# VOCALIZATION PATTERN
## of southern right whales, South Africa

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## ABSTRACT

The southern right whale (Eubalaena australis) (Ea) population in South Africa is increasing at approximately 7% per year. The inshore waters of the south coast is the primary calving, nursing, socializing, and mating area during the austral winter and spring.

The aim of this study was to quantify the vocalizations of Ea, to associate call types with behaviour and group composition, and to develop a call specific classifier for use in automated analysis of passive acoustic monitoring (PAM) data. A total of 44 days of sound recordings were collected with a Loggerhead DSG-Ocean during three periods in January/February, September, and October 2014.

The Loggerhead was deployed in 12m of water in the Greater Dyer Island area, Western Cape. Weather permitting, shore based visual observations of whales around the Loggerhead were conducted with a theodolite in September 2014 (30h25m). Ea group compositions, behaviors, and locations were recorded during hourly visual scans.

Classification of right whale vocalization was based on the objective scheme of Urazghildiiev and Parks (2014) using six main classes: Narrowband fm upsweep (NU), Narrowband fm downsweep (ND), Narrowband complex fm (NC), Narrowband high calls (NH), Complex wideband signals (WC), and Gunshot sounds (WG). Only calls with a high signal to noise ratio were included in the analysis.

All six classes of Ea vocalization were identified in the analysis. Vocalizations were mainly below 400 Hz, except the gunshots extending above 5 kHz. No calls from Ea were recorded during the period of January/February, which corresponded with the well known migration pattern of this species. The most frequent call type was NU.

## RESEARCH AREA
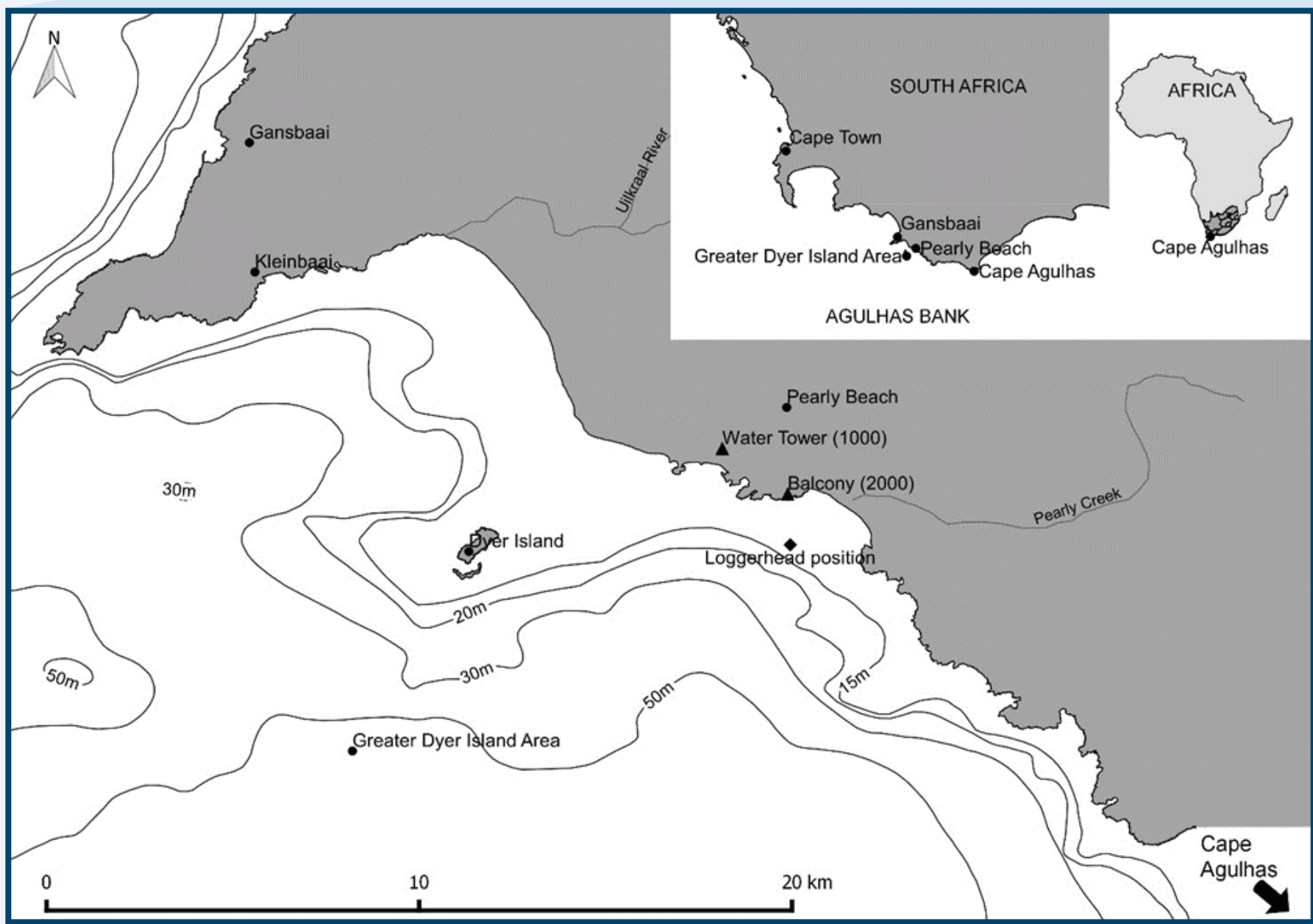
Situated inshore of the Agulhas Bank (Hutchings et al. 2009) in a shallow gently sloping sandy bay, protected from open ocean swell and seasonal winds (Elwen and Best 2004a & 2004b).



