

Centre for Marine Science and Technology

Curtin University

Southern right whale research and monitoring in the Great Australian Bight, South Australia

Field Report

2014 & 2015



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Disclaimer

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Executive Summary and Key Findings

Southern right whales (*Eubalaena australis*) (SRWs) are listed as endangered and migratory species under the Australian Commonwealth Environment Protection Biodiversity and Conservation (EPBC) Act 1991. They migrate annually from southern feeding grounds to warmer, sheltered waters in Australia to breed, calve and rest in the Austral winters between May and October. SRWs were depleted to near extinction from commercial whaling in the 18th and 19th century. Whilst SRWs are now protected and are recovering, the population is yet to be considered secure.

A robust baseline understanding of migratory whale populations is critical to promote conservation management. SRWs are long lived, slow reproducing marine mammals and to assess their health and recovery, long term population monitoring in the order of decades is required.

The Great Australian Bight Right Whale Study (GABRWS) researches the distribution, relative abundance, life histories and acoustics of SRWs at established aggregation grounds in the Great Australian Bight (GAB), South Australia (SA). The GABRWS incorporates the long term cliff based SRW monitoring at the major aggregation ground, Head of Bight (HOB) (1991-2015), and vessel based research at the small adjacent aggregation ground at Fowlers Bay (FB) (2014-2015). In 2014 and 2015, the GABRWS was completed between mid-June and late-September. Vessel based studies were completed in collaboration with the Fowlers Bay Whale Watching Tourism operators on board the whale watching vessel.

The 2015 season represented the 25th consecutive year of annual cliff based SRW population census and photo identification (ID) study at HOB. HOB is Australia's largest aggregation ground for SRWs and lies within the Commonwealth GAB Marine Reserve, where up to 40% of the Australian population of SRW are known to visit (Burnell 2001). The study collects daily census and photo ID data and provides an unbroken annual data series on SRW relative abundance, distribution and life history data; relevant for population modelling and recovery studies.

Objectives of the 2014/2015 GABRWS field studies are aligned with the Commonwealth Conservation Management Plan for Southern Right Whales (2012-2021) and include:

- Assess SRW relative abundance, distribution and life histories through shore based and vessel based research at HOB and FB, respectively. Specifically, the study will continue the long term (1991-2015) population monitoring (photo ID and census of aggregation) at HOB following historical methods for comparative studies requiring long term time series dataset.
- Investigate coastal connectivity of SRWs between FB and HOB aggregation areas through photo ID study
- 3) Assess biological and anthropogenic underwater noise at FB using passive acoustic monitoring to contribute to underwater acoustic study that will characterise the sound repertoire of SRW in southern Australia and determine ambient noise levels at FB.

Head of Bight

At HOB, land based fieldwork was completed over 45 days in 2014 and 43 days in 2015 between mid-June and end-September. Field studies included census of the aggregation ground, photo ID and fine scale behavioural studies. Field work was completed on 33-53 m high vantage points along an approximately 15 km stretch of coastline, following historical methods proven successful with this long term field study (Burnell 2001; Charlton et al. 2013a).

Relative abundance trends reveal triennial peaks in abundance, representing a cohort structured breeding cycle, driven by SRWs three to four year calving intervals. Based on historical recovery trajectories of SRW at HOB, 2014 was expected to represent the largest breeding cohort, followed by the second largest breeding cohort in 2015. However, the peak relative abundance counts were lower than anticipated in both years. When assessing comparative time periods (between mid-late August), the maximum count for total individuals sighted on one day in 2014, was 140 on August 23, which is 1.5% greater than the 2013 maximum count and 18% lower than the corresponding cohort year in 2011 (max 172). In 2015, the maximum daily count for all individuals was 75 on August 21, which is 46% lower than 2014 and 43% lower than the corresponding cohort year in 2012 (max 132).

The lower than expected relative abundance in the HOB study site in 2014 may be attributed to spatial resources pressures, leading to the expansion of SRW distribution outside of the primary aggregation area in years of high abundance. Helicopter surveys completed by DEWNR showed that 16% of SRW were distributed outside of the GABRWS shore based monitoring study site (Mackay and Goldsworthy 2015). Furthermore, photo ID data shows that a greater number of individuals were photographed in the both field seasons compared to the max number of individuals counted on one day, indicating a high degree of movement in and out of the area. The number of individuals photo ID'd exceeded the maximum daily count of females with calves by 145% in 2014 and 128% in 2015; and, for unaccompanied adults by 276% in 2014 and 289% in 2015.

Of particular concern is the size of the decline in 2015 calf production. Calving female numbers in 2015 (n. 29) were 51% lower than the prior year (2014 n. 60) and 47% lower than 2012 (n.55), the previous cohort year. 2012 represents the primary cohort expected to calve in 2015. The effort was greater in 2015 with a 3.5 month field season compared to a 14 day field season in 2012. Therefore, the number of female and calf pairs recorded in 2012, is considered a minimum number of calf production for that year. The 2015 maximum daily count of all individual classes and of female and calf pairs is the lowest recorded at Head of Bight since 2007. It is only the second time since 1996 (2007 was the first time) (Burnell 2007) that both of the prior year and prior 3-year cohort metrics for calving females have been negative, and the decline in number of calving females in 2015 are greater than would be excepted by the natural attenuation of the 2012 cohort. Aerial surveys ran by John Bannister of the WAM sighted low overall SRW numbers in the south west of Australia in 2015. Therefore, the likelihood of low whale numbers in the GABRWS study site being due to animals occupying areas outside of the site, is considered low. During the WAM aerial survey, no whales were sighted between the HOB and Ceduna (Bannister pers. comms. 2015). The low numbers of calving females present in 2015 flatten the long term trends and the low calf numbers represent some cause

for concern. It will be critical to monitor SRW calf production in future years to assess if this decline influences overall recovery.

Variability in calf production can result from cohort shifts by a significant number of females, and from movement to and from the HOB aggregation area by other females. It is possible that females expected to calve in 2015 may have 'skipped' a calving year, in which case we would expect to see a redistribution of breeding females into the 2016 cohort. Based on population trends, 2016 represents the smallest breeding cohort and in 2013 (the previous breeding year for this cohort) there were 55 calving females sighted at HOB. Therefore, the number calving females is expected to be greater than 55 by a minimum of 7% (the population recovery rate). Seasonal changes in calf production may be connected to environmental variables, climate fluctuations and the availability of prey during the feeding season in the subantarctic (Burnell 2000, Burnell 2007; Pirzl et al. 2008). Links between sea surface temperature in feeding areas and the calving success of southern right whales in Argentina and Australia has been documented (Leaper et al. 2006; Pirzl 2009).

Census data including: position location data, population class, behaviour and direction of travel were recorded for all SRW sightings. Data supports that SRWs at the HOB are predominantly distributed within the 20 m depth contour, within 2 km from shore (Figure 8 and Figure 9). The period of peak relative abundance of SRW at HOB varied by approximately two weeks between 2014 and 2015 between mid-July and end-August.

Within season mark-recapture resulted in a total of 46% (2014) and 56% (2015) of SRW photo ID'd being resighted at least once (including 57% and 81% of females with calves in 2014 and 26% and 43% of unaccompanied adults in 2015). The number of within season resights ranged from 1-16 for females and calves and 1-6 for unaccompanied adults. When considering individuals that were resighted more than once at HOB, the mean visitation was 23 days (range 2-52) in 2014 and 52 days (range 2-92) in 2015 for females with calves and 15 days (range 2-52) in 2014 and 18 days (range 2-47) in 2015 for unaccompanied adults.

Cross matching of photo ID images from 2014 and 2015 with the long term HOB Photo ID catalogue resulted in across year resights of 51% of females and calves and 21% of unaccompanied adults in 2014 and 47% of females and calves and 25% of unaccompanied adults in 2015. A total of 76 individuals were added to the HOB catalogue as first sighted in 2014 (42 females with calves, 34 unaccompanied adults) and 71 individuals as first sighted in 2015 (18 females with calves, 53 unaccompanied adults). The HOB photo ID catalogue is currently up to date and includes life history data for over 1473 individual whales, including females in the year of calving, unaccompanied adults and calves that have been resignted at least once.

