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Maintaining the monitoring of pup production at key Australian sea lion colonies in South Australia (2014/15)

Simon D Goldsworthy, Alice I Mackay, Peter D Shaughnessy, Fred Bailleul and Dirk Holman

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SARDI Aquatics Sciences
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October 2015

Final report to the Australian Marine Mammal Centre

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Co-investment from both State and Commonwealth Government environment agencies (DEWNR and AMMC) in conjunction with other funded programs has enabled the undertaking of this ambitious State-wide ASL monitoring project. SA DEWNR funded additional surveys of ASL colonies along the Bunda Cliffs in the Great Australian Bight (GAB) Marine Park in 2012/13 and 2014, as well as ongoing monitoring at Seal Bay and the Seal Slide on Kangaroo Island. The survey of some ASL colonies was supported by in-kind funding received from the Great Australian Bight Research Program (GABRP). The GABRP is a collaboration between BP, CSIRO, the South Australian Research and Development Institute (SARDI), the University of Adelaide, and Flinders University. The combined investments has provided a unique opportunity to survey all ASL colonies across South Australia over an 18 month period in 2014 and 2015.

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1. EXECUTIVE SUMMARY

This study has provided the most comprehensive survey of the Australian sea lion (ASL, *Neophoca cinerea*) population in South Australia (SA), and is the first time most colonies have been surveyed within an 18 month period, the span of a single breeding cycle. The total pup abundance was estimated to be 2,520, born across 42 breeding sites, with a mean and median pup abundance of 60 (sd = 106.6) and 23, respectively. Only five sites produced more than 100 pups (Nuyts Reef, Olive Island, Dangerous Reef, Seal Bay and The Pages Islands), and these accounted for 58% (1,460) of the State's estimated pup abundance. Two new breeding sites were discovered at Curta Rocks (7 pups) and Williams Island (5 pups), both off lower Eyre Peninsula.

For a subset of 32 breeding sites where equivalent surveys were undertaken 6-11 years earlier, pup abundance has declined from 2,902 pups to 2,215, almost one quarter fewer (23.7%, 687 pups) than those surveyed between 2004 and 2008. Six sites previously recognised as breeding or haul-out sites with occasional pupping were not recorded to have pups in this recent survey. The total size of the ASL population in SA is now estimated to be 9,652 individuals.

Change in pup abundance over two comparable surveys could be estimated for 28 sites accounting for 77% of the estimated pup abundance in SA. The key findings from these analyses were that pup numbers at most breeding sites (82%) have declined between the survey periods. The overall rate of decline was 2.9% per year, or 4.4% per breeding cycle, but varied considerably between sites and regions. Following IUCN Redlist assessment methods, the estimated change in pup abundance over three generations (38 years) assuming a constant exponential rate of change was -78.2%, indicating that the ASL population in SA meets the 'Endangered' threatened species category (decline ≥50% and ≤80%) (IUCN Standards and Petitions Subcommittee 2014). Analyses of trends in aggregated pup abundance across six regions (Bunda Cliffs, Nuyts Archipelago, Chain of Bays, SW Eyre, Spencer Gulf and Kangaroo Island) also indicated that declines were occurring across all regions, but were greatest in the west of the State and lowest in the east.

An evaluation of survey methodologies and strategies was undertaken, and recommendations on future monitoring strategies have been made. A key recommendation is to shift away from the past survey design that focused on high survey effort at a limited number of sites, to a more regionally focused survey design that aims to improve assessment of regional trends in pup abundance.

2. INTRODUCTION

2.1. Background

The Australian sea lion (ASL - *Neophoca cinerea*) is Australia's least numerous seal species. It is unique among pinnipeds, being the only species that has a non-annual and temporally asynchronous breeding cycle. It has the longest gestation period of any pinniped, as well as protracted breeding and lactation periods. The evolutionary determinants of this unusual reproductive strategy remain enigmatic. These factors, and the species' small population size, which is distributed over numerous, small colonies, make the ASL vulnerable to extinction (Goldsworthy *et al.* 2009c). The species is listed as Vulnerable under the threatened species category of the Commonwealth *Environment Protection and Biodiversity Act 1999* (EPBC Act), Vulnerable under the South Australian *National Parks and Wildlife Act* (1972) and Endangered under the International Union for the Conservation of Nature (IUCN) Redlist (Goldsworthy 2015). Recent population genetic studies have indicated little or no interchange of females among breeding colonies, even for those separated by short distances (Lowther *et al.* 2012). The important conservation implication that follows is that each breeding colony is effectively a closed population. In light of this, and with the identification of unsustainable bycatch of ASL in demersal gillnet fisheries (Goldsworthy *et al.* 2010b), conservation and management measures need to focus at the colony level.

The major threatening process most likely limiting the recovery of ASL populations is incidental bycatch mortality, especially in demersal gillnet fisheries (Goldsworthy *et al.* 2010b, Department of Sustainability Environment Water Population and Communities 2013). Between 2010 and 2012, the Australian Fisheries Management Authority (AFMA) introduced a range of management measures into the Gillnet Hook and Trap Fishery (GHAT) off South Australia to mitigate bycatch of ASL including spatial closures, electronic monitoring, and bycatch trigger limits. Logbook data reports on ASL interactions suggest these measures have resulted in a reduction in ASL bycatch in that fishery, with two mortalities reported since 2012. Management for recovery of the species requires the ability to detect changes in the status of populations over time (McKenzie *et al.* 2005, Goldsworthy *et al.* 2009a). As part of a study funded by the Department of the Environment (formally DEWHA) in 2006, through the Australian Marine Mammal Centre (AMMC, formerly ACAMMS) in 2007/08 (Goldsworthy *et al.* 2007a, 2008b, 2009c), a population survey strategy was developed, which identified key and/or representative breeding sites within regions across the range of the species that could be targeted for ongoing monitoring of trends in pup production. Geographic distance analysis among ASL colonies identified 11 distinct metapopulations or regions in the species, seven of which were in South Australia (Bunda Cliffs, Nuyts Reef, Nuyts Archipelago, Chain of Bays, SW Eyre, Spencer Gulf, Kangaroo Island) (Goldsworthy *et al.* 2007c) (Figure 1). Two methods were developed to estimate pup production in small and large ASL breeding sites. For large colonies (>40 pups), a method using individual re-sight histories of tagged pups in conjunction with mark-recapture methods was developed (Goldsworthy *et al.* 2007a, 2008b, 2009c). This has since been refined to enable estimation of apparent survival and pup production between surveys, enabling cumulative pup production to be estimated (Goldsworthy *et al.* 2010a). At small ASL breeding sites (<40 pups), a cumulative mark and count (CMC) method was developed (Goldsworthy *et al.* 2007c). The principal reason for developing these methods was to provide repeatable survey approaches that provided more accurate and reliable estimates of pup production than simple count data. Because of the large number of ASL breeding sites and the species asynchronous breeding pattern, achieving high quality trend data across all breeding sites over time is impractical, given the difficulty and expense required to reach many (McKenzie *et al.* 2005, Goldsworthy *et al.* 2009a). The strategy developed over the last nine years has therefore been to concentrate efforts on obtaining high-quality pup census data from consecutive breeding seasons from a sub-set of eight key and/or regionally representative sites in order to assess trends across the range of the species. These sites include Seal Bay and Seal Slide (Kangaroo Island), Dangerous Reef and English Island (Spencer Gulf), Olive and Jones Island (Chain of Bays), and Lilliput and Blefuscu Islands (Nuyts Archipelago) (Figure 1),

In addition to maintaining monitoring at key breeding sites, this monitoring strategy recognised the need to balance this approach with periodic surveys of the many remaining colonies which are rarely visited, and where breeding status and pup production remain uncertain. Between 2009 and 2013, AMMC have funded spot surveys of a number of sites, many of which had not been surveyed since 1996, resulting in the discovery of three previously unknown breeding sites, Cap Island (40 pups), Rocky (South) Island (12 pups) and an unnamed island (known as Little Hummock Island) between Four Hummocks and Perforated Island (12 pups) (Goldsworthy *et al.* 2013).

A key objective and action of the recently released ASL Recovery Plan is to ‘develop and apply a quantitative framework to assess the population status and potential recovery of the ASL across its range’ (Priority 1), and ‘ensure [that] sufficient and effective abundance and distribution monitoring is in place to adequately understand population size and trends at representative sites … including at the fringes of the species’ range’ (Department of Sustainability Environment Water Population and Communities 2013). Given the marked development in ASL survey methodology and census data over the last nine years, including information on the breeding ecology and demography of the species, there is need for a critical review and evaluation of the data, analytical methods, and survey sites and strategies to ensure that future monitoring strategies achieve the best quantitative framework for monitoring population status to address the Recovery Plan objectives.

A further critical issue is the limited baseline information on the status of ASL populations. In the past, estimates of the size of ASL populations have typically been based on the best available survey data for individual breeding sites, often spanning 1-2 decades. The most recent assessment of the size of the SA ASL population by Shaughnessy *et al.* (2011), mainly used data obtained between 2004 and 2008, although data for some colonies was from as early as 1990. That study estimated ASL pup abundance in SA to be 3,119.

2.2. Objectives

To address the above key issues, the objectives of the project were to:

1. Continue to provide data on the status and trends in abundance of ASL at key monitoring sites in SA, as well as a number of other locations where information on breeding status and trends in abundance are poor.
2. Achieve the first State-wide survey of all ASL breeding sites within an 18 month period, providing a contemporary assessment of the species status, and analyse historic time-series data on all sites to provide an assessment of their trends in abundance.
3. Review and evaluate sites, survey methodologies and strategies developed over the last decade. Based on these analyses, provide options and make recommendations on future monitoring strategies for the species.

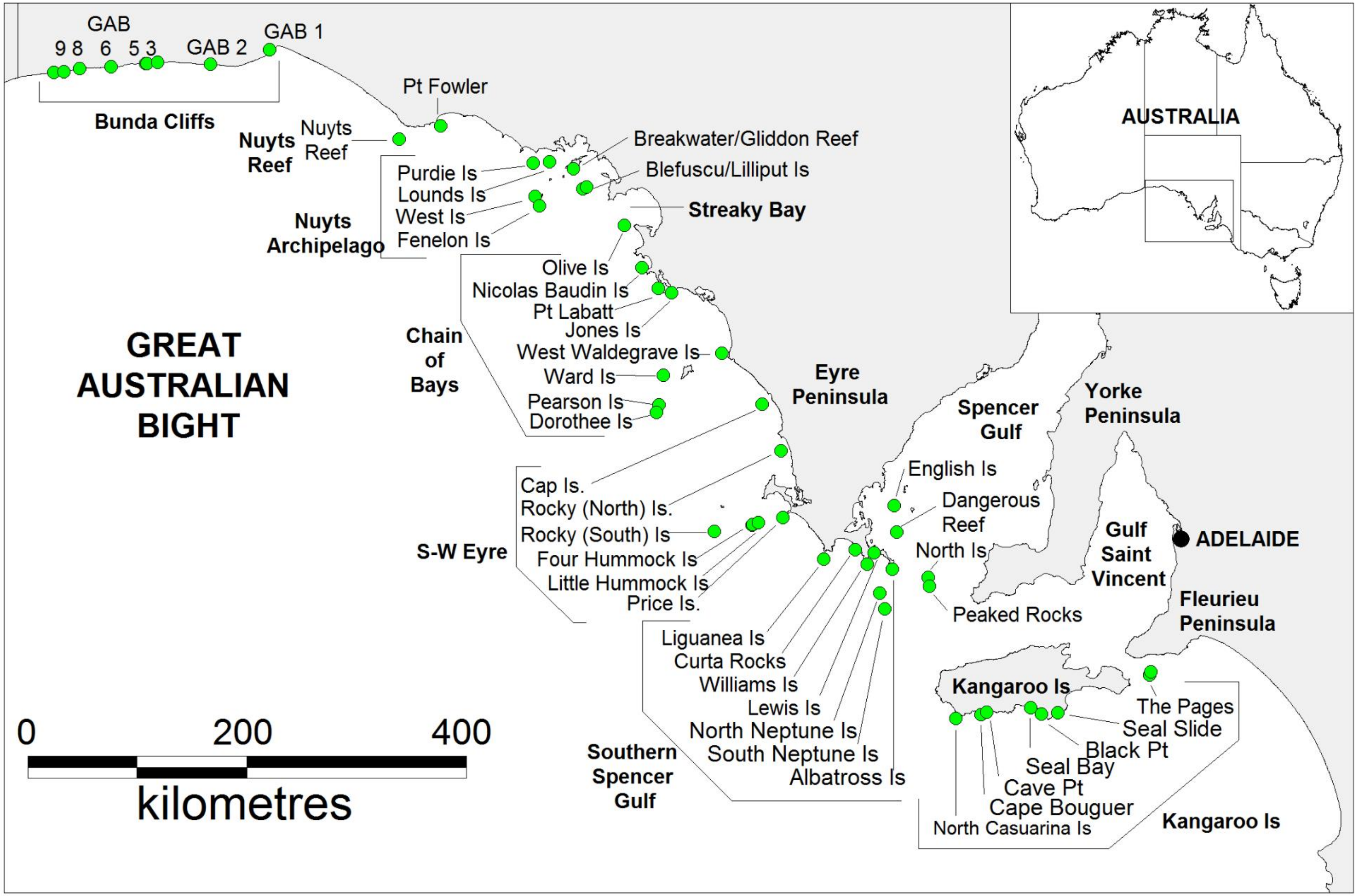

Figure 1. The location of Australian sea lion (ASL) breeding sites in SA and the seven regions (in bold) as described by Goldsworthy *et al.* (2007b).

3. METHODS

3.1. Survey methodology

Survey timing and sites

Surveys were conducted between January 2014 and May 2015, across 83 sites within the seven South Australian ASL regions (Figure 1). With the exception of sites on Kangaroo Island (accessed by vehicle) and Dangerous Reef, English, Olive and Jones Islands (accessed by boat), all other sites were accessed by helicopter (Robinson, R44 Clipper).

Live and dead pup counts

Live pups were recorded in one of five categories: black mate-guarded (pups whose mother is mate-guarded by an adult male, indicative of a pup aged 0-10 days), black (pups considered to be <4 weeks), brown (pups approximately 4 - 20 weeks), moulted (pups >20 weeks age) and dead. We recorded the number of pups that had died since the previous visit. To avoid double counting, dead pups were covered with rocks when they were counted. Where multiple surveys were conducted during a breeding season, the number of dead pups recorded at a particular survey was added to the number(s) recorded at previous survey(s). When that number was added to the number of live pups, it provided an estimate of pup abundance to that date. The presence or absence of black mate-guard pups is important in determining the timing of the survey relative to the timing of the breeding season. The breeding season was considered to have ended if no black mate-guard pups and few or no black pups were present.

Mark-recapture

Direct counting of pups to estimate their abundance is known to underestimate total pup production, because pups that are hidden from view (sightability bias) or absent from the colony (availability bias) at the time of the survey are not included. The influence of these factors on estimates of pup production can be reduced to some extent by undertaking a mark-recapture procedure. Mark-recapture methods have been used to estimate pup production at fur seal colonies in Australia since 1988 (Shaughnessy *et al.* 1995, Shaughnessy and McKeown 2002, Kirkwood *et al.* 2005), but were first applied to estimating pup production in ASL populations at Dangerous Reef in July 1999 (Shaughnessy and Dennis 1999). They have since been used at Seal Bay, Dangerous Reef, Lewis, Olive, North Page and South Page Islands, and Lilliput and Blefuscu Islands (McIntosh *et al.* 2006, Shaughnessy *et al.* 2006, Goldsworthy *et al.* 2007c, 2008b, McIntosh *et al.* 2012, Goldsworthy *et al.* 2013, 2014a).

A mark-recapture procedure was used to estimate the number of live pups at Olive, Lilliput and Blefuscu Islands, and Dangerous Reef. Pups were tagged with individually numbered plastic tags (Dalton® Size 1 Supertags), applied to the trailing edge of each fore-flipper. During each field trip, individual re-sight records were collected for marked individuals with the aid of binocular observations. As outlined above, a record of dead pups was obtained by placing rocks on top of carcasses to avoid repeat counting. Records of the total number of tagged, untagged and newly recorded dead pups were noted on each survey.

Re-sights of individual tagged pups were usually undertaken over a minimum of three days prior to recapture surveys; they were used as the sample of 'marked' individuals in the population available for the recapture surveys. During recapture surveys, the individual identity of tagged pups was determined by reading tag numbers with binoculars. The number of untagged pups and recently dead pups that had not been marked was also recorded. Pups sighted in future surveys (i.e., known to be alive) were included as having been available for re-sighting in previous recapture surveys.

Mark-recapture estimates of the number of live pups ($\widehat{N}$) were calculated using a variation of the Petersen method (attributed to D.G. Chapman by Seber 1982) with the formula:

$$\widehat{N} = \frac{(M+1)(n+1)}{(m+1)} - 1;$$

where M is the number of marked pups available for resighting, n is the number of pups examined in the recapture sample, and m is the number of marked pups in the recapture sample.

The variance of this estimate is calculated as:

$$Var(\widehat{N}) = \frac{(M+1)(n+1)(M-m)(n-m)}{(m+1)^2(m+2)};$$

Where several mark-recapture estimates ($\widehat{N}_j$) are made (one from each recapture session), they are combined by taking the mean ($\overline{N}$) using the formulae from White and Garrott (1990) (pp. 257 and 268):

$$\overline{N} = \sum_{j=1}^{q} \widehat{N}_j \big/ q\,;$$

where *q* is the number of estimates for the colony (i.e., the number of recapture surveys). The variance of this estimate is calculated as:

$$Var(\overline{N}) = \frac{1}{q^2}\sum_{j=1}^{q} Var(\widehat{N}_j)\,.$$

Following Kuno (1977), the square root of $Var(\overline{N})$ gives the standard deviation for the estimate, and the 95% confidence limits are calculated as:

$$\overline{N} \pm \left(1.96 * \sqrt{Var(\overline{N})}\right).$$

The Petersen estimate yields an accurate result as long as a number of conditions are met (Caughley 1977). These include that the probability of capturing an individual is the same for all individuals in the population; no animal is born or immigrates into the study area between marking and recapturing; marked and un-marked individuals die or leave the area at the same rate; and no marks are lost.

Cumulative pup production

The number of pup births that had occurred between consecutive mark-recapture surveys $(\hat{B}_{1-2})$, was estimated as:

$$\hat{B}_{1-2} = \overline{N}_2 - \overline{N}_1 \emptyset_{1-2},$$

where, $\overline{N}_1$ is the Petersen estimate of the number of live pups in the colony at survey 1, and $\overline{N}_2$ is the Petersen estimate of the number of live pups at survey 2. The apparent survival of pups between survey 1 and 2 ($\emptyset_{1-2}$) is estimated as the proportion of the marked pups known to be alive in survey 1 (M_1) that were known to be alive in survey 2 $(or\ M_2/M_1)$.

The variance of the estimated number of pup births between consecutive mark-recapture surveys was calculated from a general formula in Kendall and Stuart (1977):

$$Var\left(\hat{B}_{1-2}\right) = Var(\overline{N}_2) + Var(\overline{N}_1)(\emptyset_{1-2})^2 + (\overline{N}_1)^2 Var(\emptyset_{1-2}),$$

where

$$Var(\emptyset_{1-2}) = \frac{\emptyset(1-\emptyset)}{M_1}.$$

The ±95% confidence limits of $\hat{B}_{1-2}$ are calculated as:

$$\hat{B}_{1-2} \pm \left(1.96\sqrt{Var\left(\hat{B}_{1-2}\right)}\right).$$

This approach was repeated to estimate the number of births that occurred between surveys 2 and 3, and surveys 3 and 4, etc.