**FIGURE 1** Research area. Triangles marks the theodolite stations and the position of the DSG-Ocean loggerhead is marked with a diamond.

## METHODS



**FIGURE 2** Landbased visual scans, conducted every hour. Observation team consisted of 3 or more persons.

### THEODOLITE & VISUAL
- Land-based focal follows from two vantage points at 38.8 m and 14.7 m ASL using a Leica TC307 and VADAR.
- Visual scans were performed once hourly. Only observations in < Beaufort 4 included.
- Location, group composition (unaccompanied adult (UA), Surface active group (SAG) and cow-calf pairs (Cc-pair)) (Figure 3), behaviour, and number of individuals from each hourly visual scans was calculated and compared to PAM results.

### PASSIVE ACOUSTIC MONITORING
- One DSG-Ocean Loggerhead deployed in 12 m of water. A custom designed mooring was used (Figure 3).
- Right whale vocalization was identified and classified following Urazghildiiev and Parks (2014) but only focused on Up-calls and gunshots (Figure 4) as they represent the best characterized right whale sounds.
- Calls were logged manually in Raven Pro 1.5 and assigned call type, Signal-to-noise Ratio (SNR) (Figure 5), and selection category (fundamental or entire call). Parameters measure: Table 1.
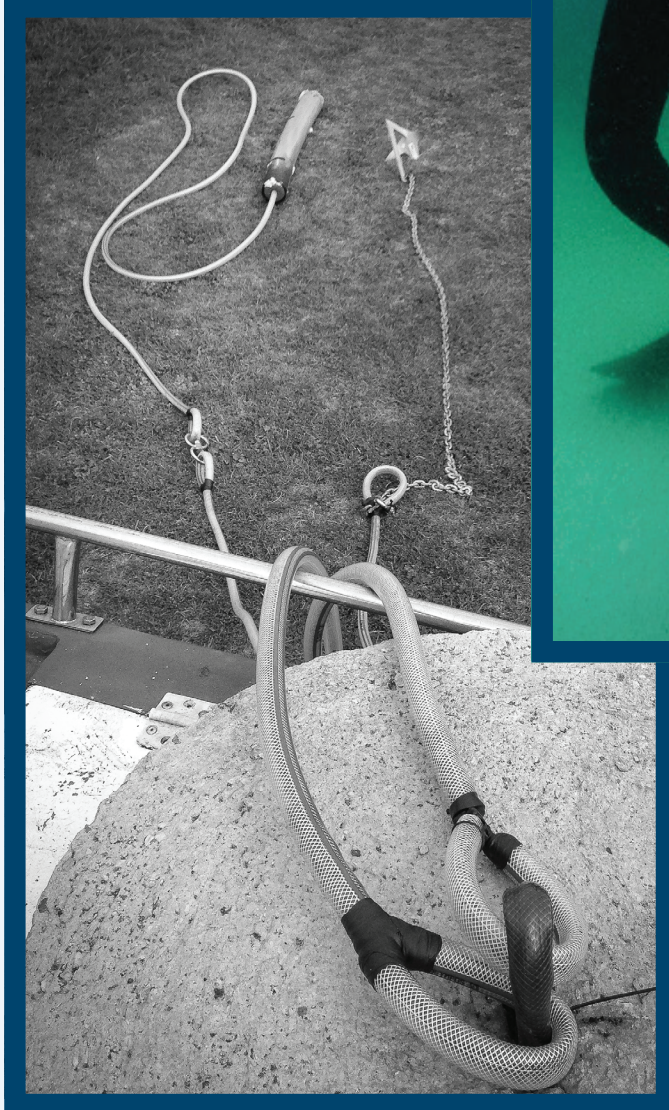
**HYDROPHONE SETTINGS** Sensitivity = -180 dBV/µpa, system gain = 20 dB. Two duty cycles: 1) Low frequency (LF) recordings, decimation factor of 8, sampling rate 10 kHz for 54.5 minutes; 2) High frequency (HF) recording, decimation factor of 1, sampling rate of 80 kHz, for 4.5 min.



