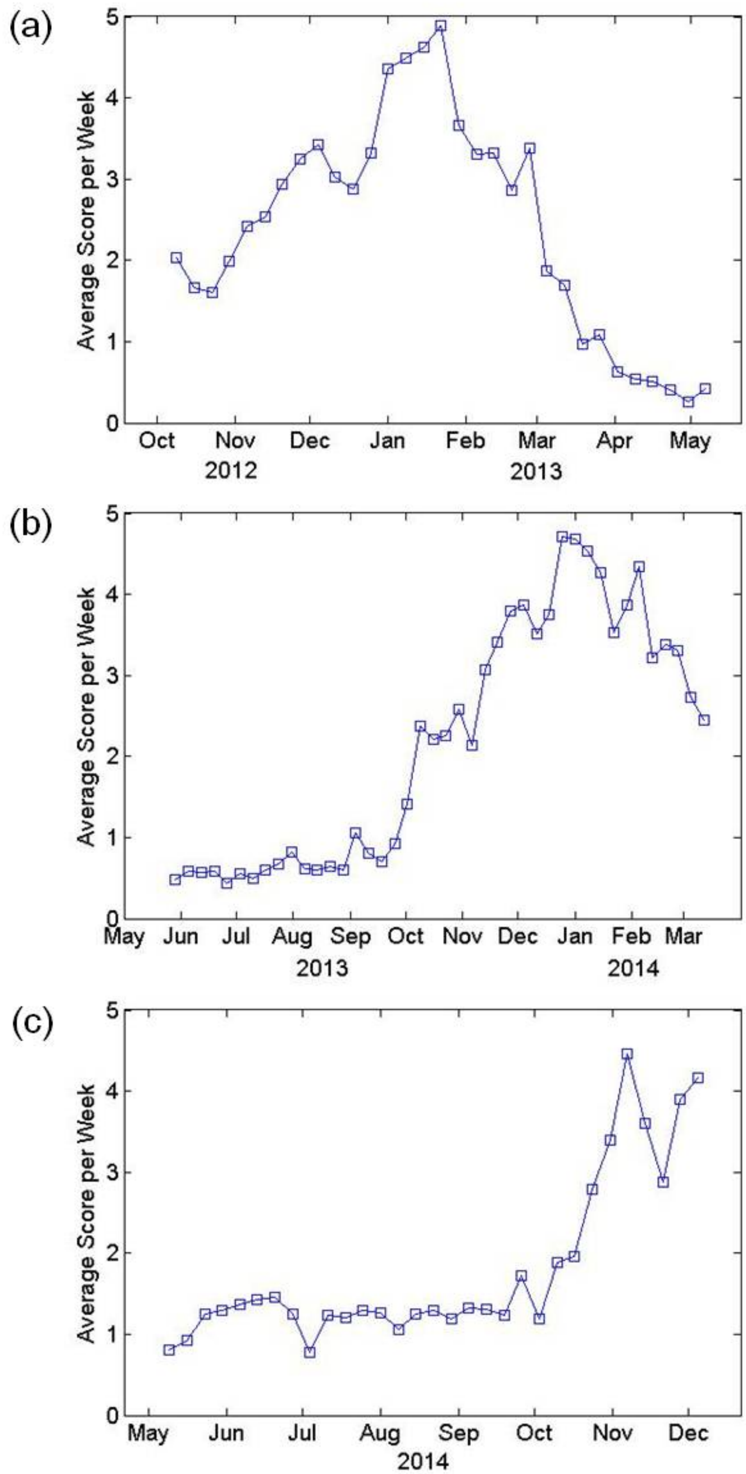

Figure 28. Weekly value of fin whale 20-Hz call acoustic index for the (a) October 2012–May 2013, (b) May 2013–March 2014, and (c) May–December 2014 Cape Hatteras Site A datasets.

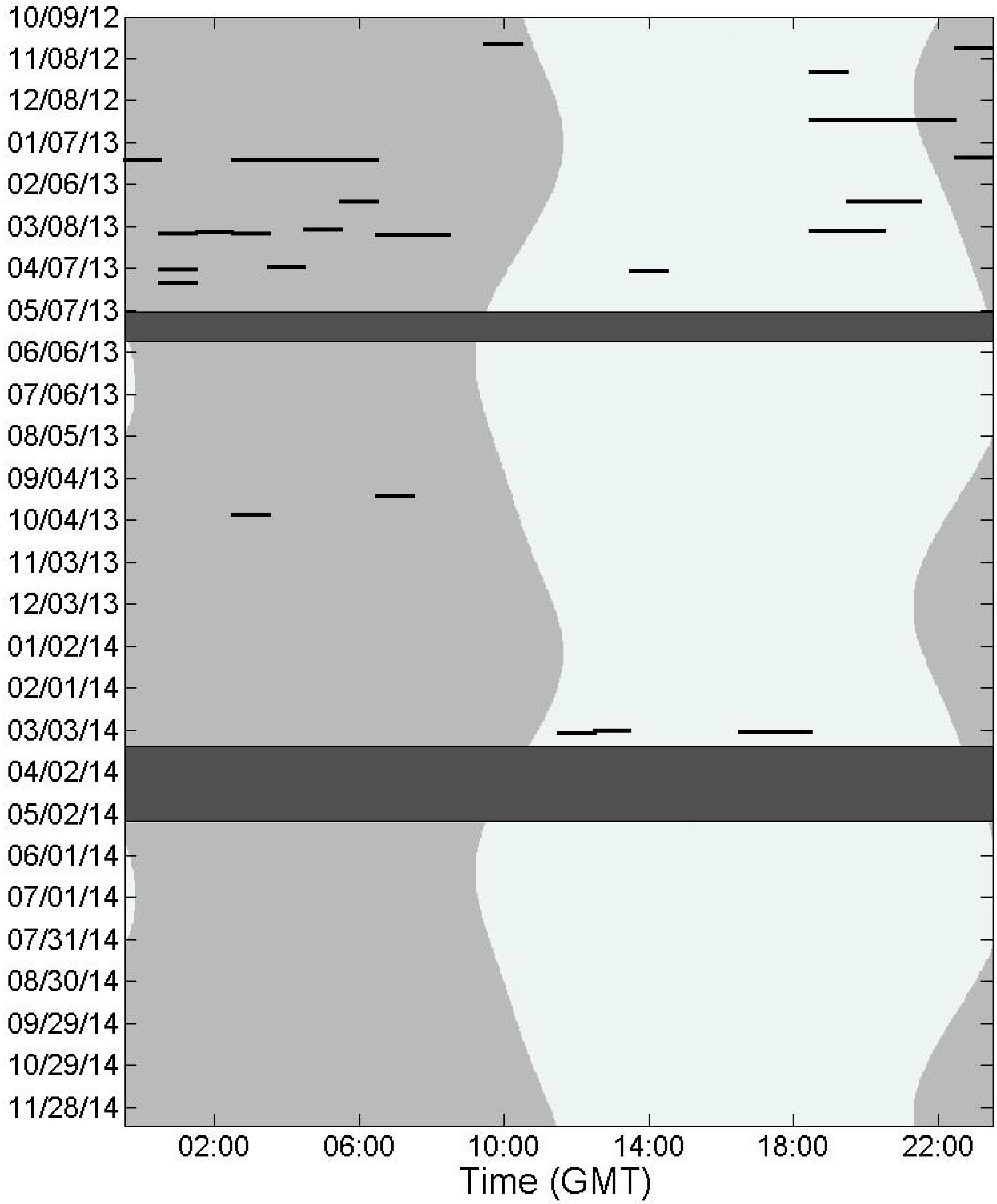

Figure 29. Fin whale 40-Hz call detections (black bars) in hourly bins within the October 2012–May 2013, May 2013–March 2014, and May–December 2014 Cape Hatteras Site A datasets. There were no fin whale 40-Hz call detections within the May–December 2014 Site A dataset.

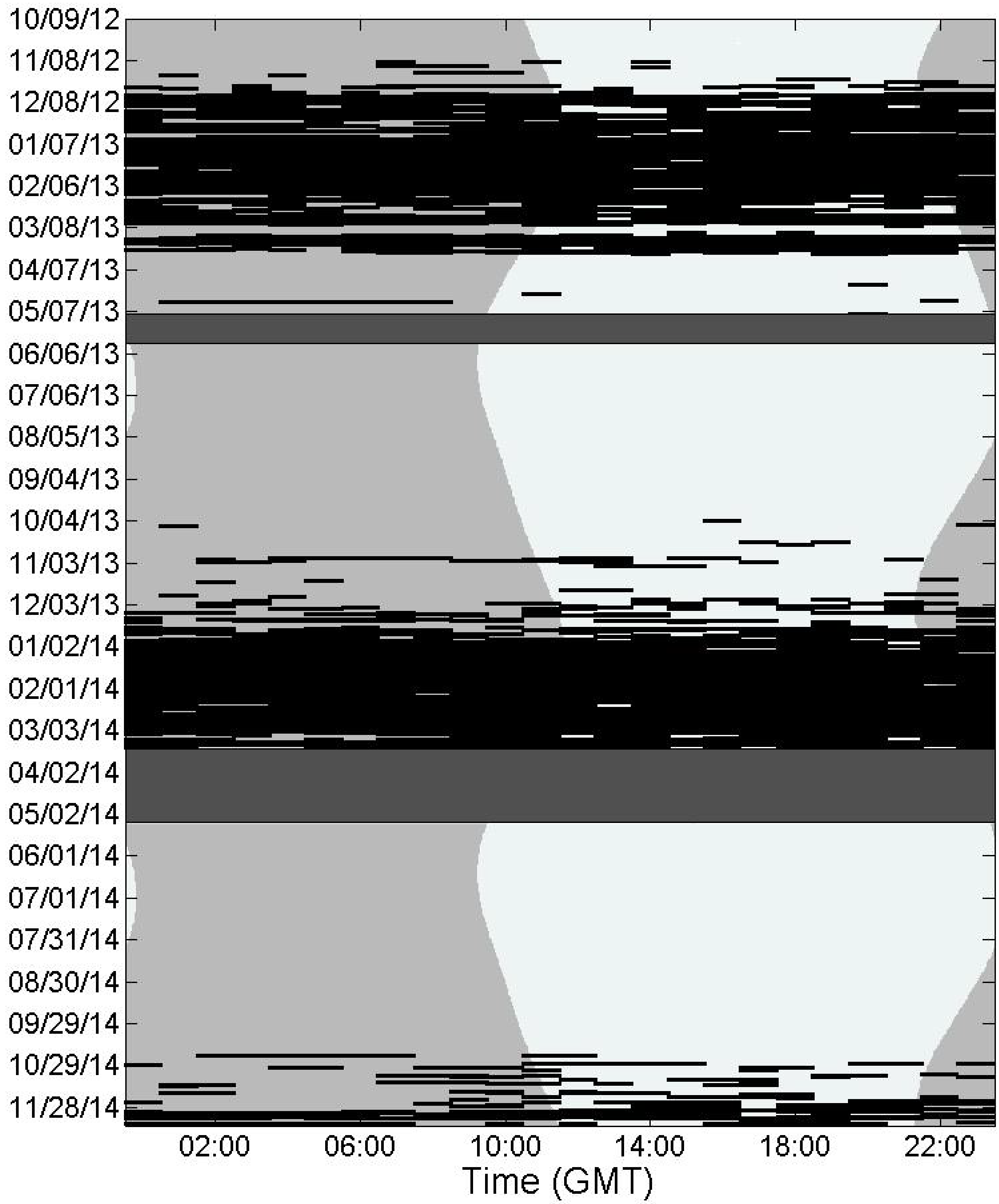

Figure 30. Minke whale pulse train detections (black bars) in hourly bins within the October 2012–May 2013, May 2013–March 2014, and May–December 2014 Cape Hatteras Site A datasets.

