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Monitoring southern right whale abundance, distribution and population dynamics at the Great Australian Bight aggregation

Alice I Mackay and Simon D Goldsworthy

SARDI Publication No. F2014/000052-2
SARDI Research Report Series No. 835

SARDI Aquatics Sciences
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March 2015

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EXECUTIVE SUMMARY

Aerial surveys of southern right whales (SRW - *Eubalaena australis*) were conducted in July, August and September 2014, encompassing the Far West Coast Marine Park (FWCMP) east to Point Bell, South Australia (SA). SRW were sighted from 17 km east of the SA-Western Australia border (129.17° W) east to Chadinga Beach (132.8° E). Highest counts were recorded in July, when 206 individuals (87 females with calves and 32 unaccompanied adults) were sighted in the survey area. In August both the density and number of whales was lower, with 121 individuals (56 females with calves and 9 unaccompanied adults) recorded. In September, 28 individuals were sighted in the survey area, comprising of 14 female-calf pairs. During all surveys, highest SRW densities (individuals km^{-1}) were recorded in an area of approximately 44.7 km^2 , from west of the Head of Bight to the east along Yalata Beach.

A total of 124 individual whales (94 females with calves and 30 unaccompanied adults) could be uniquely identified from photo-ID images obtained during the three aerial surveys. Resight rates of individuals were low between surveys, with only 3% of individuals being photographed on all three surveys and 70% of individuals only being photographed once. Resight rates were higher for females with calves than unaccompanied adult whales, 91% of which were only photographed on one occasion. A total of 16% of all female-calf pairs and 40% of all unaccompanied adults were only recorded outside of the core aggregation area around the Head of Bight.

As the population expands, there is a need to ensure that monitoring is conducted at a scale that reflects the distribution of SRW in the FWCMP, and covers emerging areas of SRW usage outside of the main Head of Bight aggregation area where SRW are more likely to be exposed to human disturbance.

While designed to monitor the SRW population, these surveys also provide a unique opportunity to collect data on the distribution and density of other marine protected species within the FWCMP.

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) and as Vulnerable under the *South Australian National Parks and Wildlife Act (1972)*. 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 ~7% 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 at the Head of Bight 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, and unaccompanied whales (adults without calves) have been shown to travel between areas up to 1,500 km apart during the calving season (Burnell 2001).

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. A difference in the calving

dynamics at the Head of Bight aggregation, compared to the rest of the SW population has also been reported, with more four year inter-calf intervals and fewer 2 year inter-calf intervals recorded than for the wider population (Bannister et al. 2011). The most recent estimated mean increase in the number of SRW at the Head of Bight aggregation, using cliff-top count data, is 5.44% per annum (Charlton et al. 2014a). 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 Head of Bight is a significant winter calving/aggregation site for a portion of the south-western population and Fowlers Bay to the east of the Head of Bight 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 Head of Bight has been studied since 1991 by the Southern Right Whale Photo Identification and Population Census Study (SRWPIPCS), with varying funding support from State and Commonwealth Government departments and from industry. Surveys are conducted from cliff-top observation points over a 10 km stretch of the Bunda Cliffs that range from 37- 60 m in elevation. These cliff top surveys record daily census counts of SRW in the study area, and collect photo-IDs of individuals that are within 300 m from the shore. However, whales that are further offshore, or at the eastern end of the survey area, are not able to be photo-ID'd from the cliff top (Charlton et al. 2014a).

Since 1993, the Western Australian Museum (WAM) has been conducting annual aerial surveys of SRW between Cape Leeuwin, WA and Ceduna, SA. These surveys provide additional information on SRW abundance, and photo-IDs in the FWCMP. However, the area between the Head of Bight and Ceduna is only surveyed twice (one eastern and one return leg) when peak numbers of 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 Head of Bight breeding/calving aggregation. Dedicated aerial surveys of the southern population between Ceduna, SA, and Sydney, New South Wales, (including Tasmania) have also been conducted in 2013 and 2014, led by Mandy Watson.

SRW are one of the key special features of the GAB Marine Park, and the Head of Bight represents a significant aggregation and calving ground for the Australian south-western SRW population. Information on the status and trends in abundance of SRW populations within the region is essential for evaluating key performance measures of the GAB Marine Park, and FWCMP, to assist DEWNR in species management decisions and meet the first interim recovery objective of the Conservation Management Plan for the Southern Right Whale 2011-2021 (DSEWPaC 2012):

"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 Head of Bight provide a continuous record of census counts of the surveyed aggregation area since 1991, and have provided key information relating to the biology and population dynamics of this species. During this period, numbers of SRW counted at the aggregation have increased from a maximum daily count of 45 adults in 1994 (Burnell and Bryden 1997) to 99 adults in 2013 (Charlton et al. 2014a). As the SRW population continues to increase (estimated at 5-7% per annum), further expansion into and use of emerging aggregation areas is likely, with increased sightings reported at Fowlers Bay since 2007 (Charlton et al. 2014b).

In 2013, the Department of Environment, Water and Natural Resources (DEWNR), as well as the Commonwealth Department for Environment (formerly DSEWPaC), supported the development of a new SRW aerial survey program to directly address the conservation and management needs of the GABMP and SRW management plan. The results of these pilot studies indicated 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.

Dedicated aerial surveys of the FWCMP and east to Ceduna, at three times during the SRW breeding and calving season, will provide data on the wider abundance and distribution of individuals within this coastal area. 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. Photo-ID data collected during these surveys, augment existing photo-ID catalogues in the Australasian Right Whale Photo Identification Catalogue

(ARWPIC) and can be used investigate within season coastal movements and between season movements of SRW in Australasia.

1.2. Objectives

The aim of this study is to provide cost-effective data on the abundance, distribution and reproductive rates of SRW in the Far West Coast Marine Park (FWCMP) by:

- conducting standardised repeatable aerial surveys to provide accurate estimates of SRW abundance in the study area,
- undertaking surveys at three times during the 2014 breeding/aggregation seasons, and
- collecting photo-IDs and geo-referenced positions of all sighted whales to provide mark-recapture estimates, and investigate the temporal and spatial distribution of individuals throughout the breeding/aggregation season.

