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ABSTRACT

Visual and acoustic data gathered during the 2015 SORP Voyage is presented here. This survey was done on board of the Argentinian vessel *Tango SB-15* in Antarctic and sub-Antarctic waters from 28 January to 13 February 2015. Active sighting effort corresponded to 11 days, during which 85h 52min were devoted to visual survey effort for and 769.5 nm were covered. A total of 158 sightings included four mysticetes (humpback, fin, sei and Antarctic minke whales) and four odontocetes species (dusky, Peale's and hourglass dolphins, as well as killer whales) were positively identified. Humpback whales were the most frequently seen species in the Western Antarctic Peninsula with a sighting frequency of 0.4 whales/nm, increasing to 0.9 and 0.4 within Gerlache Strait and Bransfield Strait / Mar de la Flota, respectively. Fin whales were the second most observed cetacean with a sighting frequency of 0.2 whales/nm within the Western Antarctic Peninsula, and 0.3 around the South Shetland Islands. Seventeen acoustic detections were recorded with the towed hydrophone array, including narrow band high-frequency (NBHF) echolocation signals produced by hourglass dolphins and possibly Peale's or Commerson's dolphins. Sperm whales were acoustically detected on two occasions as well as clicks from unidentified odontocete species were registered. Beaked whale frequency-modulated (FM) signals were detected on three occasions and correspond to the recently described BW29 signal type.

INTRODUCTION

The Southern Ocean was the main commercial whaling region from the late 19th to the 20th centuries. Over 2 million whales were taken in the Antarctic during that period (Clapham and Baker, 2009). In 1986, the International Whaling Commission (IWC) completely banned commercial whaling, and in 1994 created a whale sanctuary in the Southern Ocean. Since then, little knowledge about the current status of the populations of cetaceans in the Southern Ocean has been gathered, in part due to the difficulty of conducting research in Antarctic waters because of unfavourable weather conditions, limited access during most of the year, and the expensive costs of dedicated cetacean surveys (Moore *et al*,. 1999; Reid *et al.,* 2000; Richardson *et al.,* 2012). In order to effectively implement conservation measures for threatened species, reliable information on distribution and abundance is required. Furthermore, because cetaceans represent the upper trophic-level in the Southern Ocean, they could provide information about the overall health of the whole ecosystem; for example, fluctuations in whale abundance have been shown to correspond with changes in krill abundance, which is the main food resource for many marine mammals and seabirds in the Southern Ocean (Reid *et al.,* 2000). Large scale and long-term studies are necessary to identify spatial and temporal trends in cetacean distributions, and to assess the influence of climate change on the Southern Ocean ecosystem.

Although several cetacean species occur in the Southern Ocean, very little is known of the current status of these populations due to the challenges of working in Antarctic waters (Richardson *et al.* 2012). Real-time passive acoustic monitoring can overcome some limitations of visual surveys and increase detection rates of deep-diving odontocetes. The combined use of visual and acoustic monitoring is a powerful tool to investigate the abundance and distribution of cetaceans in Antarctic waters.

2014 marked the first SORP voyage led by Argentina, during which visual and acoustic surveys were carried out and the results were submitted to IWC's SC meeting that same year (SC/65b/SH16rev). Here we present the results of a visual and acoustic survey of cetaceans during the 2015 SORP Voyage in sub-Antarctic and Antarctic waters along the Western Antarctic Peninsula.

MATERIALS AND METHODS

Study site

The voyage was conducted onboard the Argentinian Coast Guard (Prefectura Naval Argentina) vessel *Tango SB-15*. The vessel departed from the port of Ushuaia on 28 January 2015, and navigated through the Bransfield Strait/ Mar de la Flota and the Gerlache Strait, southward to the Argentinian Antarctic base "Brown" (64° 53'S, 62° 53'W) (Fig. 1). On 13 February 2015 the vessel arrived back at Ushuaia.