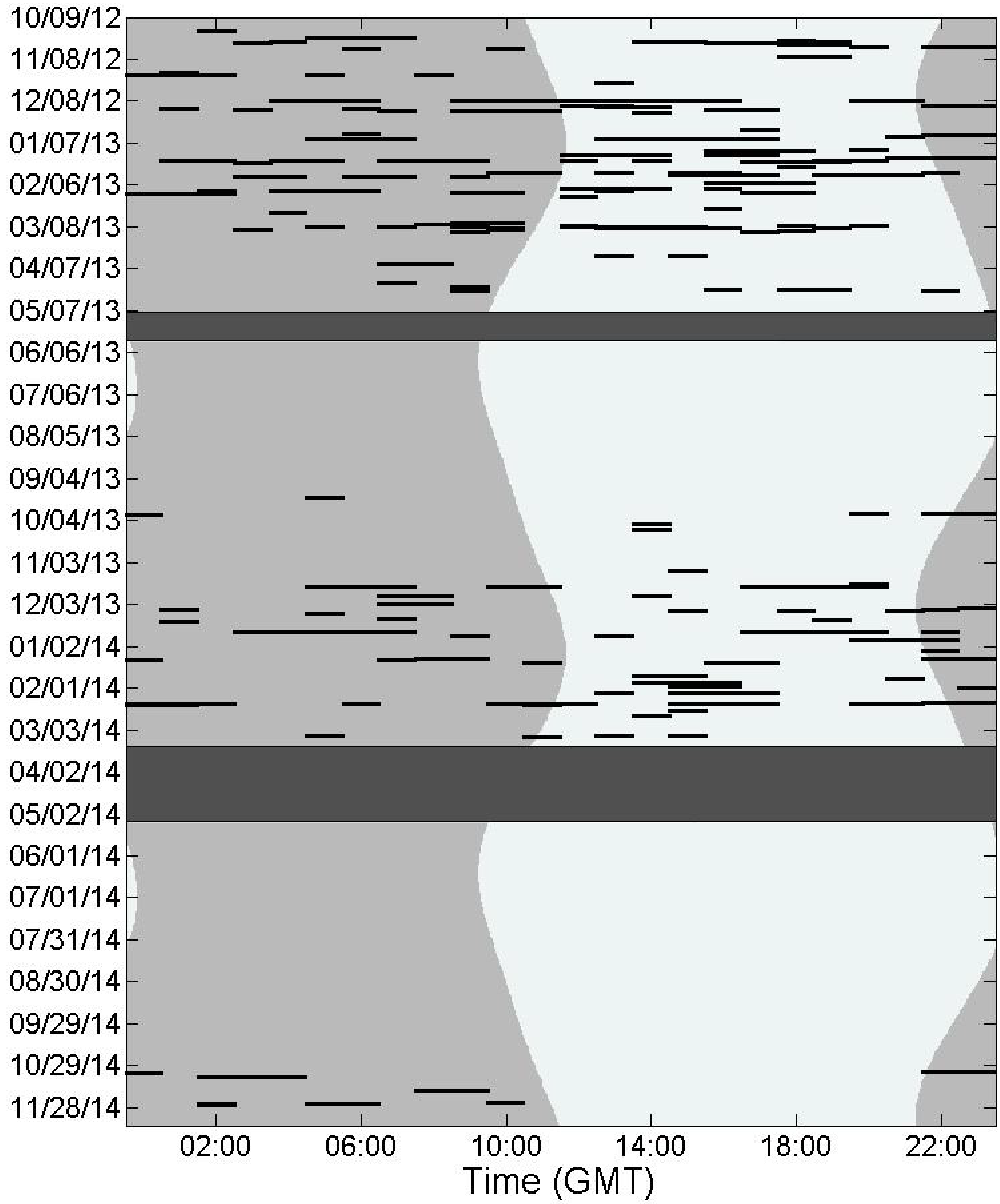

Figure 31. Sei whale downsweeps detections (black bars) in hourly bins within the October 2012–May 2013, May 2013–March 2014, and May–December 2014 Cape Hatteras Site A datasets.

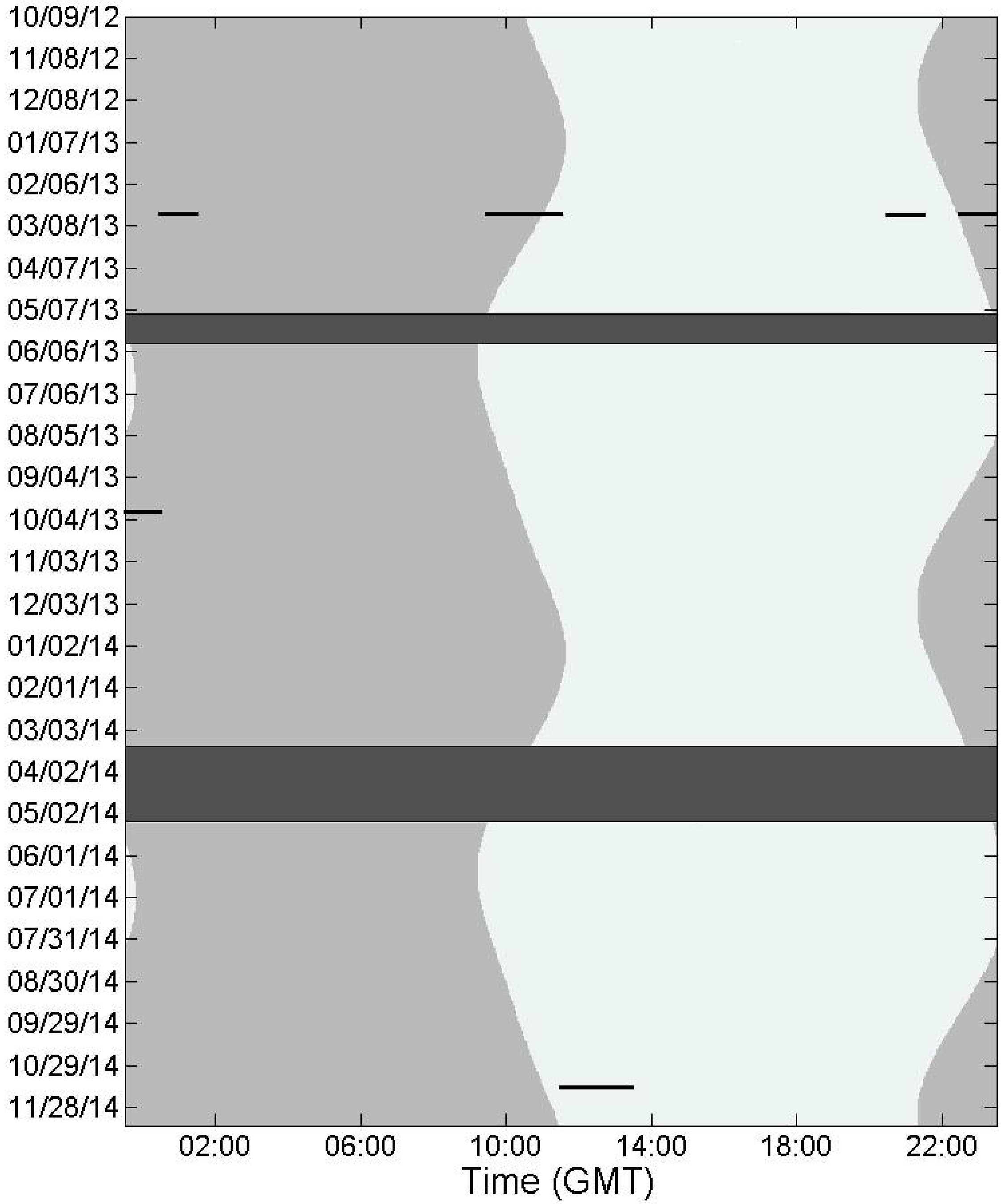

Figure 32. North Atlantic right whale up-call detections (black bars) in hourly bins within the October 2012–May 2013, May 2013–March 2014, and May–December 2014 Cape Hatteras Site A datasets.

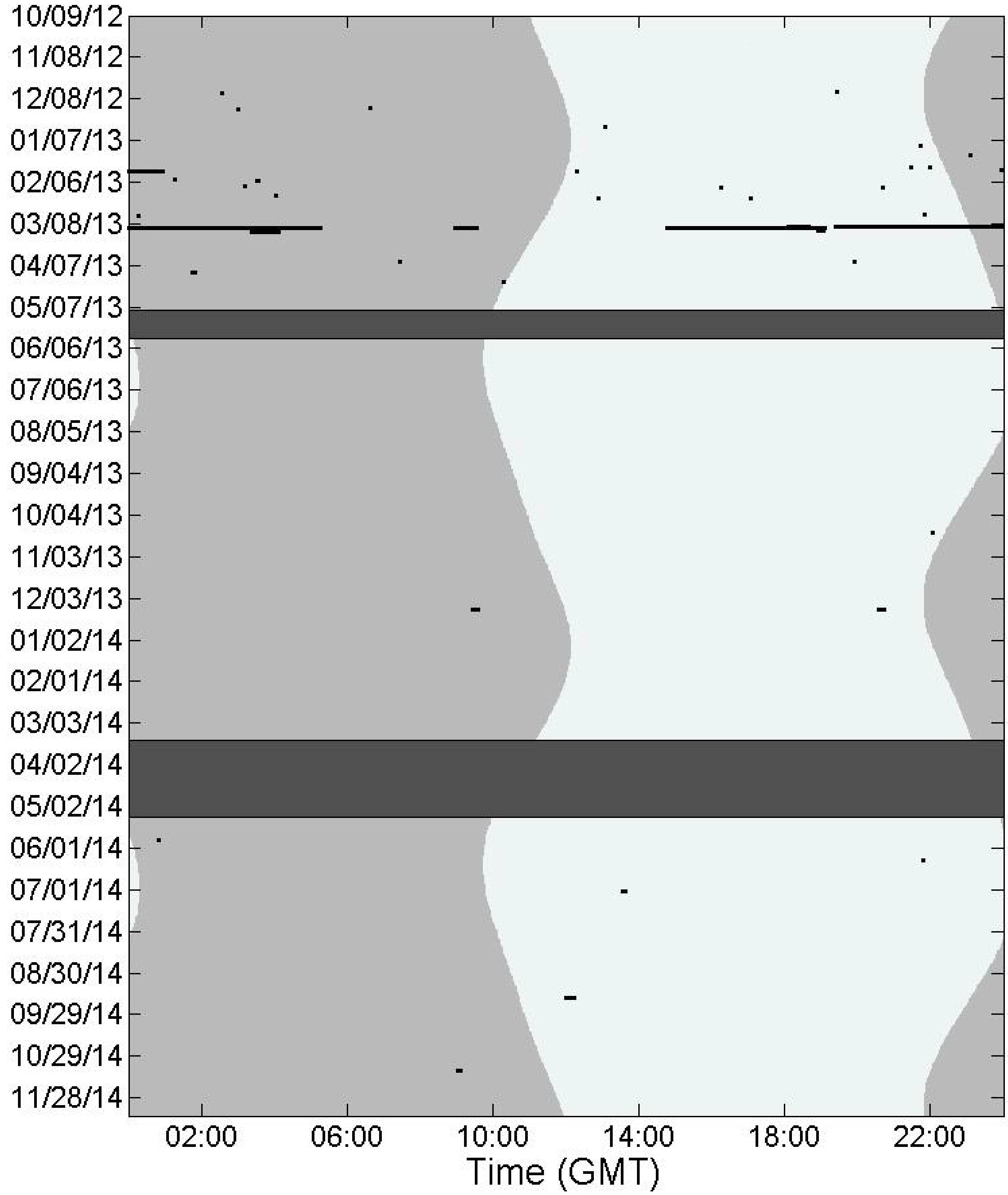

Figure 33. Humpback whale call detections (black bars) in one-minute bins within the October 2012–May 2013, May 2013–March 2014, and May–December 2014 Cape Hatteras Site A datasets.

Detected odontocetes included unidentified odontocetes, *Kogia* spp., Risso's dolphins, sperm whales, Cuvier's beaked whales, Gervais' beaked whales, Blainville's beaked whales (*Mesoplodon densirostris*), and possibly Sowerby's beaked whales. Most of the odontocete detections were assigned to the unidentified odontocete category, with the unidentified clicks being divided into five main groups based on spectral patterns (**Figure 34**). Altogether, these unidentified clicks were present nearly continuously throughout each recording period. For more details on each of the five groups of clicks and which species may have produced them, see Debich et al. (in prep). Clicks produced by *Kogia* spp. were also detected during all deployments, with a peak in occurrence during the winter months (**Figure 35**). Risso's dolphin clicks were detected sporadically during these three Site A deployments, with more detections during the night (**Figure 36**). Sperm whales were detected throughout all three deployments during both day and night, with peaks in click detections between January and February as well as between June and August (**Figure 37**). There were also several click detections that were assigned to beaked whales. Cuvier's beaked whale clicks occurred regularly throughout all three deployments, with a slight increase in detections between September and December (**Figure 38**). Gervais' beaked whale clicks occurred less frequently than Cuvier's beaked whale clicks at Cape Hatteras Site A. Most Gervais' beaked whale detections occurred between June and July and between November and March (**Figure 39**). Unlike for Cuvier's beaked whales, there were very few detections of Gervais' beaked whales between August and November. Blainville's beaked whale clicks were detected only on a few days during each deployment (**Figure 40**). Finally, higher frequency beaked whale clicks, possibly from Sowerby's beaked whale, were detected only on one day, 4 March 2013 (**Figure 41**).