2. METHODS

Aerial surveys

Aerial surveys were conducted using a Robinson R44 helicopter following the methodology developed in 2013 (Mackay and Goldsworthy 2014). 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.

The survey area was subdivided into a number of digitized maps using ArcMap 10.1 (ESRI©) and loaded into the pilot's on board mapping program. This allowed real time display of the helicopter track during surveys and could be used to determine which areas had already been surveyed for those blocks with high densities of whales.

During search mode, the helicopter was flown at a distance of approximately 1 km from the coast line. 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 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 presented in Mackay and Goldsworthy (2014). An encounter was defined as the time when a whale was first sighted to the time that the helicopter moved on from the location of that whale. Unaccompanied adults were defined as adults sighted without a calf present.

Aerial surveys were conducted on 29 July, 27 August and 25 September 2014. All surveys started at Point Bell (32° 13' S, 133° 15' E), but for logistic reasons ended at different distances west of Head of Bight. A minimum of 310 km and maximum of 440 km of coastline were surveyed within a 2 km distance from the shoreline.

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 (Figure 1). 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 three aerial surveys will be submitted to the Australasian Right Whale Photo Identification Catalogue (ARWPIC). 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). All images were scored and matched by one individual, and then a second person went through all the final IDs to ensure each was unique.

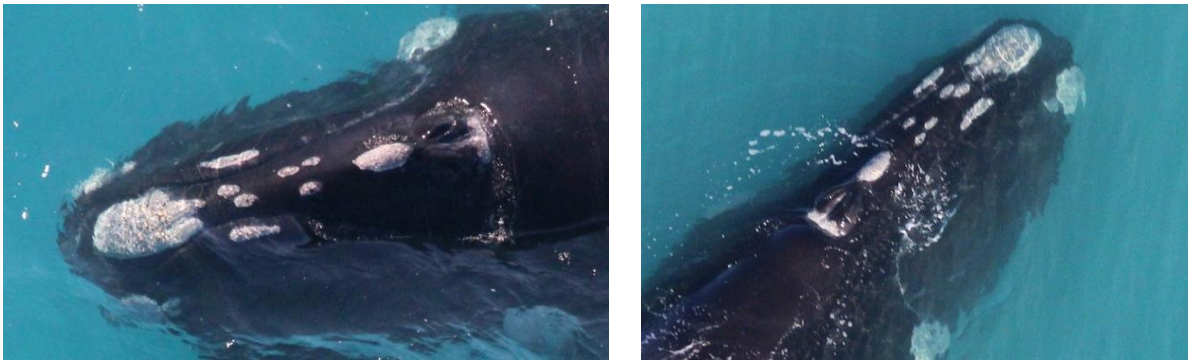

Figure 1. Example of an individual matched between two surveys from its unique callosity patterns. First photographed during the July (left) and resighted during the August (right) 2014 aerial survey.

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	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.

Data processing

All photographs were time matched to the GPS track recorded from the helicopter and to the data sheets. Movement of small number of individuals was noted, and where an individual had been counted twice, that waypoint and associated encounter data were removed from the dataset prior to analysis.

Distribution and density

GPS positions of all whale sightings were plotted in ArcMap 10.1 (ESRI©). A kernel density surface for each survey was then produced using the spatial analyst Density toolbox.

3. RESULTS

The start and end location of each aerial survey are presented in Figure 2.

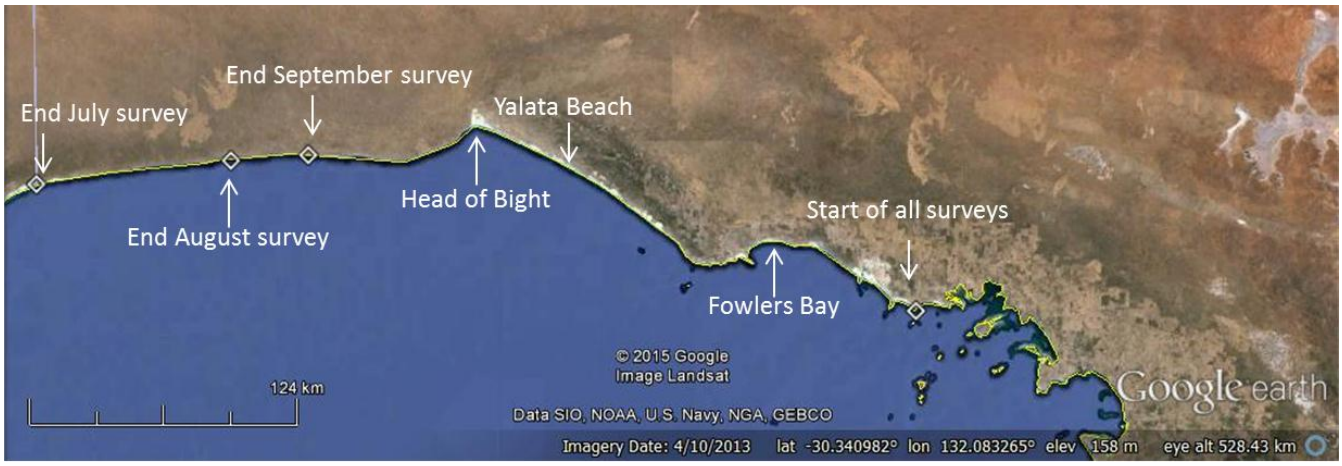

Figure 2. Start and end positions of each aerial survey for SRW conducted between 27 July and 25 September 2014.

A summary of survey effort and the total number of individuals counted on each survey are presented in Table 3.

Table 3. Summary of survey effort and SRW counts conducted between 29 July and 25 September 2014.