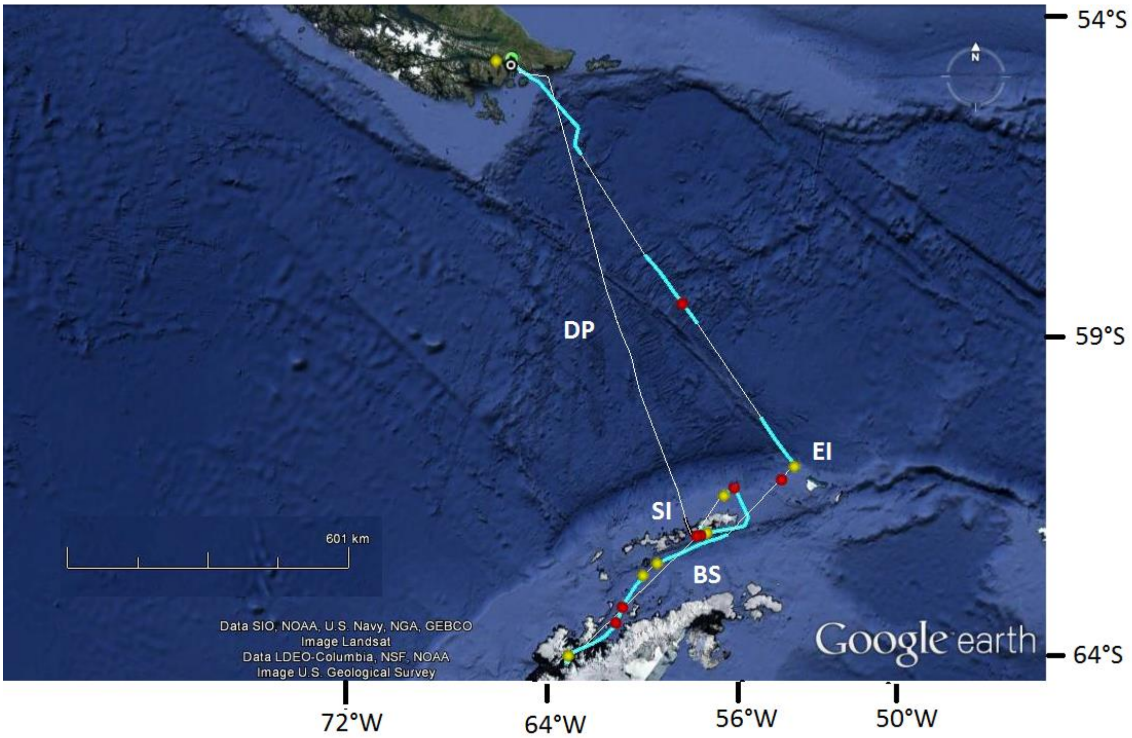

Fig.1. Map showing the track of the total navigation. Tracks of visual survey effort are shown in blue. Circles show the location of hydrophone array deployment (red) and retrieval (yellow). DP = Drake Passage; SI = South Shetland Islands / Islas Shetland del Sur (EI = Elephant Island); BS = Bransfield Strait / Mar de la Flota.

Visual survey

Observations from the bridge were conducted when the ship was underway during daylight hours using 7x50 reticuled Fujinon binoculars and the unaided eye. Data was collected by one experienced observer (and whenever possible two) on species identity, group size (minimum and maximum number of individuals were recorded and mean value was used for analysis), GPS position, vessel speed and heading, and animal bearing from the ship for all sightings. Sightings for which species identification was not possible were classified to the lowest taxonomic level identifiable. Photographs of the animals were taken with a reflex digital camera to assist in later species identification. Vessel speed and heading, wind speed and direction, Beaufort sea state, weather conditions and visibility were recorded at the start of each day and then updated every hour. The visual surveys were interrupted when the Beaufort scale was 6 or higher, in case low visibility (e.g., due to fog, precipitation) prevented observations, or whenever other vessel duties so required. A 'passing mode' method was used during surveys, in which the vessel continued to travel along the established transect line after a group of marine mammals was seen (Dawson, 2008).

