Acoustic evidence of blue whales and other baleen whale vocalizations off northern Angola.

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ABSTRACT

Passive acoustic monitoring was used to assess the presence of baleen whales off the coast of Northern Angola, off the Congo River outflow. Two Marine Autonomous Recording Units (MARUs) were deployed between 2 March and 1 December 2008 in the offshore environment (at 15 km and 24 km offshore), resulting in a nine month continuous record at a sample rate of 2,000 Hz. Every other week (50%) of the continuous data was reviewed manually on spectrograms to detect vocalizations of baleen whales in the low frequency bandwidth (0-180 Hz). Humpback whales were recorded commonly from the period 19 July to 1 December and are reported on elsewhere. A series of blue whale calls were detected on one day in the examined data, on 13 October. Comparison with published literature indicated that the calls were of the type attributed to the "Sri Lanka" population of pygmy blue whales. Prior to this observation, this call type was only reported in the Indian Ocean. The occurrence of a blue whale from this population in the low latitudes (6ºS) of the Atlantic Ocean may be the result of an accidental migrant (since it was a single observation), or alternatively may be indicate an incomplete understanding of the movements of pygmy blues. In addition to this series of calls, several other signals were recorded that may represent previously unknown vocalizations of blue whales or other baleen whales. These signals are reported here for review by experts in the field of cetacean bioacoustics.

INTRODUCTION

The coasts and pelagic regions of Africa support a diverse assemblage of marine life, including populations of large whales in variable states of recovery from commercial whaling. However, in terms of cetaceans, these are among the most poorly understood and documented regions on the globe, with many open questions regarding species presence, distribution, timing of migrations, and importance of habitat to critical life functions. Blue whales in the southern hemisphere are generally divided into two subspecies, the Antarctic or "true" blue whale (*Balaenoptera musculus intermedia*) and the pygmy blue whale (*B. m. brevicauda*). Antarctic blue whales are distributed around Antarctica during the summer months and likely migrate to as yet unknown regions in the winters. Antarctic blue whales are currently at <1% of their estimated pre-whaling abundance despite more than three decades of no hunting, and are thus among the most endangered large whales (Branch et al. 2004). Pygmy blue whales are distributed primarily in temperate and tropical latitudes and likely do not range much further south than 54ºS (Branch et al. 2007, 2009). There are several populations of pygmy blue whales described by stereotyped call types in the Indian and Pacific Oceans. Pygmy blue whales were also extensively hunted, and never had as large populations as Antarctic blues, but due to lack of information on pre-whaling abundance, their current status is unknown. There were large catches of blue whales along the west African coast from South Africa to Angola and fewer as far north as Congo and Gabon; however, there are only two reported modern sightings (Branch et al. 2007), leading many to believe that this population was nearly extirpated. There is little information indicating whether this population represented Antarctic or a distinct population of pygmy blue whales.

METHODS

Work was conducted in northern Angola off the Congo River mouth outflow at about 6ºS in the South Atlantic Ocean. Passive acoustic monitoring was one component of a larger project to assess marine mammal presence around the construction site of the Angola LNG plant. Marine Autonomous Recording Units (MARUs) used in this study were developed by the Cornell Bioacoustic Research Program (www.birds.cornell.edu/brp) and have been applied as a cost-effective means of surveying whales (including blue, fin, humpback, right, and sperm whales) in a variety of coastal, shelf edge, and deep water habitats (Cholewiak 2008, Sousa-Lima and Clark 2008, Di Iorio and Clark 2009). A MARU consists of a glass sphere (capable of withstanding pressures at up to 4,000 m depth) encapsulating an amplifier, frequency filter, programmable computer, software that schedules, records, and stores acoustic data and a disk drive to store the data, and is attached to an external hydrophone. MARUs were programmed and deployed to the sea floor, and then recovered by means of an acoustic communication circuit that signals the unit to release from its anchor and float to the surface. Between March 2 and December 1, 2008, four MARUs were deployed in two pairs in the offshore and inshore environment, respectively, off the Congo River mouth (Figure 1).