Fowlers Bay

At FB, vessel based surveys were completed on 26 days between June 13 and September 29 in 2014 and on 25 days between July 26 and August 29 in 2015. Vessel surveys involved census of the study site, photo ID and underwater noise monitoring. During vessel based surveys a total of 164 SRW sightings were recorded in 2014 and 112 sightings in 2015. SRWs sighted at FB are predominantly

distributed within the 10 m depth contour, within 1-2 km from shore and most commonly within a few hundred metres of shore (Figure 14 and Figure 15).

The maximum daily count of SRW individuals in the FB study site was 22 in 2014 and 9 in 2015. In both years the maximum sighting number was recorded on July 28. In 2014, a maximum of 10 female and calf pairs, 4 unaccompanied adults and 2 individuals of unknown status were recorded on one day. In 2015, a maximum of 2 female and calf pairs and 7 unaccompanied adults were recorded on any one day. Compared to 2014, the maximum number of all SRW's at FB in 2015 was 41% lower, the maximum number of female and calf pairs was 20% lower and in contrast the maximum number of unaccompanied adults was 175% greater.

The total number of different adult SRW photo ID'd in FB in 2014 was 18 (including 12 females with calves and 8 unaccompanied adults) and in 2015 was 19 (including two females with calves and 17 unaccompanied adults). The number of SRW photographed in the study site exceeded the maximum daily count by 120% for female and calf pairs and 200% for unaccompanied adults in 2014 and 189% for unaccompanied adults in 2015. In 2015 100% (n.2) of female and calf pairs were photo ID'd. Results indicated greater movement of female and calf pairs in and out of FB study area in 2014, compared to 2015. Within season mark-recapture resulted in resights of 61% and 73% of SRW photo ID'd SRWs in 2014 and 2015 seasons, respectively. The number of within season resights ranged from 1-20 for females and calves and 1-6 for unaccompanied adults. Recorded visitation of SRWs in the FB study area ranged from 1-74 days, with female and calf pairs displaying higher visitation periods than unaccompanied adults.

SRW individuals photographed at FB were cross matched with SRW photo ID'd at HOB in the same year to assess connectivity between the two adjacent aggregation areas. This exercise resulted in 32% (n. 6) of individuals being positively matched at both locations in 2014 including 25% (n.3) of female and calf pairs and 43% (n.3) of unaccompanied adults. In 2015, 47% (n.9) of all individual's photo ID'd at FB were positively sighted at FB and HOB, including 100% of female and calf pairs (n.2) and 43% (n.7) of unaccompanied adults. Images of individuals photographed at FB were also cross matched to the long term HOB photo ID catalogue (1991-2015), resulting in a total of 2 individuals (both females with calves) in 2014 and 3 individuals in 2015 (all of which were unaccompanied adults) being positively matched and therefore providing known life history data.

In both years an underwater noise logger was deployed approximately 12km offshore from Fowlers Bay in 45 m water depth. In 2014, the logger was deployed for 96 days between June 15 and September 21 and in 2015 the logger was deployed for 37 days between August 6 and September 11. Handheld hydrophone recordings were collected in 2014 from the vessel and in 2015; a sound trap was used on a temporary mooring system to record ambient noise in the aggregation ground for 1-12 days at a time, both in less than 10 m water depth. This data will be analysed in future to characterise the sound repertoire of southern right whales and assess biological and anthropogenic noise in FB.

Sightings of other marine life were recorded at both study sites and include cetaceans, pinnipeds, sea birds and sharks. Various datasets are distributed to relevant state and national databases such as

SA Museum, Department of Environment Cetacean sightings database, Birdwatch SA, Department of Environment and Natural Resources SA.

This document reports on the 2014/2015 GABRWS field studies, summarising the twenty-fourth and twenty-fifth consecutive years of SRW cliff based research at HOB, and; vessel based research completed at FB (2014 and 2015). It includes research methods and results from the 2014/2015 field seasons, updates on the status of the HOB identification catalogue, and provides some population trends derived from cumulative data. This report does not intend to interpret or discuss results in great detail. Further analyses and interpolation is being carried out by the authors under Curtin University Centre for Marine Science and Technology PhD programs and will be presented in future publications and thesis.

Background

SRWs are listed under the Australian Commonwealth EPBC Act as endangered and migratory species. There are four genetically distinct populations of SRWs around the globe in Argentina, South Africa, New Zealand and Australia. They migrate annually from southern feeding grounds to warmer, sheltered waters in Australia to calve, mate and rest in the Austral winter between May and October. In Australia, it is estimated that SRWs were depleted to less than 10% of their population through whaling in the 18th and 19th century. Although whaling was banned in Australia in 1935, illegal Soviet whaling removed around 100 SRWs from feeding areas near Australia just over fifty years ago, which is thought to have contributed to the absence of signs of species recovery in Australian waters until the 1970s. The Australian population is thought to have been reduced from approximately 15,000 individuals to as few as 300 (Bannister 1990).

Two discrete populations of southern right whales are suggested to exist within the Australian population, the 'western' sub-population and the 'eastern' sub-population (Caroll *et al.*, 2011). It is suggested that the 'western' Australian sub-population occupies areas between Cape Leeuwin, Western Australia (WA) and Ceduna, South Australia (SA), with an estimated population size of 2900 individuals (Bannister 2014). The 'eastern' subpopulation consists of fewer than 600 individuals and can be found along the south eastern coast, including Tasmania and rarely further north than Sydney. The western population of southern right whales is showing signs of recovery at the suggested species maximum biological rate of recovery of approximately 7% per year (Bannister 2014), whilst the 'eastern' subpopulation is not showing signs of recovery.

The majority of SRW aggregate in a relatively small range, compared with suitable habitat (Pirzl 2008). In Australia, calving/nursery grounds are primarily found off southern Western Australia and off the far west of South Australia. Key large established calving areas in Australia include: Head of Bight in SA and Doubtful Sound and Israelite Bay in Western Australia (WA). Other known small established calving areas include, Twilight Cove, Fowlers Bay, Flinders Bay and Encounter Bay (DSEWPaC 2012, Figure 1). During calving season (between May and October), SRW are generally within 2 km of the shoreline in waters less than 10 m deep (Pirzl 2008). Calving females are known to have high site fidelity and reside in calving grounds for up to three months (Burnell 2001).



Figure 1: Coastal aggregation areas for southern right whales (DSEWPaC 2012)

The GAB Marine Park (now Reserve) was established in 1995 to protect the major SRW aggregation ground in Australia, Head of Bight. Annual aerial surveys have been completed by the Western Australian Museum (WAM) since the mid-1970s to measure distribution, counts of whales and photo ID of individuals from the 'western' subpopulation (Bannister 2011). The long term SRW cliff based surveys have been completed annually at the HOB in the GAB, SA since 1991. The study collects daily census and photo ID data and provides an unbroken time series dataset on relative abundance trends and life history data of SRW (Burnell and Bryden 1997; Burnell 2001; Burnell et al., 2007; Burnell 2008; Charlton and Burnell 2011). The study has contributed to national and international studies on species recovery, genetics and connectivity (Anon 2002; Anon 2004; Burnell and Bryden 1997; Burnell 1999; Burnell 2001; Burnell 2007; Burnell *et al.*, 2007; Burnell 2008; Charlton *et al.*, 2013; Charlton *et al.*, 2013b; Pirzl 2008; Pirzl 2009; Pirzl *et al.*, 2008; Pirzl *et al.*, 2008; Pirzl *et al.*, 2009; Pirzl and Watson 2011; Patenaude & Harcourt, 2006).

Between 2007 and 2013, the cliff based monitoring was completed in mid to late August during the period of peak coastal residence (Burnell 2001) from cliff top vantage points, along a ~15 km stretch of the 33-53 m high Bunda Cliffs. Prior to 2007, the study was completed in three two week blocks in July, August and September. In 2014 and 2015 as a part of Claire Charlton's PhD and the industry partnership between Curtin University and Murphy Oil/Santos Energy, the study was expanded to 3.5 months between mid-June and end-September to redefine the period of peak SRW abundance, site use patterns and visitation rates.

SRW relative abundance trends reveal triennial peaks in abundance, representing a cohort structured breeding cycle. Recovery and population studies require monitoring on an annual basis to assess each breeding cohort independently. On any one day up to 172 individuals including 67 calves have been sighted at the HOB study site annually (max count 2011). Abundance data indicates that whilst the Australian population is recovering at approximately 7% per annum, the HOB annual growth rate is 5.5% (1991-2013) (Charlton et al., 2014a).

