# Passive Acoustic Monitoring for Cetaceans Across the Continental Shelf off Virginia:

# 2016 Annual Progress Report

*Submitted to:*

Naval Facilities Engineering Command Atlantic under Contract No. N62470-15-D-8006, Task Order 032.


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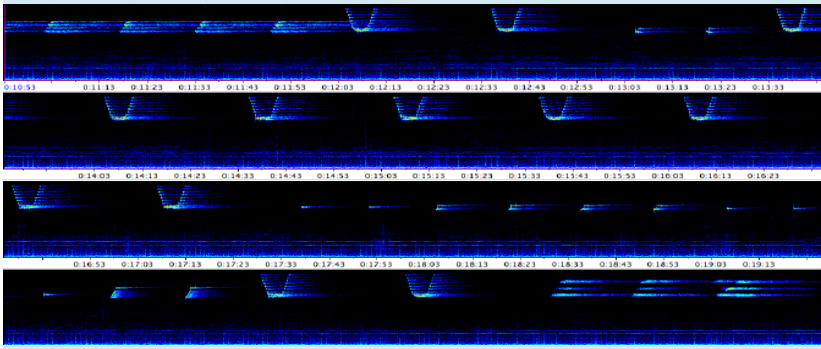

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**June 2017**

**Suggested Citation:**

Klinck, H., Rice, A. N., Estabrook, B. J., Klinck, K., Salisbury, D. P., and Charif, R. A. 2017. *Passive Acoustic Monitoring for Cetaceans Across the Virginia Continental Shelf: 2016 Annual Progress Report.* Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command (NAVFAC) Atlantic, Norfolk, Virginia, under Contract No. N62470-15-D-8006, Task Order 032. June 2017.

**Cover Graphic Credit**:

Spectrogram of naval sonar signals recorded off the coast of Virginia. Spectrogram created by Russ Charif using the Raven Sound Analysis software (Cornell University, Ithaca, NY, USA).

**This project is co-funded by the Bureau of Ocean Energy Management and the U.S. Fleet Forces Command. Odontocete and sonar analysis is managed by the Naval Facilities Engineering Command Atlantic and HDR, Inc. as part of the U.S. Navy's marine species monitoring program.**

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## Acronyms and Abbreviations

| | |
|---|---|
| AMAR | Autonomous Multichannel Acoustic Recorder |
| BOEM | Bureau of Ocean Energy Management |
| MARU | Marine Acoustic Recording Unit |
| NAVFAC | Naval Facilities Engineering Command |
| PAM | Passive Acoustic Monitoring |
| U.S. | United States |

# 1. Background

Similar to many mid-Atlantic states, little is known about the seasonal and spatial occurrence of marine mammals off the coast of Virginia, especially in offshore areas. This data gap presents a challenge for effective marine spatial planning in the context of naval operations and offshore wind energy developments in the Virginia Wind Energy Area (WEA). As with other forms of human activity in the ocean, naval operations and wind energy developments have the potential to negatively affect marine mammals through increased ship traffic, construction, and operational noise. Consequently, collecting baseline data on spatial and temporal trends of cetacean occurrence in these areas is critical to minimize or mitigate risks to protected species.

Ten bottom mounted passive acoustic recorders are deployed off the coast of Virginia and will be maintained for two years. A combination of high-frequency Autonomous Multichannel Acoustic Recorders (AMAR), and low-frequency Marine Autonomous Recording Units (MARU) was deployed in two spatial configurations (**Figure 1**) with the AMARs in a linear array extending east from the mouth of the Chesapeake Bay across the continental shelf, and MARUs deployed as a synchronized localization array within the WEA.