Total cumulative pup production (N_c) was hence estimated as:

$$N_c = \overline{N}_1 + D_1 + \hat{B}_{1-2} + \hat{B}_{2-3} + \hat{B}_{3-4},$$

where (D_1) is the cumulative number of dead pups recorded up to the end of Survey 1.
In the case of two consecutive estimates $\overline{N}_1$ and $\overline{N}_2$, the variance of the estimated total cumulative pup production (N_c) is:

$$Var(N_c) = Var(\overline{N}_1) + Var(\hat{B}_{1-2}),$$

The ±95% confidence limits of this estimate were calculated from:

$$N_c \pm \left(1.96\sqrt{Var(N_c)}\right).$$

3.2. Trends in abundance

Survey time series

Information on pup counts from past surveys at ASL breeding sites across SA was derived from published accounts, reports and databases. To simplify analyses, the timing of surveys was summarised into 6-month blocks between April and September and October and March (designated as whole years e.g. 2014, 2015; and split years 2013.5, 2014.5, respectively). Surveys were omitted if judged to have been undertaken at inappropriate times (well outside of, or early in, the breeding season).

Changes in pup abundance over two surveys

For the majority of ASL breeding sites, very few survey data are available. To maximise the number of sites over which a change in pup numbers could be assessed, we estimated the change in pup numbers between two time periods when similar survey methods had been used. Where possible, the earliest comparable survey was compared to the most recent. The rate of change in pup numbers was calculated using linear regression of the natural logarithm of pup numbers against year. The intrinsic rate of increase (r) is the slope of the regression line. It can be expressed as a percentage rate of growth (λ) as follows,

$$\lambda = 100(e^r - 1).$$

Changes in growth per breeding season were estimated as $\lambda/1.5$.

Assessment of the SA ASL population against IUCN Criterion A, was undertaken following the IUCN methods for Criterion A assessments for taxa with widely distributed or multiple populations (IUCN Standards and Petitions Subcommittee 2014). This methodology uses past and present indices of abundance to estimate the percentage change over three generations of subpopulations. Generation time for ASL has been estimated to be 12.4-12.8 years (mean = 12.6 years), hence three generations is equivalent to 38 years (Goldsworthy 2015). As the past and present estimates of pup numbers for different breeding sites are from different years and span different time periods, it is necessary to make projections in order to estimate the change in abundance for each breeding site across the same 3-generation period (1977 to 2015). For each breeding site, rates of change between past and present pup numbers were used to project pup numbers back to 1977 or forward to 2015, assuming a constant exponential rate of change (IUCN Standards and Petitions Subcommittee 2014). The overall change in the sum of pup numbers over 3-generations, across all breeding sites was then used to assess the SA ASL population against IUCN Criteria A (IUCN Standards and Petitions Subcommittee 2014).

Trends in aggregated abundance

We used the method developed by Johnson and Fritz (2014) to estimate tends in aggregated abundance across ASL regions. The method was developed to aid analysis of regional trends of abundance for species and sites with uneven and patchy sampling. The Bayesian modelling approach uses Markov Chain Monte Carlo methods and a hierarchical model to augment missing data to infer regional trends where data are patchy. The augmentation process involves three hierarchical processes: observation, availability and true abundance. Analyses were undertaken using the R package 'agTrend' (Johnson and Fritz 2014).

An important data requirement for the agTrend analyses was to ensure that all time-series data used for a breeding site were obtained using the same survey method. In instances where there had been a methodological change, we applied a correction factor to adjust a count to a mark-recapture estimate, or to adjust a count or a mark-recapture estimate to a cumulative pup production estimate. Because the relationship between these types of estimates varies between sites in relation to a range of intrinsic site factors, especially sightability, site-specific correction factors were developed and applied.

Following the agTrend methods, non-surveyed breeding seasons were designated as zero observations. Only sites with at least two surveys could be used in the analyses. The specific site-level augmentation model used to estimate missing count data varied in relation to the number of non-zero observations. Where there were >10 non-zero observations a Generalised Additive Model (GAM) was used; where there were 6 to 10 non-zero observations a General Linear Model (GLM) was fitted to the data and where there were <6 non-zero observations a GLM with intercept only was fitted (Johnson and Fritz 2014). The upper-bound limit capability in agTrend was set at 1.3 times the maximum observed pup numbers within a site. The agTrend analyses produce plots of aggregated regional abundance trends, with a line fitted to the median of the posterior predictive counts which are bounded by the 90% highest probability density credible interval. Regional trends in aggregated abundance were estimated for the last 10 years (2005 to 2015).

Trends in abundance at key sites

For the eight key monitoring sites (Seal Bay, Seal Slide, Dangerous Reef, English Island, Olive and Jones Island, and Lilliput and Blefuscu Islands), unadjusted time series of pup abundance estimates collected using consistent methods for each site were analysed using the R package agTrend (as detailed above).

4. RESULTS

4.1. State-wide census

A total of 176 individual surveys were conducted across 83 sites in SA between January 2014 and May 2015 (see Appendix 1). The timing of these surveys relative to the estimated span of breeding activity at each site, and the estimated pup numbers from these surveys, are presented in Table 1. Information for sites where pups were recorded is provided below and summarised in Table 1. In addition, dates for surveys of sites where no pups were recorded are provided in Appendix 1.

Surveys of the eight key monitoring sites were undertaken as follows. Dangerous Reef and English Island surveys were undertaken between March and October 2014 and have been reported on by Goldsworthy *et al.* (2014a). Surveys at Jones and Olive Islands were undertaken between September and December 2014, and at Lilliput and Blefuscu Islands between December 2014 and April 2015. Monitoring of pup production at Seal Bay started in December 2014 when the breeding season commenced, and was still underway at the time of writing this report (August 2015). As such, analyses of the 2014/15 breeding season are not presented here, and the value for the 2013 breeding is used instead (Goldsworthy *et al.* 2014a). Surveys at the Seal Slide were undertaken between December 2014 and May 2015. Details on survey results and how pup abundance was estimated for each site are detailed below.

<u>Bunda Cliffs</u>

There are ten recorded breeding sites for ASL along the Bunda Cliffs (Dennis and Shaughnessy 1996, Dennis 2001). The site Bunda B1 is a cave accessible by sea and has only been surveyed once in 1995. Dennis (2001) noted the cave's existence in 2001 but did not survey it; sometime after this survey the cave collapsed and it is no longer a breeding site. Nine extant breeding sites were reported by Mackay *et al.* (2013) in surveys undertaken in 2012 and 2013. In 2014, surveys were undertaken in July and October at all extant sites, with the exception of Bunda 08. A total pup abundance of 26 pups was recorded at four sites: Bunda 02 (3 pups), Bunda 06 (9 pups), Bunda 09 (7 pups based on 4 black seen in June 2014 and 3 brown seen in October 2014) and Bunda 19 (7 pups).

<u>Nuyts Reef</u>

Ground surveys were undertaken on the southern (Main) reef on 19 March, 17 August and 8 December 2014, with no signs of breeding on any of them. An aerial survey in February 2015 indicated that breeding had commenced (T. Anderson pers. com). On 15 May 2015, ground surveys counted a total of 36 and 66 pups on the Main and southernmost Eastern Reefs, respectively. A further 3 pups were counted via aerial survey of the middle Eastern Reef, giving a total pup count of 105 for Nuyts Reef. The survey was conducted near the end of the breeding season and represents the largest number of pups to have been reported for Nuyts Reef.

Point Fowler (Camel-foot Bay)

This site has previously been reported as a haul-out with occasional pupping, with one pup being recorded in August 1994 (Dennis and Shaughnessy 1996, Shaughnessy *et al.* 2011). During an aerial survey of Point Fowler on 15 May 2015, a small group of non-breeding animals was observed at Camel-foot Bay, but no pups. The timing of this survey coincided with the end of the breeding season at Nuyts Reef and Purdie Islands, the nearest breeding colonies to this site.

Purdie Island

A ground survey was undertaken on Purdie Island on 16 July 2014 with no signs of breeding. A further ground survey was undertaken on 14 April 2015 at the end of the breeding season when a total of 67 pups (1 black mate-guarded, 9 black, 53 brown, 4 dead) were counted.

West Island

A ground survey was undertaken at West Island on 8 December 2014 with no breeding activity. A further ground survey was conducted on 8 April 2015 at the end of the breeding season and 18 pups were counted (1 back mate-guarded, 5 black, 12 brown). On a follow-up aerial survey on 15 May 2015, 20 pups (18 brown, 2 moulted) were counted.

Fenelon Island

A ground survey was undertaken at Fenelon Island on 18 March 2014 with no breeding activity observed. A further ground survey was conducted on 8 April 2015 when 14 pups (4 back mate-guarded, 2 black, 8 brown) were counted near the end of the breeding season. On a follow-up aerial survey on 15 May 2015, 19 pups (2 black mate-guard, 1 black, 16 brown) were counted.

Table 1. Summary of the timing of ASL surveys across 52 current or previously recorded breeding sites in South Australia between January 2014 and May 2015. The timing of previous surveys and estimated breeding season back to November 2013 is also provided. The estimated spread of the breeding season at each site is indicated by the blue shading. The number of pups surveyed or estimated for each site is presented. Some estimates are based on prior surveys as indicated (with source). Key ASL monitoring sites are shaded grey and the type of survey method used is indicated (C = cliff-top, G = ground, A= aerial/helicopter, M = mark-recapture and cumulative pup production method).

			2012		2013												2014												2015				Pups	Pups		
Site	**Breeding site**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**Surveyed**	**Estimated**	**Year**	**Source**
1	Bunda 22 (B9)	C		C		C															C				C								0	0	2014	This report
2	Bunda 19 (B8)	C		C		C															C				C								7	7	2014	This report
3	Bunda 18 (B7)	C		C		C															C				C								0	0	2014	This report
4	Bunda 12 (B6)	C		C		C															C				C								0	0	2013	This report
5	Bunda 09 (B5)	C		C		C															C				C								7	7	2014	This report
6	Bunda 08 (B4)	C		C		C															C				C								0	0	2014	This report
7	Bunda 06 (B3)	C		C		C															C				C								9	9	2014	This report
8	Bunda 04 (B2)	C		C		C															C				C								0	0	2014	This report
9	Bunda 02 (B1.1)			C		C															C				C								3	3	2014	This report
10	Bunda B1																																0	0	2014	This report
11	Nuyts Reef (x3)											GA			GA			G					G				G		A			G	105	105	2015	This report
12	Pt Fowler (Camel-Foot Bay)																															A	0	0	2015	This report
13	Purdie Is.																					G									G		67	67	2015	This report
14	West Is.														G												G				G	A	20	20	2015	This report
15	Fenelon Is.																	G													G	A	19	19	2015	This report
16	Lounds Is.																					G									G		20	20	2015	This report
17	Breakwater Is.																										A		G				27	27	2015	This report
18	Gliddon Reef																										A		A				0	0	2015	This report
19	**Blefuscu**				A						G	GM	GM									G		A			A		GM		GM		97	97	2015	This report
20	**Lilliput**				A						G	GM	GM									G		A			A		GM		GM		72	72	2015	This report
21	**Olive Is.**				A				GM	GM							G					G		G		GM	GM						133	133	2014	This report
22	Nicolas Baudin Is.				A				GM								G					A		A			G						63	63	2014	This report
23	Ward Is.										G						G														G		44	44	2015	This report
24	Pearson Is.										G						G										G				G		30	30	2015	This report
25	Dorothee Is										G						A																0	0	2013	Goldsworthy et al. 2014
26	Point Labatt								C													A				G							0	**2**	2013	Goldsworthy et al. 2014
27	**Jones Is.**								G																	G							19	19	2014	This report
28	West Waldegrave Is.										G						G					G		A			A				G		89	89	2015	This report
29	Cap Island																G					A		G									31	31	2014	This report
30	Rocky (North) Is.				G												G					G		G									35	35	2014	This report
31	Rocky (South) Is.																	G				G		G									11	11	2014	This report
32	Four Hummocks Is.																	G				GA		G			G						6	6	2014	This report
33	Little Hummock Is.																	G				G		G									4	4	2014	This report

Table 1. Cont.

		2012		2013												2014												2015					Pups	Pups		
Site	Breeding site	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	Surveyed	Estimated	Year	Source
34	Price Is.																	A						G			G						32	32	2014	This report
35	Liguanea Is.																G					G					G					GA	25	25	2015	This report
36	Curta Rocks				A												A							G									7	7	2014	This report
37	Williams Is.																	AG				G		G									5	5	2014	This report
38	Lewis Is.				G	G																G		G									82	82	2014	This report
39	North Neptune Islands																G					G											9	9	2014	This report
40	South Neptune Islands																G					G											7	7	2014	This report
41	Albatross Is.																	G				G											95	**69**	2011	Goldsworthy et al. 2012
42	**English Is.**																	A				G											64	**34**	2011	Goldsworthy et al. 2012
43	**Dangerous Reef**																	A		G	GM	GM			GM								485	485	2014	This report
44	North Islet																	GA				A											32	**21**	2011	Goldsworthy et al. 2012
45	Peaked Rocks																	A															17	**58**	2011	Goldsworthy et al. 2012
46	North Casuarina Is. (Kangaroo Is.)																G																11	11	2014	This report
47	Cape Bouguer (Kangaroo Is.)															G		G															9	9	2014	This report
48	Cave Point (Kangaroo Is.)															G																	0	0	2014	This report
49	**Seal Bay (Kangaroo Is.)**					G	G	G	G	G	G	G	G	G	G	G	G	G								G	G	G	G	G	G	G	259	259	2013	Goldsworthy et al. 2014
50	Black Point (Kangaroo Is.)																																-	**1**	2002	Shaughnessy et al. 2009
51	**Seal Slide (Kangaroo Is.)**						G			G		G						G				G					G	G				G	8	8	2015	This report
52	The Pages Islands																				G												313	**478**	2010	Shaughnessy et al. 2013
																																Total	**2,378**	**2,520**		

Lounds Island

A ground survey was undertaken at Lounds Island on 16 July 2014, with no breeding activity observed. A further ground survey was conducted at the end of the breeding season on 7 April 2015 when 20 pups (2 black mate-guarded, 2 black, 16 brown) were counted.

Breakwater Island and Gliddon Reef

An aerial survey was undertaken at Breakwater Island and Gliddon Reef on 8 December 2014. A single black mate-guarded pup was observed on Breakwater Island, with no breeding activity observed on Gliddon Reef. A ground survey was conducted on Breakwater Island on 18 February 2015 when 27 pups were counted (3 black mate-guarded, 1 black, 21 brown, 2 dead) near the end of the breeding season. An aerial survey at Gliddon Reef on the same day indicated no breeding activity.

Blefuscu Island

Aerial surveys were undertaken of Blefuscu Island on 16 July and 28 September 2014 and identified no signs of breeding activity. An aerial survey was conducted at Blefuscu Island on 9 December 2014, when a total of 4 pups were counted (3 black mate-guarded, 1 brown pup) (Table 2). On two subsequent surveys on 17 February and 7 April 2015 44 (including 6 dead) and 45 (including 1 dead) pups were counted, respectively (Table 2). A total of 24 pups were flipper tagged on 17 February 2015 (Table 2). Mark-recapture surveys undertaken on 18 February and 7-8 April 2015, resulted in Petersen estimates of live pups of 65 (95% CL 56 – 73) and 83 (95% CL 73 – 93), respectively (Tables 2 and 3).

Based on tag re-sights between surveys 1 and 2 (Table 2), the apparent survival rate (φ) was 0.875 (sd = 0.068). Using the Petersen estimates and cumulative pup production method, the increase in pup numbers between surveys 1 and 2 was estimated to be 26 (95% CL, 11-41), giving an overall estimate of pup production at Blefuscu Island for the 2014/15 breeding season of 97 (95% CL, 79-114, Table 1 and 2).

Table 2. Summary of abundance estimates of ASL pups at Blefuscu Island in the 2014/15 breeding season: counts, tagging, cumulative mortalities and various direct count and mark-recapture estimates, for three surveys between December 2014 and April 2015. Black (MG) refers to black pups with mate-guarded mothers.

		Survey	1	2	3
		Date	**9 Dec**	**17-Feb**	**7-April**
i)	**Pup counts**				
		Black (MG)	3	4	1
		Black	0	3	1
		Brown	1	31	37
		Moulted	0	0	5
		Dead	0	6	1
		Total	4	44	45
ii)	**Pup marking, counts and cumulative dead**				
		Cumulative marked	0	24	24
		M		24	21
		Maximum unmarked counted	4	25	44
		Maximum count (live)	4	38	44
		Cumulative dead (unmarked)	0	6	7
		Cumulative dead (marked)		0	0
		Total accumulative dead		6	7
		Maximum count (live) + cumulative dead		44	51
		Cumulative marked + dead (unmarked) + max unmarked		55	75
iii)	**Petersen estimates**				
		Petersen Estimate (live)		**65**	**83**
		Petersen Estimate Lower – Upper CL		**56-73**	**73-93**
iv)	**Cumulative pup production between session 2-3**				
		Available for resighting			24
		Number resighted			21
		Apparent survival (φ) between sessions			0.875
		Variance (φ)			0.005
		sd (φ)			0.068
		Net pup production between surveys ($\hat{B}$)			26
		Variance ($\hat{B}$)			60
		Lower CL			11
		Upper CL			41
		Estimated pup production	**4**	**71**	**97**
		Lower – Upper CL			**79-114**

Table 3. Details of Petersen mark-recapture estimates for Blefuscu Island in February and April 2015 to estimate the number of live pups in the population. *M* = number of marked (tagged) pups in the population, n = the total number of pups sampled and *m* = the number of marked pups in each recapture sample. *N* = the estimated live pup population size, sd = standard deviation and V = variance. % = the percentage of marked pups in each sample, CV = the coefficient of variation. Nlo and Nup are the lower and upper 95% confidence limits (CL) of each estimate, respectively.

Date	Recapture No.	Marked *M*	Examined *n*	M-R *m*	Est *N*	sd	V	%	CV	Nlo	Nup
Survey 1											
18-Feb-15	1	24	38	13	69	10	91	34%			
18-Feb-15	2	24	24	10	56	9	84	42%			
18-Feb-15	3	24	26	10	60	10	104	39%			
18-Feb-15	4	24	32	9	82	16	259	28%			
18-Feb-15	5	24	32	12	62	9	84	38%			
18-Feb-15	6	24	37	15	58	7	43	41%			
				Mean	**65**	**4.3**		**36.8%**	**6.7%**	**56**	**73**
Survey 2											
7-Apr-15	1	21	40	8	99	22	463	20%			
7-Apr-15	2	21	23	4	105	34	1137	17%			
7-Apr-15	3	21	34	6	109	29	825	18%			
8-Apr-15	4	21	42	13	67	9	75	31%			
8-Apr-15	5	21	42	10	85	15	229	24%			
8-Apr-15	6	21	46	14	68	8	64	30%			
8-Apr-15	7	21	59	16	77	7	55	27%			
8-Apr-15	8	21	28	6	90	23	537	21%			
8-Apr-15	9	21	59	16	77	7	55	27%			
8-Apr-15	10	21	55	11	102	17	290	20%			
8-Apr-15	11	21	28	11	52	8	58	39%			
8-Apr-15	12	21	45	15	62	6	42	33%			
				Mean	**83**	**5.2**		**25.7%**	**6.2%**	**73**	**93**

Lilliput Island

Aerial surveys were undertaken of Lilliput Island on 16 July and 28 September 2014 and identified no signs of breeding activity. An aerial survey was conducted at Lilliput Island on 9 December 2014, when a total of 7 pups were counted (4 black mate-guarded, 3 brown pups, Table 4). On two subsequent surveys on 17 February and 7 April 2015 54 (including 2 dead) and 54 (including 6 dead) pups, were counted respectively (Table 4). A total of 22 pups were flipper tagged on 17 February 2015 (Table 4). Mark-recapture surveys undertaken on 18 February and 7-8 April 2015, resulted in Petersen estimates of live pups of 62 (95% CL 54 – 69) and 59 (95% CL 51 – 68), respectively (Tables 4 and 5).