Survey number	Date	Total effort (hrs)	Total track length (km)	Total coastline surveyed (km)	Total individuals	Total female-calf pairs	Total unaccompanied adults
1	29/07/2014	7.7	746.30	442	206	87	32
2	27/08/2014	7	543.67	352	121	56	9
3	25/09/2014	2.7	417.14	315	28	14	0

The highest number of whales was recorded during the July aerial survey, when a total of 206 individuals were counted (87 female-calf pairs and 32 unaccompanied adults) (Fig. 3a). In August, 121 individuals (56 female-calf pairs and 9 unaccompanied adults) were counted (Fig. 3b), and 28 (14 female-calf pairs) were counted in September (Fig. 3c). If counts are standardised to only include those individuals sighted in the smaller survey area flown in September, then the total number of sighted whales would be 193 individuals in July (86 female-calf and 21 UA) and 115 individuals (53 female-calf pairs and 9 UAs) in August.

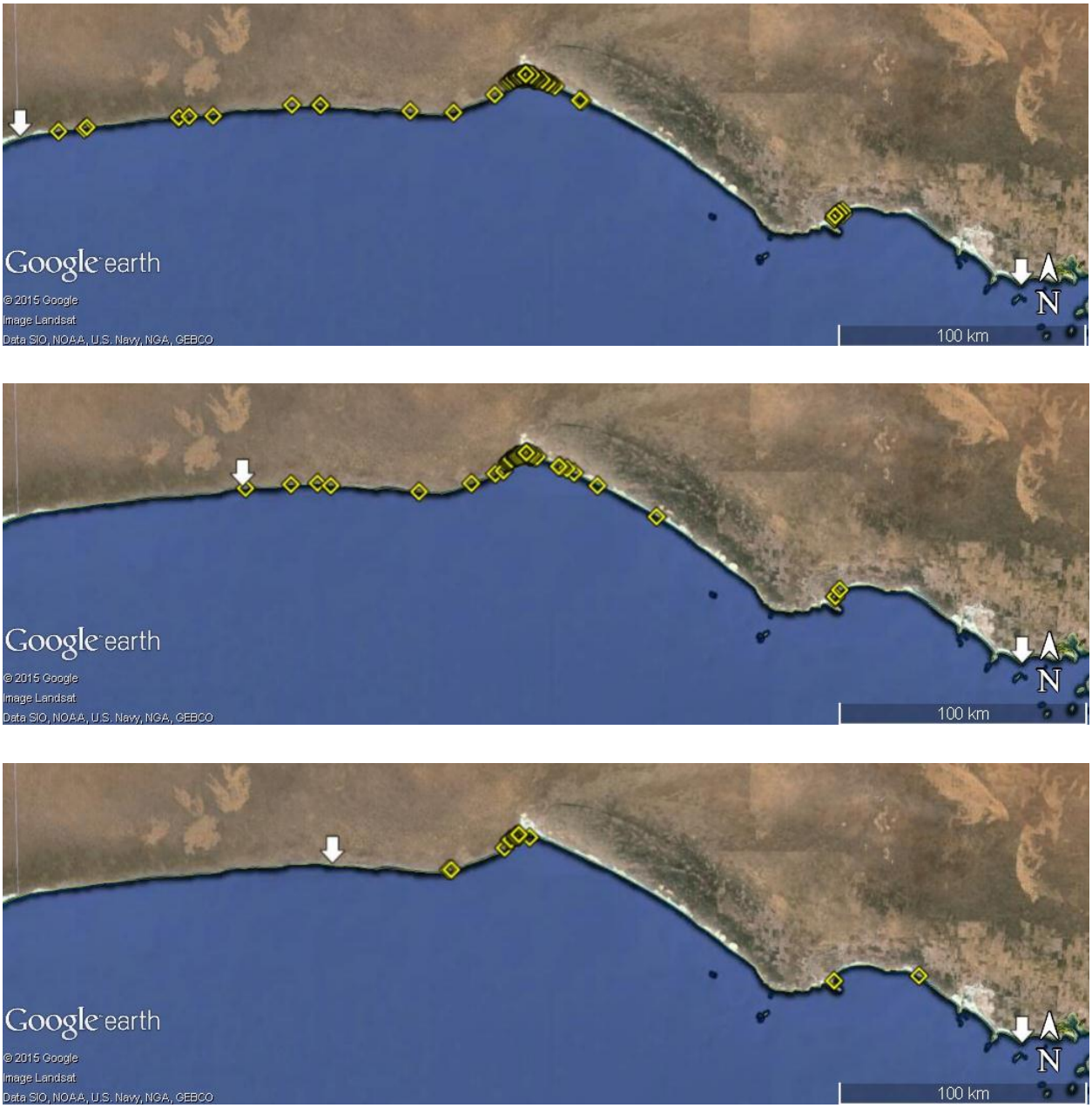

Figure 3a-c: SRW sightings locations during July, August and September aerial surveys 2014. White arrows indicate start and end locations of surveys.

The highest densities of whales were recorded from west of the Head of Bight to east along Yalata Beach. Approximately 72% of the total number of adults counted during each aerial survey were sighted in the geographical area shown in Figures 4a-c, which covers an area of approximately 44.7 km^2.

