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# Acoustic detections of beaked whales, narrow-band high-frequency pulses and other odontocete cetaceans in the Southern Ocean using an autonomous towed hydrophone recorder

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# ABSTRACT

Encased in a streamlined, flooded housing, a SoundTrap ST300HF hydrophone recording system was towed on voyages to South Georgia Island and the South Sandwich Islands and to the Antarctic Peninsula in December 2019–February 2020. Recordings were analyzed to identify acoustic detections of cetacean species. Acoustically identified species included sperm whales (*Physeter macrocephalus*), southern bottlenose whales (*Hyperoodon planifrons*), Arnoux's beaked whales (*Berardius arnuxii*), killer whales (*Orcinus orca*), and long-finned pilot whales (*Globicephala melas*). Acoustic detections also included several recognized types of beaked whale echolocation pulses (BW37/39 and BW58) as well as two likely beaked whale echolocation pulse types that do not match any previous descriptions. Narrow-band high-frequency echolocation signals (NBHF) (typical of porpoises and some dolphin species) were detected in many locations, and one of these coincided with a sighting of hourglass dolphins (*Lagenorhynchus cruciger*). This study shows the utility of an autonomous towed hydrophone system on a vessel of opportunity to study the distribution of cetaceans in rough seas that are difficult to study by visual survey methods.

### 1. Introduction

Much of what is known about odontocete cetacean distributions in the Southern Ocean has come from visual sighting surveys conducted as part of the International Whaling Commission's (IWC) Southern Ocean Whale and Ecosystem Research Programme (SOWER) from 1978 to 2009. These surveys were primarily focused on the distribution and abundance of baleen whales such as blue whales (Branch et al. 2004, 2007) and Antarctic minke whales (Branch and Butterworth 2001). However, the SOWER surveys also produced estimates of the density and abundance of the most commonly seen odontocetes (sperm whales (*Physeter macrocephalus*), killer whales (*Orcinus orca*), long-finned pilot whales (*Globicephala melas*), hourglass dolphins (*Lagenorhynchus cruciger*), and a collective category of all beaked whales (family Ziphiidae)) (Kasamatsu and Joyce 1995). The southern bottlenose whale (*Hyperoodon planifrons*) was by far the most commonly identified beaked whale in that study. However, those surveys concentrated on waters south of  $60^\circ$  S, and there is a shortage of species-specific distribution information on odontocetes in offshore regions of 40–60° S.

Passive acoustic surveys using towed hydrophones are a potential alternative to visual sighting surveys for distributional studies of odontocetes. Typically, towed hydrophone surveys have been conducted using a short, linear array of hydrophones towed behind a vessel (Heineman et al., 2016; Rankin et al., 2017). Odontocete acoustic signals received by the hydrophones are typically transmitted via a conducting tow cable back to the vessel for recording and/or real-time processing. Such systems have been used to study sperm whales in the Southern Ocean (Pierpoint et al., 1997; Gillespie et al., 1997; Leaper and Scheidat 1998; Leaper et al., 2000). Although this approach is effective, it requires a large quantity of specialized equipment and skilled operators. Here we describe the use of a simpler system with an integrated hydrophone recording system towed with a rope line. The simplicity of this system allows it to be more easily deployed from vessels of opportunity by personnel with minimal training.

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Received 28 May 2021; Received in revised form 3 September 2021; Accepted 18 September 2021 Available online 4 October 2021 0967-0645/Published by Elsevier Ltd. The use of towed hydrophone systems to study odontocete species distribution requires that species can be recognized by their acoustic signals. Although the echolocation clicks of sperm whales have been well characterized (Gould and Jones 1995), the species-specific recognition of the acoustic signals of beaked whales, dolphins and porpoises is still being developed (Baumann-Pickering et al., 2013; Rankin et al., 2017).

Beaked whales can be recognized from their characteristic echolocation pulses (or chirps) that include a frequency-modulated (FM) upsweep (Baumann-Pickering et al., 2013). To date, all beaked whale species have been found to produce a single unique FM pulse type that is diagnostic for that species (Baumann-Pickering et al., 2013; DeAngelis et al., 2018). In the Southern Ocean, five distinctive types of beaked whale pulses have been described (BW29, BW37, BW39, BW53, and BW58) and named based on their peak frequency in kHz (Trickey et al., 2015; Baumann-Pickering et al., 2015; Giorli et al., 2018). Based on its similarity to the echolocation pulse of the northern bottlenose whale (Hyperoodon ampullatus), BW29 is believed to be made by the southern bottlenose whale (Hyperoodon planifrons) (Baumann-Pickering et al., 2015). The other pulse types are likely from species in the genus Mesoplodon (Trickey et al., 2015; Baumann-Pickering et al., 2015; Giorli et al., 2018). Additional work is needed to determine whether BW37 and BW39 are truly unique or might be from the same species (Giorli et al., 2018). Echolocation pulses with a peak frequency of 16 kHz were recorded in the vicinity of Arnoux's beaked whales (Berardius arnuxii) in the Antarctic (Rogers and Brown 1999), but the recording bandwidth was limited and this should not be considered to be a complete description for that species. With at least 10 species of beaked whales in the Southern Ocean (MacLeod et al., 2006), more beaked whale FM pulses remain undescribed.

Dolphins and porpoises produce a variety of echolocation clicks and pulses which differ among taxonomic groups (Morisaka and Connor 2007). Most delphinid cetaceans produce short clicks that have a broad frequency bandwidth, along with whistles and burst pulses. All porpoise species, some dolphin species (in the genera *Cephalorhynchus, Lagenorhynchus,* and *Pontoporia*), and dwarf and pygmy sperm whales (*Kogia* spp.) produce narrow-band high-frequency (NBHF) echolocation pulses (Madsen et al., 2005). Although at least some acoustic signals have been described for most small cetaceans in the Southern Ocean (Kyhn et al. 2009, 2010; Gotz et al., 2010; Tougaard and Kyhn 2010), the full vocal repertoire has likely not been fully described for any species.

In this paper we describe the use of an autonomous towed hydrophone recording system to study odontocete acoustic signals in the Southern Ocean during a small yacht research charter voyage to South Georgia and the South Sandwich Islands and an expeditionary ecotourist voyage to the Antarctic Peninsula. High-quality recordings from this system were used to identify the acoustic detection locations of several beaked whale and other cetacean species based on previously described acoustic signals. Two likely beaked whale pulse types are described based on these recordings which appear to be unlike any that have been previously described. The autonomous towed system has the advantage of being self-contained and easy to deploy and retrieve with a minimum of training. This approach facilitates sampling of seldom studied areas, like the waters around the South Sandwich Islands, using vessels of opportunity.

#### 2. Methods

#### 2.1. Autonomous towed hydrophone system

Design details for our flooded towbody are given in Barlow (2021). A compact SoundTrap® ST300HF hydrophone recording system (Ocean Instruments, Auckland, New Zealand) was secured with set screws inside a 66.6 mm ID x 76.2 mm OD (25/8'' ID x 3'' OD) polycarbonate tube approximately 50 cm long (Fig. 1). The tapered end-caps were grooved to allow the tube to flood when towed. The ST300HF was mounted with



**Fig. 1.** One of the authors (TC) deploying the SoundTrap ST300HF hydrophone recorder (inside a streamlined towfish) from the stern of the *Pelagic Australis*. Photograph by Skip Novak.

the integrated hydrophone end pointing aft, away from the tow vessel. The first 360 m of towline was 4.8 mm (3/16") Dyneema® (high modulus polyethylene). The last 3 m of tow line was 9.5 mm (3/8") Dyneema® that was wrapped with 4.5 kg (10 lbs) of 4.8 mm (3/16") lead wire to provide weight to sink the tow body. The ST300HF was programmed to record continuously at a 576 kHz sampling rate with a 400 Hz high-pass filter. With these settings, the instrument has a flat frequency response ( $\pm$ 3 dB) from 500 Hz to 150 kHz. The depth of the tow body was measured with a Sensus Ultra® data recorder mounted inside the tube.

## 2.2. Deployments

The towed hydrophone recording system was deployed on a not-tointerfere basis during transits of the 23-m sailing yacht *Pelagic Australis* during a round-trip expedition from the Falkland Islands to the South Sandwich Islands and South Georgia from December 30, 2019 to January 29, 2020 (Leg 1) and on the 26-m eco-tourism vessel *Hans Hansson* from King George Island to Puerto Williams, Chile via the Antarctic Peninsula from February 11 to 27, 2020 (Leg 2). The *Pelagic Australis* was always under sail during deployments, usually with auxiliary engine power as well; the *Hans Hansson* was powered by a diesel engine. The system was deployed 360 m behind the vessels by hand and towed at speeds of 2–10 kts (3.7–18.5 km h<sup>-1</sup>). The system was retrieved by hand or with a manual winch.

#### 2.3. Acoustic data processing

Acoustic recordings were downloaded from the ST300HF intermittently during both expeditions. Compressed files were converted to WAV files by SoundTrap® host software. Acoustic data were analyzed with PAMGuard v2\_00\_16e open-source software (Gillespie et al., 2009). The PAMGuard software created long-term spectral averages (LTSAs) and automatically detected impulsive sounds (e.g., echolocation clicks and pulses) using an energy detector. This software also classified each impulsive sound into categories of peak frequency using the click classification function within the click detection module. Prior to click detection and classification, the acoustic data were resampled to a sampling rate of 288 kHz. We used the same classification scheme as

Simonis et al. (2020) which initially classified clicks based on peak frequency ranges of 2-15, 15-30, 30-50, 50-80 and > 80 kHz. Within the primary frequency range of beaked whales (30-50 kHz), clicks with frequency sweeps were identified by zero-crossing analysis. After the initial processing by PAMGuard software, the resulting data files were re-processed using the click template classifier within PAMGuard Viewer software. Nine waveform templates were used based on: Cuvier's beaked whale (from the North Pacific), previously identified FM pulses from Antarctic beaked whales (BW29 & BW37 from Trickey et al., 2015), an FM pulse type identified in a preliminary review of our data (BW40V, see below), a 15 kHz pulse type identified in a preliminary review of our data and believed to be from Arnoux's beaked whale, a generic NBHF click type, a 117 kHz NBHF click type identified in a preliminary review of our data, sperm whale echolocation click, and a low-frequency delphinid echolocation click type. If the correlation between a detected signal and one of these waveform templates (at the sample lag that maximizes the correlation) was greater than a given threshold, PAMGuard Viewer labeled that encounter in its database.

Detections of potential cetacean echolocation pulses were identified manually in PAMGuard Viewer. Impulsive signals (clicks and pulses) were displayed as symbols in the click detector window, with the symbol color and shape coding based on peak frequency (from the click detector classifier) and on the results of the click template classifier. An experienced acoustic analyst (JB) reviewed results in 2-min time slices in the click detector's amplitude/time display. Additionally, JB reviewed the LTSA displays in 1-h time slices to detect cetacean signals that were missed in the review of the impulsive signals. Potential acoustic detections were recognized as patterns of high-amplitude pulses with similar symbols that were clustered together. Potential detections were examined in more detail by selecting a symbol on the screen to display the waveform, frequency spectrum, and Wigner-Ville representation of the pulse represented by that symbol. Contextual information, such as the presence of whistles, burst pulses, and various other sounds, was obtained by viewing a spectrogram representation of the acoustic data at the time of a potential detection. If a potential detection was viewed as likely to be from a cetacean, the impulsive signals were grouped as a detection "event" in PAMGuard, and events were labeled and stored for later analysis and scrutiny. Event labels could represent a recognized species (e.g., sperm whale), a previously identified echolocation type (e. g., "BW37" or "NBHF"), or an unidentified category (e.g., "delphinid" or "possible beaked whale"). New event labels were added in the course of the analysis as potentially new pulse types were identified.

Information on click and pulse events was extracted from PAMGuard databases and binary files using the R packages PAMpal and PamBinaries.<sup>1</sup> For each event, a histogram of inter-pulse interval (IPI), a plot of the average pulse frequency spectrum, and a concatenated spectrogram plot of pulses was created. Although missed detections and the presence of multiple animals can result in misleading IPI estimates, we assume that the peak in the IPI histogram represents the most likely IPI of an individual. These plots were used as aids (in addition to the PAMGuard displays) in the classification of detection events.