**FIGURE 3** Diver retrieving the DSG-Ocean Loggerhead for a service and the custom designed mooring.

## CONCLUSIONS

It was possible to identify and monitor the presence of SRW acoustically from their up-calls and gunshots.

There was no correlation between the call types and presence of different southern right whale groups.

The up-calls of southern right whales could be distinguished from the up-call units that were recorded as part of a theme of a humpback song.

## RESULTS



**97 CC-PAIR** · **193 SAG** Mean group size = 2.8 ± 1 animals · **124 UA**

**FIGURE 3** Ea group compositions; Cow-calf pairs (CC-pair), Surface active group (SAG), and unaccompanied adult (UA).

### VISUAL

During September 2014 a total of 26 hours and 28 minutes of land-based visual observations were conducted while the DSG-Ocean loggerhead was recording.



Station 1000
Station 2000
S2_SAG10Resting /Logging
S2_SAG9Socializing  S2_UA4Resting /Logging
S2_SAG7Socializing  Loggerhead Bay
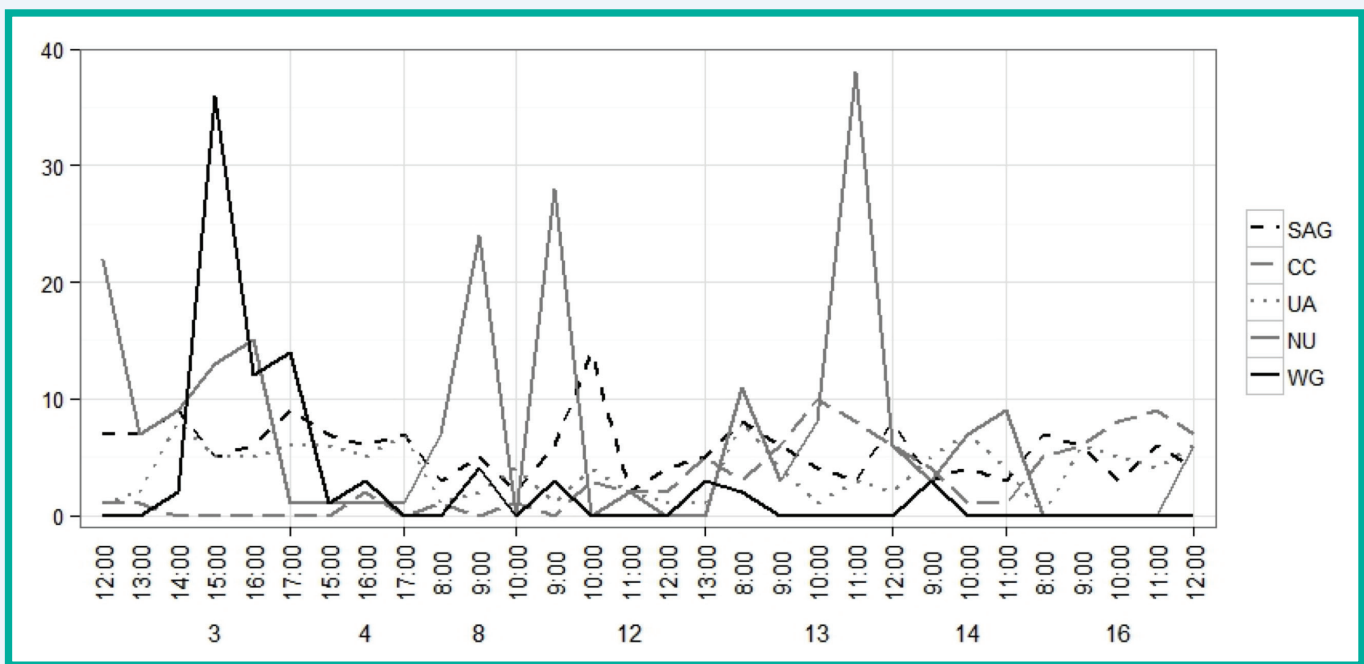S2_SAG11Socializing  S2_SAG12Socializing

