Stereotyped, repetitive gunshot call patterns produced by the North Pacific right whale, *Eubalaena japonica*

Jessica L. Crance and Catherine L. Berchok

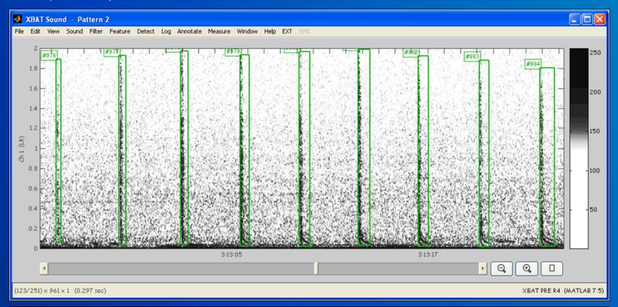
National Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA Fisheries, 7600 Sand Point Way N.E., Seattle, WA 98115-6349

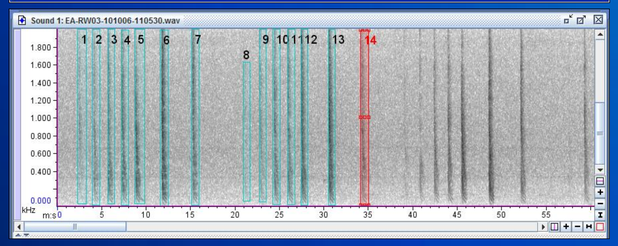
Abstract

Because of their distinct vocalizations, right whales are easily identified and distinguished from other vocalizing marine mammals, making them an ideal species for passive acoustic monitoring. As a result, numerous studies on right whale vocalizations have been conducted. In order to acoustically monitor the critically endangered North Pacific right whale (NPRW), the National Marine Mammal Laboratory has placed long-term passive acoustic recorders throughout the southeastern Bering Sea since 2007. Autonomous Underwater Recorders for Acoustic Listening (AURAL, Multi-Électronique, Quebec), located on the Pacific Marine Environmental Laboratory's oceanographic moorings along the 70m isobath in the Bering Sea, record at a sampling rate of 8 kHz either near-continuously or on a 45% duty cycle. Ecological Acoustic Recorders (EAR, Marc Lammers, Oceanwide Science Institute) have been deployed in various locations throughout the SEBS, sampling at 4 kHz on a (6.7-11%) duty cycle. In addition, during the summer field surveys, DiFAR (Directional Frequency Analysis and Recording) sonobuoys were deployed to monitor for the presence of large whales in real-time. During the 2010 Chukchi Acoustics, Oceanography, and Zooplankton (CHAOZ) study, a stereotyped, repetitive gunshot (GS) call pattern was acoustically detected on sonobuoys. The long-term moored passive acoustic recorders detected this same call pattern on two different recorders in two separate years. Further analysis revealed several different stereotyped, repetitive GS call patterns. To date, six different patterns have been documented, three of which have been analyzed. Preliminary results show that each pattern has a minimum of 30 iterations repeated over several hours, and in several cases is repeated throughout the season. Furthermore, several of these patterns have been detected not only throughout a season, but also in consecutive years, and in one instance, in non-consecutive years. While male North Atlantic right whales have been observed producing long GS bouts similar to the reproductive advertisement known in other species (Parks *et al.* 2012), right whales were not known to produce any type of repeated stereotyped pattern. This represents the first study to document stereotyped repetitive GS patterning in right whales; whether this can be classified as song remains to be determined. [Work supported by Bureau of Ocean Energy Management]

Analysis

- Xbat or Raven analysis software
- Individual calls within each pattern boxed
- Variables measured:
  - Min/max frequency
  - Start/end time, duration
  - Inter-pulse interval
    - Start of one GS to start of next
  - Inter-call interval (when possible)





Results

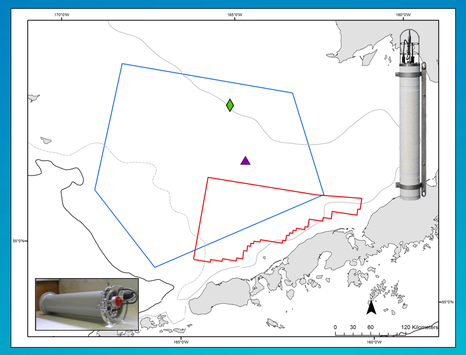
Pattern 1
- 15-22 GS, IPI: 1.043s ± 0.1054s
- 250-120Hz DS, duration: 0.879s ± 0.180s
- Duration btw GS and downsweep: 2.29s ± 0.54s.