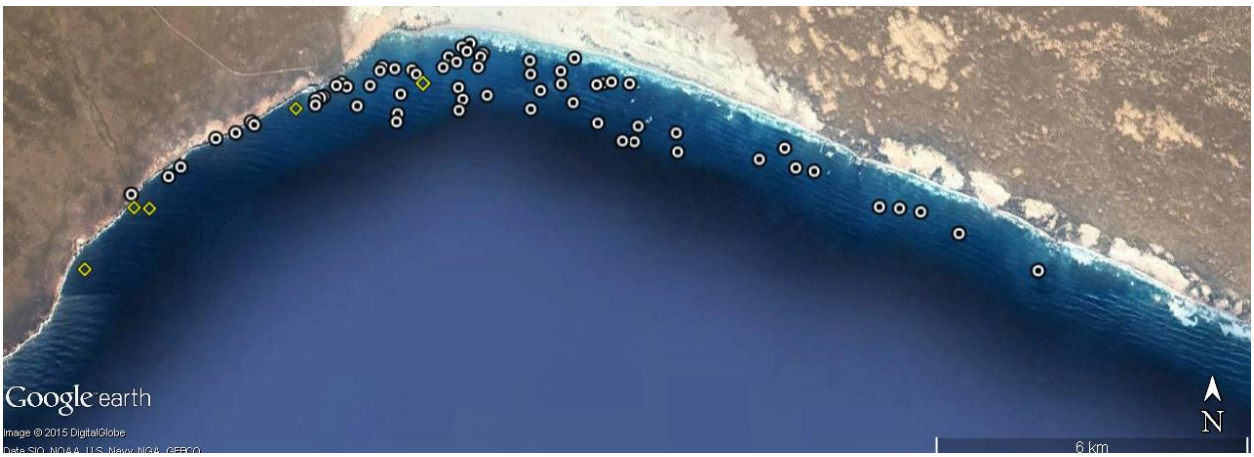

Figure 4a: SRW sighting locations 29 July 2014**.** White circles = female-calf pair (group size = 1-3), yellow diamonds = unaccompanied adults (group size = 1-10)

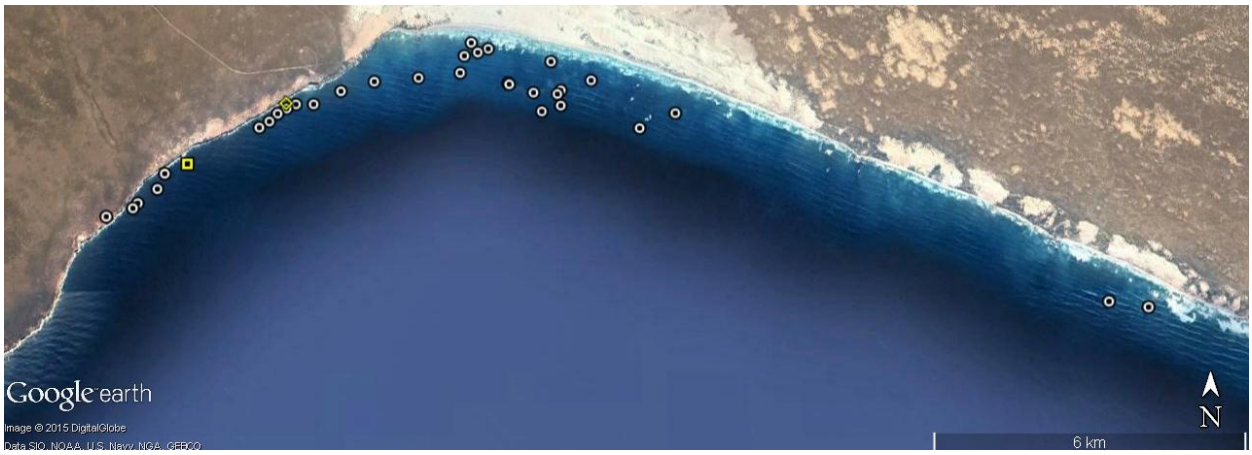

Figure 4b: SRW sighting locations 27 August 2014**.** White circles = female-calf pairs (group size = 1-3), yellow square = female calf pair (n=3) with unaccompanied adult (n=1), yellow diamonds = unaccompanied adults (n=2)

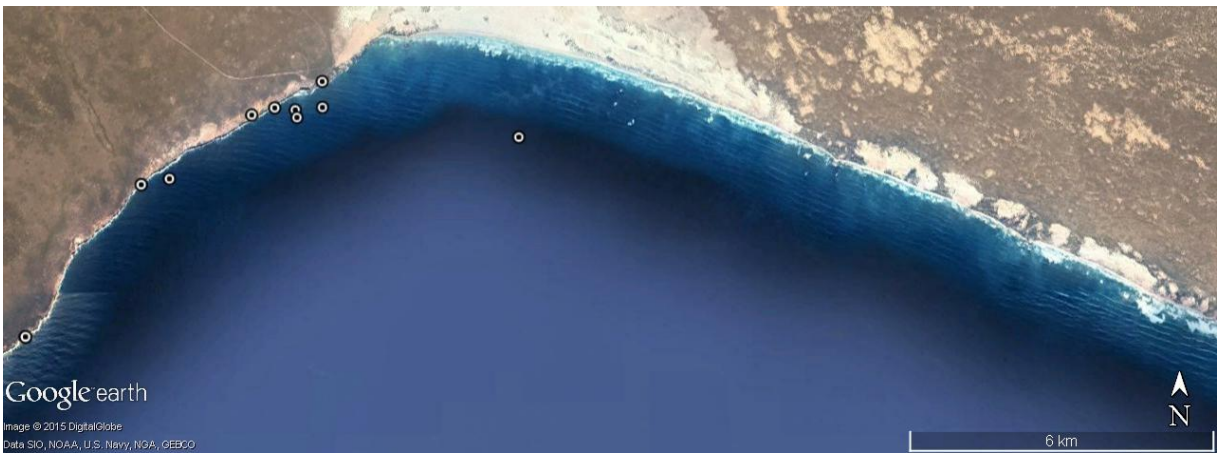

Figure 4c: SRW sighting locations 25 September 2014. White circles = female-calf pairs

Kernel density surfaces were produced for each aerial survey using sightings data and counts of individuals (Figure 5 a-c), and highlight the change in the density of individuals within this area between the July, August and September surveys. During the August survey, there was both a reduction in overall density of individuals sighted along Yalata beach, and an increase in density along the Bunda Cliffs, just west of the Head of Bight, compared to the July survey. During September, maximum sighting densities were of 1 individual km^{-2}.