## PAM

A total of 255 southern right whale up-calls and 83 gunshots were recorded during the visual observation periods.
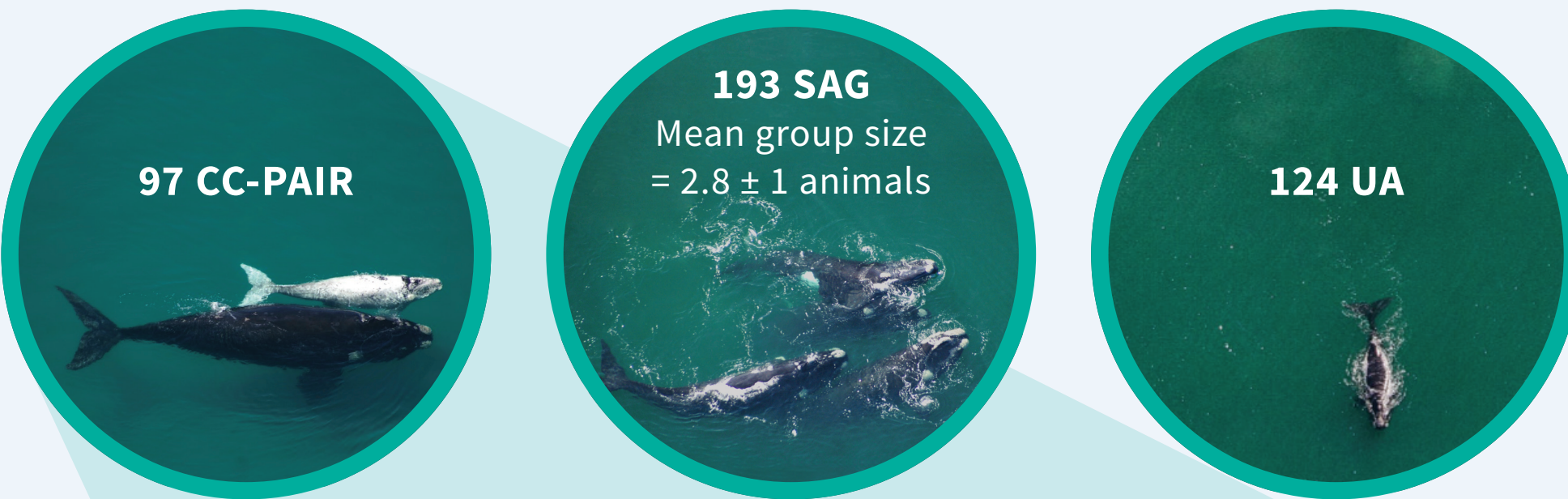
Up-calls of Ea were tonal, frequency modulated up-sweep sounds with a mean centre frequency of 107 ± 16 Hz SD, mean start frequency of 56 ± 13 Hz SD, and mean duration of 0.92 ± 0.28 s SD.

Gunshots were broadband and had a higher centre frequency than the up-calls (centre frequency 1 426 ± 976 Hz SD; Table 1). The upper frequency of some gunshots recorded at the higher sampling rate exceeded 30 kHz.