Data analyzed in this study were recorded from the offshore MARU locations (labelled MARU 1 and MARU 2 in Figure 1). The MARUs were deployed at approximately 100 meters depth, 24 km and 15 km offshore the Sereia Peninsula, on the edge of the Congo River Submarine Canyon, and separated by 9.65 km (at coordinates 6.080ºS, 12.057ºE and 6.046ºS, 12.137ºE). For these locations, MARUs were configured to record continuously for approximately 90-100 days with an effective bandwidth of 1,000 Hz (2,000 Hz sampling rate), targeting the sounds of baleen whales. Frequency response of the MARUs was 15-1,000 Hz (within approx. 3 dB), and flat from 55-585 Hz with an effective sensitivity of -151.2 +/- 1 dB and nominal dynamic range of 63.2 dB. The offshore MARUs were deployed three times for a continuous period of nine months. After the first deployment of 81 days, the retrieval system of MARU 1 malfunctioned and only MARU 2 was retrieved. The second and third deployment recorded for 88 and 101 days, respectively, and both MARUs were retrieved successfully. Recovered data includes between 1,900 and 2,425 hours of continuous recordings from each unit amounting to approximately 11,016 hours of data from the offshore locations from March 2 to December 1, 2008, with only two breaks of two days each for retrieval, refitting and redeployment.

Data were downloaded to hard drives, the acoustic data from the pair of MARUs were synchronized for each deployment, and a continuous stream of multichannel sound files was created using custom software developed by Cornell BRP. Recordings were analyzed using software Raven Pro 1.3 or 1.4 (www.birds.cornell.edu/brp/raven/RavenOverview). Spectrograms (1024pt FFT, 75% overlap) were browsed in the 0-180 Hz bandwidth for 50% of all data, visually scanning every other week for the entire nine month duration. When received signals that represented a potential baleen whale call was detected by the analysts, it was logged in a Raven selection table and checked by S.C. If a signal was either recognized or thought to be a baleen whale call type, it was assigned a label and all occurrences were logged during the browsing. Unknown signals were treated as potential call types if the signal had a recognizable and stereotyped pattern, and was repeated either in a sequence or in several different hours or days during the browsing. Humpback whale song was consistently recorded after 19 June (see SC/62/SH12) and was not considered in this analysis. Attempts were made to ignore humpback whale vocalizations and log only signals that did not represent a unit in humpback whale song; knowledge of the current years song pattern was used to facilitate this process.

RESULTS AND DISCUSSION

We examined every other week of data from 2 March to 1 December, amounting to 5688 hours of recording (summing from both MARUs) on 139 days. During this period we encountered one event that was without dispute a blue whale (Figure 1 and 2). On 13 October, between 03:47 and 05:00, 33 calls in a consistent series were recorded, many on both MARUs (figure 2). The consistent, stereotypic and repetitive utterance of these calls is indicative of song, and the series gradually faded into and then out of the recording, suggesting the animal was singing while moving, and moved into and than out of detection range of our MARUs. Comparison of these calls revealed that it was of the type attributed to the song of the North Indian Ocean population of pygmy blue whales (Figure 1), first recorded off Sri Lanka as reported by MacDonald et al (2006) as reproduced in Figure 3e. This population was originally thought to be restricted to the northern Indian Ocean, but recent evidence reported recording calls in the southern Indian Ocean off Crozet Islands (Samaran 2009). The recording of this call off Angola at 6ºS in the Atlantic Ocean represents a substantial expansion of the known range of this population. Given that this was a single occurrence, it is possible that this is a transient individual and an outlier for the population. Examination of our complete dataset in the coming months, as well as further monitoring may yield more examples and have relevance for our understanding of pygmy blue whale populations and movements in the southern hemisphere.

An additional three other signals were recorded that may represent the calls of blue whales. The first is represented in Figure 4, and consists of an amplitude modulated first component followed by a tonal component centered at 33 Hz. We documented 49 occurrences of this call on 13 days between 29 May and 16 of September. This call bears a resemblance to a single unit in the song attributed to the population of pygmy blue whales recorded in the Southwest Pacific off North Island, New Zealand, as reported by MacDonald et al. (2006). The Southwest Pacific song consists of three pulsed units followed by a tonal call, as reproduced in Figure 3a. The call recorded off Angola was similar in structure to the third unit of the Southwest Pacific song, however shorter in duration at 10-12 sec as opposed to 20 sec. Given the similarity is not as clear as for the Sri Lanka call, it is probably premature to attribute the Angola call to a blue whale from the Southwest Pacific population, which would represent an even more remarkable movement than from the Indian Ocean. However, we believe that the resemblance is close enough to postulate that this is likely the call of a blue whale.