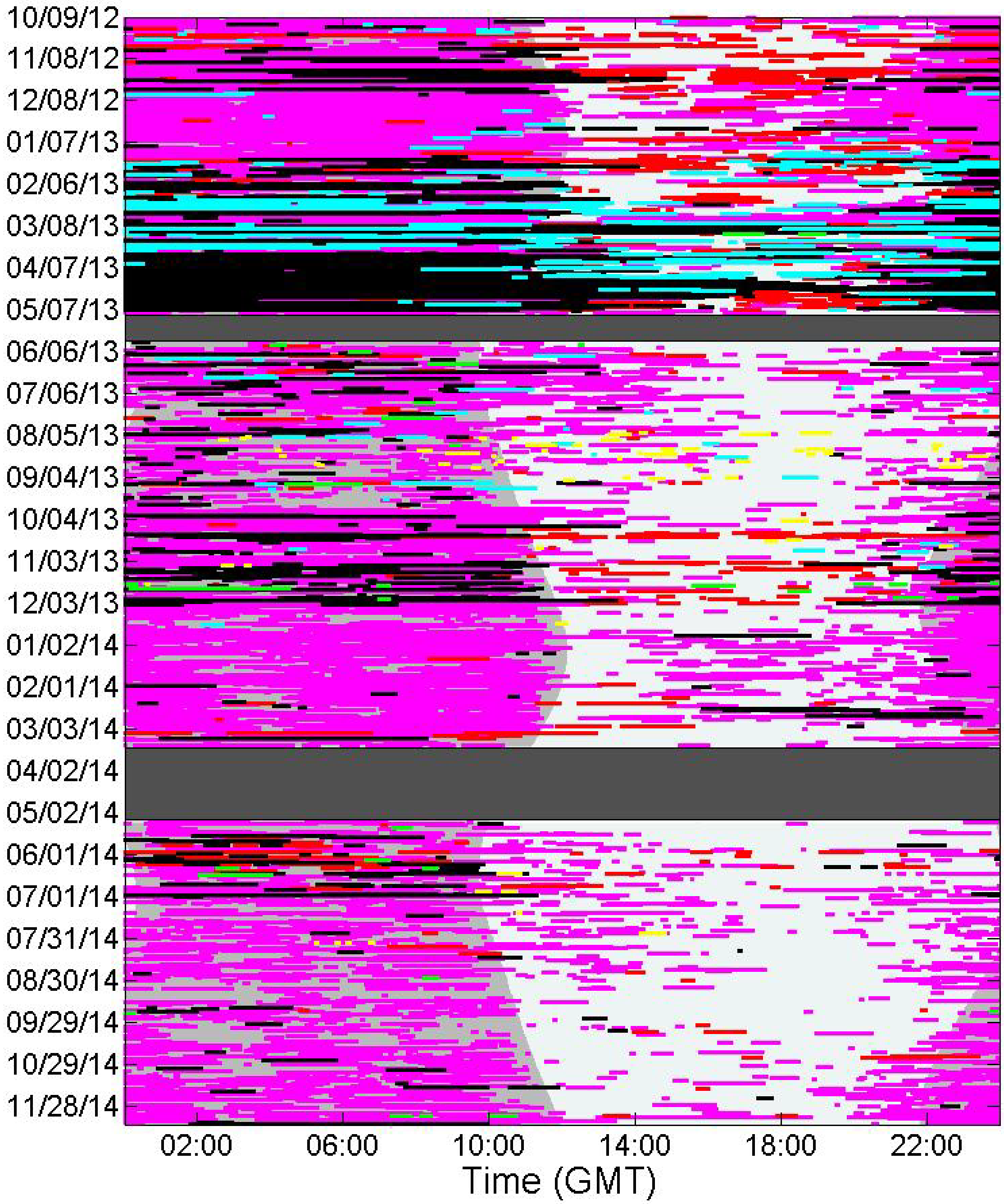

Figure 34. Unidentified odontocete click detections (different colored horizontal bars represent the different groups clicks were divided into, with those in yellow not assigned a category) in one-minute bins within the October 2012–May 2013, May 2013–March 2014, and May–December 2014 Cape Hatteras Site A datasets.

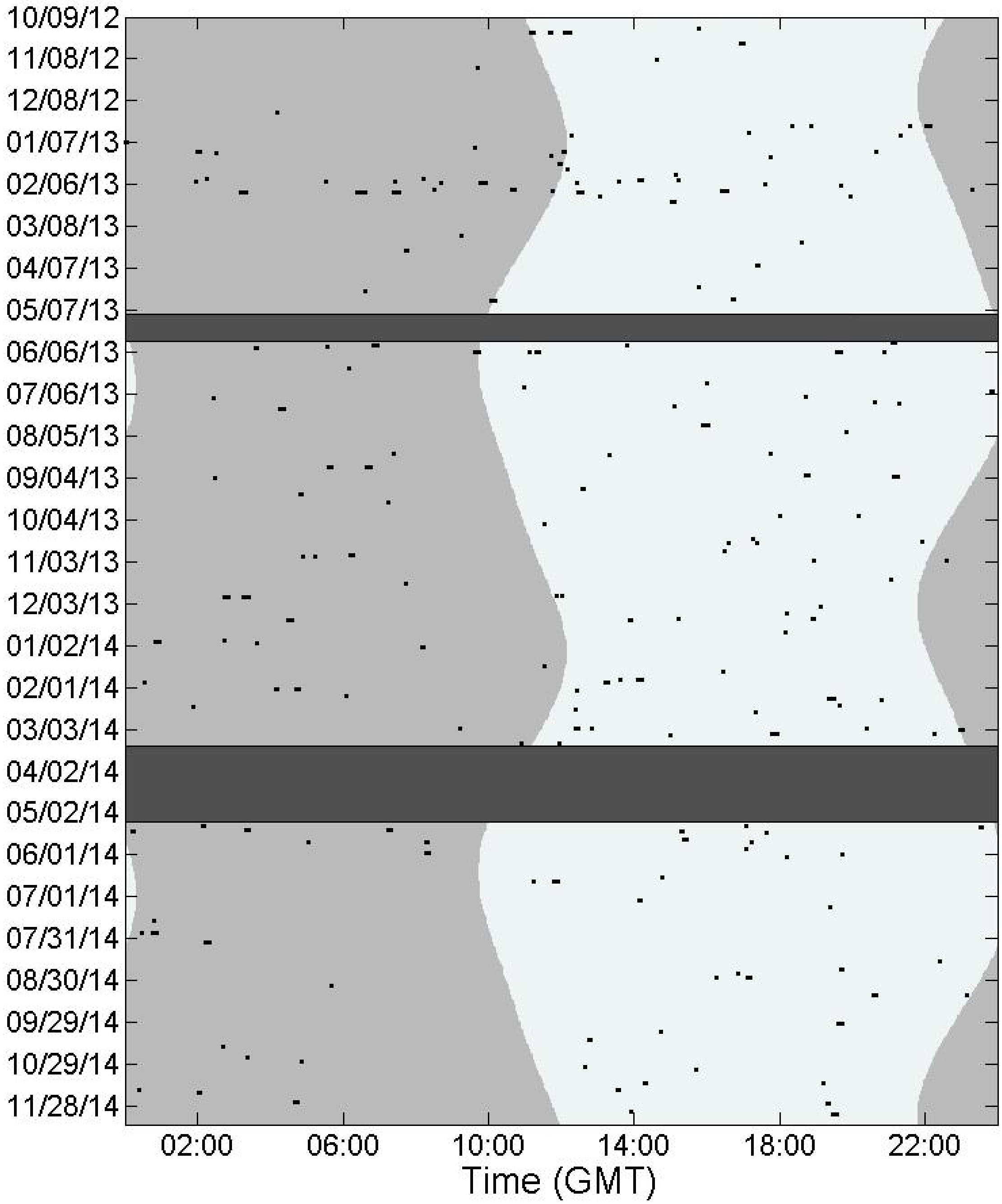

Figure 35. *Kogia* spp. click detections (black bars) in one-minute bins within the October 2012–May 2013, May 2013–March 2014, and May–December 2014 Cape Hatteras Site A datasets.

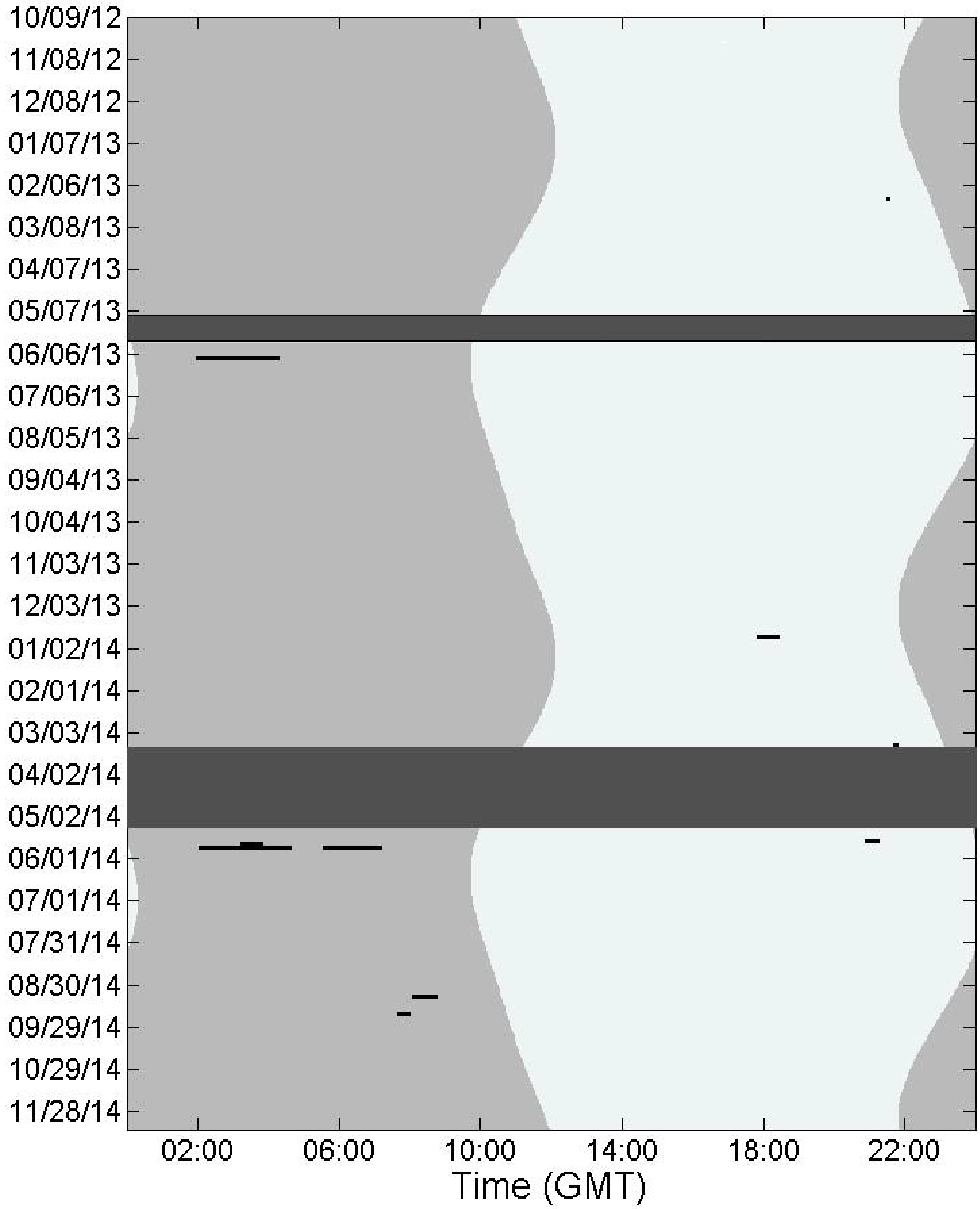

Figure 36. Risso's dolphin click detections (black bars) in one-minute bins within the October 2012–May 2013, May 2013–March 2014, and May–December 2014 Cape Hatteras Site A datasets.