**FIGURE 7**
**Y-axis:** Total number of each group type (Cc-pair, SAG, and UA) and calls (NU or WG).
**Y-axis:** time of the day (visual scan hour) and dates in September 2014. The total number of calls and of each Ea group type per visual scan hour per day was calculated.
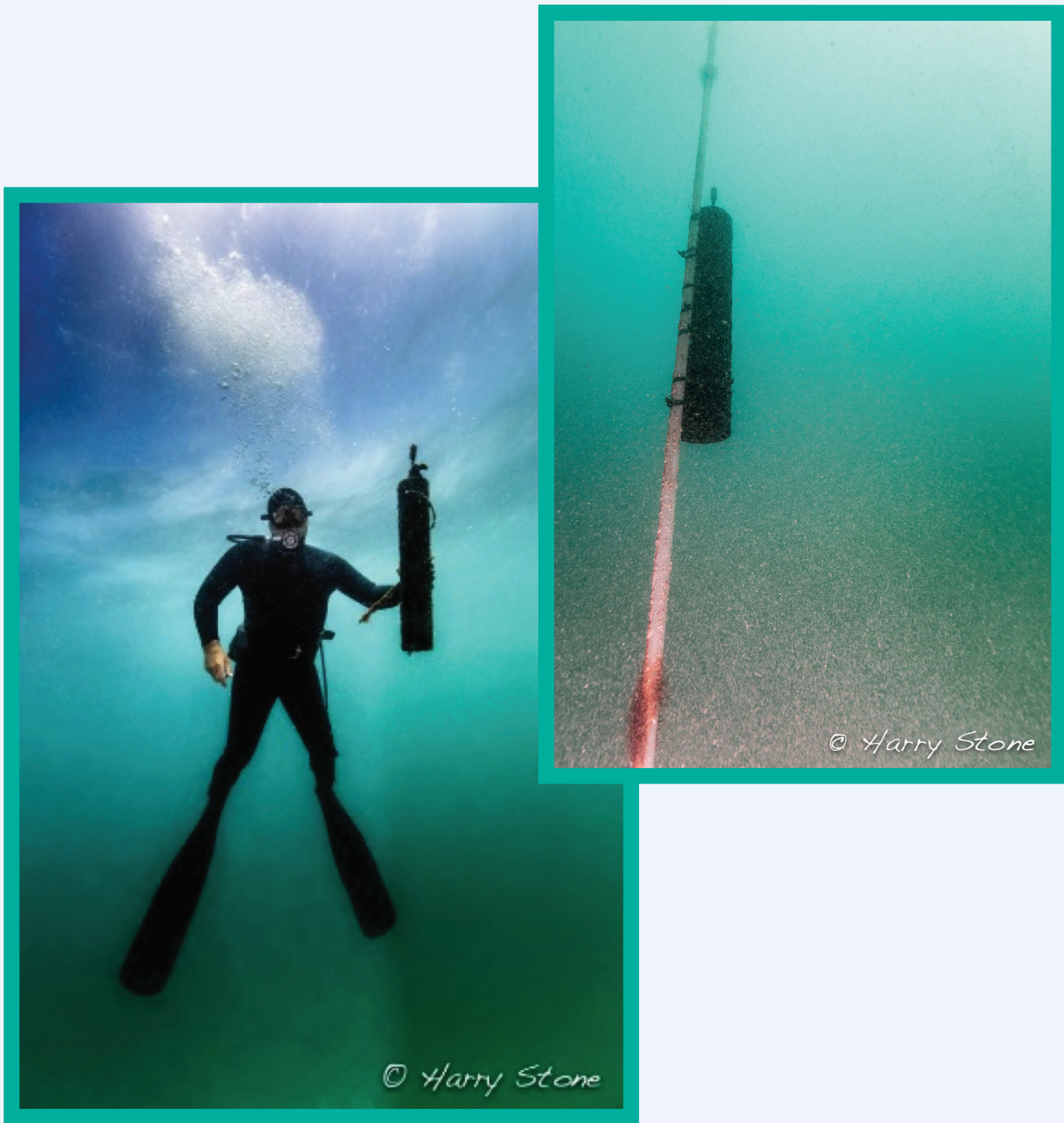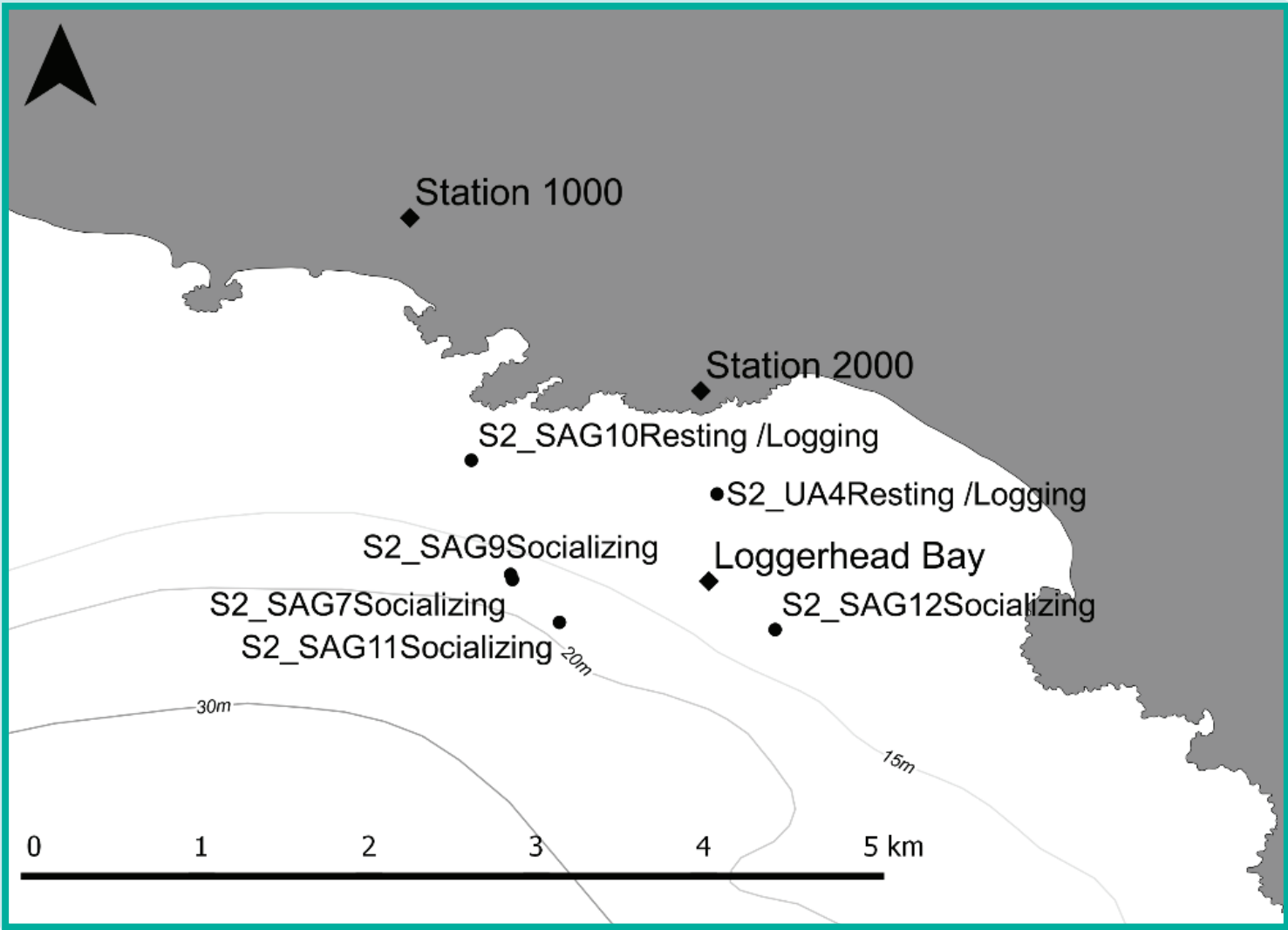
| | Southern right whale Gunshots (n=83) Mean value ± SD | Southern right whale Gunshots (n=6) Sampling rate = 80kHz Mean value ± SD | Southern right whale Up-call (n=255) Mean value ± SD | Humpback Up calls (n=20) Mean value ± SD |
|---|---|---|---|---|
| Low Frequency (Hz) | 80 ± 46 | 81 ± 16 | 56 ± 13 | 94 ± 12 |
| High Frequency (Hz) | 5 714 ± 5 603 | 19 941 ± 14 295 | 184 ± 54.5 | 198 ± 8 |
| Duration 90% (s) | 0.11 ± 0.09 | 0.07 ± 0.07 | 0.55 ± 0.18 | 0.39 ± 0.03 |
| Centre frequency (Hz) | 833 ± 713 | 1 426 ± 976 | 107 ± 16 | 149 ± 6 |
| Peak frequency (Hz) | 564 ± 534 | 1 003 ± 1 075 | 107 ± 18 | 150 ± 9 |
| Frequency 5% (Hz) | 248 ± 88 | 293 ± 30 | 80 ± 14 | 122 ± 10 |
| Frequency 95% (Hz) | 4 035 ± 1 600 | 7 116 ± 2 445 | 146 ± 30 | 173 ± 8 |