Two additional calls that may represent blue whales are shown in Figures 5 and 6, and do not match calls reported in the literature to our knowledge. We postulate that these could be blue whale calls due to the prolonged duration (in excess of 15 sec for Figure 5, and 8-10 sec for Figure 6) and frequency characteristics (both with bands in the 18-22 Hz range). The call in Figure 5 was detected in 77 occurrences on 45 days between 27 May and 29 November, and the call in Figure 6 was detected in 169 occurrences on 18 days between 10 June and 15 November. If these are in fact calls of blue whales, they would represent newly detected call types and potentially a previously unreported population of blue whales. Given the location of calls in the tropical south Atlantic, this population may represent an undescribed pygmy blue whale population.

In addition to these calls we present three other calls of unknown origin in Figures 7, 8 and 9, each of which are composed of down sweeps in varying frequency bands from 120 Hz to 40 Hz. These were all detected during periods when humpback whales were singing, as evident in the figures, however, they were not part of the song patterns that were defined for the region. It is possible that they represent non-song humpback whale song, but it is our opinion that they are more likely calls of another unidentified baleen whale.

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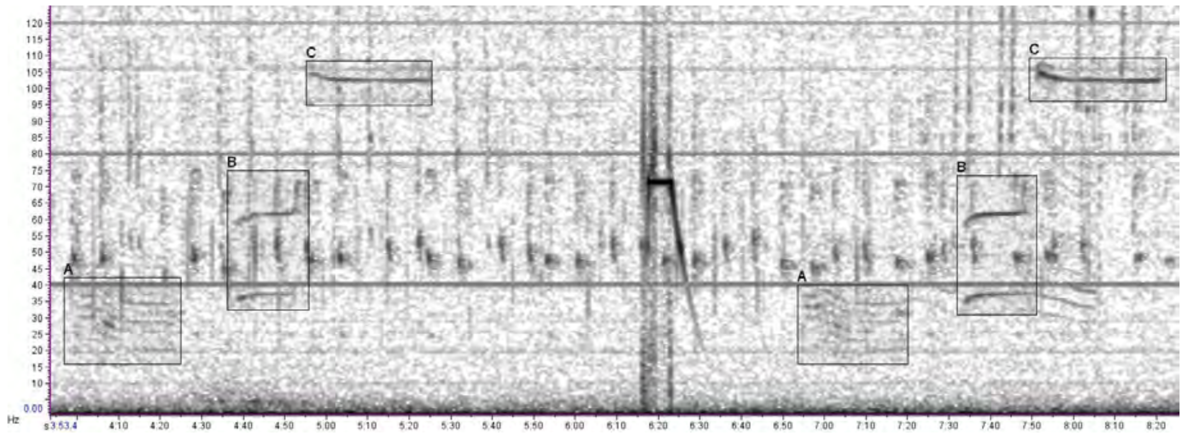

Figure 1. Spectrogram (SR 2000 Hz, 2048pt FFT, 75% overlap) of two blue whale calls on the "Sri Lanka" call type recorded off Angola on X July 2008, off the northern coast of Angola at approximately 6 S in the Atlantic Ocean. The three units of the call are labelled A , B and C for each call. A singing humpback whale is also prominent in the recording, and the feature between 6:15 and 6:30 is hard drive noise of the MARU.