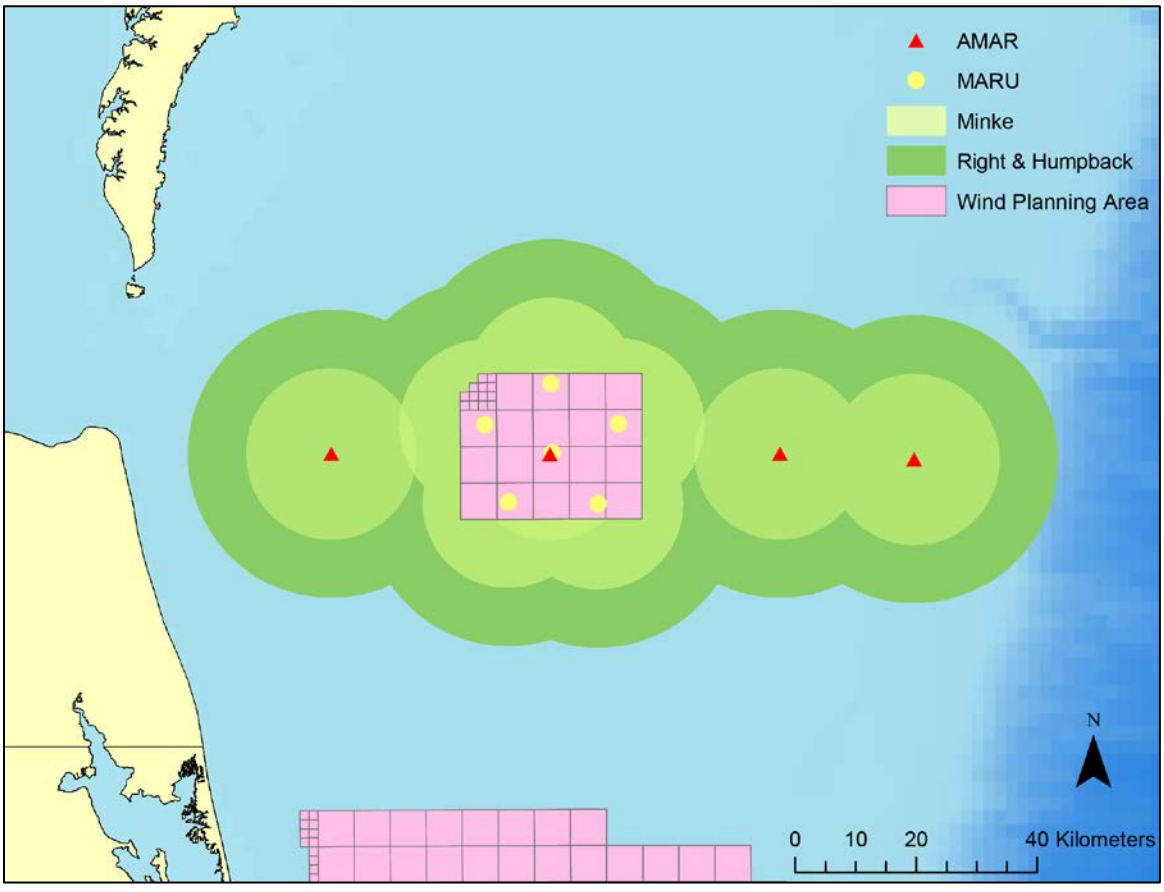


**Figure 1. Map of low-frequency (MARU, yellow circles) and high-frequency (AMAR, red triangles) recorders. The wind planning area is indicated by the pink area. The green areas indicate estimated detection ranges for minke, right, and humpback whales.**

The initial deployment was conducted in July 2015. Deployment details are summarized in Tables 1 and 2 below.

**Table 1. AMAR deployment details. All units recorded continuously but at alternating sampling rates (685 seconds at 8 kHz sampling rate and for 86 seconds at 375 kHz).**

| Deployment | # of units | Record start | Record stop | Remarks |
|---|---|---|---|---|
| 1 | 4 | 03 Jul. 2015 | 23 Jan. 2016 | |
| 2 | 3 | 08 Mar. 2016 | 28 Sep. 2016 | #4 still in the water |
| 3a | 1 | 21 Oct. 2016 | TBD | Not recovered yet |
| 3b | 3 | 28 Nov. 2016 | TBD | Weather related deployment delay; not recovered yet |

**Table 2. MARU deployment details. All units recorded continuously at 2 kHz sampling rate.**

| Deployment | # of units | Record start | Record stop | Remarks |
|---|---|---|---|---|
| 1 | 6 | 01 Jul. 2015 | 07 Dec. 2015 | |
| 2 | 6 | 07 Dec.2015 | 25 May 2016 | |
| 3 | 6 | 24 May 2016 | 19 Nov. 2016 | |
| 4 | 6 | 14 Nov. 2016 | 30 Apr.2017 | |
| 5 | 4 | 03 May 2017 | TBD | Not recovered yet |

This data is currently being analyzed using a combination of human analysts and automated approaches to describe the occurrence of

- four species of mysticetes: fin whales (*Balaenoptera physalus*), humpback whales (*Megaptera novaeangliae*), minke whales (*Balaenoptera acutorostrata*), and North Atlantic right whales (*Eubalaena glacialis*),
- odontocetes, and
- Navy sonar signals.

