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Development and implementation of a new survey protocol for monitoring southern right whales in the Great Australian Bight.

Alice I Mackay and Simon D Goldsworthy

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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EXECUTIVE SUMMARY

Southern right whales (*Eaubalaena australis*) (SRW) are listed as Endangered under the threatened species category of the Commonwealth *Environment Protection and Biodiversity Act 1999* (EPBC Act), as Vulnerable under the South Australian *National Parks and Wildlife Act* (1972), and species requires monitoring in Australian waters to meet interim recovery objectives of the Conservation Management Plan for the Southern Right Whale (DSEWPaC 2012).

One of the primary purposes of the Great Australian Bight Marine Park (GABMP) is the conservation of SRW, and the Head of Bight (HOB) is a major calving and aggregation site for the south-western Australian SRW population, and Fowlers Bay (FB), to the east of the park, is considered an emerging aggregation area. Information on the status and trends in abundance of SRW within the region is needed for evaluating key performance measures of the GABMP, to assist the State and Commonwealth Environment departments in species management decisions and to meet the interim recovery objectives of the Conservation Management Plan for the Southern Right Whale 2011–2021 (DSEWPaC 2012).

In 2013, the Department of Environment, Water and Natural Resources (DEWNR), as well as the Commonwealth Department for Environment (formerly DSEWPaC) made the decision to support the development of a new SRW aerial survey program to directly address the conservation and management needs of the GABMP and SRW management plans. The aims of the current study were to develop standardised repeatable aerial surveys to provide accurate estimates of SRW abundance and distribution at the HOB and FB. Two pilot aerial surveys, encompassing ~270 km of coastline, were conducted by helicopter in September and October 2013. Due to logistical and funding constraints, the surveys could not be conducted during the peak aggregation period (August). During the first survey, 49 SRW were sighted (25 adults and 24 calves), while a single female-calf pair was sighted during the second survey. Photo-IDs and geographic positions of all sighted whales were successfully obtained on both surveys, and no behavioural response to the presence of the helicopter was observed. The results of these pilot studies indicate that aerial surveys provide an efficient and standardised methodology with which to collect data on the abundance, distribution and reproductive state of individual whales in the study area.

To account for the three-year reproductive cycle of SRW, which results in cohort structured breeding, aerial surveys should be conducted on an annual basis. More robust estimates of SRW abundance in the survey area could be obtained by conducting multiple surveys within a single breeding season, as this would allow mark-recapture methods to be applied to photo-ID data collected during these surveys and would increase the likelihood of sighting unaccompanied whales which have shorter residency periods in the calving and aggregation area (Burnell and Bryden 1997). In addition, multiple surveys would provide better information on the fecundity, distribution and movement patterns of individual whales throughout the breeding season.

The results of the current study have shown that aerial surveys can provide relevant data on the abundance and distribution of SRW in the survey area, which are required for evaluating key performance measures of the GABMP, to assist the State and Commonwealth Environment departments in species management decisions, and meet the interim recovery objectives of the Conservation Management Plan for the SRW 2011-2021 (DSEWPaC 2012).

1. INTRODUCTION

1.1. BACKGROUND

Southern right whales (*Eubalaena australis*) (SRW) are listed as Endangered under the threatened species category of the Commonwealth *Environment Protection and Biodiversity Act 1999* (EPBC Act), as Vulnerable under the South Australian *National Parks and Wildlife Act* (1972), and monitoring of the species in Australian waters is required to meet the objectives of the Conservation Management Plan for the Southern Right Whale (DSEWPac 2012).

The species has a southern hemisphere circumpolar distribution between latitude 16°S and 65°S. Between May and October, the Australian population of SRW migrates between higher latitude feeding grounds (between 40°S and 65°S) to calving/nursery grounds in coastal Australian waters. Until recently, SRW in Australian waters have been managed as a single population estimated at approximately 3,500 individuals (DSEWPaC 2012). However, a recent genetic study has led to the proposal of two Australian populations; south-western (Western Australia and South Australia) and south-eastern (Victoria and New South Wales) (Carroll et al. 2011), that are experiencing different rates of recovery from historical whaling. While recovery and re-occupancy rates for the south-eastern population are low, the south-western population is estimated to be increasing at 6.79% per annum (Bannister 2011), near or at maximum population growth. Current population estimates put the south-western population at 2,900 individuals (Bannister 2011), or about 83% of the total estimated Australian SRW population.