The final classification of acoustic events (as a species or as a recognized echolocation pulse type) was by unanimous agreement of two experienced analysts (JB and JST). Multiple traits were used to classify beaked whale FM pulse types including the presence of an upsweep, peak frequency, ancillary frequency peaks in the spectrum, and IPI. Sperm whales were recognized from their regular echolocation clicks that are short (typically only a few cycles), with a peak frequency less than 15 kHz and an inter-click interval greater than 0.4 s. Large delphinid species were recognized from their regular echolocation clicks that are short (typically only a few cycles), with a peak frequency greater than 15 kHz, and from contextual information in the spectrogram (such as burst pulses and whistles). NBHF species were recognized from their relatively long (many cycles), high-frequency (>100 kHz) pulses. If the two analysts disagreed about a classification, their final consensus classification was based on a higher level of taxonomy (such as "unidentified beaked whale").

# 3. Results

The hydrophone was towed at a nominal depth of 4–6 m for a total of 720 h and 5250 km on Leg 1 (to South Georgia and the South Sandwich Islands) and for a total of 408 h and 2455 km on Leg 2 (to the Antarctic Peninsula). The average speeds were 7.3 and 6.0 km  $h^{-1}$  (respectively). A total of 51 acoustic detection events were found in the analyses of Leg 1 recordings and 14 acoustic detection events were found in the analyses of the Leg 2 recordings (Table 1; Figs. 2–4).

#### 3.1. Beaked whales

Sixteen of the acoustic detections had FM pulses with the characteristic frequency upsweep that has been used to identify beaked whales in other studies (Baumann-Pickering et al., 2013) (Table 2). Two others had long echolocation pulses with peak frequencies of 15–16 kHz and no evidence of an upsweep, matching the previous, bandwidth-limited recordings of Arnoux's beaked whales (Rogers and Brown 1999) (Table 2). One of these two occurred ~5 km from a sighting of Arnoux's beaked whales in Gerlache Strait during Leg 2 (approximately 1 h after that sighting). Both were classified as Arnoux's beaked whales. Table 2 gives the median frequency characteristics of all beaked whale acoustic detections.

The majority (n = 11) of the 16 acoustic detections with FM pulses were labeled by both analysts as BW29 and were therefore classified as southern bottlenose whales. Of the remaining 5 detections, two closely matched two previously described echolocation pulse types (BW37/39 and BW58) (Fig. 5). One of the others was not sufficiently distinctive to classify as a previously described pulse type or as a new pulse type and is listed in Table 2 as an unidentified beaked whale. The FM pulses associated with the other two detections were sufficiently distinctive to justify new names for these signal types (BW40V and BW41).

Our BW37/39 FM pulse type (Table 2, Fig. 5) shares characteristics with both the previously described BW37 and BW39 pulse types. The peak frequency is closer to the 39 kHz FM pulse described by Giorli et al., (2018), but the IPI (0.15 s) is intermediate between the value they measured (0.22 s) and that measured by Trickey et al. (2015) for BW37 (0.12 s). Like the other two FM pulse types, our BW37/39 pulse had a secondary frequency peak between 20 and 30 kHz.

Our BW58 FM pulse type has a lower peak frequency (53 kHz) than that described for BW58 (Baumann-Pickering et al., 2015), however both studies found a broad, flat peak at 50–60 kHz, significant energy up to 100 kHz, and a strong secondary peak at 25–28 kHz. The relative amplitude of this secondary peak is less than 10 dB below than the primary peak. The IPI in that study (0.26 s) is also similar to the value we measured (0.29 s).

The BW40V FM pulse type has a frequency valley at 40 kHz between two almost equal frequency peaks (at 34 and 48 kHz) (Fig. 5) and a median IPI of 0.48 s. This name follows the nomenclature used by Griffiths et al. (2019) to describe the BW37V beaked whale pulse type which has a frequency valley at 37 kHz between two almost equal frequency peaks at 36 and 48 kHz. This FM pulse type was found only once, on Leg 1 (Fig. 3).

The BW41 FM pulse type had peak and center frequencies of 41 kHz (Fig. 5) and a median IPI of 0.45 s. This name follows the usual nomenclature used for beaked whales with a single peak frequency; however, a secondary frequency peak at 25–27 kHz was frequently observed with an amplitude of ~10 dB less than the primary peak (Fig. 5). This FM pulse type was found only once, on Leg 1 (Fig. 3).

The signals attributed to Arnoux's beaked whales were quite variable but all had a low peak frequency (15-16 kHz) and a narrow -3 dB

<sup>&</sup>lt;sup>1</sup> https://github.com/TaikiSan21.

Locations and times of acoustic detection events that include odontocete echolocation signals detected on towed hydrophone surveys to the South Sandwich Islands and South Georgia, and to the Antarctic Peninsula. Acoustic event types are classified to species if possible. Other acoustic event types are explained in the text.