The large geographic and temporal scale of the study enables a comparison of seasonal trends in cetacean presence across the continental shelf off the coast of Virginia, as well as inter-annual variability for this region. These results will help inform the Navy and BOEM of species occurrence, highly active seasonal periods, and high-use regions or corridors to assist with environmental regulatory compliance and spatial planning.

# 2. Progress to Date

## 2.1 Mysticete species

Preliminary results from analysis of the initial deployments #1 and #2 (**Table 2**, **Figure 2**) revealed that North Atlantic right whales were most common in the area from January through March (>90% days in the month of February). Fin whales maintained a presence of greater than 50% of days per month in October, November, January and February. Humpback whales had low levels of presence in the fall, with some moderate (>30% of days) occurrence in January and April. Minke whales were detected on <10% of days in November.

Preliminary analysis of whale locations shows that whales are calling across the continental shelf, with no immediate signs of habitat preference or association (**Figure 3**).

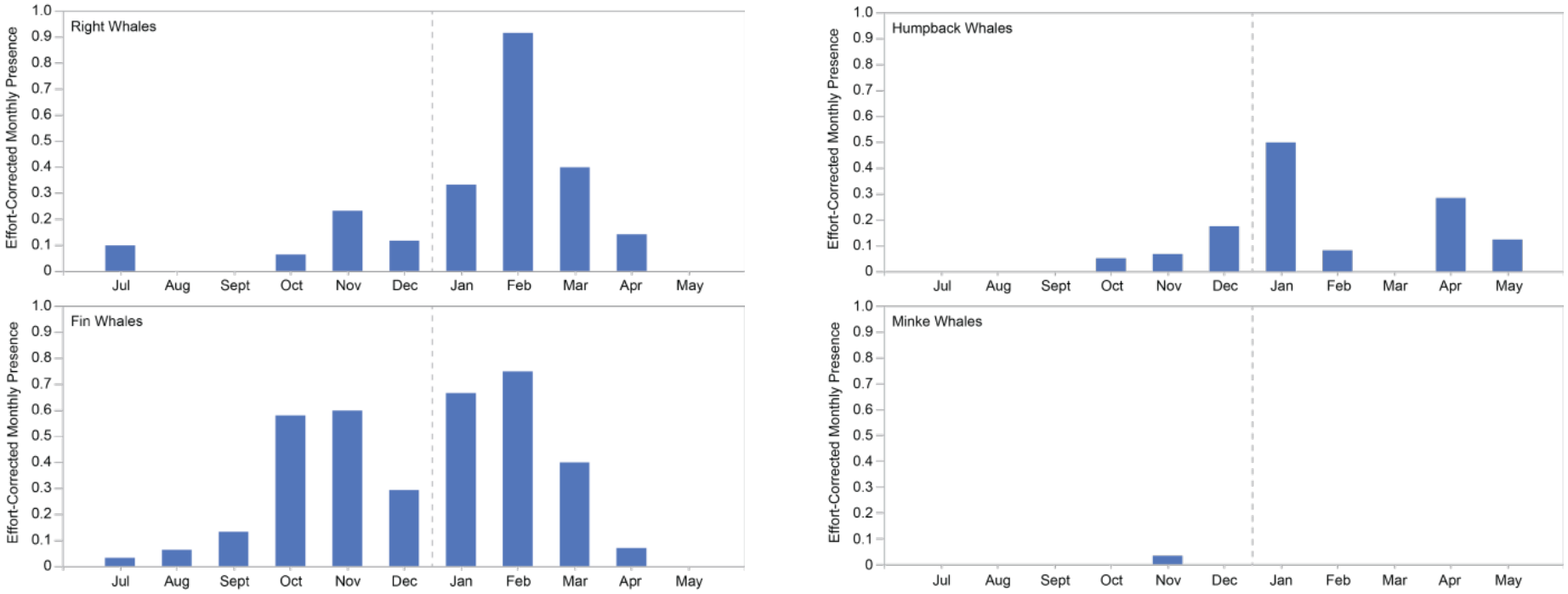


**Figure 2. Occurrence of right whales (upper left), fin whales (lower left), humpback whales (upper right), and minke whales (lower right) in the wind planning area for the period July 2015 to May 2016.**