Based on tag re-sights between surveys 1 and 2 (Table 4), the apparent survival rate (φ) was 0.818 (sd = 0.082). Using the Petersen estimates and cumulative pup production method, the increase in pup numbers between surveys 1 and 2 was estimated to be 9 (95% CL, 0-23), giving an overall estimate of pup production at Lilliput Island for the 2014/15 breeding season of 72 (95% CL, 56-89, Table 1 and 4).

Table 4. Summary of abundance estimates of ASL pups at Lilliput Island in the 2014/15 breeding season: counts, tagging, cumulative mortalities and various direct count and mark-recapture estimates, during three surveys between December 2014 and April 2015. Black (MG) refers to black pups with mate-guarded mothers.

		Survey	1	2	3
		Date	**9 Dec**	**17-Feb**	**7-8 April**
i)	**Pup counts**				
		Black (MG)	4	4	1
		Black	0	8	1
		Brown	3	40	37
		Moulted	0	0	5
		Dead	0	2	1
		Total	7	54	45
ii)	**Pup marking, counts and cumulative dead**				
		Cumulative marked	0	22	22
		M		22	18
		Maximum unmarked counted	7	26	34
		Maximum count (live)	7	52	53
		Cumulative dead (unmarked)	0	2	8
		Cumulative dead (marked)	0	0	0
		Total accumulative dead	0	2	8
		Maximum count (live) + cumulative dead	7	54	61
		Cumulative marked + dead (unmarked) + max unmarked	7	50	64
iii)	**Petersen estimates**				
		Petersen Estimate (live)		**62**	**59**
		Petersen Estimate Lower – Upper CL		**54-69**	**51-68**
iv)	**Cumulative pup production between session 2-3**				
		Available for resighting			22
		Number resighted			18
		Apparent survival (φ) between sessions			0.818
		Variance (φ)			0.007
		sd (φ)			0.082
		Net pup production between surveys ($\hat{B}$)			9
		Variance ($\hat{B}$)			54
		Lower CL			0
		Upper CL			23
		Estimated pup production	**7**	**64**	**72**
		Lower – Upper CL			**56-89**

Table 5. Details of Petersen mark-recapture estimates for Lilliput Island in February and April 2015 to estimate the number of live pups in the population. *M* = number of marked (tagged) pups in the population, *n* = the total number of pups sampled and m = the number of marked pups in each recapture sample. *N* = the estimated live pup population size, sd = standard deviation and V = variance. % = the percentage of marked pups in each sample, CV = the coefficient of variation. Nlo and Nup are the lower and upper 95% confidence limits (CL) of each estimate, respectively.

Date	Recapture No.	Marked *M*	Examined *n*	M-R *m*	Est *N*	sd	V	%	CV	Nlo	Nup
Survey 1											
18-Feb-15	1	22	32	13	53	6.6	44	41%			
18-Feb-15	2	22	33	13	55	6.9	48	39%			
18-Feb-15	3	22	37	11	72	11.6	134	30%			
18-Feb-15	4	22	33	11	64	10.1	101	33%			
18-Feb-15	5	22	37	14	57	6.7	45	38%			
18-Feb-15	6	22	26	18	68	13.9	193	31%			
				Mean	**62**	**4.0**		**35.3%**	**6.4%**	**54**	**69**
Survey 2											
7-Apr-15	1	18	53	18	53	0.0	0	34%			
8-Apr-15	2	18	44	11	70	10.3	106	25%			
8-Apr-15	3	18	34	11	54	7.6	57	32%			
				Mean	**59**	**4.3**		**30.4%**	**7.2%**	**51**	**68**

Olive Island

A ground survey was undertaken at Olive Island on 11 February 2014, with no breeding activity observed (Table 1, Appendix 1). A ground survey undertaken on 16 July 2014 noted a single black pup with a mate-guarded mother and one other pregnant female being mate-guarded. A ground survey was conducted at Olive Island on 28 September 2014, and a total of 49 (including 4 dead) pups were counted (Table 6). On two subsequent surveys on 6 November and 10 December 2014 76 (including 5 dead) and 93 (including 2 dead) pups were counted, respectively (Table 6). A total of 47 pups were flipper tagged between 6 and 7 November 2014, and a further 17 on 10 December 2014 (Table 6). Mark-recapture surveys undertaken on 7-8 November 2014, and 11-12 December 2014, resulted in Petersen estimates of live pup numbers of 109 (95% CL 100-118) and 119 (95% CL 113-125), respectively (Tables 6 and 7).

Based on tag re-sights between surveys 1 and 2 (Table 6), the apparent survival rate (φ) was 0.957 (sd = 0.029). Using the Petersen estimates and cumulative pup production method, the increase in pup numbers between surveys 1 and 2 was estimated to be 14 (95% CL, 2-27), giving an overall estimate of pup production at Olive Island for the 2014 breeding season of 133 (95% CL, 118-148, Table 6).

Table 6. Summary of abundance estimates of ASL pups at Olive Island in the 2014 breeding season: counts, tagging, cumulative mortalities and various direct count and mark-recapture estimates, during three surveys between September and December 2014.

		Survey	1	2	3
		Date	**28 Sept**	**6-7 Nov**	**10-11 Dec**
i)	**Pup counts**				
		Black (MG)	16	7	0
		Black	9	9	5
		Brown	20	55	85
		Moulted		0	1
		Dead	4	5	2
		Total	49	76	93
ii)	**Pup marking, counts and cumulative dead**				
		Cumulative marked		47	64
		M		47	62
		Maximum unmarked counted		36	45
		Maximum count (live)		71	91
		Cumulative dead (unmarked)		9	12
		Cumulative dead (marked)		0	0
		Total accumulative dead		9	12
		Maximum count (live) + cumulative dead		80	103
		Cumulative marked + dead (unmarked) + max unmarked		92	121
iii)	**Petersen estimates**				
		Petersen Estimate (live)		**109**	**119**
		Petersen Estimate Lower – Upper CL		**100-118**	**113-125**
iv)	**Cumulative pup production between session 2-3**				
		Available for resighting			47
		Number resighted			45
		Apparent survival (φ) between sessions			0.957
		Variance (φ)			0.001
		sd (φ)			0.029
		Net pup production between surveys ($\hat{B}$)			14
		Variance ($\hat{B}$)			38
		Lower CL			2
		Upper CL			27
		Estimated pup production	**49**	**118**	**133**
		Lower – Upper CL			**118-148**

Table 7. Details of Petersen mark-recapture estimates for Olive Island in November and December 2014. *M* = number of marked (tagged) pups in the population, *n* = the total number of pups sampled and m = the number of marked pups in each recapture sample. *N* = the estimated live pup population size, sd = standard deviation and V = variance. % = the percentage of marked pups in each sample. Nlo and Nup are the lower and upper 95% confidence limits (CL) of each estimate, respectively.

Date	Recapture No.	Marked *M*	Examined *n*	M-R *m*	Est *N*	sd	V	%	Nlo	Nup
Survey 1										
7-Nov-14	1	47	43	17	116	16.4	268	39.5%		
7-Nov-14	2	47	45	20	104	12.4	154	44.4%		
7-Nov-14	3	47	53	24	103	10.3	106	45.3%		
7-Nov-14	4	47	57	24	110	11.4	130	42.1%		
7-Nov-14	5	47	59	26	106	9.9	98	44.1%		
7-Nov-14	6	47	57	23	115	12.6	158	40.4%		
7-Nov-14	7	47	62	26	111	10.6	112	41.9%		
				Mean	**109**	**4.6**	**21**	**43.0%**	**100**	**118**
Survey 2										
11-Dec-14	1	62	86	41	130	8.3	68	47.7%		
11-Dec-14	2	62	70	37	117	8.1	66	52.9%		
11-Dec-14	3	62	56	31	111	9.1	82	55.4%		
11-Dec-14	4	62	76	36	130	9.8	97	47.4%		
11-Dec-14	5	62	70	45	96	4.4	19	64.3%		
11-Dec-14	6	62	68	33	127	10.4	109	48.5%		
11-Dec-14	7	62	83	41	125	7.8	62	49.4%		
11-Dec-14	8	62	76	40	117	7.4	54	52.6%		
				Mean	**119**	**3.0**	**9**	**52.9%**	**113**	**125**

Nicolas Baudin Island

Surveys undertaken at Nicolas Baudin Island on 11 February (ground) and 16 July 2014 (aerial) identified no breeding activity (Table 1, Appendix 1). On a subsequent survey on 28 September 2014 (aerial) 11 pups (6 black mate-guarded, 5 black) were counted and a final survey on 9 December 2014 (ground) near the end of the breeding season counted 63 pups (1 black, 62 brown).

Ward Island

A ground survey was undertaken at Ward Island on 11 February 2014 with no breeding activity observed. On a ground survey on 10 April 2015 at the end of the breeding season, 44 pups (36 brown, 7 moulted, 1 dead) were counted.

Pearson Island

A ground survey was undertaken at Pearson Island on 12 February 2014, with no breeding activity observed. On a ground survey at the beginning of the breeding season on 9 December 2014, 9 pups (8 black mate-guarded, 1 black) were counted. A subsequent ground survey on 10 April 2015 at the end of the breeding season counted 30 pups (27 brown, 1 moulted, 2 dead).

Dorothee Island

A ground survey on 2 August 2013 identified no signs of breeding activity. As concurrent surveys indicated that breeding seasons were well underway at Pearson and Ward Islands, Dorothee Island was not considered a breeding site (Goldsworthy *et al.* 2014a). An aerial survey was also undertaken at Dorothee Island on 12 February 2014 with no breeding activity observed (Table 1, Appendix 1).

Point Labatt

An aerial survey undertaken at Point Labatt on 17 July 2014 identified no signs of breeding activity. A survey from the observation platform above Point Labatt on 5 November 2015 also indicated no signs of breeding activity (Table 1, Appendix 1). Two brown pups were sighted at Point Labatt in the previous breeding season on 18 June 2013 (Goldsworthy *et al.* 2014a). Given the sightability from the observation platform above Point Labatt is not ideal, the numbers observed in the 2013 breeding season are used to estimate pup production at this site.

Jones Island

New born pups were first sighted at Jones Island in August 2014 (Alan Payne *pers. comm.*). A single ground survey was undertaken on Jones Island on 5 November 2014, when a total of 19 pups were counted (5 black, 12 brown and 2 dead).

West Waldegrave Island

Surveys were undertaken at West Waldegrave Island on 12 February (ground), 17 July (ground) and 28 September 2014 (aerial) and no breeding activity was observed (Table 1, Appendix 1). On an aerial survey on 9 December 2014 10 pups (6 black mate-guarded, 4 brown) were counted, and a ground survey on 9 April 2015 at the end of the breeding season counted 89 pups (62 brown, 26 moulted, 1 dead).

Cap Island

A ground survey was undertaken at Cap Island on 12 February 2014, and no breeding activity was observed. On an aerial survey on 18 July 2014, 3 pups (1 black, 2 brown) were counted, and a ground survey on 28 September 2014 at the end of the breeding season counted 31 pups (31 brown).

Rocky (North) Island

A ground survey was undertaken at Rocky (North) Island on 12 February 2014 with no breeding activity observed. On a ground survey on 18 July 2014, 20 pups (2 black mate-guarded, 1 black, 16 brown, 1 dead) were counted, and a ground survey on 28 September 2014 at the end of the breeding season counted 35 pups (27 brown, 8 moulted).

Rocky (South) Island

A ground survey was undertaken at Rocky (South) Island on 13 March 2014 with no breeding activity observed. On a ground survey on 18 July 2014, 7 pups (1 black mate-guard, 2 black, 4 dead) were counted, and on a ground survey on 29 September 2014, near the end of the breeding season, 7 pups were counted (2 black mate-guarded, 1 black, 4 brown). Inclusion of the four dead pups into the latter total provides an estimate of 11 pups.

Four Hummocks Islands

A ground survey was undertaken on the middle and northern islands in the Four Hummocks group on 13 March 2014 with no breeding activity observed. On a ground survey on 18 July 2014 of the middle island, 2 pups (1 black mate-guarded, 1 black) were counted, and on an aerial survey of the northern island one pup (black mate-guarded) was seen. A ground survey of the middle island on 29 September 2014 counted 4 pups (2 black mate-guard, 2 brown) with an additional pup (brown) observed by aerial survey on the southern island, and no pups sighted by air on the northern island. An additional black pup (~3 weeks old) was sighted during a ground survey of the middle island on 10 December 2014. Adding this to the 5 pups sighted in the September surveys gives an estimate of 6 pups for the Four Hummocks Islands.

Little Hummock Island

A ground survey was undertaken at Little Hummock Island on 13 March 2014 with no breeding activity observed. On a ground survey on 18 July 2014, 2 pups (2 black mate-guard) were counted, and a ground survey on 29 September 2014 at the end of the breeding season resulted in 4 pups (1 black, 2 brown, 1 dead).

Price Island

An aerial survey of Price Island on 13 March 2014 identified no breeding activity (Table 1, Appendix 1). A ground survey on 29 September 2014 at the beginning of the breeding season counted 7 pups (4 black mate-guarded, 1 black, 1 brown, 1 dead), and a final ground and aerial (of regions outside main pupping areas) survey on 10 December 2014 near the end of the breeding season counted 31 pups (2 black mate-guarded, 3 black, 23 brown, 3 dead). Inclusion of the one dead pup seen on the previous survey results in an estimate of 32 pups for the season.

Liguanea Island

A ground survey on 5 February 2014 (approximately 3-4 months following the end of the previous breeding season) counted 17 pups (4 brown, 13 moulted). Ground surveys on 18 July and 10 December 2014 identified no breeding activity. On a final ground survey (and aerial survey of regions outside main pupping areas) on 14 May 2014 at the end of the breeding season, 25 pups (1 black, 22 brown, 2 dead) were counted.

Curta Rocks

Curta Rocks had been identified as a possible breeding site based on aerial surveys conducted in November 2011, February 2013 and February 2014 (Goldsworthy *et al.* 2013, 2014a). On a ground survey on 30 September 2014, near the end of the breeding season, 7 pups (1 black mate-guarded, 6 brown) were counted, confirming it as a breeding site.

Williams Island

Williams Island has not previously been recognised as an ASL breeding site. A ground and aerial survey was undertaken on 14 March 2014, with no sign of breeding activity (Table 1, Appendix 1). However, on a ground survey on 19 July 2014, 4 pups (1 black, 3 brown) were counted, and a subsequent ground survey on 30 September 2014 also counted 4 pups (1 black, 3 brown). Given the black pup sighted on the second survey was likely to have been born subsequent to the July survey, the estimate of pup numbers for this site is 5. All ground surveys were accompanied by aerial surveys of the remainder of the island not surveyed by foot. These represent the first ASL breeding records for Williams Island.

Lewis Island

A ground survey on 20 July 2014 counted 35 pups (12 black mate-guarded, 16 black, 6 brown, 1 dead). Based on the number and stage of growth of these pups, this survey occurred in the first half of the breeding season. On a second ground survey near the end of the breeding season on 30 September 2014, 82 pups (7 black mate-guarded, 12 black, 61 brown, 2 dead) were counted.

North Neptune Islands

Ground surveys on 3 March and 6 March 2014 on the main and East Island counted a single brown pup and a single moulted pup, respectively. On a subsequent ground survey on East

Island on 19 July 2014, 9 pups (5 brown, 4 moulted) were counted. There was no sign of recent breeding and, based on the age of pups, breeding had finished about two months earlier.

South Neptune Islands

A ground survey on 7 February 2014 on the main island counted 2 brown pups. A subsequent survey on 19 July 2014 counted 7 pups (1 black mate-guarded, 1 brown, 5 moulted). There is some uncertainty about the timing of breeding at this site, given the single black mate-guarded pup observed in July when most pupping had probably finished by February. Given this uncertainty, we have estimated a minimum pup abundance of four, comprising the single black pup and brown pup plus the two brown pups seen in February (which would have been moulted pups in July). This assumes that three of the moulted pups had originated elsewhere.

Albatross Island

On a ground survey on 14 March 2014, 35 pups (7 black, 26 brown, 12 dead) were counted. Based on the number and growth stage of pups, this survey occurred in the first half of the breeding season. On a second ground survey on 20 July 2014, 95 pups (42 black, 51 brown, 2 dead) were counted. Based on the moult stage of these pups, this second survey probably occurred at least 1-2 months after the end of the breeding season. Given the marked increase in pup numbers from two previous surveys which were undertaken in November 2009 and May 2011, when 69 pups were recorded on both occasions (Goldsworthy *et al.* 2010a, 2012), it is likely that the survey of July 2014 included some pups dispersed from Dangerous Reef (~28 km to the north). Given uncertainly in the recent survey, we have used the previous two estimates of pup numbers (69) to provide an estimate for Albatross Island.

English Island

An aerial survey of English Island on 14 March 2014 recorded no sign of breeding activity. A subsequent ground survey on 4 July 2014 counted 64 pups (57 brown, 1 moulted, 6 dead) (Table 1, Appendix 1). One of the brown pups sighted was tagged at Dangerous Reef on 3 June 2014 (~20km to the south). It is likely that some of the untagged pups sighted at English Island also originated from Dangerous Reef, given that in the four previous surveys the estimated number of pups was far fewer: 34 (2011), 39 (2009/10), 23 (2008) and 27 (2005) (Goldsworthy *et al.* 2014a). These surveys also had to account for an unknown number of pups from Dangerous Reef potentially confounding pup production estimates (Goldsworthy *et al.* 2014a). Given uncertainly in the recent survey, we have used the 2011 survey of 34 pups to provide an estimate for English Island (Table 1).