Potential threats to SRW in Australia include: vessel strike, and entanglement, prey depletion and noise pollution. Ship strike and elevated underwater noise from vessel traffic has had a significant impact on critically endangered North Atlantic right whales (*Eubalaena glacialis*) (Clarke et al., 2009; Rice et al., 2014). SRWs are protected by the GAB Marine Reserve at HOB with vessel closures between May and November.

FB is a small established aggregation ground 170km to the south east of major aggregation at HOB. As outlined in the Commonwealth conservation management plan for the SRW, there is a need to better understand: movement patterns and distribution outside of well studies aggregation grounds; coastal connectivity between coastal habitats and status of population recovery for both the SW and SE sub-populations of SRW in Australia. Research completed to date on SRWs at FB includes the annual aerial flight completed by John Bannister of the Western Australian Museum between 1993 and 2013; a pilot vessel based study completed over three days in 2012 and four days in 2013 by Eubalaena Pty. Ltd, the South Australia Museum and Curtin University collaboratively, and; an aerial survey in 2013 and 2014 by the Commonwealth Great Australian Bight Marine Reserve (Mackay and Goldsworthy 2015). There is a need for dedicated research to assess population dynamics of southern right whales at FB to promote adaptive conservation management. This report documents the 2014 and 2015 GABRWS vessel based field studies completed at FB.

Study Objectives

Study objectives of the 2014/2015 GABRWS are to:

- 4) Assess SRW relative abundance, distribution and life histories through shore based and vessel based research at HOB and FB, respectively. Specifically, the study will continue the long term (1991-2015) population monitoring (photo ID and census of aggregation) at HOB following historical methods for comparative studies requiring long term time series dataset.
- 5) Investigate coastal connectivity of SRWs between FB and HOB aggregation areas through photo ID study
- 6) Assess biological and anthropogenic underwater noise at FB using passive acoustic monitoring to contribute to underwater acoustic study that will characterise the sound repertoire of SRW in southern Australia and determine ambient noise levels at FB.

Study objectives were achieved through shore based field research at Head of Bight and vessel based research at Fowlers Bay. This research utilises the long term Head of Bight population census and photo ID dataset provided by Eubalaena Pty. Ltd. and the South Australian Museum and; collaborations with Western Australian Museum aerial survey study ran by John Bannister.

This study addresses interim recovery objective in the Commonwealth Conservation Management Recovery Plan for Southern Right Whales (2012-2017) to demonstrate that the number of SRWs occurring off south-west Australia (nominally south-west Australian population) is increasing at or near the maximum biological rate.

Study period

Field work was completed between June and September in 2014 and 2015. Field study dates include:

- 2014: June 16 and September 30
- 2015: June 15 and September 25

To maintain consistency with the historical methods of the long term census and photo ID study completed at HOB, three 10-day intensive surveys were completed at HOB in mid to late July, August and September. In addition two censuses of the aggregation areas were completed weekly at HOB to assess the relative abundance and distribution of whales at the site between mid-June to end-September (Table 1). The study periods and research effort in days is presented in Table 1 and highlights the comparable survey period in mid-late August across years and actual survey days excluding inclement weather days.

Boat based surveys at FB were completed to collect population dynamics and acoustic data in collaboration with Fowlers Bay Eco Park & Tours on board the whale watching tourism charter vessel. In 2014 vessel based research was completed throughout the three and a half month field season (pending weather and vessel availability) and in 2015 the FB field work was reduced to a five week intensive period between July 26 and August 29.

Year	Jun 15- Jun 30	Jul 1-Jul 15	July 16- July 31	Aug 1 - Aug 15	Aug 16 - Aug 31	Sept 1 - Sept 15	Sept 16- Sept 30
2011	0	0	0	0	10	0	0
2012	0	0	0	0	9	0	0
2013	0	0	0	0	10	0	0
2014	4	3	8	2	12	3	9
2015	4	4	9	2	10	4	8

Table 1: Study periods and research effort (days) at Head of Bight between June and September 2011-2015. The green column highlights the comparable period across all years of research.

Study Site

The GAB is in the far west of SA bordering the far east of WA and is a multi-use marine area. The HOB ($31^{\circ} 29'$ S, $131^{\circ} 08'$ E) is located in SA's far west at the northern point of the GAB, within the sanctuary zone of the GAB Marine Reserve (Figure 2). The approximate extent of the coastal range of southern right whales (displayed as dotted line in Figure 1) represents the Commonwealth recognised Biologically Important Area for southern right whales, within 2 km offshore extending along the southern Australian coastline. The HOB study was completed from land based vantage points of 33 m - 53 m elevation, spanning approximately 15 km east to west and 3 km offshore (Figure 3). The land based study was completed on Yalata Aboriginal lands, adjacent to the GAB Marine Reserve.

The GAB is a multi-use area for commercial fisheries, marine parks, tourism, oil and gas and provides habitat for marine species identified as Matters of National Environmental Significance and listed under the EPBC Act, including the southern right whale. The GAB is an oil and gas frontier with BP, Chevron, Murphy Oil, Santos Energy, and Bight Petroleum exploring the area.

FB is in the west region of South Australia (32 0' S 132 30' E) approximately 170 km south-east of the HOB SRW aggregation and 150 km west of Ceduna, SA (Figure 4). FB is in the habitat protection zone of the Nuyts Archipelago Marine Park and is adjacent to the GAB Marine Reserve in the west. FB is approximately 200 km² in area (between Point Fowler and Clare Bay). FB was selected as a study site due to increased numbers of southern right whales sighted in the bay in recent years, and influenced by vessel availability and tourism operations in the area. Research is completed utilising the Fowlers Bay Eco Park & Tours whale charter vessel.



Figure 2: Head of Bight cliff based study site in the Great Australian Bight. Map shows the approximate range of southern right whale coastal habitat, Commonwealth marine reserves and oil and gas permit areas.



Figure 3: Head of Bight study area in the Great Australian Bight, South Australia, with cliff top observation points in yellow in bottom figure.



Figure 4: Location of Fowlers Bay study site within the Nuyts Archipelago State Marine Park. Image source: www.marineparks.sa.gov.au 10/6/15

Field Methodology

Cliff based study at Head of Bight

Census of Aggregation Area

Daily census of the breeding aggregation were completed to monitor calf production, relative abundance; group composition (number in group and population class; i.e. cow-calf pairs, unaccompanied adults, sub-adults); spatial and temporal use patterns, and; behaviour (See ethogram in Appendix 1). The census was carried out from 16 vantage points between 33 m and 53 m high; 33 m at the eastern most vantage point and gradually increasing to 53 m at the western most vantage point. The vantage points were between 300 and 1000 metres apart, along a stretch of 15 km of coastline. Vantage points were selected to ensure full visual coverage of the study site, based on topographic features. At each vantage point, two observers scanned the area with 10x50 Bushnell binoculars and the naked eye for a minimum of 10 minutes. Observations consisted of systematic scans from east to west, from the horizon to the cliffs, with both the naked eye and binoculars. The ocean was split into two sections, one in the east and one in the west and observers focused on one half each. Censuses were completed only in beaufort sea state conditions of 3 or lower. Daily census effort ranged between 2.9 hours and 4.9 hours (mean = 3.6) and start time was roughly 08:30 and finish time ranged between 12:30 and 16:00, timed to avoid glare in the early morning and sea breeze in the afternoon (effort includes time observing and not travel time between vantage points). No corrections have been made to data to consider bias from varied survey effort.

Care was taken to avoid duplicate sightings by moving systematically west to east and resighting the last whale before continuing to record whales at the proceeding vantage point. These methods have been deemed appropriate for census of SRW in calving grounds where whales spend much time on the surface, and the positions and relative abundance counts thus obtained represent the minimum number of whales present. Whales were classified as a group if members were within several whale lengths of each other and interacting or travelling together.

Double-blind counts to estimate missed proportions due to perception bias were not possible due to logistic constraints, and decreased detectability with distance offshore has not yet been accounted for although most whales are believed to reside within 1 km of the cliffs so this is not considered an issue when comparing densities. Cliff based counts have been compared with aerial surveys and results show that the two study methods compare favourably (Charlton et al 2014; Pirzl 2008).