The south-western SRW population is distributed between Cape Leeuwin, Western Australia (WA) and Ceduna, South Australia (SA) (Bannister 2011), with established large coastal aggregation and calving grounds in the Doubtful Island Bay and Israelite Bay areas in WA, and the Head of Bight (HOB) in SA. In general, female SRW show calving site fidelity and tend to spend 2–3 months at a particular nursery ground. However, calving whales have been recorded to travel between locations up to 700 km apart within a single season (DSEWPaC 2012), and unaccompanied whales (adults without calves) have been shown to travel between areas up to 1,500 km apart during the calving season.

Reproductive females in the population exhibit strong cohort structure as a result of a three year breeding cycle. However, this three year calving interval can vary in relation to large-scale climate variability (Leaper et al 2006) or if a female loses its calf. Gestation lasts for 12 months, with at least a 7–8 month lactation period. Reproductive females tend not to be present in these

coastal aggregation areas between calving events, therefore counts of female-calf pairs vary annually as a result of cohort structured breeding (DSEWPaC 2012). The winter distribution of Australian SRW which do not migrate to coastal calving/aggregation areas is unknown.

The HOB is a significant winter calving/aggregation site for a portion of the south-western population and Fowlers Bay (FB) to the east of the HOB is classified as an emerging aggregation area (DSEWPaC 2012). SRW are present in the area between May and October, with peak numbers occurring between mid-August and mid-September (Bannister 2011).

The SRW aggregation at the HOB has been studied for over twenty years, with varying levels of support from Commonwealth and State agencies (Department of Environment including the Australian Marine Mammal Centre (AMMC), and the Department of Environment, Water and Natural Resources (DEWNR)). These studies have been conducted to facilitate the management of the species and data have primarily been collected from cliff top surveys. These surveys are conducted over a 15 km stretch of coastline comprising of 5 km of beach (which cannot be directly surveyed) and 10 km of limestone cliffs. The potential coastal area that can be successfully surveyed from cliff top sites is dependent on the height of the observation point used (37 to 60 m) and environmental conditions (Charlton and Burnell 2011). In recent years, cliff top surveys have typically run for 12–17 days over a single field trip, usually commencing in mid-August. The cliff top surveys provide daily census counts of SRW in the study area, and opportunistic photo-IDs of individuals within several hundred meters of the shore. However, whales that are further offshore, or at the eastern end of the survey area, are not able to be photo-ID from the cliff top (Charlton and Burnell 2011).

Since 1993, aerial surveys of SRW have been conducted annually between Cape Leeuwin, WA and Ceduna, SA. These surveys provide additional information on SRW abundance, and photo-IDs in the GABMP. However, the area between the HOB and Ceduna is only surveyed twice (one eastern and one return leg) when peak numbers in female-calf pairs are likely to occur (mid-August to mid-September), and therefore aerial count data and photo-IDs are only available for a small proportion of time that whales are present at the HOB breeding/calving aggregation.

1.2. NEED

One of the primary purposes of the Great Australian Bight Marine Park (GABMP) is the conservation of SRW, and the HOB represents a significant aggregation and calving ground for the Australian south-western population. Information on the status and trends in abundance of

SRW populations within the region is needed for evaluating key performance measures of the GABMP and to assist the State and Commonwealth Environment departments in species management decisions, and to meet the interim recovery objectives of the Conservation Management Plan for the Southern Right Whale 2011-2021 (DSEWPaC 2012), the first objective of which is to:

“Demonstrate that the number of southern right whales occurring off south-west Australia (nominally south-west Australian population) is increasing at or near the maximum biological rate” (DSEWPaC 2012).

Land-based studies of the SRW aggregation at the HOB have been conducted since 1991, however for a number of reasons DEWNR does not have key information from this data set which is needed to the manage the species. Consequently, the development of a new SRW monitoring program was proposed to estimate the abundance, distribution and population dynamics of the HOB aggregation.