Acoustic monitoring

Acoustic monitoring for cetaceans was conducted using a custom-built, 4-element, oil-filled hydrophone array. The array was towed 200 m behind the vessel. Ship speed varied between 3 and 10 knots. The array was equipped with omni-directional sensors (BII-7011 Type 3, Benthowave Instrument Inc., Collingwood, Ontario, Canada) that had an approximately flat (±2 dB) hydrophone sensitivity from 30 Hz to 200 kHz of –204 dB re V/μPa. The sensors were connected to custom-built preamplifier boards and bandpass filters (Wiggins and Hildebrand, 2007).

Three mid-frequency hydrophone channels were recorded at a 192 kHz sample rate using a Steinberg UR44 (Steinberg Media Technologies, Hamburg, Germany). One high-frequency channel was recorded at a 500 kHz sample rate using an Avisoft Ultrasound-Gate USB 116 (Avisoft Bioacoustics, Berlin, Germany). Both analog-to-digital converters had a 16-bit quantization. Towed array data were recorded directly to a computer hard-disk drive. An acoustic technician monitored the incoming signals from the towed array by visually scanning a real-time scrolling spectrogram in PAMGuard (Gillespie et al. 2008) and listening on headphones. The start and end times were noted for all acoustic encounters, and the GPS position and ship track were also logged.

Data analysis

For the purposes of this paper, we considered the Western Antarctic Peninsula (WAP) as the area surveyed by the vessel south of 60°S; Bransfield Strait / Mar de la Flota (BF) as the area surveyed by the vessel between east King George Island /Isla 25 de Mayo (KGI) and Gerlache Strait; Gerlache Strait (GS) as the area surveyed by the vessel south of 64°S up to the Argentinian Base “Brown”; and South Shetland Island (SI) as the area surveyed by the vessel in the waters encompassing KGI and Elephant Island (EI). For each area sighting frequency (number of sighted individuals per nautical mile surveyed) of humpback whales and fin whales was calculated. Only data obtained during search effort was considered in the analysis. As the distribution of these species was heterogeneous throughout the study area, sighting frequency was estimated for humpback whales in BF and GS separately, and also for fin whales in SI.

Recordings collected with the towed hydrophone array were visually inspected for odontocete vocalizations using the MATLAB-based (Mathworks, Natick, MA) custom software program *Triton* (Wiggins and Hildebrand, 2007). Mysticete calls were masked by ship engine and tow noise and therefore not detectable.

RESULTS AND DISCUSSION

Visual effort corresponded to 11 days during which distance covered was 769.5 nm and 85 h 52 min of on-effort observations occurred and (Fig. 1). Sightings included four mysticetes species and four odontocetes species, for a total of 158 encounters (96.4% mysticetes and 3.2% odontocetes) (Table 1).

The geographic distribution of encountered cetaceans was not uniform within the study area (Figs. 2 and 3).

Table 1. Total number of individuals sighted for each species, number of sightings and group size (minimum and maximum number of individuals were recorded and mean value was used for analysis).

	Scientific name	Common name	N° of individuals	N° of sightings	Group size	
					Range	Mean ± SD
Mysticetes	*Balaenoptera bonaerensis*	Antarctic minke whale	2.5	1	-	-
	Balaenoptera borealis	Sei whale	5.5	1	-	-
	Balaenoptera physalus	Fin whale	71.5	40	1 – 4.5	1.79 ± 1.01
	Megaptera novaeangliae	Humpback whale	151.8	94	1 - 7	1.61 ± 0.82
	Balaenoptera spp	Unidentified rorqual	1	1	-	-
	Mysticete	Unidentified mysticete	21	15	1 - 2	1.4 ± 0.47
Odontocetes	*Lagenorhynchus australis*	Peale’s dolphin	3.5	1	-	-
	Lagenorhynchus crucicer	Hourglass dolphin	5	1	-	-
	Lagenorhynchus obscurus	Dusky dolphin	64.5	3	4.5 - 35	30 ± 7.07
	Orcinus orca	Killer whale	7.8	1	-	-