For each sighting, distance and bearing of the whale to the observer was recorded using Bushnell 1600 laser range finders and marine grade 10x50 binoculars fitted with a compass. In instances where the whale was outside the rangefinder detection range, reticulate binoculars fitted with a compass were used to measure increments below the horizon to the whale. In addition, height above sea level and GPS location of the observer team was calculated for each vantage point. Height of observation points above sea level was calculated by using a theodolite to determine the angle below the horizontal of a feature at the water's edge (usually a rock) to which the range was established using the laser range finders. Simple geometry then gave the elevation. Whale positions were calculated using code developed at CMST using the Matlab mapping toolbox (R. McCauley) to transfer the range estimate and true compass heading of the whale from the observer location (height included in calculations) onto a location on the earth. The error associated with tide was considered minimal given the tidal changes (~ 1.5 metres) relative to the distance in which whales were sited (most within 1 km) and measurement errors. Environmental conditions including wind speed and direction in knots, cloud cover in percentage, sea state using the beaufort scale and swell height were recorded qualitatively to assess sighting conditions at the start and end of each census. Glare was not recorded because methods are designed to avoid glare. Individual SRW were photo ID'd opportunistically and when photo ID opportunities presented, time was allowed to successfully complete all IDs possible.

Data was analysed in Excel and Matlab to present findings graphically and in distribution maps.

Photo Identification

Callosity patterns are keratinised skin patches colonised by cyamids. They form on the dorsal surface of the rostrum, the lip line of the lower jaw and just posterior to the blowhole. Callosities provide individually unique marking of southern right whales that persist throughout life (Payne et al., 1983). To record callosity patterns and other unique identifying marks, high resolution telephoto images are taken from the cliff top vantage points. A Nikon 7100 or D100 digital SLR camera with a Nikon 500 mm (effective 750 mm) or Sigma 500 mm lens mounted on a Manfrotto tripod is used for ID photography.

Dorsal and ventral photographs are also obtained wherever possible. Left and right lateral perspectives of callosity patterns, as well as the size and shape of ventral pigmentation (also persistent and unique) and the ano-genital configuration (gender) are documented with opportunistic photographs. Markings and any scarring are likewise photographed. Photo ID is not possible when whales are further offshore than 300 meters, nor for whales residing in the area off the beach at the eastern end of the study site. Since movement around the aggregation area is common, many of the individual whales present are likely to be available for photo-identification at some stage during the surveyed days. Photography was concentrated primarily on adults as callosity patterns are well developed. Photo identification effort for calves was increased later in the season, as they are generally too young to distinguish unique callosity patterns for future photo identification mark-recapture early in the season.

Digital photo ID images were sorted daily in the field, including within season cross matching of individuals to document the total number of individuals identified in that year. Each individual was then matched against the long term catalogue (Big Fish v6 Microsoft Access), including all calves photographed in previous years to document previously sighted and newly sighted whales.

The long term data set including the 2014 and 2015 data are being further analysed through Claire Charlton's PhD to assess population demographics. Adult survival rate, calf survival rate, fecundity rate (female calves per mature female) and the age-at-first-parturition will be calculated in Matlab (see also Burnell 2007 and 2008) and population models will follow methods in Cooke et al., 2003; Payne et al., 1990 and Brandao et al., 2011. This analysis is not included in this 2014 and 2015 field report.

Fine scale movement and behaviour

Fine scale movement and behaviour of SRW female and calf pairs and unaccompanied adults were assessed by completing focal follows using a TopCon GTS-600 theodolite and tailored software package Vadar V6 developed by Eric Knist of University of Newcastle. Focal follows were completed for a total of eighteen female and calf pairs and ten unaccompanied adults. Focal follows were completed from a cliff top vantage point of 43 m elevation in a sample area approximately 4 km along the cliff and within 2 km of shore. Animals were selected randomly by counting all individuals or pairs in the sample area and rolling a dice to determine the animal or pair to be followed. Animals were followed for a half an hour, or until the individual or pair became out of visual range. Only one individual or pair was focal followed at one time to ensure that all fine scale movements and behaviours were tracked and recorded. Behaviours were recorded according to the Ethogram presented in Appendix 1.

See Appendix 1 of the GABRWS 2015 Field Plan for detailed methodology on theodolite fine scale behaviour and movement study.

Vessel based study at Fowlers Bay

Vessel based opportunistic surveys were completed at FB to assess SRW relative abundance and distribution, spatial use patterns, behaviour, calf production and life histories. Vessel surveys were

completed daily (weather dependant) between July 4 and September 12 in 2014 and between July 26 and August 29 in 2015, on board the Fowlers Bay Eco Park & Tours charter vessel.

During vessel surveys, two researchers searched for whales from a 2.5m - 4.5m elevated platform on board the vessel (40 ft. Ashera vessel, 20 ft. Jaguar vessel or 45 ft. Calypso vessel) using Nikon 10x50 marine grade binoculars and the naked eye. Scans were completed systematically with researchers scanning one side of vessel each and scanning from the horizon to vessel as the boat transited at approximately 4knots. For each sighting, the following data were recorded: GPS location of vessel/observer; distance from vessel to whale using Bushnell 1600 rangefinder; bearing from vessel to whale using compass; group size and group composition (female and calf, unaccompanied adult, juvenile, unknown); sex of animals in the group if possible; behaviour; time and date. Time of approach and time of departure for each whale group observed was recorded. All whales were approach to a distance that the range finder could be used - generally within 400m max. Photo ID images were captured opportunistically using a Nikon 5200 Camera and Nikon 300 mm lens. The following weather conditions were recorded qualitatively at the start of each survey: wind speed, wind direction, beaufort sea state, swell, cloud cover percentage, water temperature, and air temperature. Effort and vessel tracks from the vessel's departure time from the pier to its return were recorded using a Holux M-1000C GPS data logger and information was downloaded at the end of the each day to enable correction for effort (in both space and time) for future analysis.

Researchers aimed to photo ID as many individuals as possible each trip for assessment of residency. If multiple trips were completed on one day, the maximum count of individuals on any single trip was used to represent the daily sightings record. Where possible, the individual ID for each sighting was recorded with the GPS location of the whale for assessment of individual site use patterns across the season.

Passive Acoustic Monitoring

Passive acoustic monitoring was completed at FB in 2014 and 2015 to record SRW vocalisations and biological and anthropogenic noise, using a noise logger, a hand held hydrophone (2014 only) and a sound trap (2015 only).

The underwater noise logger (LF Logger SNR047 with hydrophone s/n 454045 - built by CMST. 6000s/s, 8Hz HPF, 2800Hz anti alias filter, total gain 40dB, recording 600 of every 900 seconds) was deployed 12km offshore from FB jetty (32° 3.247'S and 132° 31.211'E) in approximately 45m water depth, between June 13 and September 28 in 2014 and August 6 and September 11 in 2015. An acoustic release was used on a weighted mooring system. The logger was deployed and retrieved from the Fowlers Bay Whale Watching Tour vessel Jaguar, with support from tour operator Rod Keogh.

Handheld recordings of underwater noise were taken opportunistically from the tourist whale watching vessel [40 *ft. Asheera vessel*] using a HTI-96-MIN hydrophone with built in pre amplifier (40 dB) and Jammin Pro HR-5 recorded. The flat frequency response of the equipment is between 20 Hz and 30 kHz. Hydrophone recordings were collected on seven days between June and August, in 2014.

The SoundTrap (202 Digital Sound recorder, 20 Hz - 60 Hz) was deployed on three occasions in August, 2015 for 48 hours, 5 days, and 12 days, respectively (equalling a total of 19 days). The sound trap was deployed in the calving area at Fowlers Bay in approximately 10 m water depth, attached to a temporary mooring and surface buoy.

Data available

- Historic: 25 years photo ID mark recapture and relative abundance trends (1991-2015)
- 2014-2015 Field data collected at Head of Bight and Fowlers Bay

Intellectual property rights of the long term population census and photo ID data set (1991-2015) are shared between Stephen Burnell of Eubalaena Pty. Ltd. and Claire Charlton. Data collected outside the methodology of the long term study during Claire Charlton's PhD is owned solely by Claire Charlton of Curtin University.

Data storage

All data is stored electronically on a Network-Attached Storage drive and backed up to external hard drives. The Head of Bight census and photo ID data is stored in a Microsoft Access database, BigFish V.6 established specifically for this project by Rebecca Pirzl and Stephen Burnell. The BigFish licence is held by Claire Charlton through the Department of Environment, Water and Natural Resources. All field data sheets are filed and stored in hard copy.