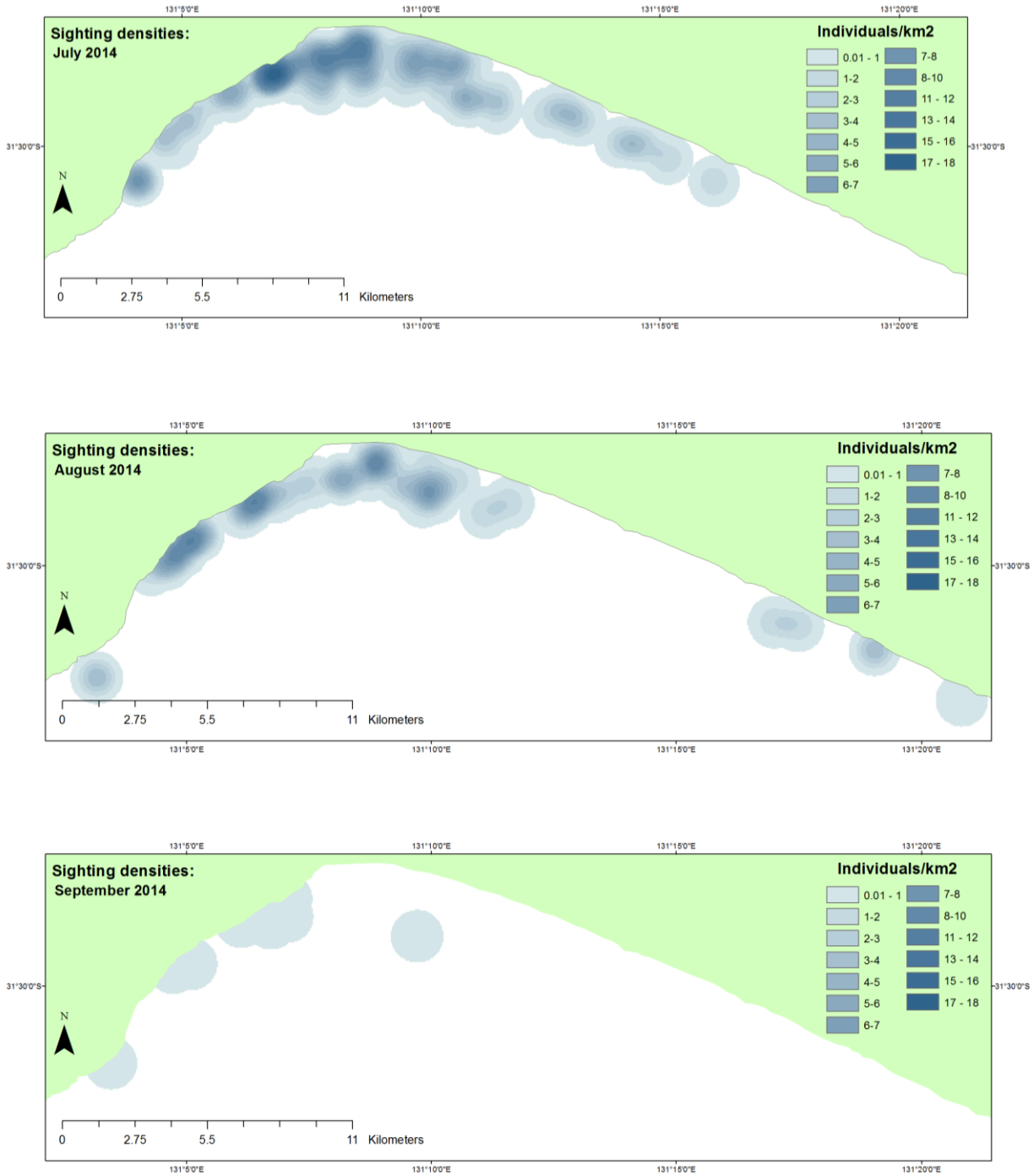

Figure 5 (a-c). Kernel density maps of SRW sightings in July, August and September 2014. Maximum density in August was 10 individuals km^{-2}

The average encounter length across all surveys was 84 seconds, with 75-86% of all encounters and 77%-86% of photo-ID approaches lasting one minute or less (Table 4). No change in behaviour was recorded during or after the approach by the helicopter to obtain photo-ID pictures during any of the surveys. The average minimum altitude during photo-ID approaches was 247 m in July (range 202 - 374 m), 265 m in August (range 204 - 375 m) and 276 m in September (range 228 - 331 m).

Table 4. Summary of encounter length and length of all photo-ID approaches by survey.

	Encounter length		Photo-ID approaches	
Survey no.	Average encounter length (sec)	Proportion of encounters of ≤ 1 min.	Average photo-ID length (sec)	Proportion of approaches of ≤ 1 min.
1	78	0.86	78	0.85
2	84	0.75	78	0.77
3	96	0.79	66	0.86

Photo IDs

Photographs of sufficient quality to clearly identify an individual were obtained for 81%, 86% and 93% of adult whales sighted in July, August and September (Table 5). A total of 72% of IDs obtained in July were quality 3 photographs and 26% were quality 2. A total of 85% of IDs obtained in August were quality 3 photographs and 13% were quality 2 photographs. All IDs obtained in September were quality 3 photographs.

Table 5. Summary of SRW photo-IDs obtained between July 27 and September 25, 2014.

Aerial survey date	Total adults counted	Total ID	Proportion of adults ID'd
29/07/2014	119	96	0.81
27/08/2014	65	55	0.86
25/09/2014	14	13	0.93

In total, individual photo-ID shots were obtained for 124 adult whales (94 females with calves, and 30 unaccompanied adults) over the three surveys. Resight rates varied between individuals, with 70% of individuals only being sighted once, and only 3% of individuals (n=4) being sighted on all three surveys. Resight rates were higher for females with calves than for

unaccompanied adults, with almost a third resighted on at least two occasions (n=30). However, of the 29 female-calf pairs that were sighted during two consecutive surveys, 90% were first sighted during the July survey, indicating the importance of surveying at multiple times within an aggregation period. The lowest resight rates were of unaccompanied adults, 91% of which were photographed on only one occasion (Figure 6).