1: sunthershielders and sound everyal veryal     9     9.4.7.1.9 <t< th=""><th>Event sequential number</th><th>Event ID</th><th>Start date/time (UTC)</th><th>Event type</th><th>Number of echolocation signals</th><th>South latitude</th><th>West longitude</th></t<>	Event sequential number	Event ID	Start date/time (UTC)	Event type	Number of echolocation signals	South latitude	West longitude		
1 1 12/1/12019 02/2 NHF 9 9,2,47/8 5,167/2   3 13 12/1/12019 02/3 NHF 3 3.2,507 5,167/2   3 0 12/1/12019 02/3 NHF 3 3.500 6,167/2   5 0 1/1/2000 15/4 Southers builtnow what 5 5 4,072 4,572   7 4 1/1/2000 15/4 Southers builtnow what 5 5 4,572 4,532   8 1/1/2000 17/18 NUMV 5 5 5,6810 4,5232   10 1 1/22000 17/18 Southers builtnow what 6 6 5,6810 4,5232   11 0 1/22000 17/18 Southers builtnow what 6 6 6,6750 8,1149   12 0 1/22000 17/18 Southers builtnow what 6 6,6750 8,1149   15 1/3/2000 12/1 NHF 3 5 8,0760 8,0767   16 1/3/2000 12/1 NHF 3 5 8,0767 8,0767   17 13/00 12/1 1/3/2000 12/4 NHF 3 8,0766 8,0767   17 13/00 12/1 1/3/2000 12/4 NHF 3 8,0766 8,	Leg 1: South Sandwich Islands and South Georgia Voyage								
2 3.3 1.2/J.2019 02.55 NHF 28 5.2.506 5.4.212   4 3.7 1.2/J.2019 02.55 NHF 27 5.2.716 6.4.212   5 9 1./1/2010 02.41 Suthern hotterner while 7 5.4.507 4.5.001 4.5.201   7 8 1./1/2020 15.64 Southern hotterner while 7 5.4.607 4.5.001 4.5.001   8 1./1/2020 15.64 Southern hotterner while 7 5.4.607 4.5.001 4.5.201   9 3.8 1./1/2020 15.25 BV4 Hotterner while 8 5.6.101 4.5.208   11 17 1.2/2020 03.24 BV4 Hotterner while 8 5.2.308 3.5.101 4.5.208   12 1.2/2020 03.24 BVHF 8 5.2.308 3.5.208 3.5.208   14 1.2/2020 03.24 NHF 8 5.3.010 4.5.208 3.5.208   15 1.2/2020 03.24 NHF 8 5.3.010 4.5.208 3.5.208   16 1.1 1.2/2020 03.24 NHF 8 5.3.010 3.5.208   16 1.2/2020 03.24 NHF 8 5.3.010 3.5.010 3.5.010   17 1.2/2020 03.24 NHF	1	31	12/31/2019 02:27	NBHF	49	52.4718	55.1660		
3 1,3 12,3(29) 97.30 1937 13 35.27168 94.2125   5 90 11/2200 07.41 NHIP 6 34.0431 41.083   5 7 11/2200 17.54 NHIP 6 54.0431 41.083   6 7 11/2200 17.54 NHIP 6 54.0431 45.0431   7 11/2200 17.54 NHIP 3 56.6007 45.0331   9 38 11/2202 07.55 NHIP 3 56.6007 45.0331   9 38 11/2202 07.55 NHIP 3 56.6007 43.0331   11 7 12/2200 07.56 NHIP 60 56.045 37.037   12 12/2200 17.54 Southern bottineou whale 60 56.045 37.037   13 12/2200 17.54 Southern bottineou whale 3 56.045 37.037   14 12/2200 17.54 Southern bottineou whale 3 57.057 38.037   15 12/2200 17.54 Southern bottineou whale 3 57.056 27.3997   16 12/2200 17.54 Southern bottineou whale 3 57.056 27.3997   16 12/2200 17.54 Southern bottineou whale 3 50.056 </td <td>2</td> <td>33</td> <td>12/31/2019 03:55</td> <td>NBHF</td> <td>28</td> <td>52.5505</td> <td>54.8724</td>	2	33	12/31/2019 03:55	NBHF	28	52.5505	54.8724		
4     3.7     1.1/2.000     NHIF     27     5.3509     9.49782       5     90     1.1/2.000     NHIF     6     5.4500     7.3583       6     7     1.1/2.000     1.541     Southern bottlease whate     15     5.4500     7.3583       9     1.1/2.000     1.74200     1.74200     1.74200     5.6110     4.5202       10     17     1.1/2.200     1.74200     Southern bottlease whate     663     56.1584     39.5701       11     7.8     1.1/2.200     2.544     Sperm whate     666     56.1584     39.5701       12     7.5     1.1/2.200     1.84     Sperm whate     666     56.1584     39.5701       13     1.1/2.200     1.1/2.200     NHIF     2     56.610     37.5771       14     1.1/2.200     NHIF     2     56.610     37.5771     35.5781       15     1.1/2.200     NHIF     2     56.7119     36.5381     30.0075       16     1.1/2.200     NHIF     Settee <td>3</td> <td>13</td> <td>12/31/2019 07:30</td> <td>BW37</td> <td>13</td> <td>52.7168</td> <td>54.2125</td>	3	13	12/31/2019 07:30	BW37	13	52.7168	54.2125		
5     90     1/1/2001     NHF     6     94,0483     94,0483       2     8     1/1/2001     Softem Fortienze whate     27     8,4721     47,3140       2     8     1/1/2002     Softem Fortienze whate     27     8,4721     47,3140       2     3     1/1/2002     Softem Fortienze whate     90     55,4101     45,2291       10     9     1/2/2002     Softem Fortienze whate     66     55,4101     45,2291       11     9     1/2/2002     Softem Fortienze whate     66     55,1013     39,3752       13     9     1/2/2002     NHF     8     86,2750     33,1149       14     1/2/2002     NHF     8     86,2750     33,8374       15     16     1/2/2002     NHF     8     86,2750     33,8374       16     1/2/2002     NHF     Anore Softem Fortemer whate     6     57,1074     34,8374       16     1/2/2002     NHF     Anore Softem Fortemer whate     6     57,1074     34,8374	4	37	1/1/2020 03:43	NBHF	247	53.9509	49.9782		
6   7   1/1/200   15.500   Southern bordinger while   15   54.500   7.2685     8   3   1/1/200   15.500   Signer   1   7.2685     9   1/2/200   25.53   NHF   1   3   56.100   45.239     10   17   1/1/200   12/200   25.55   NHF   8   55.1299   40.139     11   9   1/2/200   25.36   NHF   8   666   55.1394   40.139     12   75   1/2/200   25.66   NHF   8   56.285   39.520     13   4.64   1/2/200   1/2/200   NHF   2   54.7619   30.0075     14   1/2/200   1/2/200   NHF   10   55.7116   34.5605     15   1/2/200   1/2/200   Southern butlence while   6   50.295   30.0075     16   92   1/2/200   1/2/200   Southern butlence while   35.7116   34.5605     17   1/2/200   1/2/200   NHF   11/2/200   36.3616   30.0075     16	5	90	1/1/2020 07:43	NBHF	6	54.0943	49.1083		
7     8     11/2001     15.50     Subhern butterne whele     27     5.45.21     45.4502       9     38     11/2002     NHF     10     5     5.6401     4.5232       9     38     11/2002     NHF     10     5     5.6401     4.5232       11     9     1/2/2002     11.4     Southern butterne whele     66     5.6216     3.5321       12     37     1/2/2002     11.4     Southern butterne whele     6     5.4353     3.5221       13     32     1/2/2002     NHF     8     5.44750     3.54114       14     40     1/2/2002     NHF     12     5.64750     3.54713       15     1/2/2002     NHF     Number whele     6     5.77078     3.5075       16     11/2/2002     Number whele     14     5.54750     3.5617       21     11/2/2002     Number whele     14     5.54750     3.3576       22     23     11/2/2002     Number whele     14     5.54753	6	7	1/1/2020 15:44	Southern bottlenose whale	15	54.5590	47.3655		
8     91     1.1./2002 17:8     RW40V     5     54.6607     46.6859       9     38     1.1./2002 12:54     NW1     11     5.1.010     45.2129       10     17     1.2.2001 05:56     NW1     697     5.5.101     40.7703       12     7     1.2.2002 12:34     Sprem bulk mone whale     697     5.6.194     39.7972       13     39     1.2.2002 03:32     NBHF     8     6.2.385     39.5220       14     40     1.4.2.2002 08:32     NBHF     2     5.6.045     37.3907       15     13     1.2.4.2002 08:32     NBHF     3     5.7.0337     34.8574       16     102     1.2.4.2002 08:34     Southern botinace whale     6     57.0337     34.8574       17     101     1.2.4.2002 09:32     NBHF     NB     6     57.0337     34.8574       16     02     1.2.2.2002 01:32     NBHF     NB     6     57.0337     34.8574       17     03     1.2.2.2002 01:32     NBHF     NB	7	8	1/1/2020 15:56	Southern bottlenose whale	27	54.5721	47.3140		
9     38     1.1./2.000     25.22     NBHF     13     55.0810     45.229       11     9     1.2.2000     25.05     Walk     40     56.129     40.1339       11     9     1.2.2000     23.45     Sonthern bottlence whale     40     56.129     40.1339       14     40     1.7.2020     23.45     NHF     8     56.4750     38.1149       15     1.1.7.2020     13.21     Possible leaked whale     10     56.7419     36.0757       16     1.7.2020     13.22     Possible leaked whale     6     57.1104     34.5605       17     101     1.7.2020     10.22     Southern bottlence whale     6     57.2167     26.429       20     6     1.1.0.2020     17.44     Annour S beaked whale     7     55.8613     26.523       21     9     1.1.1.1.2020     1.4.2020     1.4.2020     1.5.20     56.464       22     9     1.1.1.1.2020     1.4.2020     1.5.20     56.453     30.317       23 <td>8</td> <td>91</td> <td>1/1/2020 17:18</td> <td>BW40V</td> <td>5</td> <td>54.6607</td> <td>46.9659</td>	8	91	1/1/2020 17:18	BW40V	5	54.6607	46.9659		
10   17   1/2/2002 10:50   Suthen bottlasse whee   60   55.1401   43.7704     11   9   1/2/2002 11:40   Suthen bottlasse whee   66   56.1584   30.9752     12   95   1/2/2002 11:40   Suthen bottlasse whee   9   56.6455   37.2007     13   9   1/2/2002 01:21   Path benked whee   10   56.6455   37.2007     16   15   1/2/2002 01:25   NEHF   2   56.6455   37.2007     16   101   1/3/2002 01:254   Southern bottlasse whae   3   57.0357   34.8374     17   101   1/3/2002 01:24   Southern bottlasse whae   45   57.078   26.6629     21   07   1/1/2/2002 02:35   Suthen bottlasse what   43   58.672   26.817     22   21   1/1/2/2002 02:45   Killer whate   7   7   58.617   30.572     23   1/1/2/2002 02:45   Killer whate   10   7   58.637   30.572     24   1/1/2/2002 02:54   Southern bottlasse whate   32   55.0317   30.5050     25 <td>9</td> <td>38</td> <td>1/1/2020 23:52</td> <td>NBHF</td> <td>13</td> <td>55.0810</td> <td>45.2329</td>	9	38	1/1/2020 23:52	NBHF	13	55.0810	45.2329		
11   9   1.2.2000 1:44   Southern bortlones while   497   66.1299   40.1399     131   39   1.2.2000 1:24   Span while   664   56.1284   39.7221     134   39   1.2.2000 1:23   NBH   8   56.2484   39.7207     135   1.7.2000 1:321   NBH   1   20.000 1:321   Span while   9   56.4491   30.0075     16   15   1.7.2020 1:321   Possible leaked while   10   56.7419   36.0075     17   101   1.7.2020 1:829   Possible leaked while   6   57.1104   34.5605     18   0.2   1.7.2020 1:829   Southern bortlones while   45   59.254   26.6539     21   93   1.1.0.2020 1:746   Arnoux's beaked while   7   57.861   26.784     23   21   1.1.1.0200 0:32   Southern bortlones while   400   85.7752   26.413     24   1.1.4.72000 1:2.8   Southern bortlones while   71   55.863   30.357     25   23   1.1.4.72020 1:2.8   Southern bortlones while   71   55.3663   33.45	10	17	1/2/2020 05:50	BW41	80	55.4101	43.7704		
12 75 1/2/2002 1/4 Sperm whale 666 56.1584 39.9752   13 39 1/2/2002 1/2/2002 1/1 8 52.238 39.522   14 41 1/2/2002 1/1 1/1 1/1 1/1 1/1 1/1   16 15 1/2/2002 1/2 1/1 1/2 1/1 1/1 1/1   17 101 1/2/2002 1/2 1/2 1/1 1/2 1/2 1/1 1/2 1/2 1/1 1/2 1/2 1/1 1/2 1/2 1/1 1/2 1/1 1/2 1/1 1/2 1/1 1/2 1/1 1/2 1/1 1/2 1/1 1/2 1/1 1/2 1/1 1/2 1/1 1/2 1/1 1/2 1/1 1/2 1/1 1/2 1/1 1/2 1/1 <td>11</td> <td>9</td> <td>1/2/2020 21:05</td> <td>Southern bottlenose whale</td> <td>497</td> <td>56.1299</td> <td>40.1339</td>	11	9	1/2/2020 21:05	Southern bottlenose whale	497	56.1299	40.1339		
13   39   1/2/2002 02:38   NBIP   8   56.288   39.520     14   40   1/2/2002 06:30   NBIP   2   56.6494   37.2607     15   41   1/2/2002 06:32   NBIP   2   56.6494   37.2607     16   10   1/2/2002 07:24   southern bottmose whale   6   57.1104   44.557     18   102   1/2/2002 07:24   southern bottmose whale   6   57.7078   66.6829     20   67   1/10/2002 07:24   Kather bottmose whale   4   58.2752   26.6137     21   93   1/10/2002 07:24   Kather bottmose whale   4   58.2752   26.8137     23   1/11/2002 00:26   Southern bottmose whale   14   58.2752   26.8137     24   94   1/12/2002 10:26   Southern bottmose whale   13   26.5788   30.1367     25   44   1/14/2002 10:26   Southern bottmose whale   13   33.550   33.759     26   1/14/2002 10:26   Southern bottmose whale   13   33.650   33.550     27   24   1/14/2002 10:23	12	75	1/2/2020 21:44	Sperm whale	668	56.1584	39.9752		
14   40   1/3/200 03:08   NBH   3   56.495   37.2007     15   4.1   1/3/200 12:21   Possible beaked whale   10   56.7417   36.0071     16   10   1.3/200 11:22   Possible beaked whale   10   56.7417   36.0071     17   101   1.3/200 11:23   Possible dephnial   10   56.7417   36.0071     18   0.3/200 11:04   Possible dephnial   28   57.0718   46.565     19   92   1.5/2020 00:24   Possible dephnial   78   58.756   26.863     21   111/1/2020 02:46   Killer whale   78   58.7572   26.8643   30.1367     22   11   1.1/1/2020 02:46   Killer whale   1620   58.3727   26.8633     23   1.1/1/2020 02:46   Killer whale   7   55.0813   30.1367     24   1.1/1/2020 02:46   Stottern bottensore whale   371   55.0813   33.4783     25   4.6   1.1/1/2020 01:53   Killer whale   7   55.083   33.7783     26   1.1/1/2020 01:53   Killer whale <td< td=""><td>13</td><td>39</td><td>1/2/2020 23:38</td><td>NBHF</td><td>8</td><td>56.2385</td><td>39.5220</td></td<>	13	39	1/2/2020 23:38	NBHF	8	56.2385	39.5220		