Results

Head of Bight

Census of Aggregation

<u>2014</u>

In 2014, SRW census of the HOB study area were completed on 45 days between 19 June and 28 September, of which four were discounted due to poor weather conditions. The maximum count for total individuals sighted in one day was 140 (range 8-140, mean 76) on 23 August. A maximum of 60 (range 8-60, mean 32) female and calf pairs, 17 unaccompanied adults (range 0-17, mean 5) and 9 individuals of unknown status (range 0-9, mean 2) were recorded on one day (Table 2; Figure 5). The period of peak abundance of SRWs at HOB in 2014 was between 21 July and 24 August. Numbers reduced to four female and calf pairs at the end of the study season on 28 September (Figure 5).

When comparing maximum daily counts of SRW to comparative time periods in previous years, the 2014 maximum count was only slightly greater (1.5%) than the 2013 maximum count of 138 (including 56 female and calf pairs and 21 unaccompanied adults). The maximum count in 2014 was 18% lower than the corresponding cohort year based on 3 year calving cycle in 2011 (max 172, including 67 female and calf pairs and 35 unaccompanied adults) (Table 2, Figure 7:). The maximum daily count for female and calf pairs in 2014 (n.60) was 7% greater than 2013 (n.56) and 10% less than the previous cohort year in 2011 (n.67) (Figure 7:). The maximum number of unaccompanied adults

counted on one day at HOB was 19% lower than 2013 (n.21) and 51% lower the corresponding cohort year in 2011 (n.35).

<u>2015</u>

In 2015, SRW census of the HOB study area were completed on 43 days between 18 June and 25 September, of which two were discounted due to inclement weather. The maximum daily count for all individuals was 75 (range 4-75, mean 49) on August 21. A maximum of 29 (range 2-29, mean 17) female and calf pairs, 27 (range 0-27, mean 8) unaccompanied adults and 3 (range 0-3, mean 0.5) individuals of unknown status were recorded on one day in 2015 (Table 2; Figure 6). The period of peak abundance of SRWs at HOB in 2015 was between July 31 and September 8. On the last day of the field study on September 25, sightings reduced to 9 female and calf pairs at Head of Bight (Figure 6).

When comparing maximum daily counts of all individuals to comparative time periods in previous years, the 2015 maximum number of SRWs observed at HOB was significantly lower (46%) than the previous year (2014 maximum 140) and 43% lower than the corresponding cohort year in 2012 (maximum 132) based on triennial cycle of peak abundance (Table 2, Figure 7:). The maximum daily count for female and calf pairs in 2015 (n.29) was 51% lower than 2014 (n.60) and 47% less than the previous cohort year in 2012 (n.55). The maximum daily count for unaccompanied adults in 2015 (n.27) was 59% greater than 2014 (n.17) and 42% greater than the previous cohort year in 2012 (n.19). The 2015 maximum daily count of all individual classes and of female and calf pairs is the lowest recorded at Head of Bight since 2007 (Figure 7:).

The last SRW anecdotal sighting recorded by tourists at HOB was on 7 October in 2014 and 5 October in 2015.

Table 2: Number of southern right whales sighted daily within the HOB aggregation area during 2014 and 2015 to 2008-2013 using comparable time periods

 between August 15 and 30.

	2015		2014		2013		2012		2011		2010		2009		2008	
	Daily range	Mean	Daily range	Mean	Daily range	Mean	Daily range	Mean	Daily range	Mean	Daily range	Mean	Daily range	Mean	Daily range	Mean
Females-Calf Pairs	2-29	17	8-60	32	36-56	49	32-55	48	33 - 67	56	33 - 42	37	51-63	58	46 - 55	50
Unaccompanied Adults	0-27	8	0-17	5	0 - 27	13	2 - 19	7	8 - 35	18	1 - 9	6	13-24	18	3 - 30	16
Unknown Status	0-3	0.5	0-9	2	5 - 16	9	0 - 5	2	3 - 12	6	1 - 10	3	0-8	3	0 - 11	1
Daily Total	4-75	49	8-140	76	89-138	119	69-132	104	131 - 172	148	80 - 95	83	97-133	117	103 - 127	115



Figure 5: Southern Right Whale relative abundance at Head of Bight, South Australia between 19 June and 28 September 2014





Figure 7: Southern right whale relative abundance trend at Head of Bight, South Australia 1992-2015

Distribution

SRWs aggregating at the HOB are predominantly distributed within the 20 m depth contour, within 2 km from shore. Female and calf pairs are most densely distributed in the bay in the eastern end of the study site, whilst unaccompanied adults are most frequently sighted along the cliff line (Figure 8 and Figure 9). Social groups of unaccompanied adults are often sighted along the cliff line and female and calf pairs are known to occupy the bay area with young calves and travel along the cliff line as the calf gets older and as the season progresses (Figure 10 and Figure 11). Patterns in distribution are similar when comparing sightings data from 2014 to 2015 (Figure 8 and Figure 9). In 2015 a greater proportion of unaccompanied adults were sighted in the eastern end of the study site, reflective of the higher number of unaccompanied adults in that year, compared to 2014. Position location data, population class, group composition, behaviour and direction of travel were recorded for 1621 and 1069 sightings of individuals or female and calf pairs at Head of Bight in 2014 and 2015, respectively, and will be used in future analysis of population dynamics. The 2014 maps do not include sightings from the eastern end of the study site. In 2014, range and bearing was not recorded for sightings when there was land in the background because of the associated error in position calculation. Instead the sighting was recorded for use in density distribution plots and in daily relative abundance counts. In 2015, the position calculated using reticulate binoculars was compared to whale location using theodolite and the error was marginal and therefore the positional data of whales recorded with land in the background, was included for 2015 sightings.



131 00 131 01 131 02 131 03 131 04 131 05 131 06 131 07 131 08 131 09 131 10 131 11 131 12 131 13 131 14 131 15

Figure 8: All sightings of southern right whales recorded within the Head of Bight study site in the Great Australian Bight, South Australia between June 19 and September 28, 2014, showing female and calf pairs in red, unaccompanied adults in blue and unknown status in green.



Figure 9: All sightings of southern right whales recorded within the population census study site at the Head of the Great Australian Bight, South Australia between June 16 and September 25, 2015, showing female and calf pairs in red, unaccompanied adults in blue and unknown status in green.



131 00 131 01 131 02 131 03 131 04 131 05 131 06 131 07 131 08 131 09 131 10 131 11 131 12 131 13 131 14 131 15

 Figure 10: Sightings locations of southern right whales in the Head of Bight, South Australia aggregation ground, within the population census study site in June (A), July (B), August (C), and September (D) in 2014. Female and calf pairs in red, unaccompanied adults in blue and unknown status in CGUSACAustralian Bight Right Whale Study Field Report 2014/2015- Charlton *et al.*, 2015
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Figure 11: Sightings locations of southern right whales in the Head of Bight, South Australia aggregation ground, within the population census study site in June (A), July (B), August (C), and September (D) in 2015. Female and calf pairs in red, unaccompanied adults in blue and unknown status in CgrateAustralian Bight Right Whale Study Field Report 2014/2015- Charlton *et al.*, 2015 Curtin University, Centre for Marine Science and Technology

Photo Identification

2014

In 2014, a total of 134 different SRW adults were photo identified at HOB, including 87 females with calves and 47 unaccompanied adults. A greater number of individuals were photo identified in the HOB study site than the maximum number of SRW sighted during daily counts (max 60 females with calves and 17 unaccompanied adults) (Table 3), indicating that there was movement of SRW into and out of the study site throughout the season. The number of SRW photographed in the study site exceeded the maximum daily count by 145% for females with calves and 276% for unaccompanied adults. Given that study effort is increased in 2014 and 2014 when compared to prior years (Table 1), it is not unexpected that the number of individuals that became available for photo ID exceeded the maximum daily count in these years.

Within season mark-recapture resulted in a total of 46% of SRW photo identified being resighted at least once during the 2014 season (57% of females with calves and 26% of unaccompanied adults). The number of within season resights ranged from 1-10 for females and calves and 1-6 for unaccompanied adults. The mean visitation period of SRWs recorded at HOB in 2014 was 13 days (range 1-73) for females with a calf and 5 days (range 1-52) for unaccompanied adults. When considering individuals that were resighted more than once at HOB, the mean occupancy was 23 days for females accompanied by a calf and 15 days for unaccompanied adults. Of the female and calf pairs resighted at least once (n.50), 60% (n.31) were sighted at HOB over a period greater than two weeks, 40% (n.22) for greater than four weeks, and 20% (n.8) for greater than six weeks. Of the unaccompanied adults resighted at least once at HOB (n.7), 71% (n.5) were sighted over a period less than two weeks and 29% (n.2) for greater than two weeks.