**TABLE 1** Call characteristics of Ea up-calls and gunshots and humpback whale up-calls (mean ± standard deviation).

Unexpectedly, humpback whale (Megaptera novaeangliae) vocalisations were present in some of the recordings and this complicated the sound analysis.
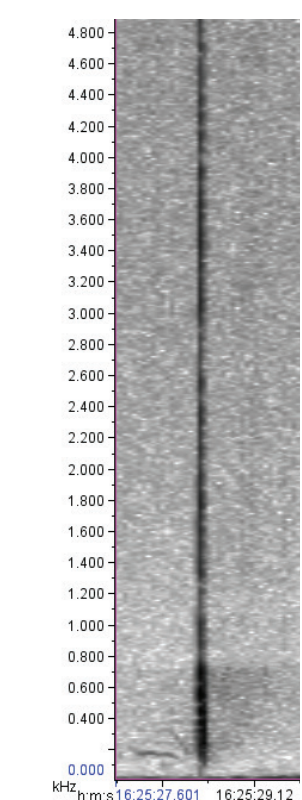
This discovery was a first for the area. Songs of humpback whales containing themes, phrases and units were registered. One of the themes contained up-call like sound units which was analysed to obtain the characteristics and to enable a definition of species-specific up-calls (Figure 6).
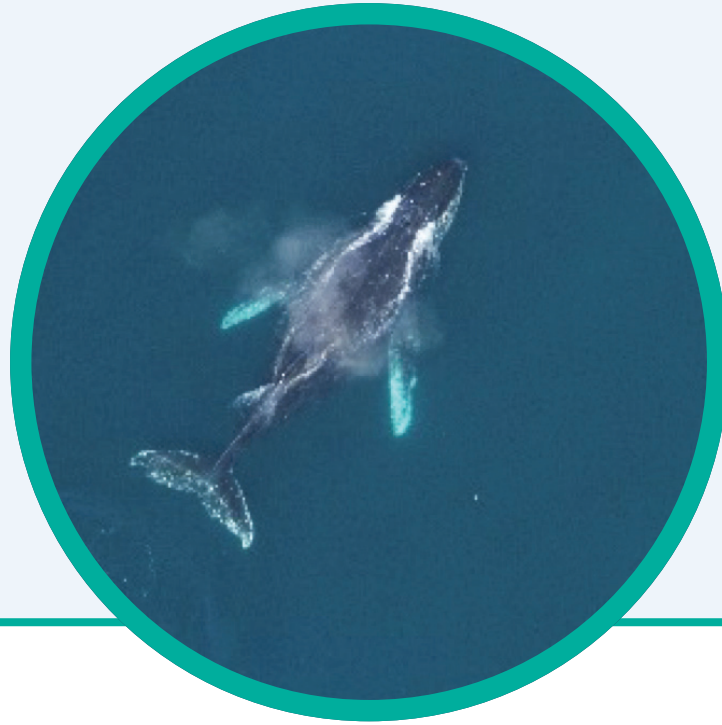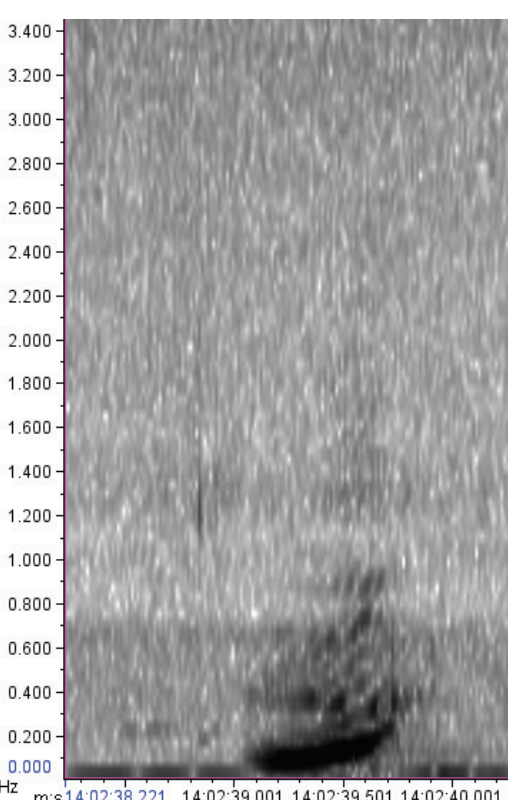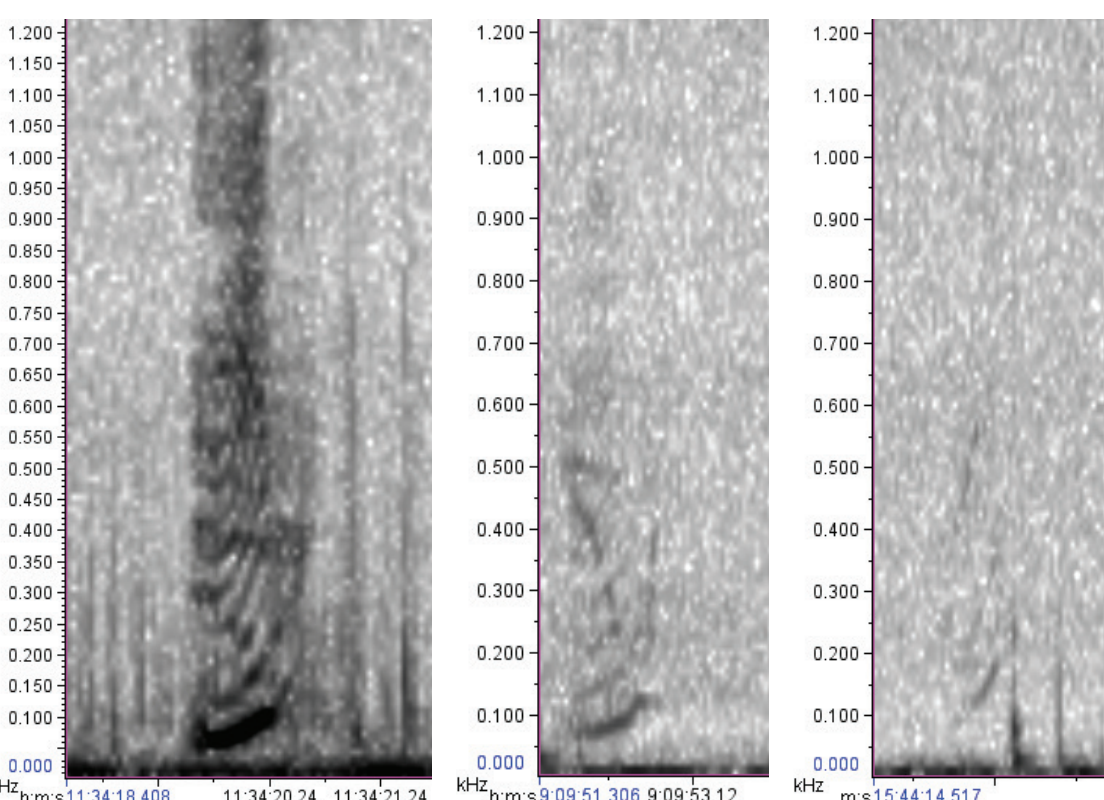


## UP-CALL    GUNSHOT



**FIGURE 4** Example of an up-call (NU) and a gunshot (WG) from southern right whales.

**SPECTROGRAM SETTINGS**
512-point Hann window (3 dB bandwidth, LF = 14 Hz, HF = 28.4Hz) with 50% overlap.
1024-point DFT, LF; time resolution = 51.2 ms, frequency resolution = 9.8 Hz.
4096-point DFT, HF; time resolution = 25.4 ms, frequency resolution = 19.5 Hz.