In order to investigate patterns in calving, intra-season population and migration dynamics, and habitat usage within and between seasons, accurate counts and identification of all individuals in the area are required. Aerial surveys provide a platform for conducting repeatable counts and for collecting photo-ID data, and have been widely used to study right whales (e.g. Elwen and Best 2004, Clark et al. 2010, Bannister 2011).

In 2013, DEWNR, in partnership with the Commonwealth Department for Environment, made the decision to support the development of a new aerial survey program to monitor SRW in the GABMP. The principal reasons for this were to overcome some of the limitations of land based monitoring (e.g. ability to obtain photo-ID of all individuals), and to develop a more tactical and effective monitoring program directly addressing the conservation and management needs of the GABMP and SRW management plans.

1.3. OBJECTIVES

The aims of this study were to:

- Develop and implement a standardised, repeatable aerial survey methodology that will provide cost-effective data to DEWNR on the abundance and distribution of SRW at the HOB and FB.

- Analyse and report the results of data collected during two pilot aerial surveys in September and October 2013.

2. METHODS

Aerial survey design

Three factors were considered in aerial survey design to ensure that: 1) the general methodology would be consistent with that used by the Western Australian Museum (led by John Bannister) during annual aerial surveys between Cape Leeuwin, WA and Ceduna, SA; 2) the development of standardised repeatable aerial surveys both within the aggregation season and over subsequent years; and 3) that the survey design would enable all whales in the survey area to be reliably counted, photo-ID and geographically located.

While annual SRW aerial surveys from Cape Leeuwin to Ceduna use a fixed wing aircraft, we trialled helicopters as a survey platform because they provide greater manoeuvrability and hovering capability. Furthermore, helicopters have been successfully used in previous studies to collect abundance and photo-ID data of SRW (Best and Ruther 1992, Groch et al. 2005, Belgrano et al. 2011). As helicopters have not previously been used to collect such data on the south-western Australian population of SRW, a component of this study was to assess whether there was any reaction by whales to this type of aircraft.

The survey area encompassed ~270 km of coastline (~ 570 km^2) centred on the HOB and FB (Figure 1). The width of the survey area was set as 2 km, to a) ensure absolute overlap with the area surveyed during the Western Australian Museum annual aerial surveys, which are generally flown within 1 km of the shore (A. Halsall *pers comm*., J. Biser *pers comm.*); and b) increase the likelihood of sighting any SRW further offshore.