12     14     1/3/2000 08:25     NR1P     2     56.049     37.2400       16     10     1/3/2000 1539     Southern bortinesse whale     6     57.110     44.5605       19     92     1/5/2000 07:24     Possible dephnind     256     57.7078     66.6529       20     6.7     1/10/2000 17:46     Amours 'keeked whale     45     59.257     26.6529       21     93     1/10/2000 07:47     Killer whale     76     58.756     26.6589       23     67     1/11/2000 07:46     Killer whale     4     58.792     26.6164       24     94     1/12/2000 19:28     Southern bortinesse whale     14     55.7838     30.1367       25     44     1/13/2000 10:28     Southern bortinesse whale     13     26.53.083     33.7781       26     23     1/14/2000 10:28     Southern bortinesse whale     37     35.3003     33.7781       27     24     1/14/2000 10:28     Southern bortinesse whale     32     32.300     45.313       26     1/27/2000 10:07	14	40	1/3/2020 05:08	NBHF	3	56.4750	38.1149		
16     15     1/3/2001/12/4     Postenic bolicance whale     10     55./14/13     34.800/3       17     101     1/3/2001/12/4     Southern ionicinose whale     6     57.0137     34.837       18     102     1/3/2001/12/4     Southern ionicinose whale     6     57.0137     34.857       19     20     1/1/2002/31/7     Kinner whate     76     52.258     26.539       21     1/1/1/2000/24.6     Killer whate     78     55.778     26.648       22     21     1/1/1/2000/24.6     Killer whate     70     55.9418     26.6523       24     94     1/2/3/2002/13.23     NBHF     7     55.9418     26.6533       25     23     1/4/4/2021/538     Southern bottiences whate     371     55.033     33.34550       28     6     1/1/4/2021/538     Southern bottiences whate     32     55.2033     34.550       30     95     1/26/2020/137     Kultern bottiences whate     31     55.033     33.4550       28     6     1/1/4/2021/528     S	15	41	1/3/2020 08:25	NBHF	2	56.6045	37.2907		
1/2   101   1.07 AUAI 17.54   Solutient Dottines whale   3   50 (30.5)   34.85/4     18   102   1.07 2020 105.4   Possible delphind   28   57.100 4   34.5605     19   92   1.67 2020 002.4   Possible delphind   28   57.100 4   35.8765   26.7889     21   06   1.10 1020 002.2   State whale   4   88.792   26.6137     23   37   1.11 12020 002.2   State whale   4   88.792   26.6437     24   94   1.12 12020 012.8   State whale   16   50.9918   26.8253     25   44   1.13 4000 102.6   Southern bottinesse whale   14   55.033   33.7853     26   23   1.14 40200 102.6   Southern bottinesse whale   3   33.8800   36.617     27   24   1.14 4020 102.6   Southern bottinesse whale   3   33.8800   36.637     30   95   1.126/2020 01.53   NBHF   12   35.8800   36.633   41.733     31   96   1.26/2020 01.53   NBHF   12   33.346   45.2550	16	15	1/3/2020 13:21	Possible beaked whate	10	56.7419	36.0075		
18   102   107 4000 1839   Solutient orderhole wate   0   0   0.1104   34.300     19   92   1.57 2020 12.4   Amous 5 backet whale   45   59.2584   26.652     21   93   1.710/2020 12.17   Killer whale   45   58.7656   28.8572   28.8137     22   21   1.711/2020 06.35   Southern bottenose whale   4   50   58.2572   28.8461     23   44   1.711/2020 06.35   Southern bottenose whale   4   56.013   22.5843   28.8461     24   44   1.714/2020 12.58   Southern bottenose whale   37.17   55.0863   33.4550     25   24   1.74/2020 12.58   Southern bottenose whale   32   55.2033   33.7783     26   1.74/2020 12.68   Southern bottenose whale   32   55.2033   34.550     27   24   1.74/2020 12.58   Southern bottenose whale   32   55.2036   42.650     31   96   1.74/2020 0.450   NBHF   12   56.613   42.550     32   47   1.726/2020 0.457   NBHF   12 <td>17</td> <td>101</td> <td>1/3/2020 17:54</td> <td>Southern bottlenose whale</td> <td>3</td> <td>57.0337</td> <td>34.8374</td>	17	101	1/3/2020 17:54	Southern bottlenose whale	3	57.0337	34.8374		
19     9.2     17/2020 00.26.1     Passine trapmin     2.26     95.00.6     20.00.6     20.00.6       21     63     17/2020 00.26.1     Giller while     7     7     55.756     26.853       23     87     17/12/2020 00.26.6     Killer while     16.20     58.5792     26.8648       24     94     1/12/2020 02.46     Killer while     17     55.6918     26.853       25     44     1/14/2020 15.28     Southern bottlenose whale     14     55.613     33.4550       26     23     1/14/2020 15.28     Southern bottlenose whale     32     55.2033     33.7783       29     104     1/25/2020 15.35     Southern bottlenose whale     32     53.8050     40.2650       31     96     1/26/2020 0.435     NBHF     12     53.3450     45.2550       33     48     1/27/2020 0.246     NBHF     12     53.3450     45.2550       35     97     1/27/2020 0.522     NBHF     24     53.3450     45.2550       36     98	18	102	1/3/2020 18:59	Southern Dottienose whale	D 258	57.1104	34.5605		
20     0     1/10/2000 12:17     Mutual pread water     43     35     35.2.5.84     252.5.84       21     11/1/2000 02:21     Suttler whate     40     88.2572     25.864       23     87     11/1/2000 02:23     Suttler whate     1620     56.3783     20.8573       24     11/1/2000 02:23     UBER filled odontocce     17     55.3783     20.1567       25     44     11/1/2000 12:25     Southern bottlenose whate     14     55.3783     33.4550       26     1/14/2020 15:28     Southern bottlenose whate     32     55.3083     33.4550       28     6     1/4/2020 15:28     Southern bottlenose whate     32     53.3850     36.517       29     104     1/25/2020 15:37     Southern bottlenose whate     32     53.3850     36.517       30     95     1/26/2020 01:53     Southern bottlenose whate     32     53.3850     45.2530       31     96     1/26/2020 01:53     Southern bottlenose whate     32     53.3350     45.737       31     97     1/26/2020	19	92 67	1/5/2020 00:24	Possible delphinid	258 4E	57.7078	26.6829		
1   93   1/10/20010323   Numer   1/0   20   85.7638   20.7638     221   87   1/11/2020 02:40   Killer whale   1620   85.2572   20.8449     23   87   1/11/2020 02:40   Killer whale   17   86.3572   20.8449     24   94   1/12/2020 12:28   Southern bottlenose whale   14   55.1083   33.4560     26   23   1/14/2020 15:38   Southern bottlenose whale   32   55.3083   33.4560     28   6   1/14/2020 15:38   Southern bottlenose whale   32   55.3083   33.4560     30   95   1/26/2020 15:38   Southern bottlenose whale   32   55.3083   43.7783     31   96   1/26/2020 04:37   Unidentified dejhinid   107   53.3450   44.2550     32   47   1/26/2020 05:35   NbHF   5   53.3450   45.2550     34   49   1/27/2020 05:24   NbHF   5   53.3450   45.2560     35   97   1/27/2020 05:24   NbHF   5   53.3450   45.25767     35	20	02	1/10/2020 17:46	Killer whole	45	59.2584	20.9539		
22     21     11     11     2400 02.44     Soliter Inductione whate     4     95.572     26.6137       23     87     11.12/2020 102.46     Stiller whate     1620     Stiller whate     1620     Stiller whate     1620     Stiller whate     17     Stiller whate     Stiller whate     17     Stiller whate     <	21	93	1/10/2020 23:17	Killer wilale	78	58./050	20./880		
23     57     1/1/2020 1928     Nume minice     1620     58.29/2     25.68/5       24     44     1/13/2020 1928     Numerified odontocette     17     55.0918     25.6253       25     44     1/13/2020 1028     Southern bottenose whale     371     55.3083     33.4550       26     23     1/14/2020 1528     Southern bottenose whale     321     55.3083     33.4550       28     6     1/14/2020 1528     Southern bottenose whale     32     55.8650     36.6117       30     95     1/26/2020 1237     Southern bottenose whale     3     55.8650     36.617       31     96     1/26/2020 0467     Unidentified delphind     107     55.3653     41.7373       33     48     1/27/2020 0133     NBHF     5     53.3450     45.2550       34     49     1/27/2020 0122     NBHF     5     53.3450     45.2550       35     97     1/27/2020 0324     Long finned pilot whale     32     53.3450     45.2550       36     98     1/27/2020 03.	22	21	1/11/2020 00:32	Killer whole	4	58.5/92	20.8137		
24     34     1/12/2020 19:28     Differentiate domineter     1/     35.9918     20.623       25     44     1/13/2020 11:28     NBHF     7     55.7683     30.1567       26     23     1/14/2020 10:26     Southern bottienose whale     371     55.8033     33.7783       28     6     1/14/2020 16:38     Southern bottienose whale     32     55.2033     33.7783       29     104     1/25/2020 23:47     Southern bottienose whale     3     58.8050     40.2650       31     96     1/26/2020 01:33     Killer whale     97     53.84050     40.2650       34     49     1/27/2020 01:407     Unidentified delphinid     107     53.3450     45.2550       34     49     1/27/2020 01:40     NBHF     2     53.3450     45.2550       35     97     1/27/2020 01:40     Long finned plot whale     52     53.3067     45.7367       36     98     1/27/2020 09:47     NBHF     9     53.3067     45.7367       37     99     1/27/2020 09:47 <td>23</td> <td>8/</td> <td>1/11/2020 02:46</td> <td>Killer wilale</td> <td>1620</td> <td>56.25/2</td> <td>20.8048</td>	23	8/	1/11/2020 02:46	Killer wilale	1620	56.25/2	20.8048		
25   43   1/12/2020   11.30   NPIP   7   55.7863   30.1307     26   23   1/14/2020   11.25   Southern bottlenose whale   371   55.0117   32.6583     27   24   1/14/2020   15.28   Southern bottlenose whale   32   55.2033   33.7783     28   6   1/14/2020   12.52/2020   Southern bottlenose whale   32   53.8050   39.6317     30   95   1/26/2020   01.53   Killer whale   97   53.7367   40.7000     31   96   1/26/2020   00.53   NBHF   12   53.4350   45.2550     32   47   1/26/2020   00.52   NBHF   24   53.3450   45.2550     34   49   1/27/2020   03.22   Long-finned plit whale   297   53.3067   45.7367     35   97   1/27/2020   04.45   NBHF   9   53.1560   47.1317     40   100   1/27/2020   04.47   NBHF   9   53.1650   47.1317     41   52   1/27/2020   NBHF	24	94	1/12/2020 19:28		1/	50.9918	20.8233		
20   23   1/14/2020   Southern bottensee whate   371   55.0183   33.4550     27   24   1/14/2020   15.38   Southern bottensee whate   371   55.0183   33.4550     28   6   1.11/2020   15.38   Southern bottensee whate   3   35.8500   39.6317     30   95   1.26/2020   0153   Killer whate   9   53.0853   40.2000     31   96   1.26/2020   0153   Niller whate   9   53.0853   41.3733     33   48   1.27/2020   01.40   NiHF   5   53.3450   45.2550     34   49   1.27/2020   02.26   NiHF   9   53.3057   45.5133     35   97   1.27/2020   03.34   Long-finned pliot whate   52   53.3057   45.7367     38   51   1.27/2020   04.47   NiHF   9   53.1650   47.1317     39   7.2   1.27/2020   04.47   NiHF   9   53.1650   47.1317     31   1.27/2020   04.47   NiHF   9   <	25	44	1/13/2020 21:13	NBHF Courthouse bottlesson sub-th-	/	55./883	30.1367		
27   24   1/14/2020   16.2.6.8   Southern bottensee whate   32   55.2033   33.7783     29   104   1/25/2020   12.3   Southern bottensee whate   32   55.2033   33.7783     30   95   1/26/2020   01.53   Nittler whate   97   53.8050   96.51/25     31   96   1/26/2020   01.53   Nittler whate   97   53.6533   41.3733     33   48   1/27/2020   00.63   NBHF   12   53.4550   45.2550     34   49   1/27/2020   03.22   Long-finned plot whate   22   53.3450   45.2550     35   97   1/27/2020   03.22   Long-finned plot whate   59   53.3067   45.7367     36   98   1/27/2020   03.44   Long-finned plot whate   29   53.1650   47.1317     39   72   1/27/2020   NBHF   9   53.1650   47.1317     40   100   1/27/2020   NHF   9   53.1650   47.1317     41   52   1/27/2020   NHF   103	26	23	1/14/2020 10:26	Southern bottlenose whale	14	55.6117	32.6583		