Dangerous Reef

An initial aerial (helicopter) survey was conducted at Dangerous Reef on 14 March 2014, and counted 3 (black mate-guarded) pups, indicating the commencement of the breeding season. Four subsequent ground surveys on 14 May, 2 June, 2 July, and 14 October 2014 counted 217 (including 31 dead), 257 (including 32 dead), 280 (including 76 dead) and 126 (including 66 dead) pups, respectively (Goldsworthy *et al.* 2014a). A total of 162 pups were flipper tagged on 3 - 5 June 2014, and a further 86 were tagged on 2-3 July 2014 (248 cumulative number tagged) (Goldsworthy *et al.* 2014a). Mark-recapture surveys undertaken on 2-5 June, 2-4 July and 14-18 October 2014, resulted in Petersen estimates of live pups of 282 (95% CL 275-289), 319 (95% CL 312-326) and 166 (95% CL 156-175), respectively (Goldsworthy *et al.* 2014a). Based on tag re-sights between surveys 3 and 4, and 4 and 5, the apparent survival rates (φ) were 0.776 (sd = 0.034) and 0.412 (sd = 0.031), respectively. Using the Petersen estimates and cumulative pup production method, the net increase in pup numbers between surveys 3 and 4, and 4 and 5 was estimated to be 100 (95% CL, 79-121) and 34 (95% CL, 12-56), respectively, giving an overall estimate of pup production at Dangerous Reef for the 2014 breeding season of 485 (95% CL, 462-508, Table 1) (Goldsworthy *et al.* 2014a).

North Islet

A ground survey of the western end of North Islet on 14 March 2014 indicated no sign of breeding there, but an aerial survey of the remainder of the north and west coast revealed some new born pups and mate-guarded females, indicating breeding had started. A subsequent aerial survey on 20 July 2014 counted 32 pups (1 brown, 31 moulted). Most had moulted, indicating that the breeding season had finished several months earlier and that many of the pups sighted may have swum in from elsewhere. Given this uncertainty, we have used the best previous estimate based on a complete ground count undertaken on 16 May 2011 when 21 pups were counted (18 brown, 3 moulted) (Goldsworthy *et al.* 2012).

Peaked Rocks

An aerial survey was conducted of the east and west islets of Peaked Rocks on 14 March 2014. No breeding was observed on the western rock. High seas prevented landing on the eastern rock, but an aerial survey counted a minimum of 17 brown pups. Given the unreliability of this survey, we have used the best previous estimate based on a complete ground count undertaken 16 May 2011 when 58 pups were counted (1 black, 39 brown, 17 moulted, 1 dead) (Goldsworthy *et al.* 2012).

North Casuarina Island (Kangaroo Island)

A thorough ground count was undertaken of North Casuarina Island on 29 January 2014 when 11 pups (10 brown, 1 moulted) were counted.

Cape Bouguer (Kangaroo Island)

A ground count was undertaken at Cape Bouguer on 23 January 2014 when 6 pups (5 black, 1 brown) were counted. A subsequent survey on 20 March 2014 counted 9 pups (3 black, 3 brown, 2 moulted, 1 dead).

Cave Point (Kangaroo Island)

A ground count was undertaken at Cave Point on 23 January 2014 when no pups or other signs of breeding were seen. This survey coincided with the breeding seasons at other ASL breeding sites on Kangaroo Island (Table 1). Small numbers of pups have been previously reported at Cave Point in February 1990 (3 pups) and January 1993 (1 pup) but none were sighted there in subsequent surveys in January 2002, July 2002, January 2003, February 2004, January 2005 (Shaughnessy *et al.* 2009), and this most recent survey in January 2014.

Seal Bay (Kangaroo Island)

Pup production at Seal Bay for the 2013 breeding season was estimated to be 268 (range 259 – 277) (Goldsworthy *et al.* 2013). Since 2002, Seal Bay pup production has been estimated using a combination of three methods: direct counts of live and dead pups, cumulative survey of new births and deaths, and mark-recapture methods using the Petersen estimates, with the first two methods providing an absolute minimum. The overall estimate of pup production has been taken as the largest of the three estimates (Goldsworthy *et al.* 2014a). However, recent observations indicate that the clip marks applied to brown pups when microchipped are not readily visible once pups have moulted. This loss of marks violates the assumptions of the Petersen estimate (Caughley 1977), and has likely led to over-estimates of pup production in some years. For this analysis, we have therefore used the cumulative birth estimate of 259 pups for the 2013 breeding season (Goldsworthy *et al.* 2014a).

Black Point (Kangaroo Island)

No survey was undertaken at Black Point. There have been two confirmed sightings of single pups, in May 1986 and January 2002, which are likely to have been born at Black Point given their small size and estimated age (< 3 months old), and an additional sighting of a pup swimming with its mother in March 2005, which may have originated from elsewhere (Shaughnessy *et al.* 2009). In the absence of other information we have assumed a pup count of one for Black Point.

Seal Slide (Kangaroo Island)

Ground counts were undertaken at Seal Slide on 17 December 2014 when 4 pups were counted (3 black mate-guarded, 1 black), on 21 January 2015 when 8 pups were counted (1 black, 6 brown, 1 dead) and 12 May 2015 when 14 pups were counted (12 brown, 1 moulted, 1 dead). It is estimated that the May 2015 survey was undertaken at least two months following the end of the breeding season and some of the pups may have originated from Seal Bay. Given uncertainty in the final survey, we have used results from the January 2015 survey (8 pups) which occurred at the end of the breeding season (when there was no sign of mate-guarding) as the estimate for pup production in the 2014/15 breeding season.

The Pages Islands

The Pages consist of two small islands (North and South Page Islands) and are considered as a single breeding colony based on close geographical proximity (<2 km), and high genetic similarity (two shared mtDNA haplotypes in similar proportions) (Lowther *et al.* 2012). A single ground count was undertaken on both islands on 25 June 2014 when 178 (173 brown, 5 dead) and 135 (3 black, 111 brown, 15 moulted, 6 dead) pups were counted on North and South Page Islands, respectively, giving a total count of 313 for The Pages Islands. The survey is considered an underestimate because it was done 1-2 months after the end of the breeding season. A survey of the Pages undertaken during the 2009/10 season, when 478 pups were counted (Shaughnessy *et al.* 2013), is considered the best recent survey, and is used as the estimate of pup production here.

Overall assessment

Pups were recorded at 40 of the surveyed sites (83) with 2,378 pups observed in total (Table 1). For seven sites where there were issues with pup surveys (mostly due to inappropriate timing), the estimate for pup numbers from the most recent reliable survey was substituted (Table 1 and detailed above). Accounting for these figures gives a total estimate of ASL pup abundance in SA of 2,520 (Table 1). The number of breeding sites (including Black Point and Point Labatt) is 42, with a mean and median pup production of 60 (sd = 106.6) and 23, respectively. Only five sites produced more than 100 pups (Nuyts Reef, Olive Island, Dangerous Reef, Seal Bay and The Pages), and these accounted for 58% (1,460) of the total estimated pup abundance in SA.

4.5 Trends in abundance

Change in pup abundance over two surveys

The estimated change in pup abundance between two time periods where similar survey methods have been used could be calculated for 29 (69%) of the 42 extant breeding sites surveyed in this study, or 77% (1,939) of the current SA pup abundance (Table 8). The change in surveyed pup numbers over time is presented for each of these sites in Appendix 2, along with the estimated annual rate of change in pup abundance on an annual basis, per breeding season (1.5 years) and over three-generations (38 years). These estimates are summarised for the seven ASL regions of SA in Table 8.

The period over which changes in pup abundance was calculated ranged from 6 to 44 years (mean = 13.2, sd = 8.2) (Appendix 2). Decreases in pup counts were observed for 23 (82%) sites, and increases for 5 (18%) sites (Table 8). Estimated annual rates of change in pup numbers ranged from -10.1% to 3.9% and averaged -2.9% (sd = 3.6%) (Appendix 2, Table 8). Estimated rates of change in pup numbers per breeding season ranged from -15.1% to 5.9% to, and averaged -4.4% (sd = 5.4%) (Appendix 2, Table 8). Regional declines were greatest for the Nuyts Archipelago region (-4.6%/year or -6.9%/breeding season), and lowest for the Kangaroo Island region (-0.9%/year or -1.4%/breeding season) (Table 8). The overall estimated change in pup abundance over three generations for the SA ASL population was -78.2% (assuming a constant exponential rate of change) (Table 8).

Regional trends in aggregated abundances (2005-2015)

Estimates from trend analyses of aggregated regional abundance for six ASL regions across SA are presented in Table 9. Over the last ten years, ASL populations have been in decline across their entire SA range, although there is marked variation in the extent of the decline (Table 9). As with results from the change in pup numbers over two surveys, trends in aggregated regional abundances showed the greatest rate of decline in the Nuyts Archipelago region (-3.3% per year, or -5.0% per breeding season), and were lowest from the Kangaroo Island region (-0.4% per year, or -0.6% per breeding season). Rates of decline were also high for the Bunda Cliffs (-2.9% per year, or -4.3% per breeding season) and Chain of Bays regions (-2.8% per year, or -4.3% per breeding season, Table 9). The posterior predictive distributions of aggregated ASL counts for the six regions are presented in Figure 2.

Both the change in pup abundance over two surveys and regional trends in aggregated pup abundance methods produced similar results in terms of estimated rates of decline for the ASL regions (-2.5 and 1.9% per year; and -3.8 and -2.9% per breeding season, respectively). The mean difference in estimated rates of decline between the two methods across the six regions was 0.9% (sd = 0.6, range 0.3 to1.9) per breeding season, and 1.4% (sd = 0.9, range 0.5 to 2.8) per breeding cycle, with the change over two surveys method producing higher rates of decline compared to the aggregated regional abundance method (Table 8 and 9).

Trends in key monitoring sites

Estimates of the trends in pup abundances at the eight key ASL monitoring sites across SA are presented in Table 10 and Figures 3 and 4. Individual site plots demonstrate the dual effects of short time series and variability in pup numbers between breeding seasons on trend estimates, and the variability in the credible range of those estimated trends (Figure 3 and 4, Table 10). These factors make it difficult to discern trends for Blefuscu and Lilliput Islands and the Seal Slide, with median estimates in trends close to zero, and the lower and upper credible limits spread in similar magnitude above and below zero (Table 10). Analyses of pup surveys at these sites to date suggest their population sizes are stable. The number of seasons of surveys at Olive and Jones Islands are similar and they show a similar range of credible limits, although trends are in opposite directions (Figure 3, Table 10). Results for Olive Island suggest that pup numbers are declining by 4.4% per year, or 6.5% per breeding season. In contrast, pup numbers at Jones Island are increasing by 3.2% per year or 4.8% per breeding season (Figure 3, Table 10). There is an indication that pup numbers at English Island are increasing (5.5% per year, or 8.2% per breeding season), but the credible ranges are very large.

At Dangerous Reef and Seal Bay, several methods have been used to estimate pup abundance, including counts of live and dead pups, mark-recapture and cumulative pup production methods. These different methods cover different time periods. For Dangerous Reef, pup count data cover a 39 year period and suggest that pup numbers have increased slightly, whereas mark-recapture and cumulative pup production data indicate a decline over the last 7-15 years (Table 10, Figure 4). The differences are driven by the increase in pup counts in the 2000s (peaking in 2006 and 2007) and their subsequent decline (Figure 4). For Seal Bay, data on the maximum count of live pups throughout consecutive breeding seasons is available for the last 28 years, and indicates an ongoing decline of 1.2% per year or 1.9% per breeding season; in contrast, cumulative pup production data suggest that over the last 11 years, pup abundance has been relatively stable or has increased slightly (Figure 4, Table 10).

Table 8. Summary of estimates of regional trends in ASL abundance across SA, based on changes in pup abundance over two surveys estimated for individual breeding sites (see Appendix 2). The number of breeding sites per region, and those with useable time series are indicated, as are the number that have decreased, increased or remained stable. The mean percentage rate of change (λ) of breeding sites within regions is given per year and per breeding season (1.5 years). The mean rates of change of all 29 sites are presented, as is the mean of the mean regional rates of change (in parentheses). Estimated changes in pup abundance within regions (for sites with time series data, see Appendix 2) across 3-generations (38 years, 1977 to 2015) are also provided, assuming a constant exponential rate following IUCN guideline to assess species under Criterion A. Note, current pup numbers have been extrapolated forward for some sites that were not surveyed in 2015, and therefore this figure differs to the actual pup counts obtained in this survey.

Region	No. breeding sites	No. with time series	No. decreased	No. increased	λ/yr (%)	λ/breeding season (%)	Pup Nos 3 gen ago	Pup Nos current	Change in 3-gen (%)
Bunda Cliffs	5	3	3	0	-3.67	-5.51	97	22	-77.0%
Nuyts Reef	1	0	-	-	-	-	-	-	-
Nuyts Archipelago	7	7	5	2	-4.61	-6.92	3,441	322	-90.6%
Chain of Bays	7	6	5	1	-2.22	-3.32	1,746	374	-78.6%
SW Eyre	6	2	1	1	-0.96	-1.44	40	38	-4.4%
Spencer Gulf	11	7	6	1	-2.83	-4.25	2,700	580	-78.5%
Kangaroo Island	6	3	3	0	-0.94	-1.41	736	576	-21.8%
Sum/mean	**43**	**28**	**23 (82%)**	**5 (18%)**	**-2.90 (-2.54)**	**-4.35 (-3.81)**	**8,759**	**1,912**	**-78.2%**

Table 9. Trend estimates for six regional ASL metapopulations in SA between 2005 and 2015 calculated using the hierarchical modelling and Bayesian inference methodology to augment missing abundance data and estimate regional trends in aggregated abundance (see Johnson and Fritz 2014). Trend estimates are given for the posterior median, and lower and upper 90% highest probability density credible intervals (CI) of λ by year, and by breeding season (1.5 years).

Region	λ yr^{-1}			λ breeding season^{-1}		
	Median	Lower CI	Upper CI	Median	Lower CI	Upper CI
Bunda Cliffs	-2.86	-6.65	0.98	-4.29	-9.98	1.20
Nuyts Archipelago	-3.31	-4.82	-1.53	-4.96	-7.23	-2.29
Chain of Bays	-2.87	-4.97	-0.80	-4.30	-7.45	-1.20
SW-Eyre	-1.27	-8.66	5.23	-1.91	-12.99	7.84
Spencer Gulf	-0.95	-4.42	2.57	-1.43	-6.63	3.86
Kangaroo Island	-0.39	-3.57	2.71	-0.58	-5.36	4.06

Table 10. Trend estimates for eight key ASL sites in SA for various time intervals calculated using the hierarchical modelling and Bayesian inference methodology to augment missing abundance data and estimate regional trends in aggregated abundance (see Johnson and Fritz 2014). Trend estimates are given for the posterior median, and lower and upper 90% highest probability density credible intervals (CI) of λ by year and by breeding season (1.5 years). M-R and CPP refer to mark-recapture and cumulative pup production methods, respectively

Site	Year range	λ yr^{-1}			λ breeding season^{-1}		
		Median	Lower CI	Upper CI	Median	Lower CI	Upper CI
Blefuscu Island	2008-2015	-0.03	-5.13	5.33	-0.04	-7.70	8.29
Lilliput Island	2008-2015	-0.01	-2.89	3.03	-0.01	-4.34	4.54
Olive Island	2006-2015	-4.36	-9.95	1.43	-6.54	-14.92	2.14
Jones Island	2001-2014	3.21	-2.13	8.29	4.82	-3.19	12.43
Dangerous Reef (counts)	1975-2014	1.13	-0.10	2.75	1.70	-0.15	4.12
Dangerous Reef (M-R)	1999-2014	-0.90	-4.50	3.57	-1.35	-6.75	5.36
Dangerous Reef (CPP)	2007-2014	-6.27	-14.54	4.35	-9.40	-21.81	6.53
English Island	2005-2014	5.45	-9.99	20.23	8.17	-14.98	30.48
Seal Bay (live counts)	1985-2013	-1.24	-2.01	-0.37	-1.86	-3.01	-0.56
Seal Bay (CPP)	2002-2013	1.06	-1.41	3.73	1.59	-2.12	5.59
Seal Slide	2002-2015	-0.68	-5.59	4.16	-1.02	-8.39	6.24

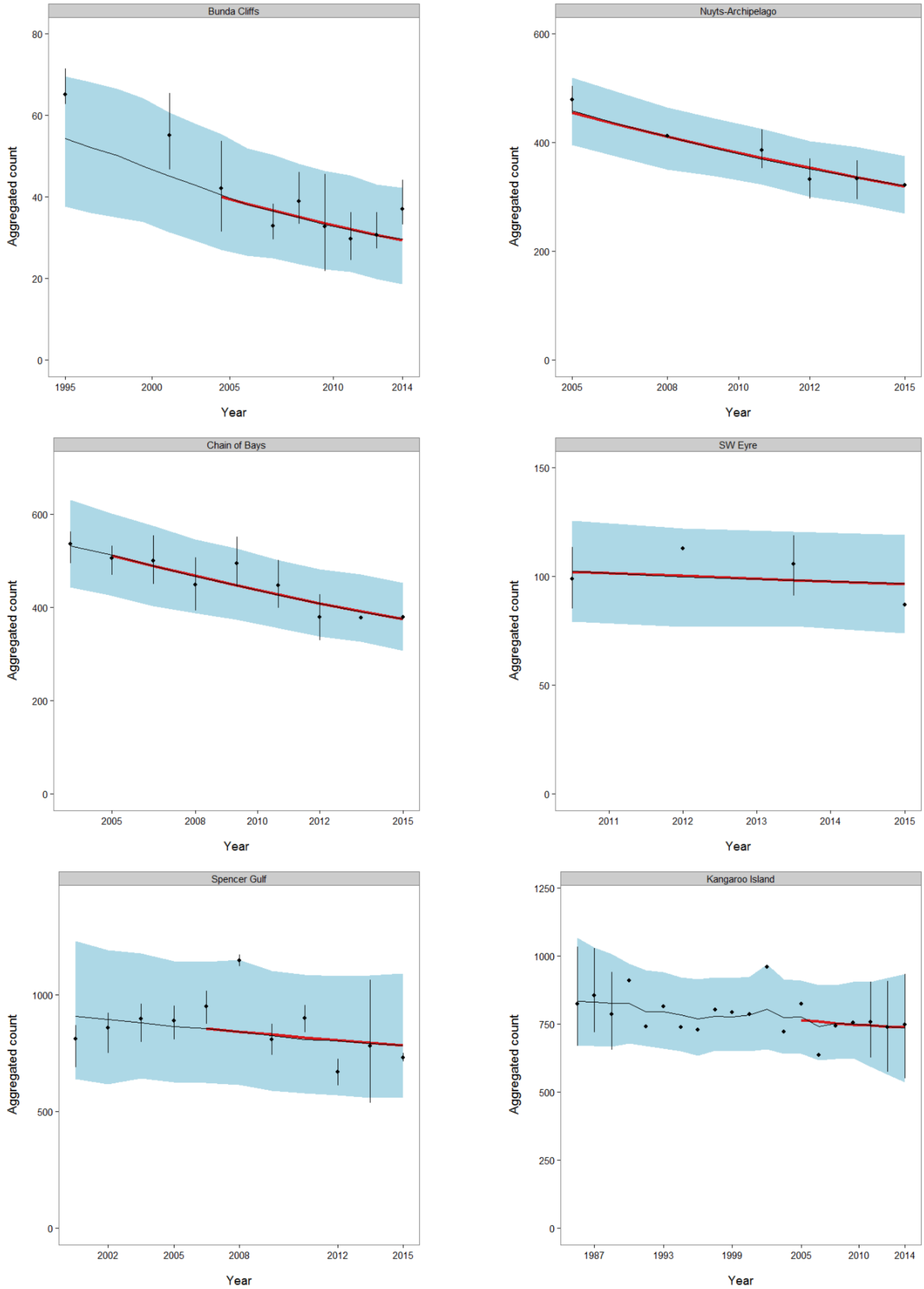

Figure 2. Predicted distribution of aggregated abundance and trend for six ASL regions in SA. The blue envelope represents the 90% highest probability density credible interval of the posterior predictive counts. Points and error bars represent the observed counts with augmented missing values; the red lines are the fitted least-squares predictive trend over the last decade (2005 to 2015) and the black lines are the median of the posterior predictive counts.