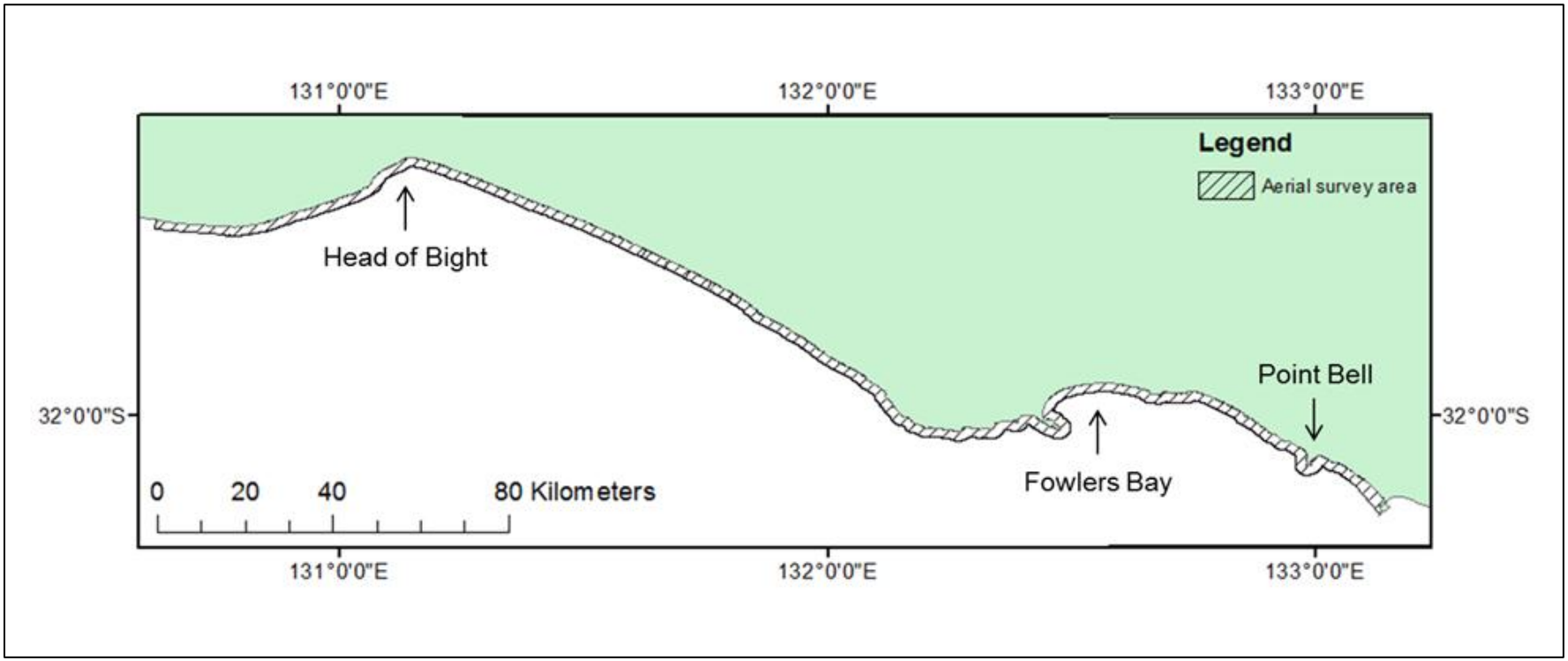


Figure 1. Extent of aerial survey area, encompassing the Head of Bight and Fowlers Bay.

Aerial surveys

Aerial surveys were conducted using a Robinson R44 helicopter. Due to funding and logistical constraints, pilot aerial surveys did not commence until late in the 2013 aggregation season. Although the numbers of whales were expected to be low, the pilot surveys provided the opportunity to assess whether there was any behavioural reaction of individuals to the helicopter and the utility of the platform for collecting photo-ID and distribution data. The survey team consisted of two observers (the pilot and an observer in the front passenger seat), and a photographer who was seated behind the pilot. The observer in the front passenger seat was also the data recorder. Once a whale was sighted, the initial time of sighting was recorded as the beginning of the encounter. During the encounter, the behaviour of the whale(s) prior to and after a photo-ID approach was recorded, including whether any behavioural change was observed. When an approach to photo-ID whales was initiated, the helicopter descended to no lower than 200 m in accordance with permit specifications. The photographer was positioned in the passenger seat behind the pilot so that both would have a similar view of whales being approached for photo-ID. The photographer, wearing a safety harness, leant out of the open passenger door to obtain photos as vertically as possible of each whale. Photographs were taken using a Canon 40D digital SLR camera with a 300–500 mm lens set to “sports mode”. The data recorder noted the start and end time of each photo-ID descent, the frame numbers of all pictures taken, and the lowest altitude flown during that descent. Helicopter altitude was recorded from the pilot’s personal aviation program and from a handheld GPS (Garmin GPSMAP 78s), that was also used to make a waypoint of the geographic position of each whale. The data recording sheet used during the surveys is provided in Appendix 1.

Behavioural response to photo-ID approach

Upon initial sighting, the behaviour of female-calf pairs, or individual whales, was assigned to one of 6 broad behavioural categories listed in Table 1. The behaviour of the whale(s) was again recorded once photographs had been obtained and the helicopter had moved on from that group.

Table 1. The different categories that the behaviour of individual whales could be recorded as both prior to and immediately after a photo-ID approach by the helicopter.