28     6     1/14/2020     Southern Dottenose While     22     52.003     33.7/83       29     104     1/25/2020     Southern Dottenose While     3     53.8050     36.377       30     95     1/26/2020     Ottenern Dottenose While     3     77     53.8050     40.2650       31     96     1/26/2020     Unidentified delphinid     107     53.3653     41.3733       33     48     1/27/2020     0.81HF     5     53.3450     45.2550       34     49     1/27/2020     0.226     NBHF     24     53.3450     45.2550       35     97     1/27/2020     0.226     NBHF     24     53.3067     45.7367       36     98     1/27/2020     0.226     NBHF     9     53.1650     47.1317       37     99     1/27/2020     0.947     NBHF     47     53.1650     47.1317       38     51     1/27/2020     0.947     NBHF     10     53.1317     47.3683       41     100	27	24	1/14/2020 15:28	Southern bottlenose whale	3/1	55.3083	33.4550		
29     104     1/25/2020     Solither Dottensee whale     3     53.8500     39.6317       30     95     1/26/2020     Killer whale     97     53.8600     40.2650       31     96     1/26/2020     Unidentified delphinid     107     53.8300     40.2650       32     47     1/26/2020     NBHF     12     53.8353     41.3733       33     48     1/27/2020     0.26     NBHF     5     53.3450     45.2550       35     97     1/27/2020     0.324     Long-finned pliot whale     32     53.3250     45.133       36     98     1/27/2020     0.814     69     53.3067     45.7367       37     99     1/27/2020     0.409     Long-finned pliot whale     1297     53.1650     47.1317       40     100     1/27/2020     NBHF     9     53.1650     47.1317       41     52     1/27/2020     NBHF     693     53.1317     47.3683       43     107     1/27/2020     NBHF <t< td=""><td>28</td><td>6</td><td>1/14/2020 16:38</td><td>Southern bottlenose whale</td><td>32</td><td>55.2033</td><td>33.//83</td></t<>	28	6	1/14/2020 16:38	Southern bottlenose whale	32	55.2033	33.//83		
30   95   1.240/2020 01:53   Miller Wrate   97   53.8050   40.2650     31   96   1.260/2020 06:35   NBHF   12   53.6533   41.3733     33   48   1.277/2020 01:40   NBHF   5   53.3450   45.2550     34   49   1.277/2020 02:26   NBHF   24   53.3450   45.2550     35   97   1.277/2020 03:34   Long-finned pilot whale   59   53.3067   45.7367     36   98   1.277/2020 09:45   NBHF   9   53.1650   47.1317     39   72   1.277/2020 09:47   NBHF   9   53.1650   47.1317     40   100   1.277/2020 10:47   NBHF   90   53.1317   47.3683     41   52   1.277/2020 11:18   Unidentified delphinid   247   53.1650   47.1317     41   54   1.277/2020 11:18   Unidentified large delphinid   1465   52.8783   49.7517     42   54   1.272/2020 11:18   Unidentified large delphinid   1465   52.8783   49.7517     43   107   1	29	104	1/25/2020 23:4/	Southern Dottienose whale	3	53.8500	39.6317		
31   96   1.22/2020 (0:55)   NBHF   102   53.7.667   40.7000     32   47   1.26/2020 (0:55)   NBHF   12   S3.6533   41.3733     33   48   1.277/2020 (0:26)   NBHF   5   S3.3450   45.2550     35   97   1.277/2020 (0:22)   Long-finned plot whale   32   S3.350   45.5133     36   98   1.277/2020 (0:42)   Long-finned plot whale   659   53.3067   45.7367     37   99   1.277/2020 (0:47)   NBHF   9   53.1650   47.1317     39   72   1.277/2020 (0:47   NBHF   47   S3.1650   47.1317     40   100   1.272/2020 (0:47   NBHF   693   S3.1317   47.3683     41   52   1.272/2020 (0:47   NBHF   693   S3.1317   47.3683     42   54   1.272/2020 11:17   NBHF   693   S3.1317   47.3683     43   107   1.272/2020 11:18   Unidentified dontocete   4   S3.1317   47.3683     44   56   1.272/2020 11:18   NBHF	30	95	1/26/2020 01:53	Killer whale	97	53.8050	40.2650		
32   47   1/20/2020 01:40   NBHP   12   53.05.33   41.37.33     33   48   1/27/2020 01:40   NBHF   5   53.3450   45.2550     34   49   1/27/2020 03:22   Long-finned pilot whale   24   53.3450   45.2530     35   97   1/27/2020 03:34   Long-finned pilot whale   659   53.3067   45.7367     38   51   1/27/2020 09:45   NBHF   9   53.1650   47.1317     39   72   1/27/2020 09:47   NiBHF   47   53.1650   47.1317     40   100   1/27/2020 09:47   NiBHF   693   53.1317   47.3683     41   52   1/27/2020 10:47   NBHF   100   53.1317   47.3683     42   54   1/27/2020 11:18   NBHF   100   53.1317   47.3683     43   107   1/27/2020 11:18   NBHF   100   53.1317   47.3683     44   56   1/27/2020 11:51   NBHF   191   52.6460   51.7467     45   105   1/28/2020 05:59   NBHF   191	31	96	1/26/2020 04:0/		10/	53./36/	40.7000		
33   48   1/2//2020 0:2:6   NBH   5   5.3,48:0   42.2530     34   49   1/27/2020 0:2:6   NBH   24   5.3,3450   45.2550     35   97   1/27/2020 0:2:2   Long-finned pilot whale   52   53.3250   45.5133     36   98   1/27/2020 0:4:3   Long-finned pilot whale   1297   53.3067   45.7367     38   51   1/27/2020 0:4:7   NBHF   9   53.1650   47.1317     40   100   1/27/2020 0:4:7   NBHF   693   53.1317   47.3683     41   52   1/27/2020 0:4:7   NBHF   693   53.1317   47.3683     42   54   1/27/2020 1:17   NBHF   10   53.1317   47.3683     43   107   1/27/2020 1:15   NBHF   19   53.1313   47.6200     44   56   1/27/2020 1:15   NBHF   19   53.1033   47.6200     45   105   1/27/2020 1:15   NBHF   19   53.103   52.6400   51.7467     46   89   1/28/2020 0:59   NBHF <t< td=""><td>32</td><td>47</td><td>1/26/2020 06:35</td><td>NBHF</td><td>12</td><td>53.6533</td><td>41.3/33</td></t<>	32	47	1/26/2020 06:35	NBHF	12	53.6533	41.3/33		
34     49     1/21/2020     NBFF     24     5	33	48	1/2//2020 01:40	NBHF	5	53.3450	45.2550		
35   97   1/27/2020   03:34   Long-finned pilot whale   659   53.3067   45.7367     37   99   1/27/2020   04:09   Long-finned pilot whale   1297   53.3067   45.7367     38   51   1/27/2020   09:45   NBHF   9   53.1650   47.1317     39   72   1/27/2020   09:47   NBHF   47   53.1650   47.1317     40   100   1/27/2020   10:47   NBHF   693   53.1317   47.3663     42   54   1/27/2020   11:8   Unidentified dototoccet   4   53.1317   47.3663     43   107   1/27/2020   11:8   Unidentified dototoccet   4   53.1317   47.3663     44   56   1/27/2020   12:15   NBHF   19   53.1033   47.6200     45   105   1/27/2020   12:16   NBHF   191   52.6987   51.2900     46   89   1/28/2020   03:39   Unidentified large delphinid   1465   52.4967   52.7600     47   57   1/28/2020 <td< td=""><td>34</td><td>49</td><td>1/2//2020 02:20</td><td>NDFIF</td><td>24</td><td>53.3450</td><td>45.2550</td></td<>	34	49	1/2//2020 02:20	NDFIF	24	53.3450	45.2550		
36   39   1/2/2020 03:34   Long-finned pilot whale   059   050   45./367     37   99   1/27/2020 09:45   NBHF   9   53.1650   47.1317     38   51   1/27/2020 09:47   NBHF   9   35.1650   47.1317     40   100   1/27/2020 09:47   NBHF   693   53.1650   47.1317     41   52   1/27/2020 10:47   NBHF   693   53.1317   47.3683     42   54   1/27/2020 11:17   NBHF   693   53.1317   47.3683     43   107   1/27/2020 11:18   Unidentified dontocete   4   53.1317   47.3683     44   56   1/27/2020 12:15   NBHF   19   53.1033   47.6200     45   105   1/27/2020 12:15   NBHF   191   52.6987   51.2900     47   57   1/28/2020 02:59   NBHF   9   52.4967   52.7600     47   57   1/28/2020 05:59   NBHF   9   52.4967   52.7600     50   60   1/28/2020 19:49   NBHF   10   53.18	35	97	1/2//2020 03:22	Long-finned pilot whale	32	53.3230	45.5133		
37   39   1/2/2020 09:45   NBHF   9   53.067   45.7807     38   51   1/27/2020 09:47   NBHF   47   53.1650   47.1317     40   100   1/27/2020 09:47   NBHF   47   53.1650   47.1317     41   52   1/27/2020 10:47   NBHF   693   53.1317   47.3683     42   54   1/27/2020 11:18   Unidentified dontocete   4   53.1033   47.6200     43   107   1/27/2020 11:18   NBHF   10   53.1033   47.6200     44   56   1/27/2020 12:15   NBHF   19   53.1033   47.6200     45   105   1/28/2020 03:39   Unidentified large delphinid   1465   52.6783   49.7517     46   89   1/28/2020 03:39   NBHF   191   52.6400   51.7467     48   59   1/28/2020 03:39   NBHF   6   52.24967   53.2333     50   60   1/28/2020 19:49   NBHF   10   52.2250   55.1850     51   106   1/29/2020 05:13   NBHF   10	30	98	1/2//2020 03:34	Long-finned pilot whale	1207	53.3007	45./30/		
38   31   1/2//2020 05:47   NBHF   9   35.1030   47.1317     40   100   1/27/2020 09:47   Unidentified delphinid   247   53.1650   47.1317     40   100   1/27/2020 09:47   Unidentified delphinid   247   53.1650   47.1317     41   52   1/27/2020 11:17   NBHF   693   53.1317   47.3683     42   54   1/27/2020 11:17   NBHF   10   53.1317   47.3683     43   107   1/27/2020 11:15   NBHF   19   53.1033   47.6200     45   105   1/27/2020 12:15   NBHF   19   53.1033   47.6200     46   89   1/28/2020 05:59   NBHF   191   52.6400   51.7407     47   57   1/28/2020 05:59   NBHF   6   52.4967   52.7600     49   106   1/28/2020 15:08   NBHF   90   52.4167   53.2333     50   60   1/28/2020 15:39   NBHF   15   52.250   55.1850     51   61   1/29/2020 16:33   Possible delphinid   34	37	99 E1	1/27/2020 04:09	NPLIE	1297	53.3007	43.7307		
39   72   1/2/2020 09:47   NBIF   47   53.1650   47.1317     40   100   1/27/2020 09:47   NBHF   693   53.1317   47.3683     41   52   1/27/2020 11:17   NBHF   693   53.1317   47.3683     42   54   1/27/2020 11:18   NBHF   10   53.1317   47.3683     43   107   1/27/2020 11:15   NBHF   19   53.1033   47.6200     45   105   1/27/2020 12:15   NBHF   19   52.6497   51.2900     46   89   1/28/2020 03:39   Unidentified large delphinid   1465   52.6497   51.2900     47   57   1/28/2020 09:50   NBHF   191   52.6400   51.7467     48   59   1/28/2020 09:50   NBHF   6   52.4967   52.7600     49   106   1/28/2020 19:49   NBHF   15   52.8250   55.1850     51   61   1/28/2020 19:57   NBHF   10   64.6523   62.2670     2   38   2/17/2020 19:56   NBHF   10   64.55393 </td <td>38 20</td> <td>51 72</td> <td>1/27/2020 09:45</td> <td>NDHE</td> <td>9</td> <td>53.1050</td> <td>47.1317</td>	38 20	51 72	1/27/2020 09:45	NDHE	9	53.1050	47.1317		
10   1/2/2020 01.47   Ondernine depining   247   53.1030   47.101     41   52   1/27/2020 01.47   NBHF   693   53.1317   47.3683     42   54   1/27/2020 11.17   NBHF   10   53.1317   47.3683     43   107   1/27/2020 11.18   Undentified odonotcet   4   53.1317   47.3683     44   56   1/27/2020 12.15   NBHF   19   53.1033   47.6200     45   105   1/27/2020 12.15   NBHF   191   52.6487   51.2900     46   89   1/28/2020 05:59   NBHF   191   52.6400   51.7467     47   57   1/28/2020 05:50   NBHF   6   52.4967   52.2600     49   106   1/28/2020 15:08   NBHF   90   52.4167   53.2333     50   60   1/28/2020 15:3   NBHF   15   52.2250   55.1850     51   61   1/29/2020 05:13   NBHF   10   63.5593   65.7100     2   Anteritie depinind   349   64.6523   62.2670	39 40	100	1/27/2020 09:47	NDFIF Unidentified delphinid	47	53,1050	47.1317		
11   32   12/2020 10:7/   NBHF   050   50.1017   47.3063     12   54   1/27/2020 11:18   Unidentified dontocete   4   53.1317   47.3683     13   107   1/27/2020 11:18   Unidentified dontocete   4   53.1317   47.3683     14   56   1/27/2020 11:10   Unidentified large delphinid   1465   52.8783   49.7517     16   89   1/28/2020 03:39   Unidentified large delphinid   9430   52.6407   52.7600     17   57   1/28/2020 05:59   NBHF   6   52.4967   52.7600     48   59   1/28/2020 12:08   NBHF   90   52.4167   53.2333     50   60   1/28/2020 19:06   NBHF   4   51.8350   56.9667     Leg 2: Antarctic Peninsula Voyage     1   39   2/16/2020 16:33   Possible delphinid   349   64.6523   62.2670     2   38   2/17/2020 19:06   Arroux's beaked whale   4   64.7639   62.8748     3   40   2/24/2020 10:57   NBHF   10   63.5593	40	52	1/27/2020 09.47	NRHE	603	53 1317	47.1317		
12   34   1/2//2020 11:1/   NBH   10   53.1317   47.3063     43   107   1/27/2020 11:15   NBHF   19   53.1033   47.6200     44   56   1/27/2020 12:15   NBHF   19   53.1033   47.6200     45   105   1/27/2020 21:01   Unidentified large delphinid   1465   52.8783   49.7517     46   89   1/28/2020 03:39   Unidentified large delphinid   9430   52.6987   51.2900     47   57   1/28/2020 05:59   NBHF   191   52.4000   51.7467     48   59   1/28/2020 19:68   NBHF   90   52.4167   53.2333     50   60   1/28/2020 19:49   NBHF   4   51.8350   56.9667     Leg 2: Antarctic Peninsula Voyage	41	54	1/27/2020 10.47	NBHE	10	53.1317	47.3063		