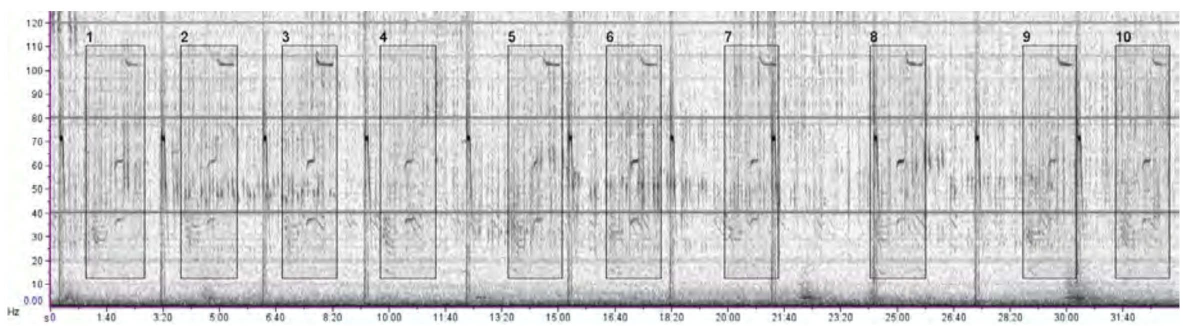

Figure 2. Spectrogram (SR 2000 Hz, 2048pt FFT, 75% overlap) showing a series of 10 blue whale calls of the "Sri Lanka" type during the highest amplitude portion of the complete series.