Behavioural Category	Code
Resting	R
Travelling	T
Social	SO
Breach	BR
Evasive dive	ED
Tail slap	TS

Photo-ID grading, collation, matching and storage

Southern right whales can be individually identified by the pattern of callosities on the rostrum of the animal (Payne 1986); the placement, size and configuration of which are individually distinctive. Callosities are raised thickened patches of epidermal tissue, which on adults have a white appearance due to the presence of cyamids or “whale lice” which live on the callosities. All photographic images collected during the two aerial surveys will be submitted to the Australasian Right Whale Photo Identification Catalogue (ARWPIC) once it is fully operational (May 2014).

Images of individual whales were grouped by encounter and then by individual within that encounter, and the callosity patterns for each individual adult were recorded to form a catalogue of all sightings. Photo-quality was scored using the 3 star grading system outlined in the ARWPIC image and data submission protocols (Beta version) (Table 2).

Table 2. Description of features used to assign image quality of photographs of individual whales as provided in the ARWPIC image and data submission protocols.

Image quality grade	**Features**
3 Star	Image is in sharp focus, taken in good light, with no or minimal water distortion, all or most of the identifying callosities are visible and glare is absent or does not obscure features of interest.
2 Star	Image is in focus, taken in reasonable light, with water distortion, most of the identifying callosities are visible and any glare only slightly obscures features of interest.
1 Star	Image is out of focus, or taken in poor light, or water distortion and or glare obscures features of interest, or not all identifying callosities are visible.

3. RESULTS

3.1. Aerial surveys

Two aerial surveys were conducted on 29 September and 18 October 2013. Both surveys were flown from east to west, with survey effort beginning at Point Bell (133.13° E, -32.2° S), and ending approximately 50 km west of the Head of Bight (130.6° E, -31.6º S) (Fig 1).

The first aerial survey lasted approximately 3 hours, during which a total of 49 whales (25 adults and 24 calves) were sighted. Apart from one group of 8 whales (4 female-calf pairs) and one group of 3 whales (a female-calf pair plus an unaccompanied adult), all other sightings were of single female-calf pairs.

The second aerial survey lasted approximately 2 hours and 40 mins, during which only one female-calf pair was sighted. Figure 2 shows the GPS locations and group size of all whale sightings recorded during the first and second aerial surveys.

Approximately 60% of all whales sighted during the first aerial survey were recorded in the core HOB area, as was the single female-calf pair recorded during the second survey (Figure 2). In this area, female-calf pairs were distributed from ~300 m up to ~1.6 km from the coastline.