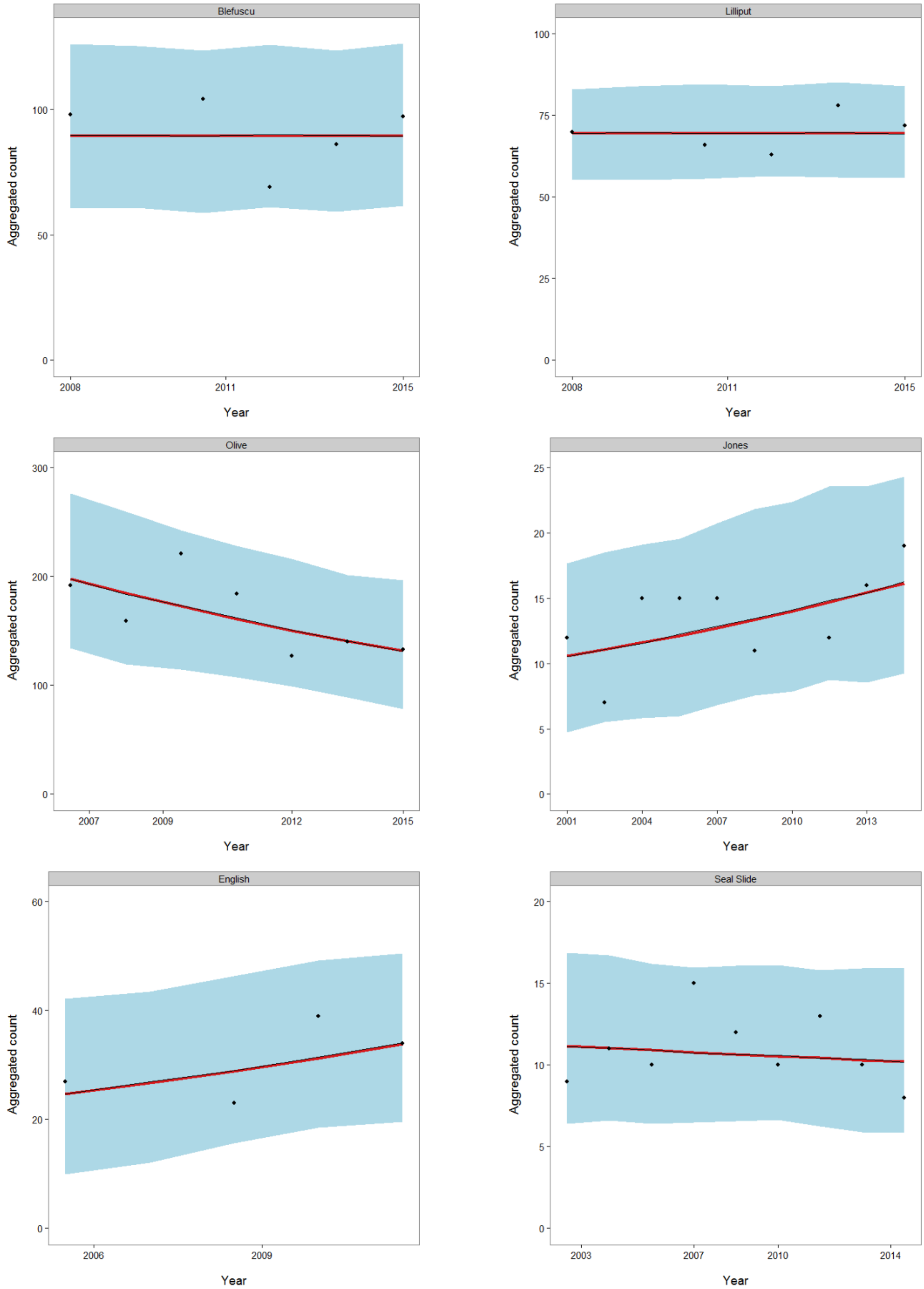

Figure 3. Predicted pup abundance for six of the eight key ASL monitoring sites across SA. The blue envelope represents the 90% highest probability density credible interval of the posterior predictive counts. Points represent the observed counts; the red line is the fitted least-squares predictive trend over the time series.

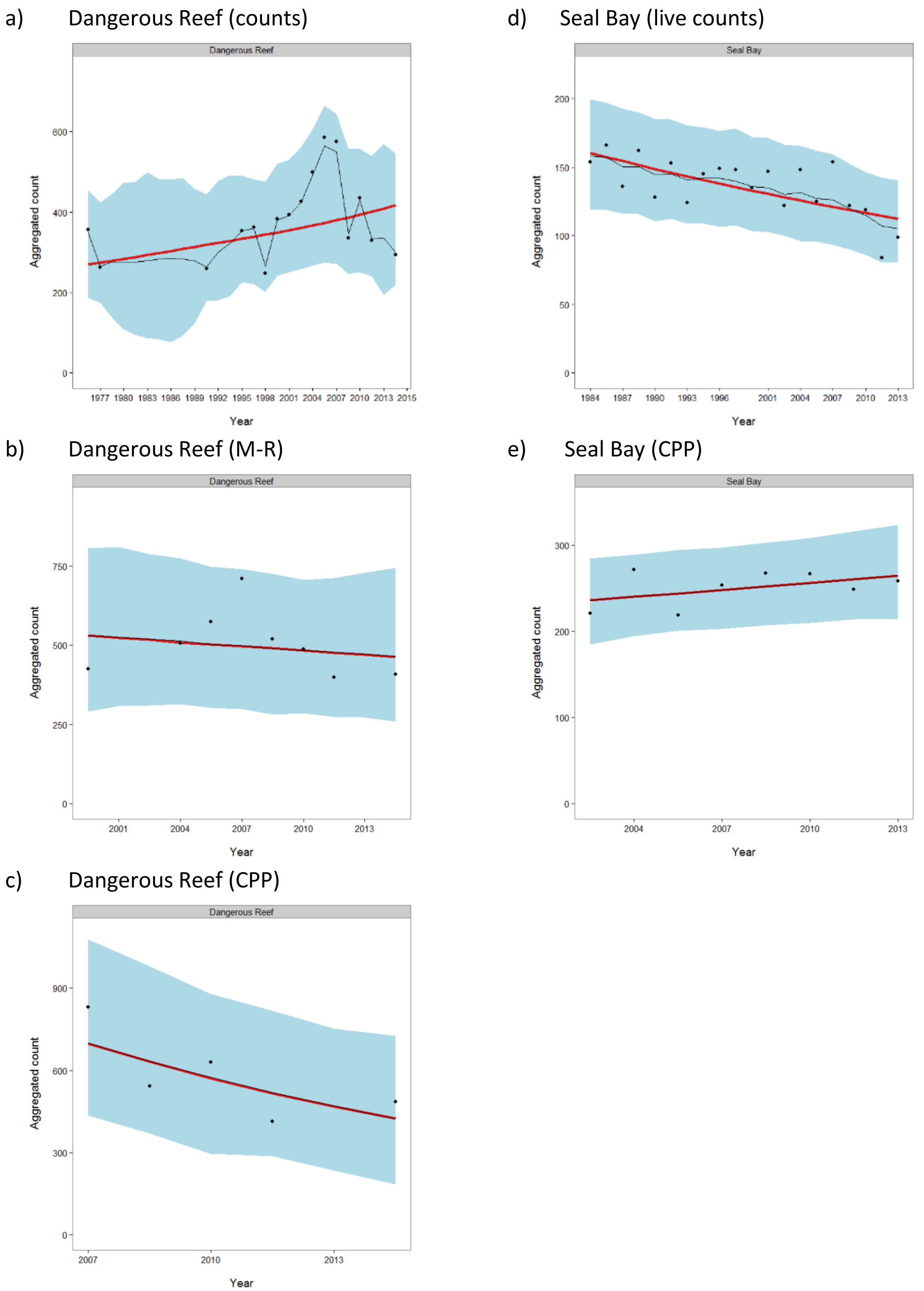

Figure 4. Predicted pup abundance for six of the eight key ASL monitoring sites across SA. The blue envelope represents the 90% highest probability density credible interval of the posterior predictive counts. Points represent the observed counts; the black line is the median posterior predictive abundance and the red line is the fitted least-squares predictive trend over the time series. M-R = mark-recapture, CPP= cumulative pup production.

5. DISCUSSION

5.1. Population status

This study represents the most comprehensive survey of the SA ASL population, and the first time most of the colonies in the State have been surveyed within an 18 month period, the approximate span of one breeding cycle. The total pup abundance of the population was estimated to be 2,520, born across 42 breeding sites, with a mean and median pup abundance of 60 (sd = 106.6) and 23, respectively. Only five sites produced more than 100 pups (Nuyts Reef, Olive Island, Dangerous Reef, Seal Bay and The Pages), and these accounted for 58% (1,460) of the State's estimated pup abundance. Two new breeding sites were discovered at Curta Rocks (7 pups) and Williams Island (5 pups), both off lower Eyre Peninsula in the Spencer Gulf region.

Prior to this study, the most comprehensive survey was compiled by Shaughnessy *et al.* (2011), and based on surveys primarily undertaken between 2004 and 2008 (although data for some colonies was from as early as 1990). That survey estimated ASL pup abundance in SA to be 3,119, almost 600 greater than the present survey, conducted 6 to 11 years later. However, the survey of Shaughnessy *et al.* (2011) did not include five recently discovered breeding sites (Cap Island, Rocky (South) Island, Little Hummock Island, Curta Rocks and Williams Island) with a combined pup abundance of 58 (this survey). In addition, recent survey results suggest that surveys undertaken at three of the sites by Shaughnessy *et al.* (2011) (Nuyts Reef, Rocky (North) Island and North Casuarina Island) were undertaken either too early, or outside of the breeding season, and to have potentially underestimated pup abundances at those sites by 117 based on recent survey results (total pup abundance for the three sites 151). Most of this difference is attributed to Nuyts Reef, a collection of very remote offshore islets previously only accessed by vessel, and where surveys of the middle and western islets in March 1990 and April 2004 recorded 3 and12 pups, respectively (Gales *et al.* 1994, Shaughnessy *et al.* 2005). Surveys conducted at the end of the breeding season in May 2015 recorded 69 and 36 pups at the middle and western islets, respectively, giving a total of 105 pups.

In order to make meaningful comparisons between surveys undertaken in this study and those undertaken 6-11 years earlier by Shaughnessy *et al.* (2011), it is necessary to exclude the newly discovered breeding sites and inadequately surveyed sites identified above, as well as sites where adjusted counts were used along the Bunda Cliffs (Shaughnessy *et al.* 2011). With these adjustments, the pup abundance estimates for the 2004 to 2008 surveys are reduced to 2,902 pups from 32 sites. For these same sites the total pup abundances in the 2014-2015 surveys was 2,215; almost one quarter fewer (23.7%, 687 pups) than those reported by Shaughnessy *et al.* (2011). Most of this difference is attributed to reductions in observed pup numbers at The Pages (Kangaroo Island), Dangerous Reef and Lewis Island (Spencer Gulf), West Waldegrave, Nicolas Baudin and Olive Islands (Chain of Bays), and Purdie, West, Fenelon, and Lounds Islands (Nuyts Archipelago). Ten sites previously recognised as breeding sites or haul-out sites with occasional pupping were not recorded to have pups in this recent survey (Bunda 22 (B9), Bunda 18 (B7), Bunda 12 (B6), Bunda 8 (B4), Bunda 4 (B2), Bunda 1, Pt Fowler (Camel Foot Bay), Gliddon Reef, Dorothee Island, Cave Point (Kangaroo Island)). The status of the breeding site at Black Point (Kangaroo Island) remains uncertain.

Shaughnessy *et al.* (2011) estimated the total size of the ASL population in SA to be 12,726, based on a pup numbers to total population size multiplier of 4.08, derived from Goldsworthy and Page (2007). However that multiplier was based on a generic otariid life-table developed by Goldsworthy *et al.* (2003), adjusted for a 1.5 year breeding interval and female longevity of 25 years (Goldsworthy and Page 2007). A more recent ASL life-table utilised survival estimates from the Seal Bay population (Goldsworthy *et al.* 2007b), which were adjusted to achieve a stable population structure (Goldsworthy *et al.* 2010b). It estimated a multiplier of pup numbers to total population size of 3.83 for a stable population (Goldsworthy *et al.* 2010b). Using this multiplier, the size of the SA ASL population based on 2004 to 2008 surveys was 11,946; and for the current (2014/15) surveys it is 9,652. These are likely to be an over-estimate given the appropriate multiplier depends on the rate of change of the population (Harwood and Prime 1978); in both instances assumed to be stable (Goldsworthy *et al.* 2010b). Given the reduction in pup abundance between the two surveys, a lower multiplier may be more appropriate.

5.2. Trends in abundance

This study is the first to provide quantitative estimates of the status and trends in abundance of ASL populations across their entire SA range. The two methods used to examine trends (change in pup abundance over two surveys and regional trends on aggregated abundances) produced similar results with respect to the status and trends in pup abundance across six ASL regions.

The regional analysis indicates that declines have occurred across the range of the species in SA. The extent of these declines over the last three generations is estimated to be between 22% and 91% (Table 8). Western populations off the Eyre Peninsula (Nuyts Archipelago and Chain of Bays) and in the Great Australian Bight (Bunda Cliffs) have shown the greatest rates of decline. A key example of a marked regional decline was noted for breeding sites in the western Nuyts Archipelago, where surveys undertaken in 2015 at Purdie, West, Fenelon and Lounds Islands counted 126 pups, which was less than half the number counted in surveys at these sites conducted between 2005 and 2008 (262 pups, Shaughnessy *et al.* 2011). Other major colonies in the Chain of Bays region (Olive Island, Nicolas Baudin and West Waldegrave) have also shown marked declines in pup abundance (~37%) since surveys undertaken in the early to late 2000s.

For 49 ASL sites where current or previous pup production has been reported, a subset of 29 sites provided at least two comparable surveys at least six years apart (mean interval 13.4 years, range 6.0 – 44.5 years). These sites accounted for 77% (1,939) of the estimated pup abundance in SA, and provided indicators of trends in abundance across six of the seven ASL regions across SA (Table 8). The key findings of these analyses are that pup numbers at most breeding sites (79%), and in all regions, have declined between the survey periods. The overall rate of decline is 2.9% per year or 4.4% per breeding cycle, but varies considerably between sites and regions (Table 8).

Following IUCN Redlist assessment methods, the estimated change in pup abundance over three generations (38 years) based on the observed change in pup abundance across SA and assuming a constant exponential rate of change was -78.2% (Table 8). Based on this analysis under IUCN Criterion A2b (A2, Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased OR may not be understood OR may not be reversible, b) an index of abundance appropriate to the taxon), the ASL SA population meets the 'Endangered' threatened species category (decline ≥50% and ≤80%) (IUCN Standards and Petitions Subcommittee 2014). This is consistent with the recent IUCN Redlist assessment for the species (Goldsworthy 2015), but is higher than the current 'Vulnerable' status under the Australian Government's EPBC Act (Department of Sustainability, Environment, Water, Population and Communities2013).

Results from key monitoring sites provide the best time series for a range of breeding sites, but the extent to which they represent regional changes in abundance varies considerably. The time series from Lilliput and Blefuscu Islands are relatively short, but suggest that pup abundance at these sites has been relatively stable over the last 7-8 years. This is in marked contrast to breeding sites ~35-45 km to the west of Lilliput and Blefuscu Islands in the western Nuyts Archipelago (Purdie, West, Fenelon and Lounds Islands), where pup abundance appears to have more than halved in the last 7-10 years. Similarly, pup abundance at Olive Island (~40 km to the south-east of Lilliput Island) has declined by ~35% over the last decade. Unlike Olive Island, Jones Island a further ~65 km to the south appears to have increased marginally.

Satellite telemetry studies on ASL have indicated marked variability in the foraging behaviour of adult females within and among breeding sites (Goldsworthy *et al.* 2009d, Lowther and Goldsworthy 2011, Lowther *et al.* 2011, 2012). These studies have shown that at some sites, females appear to specialise in shallow inshore foraging, while at other sites they specialise in deeper offshore foraging. At other sites, females employ a mixture of foraging strategies. Individual specialisation in particular foraging ecotypes, and the degree of spatial variability in the location of key foraging areas, along with the species extreme female philopatry (Campbell *et al.* 2008, Lowther *et al.* 2012), means that there is potentially high heterogeneity in exposure to natural and anthropogenic risks for individual breeding sites, even those in close geographic proximity. This may explain the marked heterogeneity in pup abundance and trends among breeding sites within regions, and indeed across the range of the species.

5.3. Evaluation of survey methodology

Survey methodology for ASL has progressively developed and improved over the last 20 years. A discussion of key issues around survey methodology follows.

<u>Timing of surveys</u>

Given the asynchronous breeding pattern of the species, a critical aspect of the success of any ASL survey, irrespective of the methodology used, is getting the timing of survey right with respect to the breeding season. For large colonies, we typically aim to commence surveys in the 3rd month of breeding and conduct an additional survey at the end of the breeding season. With small colonies it is possible to undertake suitable ground counts at the end of the breeding season, as the breeding season may only last 3-4 months. Investing in and maintaining this knowledge can save considerable costs by ensuring that the timing of future surveys is appropriate.

Some key points on survey timing include:

Interbreeding interval is not consistent within and between colonies – although available data suggests the breeding interval is generally between 17 and 18 months, it can vary between breeding seasons and among colonies. At Seal Bay, the range in interbreeding interval has been estimated to be 16 to 19.9 months (Shaughnessy *et al.* 2006), but it has not been estimated for any other breeding colony. The extent to which the variation in interbreeding interval relates to the duration of a breeding season is unclear.

Breeding season duration varies relative to the size of the colony – breeding seasons are longer, lasting 6-9 months, in large colonies (up to 12 months has been recorded at Seal Bay, Goldsworthy *et al.* 2014a), and are shorter in duration, lasting 3-4 months, in small colonies. In small colonies, surveys conducted at the end of the breeding season rarely record any moulted pups, indicating that breeding is over before the oldest pups have moulted, which most likely occurs around 5 months of age (Shaughnessy *et al.* 2005). At larger colonies, moulted pups are present while some pups are still being born. The accepted wisdom of a 4-5 month breeding season for the species (Gales *et al.* 1994) is probably only applicable to larger colonies (although as noted above duration there can last 9 months or more).

Breeding season duration can vary between seasons – survey data from Seal Bay and Dangerous Reef indicate marked variability in the duration of successive breeding seasons within sites (which can range between 6 and 12 months, see Goldsworthy *et al.* 2014a). This can impact on the timing of surveys as well as on the number and spread of surveys required to adequately survey some sites, especially larger colonies.

Colony access

Even if the knowledge of the timing of breeding at sites is excellent, this counts for little if access to islands is reliant on vessels, and therefore governed by sea conditions. In SA, most ASL colonies (with a few exceptions) cannot be reliably or safely accessed by sea. Helicopters, where they can be used, bring great efficiency and capacity to survey multiple sites quickly and efficiently, and enable regional monitoring of breeding phenology without necessarily having to land. Landings undertaken carefully cause little disruption to animals.