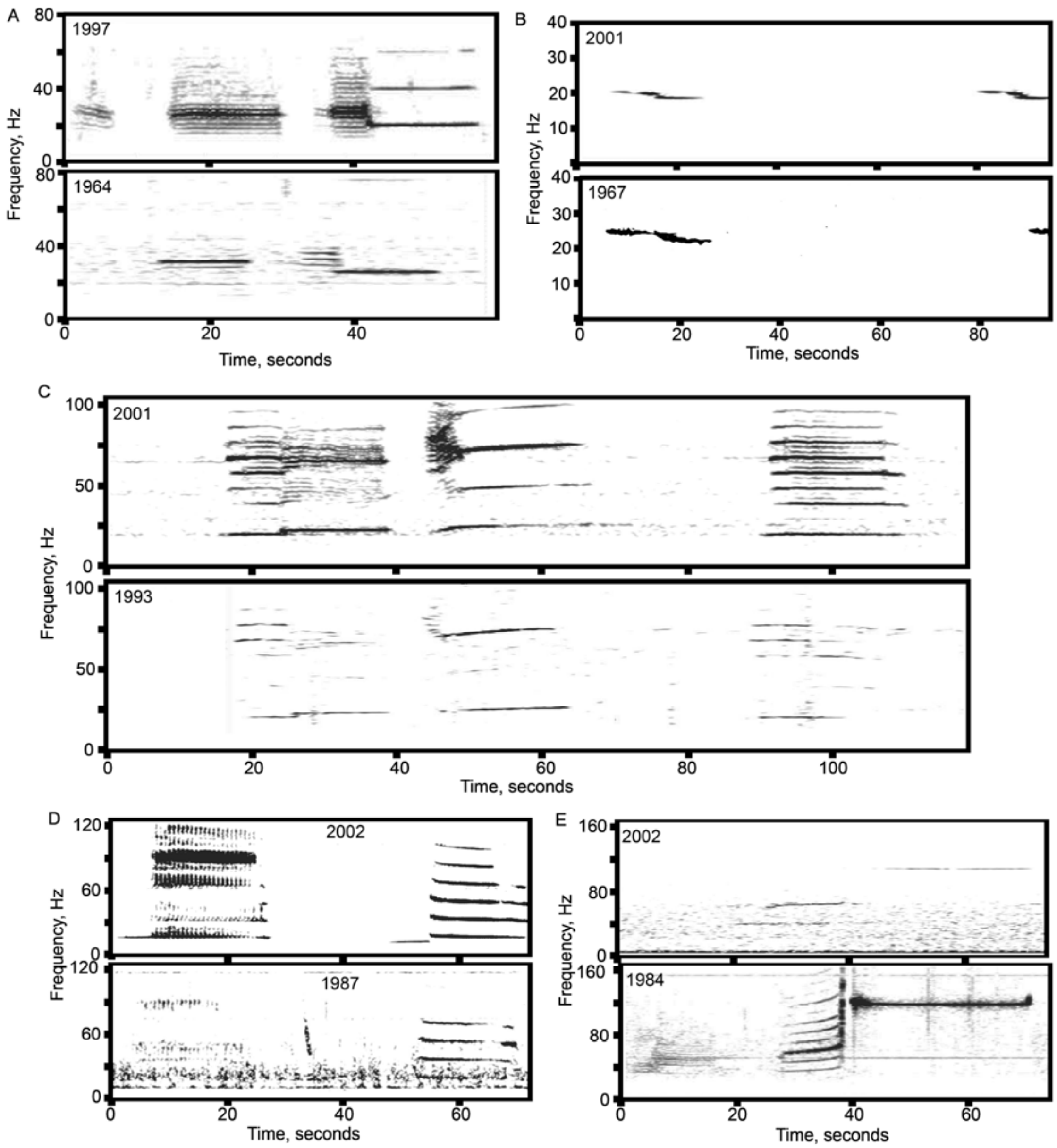

Figure 3. Examples of blue whale song from pygmy blue whale populations globally, reproduced from Figure 2 of MacDonald et al (2006) as reported in J. Cetacean Research and Management, 8, 55–65. Figure caption: "Recordings from New Zealand (A), the Central North Pacific (B), Australia (C), the Northeast Pacific (D) and North Indian Ocean (E) illustrate the stable character of the blue whale song over long time periods. All song types for which long time spans of recording are available show some frequency drift through time, but only minor change in character. These examples were chosen because recordings over a significant time span were available to the authors in raw form, and not because these song types are more stable than the others. The stability of song character in the other types and for longer time spans in these types is available to various degrees in copyrighted spectrograms and/or written descriptions. The missing first units in the 1964 New Zealand example and 2002 Sri Lanka example are probably due to lower signal to noise ratio, rather than a change in the song."

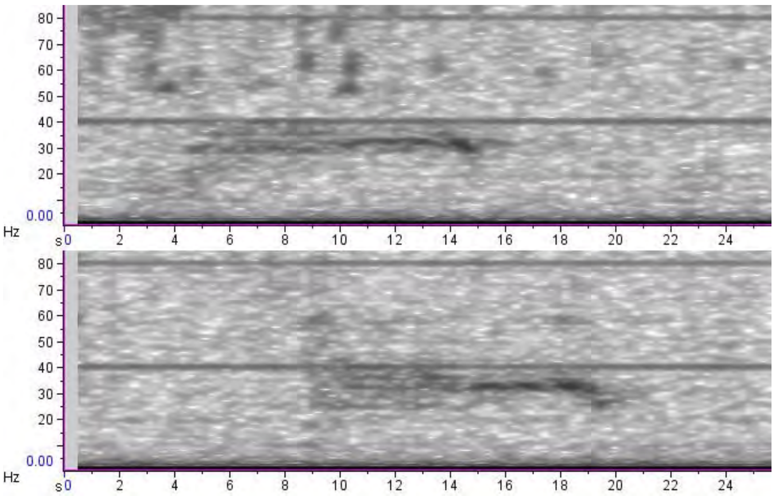

Figure 4. Series of signals of unknown origin, potentially representing a previously un-described blue whale call, recorded on both MARUs (2048 pt FFT, 75% overlap), the top panel representing the MARU at 24km offshore and the bottom panel representing the MARU at 15km. This call had a dominant or fundamental frequency at ca. 30 Hz with amplitude modulation evident in the first half of the call.

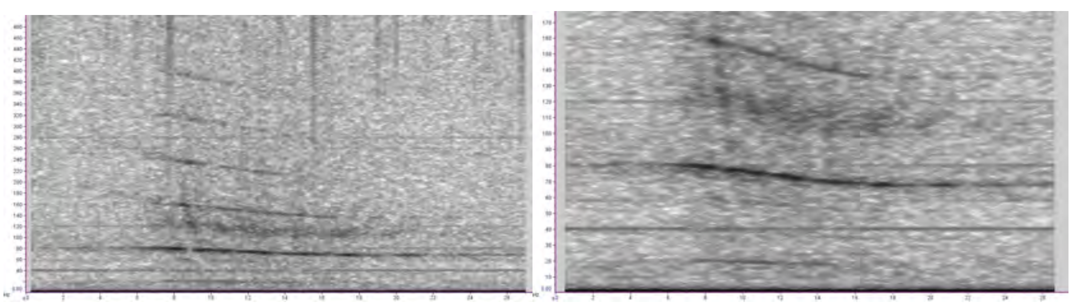

Figure 5. Example of signal of unknown origin, potentially representing a previously un-described blue whale call (2048 pt FFT, 74% overlap – left: 500Hz bandwidth showing harmonic bands; right: 180 Hz bandwidth showing detail of low frequency bands including fundamental frequency at ca. 20 Hz).