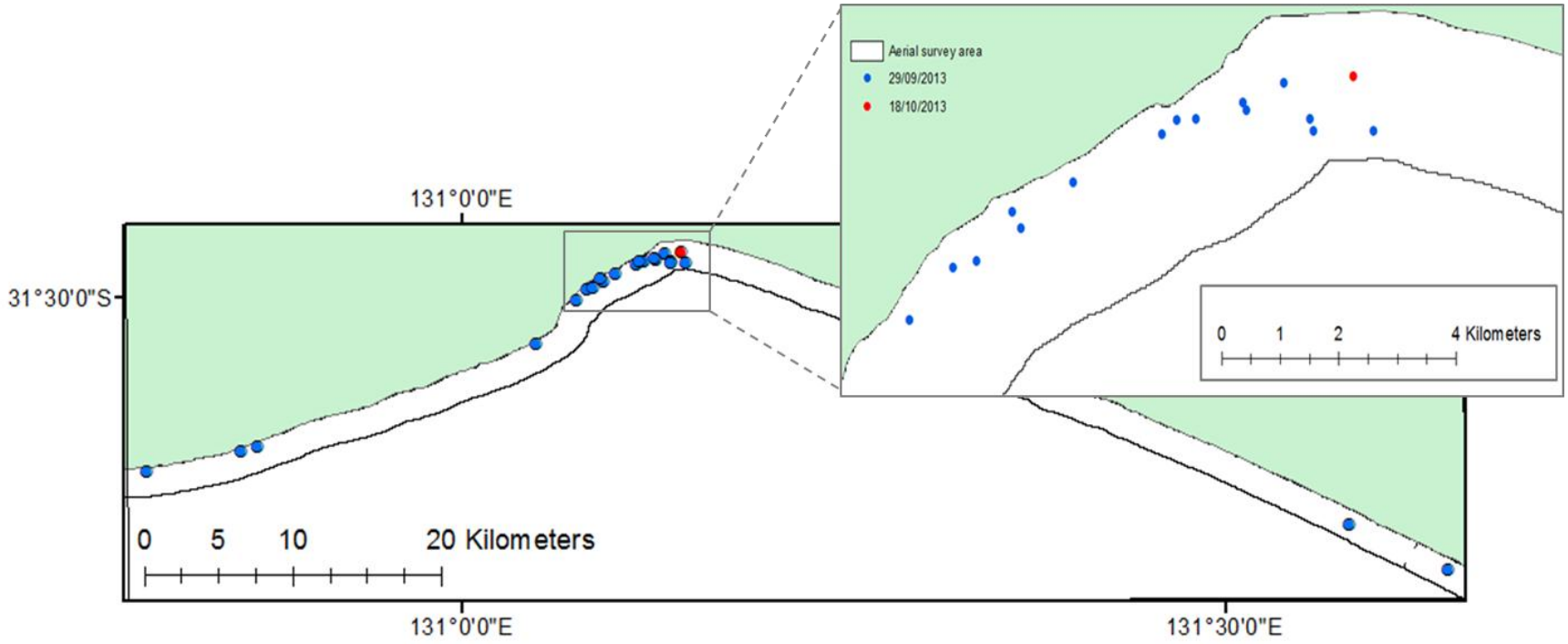


Figure 2. Location all SRW encounter locations during the aerial survey conducted on 29 September (blue dots) and on the 18 October 2013 (red dot). The inset provides the location of SRW encounters within the core HOB area from both surveys. All encounters in this core area were of single female-calf pairs.

3.2. Behavioural response to photo-ID approach

No change of behaviour was recorded for any individual whale before, during or after the photo-ID approach. Twenty-two of the 24 female-calf pairs, and the one unaccompanied adult, were resting when first sighted. These individuals continued to rest during and after the photo-ID approach with no change in behaviour or signs of disturbance by, or reaction to, the helicopter exhibited by any of the adults or accompanying calves. Two female-calf pairs were travelling prior to the photo-ID approach, and both maintained course and speed during and post photo-ID approach and did not exhibit any signs of disturbance or reaction.

Seventy-six percent of photo-ID approaches lasted one minute or less, 24% lasted two minutes, and the average minimum altitude during photo-ID was 215 m (range 204-286 m). Successful photographs were obtained of 22 female-calf pairs from a single photo-ID approach. A second photo-ID approach was taken of two female-calf pairs and the unaccompanied adult (that had not fully surfaced during the first approach) with each second approach lasting 1 minute or less.

3.3. Photo-ID

Photographs suitable for individual identification were obtained for all adult whales sighted during both aerial surveys. During the first survey, 3– or 2–star quality identification images were obtained for 92% of individual adult whales. For two individuals the highest obtained quality images were graded as 1–star quality, where the image quality was predominantly affected by glare and/or water distortion.

During the second survey, 3–star identification images were obtained of the sole female-calf pair sighted. This pair was successfully matched to a female-calf pair sighted during the first aerial survey, 1 km from the sighting location during the second survey.

4. DISCUSSION

The results of the two pilot aerial surveys show that the aerial survey design and data collection protocols developed for this project provide a practical, standardised and repeatable methodology to obtain accurate estimates of southern right whale abundance and distribution in the survey area. During the first aerial survey 40% of whales were sighted and photo-ID outside of the coastal area traditionally surveyed from cliff top study sites. In addition, four female-calf pairs were distributed at the eastern end of the cliff top survey area, and therefore would not have been available to be photo-ID from the cliff top. Aerial surveys therefore provide a methodology to ensure that whales distributed outside of the core HOB area (greater GABMP and FB) can be accurately counted and photo-ID.