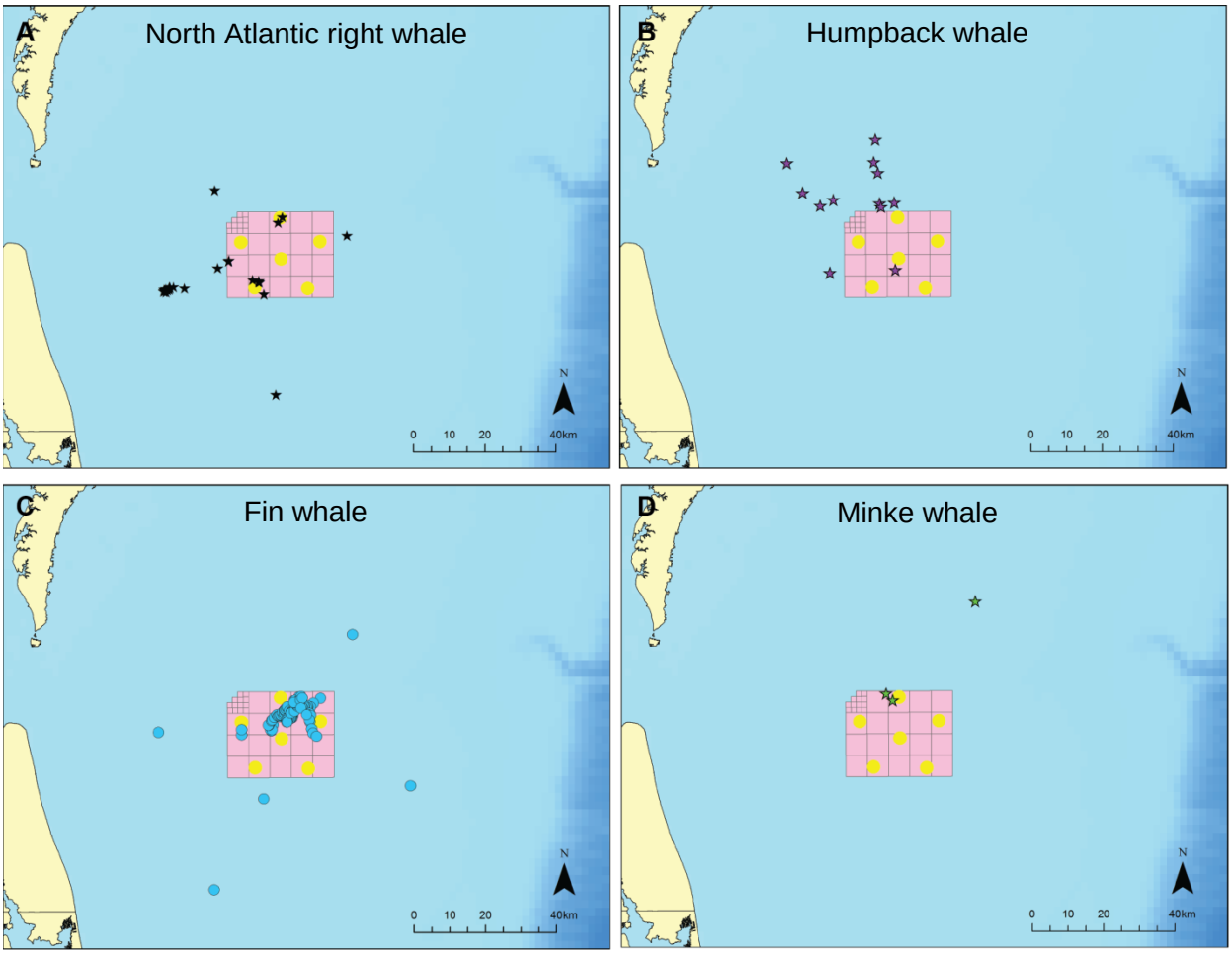


**Figure 3. Preliminary locations of baleen whales determined from acoustic detections relative to the Virginia wind planning area (in pink) from July 2015 through May 2016. Yellow dots indicate MARU locations. Data shown were recorded between July 2015 and May 2016.**

## 2.2 Odontocete species

The high-frequency AMAR data is being collected at a sample rate of 375 kHz and a duty cycle of 86 s every 685 s (totaling in 402 s of data each hour). Data is being analyzed as follows:

- High-Frequency (HF, >100 kHz) odontocetes. An automated click detector is being used to detect click trains of harbor porpoise and *Kogia* species in the data set. Every detection is visually reviewed by an analyst to confirm the detection and, if possible, to classify the signals to a species level.