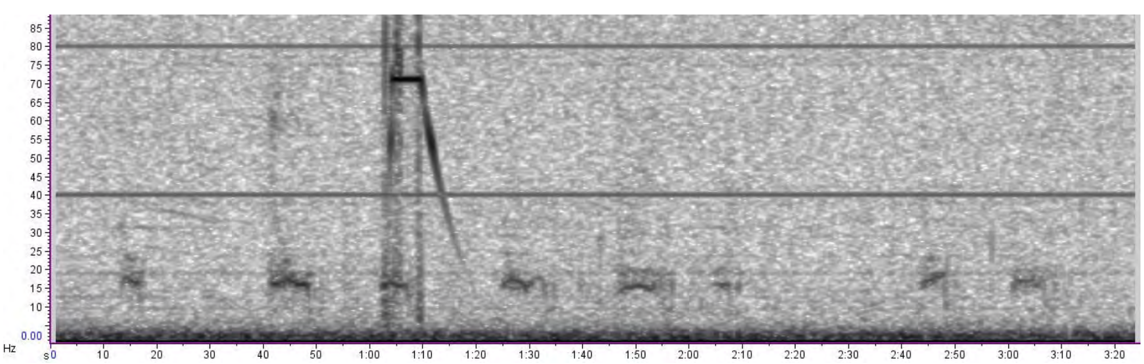

Figure 6. Series of signals of unknown origin, potentially representing a previously un-described blue whale call (4096 pt FFT, 75% overlap). Series tended to be unpatterned with calls at ca. 18 Hz.

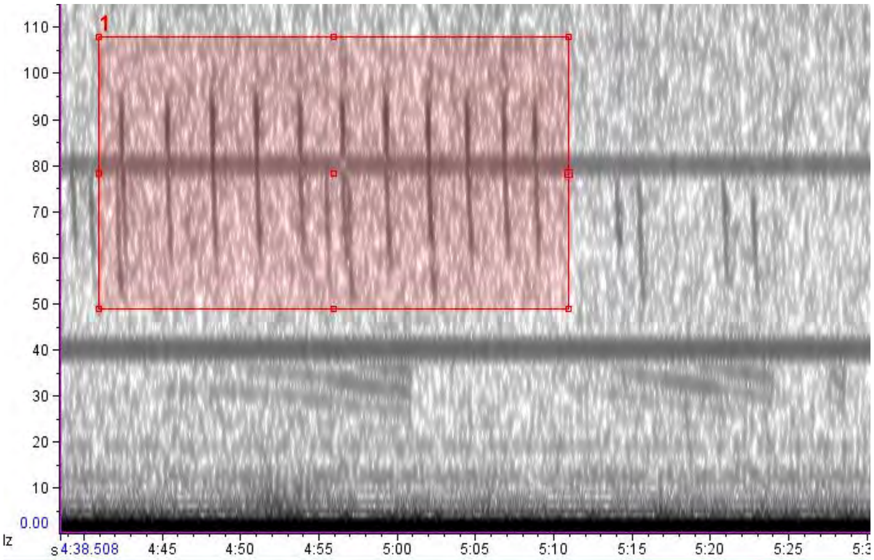

Figure 7. Example of a series of down sweep calls from an unknown source.