Photo-IDs were successfully collected for all adult whales sighted during the pilot aerial surveys and no whales elicited a behavioural response to a photo-ID approach by the helicopter. The helicopter provided a more manoeuvrable and stable platform for photo-ID than a fixed-wing aircraft, and meant that once whales were sighted, the pilot was able to hover and hold position away from the whales and only begin an approach when individuals were at the surface, or about to surface. This allowed the photographer to generally obtain sufficient photos during one "pass" of the whale(s) and resulted in the majority of photo-ID approaches lasting one minute or less. Once photographs were obtained, the helicopter was able to quickly move away from the whale(s), increase altitude and provide a vantage point to assess post photo-ID approach behaviour. Although the average minimum altitude during photo-ID was 215 m, photographs could be taken from a higher altitude to ensure that the whole body of the whale is recorded within the frame.

High quality photo-IDs were obtained for 92% of individual adult whales, while for two individuals the highest obtained quality images were graded as 1 star, as a result of glare and/or water distortion. Although of lower quality, the sequences of photos taken of these individuals still allowed for a record of the full callosity pattern of each individual to be made. The use of a polarising lens in future should reduce the effect of glare on the quality of photo-ID shots.

Due to logistical and funding constraints, surveys were not able to be conducted earlier in the 2013 breeding season. However, the late timing of the surveys facilitated 'proof of concept' assessment of the effects of the helicopter on the whales at a time of low whale numbers, and

the development of survey skills and methodology. The inclusion of count and photo-ID data from Fowlers Bay will provide useful and needed information from this emerging aggregation area, which is known to have been a historically important nursery ground.

During times of peak abundance, it is likely to be more difficult to keep track of which individuals have been counted and identified within the survey area. For example, during a surveillance flight of the GABMP that was conducted by DEWNR on the 5th of August, 2013, 52 female-calf pairs and 43 unaccompanied adult whales were opportunistically counted (D. Holman *pers comm*.). In order to ensure that all whales in the survey area can be reliably counted, photo-identified and geographically located, a grid system of 5 km x 2 km blocks has been designed that can be provided to the helicopter pilot in future surveys. This will provide a simple method for the observers and pilot to keep track of sightings and be able to ensure that all whales within a given block will be counted and photo-ID before the subsequent block is surveyed (Appendix 2).

The collection of photo-IDs of all sighted whales within a standardised survey area at multiple times within a breeding season, would allow for mark-recapture methods to be applied to the data, and provide an estimate of total abundance during the annual breeding season. Multiple surveys would also improve our understanding of the fecundity, distribution and movement patterns of individual whales within, and between breeding seasons.

RECOMMENDATIONS

Aerial surveys should be conducted on an annual basis to account for inter-annual variability in counts of reproductive females, which occurs primarily as a result of the three-year breeding cycle. The collection of photo-IDs of all sighted whales within a standardised survey area at multiple times within a breeding season, would allow for mark-recapture methods to be applied to the data, and provide an estimate of total abundance during the annual breeding season.

It is recommended that at least three surveys per season are undertaken each year; in July, August (the historical peak in abundance) and September to provide a better understanding of the fecundity, distribution and movement patterns of individual whales with the calving/aggregation period, and to provide an estimate of total abundance using mark-recapture methodology.