- Mid-Frequency (MF, 1-100 kHz) odontocetes. Long-term spectral average (LTSA) plots with a temporal resolution ($\Delta$t) of 5 seconds and a frequency resolution ($\Delta$f) of 200 Hz are calculated using the Triton Software Package (Scripps Whale Acoustics Lab, La Jolla, CA, USA). Data are visually and aurally inspected by experienced analysts for odontocete sounds. After initial screening data containing odontocete whistles and clicks are analyzed using the Real-time Odontocete Call Classification Algorithm (ROCCA)

software to potentially classify signals to species level. An example of an odontocete encounter is shown in **Figure 4** below.

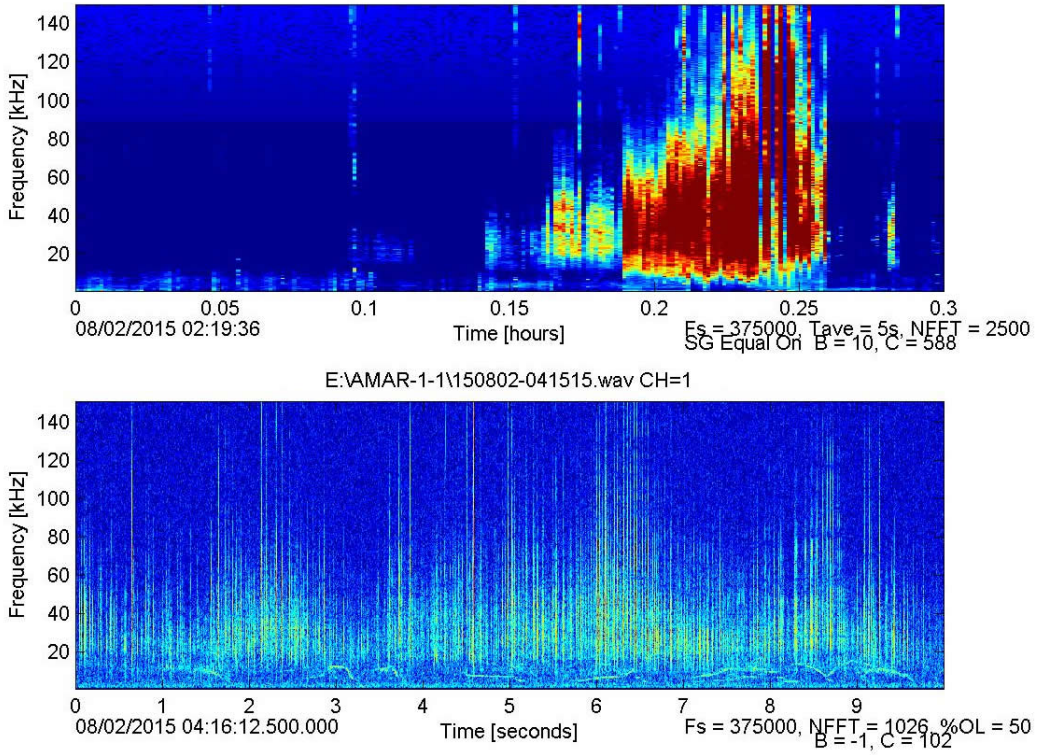


**Figure 4. Long-term spectral average (LTSA) plot (top) indicating an odontocete encounter recorded with the inshore high-frequency recorder in August 2015. The spectrogram (bottom) shows the corresponding whistles (tonal sounds in the 10-20 kHz range) and echolocation clicks (broadband transient signals).**

Preliminary results indicate a high number of odontocete encounters in the data sets. For the first 6 months of data (July 2015 to January 2016), there was a clear inshore-offshore pattern in total number of encounters. During this period a total of approximately 600 encounters were detected in the inshore data set recorded with AMAR1. For the same period, the AMAR2 data set contained approximately 330 encounters and the AMAR3 data set detected roughly 260 encounters. The data set collected with AMAR4is currently being analyzed.

The median encounter duration recorded at AMAR1 was around 27 minutes. The median encounter durations at AMAR2 and AMAR3 were shorter around 14 and 13 minutes, respectively.

Ongoing analysis efforts focus on deriving seasonality patterns as well as inshore-offshore differences in species composition.

## 2.3 Sonar analysis

A wide variety of sonar signals was recorded by the AMARs during the deployment. An example is shown in **Figure 5** below.