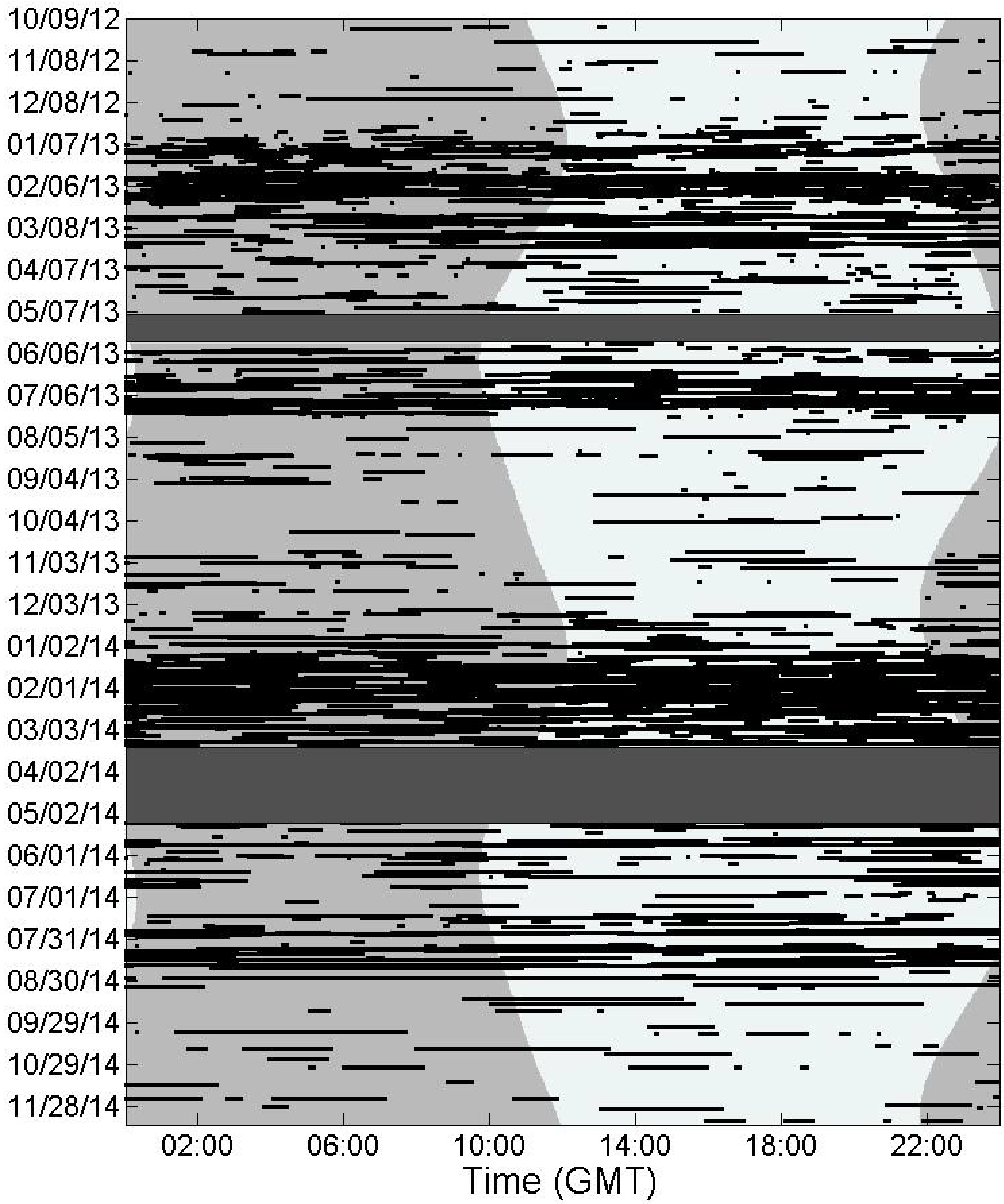

Figure 37. Sperm whale click detections (black bars) in one-minute bins within the October 2012–May 2013, May 2013–March 2014, and May–December 2014 Cape Hatteras Site A datasets.

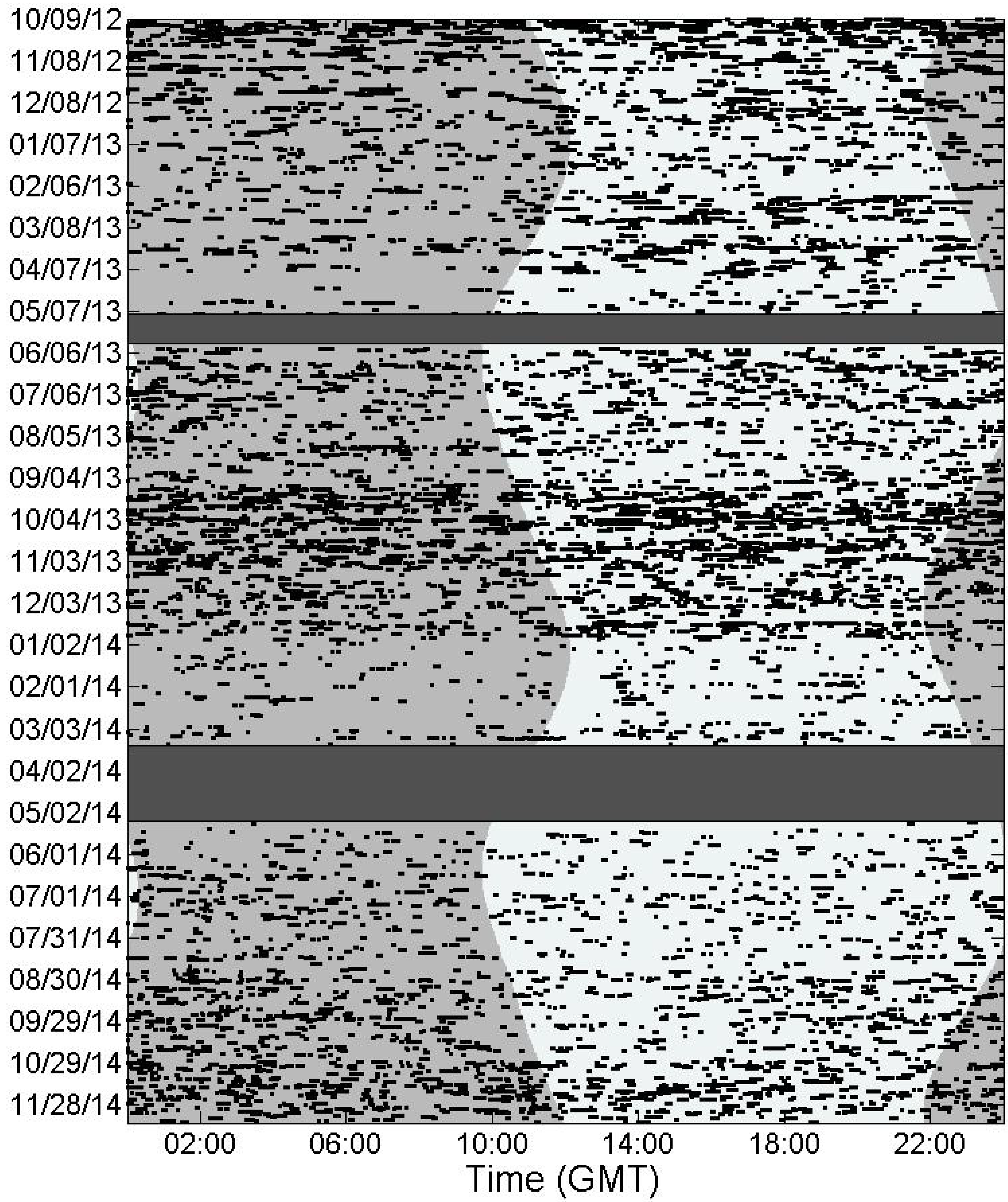

Figure 38. Cuvier's beaked whale click detections (black bars) in one-minute bins within the October 2012–May 2013, May 2013–March 2014, and May–December 2014 Cape Hatteras Site A datasets.

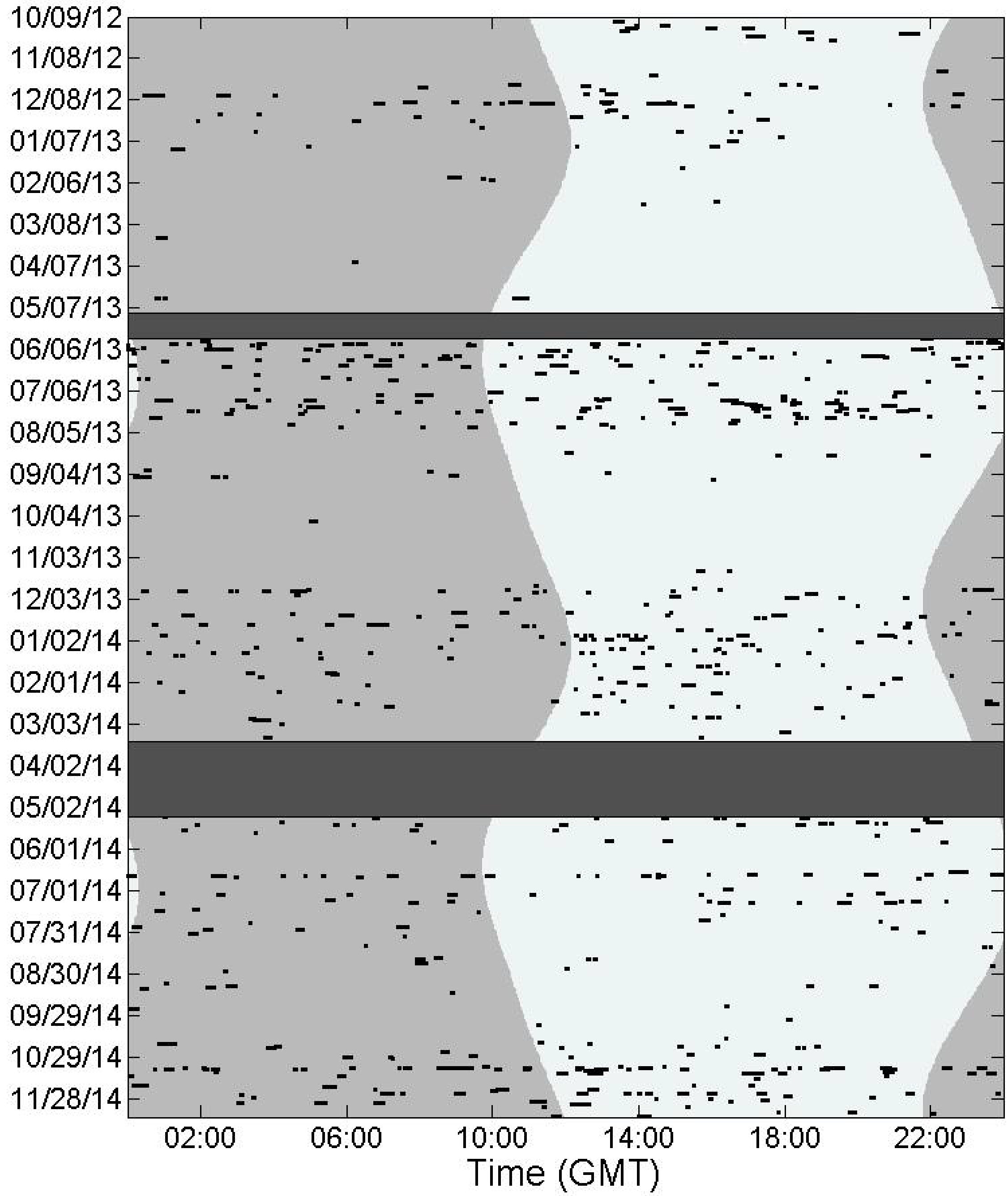

Figure 39. Gervais' beaked whale click detections (black bars) in one-minute bins within the October 2012–May 2013, May 2013–March 2014, and May–December 2014 Cape Hatteras Site A datasets.

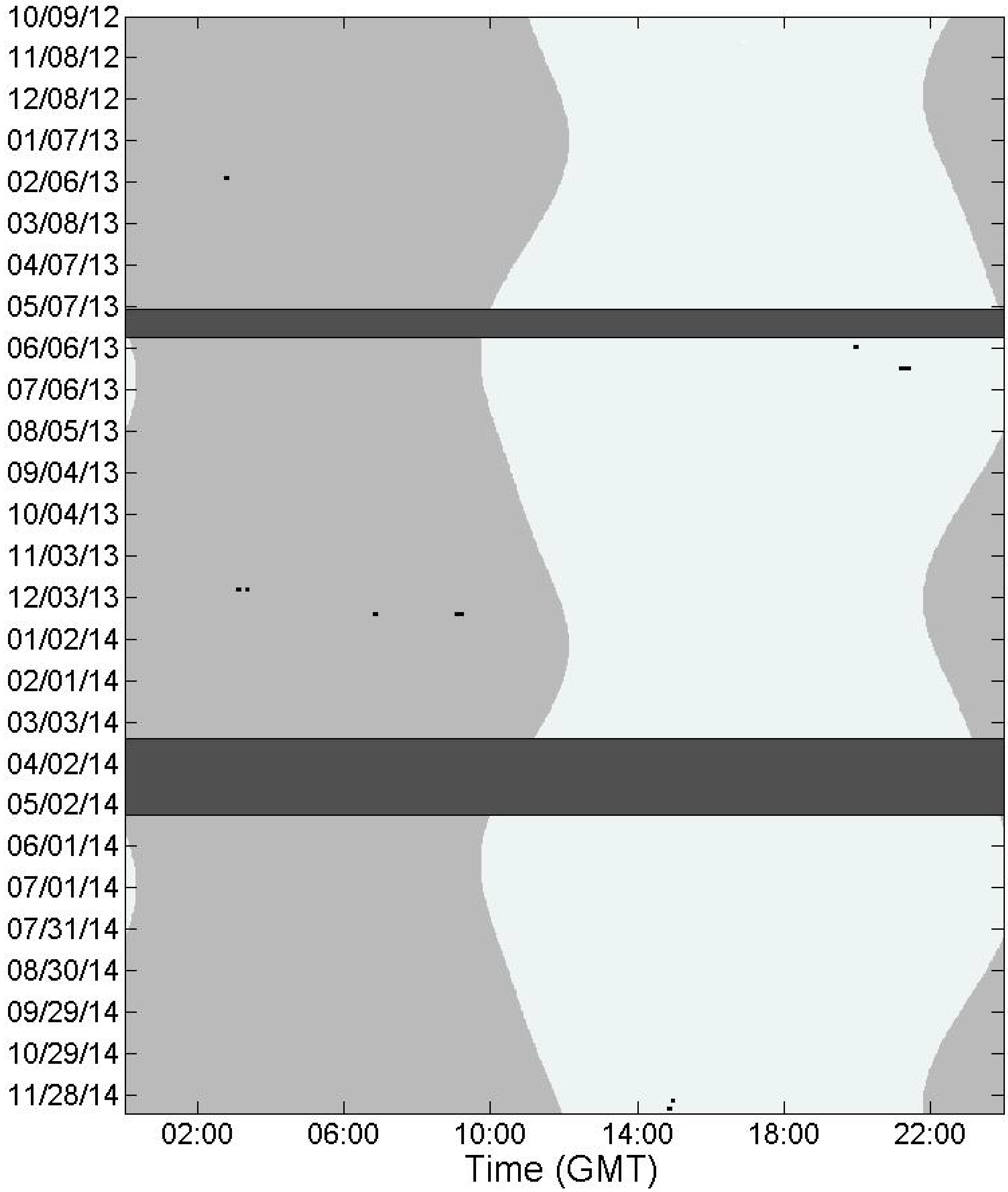

Figure 40. Blainville's beaked whale click detections (black bars) in one-minute bins within the October 2012–May 2013, May 2013–March 2014, and May–December 2014 Cape Hatteras Site A datasets.