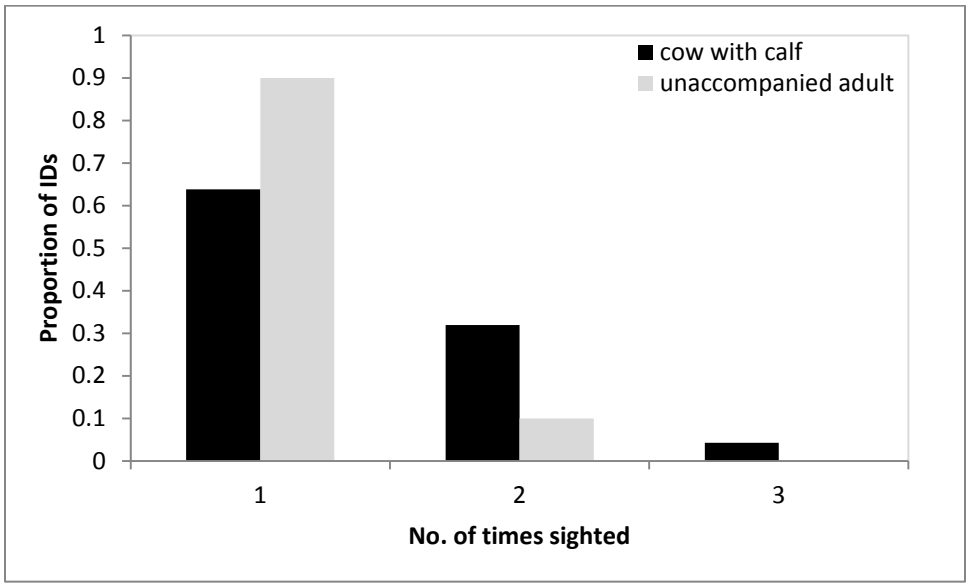

Figure 6. Resight rates for individually identified whales from 29 July to 25 September 2014.

Although the highest proportion of individuals were sighted in the area from Yalata beach to west of the Head of Bight, 16% of photo-ID'd female-calf pairs and 40% of photo-ID'd unaccompanied adults were only recorded outside of this main aggregation area.

Currently, the photo-ID data collected from this one season does not provide enough power to obtain a robust estimate of SRW whale abundance in the survey area using mark-recapture due to the low individual resight rates, high variation in individual recapture probability and a high rate of migration in and out of the survey area. Further photo-ID data collected over successive seasons are required to quantify migration rates, variability in individual resight probabilities, and probability that an individual may be resighted (counted) but not photo-ID'd.

However, photo-ID data collected during the current study provide a minimum estimate of 124 adult whales and 94 calves visiting the survey area at least once during the aggregation period.

Individual distribution patterns

Of the four identified female-calf pairs that were sighted on all three surveys, one was sighted on each occasion at Fowlers Bay (Fig. 7). The maximum distance between the July and September sighting locations of this female-calf pair was 3.3 km.

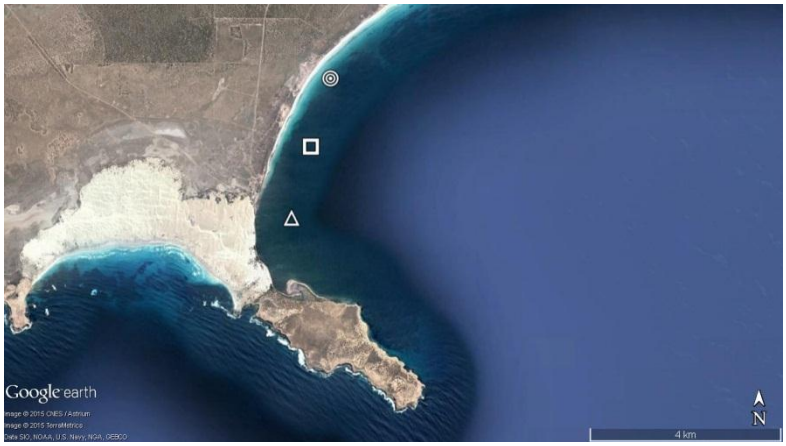

Figure 7: Sighting locations of an adult females and calf sighted at Fowlers Bay from each survey. Circle = July survey, Square = August survey, Triangle = September survey

The three other identified female-calf pairs that were sighted on all three surveys showed movement through the general area of Yalata Beach to west of the Head of Bight. The maximum distance between initial and final sightings locations of each female-calf pairs from the three surveys (assuming coastal movement) was 7.5 km (Fig. 8 a), 14.5 km (Fig. 8 b) and 32.5 km, respectively (Fig. 8 c).

Figure 8 (a-c) Sighting locations at Head of Bight of three adult females with calves from each aerial survey. Circle = July survey, Square = August survey, Triangle = September survey. Yellow marker indicates location of the Head of Bight Visitor Centre.

For individuals that were sighted on two surveys, 60% or more of female-calf pairs were within 10 km or less of the location they were sighted during the previous survey, and 24% within 2 km of the previous sighting (Fig. 9). The three unaccompanied adults that were encountered on two consecutive surveys were subsequently sighted within 2 km of their initial locations. The greatest distances travelled between consecutive sightings were recorded for two female-calf pairs that were initially sighted in Fowlers Bay and subsequently sighted at the Head of Bight and West of the Head of Bight, a distance of 161 km and 240 km, respectively.