Proximity to other breeding sites

Where the timing of breeding of neighbouring breeding sites occurs earlier or is similar to a breeding site that is being surveyed, estimates of pup abundance can be confounded if there is the potential for movement of pups between sites. This is especially so for cases where small breeding sites neighbour large breeding sites. For example, tagged pups from Dangerous Reef have been sighted while undertaking surveys at English and Lewis Islands (Goldsworthy *et al.* 2008b, 2009c). Although the number of tagged individuals that move between colonies can be readily estimated based on tag resights, the number of untagged individuals that may be present is often unknown, although efforts to estimate the proportion of these based on the number of tagged individuals have been made (Goldsworthy *et al.* 2008b). Tagged pups from Nicolas Baudin Island have been sighted at Jones Island (Goldsworthy *et al.* 2014a), and inter-colony movement of pups is suspected to have contributed to higher pup counts for late season surveys at English and Albatross Islands during recent surveys. These colonies are only ~20 km from Dangerous Reef.

'Alternate states' in breeding

At a number of breeding sites where consecutive surveys have been undertaken, there can be marked inter-seasonal variability in pup counts. At some sites, the variability in the counts appears to alternate in relation to the seasons (e.g. summer breeding season followed by winter; spring breeding season followed by autumn). For example, at Seal Bay, counts of live pups are typically greater, and pup mortality rates lower, in winter breeding seasons compared to summer breeding seasons (Goldsworthy *et al.* 2014a). In contrast, live pup counts tend to be lower, and pup mortality rates higher, in winter breeding seasons compared to summer breeding seasons at Dangerous Reef (Goldsworthy *et al.* 2014a).

At Dangerous Reef, the impact of alternate states on survey methodology and pup abundance estimates has been examined. Goldsworthy *et al.* (2014a) compared three key pup production metrics assessed over four consecutive breeding seasons at Dangerous Reef (2006/07, 2008, 2009/10 and 2011). These were: 1) minimum live and dead pups (cumulative marked [tagged] pups plus cumulative dead [unmarked] pups plus maximum unmarked pups counted); 2) maximum Petersen estimates; and 3) cumulative pup production. Comparison of these metrics indicated an apparent alternation between two states. In winter breeding seasons (2008 and 2011), the pup estimates based on all three metrics were similar to each other, but in summer breeding seasons (2006/07 and 2009/10), estimates based on all three metrics were very different, with cumulative pup production estimates being greater than the Petersen estimates, which were greater than the estimates based on the minimum estimate of live and dead pups. The latter (summer) pattern makes intuitive sense, because Petersen estimates exceed those based on marked and counted pups, and cumulative pup production estimates (which include estimates pup production that occurs between successive Petersen estimates) provide a greater estimate than isolated Petersen estimates. Goldsworthy *et al.* (2011) questioned why in the summer breeding seasons these latter two metrics provided no better estimates than the minimum count of live and dead pups. They suggested the difference may relate to changes in pup behaviour and breeding chronology between summer and winter breeding seasons that affected the sightability of pups and impacted on the assumptions of the Petersen estimate (including temporary migration, survival and sightability). Analyses of the data from the four seasons to estimate survival and capture probabilities using the Cormack–Jolly–Seber (CJS) model, found no significant differences in re-sight probability between breeding seasons (they were essentially equal to 1 in all breeding seasons). Although survival (across the period of surveys within breeding seasons) varied markedly between breeding seasons, there was no apparent relationship between survival in the summer or winter seasons (Goldsworthy *et al.* 2014a). What drives these alternate states and how they impact on survey methodology and results requires further research.

Use of colony appropriate survey methods

Survey choice is contingent on many factors; most important are funding and time available to commit to single or multiple surveys. Although all sites are amenable to direct counting methods, these can be unreliable and significantly underestimate pup numbers. The suitability and reliability of direct counts depends on the site terrain and sightability of pups, which are affected by vegetation and the amount of other cover present. In large breeding sites, direct counting tends to underestimate pup abundance. Furthermore, direct counting can be difficult in large and high density colonies, especially where pups move away from the counter. Reliable and consistent counts can best be made at small, isolated and exposed sites where all pups can be readily found and there is limited opportunity for pups from neighbouring colonies to be present. Furthermore, smaller colonies have shorter breeding seasons, so pups will still be in their brown lanugo by the end of the breeding season, and therefore show a lower propensity to disperse.

As colony size and the length of the breeding season increases, so does the likelihood that pups born early in the breeding season will have moulted before the breeding season ends, be more aquatic and absent from the colony on foraging trips or disperse to neighbouring sites. These factors all contribute to the availability biases in surveys. For such sites, multiple surveys provide better estimates of pup abundance; appropriate survey methods include capture, mark and resight (CMR), mark-recapture (M-R) methods following the Petersen estimate, and cumulative pup production (CPP) methods. The CPP method not only estimates the number of pups present at each survey period, but also the pup production between surveys. These methods have been extensively detailed previously (e.g. Goldsworthy et al. 2014) and are used in this report (with the exception of CMR).

For the larger key monitoring sites, we typically utilise three survey methods; ground counts, M-R and CPP. These are undertaken over a minimum of two, and up to five surveys, depending on the size of the colony and length of the breeding season. There is clearly some trade-off between survey effort and survey precision/accuracy. At this stage we have not been able to readily assess the balance between the two. However, given the length of pupping seasons, we consider that 2-3 surveys are the minimum if the full extent of breeding is to be monitored. We have focused efforts to optimise survey conditions and reduce sources of variability, with an overall aim to reduce survey effort without compromising accuracy.

Estimating regional trends of aggregated pup abundance

The newly developed agTrend analysis tool utilised in this study enabled for the first time the estimation of regional trends in pup abundance across the SA range of the species. The benefits of this method were that most of the pup abundance data available for all the breeding sites could be integrated into the analysis, rather than just those from the key monitoring sites. Furthermore, methodological differences between sites are not important, the critical factor being that survey methods within sites were consistent. For some sites, correction factors were used to maximise the data available and so extend the time series used in analyses. The agTrend method also highlighted the benefits of obtaining data from all sites within regions within the same survey period, because doing so significantly reduced the variance of abundance estimates. Although the modelling approach is designed to deal with patchy data, the confidence in estimates of trends in abundance can be improved if (at least in some seasons) the time series data are available for all sites, especially those that contribute proportionally more pups because missing these would magnify the credible intervals of the posterior predictive counts. The use of such analyses may change the optimal survey design for the species. Rather than focusing effort on one or two sites across a number of regions within a season, a better survey strategy may be to ensure that all sites within a region are surveyed within one season, perhaps selecting one or two regions to survey each season.

<u>Evaluation of appropriateness of key monitoring sites</u>

The key monitoring sites provide the best contemporary time series on pup abundance for ASL populations across SA. However, their selection for the survey in 2007 was constrained at the time to islands accessible by vessel, so selection was principally governed by sites where access was achievable, reliable and safe (Goldsworthy *et al.* 2007c). Had helicopter support out of Ceduna been available then, the selection of colonies as key monitoring sites would have differed from those chosen, especially for western Eyre Peninsula.

The eight key monitoring sites occur in four of the seven ASL regions of SA and include: Seal Bay and Seal Slide (Kangaroo Island); Dangerous Reef and English Island (Spencer Gulf); Olive and Jones Islands (Chain of Bays); and Lilliput and Blefuscu Islands (Nuyts Archipelago). Seal Bay and Seal Slide are accessible by vehicle, and at Seal Bay there is a daily presence at the site to support guided tours. Seal Bay is a critical monitoring site as much of our understanding of the breeding biology and reproductive ecology of the species is based on data from this location, including an important ongoing population demography program (Goldsworthy *et al.* 2014a). Both sites have a proven record of providing reliable and cost-effective data on their status and trends in abundance.

Dangerous Reef and English Island in Spencer Gulf have usually been accessed by vessel. Dangerous Reef represents a large and challenging site to survey because of the length of the breeding season, the marked variability in pup numbers and apparent alternate states in breeding which presents issues in analysing and interpreting the data. Alternately, it is regionally a very significant colony, as well as being the largest colony for the species. Most surveys at English Island have been compromised by the presence of an unknown number of dispersed pups from Dangerous Reef. Given that the timing of breeding at English Island falls within the period of breeding at Dangerous Reef, the issue of dispersed pups becomes greater as the breeding season progresses. For these reasons, English Island should not continue as a key regional monitoring site.

Olive Island and Jones Island in the Chain of Bays region are reliably and safely accessible by vessel from Streaky Bay and Baird Bay, respectively. Olive Island has provided reliable mark-recapture and cumulative pup production survey estimates. A key attribute is its isolation from other breeding sites (limited dispersal of pups) and the fact that breeding usually commences at Olive Island around four months earlier than at the nearest breeding sites at Lilliput and Blefuscu Islands. Jones Island is well monitored with regular swim with the sea lions ecotourism occurring at the site, with the operator able to provide information on the timing and stage of breeding which helps ensure that surveys occur at the appropriate time. Ensuring surveys do not occur too late in the breeding season is important at this site, as pups from Nicolas Baudin Island can otherwise augment counts (Goldsworthy *et al.* 2014a).

Lilliput and Blefuscu Islands in the Nuyts Archipelago are accessible by vessel, but in recent years have been accessed by helicopter from Ceduna. Blefuscu Island, Breakwater Island and Gliddon Reef were initially selected as key monitoring sites, but the latter locations could not always be reliably accessed via vessel. In addition, some movement of tagged pups between Lilliput and Blefuscu Islands has been noted in earlier surveys. As a result of those factors, both Lilliput and Blefuscu Islands have become key monitoring sites for the region. Both have proven amenable to M-R and CPP survey methods. Count data from these sites show similar trends to those from M-R and CPP methods; consequently there is the potential to use correction factors to estimate pup abundances from count data. Results from the 2015 survey indicate that the trends at these two sites are different from those at sites in the western part of the Nuyts Archipelago, and as such are not representative of regional changes in pup abundance.

5.4. Recommendations on future monitoring strategies for the species

This study identified that the ASL population in SA is much smaller than previously estimated, and in decline. A future monitoring strategy is essential to meet the objectives of the Australian sea lion Recovery Plan (Department of Sustainability, Environment, Water, Population and Communities 2013) and ensure that management measures to mitigate threatening processes, particularly bycatch mortality in demersal gillnet fisheries, are adequate to ensure recovery of the species.

A key need for a future monitoring strategy is to find a balance between fine-scale monitoring of some sites, with the need for broader, regionally focused monitoring. The former enables an assessment of changes in pup abundance between breeding seasons and provides context to changes at other sites that are surveyed infrequently. The latter assesses regional trends in pup abundance and provides for a more comprehensive assessment of the conservation status of the species across its range. Justification for this change in survey strategy has come about because of improved information on pup abundance at ASL breeding sites across SA over the last decade, coupled with improved analytical methods to estimate regional trends in pup abundance. These analytical methods work best with regionally comprehensive surveys which, with the use of helicopters, are now more feasible and affordable.

To achieve regular, regionally comprehensive surveys will require a reduction in the number of key monitoring sites. We suggest halving the number of key monitoring sites from eight to four, retaining Seal Bay and Seal Slide on Kangaroo Island, and Olive and Jones Islands in Chain of Bays. Resources saved from reducing fine scale monitoring effort at Lilliput and Blefuscu Islands would be better directed at obtaining more regular regional pup abundance estimates, at colonies in Nuyts Reef, Nuyts Archipelago and Chain of Bays regions. Similarly, resources directed at monitoring Dangerous Reef and English Island could be directed to facilitating regional surveys of Spencer Gulf and SW Eyre Peninsula regions. Regions could be surveyed alternately (i.e. one or two regions per year, each region surveyed once every three years), but some effort would need be maintained to ensure that information on the timing of breeding at each colony is not lost, as this will be critical to ensuring that future survey effort is not wasted (i.e. surveys undertaken at the wrong time). Further investment in remote cameras to monitor the timing of breeding seasons is warranted.

6. CONCLUSIONS

This study has provided the most comprehensive survey of the Australian sea lion (ASL) population in South Australia, and is the first time most of the colonies in the State have been surveyed within an 18 month period. This study identified that the ASL population in SA is smaller than previously estimated (pup abundance ~2,500 and total abundance <10,000), and in decline. Analyses suggest that across the species SA range, pup abundance has declined by almost one quarter over the last decade or less. Ongoing monitoring is essential to meet the Australian Sea Lion Recovery Plan objectives, and in future could shift to a more regionally focused survey design that aims to improve assessment of regional trends in pup abundance across the range of the species.

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Appendix 1. Date and locations of Australian sea lion (ASL) surveys undertaken between January 2014 and May 2015.The method used at each survey site, and the counts of pups in several categories are indicated. Black MG indicates black pups with mate-guarded mothers.

Date	Site	Survey method	Black MG	Black	Brown	Moulted	Dead	Total	Notes
18-Jun-14	Bunda 22 (B9)	Clifftop	0	0	0	0	0	0	No signs of breeding
04-Oct-14	Bunda 22 (B9)	Clifftop	0	0	0	8	0	8	Post-season, pups may have originated elsewhere
05-Oct-14	Bunda 22 (B9)	Clifftop	0	0	0	0	0	0	No signs of breeding
18-Jun-14	Bunda 21 (H14)	Clifftop	0	0	0	0	0	0	No signs of breeding
04-Oct-14	Bunda 21 (H14)	Clifftop	0	0	0	0	0	0	No signs of breeding
18-Jun-14	Bunda 20 (H13)	Clifftop	0	0	0	0	0	0	No signs of breeding
04-Oct-14	Bunda 20 (H13)	Clifftop	0	0	0	1	0	1	Post-season
18-Jun-14	Bunda 19 (B8)	Clifftop	0	0	7	0	0	7	Post-season
04-Oct-14	Bunda 19 (B8)	Clifftop	0	0	0	0	1	1	Post-season
18-Jun-14	Bunda 18 (B7)	Clifftop	0	0	0	0	0	0	No signs of breeding
04-Oct-14	Bunda 18 (B7)	Clifftop	0	0	0	1	0	1	Post-season, pup may have originated elsewhere
18-Jun-14	Bunda 17 (H12)	Clifftop	0	0	0	0	0	0	No signs of breeding
04-Oct-14	Bunda 17 (H12)	Clifftop	0	0	0	1	1	2	Post-season, pup may have originated elsewhere
18-Jun-14	Bunda 16 (H10)	Clifftop	0	0	0	0	0	0	No signs of breeding
04-Oct-14	Bunda 16 (H10)	Clifftop	0	0	0	0	0	0	No signs of breeding
18-Jun-14	Bunda 15 (HX3)	Clifftop	0	0	0	0	0	0	No signs of breeding
18-Jun-14	Bunda 14 (H8)	Clifftop	0	0	0	0	0	0	No signs of breeding
04-Oct-14	Bunda 14 (H8)	Clifftop	0	0	0	0	0	0	No signs of breeding
18-Jun-14	Bunda 13 (H7)	Clifftop	0	0	0	0	0	0	No signs of breeding
04-Oct-14	Bunda 13 (H7)	Clifftop	0	0	0	0	0	0	No signs of breeding
18-Jun-14	Bunda 12 (B6)	Clifftop	0	0	0	0	0	0	No signs of breeding
04-Oct-14	Bunda 12 (B6)	Clifftop	0	0	0	0	0	0	No signs of breeding
18-Jun-14	Bunda 11 (H6/HX)	Clifftop	0	0	0	0	0	0	No signs of breeding
04-Oct-14	Bunda 11 (H6/HX)	Clifftop	0	0	0	0	0	0	No signs of breeding
19-Jun-14	Bunda 10 (H5)	Clifftop	0	0	0	0	0	0	No signs of breeding

Date	Site	Survey method	Black MG	Black	Brown	Moulted	Dead	Total	Notes
04-Oct-14	Bunda 10 (H5)	Clifftop	0	0	0	0	0	0	No signs of breeding
19-Jun-14	Bunda 09 (B5)	Clifftop	2	2	0	0	0	4	Mid-breeding season
04-Oct-14	Bunda 09 (B5)	Clifftop	0	0	3	3	0	6	Post breeding season
19-Jun-14	Bunda 08 (B4)	Clifftop	0	0	0	0	0	0	No signs of breeding
19-Jun-14	Bunda 08 (B4) eastern end	Clifftop	0	0	0	0	0	0	No signs of breeding
05-Oct-14	Bunda 08 (B4)	Clifftop	0	0	0	0	0	0	No signs of breeding
19-Jun-14	Bunda 07 (H4)	Clifftop	0	0	0	0	0	0	No signs of breeding
05-Oct-14	Bunda 07 (H4)	Clifftop	0	0	0	0	0	0	No signs of breeding
19-Jun-14	Bunda 06 (B3)	Clifftop	3	4	2	0	0	9	Mid-season
05-Oct-14	Bunda 06 (B3)	Clifftop	0	0	3	0	0	3	End of breeding season
19-Jun-14	Bunda 04 (B2)	Clifftop	0	0	0	0	0	0	No signs of breeding
05-Oct-14	Bunda 04 (B2)	Clifftop	0	0	0	0	0	0	No signs of breeding
17-Jun-14	Bunda 03 (H2)	Clifftop	0	0	0	0	0	0	No signs of breeding
05-Oct-14	Bunda 03 (H2)	Clifftop	0	0	0	0	0	0	No signs of breeding
17-Jun-14	Bunda 02 (B1.1)	Clifftop	0	3	0	0	0	3	Early breeding season
05-Oct-14	Bunda 02 (B1.1)	Clifftop	0	0	0	0	0	0	No signs of breeding
17-Jun-14	Bunda 01 (H1)	Clifftop	0	0	0	0	0	0	No signs of breeding
05-Oct-14	Bunda 01 (H1)	Clifftop	0	0	0	0	0	0	No signs of breeding
19-Mar-14	Nuyts Reef (Southern)	Ground	0	0	0	0	0	0	No sign of breeding
19-Mar-14	Nuyts Reef (Eastern)	Aerial	0	0	0	0	0	0	No sign of breeding
08-Dec-14	Nuyts Reef (Southern)	Ground	0	0	0	0	0	0	Breeding not started
08-Dec-14	Nuyts Reef (Eastern)	Aerial	0	0	0	0	0	0	Breeding not started
27-Aug-14	Nuyts Reef (Southern)	Ground	0	0	0	0	0	0	No sign of breeding
27-Aug-14	Nuyts Reef (Eastern)	Ground	0	0	0	0	0	0	No sign of breeding
15-May-15	Nuyts Reef (Southern)	Ground	2	4	29	0	1	36	Excellent ground count at end of breeding season
15-May-15	Nuyts Reef (Eastern - southern)	Ground	4	14	47	1	0	66	Excellent ground count at end of breeding season
15-May-15	Nuyts Reef (Eastern - middle)	Aerial	0	0	3	0	0	3	Excellent aerial survey at end of breeding season
15-May-15	Camel Foot Bay	Aerial	0	0	0	0	0	0	No sign of breeding