Photographs of 86 different females with calves and 43 unaccompanied adults were of sufficient quality to be matched to the HOB photo ID catalogue (1991-2013). A total of 44 females with calves and 9 unaccompanied adults were positively matched to the long term catalogue, resulting in across year resights of 51% of females and calves and 21% of unaccompanied adults. A total of 29 calves were photographed at an age that callosities were formed to a level satisfactory for inclusion to the HOB photo ID database however, calves are only HOB catalogue as first sighted in 2014 (42 females with calves and 34 unaccompanied adults).

<u>2015</u>

In 2015, a total of 114 different SRW adults were photo identified at HOB, including 36 females with calves and 78 unaccompanied adults. A greater number of individuals were photo identified in the HOB study site than the maximum number of SRW sighted during daily counts (Max 28 females with calves and 27 unaccompanied adults) (Table 3), indicating that there was movement of SRW into and out of the study site throughout the season. The number of SRW photographed in the study site exceeded the maximum daily count by 128% for females with calves and 289% for unaccompanied adults.

Within season mark-recapture resulted in a total of 56% of SRW photo identified being resighted at least once during the 2015 season (81% of females accompanied by a calf and 43% of unaccompanied adults). The number of within season resights ranged from 1-16 for females and calves and 1-6 for unaccompanied adults. The mean visitation of SRW recorded at HOB in 2015 was 38 days (range 1-92) for females accompanied by a calf and 6 days for unaccompanied adults (range 1-47). When considering individuals that were resighted more than once at Head of Bight, the mean occupancy was 60 days for females with calves and 18 days for unaccompanied adults.

Of the female and calf pairs resighted at least once (n.30), 83% (n.25) were sighted at HOB over a period greater than 27 days, 50% (n.15) for greater than 40 days, and 27% (n.8) for greater than 60 days. Three individuals were sighted at HOB for a period greater than 80 days. Of the unaccompanied adults resighted at least once at HOB (n.34), 74% (n.25) were sighted over a period less than two weeks and 27% (n.9) for greater than two weeks. Females with calf were first sighted as pregnant adults on seven occasions at HOB, representing 19% of photo identified females with a calf.

Photographs of 36 females with calves and 73 unaccompanied adults were of sufficient quality to be matched to the Head of Bight photo ID catalogue (1991-2014). A total of 17 females with calves and 18 unaccompanied adults were positively matched to the long term catalogue, resulting in across year resights of 47% of females and calves and 25% of unaccompanied adults. A total of 18 calves were photographed at an age that callosities were formed to a level satisfactory for addition to the Head of Bight photo ID catalogue. Therefore a total of 71 individuals were added to the HOB catalogue as first sighted in 2015 (18 females with calves and 53 unaccompanied adults).

 Table 3: Photo identification resights within season and with the Head of Bight Catalogue (1991-2013), for 2014 and 2015)

	Year	All individuals	Females-Calf Pairs	Unaccompanied Adults
No. individuals	2014	137	87	47
Photo ID'd	2015	115	36	77
No. individuals re-	2014	62	50	12
sighted within year	2015	63	29	34
No. individuals	2014	53	44	9
catalogue	2015	35	17	18

Fowlers Bay

Vessel based surveys

Vessel based surveys were completed in collaboration with Fowlers Bay Eco Park & Tours on board the whale watching tourism charter vessel for assessment of SRW population dynamics in FB. In 2014, a total of 29 vessel surveys were completed across 26 different days between July 4 and September 12, and in 2015 a total of 27 vessel surveys were completed across 25 days between July 26 and August 29. A total of 47 boat hours were completed in 2014 and 49 in 2015. The survey transects and effort was dependent on the tourism operators and the average speed was 4 knots.

Relative Abundance and distribution

<u>2014</u>

In 2014, the maximum daily count of SRW in the FB study site was 22 individuals (range 0-22, mean 9) on July 28. A maximum of 10 (range 0-10, mean 4) female and calf pairs, 4 unaccompanied adults (range 0-4, mean 1 and 2 individuals of unknown status (range 0-2, mean 0) were recorded on one day (Table 4; Figure 12). The period of peak abundance of southern right whales at FB in 2014 was between 27 July and 21 August. Number of SRWs reduced to zero in FB at the end of the study field season on 12 September (Figure 12).

<u>2015</u>

In 2015, the maximum daily count of SRW in the FB study site was 9 individuals (range 0-9, mean 5) on July 28. A maximum of 2 (range 0-2, mean 1) female and calf pairs and 7 unaccompanied adults (range 0-7, mean 2) were recorded on any one day (Table 4; Figure 13). There was no defined period of peak abundance in FB in 2015. Numbers reduced to zero SRW in Fowlers Bay on 26 August and on the last survey day at Fowlers Bay on August 29, one female and calf pair was sighted (Figure 13). Compared to 2014, the maximum number of all SRW's at FB in 2015 was 41% lower, the maximum number of female and calf pairs was 20% lower and in contrast the maximum number of unaccompanied adults was 175% greater.

The last anecdotal sighting of SRWs in FB was made from tourism operators of the FB Whale Watching Charter on 10 October.

	2014		2015	
	Daily range	Mean	Daily range	Mean
Females and calves	0-22	9	1-2	1.2
Unaccompanied Adults	0-4	0.7	0-7	2.2
Daily Maximum	0-22	9	0-9	4.5

Table 4: Sightings data of southern right whales at Fowlers Bay, South Australia 2014 and 2015



Figure 12: Southern right whale maximum daily sightings of female and calf pairs and unaccompanied adults at Fowlers Bay South Australia between July 4 and September 12, 2014





Distribution

During vessel based surveys at FB, a total of 164 SRW sightings were recorded in 2014 and 112 sightings were recorded in 2015. Southern right whales sighted at FB are predominantly distributed within the 10m depth contour, within 1-2km from shore and most commonly within a few hundred metres of shore. SRWs were distributed between Fowlers Point and 8km south east of the Fowlers Bay Jetty, but were most commonly sighted between 1km and 5 km from the jetty (Figure 14 and Figure 15). Photo ID resights of the two female and calf pairs that resided in FB in 2015 show varied patterns of site use (Figure 16).



Figure 14: All sightings of southern right whales recorded within Fowlers Bay study site South Australia between June 15 and September 12, 2014. Black dots show all southern right whale sightings, including females accompanied by a calf and unaccompanied adults.



Figure 15: All sightings of southern right whales recorded within Fowlers Bay study site South Australia between July 26 and August 29, 2015. Black dots show all southern right whale sightings, including females accompanied by a calf and unaccompanied adults.





<u>2014</u>

In 2014, a total of 18 different SRW adults were photo identified at FB, including 12 females with calves and 8 unaccompanied adults. A greater number of individuals were photo identified in the FB study site than the maximum number sighted during daily counts (female and calf pairs = 10 and unaccompanied adults =4), indicating that there was movement of SRW into and out of the study site throughout the season. The number of SRW photographed in the study site exceeded the maximum daily count by 120% for female and calf pairs and 200% for unaccompanied adults.

Within season mark-recapture resulted in a total of 61% of SRW photo identified being resighted at least once during the 2014 season (92% of females with calves (n.11) and 25% of unaccompanied adults (n.2). The number of within season resights ranged from 0-11 for females and calves and 1-3 for unaccompanied adults. Within season resights of SRW show that SRW visitation in the FB study area ranged from 1-74 (mean 16) days, including 1-75 (mean 25) days for female and calf pairs and 1-2 (mean 1) days for unaccompanied adults. The visitation period of females with calves in the FB

study area was greater than two weeks for 75% of individuals and greater than four weeks for 25% of individuals. On two occasions females with calves were first sighted as pregnant females in FB.

SRW individuals photographed at FB were cross matched with SRW photo ID'd at HOB in the same year. This exercise resulted in 32% (n.6) individuals being positively matched at both locations, including 25% (n.3) of female and calf pairs and 43% (n.3) of unaccompanied adults.

Images of 9 out of 12 females with a calf, and 5 out of 7 unaccompanied adults photo ID'd at FB were of sufficient quality to be matched to the HOB photo ID catalogue (1991-2013). A total of two individuals (both females with calves) were positively matched to the long term catalogue, resulting in across year resights of 22% of females and calves and 0% of unaccompanied adults.