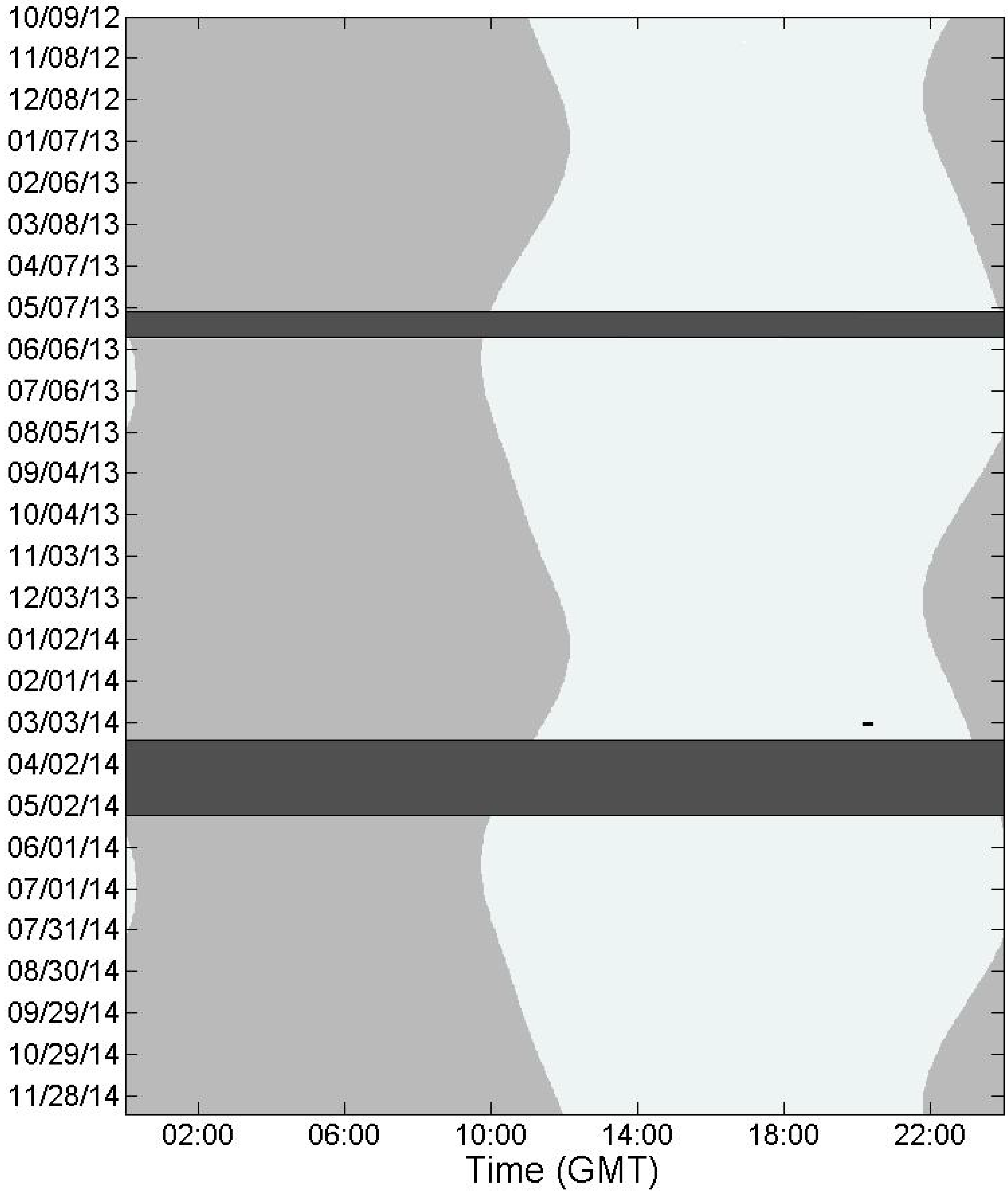

Figure 41. Possible Sowerby's beaked whale click detections (black bars) in one-minute bins within the October 2012–May 2013, May 2013–March 2014, and May–December 2014 Cape Hatteras Site A datasets. There were no detections within the October 2012–May 2013 and May–December 2014 Site A datasets

Mid-frequency active sonar was detected intermittently during the three deployments at Cape Hatteras Site A, with a peak in detections occurring in late October 2012 (**Figure 42**). Airguns were detected throughout all deployments during both day and night, with peaks in detections in June 2013 and between June and October 2014 (**Figure 43**).

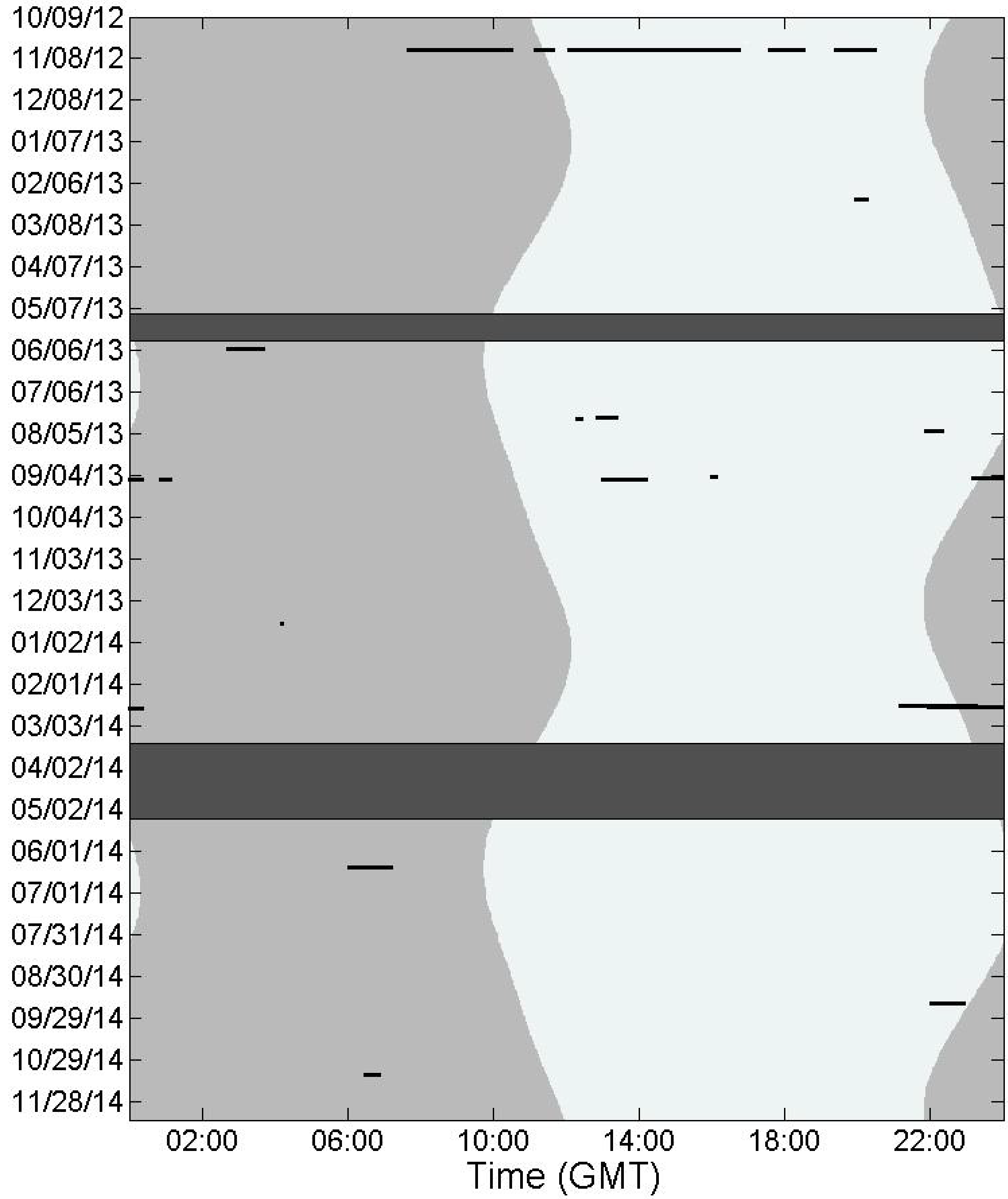

Figure 42. Mid-frequency active sonar (black bars) detected within the October 2012–May 2013, May 2013–March 2014, and May–December 2014 Cape Hatteras Site A datasets.

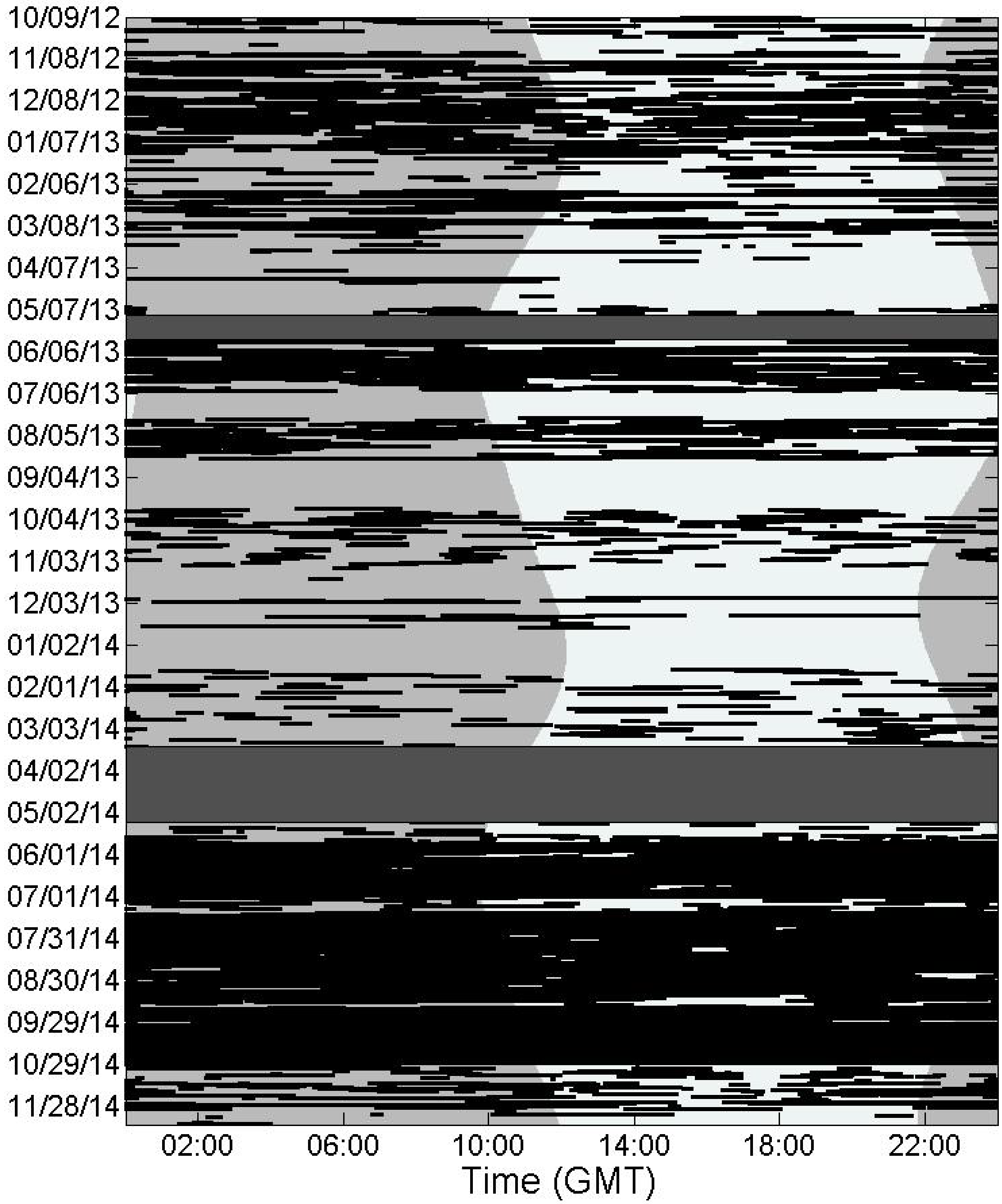

Figure 43. Airgun detections (black bars) within the October 2012–May 2013, May 2013–March 2014, and May–December 2014 Cape Hatteras Site A datasets.