Date	Site	Survey method	Black MG	Black	Brown	Moulted	Dead	Total	Notes
15-May-15	Sinclair Island	Aerial	0	0	0	0	0	0	No sign of breeding
15-May-15	Pt Bell Reef	Aerial	0	0	0	0	0	0	No sign of breeding
16-Jul-14	Purdie Island	Ground	0	0	0	0	0	0	No sign of breeding
07-Apr-15	Purdie Island	Ground	1	9	53	0	4	67	Excellent ground count at end of breeding season
08-Dec-14	West island	Ground	0	0	0	0	0	0	No sign of breeding
08-Apr-15	West Island	Ground	1	5	12	0	0	18	Excellent ground count at end of breeding season
15-May-15	West Island	Aerial	0	0	18	2	0	20	Excellent aerial survey/breeding season over
18-Mar-14	Fenelon Island	Ground/Aerial	0	0	0	24	0	24	~6m past end of breeding season
08-Apr-15	Fenelon Island	Aerial	4	2	8	0	0	14	Excellent ground count/breeding almost over
15-May-15	Fenelon Island	Ground	2	1	16	0	0	19	Excellent aerial survey/breeding season over
08-Apr-15	Masillon Island	Aerial	0	0	0	0	0	0	No sign of breeding
15-May-15	Masillon Island	Aerial	0	0	0	0	0	0	No sign of breeding
16-Jul-14	Lounds Island	Ground	0	0	0	0	0	0	No sign of breeding
07-Apr-15	Lounds Island	Ground	2	2	16	0	0	20	Excellent ground count at end of breeding season
08-Dec-14	Breakwater Island	Aerial	1	0	0	0	0	1	Excellent aerial survey/breeding just begun
18-Feb-15	Breakwater Island	Ground	3	1	21	0	2	27	Excellent ground count/end of breeding season
08-Dec-14	Gliddon Reef	Aerial	0	0	0	0	0	0	Excellent aerial survey/no sign of breeding
18-Feb-15	Gliddon Reef	Aerial	0	0	0	0	0	0	Excellent aerial survey/no sign of breeding
16-Jul-14	Blefuscu Island	Ground	0	0	0	0	0	0	No sign of breeding
28-Sep-14	Blefuscu Island	Aerial	0	0	0	0	0	0	No sign of breeding
09-Dec-14	Blefuscu Island	Aerial	3	1	0	0	0	4	Excellent aerial survey - breeding season just begun
17-Feb-15	Blefuscu Island	Ground	4	3	31	0	6	44	Excellent ground survey - mid-season
07-Apr-15	Blefuscu Island	Ground	1	1	37	5	1	45	Excellent ground survey at end of breeding season
16-Jul-14	Lilliput Island	Ground	0	0	0	0	0	0	No sign of breeding
28-Sep-14	Lilliput Island	Aerial	0	0	0	0	0	0	No sign of breeding
09-Dec-14	Lilliput Island	Aerial	0	4	3	0	0	7	Excellent aerial survey/breeding season just begun
17-Feb-15	Lilliput Island	Ground	4	8	40	0	2	54	Excellent ground survey/mid-season
07-Apr-15	Lilliput Island	Ground	1	1	37	5	1	45	Excellent ground survey/end of breeding season

Date	Site	Survey method	Black MG	Black	Brown	Moulted	Dead	Total	Notes
11-Feb-14	Olive Island	Ground	0	0	0	0	0	0	No sign of breeding
16-Jul-14	Olive Island	Ground	1	0	0	0	0	1	Excellent ground survey/breeding just begun
28-Sep-14	Olive Island	Ground	16	9	20	0	4	49	Excellent ground survey/breeding well underway
06-Nov-14	Olive Island	Ground	7	9	55	0	5	76	Excellent ground survey/breeding well underway
10-Dec-14	Olive Island	Ground	0	5	85	1	2	93	Excellent ground survey/end of breeding season
11-Feb-14	Nicholas Baudin Island	Ground	0	0	0	0	0	0	No signs of breeding
17-Jul-14	Nicholas Baudin Island	Aerial	0	0	0	0	0	0	No signs of breeding
28-Sep-14	Nicolas Baudin Island	Aerial	6	5	0	0	0	11	Excellent aerial survey/breeding just begun
09-Dec-14	Nicholas Baudin Island	Ground	0	1	62	0	0	63	Excellent ground survey/end of breeding season
11-Feb-14	Ward Island	Ground	0	0	0	0	0	0	No signs of breeding
10-Apr-15	Ward Island	Ground	0	0	36	7	1	44	Excellent ground survey/end of breeding season
12-Feb-14	Pearson Island	Ground	0	0	0	0	0	0	No signs of breeding
09-Dec-14	Pearson Island	Ground	8	1	0	0	0	9	Excellent ground survey/mid-season
10-Apr-15	Pearson Island	Ground	0	0	27	1	2	30	Excellent ground survey/end of breeding season
17-Jul-14	Point Labatt	Aerial	0	0	0	0	0	0	No signs of breeding
05-Nov-14	Point Labatt	Clifftop	0	0	0	0	0	0	No signs of breeding
05-Nov-14	Jones Island	Ground	0	5	12	0	2	19	Excellent ground survey/end of breeding season
12-Feb-14	West Waldegrave Island	Ground	0	0	0	0	0	0	No signs of breeding
17-Jul-14	West Waldegrave Island	Ground	0	0	0	0	0	0	No signs of breeding
28-Sep-14	West Waldegrave Island	Aerial	0	0	0	0	0	0	No signs of breeding
09-Dec-14	West Waldegrave Island	Aerial	6	0	4	0	0	10	Aerial survey/breeding season about 2 m in
09-Apr-15	West Waldegrave Island	Ground	0	0	62	26	1	89	Excellent ground survey/end of breeding season
12-Feb-14	Cap Island	Ground	0	0	0	0	0	0	No signs of breeding
18-Jul-14	Cap Island	Aerial	0	1	2	0	0	3	Average aerial survey/big sea not possible to land
28-Sep-14	Cap Island	Ground	0	0	31	0	0	31	Excellent ground survey/end of breeding season
12-Feb-14	Rocky (North) Island	Ground	0	0	0	0	0	0	No signs of breeding
18-Jul-14	Rocky (North) Island	Ground	2	1	16	0	1	20	Excellent ground survey/mid-season
28-Sep-14	Rocky (North) Island	Ground	0	0	27	8	0	35	Excellent ground survey/end of breeding season

Date	Site	Survey method	Black MG	Black	Brown	Moulted	Dead	Total	Notes
13-Mar-14	Rocky (South) Island	Ground	0	0	0	0	0	0	No signs of breeding
18-Jul-14	Rocky (South) Island	Ground	1	2	0	0	4	7	Excellent ground count in early breeding season
29-Sep-14	Rocky (South) Island	Ground	2	1	4	0	0	7	Excellent ground survey/end of breeding season
13-Mar-14	Greenly Island	Ground	0	0	0	0	0	0	No signs of breeding
13-Mar-14	Four Hummock Islands	Ground/Aerial	0	0	0	0	0	0	No signs of breeding
18-Jul-14	Four Hummock Islands	Ground/Aerial	1	1	0	0	0	2	Ground survey Middle Is, areial survey of South/North Is
29-Sep-14	Four Hummock Islands	Ground/Aerial	2	0	3	0	0	5	Ground survey Middle Is, areial survey of South/North Is
10-Dec-14	Four Hummock Islands	Ground/Aerial	0	1	2	0	0	3	Ground survey Middle Is, areial survey of South/North Is
13-Mar-14	Little Hummock Island	Ground	0	0	0	0	0	0	No signs of breeding
18-Jul-14	Little Hummock Island	Ground	2	0	0	0	0	2	Excellent ground survey/mid-season
29-Sep-14	Little Hummock Island	Ground	0	1	2	0	1	4	Excellent ground survey/end of breeding season
13-Mar-14	Price Island	Aerial	0	0	0	0	0	0	No signs of breeding
29-Sep-14	Price Island	Ground	4	1	1	0	1	7	Excellent ground survey/breeding just begun
10-Dec-14	Price Island	Ground/Aerial	2	3	23	0	3	31	Excellent ground survey/end of breeding season
13-Mar-14	Golden Island	Aerial	0	0	0	0	0	0	No signs of breeding
3-Feb-14	Liguanea Island	Ground	0	0	4	13	0	17	Ground survey/~2m post end of breeding season
18-Jul-14	Liguanea Island	Aerial	0	0	0	0	0	0	No signs of breeding
10-Dec-14	Liguanea Island	Ground	0	0	0	0	0	0	No signs of breeding
14-May-15	Liguanea Island	Ground/Aerial	0	1	22	0	2	25	Excellent ground-aerial survey/end of breeding season
13-Feb-14	Curta Rocks	Aerial	0	0	0	0	0	0	No signs of breeding
30-Sep-14	Curta Rocks	Ground/Aerial	1	0	6	0	0	7	Excellent ground-aerial survey/end of breeding season/new colony
14-Mar-14	Williams Island	Ground/Aerial	0	0	0	0	0	0	No signs of breeding activity
19-Jul-14	Williams Island	Ground/Aerial	0	1	3	0	0	4	Excellent ground survey/mid-season/new colony
30-Sep-14	Williams Island	Ground/Aerial	0	1	3	0	0	4	Excellent ground survey/end of breeding season
20-Jul-14	Lewis Island	Ground	12	16	6	0	1	35	Excellent ground count/early breeding
30-Sep-14	Lewis Island	Ground	7	12	61	0	2	82	Excellent ground survey/near end of breeding season
03-Feb-14	North Neptune (Main) Is	Ground	0	0	1	0	0	1	Ground survey
06-Feb-14	East Island	Ground	0	0	0	1	0	1	Ground survey-post breeding?

Date	Site	Survey method	Black MG	Black	Brown	Moulted	Dead	Total	Notes
19-Jul-14	East Island	Ground	0	0	5	4	0	9	Ground survey/end of breeding season
14-Feb-14	South Neptune (Main) Is	Ground	0	0	2	0	0	2	Ground survey/end of breeding season
19-Jul-14	South Neptune (Main) Is	Ground	1	0	1	5	0	7	Ground survey/~2m post breeding (exception 1 black pup)
13-Mar-14	Smith Island	Aerial	0	0	0	0	0	0	No signs of breeding activity
20-Jul-14	Little Island	Aerial	0	0	0	2	0	2	No signs of breeding activity/moulted pups probably moved from Lewis
20-Jul-14	Grindle Island	Aerial	0	0	0	0	0	0	No signs of breeding activity
14-Mar-14	Dangerous Reef	Aerial	3	0	0	0	0	3	Aerial survey/breeding just begun
14-May-14	Dangerous Reef	Ground	17	42	127	0	31	217	Excellent ground survey/early-season
02-Jul-14	Dangerous Reef	Ground	10	17	197	1	32	257	Excellent ground survey/mid-season
02-Jul-14	Dangerous Reef	Ground	8	5	190	1	76	280	Excellent ground survey/late-season
14-Oct-14	Dangerous reef	Ground	1		44	15	66	126	Excellent ground survey/end of season
20-Jul-14	Donington Reef	Ground	0	0	0	0	0	0	No signs of breeding activity
14-Mar-14	Rabbit Island	Aerial	0	0	0	0	0	0	No signs of breeding activity
14-Mar-14	English Island	Aerial	0	0	0	0	0	0	No signs of breeding activity
04-Jul-14	English Island	Ground	0	0	57	1	6	64	Ground survey/post-season -some pups from Dangerous Reef
14-Mar-14	Sibsey Island	Aerial	0	0	0	0	0	0	No signs of breeding activity
20-Jul-14	Sibsey Island	Aerial	0	0	2	2	0	4	No signs of breeding activity/pups probably from Dangerous Reef
14-Mar-14	Spilsby Island	Aerial	0	0	0	0	0	0	No signs of breeding activity
14-Mar-14	Albatross Island	Ground	0	7	26	0	2	35	Excellent ground survey/mid-season
20-Jul-14	Albatross Island	Ground	0	0	42	51	2	95	Excellent ground survey/post breeding, some pups probably from Dangerous Reef
14-Mar-14	Southwest Rocks	Aerial	0	0	0	0	0	0	No signs of breeding activity
14-Mar-14	North Islet	Ground/Aerial	0	0	0	0	0	0	No signs of breeding activity on ground survey, some on aerial
20-Jul-14	North Islet	Aerial	0	0	1	31	0	32	Aerial survey/post breeding season
14-Mar-14	Wedge Island	Aerial	0	0	0	0	0	0	No signs of breeding activity
14-Mar-14	Peaked Rocks (East)	Aerial	0	0	17	0	0	17	Aerial survey-could not land/post breeding season
14-Mar-14	Peaked Rocks (West)	Aerial	0	0	0	0	0	0	No signs of breeding activity
14-Mar-14	Althorpe Island	Aerial	0	0	0	0	0	0	No signs of breeding activity
14-Mar-14	Haystack Island	Aerial	0	0	0	0	0	0	No signs of breeding activity

Date	Site	Survey method	Black MG	Black	Brown	Moulted	Dead	Total	Notes
14-Mar-14	Seal Island	Aerial	0	0	0	0	0	0	No signs of breeding activity
29-Jan-14	North Casuarina Island	Ground	0	0	10	1	0	11	Excellent ground survey/end of season
23-Jan-13	Cape Bouguer	Ground	0	5	1	0	0	6	Excellent ground survey/mid-season
20-Mar-13	Cape Bouguer	Ground	0	3	3	2	1	9	Excellent ground survey/end of season
23-Jan-14	Cave Point	Ground	0	0	0	0	0	0	No signs of breeding activity
17-Dec-14	Seal Slide	Ground	3	1	0	0	0	4	Excellent ground survey/mid- season
21-Jan-15	Seal Slide	Ground	0	1	6	0	1	8	Excellent ground survey/late- season
12-May-15	Seal Slide	Ground	0	0	12	1	1	14	Ground survey/post breeding season
25-Jun-14	North Page Island	Ground	0	0	173	0	5	178	Ground survey/1-2 m post breeding season
25-Jun-14	South Page Island	Ground	0	3	111	15	6	135	Ground survey/1-2 m post breeding season

Appendix 2. Estimates of trends in ASL abundance across SA, based on change in pup abundance over two comparable surveys. The mean percentage rate of change (*λ*) is given per year and per breeding season (1.5 years). Estimated changes in pup abundance across 3-generations (38 years), are also provided assuming a constant exponential rate following IUCN guideline to assess species under Criterion A.

Breeding site	Region	Year 1	Year 2	Year 2-1	Pup No. Yr 1	Pup No. Yr 2	r	λ/yr	λ/season	Pup numbers 3 gen ago	Pup numbers 2015	Source Year 1	Source Year 2
Bunda 19 (B8)	Bunda Cliffs	1995	2014	19.0	16	7	-0.044	-4.258	-6.386	35	7	Dennis and Shaughnessy (1996)	This survey
Bunda 09 (B5)	Bunda Cliffs	1995	2014	19.0	18	7	-0.050	-4.849	-7.274	44	7	Dennis and Shaughnessy (1996)	This survey
Bunda 06 (B3)	Bunda Cliffs	1995	2014	19.0	13	9	-0.019	-1.917	-2.875	18	9	Dennis and Shaughnessy (1996)	This survey
Purdie Is.	Nuyts Archipelago	2005	2015	10.0	132	67	-0.068	-6.556	-9.834	870	67	Shaughnessy et al. 2009	This survey
West Is.	Nuyts Archipelago	2005	2015	10.0	56	20	-0.103	-9.784	-14.676	980	20	Shaughnessy et al. 2009	This survey
Fenelon Is.	Nuyts Archipelago	2008	2015	7.0	40	19	-0.106	-10.089	-15.133	1,058	19	Goldsworthy et al. 2009	This survey
Lounds Is.	Nuyts Archipelago	2008	2015	7.0	34	20	-0.076	-7.300	-10.950	351	20	Goldsworthy et al. 2010	This survey
Breakwater Is./Gliddon	Nuyts Archipelago	2005	2015	10.0	24	27	0.012	1.185	1.777	17	27	Shaughnessy et al. 2009	This survey
Blefuscu	Nuyts Archipelago	2007.5	2015	7.5	98	97	-0.001	-0.137	-0.205	102	97	Goldsworthy et al. 2009	This survey
Lilliput	Nuyts Archipelago	2007.5	2015	7.5	70	72	0.004	0.376	0.564	62	72	Goldsworthy et al. 2009	This survey
Olive Is.	Chain of Bays	2006	2014.5	8.5	192	133	-0.043	-4.227	-6.341	666	130	Goldsworthy et al. 2007	This survey
Nicolas Baudin Is.	Chain of Bays	2006	2014.5	8.5	98	63	-0.052	-5.065	-7.598	438	61	Shaughnessy 2008	This survey
Ward Is.	Chain of Bays	2006	2015	9.0	45	44	-0.002	-0.249	-0.374	48	44	D. Armstrong, in Robinson et al. (2008)	This survey
Pearson Is.	Chain of Bays	2005	2015	10.0	35	30	-0.015	-1.530	-2.295	54	30	K. Peters & B. Page, in Goldsworthy et al. (2009	This survey
Jones Is.	Chain of Bays	2004.5	2014.5	10.0	15	19	0.024	2.392	3.588	8	19	Goldsworthy et al. 2008	This survey
West Waldegrave Is.	Chain of Bays	2003	2015	12.0	157	89	-0.047	-4.620	-6.930	532	89	Shaughnessy et al. 2005	This survey
Four HummocksIsland	SW-Eyre	1995.5	2014	18.5	11	6	-0.033	-3.223	-4.835	20	6	Shaughnessy et al. 2005	This survey
Price Is.	SW-Eyre	1995.5	2014.5	19.0	25	32	0.013	1.308	1.962	20	32	Shaughnessy et al. 2005	This survey
Liguanea Is.	Spencer Gulf	2004.5	2015	10.5	43	25	-0.052	-5.034	-7.551	176	25	Shaughnessy et al. 2009	This survey
Lewis Island	Spencer Gulf	2007	2014	7.0	149	82	-0.085	-8.178	-12.267	1,894	75	Goldsworthy et al. 2008	This survey
North Neptune, East	Spencer Gulf	2005	2014	9.0	14	9	-0.049	-4.791	-7.186	55	9	Shaughnessy et al. 2009	This survey
South Neptune, Main	Spencer Gulf	1969.5	2013.5	44.0	10	7	-0.008	-0.807	-1.211	9	7	Stirling *in lit* in Shaughnessy et al. 2011	This survey
English Is.	Spencer Gulf	2005	2011	6.0	27	34	0.038	3.917	5.875	9	40	Shaughnessy et al. 2009	Goldsworthy et al. 2012
Dangerous Reef (Max M	Spencer Gulf	1999	2014.5	15.5	425	408	-0.003	-0.263	-0.395	450	407	Goldsworthy et al. 2007	This survey
North Is.	Spencer Gulf	2005	2011	6.0	28	21	-0.048	-4.682	-7.022	106	17	Shaughnessy et al. 2009	Goldsworthy et al. 2012
Seal Bay (Kangaroo Is.)	Kangaroo Island	1985.5	2014.5	29.0	154	102	-0.014	-1.411	-2.116	173	101	Shaughnessy et al. 2006	This survey
Seal Slide (Kangaroo Is.)	Kangaroo Island	2002.5	2014.5	12.0	9	8	-0.010	-0.977	-1.465	12	8	Dennis 2005	This survey
The Pages (x2)	Kangaroo Island	1989.5	2009.5	20.0	522	478	-0.004	-0.439	-0.659	551	467	Shaughnessy et al. 2013	Shaughnessy et al. 2013
										8,759	1,912		

Appendix 3. Time series data on ASL used to estimate regional trends in aggregated pup abundance. Site and region are indicated, as is the season and year of survey, along with survey method (Gales 1990, Gales *et al.* 1994, Dennis and Shaughnessy 1996, Shaughnessy *et al.* 1997, Shaughnessy and Dennis 1999, Dennis 2001, Shaughnessy and Dennis 2001, Shaughnessy and Dennis 2003, Dennis 2005, Shaughnessy 2005b, Shaughnessy 2005a, Shaughnessy *et al.* 2005, Shaughnessy *et al.* 2006, Goldsworthy and Page 2007, Goldsworthy *et al.* 2007a, Goldsworthy *et al.* 2007c, Goldsworthy *et al.* 2008a, Goldsworthy *et al.* 2008b, Shaughnessy 2008, Goldsworthy *et al.* 2009a, Goldsworthy *et al.* 2009b, Goldsworthy *et al.* 2009c, Goldsworthy *et al.* 2009d, Shaughnessy *et al.* 2009, Goldsworthy *et al.* 2010a, Goldsworthy *et al.* 2010b, Shaughnessy 2010, Goldsworthy *et al.* 2011, Shaughnessy *et al.* 2011, Goldsworthy *et al.* 2012, Goldsworthy *et al.* 2013, Goldsworthy *et al.* 2014a, Goldsworthy *et al.* 2014b).