<u>2015</u>

In 2015, a total of 19 different SRW adults were photo identified at FB, including two females with calves and 17 unaccompanied adults. A greater number of individuals were photo identified in the FB study site than the maximum number of SRW sighted during daily counts (female and calf pairs=2, unaccompanied adults=9), indicating that there was movement of SRW into and out of the study site throughout the season. Photo ID images were successfully collected for 100% of female and calf pairs that were sighted in FB. The number of SRW photographed in the study site exceeded the maximum daily count by 189% for unaccompanied adults.

Within season mark-recapture resulted in a total of 73% of SRW photo ID'd being resighted at least once during the 2015 season (100% of females with calves (n.2) and 71% of unaccompanied adults (n.12)). The number of within season resights ranged between 8 and 20 for females and calves and 1 and 6 for unaccompanied adults. Within season resights of SRW show that animals remained in the FB study area for between 1 and 35 days. The two female and calf pairs sighted at FB occupied the area for 11 days and 35 days (of 35 day study period). The sighting period for unaccompanied adults at FB in 2015 ranged between 1 and 15 days, with four individuals sighted over a period greater than one week.

SRW individuals photographed at FB were cross matched with SRW photo ID'd at HOB in the same year. This exercise resulted in 47% (n.9) individuals being positively matched at both locations, including 100% of female and calf pairs and 43% of unaccompanied adults.

Images of all females with a calf, and 16 out of 17 unaccompanied adults photo ID'd at FB were of sufficient quality to be matched to the HOB photo ID catalogue (1991-2014). A total of three individuals (all of which were unaccompanied adults) were positively matched to the long term catalogue, resulting in across year resights of 0% of females and calves and 19% of unaccompanied adults. Both calves were photographed at an age that callosities were formed to a level satisfactory for resight in future years.

Underwater acoustics

In both years an underwater noise logger was deployed approximately 12km offshore from FB in 45m water depth. In 2014, the logger was deployed for 96 days between 15 June and 21 September and in 2015 the logger was deployed for 37 days between 6 August and 11 September. Handheld hydrophone recordings were collected in 2014 from the vessel and in 2015; a sound trap was used on a temporary mooring system to record ambient noise in the aggregation ground for 1-5 days at a time, both in less than 10m water depth. This data will be analysed in future to characterise the sound repertoire of southern right whales and assess biological and anthropogenic noise in FB.

Other marine fauna observations

Other marine fauna sightings recorded during the 2014/2015 GABRWS field studies include: humpback whales, bottlenose and common dolphins, a stranded pygmy sperm whale, leatherback turtles, great white sharks, little penguins, Australian sea lions and New Zealand fur seals, sea birds and shore birds and large salmon schools. Records of position, species, number of individuals and behaviour were collected for all sightings. Sightings of EPBC Act listed species are presented in Table 5. Data is distributed to relevant state and national databases such as SA Museum, Department of Environment Cetacean sightings database, Birdwatch SA, Department of Environment and Natural Resources SA. **Table 5:** Other marine fauna sightings at Head of Bight and Fowlers Bay during the 2014/2015 GreatAustralian Bight Right Whale Study.

Species

	Head of Bight		Fowlers Bay				
	2014	2015	2014	2015			
Bottlenose Dolphins	180/16	~260/23 (group sizes 1-50+)	15/4 (group size 1-6)	~70/7 (group sizes 1-15)			
Common Dolphins	~10/1	0	50/3 (group size 10-20)	5/1			
Humpback Whale	5/3 (group size 1- 2)	11/7 (group sizes 1-2)	10/5 (group size 1-3)	5			
New Zealand Fur Seal	4/3	6/5	Not recorded	86/10 (group sizes 1-18)			
Australian Sea Lion	9/5	18/2	Not recorded	38/11 (group sizes 1-8)			
Penguin	3/2	4/3 (also heard on an additional 6 occasions but not seen)	0	6/1			
Leatherback Turtle	1	0	0	0			
Great White Shark	2/2	3/3		0			
White Bellies Sea Eagle	Pair sighted throughout season, not recorded daily	41/32 (1 pair only)	Not recorded	Not recorded			
Osprey	0	0	Not recorded at FB	Not recorded at FB			
Albatross	2/2	3/3	Not recorded at FB	Not recorded at FB			
Pygmy Sperm Whale	1 (stranded)	0	0	0			

Total number of individuals sighted/ number of group sightings

Great Australian Bight Right Whale Study Field Report 2014/2015- Charlton *et al.*, 2015 Curtin University, Centre for Marine Science and Technology

Discussion

The 2015 field season marked the 25th consecutive year of SRW research at HOB, providing a long term annual time series dataset to assess SRW population demographics. Long term population monitoring in the order of decades is required for long lived marine mammal species to understand biological parameters that drive species recovery. Biological parameters include: calving intervals, age of sexual maturity, calf production, mortality and survival. This study presents the first boat based research on SRW in FB and provides information on population dynamics including distribution, abundance, site use, occupancy, behaviour and acoustics. Data from the 2014/2015 field seasons will contribute to Curtin University Centre for Marine Science and Technology PhD programs on population demographics and underwater acoustics of southern right whales in southern Australia.

Relative abundance and life history data from the long term study at HOB reveal a cohort structured breeding cycle, based on the three to four year calving cycle of SRW. Therefore annual monitoring is required to inform population trends and recovery. Historical trends suggest that 2014 represents the largest breeding cohort and that 2015 was expected to represent a smaller breeding cohort. Peak relative abundance recorded at HOB study site in 2014 and 2015 was lower than expected, based on long term trends.

The lower than expected relative abundance in the HOB study site in 2014 may be attributed to spatial resources pressures, leading to the expansion of SRW distribution outside of the primary aggregation area in years of high abundance. Helicopter surveys completed by DEWNR showed that 16% of SRW were distributed outside of the GABRWS shore based monitoring study site (Mackay and Goldsworthy 2015). Furthermore, photo ID data shows that 45% more individuals were photographed throughout the season than the max number of individuals counted on one day.

Of particular concern is the size of the decline in 2015 calf production. Calving female numbers in 2015 (n. 29) were 51% lower than the prior year in 2014 (n. 60) and 47% lower than 2012 (n. 55), the previous cohort year. The 2015 maximum daily count of all individual classes and of female and calf pairs is the lowest recorded at Head of Bight since 2007. It is only the second time since 1996 (2007 was the first time) (Burnell 2007) that both of the prior year and prior 3-year cohort metrics for calving females have been negative, and the decline in number of calving females in 2015 are greater than would be excepted by the natural attenuation of the 2012 cohort. The low numbers of calving females present in 2015 flatten the long term trends, and these low calf numbers represent some cause for concern. It will be critical to monitor SRW calf production in future years to assess if this decline influences overall recovery.

Variability in calf production can result from cohort shifts by a significant number of females, and from movement to and from the HOB aggregation area by other females. It is possible that females expected to calve in 2015 may have 'skipped' a calving year, in which case we would expect to see greater abundance of females with calves in 2016. Seasonal changes in calf production may be connected to environmental variables, climate fluctuations and the availability of prey during the feeding season in the subantarctic (Burnell 2000, Burnell 2007; Pirzl et al 2008). Specific events such

as restricted prey availability in a given year could cause females to shift cohorts and result in reduced calf production. Our long term data on reproductive females show that individual females do redistribute across cohorts, and peaks in production may be expected to shift over time as a result (Burnell 2007). Links between sea surface temperature in feeding areas and the calving success of southern right whales in Argentina and Australia has been documented (Leaper et al., 2006; Pirzl 2009). Collaborative research and analysis is planned to assess correlations between abundance trends and calf production with climate factors and health/body condition.

As SRW numbers increase over time, it is important to understand their movements inside and outside of recognised aggregation areas and marine park sanctuary zones. Aerial surveys completed by the WAM over the last three decades have supported that the majority of SRW are distributed within the HOB GABRWS study site (Bannister 2014). However, helicopter surveys completed by the Department of Environment in 2014 showed that whales were distributed in highest densities in an area of approximately 44.7 km² from west of HOB to the east along Yalata Beach. 16% of photo-ID'd female-calf pairs and 40% of unaccompanied adults were photographed outside of the key aggregation ground at HOB (Mackay and Goldsworthy 2015). Given the high effort and number of photo ID's captured throughout the season, it is assumed that a high proportion of individuals in the area moved into the HOB study site throughout the research season and became available for photo ID.