107   1/2//2020   11:15   NBHF   19   53:131/   47.3083     444   56   1/27/2020   12:15   NBHF   19   53:1033   47.6200     45   105   1/27/2020   12:10   Unidentified large delphinid   1465   52.8783   49.7517     46   89   1/28/2020   03:39   Unidentified large delphinid   9430   52.6987   51.2900     47   57   1/28/2020   05:59   NBHF   19   15.24067   52.7600     48   59   1/28/2020   09:50   NBHF   6   52.4967   52.2760     49   106   1/28/2020   12:08   NBHF   9   52.2250   55.1850     51   61   1/29/2020   15:13   NBHF   4   51.8350   56.9667     Leg 2: Antarctic Peninsula Voyage     1   39   2/16/2020   16:33   Possible delphinid   349   64.6523   62.2670     2   38   2/17/2020   19:25   NBHF   10   63.5157   65.7100     4   9   2/	42	107	1/27/2020 11.17	NDFIF Unidentified adoptosets	10	53.1317	47.3063		
14   30   1/2/2020 12:15   NBHF   19   53.1033   47.0200     45   105   1/27/2020 21:01   Unidentified large delphinid   1465   52.8783   49.7517     46   89   1/28/2020 03:39   Unidentified large delphinid   9430   52.6987   51.2900     47   57   1/28/2020 05:59   NBHF   191   52.4967   52.7600     48   59   1/28/2020 12:08   NBHF   90   52.4167   53.2333     50   60   1/28/2020 19:49   NBHF   15   52.2250   55.1850     51   61   1/29/2020 05:13   NBHF   4   51.8350   56.9667     Leg 2: Antarctic Peninsula Voyage     7   39   2/16/2020 16:33   Possible delphinid   349   64.6523   62.2670     2   38   2/17/2020 19:06   Arnoux's beaked whale   4   64.7639   62.8748     3   40   2/24/2020 11:25   NBHF   10   63.5157   65.7827     5   10   2/24/2020 11:25   NBHF   8   63.4741   65.8505 <t< td=""><td>43</td><td>107</td><td>1/27/2020 11:18</td><td>NIPLIE</td><td>4</td><td>53.1317</td><td>47.3063</td></t<>	43	107	1/27/2020 11:18	NIPLIE	4	53.1317	47.3063		
105   172/1202 01:03   Unidentified large delphinid   1403   52.6987   51.2900     46   89   1/28/2020 05:59   NBHF   191   52.6400   51.7467     48   59   1/28/2020 05:59   NBHF   6   52.4967   52.7500     49   106   1/28/2020 12:08   NBHF   90   52.4167   53.2333     50   60   1/28/2020 15:3   NBHF   15   52.250   55.1850     51   61   1/29/2020 05:13   NBHF   4   51.8350   56.9667     Leg 2: Antarctic Peninsula Vyage   7   7   64.6523   62.2670   62.8748     2   38   2/16/2020 16:53   NBHF   10   63.5593   65.7100     4   9   2/24/2020 10:57   NBHF   10   63.5157   65.7827     5   10   2/24/2020 11:25   NBHF   8   63.4741   65.8872     6   37   2/24/2020 11:50   NBHF   8   63.4741   65.8875     6   37   2/24/2020 11:55   Suthern bottlenose whale   9   62.4652	44	105	1/27/2020 12:13	Unidentified large delphinid	19	52 9793	47.0200		
10   35   1/28/2020 05.59   Olderhinder large delphind   94.50   52.6360   51.7467     47   57   1/28/2020 05:59   NBHF   191   52.6400   51.7467     48   59   1/28/2020 09:50   NBHF   6   52.4967   52.7600     49   106   1/28/2020 19:49   NBHF   90   52.4167   53.2333     50   60   1/28/2020 05:13   NBHF   4   51.8350   56.9667     Leg 2: Antarctic Peninsula Voyage   7   4   51.8350   62.670   62.670     1   39   2/16/2020 16:33   Possible delphinid   349   64.6523   62.2670     2   38   2/17/2020 19:06   Arnoux's beaked whale   4   64.7639   62.8748     3   40   2/24/2020 10:57   NBHF   10   63.5593   65.7100     4   9   2/24/2020 10:57   NBHF   8   63.4741   65.8505     6   37   2/24/2020 11:50   NBHF   8   63.2157   65.7827     5   10   2/24/2020 13:40   Killer whale   771<	45	105	1/27/2020 21:01	Unidentified large delphinid	0430	52.6785	51 2000		
A8   59   1/28/2020 09:50   NBH   FM   FM   FM   FM   S2.0400   S2.0400   S2.7600     49   106   1/28/2020 19:49   NBHF   90   52.4167   53.2333     50   60   1/28/2020 19:49   NBHF   15   52.2250   55.1850     51   61   1/29/2020 05:13   NBHF   4   51.8350   56.9667     Leg 2: Antarctic Peninsula Voyage	40	57	1/28/2020 05:59	NBHE	101	52.6400	51 7467		
A9   106   1/28/2020 12:08   NBHF   90   52:4167   53:2333     50   60   1/28/2020 12:08   NBHF   90   52:4267   53:1850     51   61   1/29/2020 05:13   NBHF   4   51:8350   56:9667     Leg 2: Antarctic Peninsula Voyage	48	59	1/28/2020 09:50	NBHE	6	52.0400	52 7600		
100   1726/2020 19:49   NBH   50   50   50   50.51850     50   60   1/28/2020 19:49   NBHF   15   52.2250   55.1850     51   61   1/29/2020 05:13   NBHF   4   51.8350   56.9667     Leg 2: Antarctic Peninsula Voyage	40	106	1/28/2020 12:08	NBHE	90	52.4907	53 2333		
50   60   1/29/2020   17.47   INIT   15   51   51   51   1/29/2020   55.133   NBHF   4   51.8350   56.9667     Leg 2: Antarctic Peninsula Voyage   7   64.6523   62.2670   64.6523   62.2670     1   39   2/16/2020   10:57   NBHF   10   63.5593   65.7100     2   38   2/17/2020   10:57   NBHF   10   63.5593   65.7100     4   9   2/24/2020   11:50   NBHF   75   63.5157   65.7827     5   10   2/24/2020   11:50   NBHF   8   63.4741   65.8505     6   37   2/24/2020   13:40   Killer whale   771   63.2616   65.9872     7   6   2/24/2020   19:56   Southern bottlenose whale   9   61.428   66.1428     8   41   2/25/2020   03:48   NBHF   11   58.6049   67.2791     10   42   2/26/2020   03:48   Unidentified delphinid   101   58.6049   67.2791 <t< td=""><td>50</td><td>60</td><td>1/28/2020 12:00</td><td>NBHE</td><td>15</td><td>52.4107</td><td>55 1850</td></t<>	50	60	1/28/2020 12:00	NBHE	15	52.4107	55 1850		
Interpretation   Inter	51	61	1/20/2020 15:13	NBHE	4	51,8350	56 9667		
139 $2/16/2020$ 16:33Possible delphinid349 $64.6523$ $62.2670$ 238 $2/17/2020$ 19:06Arnoux's beaked whale4 $64.7639$ $62.8748$ 340 $2/24/2020$ 10:57NBHF10 $63.5593$ $65.7100$ 49 $2/24/2020$ 11:25NBHF75 $63.5157$ $65.7827$ 510 $2/24/2020$ 11:50NBHF8 $63.4741$ $65.8505$ 637 $2/24/2020$ 13:40Killer whale $771$ $63.2616$ $65.9872$ 76 $2/24/2020$ 13:40Killer whale9 $62.4652$ $66.1428$ 841 $2/25/2020$ 00:21BWS849 $61.9277$ $66.2751$ 911 $2/26/2020$ 03:48NBHF11 $58.6049$ $67.2791$ 1042 $2/26/2020$ 03:17NBHF5 $55.7031$ $66.5610$ 1213 $2/27/2020$ 04:12NBHF8 $55.5974$ $66.0491$ 1415 $2/27/2020$ 04:12NBHF $32$ $55.5576$ $66.4912$	Leg 2: Antarctic Peninsula	Voyage	1/2//2020 03.13	NDIII	т	51.0550	30.9007		
1   39   2/17/2020 19:05   Possible deplining   549   64.0325   62.2070     2   38   2/17/2020 19:06   Arnoux's beaked whale   4   64.7639   62.8748     3   40   2/24/2020 10:57   NBHF   10   63.5593   65.7100     4   9   2/24/2020 11:25   NBHF   75   63.5157   65.7827     5   10   2/24/2020 11:50   NBHF   8   63.4741   65.8505     6   37   2/24/2020 13:40   Killer whale   771   63.2616   65.9872     7   6   2/24/2020 19:56   Southern bottlenose whale   9   62.4652   66.1428     8   41   2/25/2020 00:21   BWS8   49   61.9277   66.2751     9   11   2/26/2020 03:48   NBHF   11   58.6049   67.2791     10   42   2/26/2020 03:48   Unidentified delphinid   101   58.6049   67.2791     11   12   2/27/2020 04:17   NBHF   5   55.7031   66.5610     12   13   2/27/2020 04:12   NBHF	1	20	2/16/2020 16:22	Descible delphinid	240	64 6522	62 2670		
2   36   2/17/2020 19:00   NBMF   4   647.053   65.0740     3   40   2/24/2020 10:57   NBHF   10   63.5593   65.7100     4   9   2/24/2020 11:25   NBHF   75   63.5157   65.7827     5   10   2/24/2020 11:50   NBHF   8   63.4741   65.8505     6   37   2/24/2020 19:56   Southern bottlenose whale   9   62.4652   66.1428     8   41   2/25/2020 00:21   BW58   49   61.9277   66.2751     9   11   2/26/2020 03:48   NBHF   11   58.6049   67.2791     10   42   2/26/2020 03:48   Unidentified delphinid   101   58.6049   67.2791     10   42   2/26/2020 03:17   NBHF   5   55.7031   66.5010     11   12   2/27/2020 04:12   NBHF   8   55.5934   66.5085     13   14   2/27/2020 04:12   NBHF   32   55.5741   66.4991     14   15   2/27/2020 04:12   NBHF   32   55.5574	1	39	2/17/2020 10:33	Arnoux's beaked whale	л Л	64 7630	62.2070		
3   40   2/24/2020 11:25   NBHF   10   63.353   65.7827     4   9   2/24/2020 11:25   NBHF   75   63.5157   65.7827     5   10   2/24/2020 11:250   NBHF   8   63.4741   65.8505     6   37   2/24/2020 13:40   Killer whale   771   63.2616   65.9872     7   6   2/24/2020 19:56   Southern bottlenose whale   9   62.4652   66.1428     8   41   2/25/2020 00:21   BW58   49   61.9277   66.2751     9   11   2/26/2020 03:48   NBHF   11   58.6049   67.2791     10   42   2/26/2020 03:48   Unidentified delphinid   101   58.6049   67.2791     11   12   2/27/2020 03:17   NBHF   5   55.7031   66.5010     12   13   2/27/2020 04:04   NBHF   8   55.5934   66.5085     13   14   2/27/2020 04:12   NBHF   32   55.5741   66.4991     14   15   2/27/2020 04:12   NBHF   32   55.5	2	38	2/17/2020 19:00	NRHE	10	63 5503	65 7100		
452/24/2020 11:25NBHF7363.31765.762/5102/24/2020 11:50NBHF863.474165.85056372/24/2020 13:40Killer whale77163.261665.9872762/24/2020 19:56Southern bottlenose whale962.465266.14288412/25/2020 00:21BW584961.927766.27519112/26/2020 03:48NBHF1158.604967.279110422/26/2020 03:48Unidentified delphinid10158.604967.279111122/27/2020 03:17NBHF555.703166.561012132/27/2020 04:04NBHF855.593466.508513142/27/2020 04:12NBHF3255.575666.491214152/27/2020 04:20NBHF3255.557666.4912	3	40	2/24/2020 10.37	NRUE	75	63 51 57	65 7827		
6   37   2/24/2020 13:40   Killer whale   771   63.2616   65.9872     7   6   2/24/2020 19:55   Southern bottlenose whale   9   62.4652   66.1428     8   41   2/25/2020 00:21   BW58   49   61.9277   66.2751     9   11   2/26/2020 03:48   NBHF   11   58.6049   67.2791     10   42   2/26/2020 03:17   NBHF   5   55.7031   66.5610     12   13   2/27/2020 04:04   NBHF   8   55.5934   66.5085     13   14   2/27/2020 04:12   NBHF   46   55.5741   66.4991     14   15   2/27/2020 04:20   NBHF   32   55.5576   66.4912	5	10	2/24/2020 11:20	NBHF	8	63 4741	65 8505		
7   6   2/24/2020 19:56   Southern bottlenose whale   9   62.4652   66.1428     8   41   2/25/2020 00:21   BWS8   49   61.9277   66.2751     9   11   2/26/2020 03:48   NBHF   11   58.6049   67.2791     10   42   2/26/2020 03:17   NBHF   5   55.7031   66.5610     12   13   2/27/2020 04:12   NBHF   8   55.5934   66.5085     13   14   2/27/2020 04:12   NBHF   32   55.5741   66.4991     14   15   2/27/2020 04:20   NBHF   32   55.5576   66.4912	6	37	2/24/2020 11:30	Killer whale	771	63 2616	65 9872		
8 41 2/25/2020 00:21 BW58 49 61.9277 66.2751   9 11 2/26/2020 00:21 BW58 49 61.9277 66.2751   10 42 2/26/2020 03:48 NBHF 11 58.6049 67.2791   11 12 2/27/2020 03:17 NBHF 5 55.7031 66.5610   12 13 2/27/2020 04:12 NBHF 8 55.5934 66.5085   13 14 2/27/2020 04:12 NBHF 32 55.5741 66.4991   14 15 2/27/2020 04:20 NBHF 32 55.5576 66.4912	7	6	2/24/2020 13.40	Southern bottlenose whale	9	62 4652	66 1428		
9 11 2/20/2020 03:48 NBHF 11 58.6049 67.2791   10 42 2/26/2020 03:48 Unidentified delphinid 101 58.6049 67.2791   11 12 2/27/2020 03:77 NBHF 5 55.7031 66.5010   12 13 2/27/2020 04:12 NBHF 8 55.5934 66.5085   13 14 2/27/2020 04:20 NBHF 32 55.576 66.4912	, 8	41	2/27/2020 19.00	BW58	49	61 9277	66 2751		
11     2/20/2020 03:00     NBHF     11     56.0049     67.2791       10     42     2/26/2020 03:48     Unidentified delphinid     101     58.6049     67.2791       11     12     2/27/2020 03:17     NBHF     5     55.7031     66.5610       12     13     2/27/2020 04:04     NBHF     8     55.5934     66.5085       13     14     2/27/2020 04:20     NBHF     46     55.5776     66.4991       14     15     2/27/2020 04:20     NBHF     32     55.5576     66.4912	9	11	2/20/2020 00.21	NBHE	11	58 6049	67 2701		
10     12     2/27/2020 03:17     NBHF     50     55.7031     66.5610       12     13     2/27/2020 04:04     NBHF     8     55.5934     66.5085       13     14     2/27/2020 04:20     NBHF     46     55.57741     66.4991       14     15     2/27/2020 04:20     NBHF     32     55.5576     66.4912	10	42	2/26/2020 03.40	Unidentified delphinid	101	58 6049	67 2791		
12     12     12     12     12     13     5     55     66.001     60.001       12     13     2/27/2020 04:04     NBHF     8     55.5934     66.5085       13     14     2/27/2020 04:12     NBHF     46     55.5741     66.4991       14     15     2/27/2020 04:20     NBHF     32     55.5576     66.4912	11	12	2/20/2020 03.40	NBHF	5	55 7031	66 5610		
13     14     2/27/2020 04:12     NBHF     46     55.5741     66.4991       14     15     2/27/2020 04:20     NBHF     32     55.5576     66.4912	12	13	2/27/2020 03:17	NBHF	8	55 5934	66 5085		
14 15 2/27/2020 04:20 NBHF 32 55.5576 66.4912	13	14	2/27/2020 04.04	NBHF	46	55 5741	66 4991		
	14	15	2/27/2020 04:20	NBHF	32	55.5576	66.4912		