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6. Jacksonville

6.1 Methods

Data Collection

During this reporting period the small mooring HARP deployed in approximately 806 m at 30.15060 N, 79.77005 W off the coast of Jacksonville, FL (JAX Site D) on 23 August 2014 was recovered on 2 July 2015 (**Table 8**; **Figure 44**). The deployment period was 314 days. The HARP was then re-deployed that same day at the same site in approximately 800 m at 30.1489 N, 79.7711 W (**Table 8**; **Figure 44**). This HARP is still out in the field and is scheduled to be recovered in April 2016. Both HARPs were set to sample continuously at 200 kHz. A schematic diagram of the HARP moorings for the August 2014 and July 2015 deployments can be seen in **Figure 45**.

Table 8. Jacksonville, Florida, HARP data sets analyzed and detailed in this report.

Site	Deployment Date	Retrieval Date	Recording Start Date	Recording End Date	Latitude (N)	Longitude (W)	Depth (m)	Sampling Rate	Duty Cycle
9C	12-May-13	17-Feb-14	13-May-13	20-Jun-13	30.3328	80.2007	94	200 kHz	continuous
10C	17-Feb-14	23-Aug-14	17-Feb-14	23-Aug-14	30.3264	80.2049	88	200 kHz	continuous
11D	23-Aug-14	2-Jul-15	23-Aug-14	22-May-15	30.1506	79.7700	~806	200 kHz	continuous
12D	2-Jul-15	N/A	3-Jul-15	N/A	30.1489	79.7711	800	200 kHz	continuous

Data Analysis

Data from the August 2014–July 2015 JAX Site D deployment are currently being analyzed and will be reported on in next year's annual report. Data from the two deployments at JAX Site C (the May 2013–February 2014 deployment that yielded 926.5 hours of recording time over 39 days and the February–August 2014 deployment that yielded 4488.3 hours of recording time over 188 days, **Table 8**) have been analyzed for marine mammal and anthropogenic sounds and will be reported here as a summary of Debich et al. (2015).

For the May 2013–February 2014 dataset, manual detection of delphinid echolocation was difficult due to strong activity of snapping shrimp. Thus, unlike in previous datasets and unlike in the February–August 2014 JAX Site C dataset, to determine time periods with acoustic encounters with dolphins (based on clicks), the Teager Kaiser energy click detector was run with a threshold set high enough to yield no false detections (yet allow for an acceptable number of missed detections). Explosions were also detected automatically, using a matched filter detector described in further detail in Debich et al. (2015). See Debich et al. (2015) for a more detailed description of analysis methods.

Data Quality

The data during the May 2013–February 2014 JAX Site C deployment between May 23, 2013 and June 7, 2013 appeared as if they were duty cycled due to a loose connector on the datalogger

Ether/IDE card, which was discovered after the instrument was recovered. This loose connection caused disk skipping and ‘buffer wrap around’ concurrent with intense periods of strumming and full/new moon phases. Instead of continuous recording during this period, the recording times varied from 20-21 minutes on with 6-14 minutes off. Because disks were skipped and because some disks were only partially written to due to the problems mentioned above, data were only recorded for 39 days.

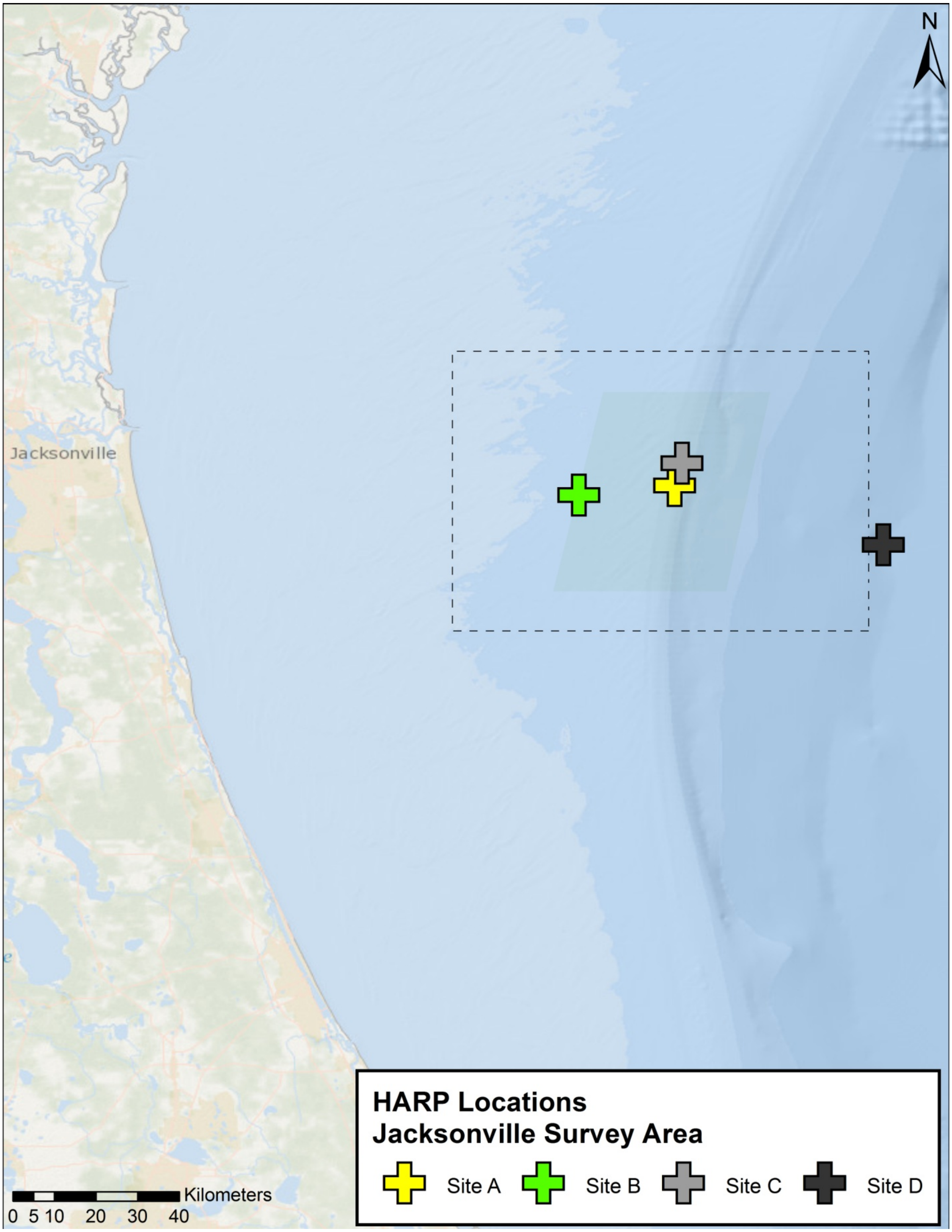

Figure 44. Location of HARP deployment sites in the Jacksonville, Florida, survey area.

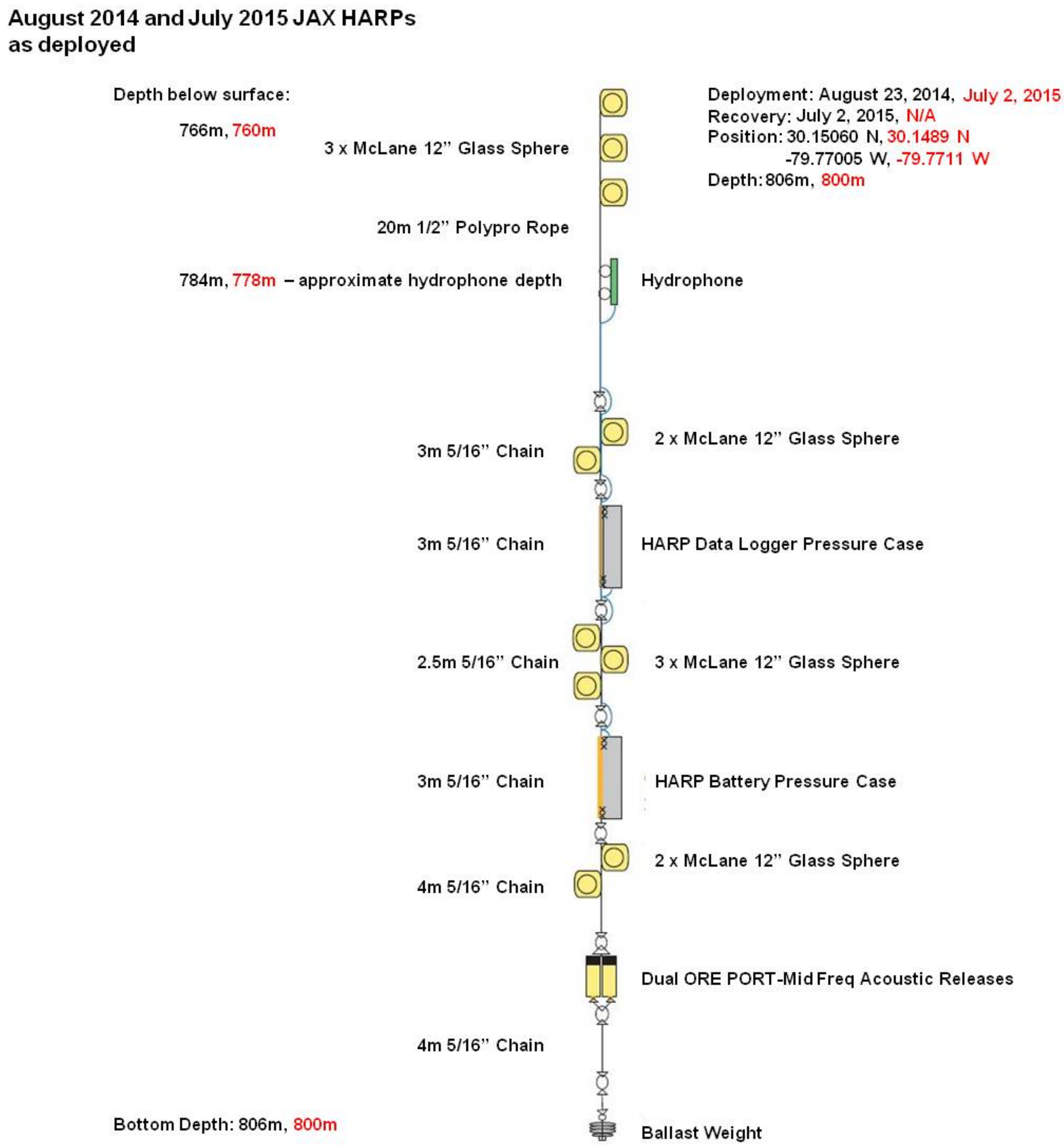

Figure 45. Schematic diagram showing details of the Site D Jacksonville HARP deployments (small mooring) made in August 2014 and July 2015. Note that diagram is not drawn to scale.

6.2 Results

These results are a summary of Debich et al. (2015). Monthly averages of underwater ambient noise during the two JAX Site C datasets described here (the May–June 2013 dataset and the February–August 2014 dataset) are shown in **Figure 46**. **Tables 9 and 10** summarize the detected and identified marine mammal vocalizations during these two datasets**. Figures 47 through 52** show the daily occurrence patterns for the different marine mammal groups (classified to species when possible) at JAX Site C during the two deployment periods. **Figure 53** shows the occurrence of mid-frequency active sonar.