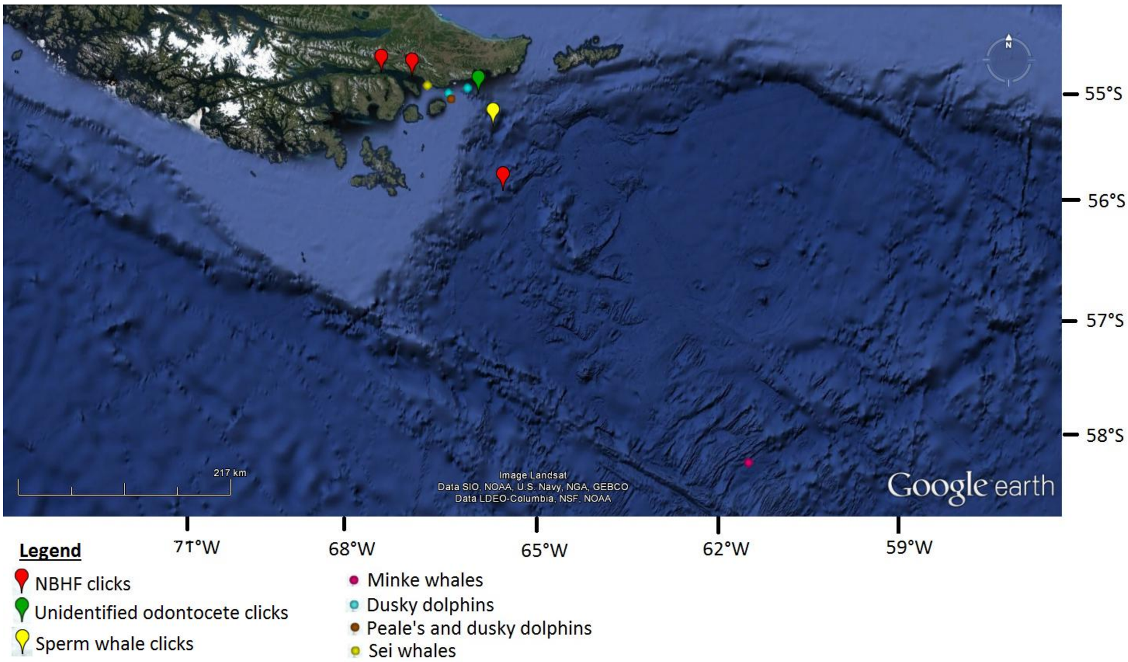

Fig. 2. Location of visual and acoustic detections of cetaceans in Beagle Channel and Drake Passage. Each symbol represents a single detection event that may include one or many individuals.