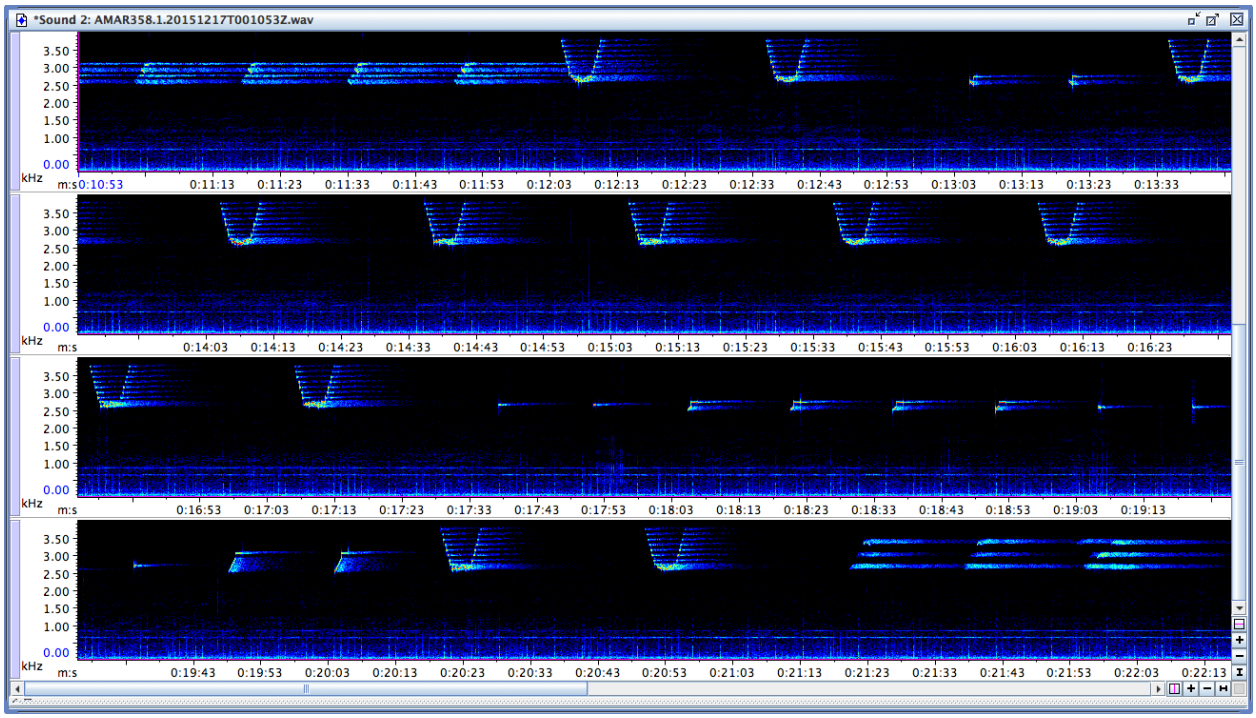


**Figure 5. Example of Navy sonar signals recorded off the Virginia coast in December 2015.**

A band-limited energy detector in the Raven Sound Analysis software (Cornell University, Ithaca, NY, USA) was trained to detect these signals of interest. The performance of the detector (precision-recall) is currently being analyzed using the initial 6 months of high-frequency data and will be compared to the performance of the SonarFinder software (Biowaves Inc., Encinitas, CA, USA).

# 3. Future Work

Within the next few months we will complete the acoustic data collection and continue the data analysis. The final instrument recovery will occur in September 2017. The ongoing data analysis focuses on three major tasks:

- Determine the temporal occurrence and spatial distributions of vocalizing marine mammals (odontocetes and baleen whales) and potentially fish species, identified using a combination of automated call detection/classification software and expert human validation.

- Estimate specific spatial locations and movements of baleen whales and specifically right whales within and near the Virginia WEA, using an acoustic localization array. For each right whale contact call recorded by three or more hydrophones, the location of the

calling right whale will be estimated using software that computes the most likely location for the whale based on arrival time differences.

- Assess ambient sound levels throughout the Virginia WEA and across the continental shelf by analyzing historic and current acoustic data sets.
- Synthesize all data products to determine the potential impacts of noise generated by the construction and operation of a wind energy facility on the ecosystem.

The draft technical report is due to BOEM (and NAVFAC) on 9 April 2018. The final report will be submitted to the sponsors no later than 9 August 2018. This report will cover details on the data collection, the baleen and odontocete acoustic data analysis, and derived results.

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