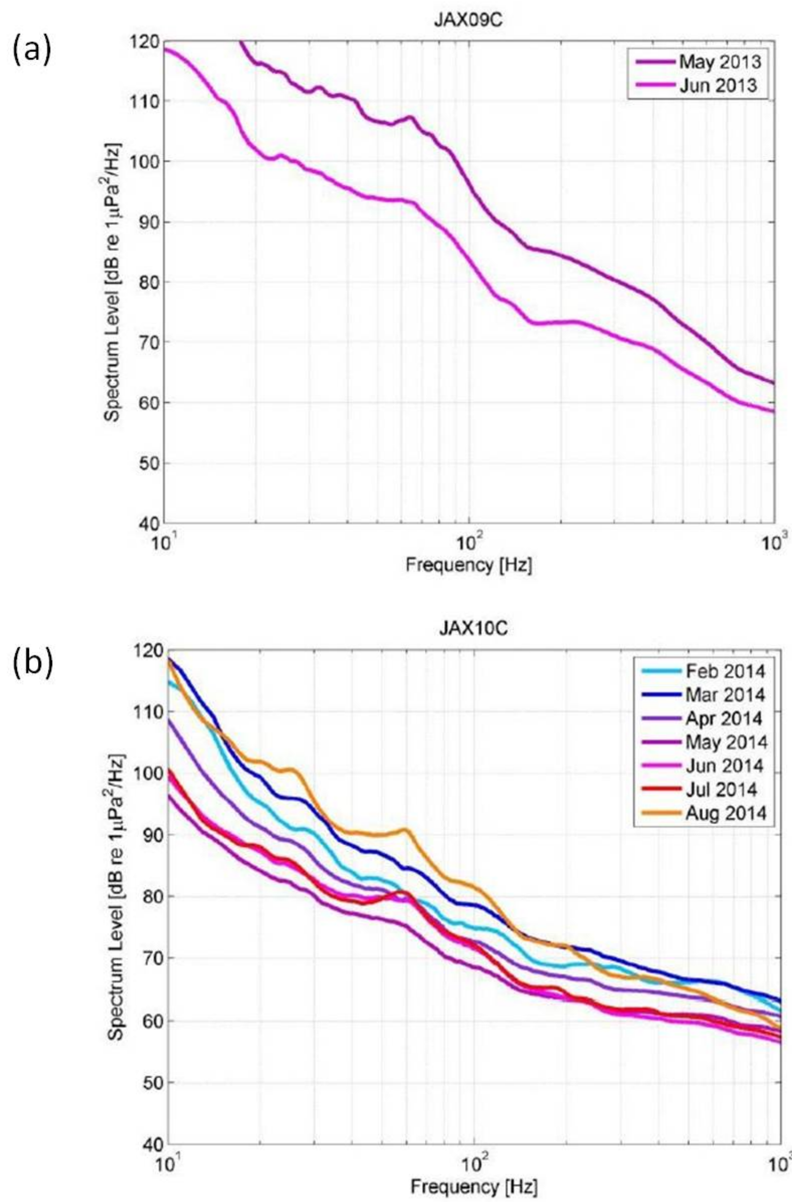

Figure 46. Monthly averages of ambient noise at JAX Site C for (a) May–June 2013 and (b) February–August 2014. Figures from Appendix 6 of Wiggins 2015.

Table 9. Summary of detections of marine mammal vocalizations at JAX Site C for May–June 2013. 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 total recording days
Unidentified odontocete	clicks, whistles, burst-pulses	166.6	21.5	39	100

Table 10. Summary of detections of marine mammal vocalizations at JAX Site C for February–August 2014. *For all mysticetes except humpback whales, total duration of vocalizations (hours) and percent of recording duration are based on data analyzed in hourly bins; for humpback whales and 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 total recording days
Fin whale	20 Hz	8	0.2	2	1.1
Minke whale	pulse train (slow-down, speed-up, regular)	166	3.7	27	14.4
Humpback whale	song or non-song (not separate)	3.8	0.1	46	24.5
Possible mysticete	5-pulse signal	580	12.9	82	43.6
Unidentified odontocete	clicks, whistles	2210.7	49.3	186	98.9
Risso's dolphin	clicks	1	0.02	1	0.5

Mysticietes were only detected in the February–August 2014 JAX Site C dataset, with calls from fin whales, minke whales, and humpback whales. Fin whale 20-Hz pulses were detected in February (**Figure 47**). Minke whale pulse trains were detected in February and March (**Figure 48**). Humpback whales were detected in February through June, with a peak in detections in late March and slightly more calling during daytime hours (**Figure 49**). In addition to the above low-frequency detections, a 5-pulse signal was also detected, with a peak in detections in July (**Figure 50**). Most 5-pulse signal detections occurred slightly before sunset and during nighttime hours (**Figure 51**). As stated in previous reports, this call is presumed to be produced by a mysticete due to its character, prevalence, and intensity.

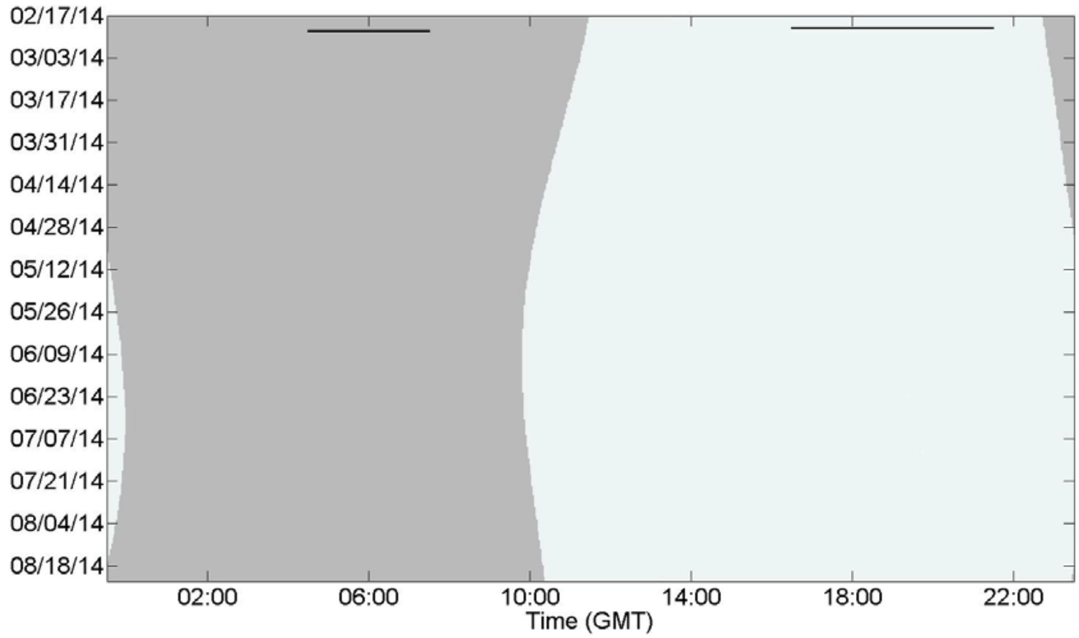

Figure 47. Fin whale 20-Hz pulse detections (black bars) in hourly bins within the February–August 2014 JAX Site C dataset. Vertical gray shading here and in all subsequent figures of the same type indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil). No fin whale 20-Hz pulses were detected in the May–June 2013 JAX Site C dataset.

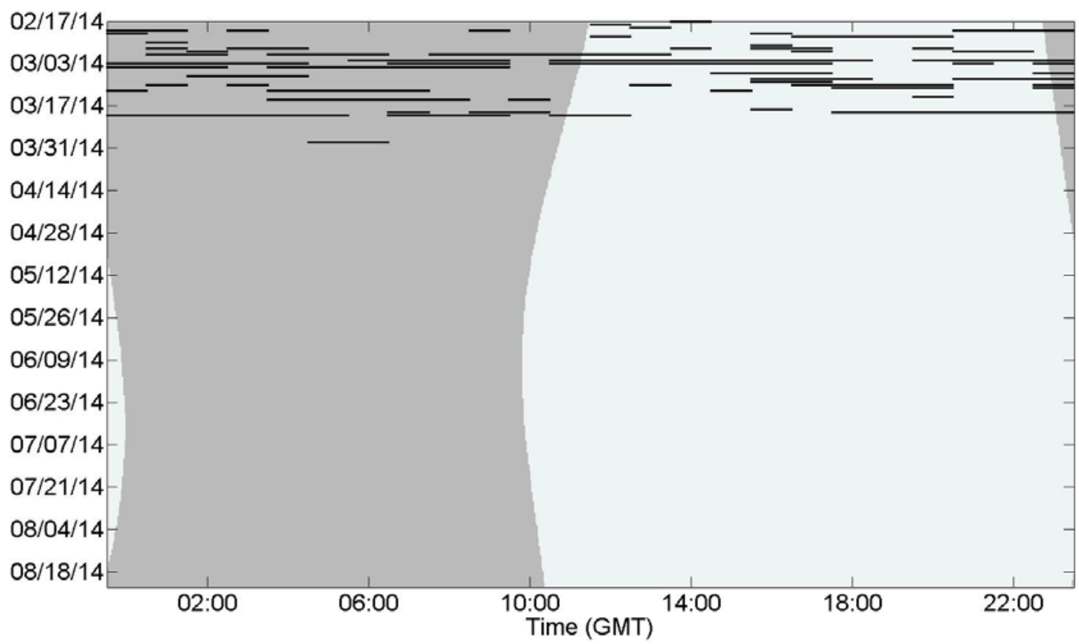

Figure 48. Minke whale pulse train detections (black bars) in hourly bins within the February–August 2014 JAX Site C dataset. No minke whale pulse trains were detected in the May–June 2013 JAX Site C dataset.

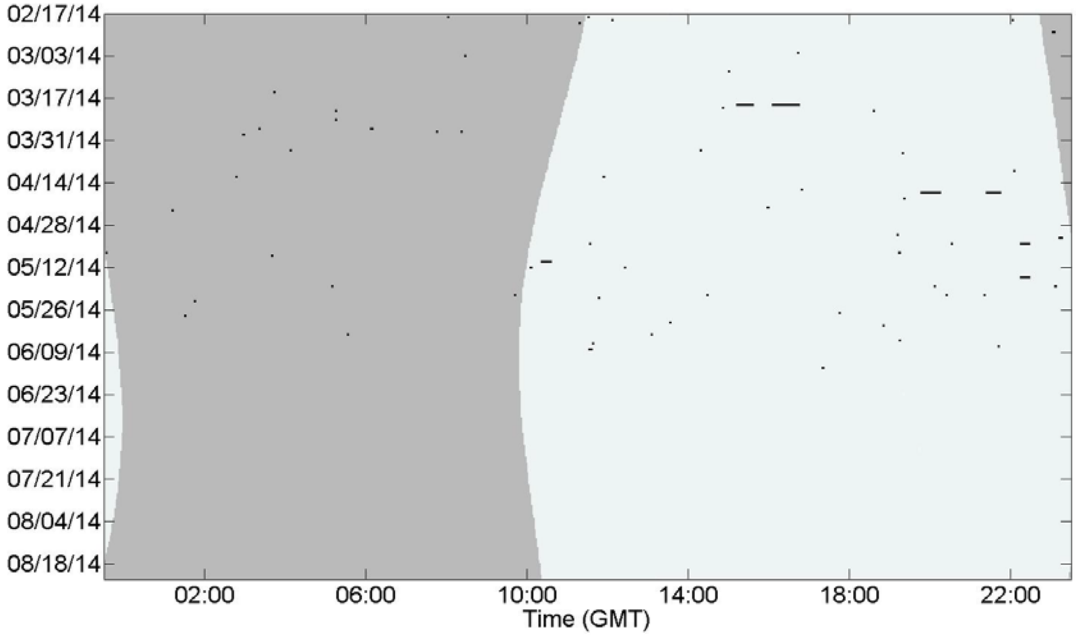

Figure 49. Humpback whale call detections (black bars) in one-minute bins within the February–August 2014 JAX Site C dataset. No humpback whale calls were detected in the May–June 2013 JAX Site C dataset.

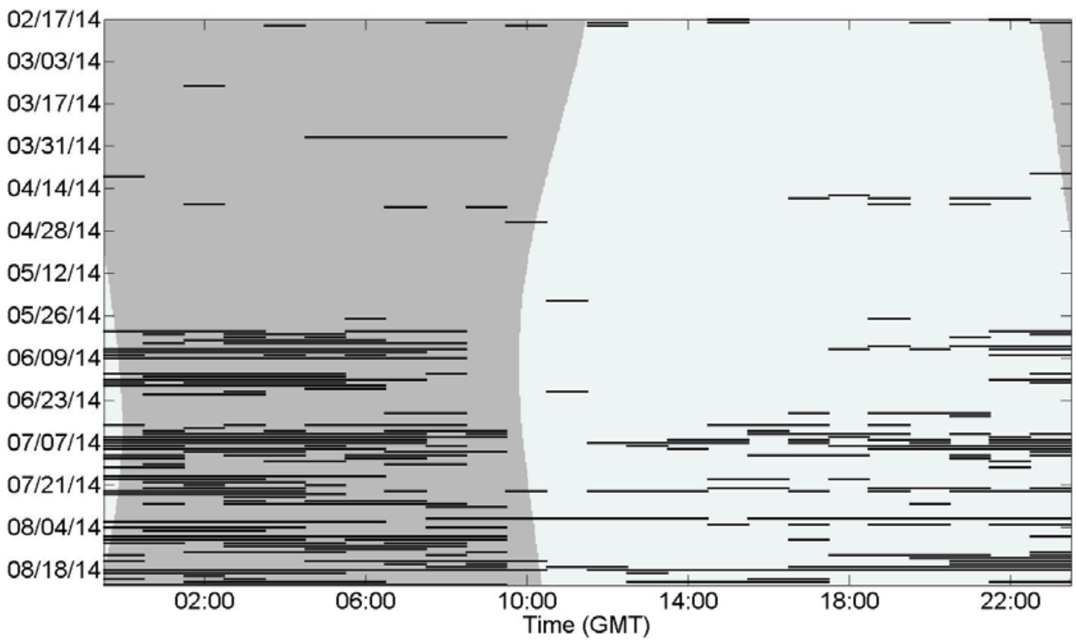

Figure 50. 5-pulse signal detections (black bars) in hourly bins within the February–August 2014 JAX Site C dataset. There were no detections of the 5-pulse signal in the May–June 2013 JAX Site C dataset.