Pattern 2
- 8-12 low freq. pulses, IPI: 2.51s ± 0.24s
- 15-20 amp. modulated GS, IPI: 3.81s ± 0.4s
- Duration btw pulses and GS: 12.53s ± 0.423s

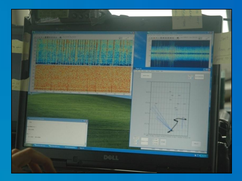
Pattern 3
- 5-8 amp. modulated GS
- IPI: 1.58s ± 0.09s; last 3 GS: 3.29s ± 0.26s
- ICI: 5.362s ± 0.38s

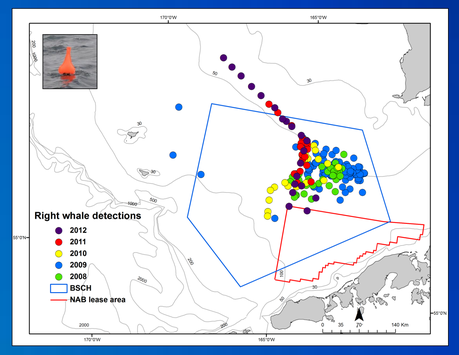
Data collection

- AURALs
  - 2007-2012
  - PMEL's M2 mooring
  - Samp. rate: 8kHz
  - Duty cycle: near continuous
- EARs
  - 2008-2012
  - Samp. rate: 4kHz
  - Duty cycle: 6.7-11%

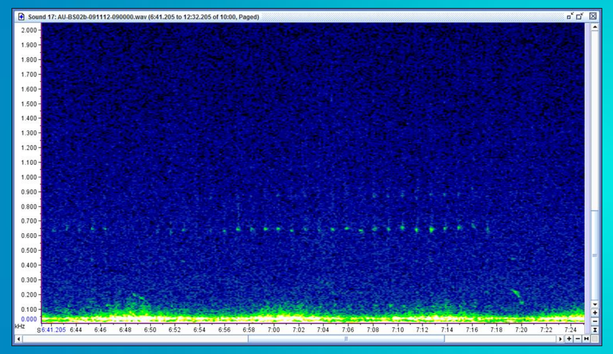


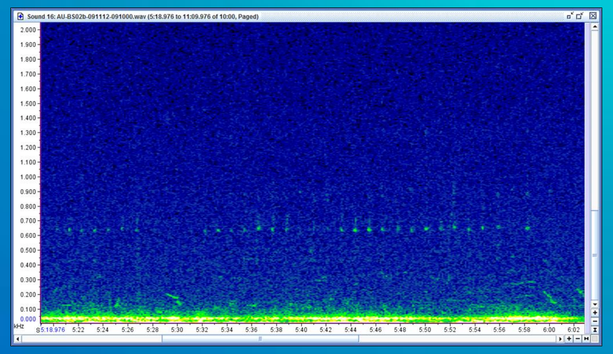
Sonobuoys
- 24-hr acoustic monitoring
- DiFAR directional sonobuoys
- 3 WINRADIO receivers for multi-channel recording
- MOTU UltraLite mk3 audio interface
- Custom-designed monitoring and tracking program in Matlab
- DiFAR demultiplexing software (Greeneridge Sciences, Inc.)
- GPS feed provided date, time, and position of ship and sonobuoy