## SIGNAL TO NOISE RATIO



**FIGURE 5** Three SNR categories: **Excellent**, **Potential** and **Poor**. Only calls with excellent or potential SNR was included in the analysis.

## HUMPBACK WHALE THEME WITH UP-CALLS
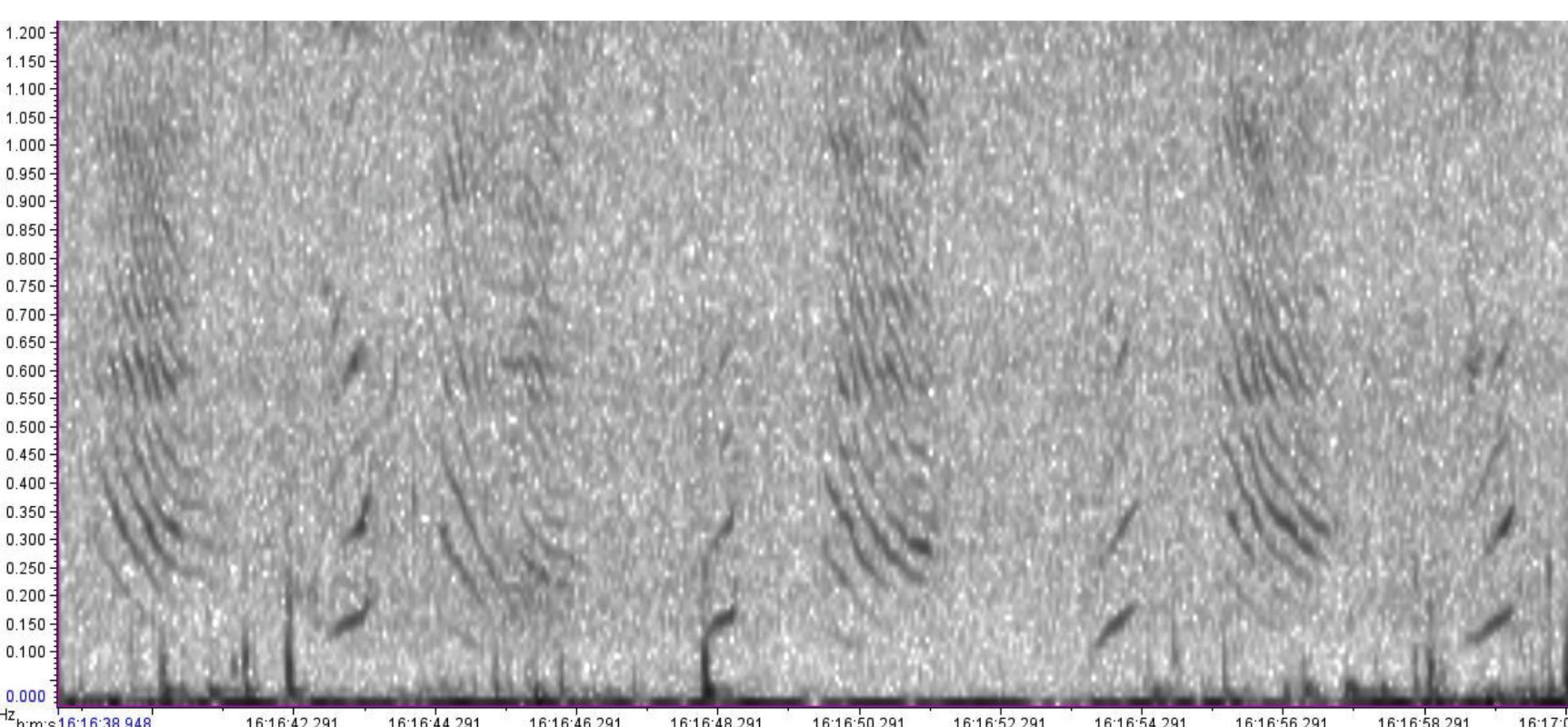


**FIGURE 6** Humpback whale themes containing up-call like sound units which was analysed to obtain the characteristics.

- Out of 29 hours with animals present, sounds attributable to southern right whales were recorded in 23 hours (78%).
- Total number of each group type and call type was calculated and compared (Figure 7).
- There was no significant correlation between up-calls or gunshots and the number of UAs, SAGs, and Cc-pairs present in the bay.

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