The GABRWS has provided an improved understanding of SRW movements in and out of aggregation areas and connectivity between HOB and FB. The number of individuals photo ID'd exceeded the maximum number of SRW sighted during daily counts, in 2014 and 2015 at HOB and FB. Cross matching of photo ID images from HOB and FB show that there is connectivity between the two aggregation areas. Approximately 40% of SRW photographed at FB were resighted at HOB during the same year. Interestingly, in 2015, all individuals resighted at both locations accept one were first sighted at FB and later sighted at HOB, supporting an east to west movement. It is important to understand coastal connectivity and the use of corridors between aggregation areas for conservation management. Results indicate that the corridor between the two areas is important for within season coastal movement and that whales use areas outside of the marine park and the marine mammal sanctuary zone.

Photo ID mark recapture resulted in resights of 50% of female and calf pairs photo ID'd at HOB across 2014 and 2015 with the long term HOB catalogue, providing information on life histories relevant for assessing species recovery and health and detecting impacts and changes to recovery over time. Mark recapture rates have reduced when compared to 92% resights recorded between 1991 and 1996 (Burnell and Bryden 1997). Between 2007 and 2014 the mark recapture rate was 51% for calving females and 20% for unaccompanied adults. Rates were influenced by a particularly low resight rate in 2011 of 16%, which was the peak abundance year at HOB with record high sightings of 67 females with calves and 35 unaccompanied adults (Charlton *et al.,* 2014a). As the population continues to grow, it is likely that recruitment by first time breeders may result in a reduced mark recapture rate. The HOB catalogue is up to date and maintained and now includes 1473 different

individuals. This study provides a comprehensive dataset on known individuals for population modelling requiring long term mark recapture data.

Understanding abundance at key aggregation areas on a temporal scale is important for understanding timing of migration and extent of calving seasons, for the purpose of managing marine based activities occurring in the broader area outside of critical breeding habitats. Improved information on peak abundance periods and residence was provided through expanding the research season to three and a half months in 2014 and 2015 at HOB and FB. Preliminarily findings suggest that the period of peak abundance at HOB varies by approximately 2 weeks between mid-July and end-August. Visitation of SRW recorded in HOB and FB aggregation areas ranged from 1-93 days for females accompanied by a calf and 1-52 days for unaccompanied adults, indicating that female and calf pairs remain in the area for up to 3 months whilst unaccompanied adults are more transient and have lower visitation rates, as expected. The final year of the expanded field research as a part of Claire Charlton's PhD is imperative to the assessment of trends across all three SRW population cohorts.

Other research completed on SRWs in the GAB in 2014 and 2015 included: The Western Australian Museum annual aerial survey ran by John Bannister from Cape Leeuwin to Ceduna (2014 and 2015); the GAB Marine Reserve and South Australian Research and Development Institute (SARDI) completed three helicopter aerial surveys between the WA border and Fowlers Bay in 2014; SARDI and a team of collaborative researchers completed a satellite tagging and genetics study at Head of Bight with support and funding from the Commonwealth Government in 2014. The GABRWS team studied the short term impacts from satellite tags on SRW through photo identification mark recapture, as well as provided photo identification images, positional data and life histories of tagged and biopsied individuals to SARDI and AAD. These findings were written up as a Curtin University CMST report (CMST report 2015-11) and a publication on short term impacts of tagging is currently in preparation (Charlton & Ward 2015 *in prep*).

Concluding statements

The GABRWS researches the distribution, relative abundance, life histories and acoustics of SRWs at established aggregation grounds in the GAB at HOB and FB. The GABRWS incorporates the long term cliff based SRW monitoring at the major aggregation ground, HOB (1991-2015), and vessel based research at the small adjacent aggregation ground at FB (2014-2015). The long term HOB cliff based research has operated since 1991 and has amassed 25 years of continuous baseline data which has contributed to national and international databases.

Data from this long term study has contributed to collaborative projects, management initiatives and advancements in understanding of southern right whale recovery and population biology in Australia. Through annual reports to the Commonwealth Government and publications to date, this study has provided data on: aggregation use trends, reproductive rates, age at sexual maturity, age at independence, site fidelity, visitation rates, residency periods, coastal and long range movements, calf

mortality, genetics, predation, interactions between conspecifics and interspecifics and health of the recovering population (Burnell and Bryden 1997; Burnell 1999; Burnell 2001; Burnell 2007; Burnell et al., 2007; Burnell 2008; Charlton and Burnell 2011; Charlton et al 2013a; Pirzl 2008; Pirzl 2009; Pirzl et al., 2008; Patenaude & Harcourt, 2006; Pirzl et al., 2009). Furthermore, it is an integral part of international efforts to undertake a more comprehensive comparison of southern hemisphere right whales (Anon 2002; Anon 2004; Pirzl and Watson 2011; Charlton et al 2013b). The research directly addresses objectives in the EPBC Conservation Management Plan for the Southern Right Whale.

The GAB is a multi-use area for commercial fisheries, marine parks, tourism, oil and gas and provides habitat for marine species identified as Matters of National Environmental Significance and listed under the EPBC Act, including the southern right whale. The GABRWS is funded by joint venture partners of an oil and gas exploration permit in the GAB; Murphy Oil and Santos Energy through sponsorship of a three year Curtin University PhD Program. This sponsorship delivers cost effective and robust scientific data and ensures the continuation of the long term southern right whale monitoring in the GAB. This study provides baseline data on SRWs and informs both industry and government for risk based decision making to manage risks to SRWs. The continuation of long term annual monitoring of southern right whales in the GAB is essential for effective species conservation management and before and after impact assessment.

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Appendix 1: GABRWS southern right whale behaviour ethogram

Milling (MIL): The whale is moving inconsistently, changing direction repeatedly within a similar area.

Travelling (T): The whale is moving in a consistent direction across an area.

Resting Underwater (R): The whale is lying beneath the surface of the water with very little activity, surfacing only for respiration.

Logging on the Surface (L): The whale is lying on the water surface with very little activity and looks like a 'log' lying on the water.

Belly Up (BUP): The whale is floating in the water with its ventral side/ belly up. Common in cow-calf pods.

Socialising (S): Two or more whales interacting with each other (eg. physical interaction, rolling around each other or two mother-calf pairs approaching and interacting.

Suckling Young (SY): The calf is positioned below the mother at a 45 - 90° angle with her rear half and remains underneath her for a length of time.

Mating (M): A whale positions itself underneath or alongside a female (in line with her genital slit) and attempts to lock its pectoral fins around her; multiple individuals may be positioned around one female; visible penis; multiple approaches by male/s; resisting female belly up (sometimes female rapidly moves away and/or vocalises).

Mother-Calf Interaction (MC): Physical interaction between a cow and calf; calf rolling around or playing with the cow; cow nudging calf upwards with her rostrum.

Fluke (tail) Slap (FS): The fluke and a some of the peduncle is raised out of the water and forcibly slapped against the water surface.

Peduncle Slap (PEDS): The entire fluke and peduncle is raised clear out of the water and forcibly slapped against the water surface.

Sailing (SAIL): The whale is balanced head down in the water with its fluke held stationary above the water for extended periods of time without slapping motions.

Dive (D): The whale is seen to dive, without lifting its fluke in the air (Fluke down dive).

Fluke (tail) Up Dive (FUP): A dive where the fluke is lifted from the water as the whale dives, and is held vertically so that its ventral surface can be seen from behind.

Breach (BR): A leap in which most or all of the whale's body (70-100%) exits the water. The whale usually, but not always, twists in the air and lands on its dorsal or lateral side.

Spy Hop (SH): A vertical lifting of the head (usually exposing the entire rostrum and head) above the water surface. Usually just a single low-energy bobbing motion.

Head Slap (HS): The head is raised out of the water, pointing straight up at 90° to the surface, and forcibly slapped with its ventral surface against the water.

Pec Wave (PW): The lifting of the pectoral fin clear out of the water, without violent slapping motion.

Pec Slap (PS): The left or right pectoral is raised out of the water and forcibly slapped with the ventral side against the water; whale usually on its side.

Splash (SP): An undetermined behaviour that resulted in a splash. Usually recorded when a whale is far away.

Footprint (F): Upwelling of water causing circular ripples on the surface of the water. This is usually 'proof' that a whale was there.

Blow (B): Visible plume of v-shaped water vapour exhaled by the whale upon surfacing. It is assumed the back of the whale is also seen. Usually recorded when a whale is far away.

Vocal blow (VB): Blow accompanied by a loud vocalisation, may sound like a trumpeting or tonal blow.