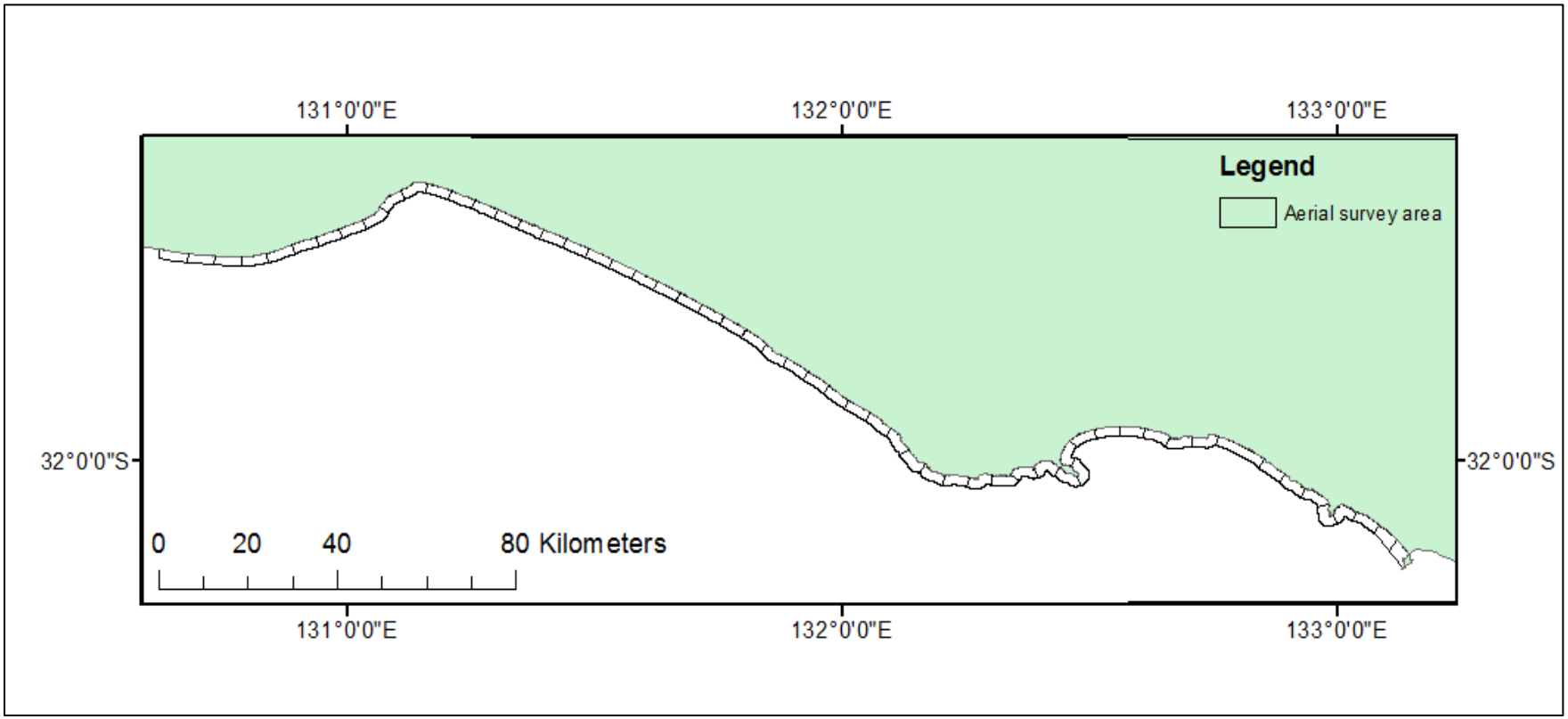
The collection of photo-IDs could be improved by using a polarising lens to decrease glare and by flying at a higher altitude to ensure that the whole body of the whale is photographed.

All photo-IDs should be uploaded to ARWPIC (once operational) to allow cross-matching by researchers collecting photo-IDs during cliff based surveys at the HOB and aerial surveys between Cape Leeuwin, WA and Ceduna, SA (since 1993) and between Ceduna, SA and Sydney, NSW (initiated in 2013).

APPENDIX 1: FIELD DATA ENTRY FORM

Date: **Survey start time:** **Survey end time:** **Start waypoint:** **End waypoint:**												**Observer:** **Photographer:** **Pilot:**	**Notes:**						
Encounter number &Time between first sighting whale(s) & end of encounter				**No. of whales** **FC = female/calf, UA = unaccomp. adult**			**Photo ID (minimum descent of 200m)** **Behaviour codes:** **R = resting ED = evasive dive BR = breach T = travelling TS = tail slap SO = social** **ID in group: for example if the group contains 3 FC pairs then first FC pair approached for photo-ID would be FC1**										**Environ-mental conditions**	
Enc No	**Way point enc**	**Time Start**	**Time End**	**Total in group**	**FC**	**UA**	**ID in group:**	**Time start**	**Time end**	**Behaviour to approach**		**Dist-urbance**	**Min. Height (m/ft)**	**Way Point Ind**	**Photo ID y/n**	**Start Frame no.**	**End Frame no.**	**Sea state**	**Wind knots**
										Pre	Post	**Y/N**							

APPENDIX 2: DIVISION OF SURVEY AREA INTO 2 X 5KM BLOCKS



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