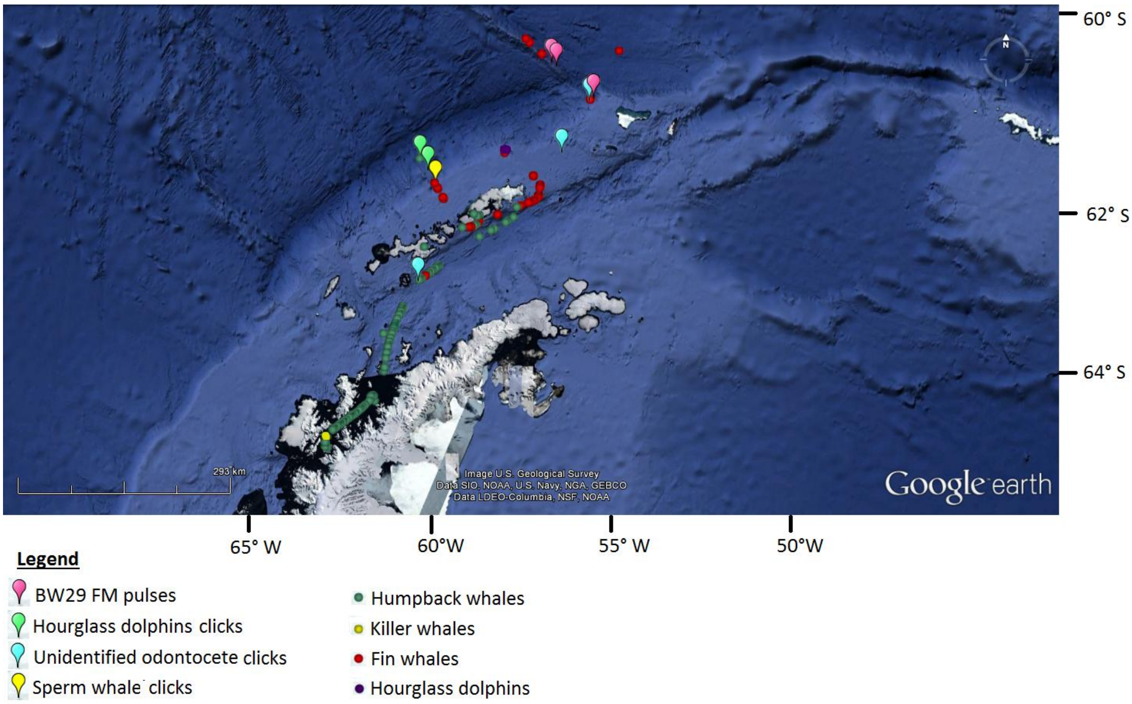

Fig. 3. Location of visual and acoustic detections of cetaceans around Western Antarctic Peninsula and Islas Shetland del Sur/ South Shetland Islands. Each symbol represents a single detection event that may include one or many individuals.

Within the WAP, humpback whales were the most frequently sighted species, with a sighting frequency of 0.4 whales/nm. The sighting frequency was highest for this species within GS in comparison to BS (0.9 and 0.4, respectively) (Table 2). These findings agree with those made by other authors that showed that highest concentrations of humpback whales are found within safe coastal waters, particularly within GS but also within BS (Reyes Reyes, *et al.*, 2014a; Reyes Reyes *et al.*, 2014b; Feindt-Herr *et al.*, 2013; Reyes Reyes, 2013; Secchi *et al.*, 2001).

Fin whales showed a sighting frequency of 0.2 whales/nm within the WAP, but when SI was considered separately its sighting frequency increased to 0.3 (Table 2). This is in concordance with previous studies conducted along the WAP that showed highest concentrations of fin whales in less protected waters NW of KGI and near EI (Reyes Reyes, *et al.,* 2014a; Reyes Reyes *et al.,* 2014b; Santora *et al.*, 2014; Feindt-Herr *et al.*, 2013).
Antarctic minke whales and sei whales were observed each on one occasion in the Drake Passage and within the Beagle Channel, respectively (Table 1, Fig. 2). The lack of sei whale sightings within the WAP is consistent with the findings of previous surveys (Reyes Reyes, *et al.*, 2014a; Reyes Reyes *et al.,* 2014b; Reyes Reyes, 2013).

Table 2. Total number of humpback and fin whales, nautical miles surveyed and sighting frequency. WAP = Western Antarctic Peninsula; SI = South Shetland Islands / Islas Shetland del Sur; BS = Bransfield Strait / Mar de la Flota; GS = Gerlache Strait (minimum and maximum number of individuals were recorded and mean value was used for analysis).

Area	Species	N° of individuals	Nm surveyed	Sighting frequency
WAP	Fin whale	71.5	425.5	0.2
	Humpback whales	151.8		0.4
SI	Fin whale	70.5	235.9	0.3
BS	Humpback whale	81	194.2	0.4
GS	Humpback whale	69.8	82.6	0.9