Fig. 2. Acoustic detection locations (colored circles) for southern bottlenose whales (yellow), Arnoux's beaked whales (green), and sperm whales (orange). Vessel transects include periods with towed hydrophone recordings (bold black lines) and without recordings (thin orange lines). Shelf waters (<200 m depth) are delimited by a thin black line. Negative values indicate south latitudes and west longitudes.



Fig. 3. Acoustic detection locations (colored circles) for beaked whale pulse types BW37/39 (yellow), BW58 (green), BW40V (orange), and BW41 (blue). Other features are as in Fig. 2.

bandwidth (2.3–3.3 kHz) (Table 2, Fig. 5). A high signal-to-noise ratio (SNR) pulse recorded near the sighting of this species in the Gerlache Straight had a sudden onset (like a delphinid echolocation click) followed by an apparent downsweep (Fig. 5). The highest SNR pulse of the other acoustic detection, at the south end of the South Sandwich Islands, was a long signal with a relatively constant frequency throughout (Fig. 5). Pulses from both detections showed secondary frequency peaks at 28–29 kHz.

# 3.2. NBHF species

A total of 30 acoustic events were detected with NBHF signals (Fig. 4, Table 3). The mean peak frequency for the median values for each event was 127.7 kHz (range = 122.0-131.0 kHz). A bivariate plot of peak frequency and -3 dB bandwidth did not show any obvious clustering of values that might be used to discern species (Fig. 6). One of the NBHF events (ID = 54) with a peak frequency of 129 kHz was recorded at the

same time as a sighting of hourglass dolphins. Another of the NBHF events (ID = 72) with a peak frequency of 124 kHz occurred at the same time as delphinid burst pulses (ID = 100) with a peak frequency of 43 kHz. These two signal types overlapped in time, but it is not known if they were made by the same species.

## 3.3. Other species

Other acoustic detection events included four killer whale encounters with peak frequencies of 18–25 kHz, three long-finned pilot whale encounters with peak frequencies of 39–49 kHz (all within a 1-hr period), one sperm whale encounter with a peak frequency of 14 kHz (lasting 46 min), and several possible/unidentified delphinid encounters without NBHF pulses (Tables 1 and 4). All of the killer whale detections and two of the long-finned pilot whale detections included burst pulses as well as delphinid-type echolocation clicks. Two of the killer whale detection had a



Fig. 4. Acoustic detection locations (colored circles) for narrow-band high-frequency (NBHF) species (yellow), killer whales (green), and long-finned pilot whales (orange). Other features are as in Fig. 2.

median inter-click interval of 0.75 s.

#### 4. Discussion

Our study demonstrates the utility of autonomous towed hydrophones to study the distribution of odontocetes from vessels of opportunity with a minimum of effort. The number of odontocete acoustic detections (n = 65) is much higher than the number of concurrent odontocete sightings (n = 2) in these rough waters. Our study benefitted from the relatively slow transit speed of the two vessels we used (less than 15 km h<sup>-1</sup>). Although towed hydrophone surveys for odontocetes have been routinely used as speeds of up to 10 kts (18 km  $h^{-1}$ ) (Rankin et al., 2017), greater speeds might be problematic. At higher speeds, propeller cavitation noise is a greater problem, but that can be mitigated to some degree by using properly maintained low-cavitation propellers (Chekab et al., 2013). Another noise problem occurs when the hydrophone strikes air bubbles entrained by breaking waves in the upper water layer. At higher speeds, more weight is required to get a towed hydrophone below this bubble layer. Higher speeds also contribute to greater flow noise. Towed hydrophone surveys like ours may not be possible on vessels of opportunity that transit at speeds greater than 10 kts.

We were conservative in our classification of species or pulse type from acoustic events found in our recordings. We based classifications on the closest match to previous descriptions. When in doubt, we labeled the events as unidentified odontocetes. We described potentially new sound types only when a signal clearly did not match any previously described cetacean signals. Although this approach is common practice, it is not entirely satisfactory. Because classifications are subjective, it is difficult to quantify the errors in classification. All classification methods are likely to have some errors, but it takes a large dataset with known species to quantify misclassification error. Ultimately, studies like this should base species and other classifications on objective, wellvalidated classification methods with known error rates, such as that developed recently by Rankin et al. (2017). Until enough data are available to make this feasible, it is important to consider that some species classification errors are likely and that the reliable characterization of new signal types can only occur from replicated observations.

#### 4.1. Beaked whales

The two beaked whale species that were classified with a high degree

of confidence were the southern bottlenose whale and Arnoux's beaked whale. Southern bottlenose whales were the most commonly seen odontocete species on the IWC's circum-Antarctic sighting surveys (Kasamatsu and Joyce 1995), which matches our observation as the most-frequently recorded beaked whale in our acoustic data. The other likely beaked whale species in the Southern Hemisphere include Shepherd's beaked whale (*Tasmacetus shepherdi*), Cuvier's beaked whale (*Ziphius cavirostris*) and five species in the genus *Mesoplodon*: the strap-toothed beaked whale (*M. layardii*), Gray's beaked whale (*M. spade*-toothed beaked whale (*M. traversii*) (MacLeod et al., 2006).

Of the Southern Hemisphere beaked whale species found in cold waters, recordings in the near vicinity of confirmed sightings have only been made for Arnoux's beaked whale and Shepherd's beaked whale. Our recordings in the Gerlache Strait (near a sighting of Arnoux's beaked whales) and south of the South Sandwich Islands matched the 16 kHz signals that were previously described for Arnoux's beaked whales (Rogers and Brown 1999). Unlike the previous recordings of Rogers and Brown (1999), our recordings at a sampling rate of 576 kHz were not bandwidth-limited and show additional detail not seen in these previous recordings. In addition to a strong frequency peak at 15-16 kHz, our recordings show faint secondary peaks at 28 and 34 kHz and some energy above ambient noise up to 40 kHz (Fig. 5). Leunissen et al. (2018) recorded broadband echolocation clicks with a 19 kHz peak frequency in the vicinity of Shepherd's beaked whales. None of our beaked whale acoustic events matched those signals; however, because these broadband clicks do not match our expected pattern of FM pulses, we might not have recognized these as a beaked whale in our recordings.

Previously described beaked whale FM pulses that are not yet be attributed to a sighted species include BW29, BW37, BW58, BW39, and BW53. Of these, BW29 and BW37 were previously recorded near the South Scotia Ridge (Trickey et al., 2015) and Elephant Island (Baumann-Pickering et al., 2015). BW58 was only recorded near Elephant Island (Bauman-Pickering et al., 2015). BW39 and BW53 were only recorded east of Cook Strait in New Zealand (Giorli et al., 2018). We add two new FM pulse types to this previous list of five: BW40V and BW41.

We agree with previous authors (Trickey et al., 2015; Baumann-Pickering et al., 2015) that based on its distribution, common occurrence, and similarity to the FM pulse signal produced by northern bottlenose whales, BW29 are highly likely made by southern bottlenose whales. Gray's and strap-toothed beaked whales have been described as

Frequency characteristics of beaked whale acoustic detections. Median values of peak frequencies and bandwidth metrics (at -3 dB and -10 dB re: peak) are given for all pulses that were at least 15 dB above the noise level at the peak frequency. Event IDs correspond to events in Table 1.

			Bandwidth @ -3 dB			Bandwidth @ -10 dB				
Event ID	Event Type	Peak frequency (kHz)	Center frequency (kHz)	Bandwidth (kHz)	Lower frequency (kHz)	Upper frequency (kHz)	Center frequency (kHz)	Bandwidth (kHz)	Lower frequency (kHz)	Upper frequency (kHz)
13 7	BW37/39 Southern bottlenose whale	39.0 28.5	38.8 28.9	5.8 5.6	35.7 25.7	41.9 31.5	39.2 32.2	10.9 15.0	33.6 23.3	44.8 40.0
8	Southern bottlenose whale	29.0	29.0	5.8	26.6	32.0	30.8	13.8	23.6	38.1
91	BW40V	48.0	47.6	6.5	43.8	51.3	41.3	23.3	29.6	53.2
17	BW41	41.0	41.5	3.0	39.5	42.9	40.6	13.7	33.5	47.3
9	Southern bottlenose whale	33.5	32.8	4.5	30.1	35.6	33.7	14.7	25.4	41.8
15	Possible beaked whale	39.0	38.7	3.6	37.0	40.2	38.3	6.7	35.1	41.7
101	Southern bottlenose whale	28.5	29.2	8.1	25.1	33.2	30.7	15.6	22.9	38.5
102	Southern bottlenose whale	31.0	30.1	5.5	26.4	34.1	31.1	14.3	23.5	38.9
67	Arnoux's beaked whale	15.0	15.0	2.3	13.8	16.4	15.0	5.0	12.9	17.3
21	Southern bottlenose whale	31.0	30.2	7.3	26.5	34.6	33.1	17.1	24.5	41.7
23	Southern bottlenose whale	37.0	36.6	4.4	33.3	40.2	33.9	22.9	22.7	45.4
24	Southern bottlenose whale	34.0	33.8	4.8	30.4	36.6	35.7	18.7	25.2	46.3
6	Southern bottlenose whale	28.0	28.4	5.1	25.7	31.6	29.1	10.6	24.0	34.2
104	Southern bottlenose whale	29.0	30.3	8.3	26.2	34.5	32.7	17.4	24.1	41.4
38	Arnoux's beaked whale	16.0	17.3	3.3	13.9	20.3	18.8	5.6	13.1	21.5
6	Southern bottlenose whale	29.0	29.1	5.9	25.7	32.9	31.6	15.9	22.3	41.0
41	BW58	53.0	53.4	6.1	49.1	57.7	52.5	17.3	42.9	61.8

likely sources for four FM pulse types (BW37, BW58, BW39, and BW53) (Baumann-Pickering et al., 2015; Giorli et al., 2018). Our BW58 pulse type is clearly similar to that signal as described by Baumann et al. (2015). Giorli et al. (2018) suggests that BW37 and BW39 might represent natural variation within the range of a single species. Our measurements of BW37/39 are intermediate to those described for BW37 and BW39 and generally support this suggestion. If this is true and if each beaked whale species only makes one type of FM pulse (Baumann-Pickering et al., 2013), the five unattributed pulse types (BW37/39, BW53, BW58, BW40V, and BW41) likely correspond to the five species of *Mesoplodon* found in the Southern Ocean.

The geographic distribution of the five unattributed pulse types (or six, if BW37 and BW39 are different) may provide some clues about their source. Only two *Mesoplodon* species (Gray's and strap-toothed beaked whales) have been commonly seen south of the Antarctic Convergence (MacLeod et al., 2006). Given that BW37 and BW58 have been recorded well south of the Antarctic Convergence, they are likely produced by these two most southern of the *Mesoplodon* species. The other FM pulse types (BW53, BW40V and BW41) might therefore be made by the more northern *Mesoplodon* species (Andrew's, Hector's and spade-toothed beaked whales). Although Shepherd's beaked whales are known to

make broad-band, dolphin-like echolocation clicks (Leunissen et al., 2018), they may also make one of these described FM pulses. Clearly more research is needed to attribute specific FM pulses to beaked whale species. This will require dedicated efforts to identify beaked whales at sea (visually, photographically or genetically) and to acoustically sample in the vicinity of those whales to record and characterize the echolocation pulses produced during their next foraging dive.