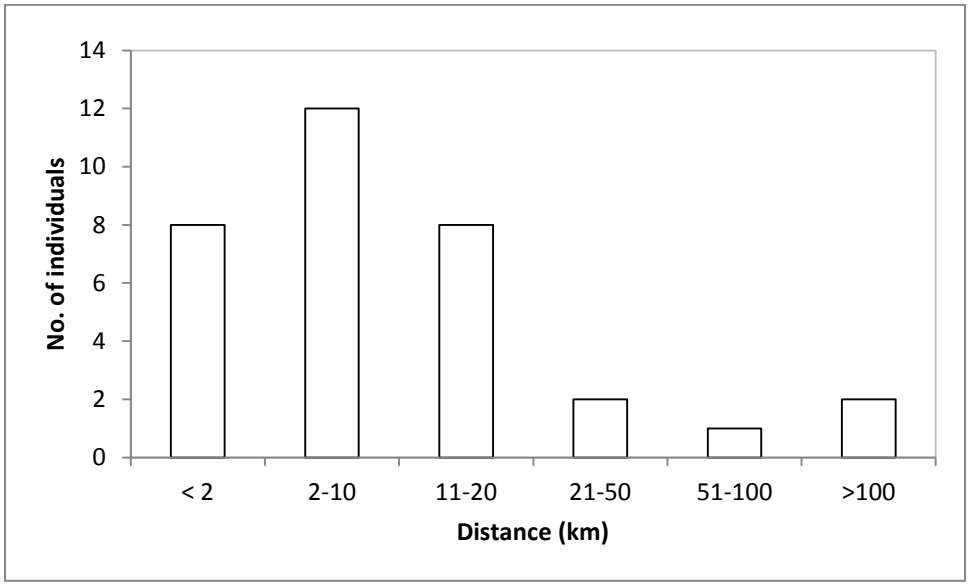

Figure 9. Maximum measured distance between sighting locations of individually identified whales between July 29 and September 25, 2014.

Sightings of other marine species

The sighting location of other species was also recorded and where possible photographs were taken. The most numerously sighted species were dolphins, most likely *Tursiops* sp., which were sighted at various locations between the survey start point and west of the Head of Bight, and Australian sea lions (*Neophoca cinerea*), which were predominantly sighted in the region of the Bunda Cliffs.

Three humpback whales (*Megaptera novaeangliea*) and three white sharks (*Carcharadon carcharias*) were sighted during the July survey, while two leatherback turtles (*Dermochelys coriacea*) were sighted during the August survey.

4. DISCUSSION

SRWs were sighted between 17 km from the SA-WA border (129.17° W) east to Chadinga Beach (132.8° E). The distributions and densities of whale sightings varied between surveys, particularly at Fowlers Bay, and in the area of Yalata Beach and Head of Bight. Previously, across aggregation season cliff-top survey counts of SRW at the Head of Bight have recorded peak number of individuals occurring around mid-August (e.g. Pirzl and Burnell 2005). Aerial surveys were therefore timed to bridge the historical peak in numbers recorded at the Head of Bight aggregation and to be close to the timing of flights conducted by the Western Australian Museum.

SRW numbers were highest in July, when a total of 206 individuals (87 females with calves and 32 unaccompanied) were sighted in the survey area. In August both the density and number of whales was lower, with 121 individuals (56 females with calves and 9 unaccompanied adults) recorded. In September, 28 individuals were sighted in the survey area, comprising of 14 female-calf pairs. During all surveys, highest SRW densities (individuals km^{-1}) were within an area of approximately 44.7 km^2 , from west of the Head of Bight to the east along Yalata Beach.

The helicopter provided a stable and efficient platform from which to collect both sighting and photo-ID location, with an overall average encounter length of 1.4 minutes and an average photo-ID approach of 1.3 minutes for all surveys. No behavioural change was observed during or after the approach by the helicopter, and the average minimum flying altitude across all surveys was 263 m.

On average, high quality photo-IDs were successfully obtained for 87% (81-93%) of all sighted whales. The most common reason that a photo-ID of a sighted whale was not obtained, was that the individual was at rest below the surface for an extended period. A total of 124 individual whales (94 females with calves and 30 unaccompanied adults) could be uniquely identified from photo-ID images obtained during the three aerial surveys.

Resight rates of individuals were low between surveys, with only 3% of individuals being photographed on all three surveys and 70% of individuals only being photographed once. Resight rates were higher for females with calves than for unaccompanied adult whales, 91% of

which were only photographed on one occasion. Individual resight rates will be underestimates if an individual was present, and counted in the survey area, but not successfully photographed.

The 124 adult SRW individually identified from photo-IDs taken during the three aerial surveys represent 80% of the total number of individual adult whales (n=156) identified by the Southern Right Whale Photo Identification and Population Census Study (SRWPIPCS) at Head of Bight from 45 days of cliff-top monitoring during the 2014 aggregation period (C. Charlton *pers comm.*). In previous years when the cliff-study was restricted to a single 14 day period in late August, the total number of individual photo-IDs of adult SRW was much lower (e.g. 58 unique IDs in 2013; Charlton et al. 2014a).

The high number of individual IDs obtained from the three aerial surveys shows this methodology can provide a large amount of data on individual whales for a relatively small amount of effort, both in terms of cost and survey time. However, 45% of females with calves and 67% of unaccompanied adults were only sighted during the July survey, and during the September survey 5 females with calves were ID'd for the first time.

These data show the importance of ensuring that surveys are undertaken at multiple times during the aggregation season to maximise both counting and photo-ID of individual whales. Given that the highest numbers of whales were counted in mid-July, future surveys should be moved forward by a couple of weeks to increase the probability of sighting and photographing females with calves within the survey area during the aggregation period.

Individual distribution patterns

All four individuals that were resighted on each survey were adult females accompanied by calves. One of these individuals was sighted on each survey at Fowlers Bay, within 3.3 km of its sighting location in July. Three other female-calf pairs showed movement through the general area of Yalata Beach to west of the Head of Bight between July, August and September, with distances ranging from 7.5 km and 32 km from the location where they were initially sighted in July. Burnell and Bryden (1997) noted that females remained in the shallows along the Yalata Beach area during, and for a period after calving, before moving further west in the aggregation area.

Assuming there was no movement out of the survey area between flights, the four female-calf pairs recorded on all three surveys had a minimum residency period in the survey area of 56

days. Burnell and Bryden (1997) reported a mean residency period of females with calves within the Head of Bight area of 70.9 days during the 1992-1994 aggregation periods, although females which calved later in the season tended to have shorter residency periods.