Killer whales were sighted once within GS (Fig. 3) and the group consisted of 7 to 8 individuals, including one calf (Table 1, Fig. 3).
All three southern hemisphere *Lagenorhynchus* species were visually detected during this survey. Dusky dolphins were observed three times, including a mixed group with Peale's dolphins (Table 1, Fig. 2). Hourglass dolphins were observed once NE of KGI in a group of 5 individuals (Table 1, Fig. 3). Additionally, the towed hydrophone array data revealed narrow band high-frequency (NBHF) clicks produced by this species on two occasions NW of KGI (Table 3, Fig. 3). NBHF echolocation signals of unknown origin were registered six times (Table 3, Fig. 2). Stereotyped NBHF clicks have been reported for six species of phocoenids (Au, 1993; Basset *et al.*, 2009; Li *et al.*, 2007), six dolphin species in the Lissodelphininae subfamily (Kyhn et al., 2010; Götz et al., 2010; Kyhn et al., 2009), the pygmy sperm whale (Madsen et al., 2005) and the Franciscana dolphin (Melcón et al., 2012). There was no visual confirmation but given the location, these acoustic encounters could be with Peale's or Commerson's dolphins.
Two acoustic detections were positively attributed to sperm whales, one near Cape Horn and the other NW of KGI (Table 3, Figs. 2 and 3). No visual sightings of sperm whales occurred during this survey.
On three occasions frequency modulated (FM) echolocation pulses produced by beaked whales were detected in the hydrophone array data collected NW of EI (Table 3, Fig. 3). Albeit a lack of visual detections of beaked whales during the survey, these signals correspond to the recently described Antarctic BW29 FM pulse type (Trickey et al., 2015). Based on numerous acoustic encounters of this signal type during the 2014 and 2015 surveys, and known established high density of southern bottlenose whales in the survey area (Santora and Brown, 2010, Van Waerebeek et al., 2010), this species has been considered the most likely candidate.
Additionally, four acoustic encounters consisting of clicks from unidentified species of odontocetes were detected (Table 3, Figs. 2 and 3).
The combined use of visual surveys and real-time passive acoustic monitoring allowed for improved detection of odontocetes in the surveyed area.
The present study provides data gathered during the 2015 SORP Voyage in the WAP, adding information on the current status of cetaceans in Antarctic and sub-Antarctic waters. This effort is part of a long term, international, collaborative project aimed to contribute to the goals of the Southern Ocean Research Partnership (SORP).

Table 3. Summary of acoustic detections from the towed hydrophone array. Start and end times are in GMT.

Detection code	Deployment	Date	Start Time	End time	Species	Latitude	Longitude
BW29_1	TA_01	2015-01-30	12:15	12:19	Unidentified beaked whale	60°28.91'S	56°57.67'W
BW29_2	TA_01	2015-01-30	12:53	13:05	Unidentified beaked whale	60°31.83'S	56°50.77'W
BW29_3	TA_01	2015-01-30	14:38	14:39	Unidentified beaked whale	60°53.20'S	55°57.50'W
UO_1	TA_01	2015-01-30	15:12	15:13	Unidentified odontocete	60°55.45'S	56°3.40'W
UO_2	TA_02	2015-01-31	02:25	02:31	Unidentified odontocete	61°31.53'S	56°41.95'W
UO_3	TA_02	2015-01-31	17:35	17:54	Unidentified odontocete	62°58.45'S	60°17.89'W
UO_4	TA_07	2015-02-12	20:45	21:10	Unidentified odontocete	55°26.12'S	65°41.11'W
SW_1	TA_07	2015-02-10	20:17	23:38	Sperm whale	61°52.16'S	59°46.18'W
SW_2	TA_07	2015-02-12	20:58	21:20	Sperm whale	55°24.39'S	65°41.75'W
NBHF_1	TA_07	2015-02-10	21:37	21:42	Hourglass dolphin	61°42.11'S	59°56.53'W
NBHF_2	TA_07	2015-02-10	22:42	22:47	Hourglass dolphin	61°34.24'S	60° 7.39'W
NBHF_3	TA_07	2015-02-12	13:15	13:25	Unidentified delphinid species	56°1.50'S	65°20.50'W
NBHF_4	TA_07	2015-02-12	19:05	19:10	Unidentified delphinid species	55°57.90'S	65°33.00'W
NBHF_5	TA_07	2015-02-13	02:20	02:25	Unidentified delphinid species	55°8.37'S	66°4.00'W
NBHF_6	TA_07	2015-02-13	02:35	02:37	Unidentified delphinid species	55°9.4'S	66°4.78'W
NBHF_7	TA_07	2015-02-13	02:50	02:51	Unidentified delphinid species	55°9.14'S	66°7.26'W
NBHF_8	TA_07	2015-02-13	03:00	03:05	Unidentified delphinid species	55°8.76'S	66°9.87'W

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