Detected odontocete vocalizations included clicks and whistles (**Figures 51 through 52**). Most of these detections were assigned to the unidentified odontocete category (**Figure 51**), with clicks being divided into seven main groups based on spectral patterns in the May–June 2013 dataset and into eight main groups based on spectral patterns in the February–August 2014 dataset (see Debich et al. 2015 for more details). Risso's dolphins were only detected in the February–August 2014 dataset, with only one detection assigned to this species at the beginning of July 2014 (**Figure 52**).

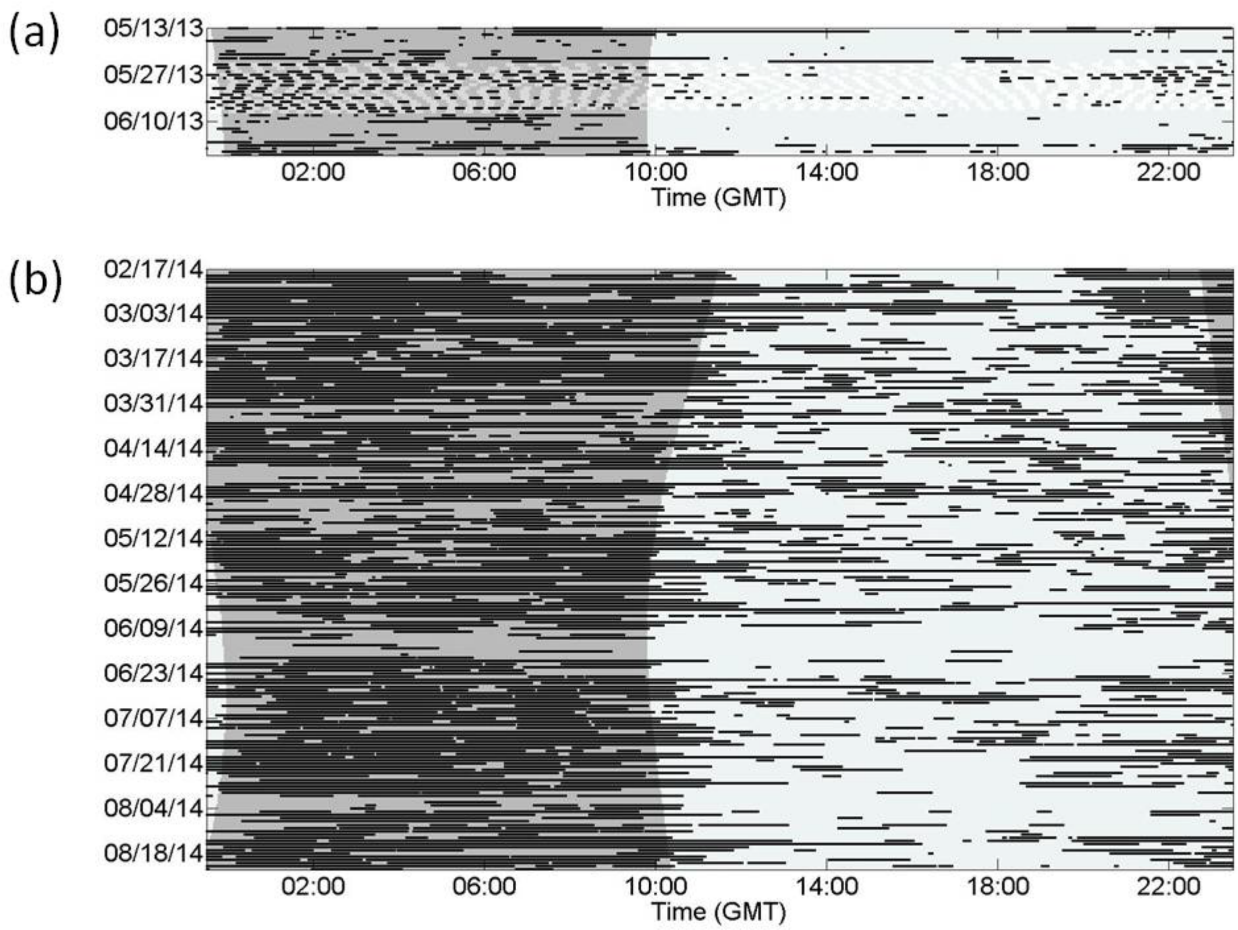

Figure 51. Unidentified odontocete click and whistle detections (black bars) within the (a) May–June 2013 and (b) February–August 2014 JAX Site C datasets. For this figure and Figure 53, vertical gray shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil), and lighter shading in (a) indicates times when disk skipping occurred in recording as described in the Data Quality section.

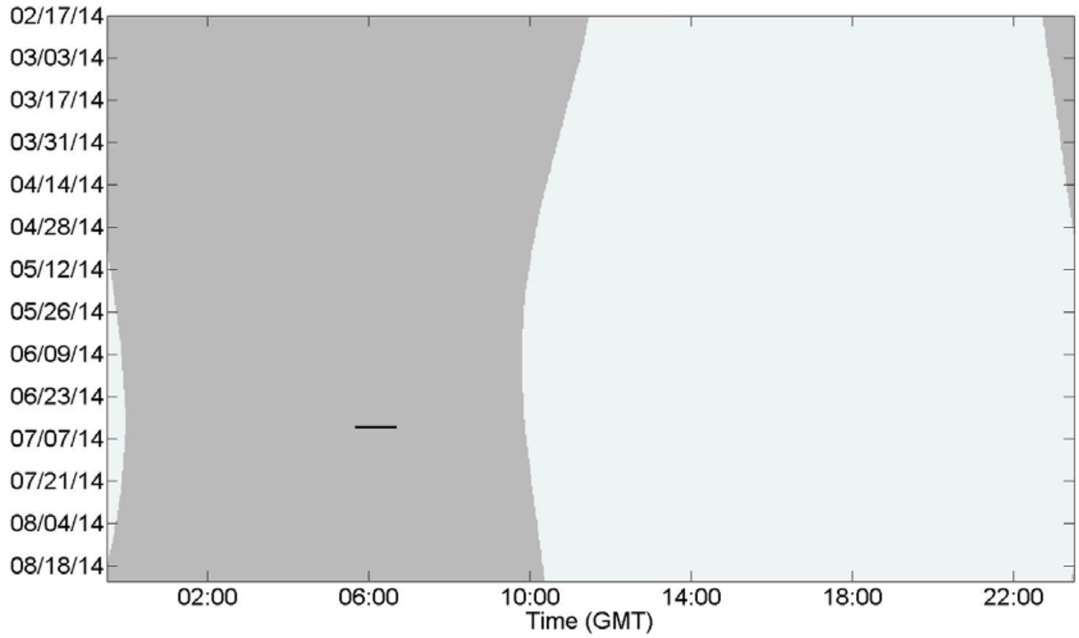

Figure 52. Risso's dolphin click detections (black bars) in one-minute bins within the February–August 2014 JAX Site C dataset. There were Risso's dolphin click detections within the May–June 2013 JAX Site C dataset.

Mid-frequency active sonar was detected intermittently during both deployments at Jacksonville Site C, with a peak in detections occurring in June 2013 (**Figure 53**).

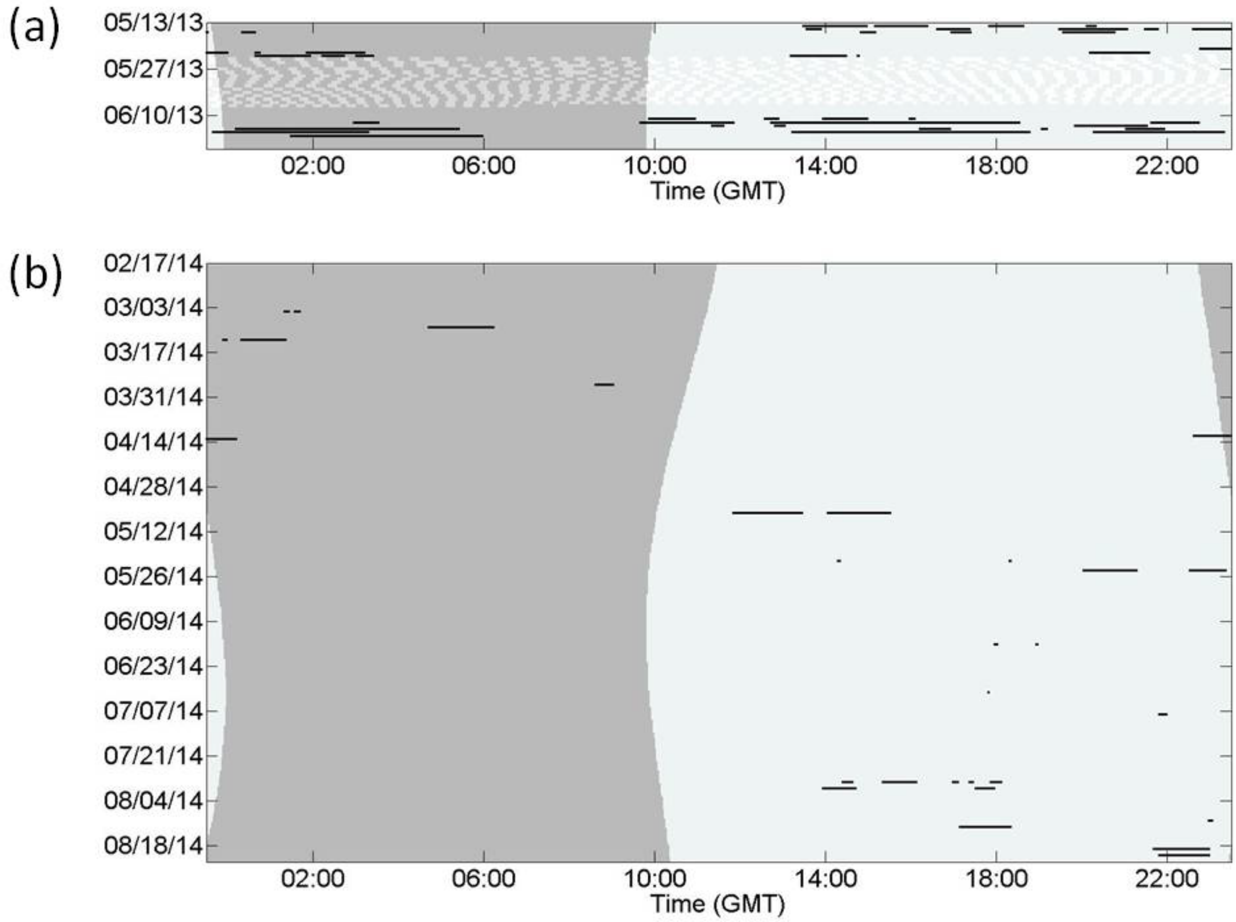

Figure 53. Mid-frequency active sonar (black bars) detected within the (a) May–June 2013 and (b) February–August 2014 JAX Site C datasets.

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7. Current and Anticipated Analyses for 2016

7.1 Norfolk Canyon

Scripps Institution of Oceanography is currently analyzing the June 2014–April 2015 dataset from Norfolk Canyon Site A for whistles. All other analyses for this dataset have been finished. Detailed and technical reports will be provided once the whistle analysis of this dataset is complete.

7.2 Cape Hatteras

Scripps Institution of Oceanography is currently analyzing the October 2012–May 2013 dataset, the May 2013–March 2014 dataset, and the May–December 2014 dataset from Cape Hatteras Site A for whistles. All other analyses for these three datasets have been finished. Detailed and technical reports will be provided once all analyses of these datasets are complete. Once the HARP currently deployed in Cape Hatteras at Site A (deployed 6 April 2015) is recovered, that dataset will be fully analyzed by Scripps Institution of Oceanography over the next year. A detailed and technical report will be provided once the analysis of the dataset is complete.

7.3 Jacksonville

Scripps Institution of Oceanography is currently analyzing the August 2014–May 2015 dataset from Jacksonville Site D. Once the HARP deployed in Jacksonville at Site D (deployed 2 July 2015) is recovered, that dataset will be fully analyzed by Scripps Institution of Oceanography over the next year. Detailed and technical reports of these two datasets will be provided once the analysis is complete.

8. Acknowledgements

We would like to thank US Fleet Forces Command and Joel Bell (Naval Facilities Engineering Command Atlantic) for providing support for this work. We thank Tim Boynton, Zach Swaim, Ryan Griswold, John Hurwitz, and Stormy Harrington and crew of the Tiki XIV for help with HARP preparation, deployments, and retrievals. We thank Sean Wiggins and Bruce Thayre for help in removing glitches in the Hatteras datasets. We thank Simone Baumann-Pickering for help with the beaked whale code. Jennifer Dunn provided administrative support, and Heather Foley created the maps in this report.

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