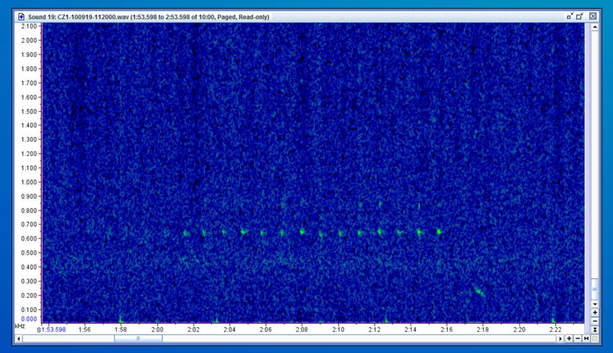




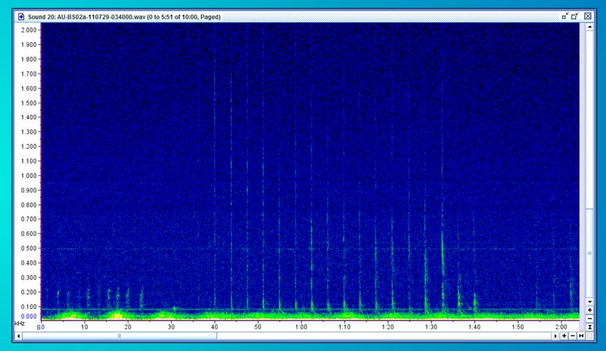
Pattern 1

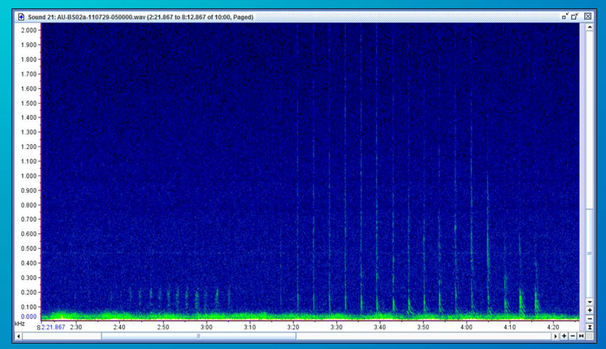


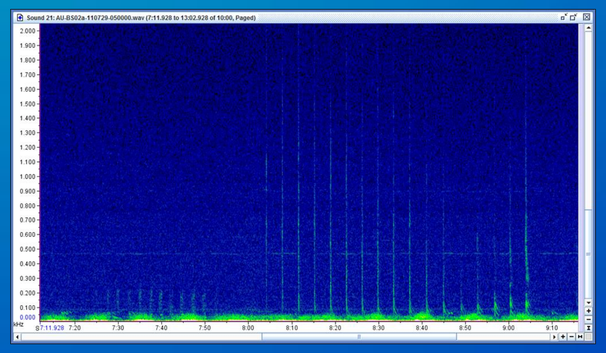




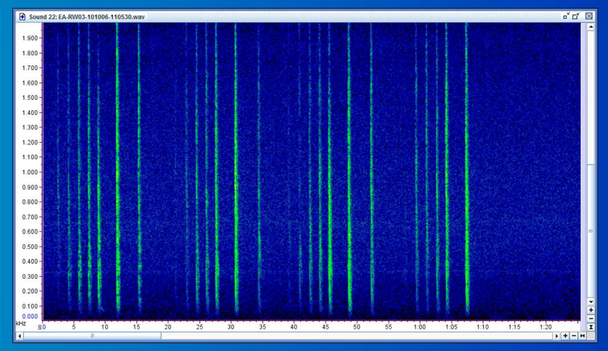
Pattern 2

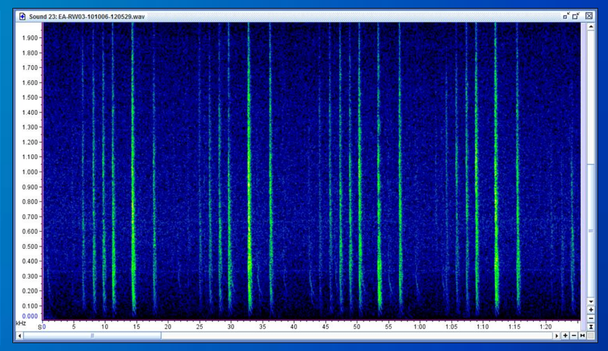






Pattern 3





CONCLUSIONS

- **First documented instance of stereotyped, repetitive call patterns in right whales**
- **6 patterns documented thus far, 3 analyzed**
  - **Minimum 30 iterations of each pattern**
- **Patterns span season, two consecutive years, and non-consecutive years**

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