A total of 60% of female-calf pairs that were resighted twice or more were within 10 km or less of the location they were sighted during the previous survey. In contrast, two female-calf pairs that were initially sighted in Fowlers Bay were subsequently sighted at the Head of Bight and west of the Head of Bight, a distance of 161 km and 240 km, respectively. An unaccompanied adult sighted in Fowlers Bay during the August aerial survey was subsequently sighted at the Head of Bight during a vessel-based SRW telemetry project in September (SARDI *unpublished data*). Movements of both female-calf pairs and unaccompanied adults have previously been reported between Fowlers Bay and the Head of Bight (Charlton et al. 2014b) and as the south-western SRW population continues to increase, further expansion into this historical calving ground is likely.

In contrast to females with calves, unaccompanied adults had the lowest resight rates, with 91% only sighted on one occasion. Burnell and Bryden (1997) reported average residency periods for unaccompanied adults at Head of Bight of 20.4 days during the 1992-1994 aggregation periods, although some individuals were only seen for a few hours.

Burnell (2001) investigated the coastal movement of individual right whales around Australia using sighting data from different locations, and found within season movements of individuals to or from the Head of Bight ranging from 211 - 1,490 km. Coastal sightings of these individuals were predominantly made between the Head of Bight and locations in WA, although sightings were also made at Port Lincoln, Victor Harbor and Kangaroo Island. The furthest within season movements were undertaken by unaccompanied adults, although one female-calf pair was sighted at Port Lincoln and then resighted at the Head of Bight a month later, approximately 704 km away.

During our study, movement of identifiable individuals was recorded within the core aggregation area of west of the Head of Bight to east along Yalata Beach and between Fowlers Bay and Head of Bight. In addition, 16% of all female-calf pairs and 40% of all unaccompanied adults were only ever recorded outside of this core aggregation area. These do not include individuals ID'd at Fowlers Bay. As the population continues to recover, increasing densities at established aggregation sites are likely to lead to further expansion in the distribution of individuals during

the calving season along coastal regions and to areas of historical high use. In recent years, re-colonisation of previous calving habitats by SRW in mainland New Zealand and range expansion from the New Zealand subantarctic aggregation area has been recorded (Carrol et al. 2014).

Increasing the understanding of long-range movement rates of individuals between aggregation areas, both within and between breeding seasons, will improve the robustness of mark-recapture population models and understanding population dynamics. This is particularly relevant for females, as a number of studies have shown that they spend significantly less time at aggregation areas in non-calving years than in years when they have a calf (e.g. Burnell and Bryden 1997, Rowntree et al. 2001). The ability to successfully ID females in the aggregation area is essential for understanding factors that may drive unexpected changes in “cohort” structure; which could be a result of individual changes in breeding cycle, or linked to wider environmental factors (Leaper et al. 2006). Differences in calving intervals within the south western population exist; more females were observed to have a four year calving interval at the Head of Bight than was recorded in general for females in the wider south western population (Bannister et al. 2011).

Photo-IDs collected during our study will augment existing SRW catalogues in ARWPIC and allow investigation of connectivity between sites, both at the national and international level. As well as within season coastal movements, inter-year movements of photo-ID SRW between the Australian and subantarctic New Zealand populations has been recorded (Prizl et al. 1999).

Dedicated surveys of the entire FWCMP and coastal areas east of the park will provide important information on the distribution, densities and within season movements of SRW. In addition to both large and emerging aggregation areas, Biologically Important Areas (BIAs) identified for SRW also include coastal connecting habitat, areas of historic high use or currently unused or underused habitat (DSEWPaC 2012).

While designed to monitor the SRW population, these surveys also provide a unique opportunity to collect data on the distribution and density of other marine protected species within the FWCMP.

5. CONCLUSION

The current study provides detailed information on the distribution and abundance of SRWs within the Far West Coast Marine Park, and east to Point Bell, SA, at three times during the 2014 aggregation season.

Results demonstrate that helicopter based aerial surveys provide a cost effective methodology to investigate patterns in abundance and distribution, and provide a reliable and efficient platform from which to collect individual photo-ID data.

A total of 124 individuals were uniquely identified from photographs taken during the three surveys, demonstrating that a large amount of data can be collected for relatively small survey effort. However, 45% of females with calves were only sighted during the July survey, and during the September survey 5 females with calves were ID'd for the first time. In addition 90% of the female-calf pairs that were sighted on two consecutive surveys were first sighted in July.

Given the high proportion of females with calves that were only sighted during the July survey, and the low number of females with calves that were first ID'd during the September survey, it is recommended that the timing of future surveys is brought forward by a couple of week. This would increase the probability of sighting and identifying females with calves within the survey area during the aggregation period.

Due to low within season resight rates, photo-IDs collected in 2014 do not provide sufficient power to produce robust mark-recapture estimates. The high number of individuals that were sighted on only one survey indicates the high level of movement of whales in and out of the survey area.

While densities of whales were highest in the area around the Head of Bight, 16% of all female-calf pairs and 40% of all unaccompanied adults were only ever recorded outside of this core aggregation area. As the population expands, there is a need to ensure that monitoring is conducted at a scale and frequency that reflects the distribution and residency period of SRW in the Far West Coast Marine Park, and covers emerging areas of high SRW usage outside of the main Head of Bight aggregation area, where SRW are more likely to be exposed to human disturbance.

Cross-matching of individual photo-IDs collected by the Great Australian Bight Right Whale Study and our study is planned as part of an ongoing postgraduate project, and will provide further information on the minimum number of adult SRW present in the FWCMP and at Fowlers Bay during the 2014 aggregation. Photo-IDs will also be made available through ARWPIC for further cross matching with other SRW catalogues including the WA museum (John Bannister), South East Australian catalogue (Mandy Watson) and Tasmanian catalogues (Mandy Watson).

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