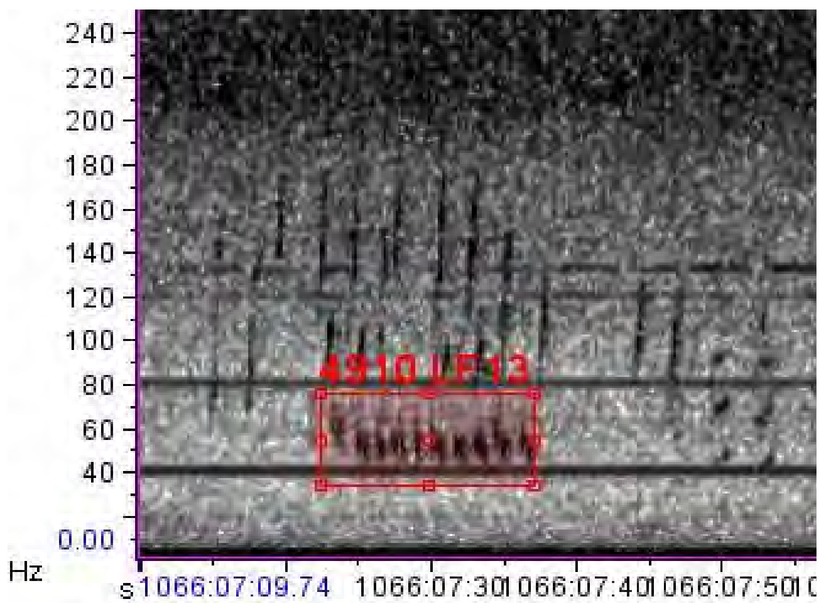

Figure 8 – Example of paired down sweep calls from an unknown source.

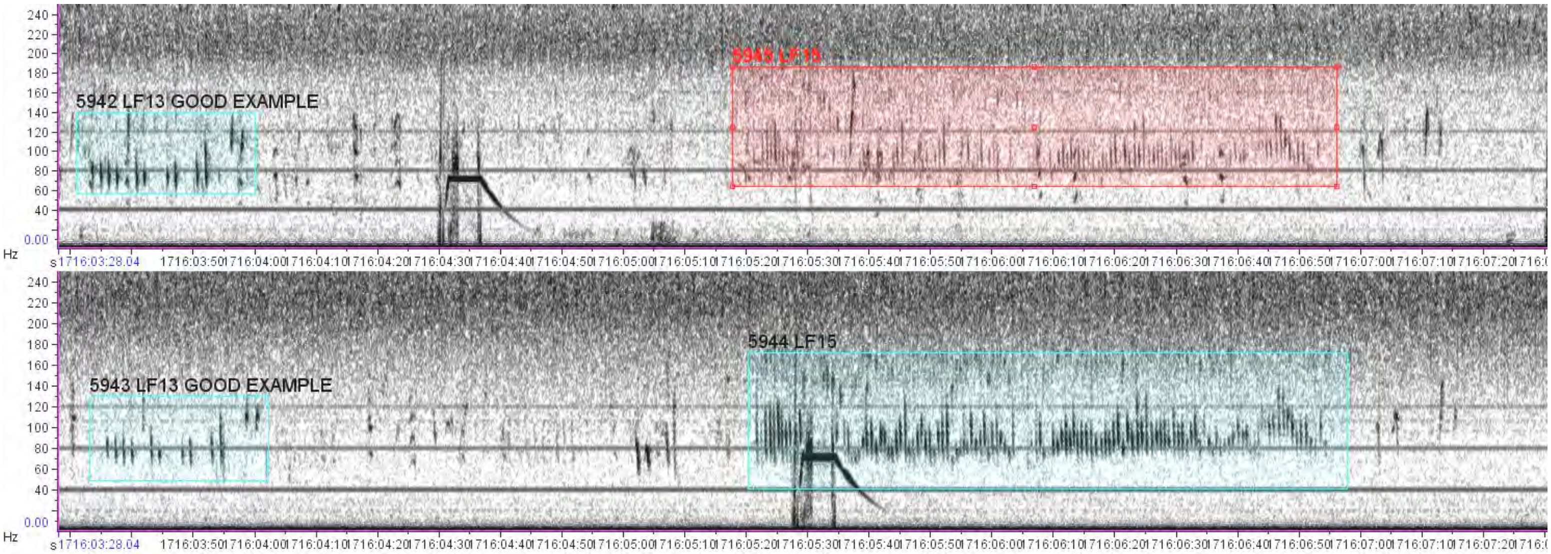

Figure 9. Example of a series of down sweep calls from an unknown source.