# 4.2. NBHF species

NBHF pulses are made by a diverse group of odontocete species that are not closely related taxonomically. The common use of 120–150 kHz signals may have developed in multiple taxa by convergent evolution as an approach to avoid being detectable by killer whales while maintaining sufficient echolocation range to detect their prey (Morisaka and Connor 2007). Although the frequency range used for NBHF pulses is small, there are still differences in signals between species that can be used to classify species. Kyhn et al. (2009) found that the duration of NBHF pulses of hourglass dolphins was approximately twice that of Hector's dolphins (*Cephalorhynchus hectori*) with no overlap in the ranges between species. Kyhn et al. (2010) found that Peale's dolphins



Fig. 5. Acoustic characteristics of five beaked whale FM pulse types. Panels include waveform (left) and Wigner-Ville tranformations (center) of the loudest click for each detection event and the mean spectrum of all clicks with a SNR >20 dB at the peak frequency (right). Noise levels in the spectrum plot (dotted line) are based on the prior sampling window (of the same size as the waveform window).

(*Lagenorhynchus australis*) and Commerson's dolphins (*Cephalorhynchus commersonii*) could be largely distinguished based on centroid frequency even though mean values differed by only 4 kHz. Griffiths et al. (2020) used multivariate clustering to identify three NBHF pulse types: two of which likely corresponded to Dall's porpoises (*Phocoenoides dalli*) and one to pygmy sperm whales (*Kogia breviceps*).

Most of the NBHF detections in our study occurred in deep pelagic waters far from a coastal shelf (Fig. 4). Pelagic species that produce NBHF pulses in the Southern Ocean include hourglass dolphins and spectacled porpoises (*Phocoena dioptrica*). It is likely that our NBHF detections are from these two species. Echolocation has not been studied in spectacled porpoises (Erbe, 2004), so there is insufficient information at this time to distinguish between these species in our data. A simple bivariate plot of peak frequency and bandwidth of NBHF signals did not show any obvious clustering in our data (Fig. 6). Multivariate clustering techniques may have more power to discern clusters that could help in

species classifications (Griffiths et al., 2020). Ultimately, recordings are needed in the presence of spectacled porpoises to validate clustering methods for species classifications.

The echolocation signals associated with a sighting of hourglass dolphins (acoustic event ID = 54) had bandwidths (at -3 and -10 dB) and a peak frequency that are within the range of values measured by Kyhn et al. (2009) for this species. In fact, all the NBHF events we recorded (Table 3) had median peak frequencies within this published range for hourglass dolphins and the vast majority also had -3 and -10 dB bandwidths within the published ranges for this species.

#### 4.3. Sperm whales

Sperm whales were detected only once in our study, albeit almost continuously for 46 min. In contrast, sperm whales were seen much more frequently than killer whales and pilot whales on Antarctic

Frequency characteristics for detections of odontocetes with narrow-banded high-frequency (NBHF) echolocation pulses. Median values of peak frequencies and bandwidth metrics (at -3 dB and -10 dB re: peak) are given for all pulses that were at least 15 dB above the noise level at the peak frequency. Event IDs correspond to events in Table 1.

		Bandwidth @ -3 dB				Bandwidth @ -10 dB				
Event ID	Peak frequency (kHz)	Center frequency (kHz)	Bandwidth (kHz)	Lower frequency (kHz)	Upper frequency (kHz)	Center frequency (kHz)	Bandwidth (kHz)	Lower frequency (kHz)	Upper frequency (kHz)	
31	130.0	130.2	4.8	126.5	133.0	130.3	12.3	124.6	137.3	
33	126.0	126.1	4.2	124.0	128.3	127.2	9.5	122.6	132.0	
37	125.0	124.4	6.6	117.1	129.3	123.6	19.2	113.7	133.5	
90	122.0	122.3	4.6	119.9	124.7	123.1	9.1	118.5	127.5	
38	127.0	126.8	4.8	124.5	129.2	127.6	9.3	122.9	132.2	
39	126.0	126.2	5.1	123.6	127.9	126.6	11.3	121.6	131.1	
40	129.5	128.8	6.6	125.5	132.0	128.9	9.9	123.9	133.8	
41	131.0	130.8	7.3	127.1	134.4	130.3	13.4	123.5	137.0	
44	128.5	128.5	6.1	125.6	131.7	129.0	11.5	123.2	134.4	
47	127.0	127.0	5.9	124.0	129.4	127.0	10.5	122.0	132.2	
48	129.5	130.0	6.7	126.4	133.5	129.7	13.6	122.9	136.5	
49	128.0	128.2	4.9	125.5	130.8	127.6	10.1	122.5	132.7	
51	130.5	130.3	4.2	127.2	133.7	132.1	13.6	124.1	138.3	
72	124.0	123.5	4.0	121.4	125.5	123.6	8.1	119.5	127.5	
52	124.0	124.5	6.1	121.2	127.7	124.6	11.5	118.8	130.5	
54	129.0	129.5	7.4	125.7	133.3	130.4	12.0	124.4	136.5	
56	128.0	128.0	6.3	125.0	130.7	128.8	10.7	123.4	134.0	
57	128.0	127.6	7.8	123.4	132.0	126.6	18.0	118.2	134.7	
59	128.0	129.3	8.0	125.3	133.3	130.5	14.3	123.4	137.4	
106	124.0	123.4	4.2	121.2	125.5	123.9	9.9	119.1	128.8	
60	128.0	128.1	5.5	124.9	131.3	128.6	12.4	122.6	134.6	
61	131.0	131.5	5.2	128.9	133.8	129.9	10.1	124.8	135.0	
40	126.0	125.6	4.9	123.5	128.1	125.8	10.5	120.7	130.7	
9	127.0	127.5	4.8	124.7	129.8	128.1	9.3	123.3	133.0	
10	130.0	130.3	8.5	126.0	134.7	130.6	14.2	123.7	137.2	
11	130.0	129.8	6.8	126.5	132.6	130.1	17.6	120.0	137.8	
12	128.0	128.5	5.9	125.6	131.3	128.7	10.0	123.9	133.1	
13	127.0	127.3	8.6	123.5	131.0	127.0	15.2	120.0	135.2	
14	129.0	128.8	6.4	124.9	132.3	129.0	13.8	121.9	136.6	
15	130.0	130.4	5.1	127.7	132.7	131.5	11.6	125.4	137.4	



Fig. 6. Bivariate plot of median peak frequencies and bandwidths for all NBHF detection events.

sighting surveys (Kasamatsu and Joyce 1995) and were acoustically detected much more frequently on previous towed hydrophone surveys in the Southern Ocean (Pierpoint et al., 1997; Gillespie 1997; Leaper and Scheidat 1998; Leaper et al., 2000). These previous acoustic surveys used a linear array of two hydrophones which allowed the differentiation of individual whales based on their bearing angles relative to the array. We likely failed to detect sperm whales because, unlike these previous studies, we did not monitor our recordings aurally (which is the most effective way to discern faint sperm whale clicks, Gillespie (1997)) and we could not discriminate between sperm whale clicks and propeller cavitation using bearing angle. Using a hydrophone array, our 46-min detection almost certainly would have been comprised of multiple sperm whales. Sperm whales had a similar patchy distribution on these previous surveys and it was not uncommon for detections to be highly clustered (*op. cit.*). For effective sperm whale surveys using an autonomous towed system, we recommend that two hydrophones be used in a linear array and that stereo recordings be monitored aurally by analysts who are experienced in detecting sperm whale clicks. Based on their inter-click intervals ( $\sim$ 0.75 s), the acoustically detected sperm whales were likely males (Goold and Jones 1995).

# 4.4. Other species

The most frequently detected large delphinids were killer whales and long-finned pilot whales, which match the species composition of sightings on the IWC circum-Antarctic surveys (Kasamatu and Joyce

Frequency characteristics for detections of broadband echolocation clicks from delphinids. Median values of peak frequencies and bandwidth metrics (at -3 dB and -10 dB re: peak) are given for all pulses that were at least 15 dB above the noise level at the peak frequency. Event IDs correspond to events in Table 1.

			Bandwidth @ -3 dB			Bandwidth @ -10 dB				
Event ID	Event Type	Peak frequency (kHz)	Center frequency (kHz)	Bandwidth (kHz)	Lower frequency (kHz)	Upper frequency (kHz)	Center frequency (kHz)	Bandwidth (kHz)	Lower frequency (kHz)	Upper frequency (kHz)
92	Possible delphinid	45.0	46.0	5.7	42.2	49.4	44.3	22.1	31.9	57.0
93	Killer whale	25.0	23.0	6.7	16.9	27.8	23.7	23.4	11.3	35.2
87	Killer whale	18.0	18.6	7.3	14.6	22.1	22.5	21.7	11.6	33.4
95	Killer whale	24.0	22.4	6.8	16.3	28.3	24.4	23.8	11.4	36.1
96	Unidentified delphinid	47.0	46.6	5.5	43.8	49.2	51.4	33.1	33.5	70.1
97	Long-finned pilot whale	39.0	38.6	6.0	34.8	41.4	40.0	18.0	30.5	48.7
98	Long-finned pilot whale	41.0	40.7	4.3	38.4	42.7	41.2	15.2	33.2	50.7
99	Long-finned pilot whale	49.0	48.4	5.2	45.1	51.2	50.9	25.7	36.4	63.9
100	Unidentified delphinid	43.0	43.8	9.9	38.0	49.9	45.9	23.2	32.6	58.8
105	Unidentified delphinid	32.0	31.9	8.2	26.9	36.3	31.9	21.6	20.6	42.8
89	Unidentified delphinid	30.0	29.6	4.3	27.0	32.3	30.4	13.8	22.3	38.1
39	Possible delphinid	92.0	89.5	3.9	87.5	91.9	89.0	14.2	80.5	97.0
37	Killer whale	23.0	22.7	6.8	19.1	26.5	23.7	17.7	13.1	33.1
42	Unidentified delphinid	43.0	44.4	6.7	40.1	50.8	23.0	23.8	33.9	56.9

1995). The median peak frequencies of the echolocation clicks from the detections of killer whales (18–25 kHz, n = 4 detection events) and long-finned pilot whales (39–49 kHz, n = 3) were lower than the mean values (29 & 50 kHz, respectively) measured in a Norwegian fjord (Eskesen et al., 2011). This shift in peak frequency is likely caused by the loss of the higher frequency components in these broad-band signals due to propagation losses at greater ranges (Ainslie 2013). Although the detection range is not known for our samples, they are likely to be much greater than the 20–120 m range for the Norwegian measurements. The lower –10 dB bandwidth frequencies (11.3–13.1 kHz for killer whales and 30.5–36.4 kHz for short-finned pilot whales, Table 4) may be a more reliable metric to characterize the echolocation clicks for these species because it should be less prone to range-dependent frequency shifts than peak frequency.

#### 5. Conclusions

Autonomous towed hydrophone recording systems can be used to effectively quantify the distribution of odontocete cetaceans in hard-tostudy areas with relatively little cost or dedicated time. They can be deployed from vessels of opportunity without interfering with their primary missions. They are far easier to maintain than traditional towed hydrophone arrays which have long conducting cables and complicated computer recording systems, and operators require little acoustic or electronic expertise.

The use of autonomous towed hydrophone recorders is especially promising for studying the distribution of beaked whales and other small odontocetes that are hard to see on visual sighting surveys. Beaked whale FM pulses appear to be species-specific, but more information is needed to allow species classification from these signals. Dedicated studies are needed to link known species with the identified FM pulse types. Additional work is also needed to quantify the range of variation in these recognized FM pulse types. Similarly, dedicated research is needed to identify species of odontocetes from their NBHF echolocation signals. In particular, NBHF characterizations are needed for spectacled porpoises, and classification algorithms are needed to discriminate among all the Southern Hemisphere NBHF species. The future use of autonomous towed hydrophone systems could be greatly aided by the addition of a second hydrophone, creating a twoelement linear towed array. Bearing angles estimated from a twoelement array would be helpful in estimating detection range from the convergence of bearing angles. A consistent progression of bearing angles is also helpful in discriminating true odontocete detections in a clutter of noise from random directions or from the ship.

## Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Data was collected via a hydrophone deployed aboard two voyages as platforms of opportunity. One of the two voyages was a commercial tourism voyage operated by Cheesemans' Ecology Safaris owned by coauthor Ted Cheeseman. The authors do not believe the arrangement has any impact on the integrity of the research.

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