Site	Region	Season	Year	Count	Survey method	Notes
Bunda 00 (B1)	Bunda Cliffs	1	1995	13	Cliff	
Bunda 00 (B1)	Bunda Cliffs	2	1996.5	0	Cliff	
Bunda 00 (B1)	Bunda Cliffs	3	1998	0	Cliff	
Bunda 00 (B1)	Bunda Cliffs	4	1999.5	0	Cliff	
Bunda 00 (B1)	Bunda Cliffs	5	2001	0	Cliff	
Bunda 00 (B1)	Bunda Cliffs	6	2003	0	Cliff	
Bunda 00 (B1)	Bunda Cliffs	7	2004.5	0	Cliff	
Bunda 00 (B1)	Bunda Cliffs	8	2006	0	Cliff	
Bunda 00 (B1)	Bunda Cliffs	9	2007	0	Cliff	
Bunda 00 (B1)	Bunda Cliffs	10	2008	0	Cliff	
Bunda 00 (B1)	Bunda Cliffs	11	2009.5	0	Cliff	
Bunda 00 (B1)	Bunda Cliffs	12	2011	0	Cliff	Was surveyed but zero pups
Bunda 00 (B1)	Bunda Cliffs	13	2012.5	0	Cliff	Was surveyed but zero pups
Bunda 00 (B1)	Bunda Cliffs	14	2014	0	Cliff	Was surveyed but zero pups
Bunda 02 (B1.1)	Bunda Cliffs	1	1995	0	Cliff	
Bunda 02 (B1.1)	Bunda Cliffs	2	1996.5	0	Cliff	
Bunda 02 (B1.1)	Bunda Cliffs	3	1998	0	Cliff	
Bunda 02 (B1.1)	Bunda Cliffs	4	1999.5	0	Cliff	
Bunda 02 (B1.1)	Bunda Cliffs	5	2001	0	Cliff	
Bunda 02 (B1.1)	Bunda Cliffs	6	2003	0	Cliff	
Bunda 02 (B1.1)	Bunda Cliffs	7	2004.5	0	Cliff	
Bunda 02 (B1.1)	Bunda Cliffs	8	2006	0	Cliff	
Bunda 02 (B1.1)	Bunda Cliffs	9	2007	0	Cliff	
Bunda 02 (B1.1)	Bunda Cliffs	10	2008	2	Cliff	
Bunda 02 (B1.1)	Bunda Cliffs	11	2009.5	0	Cliff	Was surveyed but zero pups
Bunda 02 (B1.1)	Bunda Cliffs	12	2011	0	Cliff	Was surveyed but zero pups
Bunda 02 (B1.1)	Bunda Cliffs	13	2012.5	0	Cliff	Was surveyed but zero pups
Bunda 02 (B1.1)	Bunda Cliffs	14	2014	3	Cliff	
Bunda 04 (B2)	Bunda Cliffs	1	1995	2	Cliff	
Bunda 04 (B2)	Bunda Cliffs	2	1996.5	0	Cliff	
Bunda 04 (B2)	Bunda Cliffs	3	1998	0	Cliff	
Bunda 04 (B2)	Bunda Cliffs	4	1999.5	0	Cliff	
Bunda 04 (B2)	Bunda Cliffs	5	2001	3	Cliff	
Bunda 04 (B2)	Bunda Cliffs	6	2003	0	Cliff	

Site	Region	Season	Year	Count	Survey method	Notes
Bunda 04 (B2)	Bunda Cliffs	7	2004.5	0	Cliff	
Bunda 04 (B2)	Bunda Cliffs	8	2006	0	Cliff	
Bunda 04 (B2)	Bunda Cliffs	9	2007	0	Cliff	
Bunda 04 (B2)	Bunda Cliffs	10	2008	0	Cliff	Was surveyed but zero pups
Bunda 04 (B2)	Bunda Cliffs	11	2009.5	0	Cliff	Was surveyed but zero pups
Bunda 04 (B2)	Bunda Cliffs	12	2011	2	Cliff	
Bunda 04 (B2)	Bunda Cliffs	13	2012.5	0	Cliff	Was surveyed but zero pups
Bunda 04 (B2)	Bunda Cliffs	14	2014	0	Cliff	Was surveyed but zero pups
Bunda 06 (B3)	Bunda Cliffs	1	1995	13	Cliff	
Bunda 06 (B3)	Bunda Cliffs	2	1996.5	0	Cliff	
Bunda 06 (B3)	Bunda Cliffs	3	1998	0	Cliff	
Bunda 06 (B3)	Bunda Cliffs	4	1999.5	0	Cliff	
Bunda 06 (B3)	Bunda Cliffs	5	2001	16	Cliff	
Bunda 06 (B3)	Bunda Cliffs	6	2003	0	Cliff	Was surveyed but zero pups
Bunda 06 (B3)	Bunda Cliffs	7	2004.5	10	Cliff	
Bunda 06 (B3)	Bunda Cliffs	8	2006	0	Cliff	
Bunda 06 (B3)	Bunda Cliffs	9	2007	7	Cliff	
Bunda 06 (B3)	Bunda Cliffs	10	2008	5	Cliff	
Bunda 06 (B3)	Bunda Cliffs	11	2009.5	0	Cliff	Was surveyed but zero pups
Bunda 06 (B3)	Bunda Cliffs	12	2011	2	Cliff	
Bunda 06 (B3)	Bunda Cliffs	13	2012.5	8	Cliff	
Bunda 06 (B3)	Bunda Cliffs	14	2014	9	Cliff	
Bunda 08 (B4)	Bunda Cliffs	1	1995	1	Cliff	
Bunda 08 (B4)	Bunda Cliffs	2	1996.5	0	Cliff	
Bunda 08 (B4)	Bunda Cliffs	3	1998	0	Cliff	
Bunda 08 (B4)	Bunda Cliffs	4	1999.5	0	Cliff	
Bunda 08 (B4)	Bunda Cliffs	5	2001	0	Cliff	
Bunda 08 (B4)	Bunda Cliffs	6	2003	0	Cliff	Was surveyed but zero pups
Bunda 08 (B4)	Bunda Cliffs	7	2004.5	0	Cliff	
Bunda 08 (B4)	Bunda Cliffs	8	2006	0	Cliff	
Bunda 08 (B4)	Bunda Cliffs	9	2007	0	Cliff	Was surveyed but zero pups
Bunda 08 (B4)	Bunda Cliffs	10	2008	0	Cliff	
Bunda 08 (B4)	Bunda Cliffs	11	2009.5	0	Cliff	Was surveyed but zero pups
Bunda 08 (B4)	Bunda Cliffs	12	2011	2	Cliff	
Bunda 08 (B4)	Bunda Cliffs	13	2012.5	0	Cliff	Was surveyed but zero pups
Bunda 08 (B4)	Bunda Cliffs	14	2014	0	Cliff	Was surveyed but zero pups
Bunda 09 (B5)	Bunda Cliffs	1	1995	18	Cliff	
Bunda 09 (B5)	Bunda Cliffs	2	1996.5	0	Cliff	
Bunda 09 (B5)	Bunda Cliffs	3	1998	0	Cliff	
Bunda 09 (B5)	Bunda Cliffs	4	1999.5	0	Cliff	
Bunda 09 (B5)	Bunda Cliffs	5	2001	16	Cliff	
Bunda 09 (B5)	Bunda Cliffs	6	2003	0	Cliff	
Bunda 09 (B5)	Bunda Cliffs	7	2004.5	0	Cliff	
Bunda 09 (B5)	Bunda Cliffs	8	2006	0	Cliff	Was surveyed but zero pups
Bunda 09 (B5)	Bunda Cliffs	9	2007	11	Cliff	

Site	Region	Season	Year	Count	Survey method	Notes
Bunda 09 (B5)	Bunda Cliffs	10	2008	0	Cliff	Was surveyed but zero pups
Bunda 09 (B5)	Bunda Cliffs	11	2009.5	0	Cliff	Was surveyed but zero pups
Bunda 09 (B5)	Bunda Cliffs	12	2011	9	Cliff	
Bunda 09 (B5)	Bunda Cliffs	13	2012.5	5	Cliff	
Bunda 09 (B5)	Bunda Cliffs	14	2014	7	Cliff	
Bunda 12 (B6)	Bunda Cliffs	1	1995	5	Cliff	
Bunda 12 (B6)	Bunda Cliffs	2	1996.5	0	Cliff	
Bunda 12 (B6)	Bunda Cliffs	3	1998	0	Cliff	
Bunda 12 (B6)	Bunda Cliffs	4	1999.5	0	Cliff	
Bunda 12 (B6)	Bunda Cliffs	5	2001	3	Cliff	
Bunda 12 (B6)	Bunda Cliffs	6	2003	0	Cliff	Was surveyed but zero pups
Bunda 12 (B6)	Bunda Cliffs	7	2004.5	0	Cliff	Was surveyed but zero pups
Bunda 12 (B6)	Bunda Cliffs	8	2006	0	Cliff	
Bunda 12 (B6)	Bunda Cliffs	9	2007	2	Cliff	
Bunda 12 (B6)	Bunda Cliffs	10	2008	1	Cliff	
Bunda 12 (B6)	Bunda Cliffs	11	2009.5	1	Cliff	
Bunda 12 (B6)	Bunda Cliffs	12	2011	2	Cliff	
Bunda 12 (B6)	Bunda Cliffs	13	2012.5	2	Cliff	
Bunda 12 (B6)	Bunda Cliffs	14	2014	0	Cliff	Was surveyed but zero pups
Bunda 18 (B7)	Bunda Cliffs	1	1995	0	Cliff	Was surveyed but zero pups
Bunda 18 (B7)	Bunda Cliffs	2	1996.5	0	Cliff	
Bunda 18 (B7)	Bunda Cliffs	3	1998	0	Cliff	
Bunda 18 (B7)	Bunda Cliffs	4	1999.5	0	Cliff	
Bunda 18 (B7)	Bunda Cliffs	5	2001	0	Cliff	Was surveyed but zero pups
Bunda 18 (B7)	Bunda Cliffs	6	2003	0	Cliff	Was surveyed but zero pups
Bunda 18 (B7)	Bunda Cliffs	7	2004.5	0	Cliff	Was surveyed but zero pups
Bunda 18 (B7)	Bunda Cliffs	8	2006	0	Cliff	
Bunda 18 (B7)	Bunda Cliffs	9	2007	1	Cliff	
Bunda 18 (B7)	Bunda Cliffs	10	2008	9	Cliff	
Bunda 18 (B7)	Bunda Cliffs	11	2009.5	0	Cliff	Was surveyed but zero pups
Bunda 18 (B7)	Bunda Cliffs	12	2011	3	Cliff	
Bunda 18 (B7)	Bunda Cliffs	13	2012.5	1	Cliff	
Bunda 18 (B7)	Bunda Cliffs	14	2014	0	Cliff	Was surveyed but zero pups
Bunda 19 (B8)	Bunda Cliffs	1	1995	16	Cliff	
Bunda 19 (B8)	Bunda Cliffs	2	1996.5	0	Cliff	
Bunda 19 (B8)	Bunda Cliffs	3	1998	0	Cliff	
Bunda 19 (B8)	Bunda Cliffs	4	1999.5	0	Cliff	
Bunda 19 (B8)	Bunda Cliffs	5	2001	0	Cliff	Was surveyed but zero pups
Bunda 19 (B8)	Bunda Cliffs	6	2003	0	Cliff	
Bunda 19 (B8)	Bunda Cliffs	7	2004.5	0	Cliff	Was surveyed but zero pups
Bunda 19 (B8)	Bunda Cliffs	8	2006	0	Cliff	
Bunda 19 (B8)	Bunda Cliffs	9	2007	4	Cliff	
Bunda 19 (B8)	Bunda Cliffs	10	2008	8	Cliff	
Bunda 19 (B8)	Bunda Cliffs	11	2009.5	0	Cliff	Was surveyed but zero pups
Bunda 19 (B8)	Bunda Cliffs	12	2011	0	Cliff	Was surveyed but zero pups

Site	Region	Season	Year	Count	Survey method	Notes
Bunda 19 (B8)	Bunda Cliffs	13	2012.5	7	Cliff	
Bunda 19 (B8)	Bunda Cliffs	14	2014	7	Cliff	
Bunda 22 (B9)	Bunda Cliffs	1	1995	7	Cliff	
Bunda 22 (B9)	Bunda Cliffs	2	1996.5	0	Cliff	
Bunda 22 (B9)	Bunda Cliffs	3	1998	0	Cliff	
Bunda 22 (B9)	Bunda Cliffs	4	1999.5	0	Cliff	
Bunda 22 (B9)	Bunda Cliffs	5	2001	0	Cliff	Was surveyed but zero pups
Bunda 22 (B9)	Bunda Cliffs	6	2003	0	Cliff	
Bunda 22 (B9)	Bunda Cliffs	7	2004.5	0	Cliff	Was surveyed but zero pups
Bunda 22 (B9)	Bunda Cliffs	8	2006	0	Cliff	Was surveyed but zero pups
Bunda 22 (B9)	Bunda Cliffs	9	2007	0	Cliff	Was surveyed but zero pups
Bunda 22 (B9)	Bunda Cliffs	10	2008	0	Cliff	Was surveyed but zero pups
Bunda 22 (B9)	Bunda Cliffs	11	2009.5	0	Cliff	Was surveyed but zero pups
Bunda 22 (B9)	Bunda Cliffs	12	2011	1	Cliff	
Bunda 22 (B9)	Bunda Cliffs	13	2012.5	0	Cliff	Was surveyed but zero pups
Bunda 22 (B9)	Bunda Cliffs	14	2014	0	Cliff	Was surveyed but zero pups
Nuyts Reef	Nuyts-Archipelago	1	2005	0	Count	
Nuyts Reef	Nuyts-Archipelago	2	2006.5	0	Count	
Nuyts Reef	Nuyts-Archipelago	3	2008	0	Count	
Nuyts Reef	Nuyts-Archipelago	4	2009.5	0	Count	
Nuyts Reef	Nuyts-Archipelago	5	2010.5	0	Count	
Nuyts Reef	Nuyts-Archipelago	6	2012	0	Count	
Nuyts Reef	Nuyts-Archipelago	7	2013.5	0	Count	
Nuyts Reef	Nuyts-Archipelago	8	2015	105	Count	
Purdie	Nuyts-Archipelago	1	2005	132	Count	
Purdie	Nuyts-Archipelago	2	2006.5	0	Count	
Purdie	Nuyts-Archipelago	3	2008	95	Count	
Purdie	Nuyts-Archipelago	4	2009.5	0	Count	
Purdie	Nuyts-Archipelago	5	2010.5	0	Count	
Purdie	Nuyts-Archipelago	6	2012	0	Count	
Purdie	Nuyts-Archipelago	7	2013.5	0	Count	
Purdie	Nuyts-Archipelago	8	2015	67	Count	
West	Nuyts-Archipelago	1	2005	56	Count	
West	Nuyts-Archipelago	2	2006.5	0	Count	
West	Nuyts-Archipelago	3	2008	39	Count	
West	Nuyts-Archipelago	4	2009.5	0	Count	
West	Nuyts-Archipelago	5	2010.5	0	Count	
West	Nuyts-Archipelago	6	2012	0	Count	
West	Nuyts-Archipelago	7	2013.5	0	Count	
West	Nuyts-Archipelago	8	2015	20	Count	
Fenelon	Nuyts-Archipelago	1	2005	0	Count	
Fenelon	Nuyts-Archipelago	2	2006.5	0	Count	
Fenelon	Nuyts-Archipelago	3	2008	40	Count	
Fenelon	Nuyts-Archipelago	4	2009.5	0	Count	
Fenelon	Nuyts-Archipelago	5	2010.5	0	Count	

Site	Region	Season	Year	Count	Survey method	Notes
Fenelon	Nuyts-Archipelago	6	2012	0	Count	
Fenelon	Nuyts-Archipelago	7	2013.5	0	Count	
Fenelon	Nuyts-Archipelago	8	2015	19	Count	
Lounds	Nuyts-Archipelago	1	2005	0	Count	
Lounds	Nuyts-Archipelago	2	2006.5	0	Count	
Lounds	Nuyts-Archipelago	3	2008	34	Count	
Lounds	Nuyts-Archipelago	4	2009.5	0	Count	
Lounds	Nuyts-Archipelago	5	2010.5	0	Count	
Lounds	Nuyts-Archipelago	6	2012	0	Count	
Lounds	Nuyts-Archipelago	7	2013.5	0	Count	
Lounds	Nuyts-Archipelago	8	2015	20	Count	
Breakwater/Gliddon	Nuyts-Archipelago	1	2005	24	Count	
Breakwater/Gliddon	Nuyts-Archipelago	2	2006.5	0	Count	
Breakwater/Gliddon	Nuyts-Archipelago	3	2008	22	Count	
Breakwater/Gliddon	Nuyts-Archipelago	4	2009.5	0	Count	
Breakwater/Gliddon	Nuyts-Archipelago	5	2010.5	0	Count	
Breakwater/Gliddon	Nuyts-Archipelago	6	2012	0	Count	
Breakwater/Gliddon	Nuyts-Archipelago	7	2013.5	0	Count	
Breakwater/Gliddon	Nuyts-Archipelago	8	2015	27	Count	
Blefuscu	Nuyts-Archipelago	1	2005	124	Count	Adjust Count to MR x 1.283; MR to CPP x 1.153
Blefuscu	Nuyts-Archipelago	2	2006.5	0	Count	
Blefuscu	Nuyts-Archipelago	3	2008	113	MR	Adjust Count MR to CPP x 1.153
Blefuscu	Nuyts-Archipelago	4	2009.5	0	Count	
Blefuscu	Nuyts-Archipelago	5	2010.5	120	MR	Adjust MR to CPP x 1.153
Blefuscu	Nuyts-Archipelago	6	2012	80	MR-late	Adjust MR to CPP x 1.153
Blefuscu	Nuyts-Archipelago	7	2013.5	86	CPP	
Blefuscu	Nuyts-Archipelago	8	2015	97	CPP	
Lilliput	Nuyts-Archipelago	1	2005	95	Count	Adjust Count to MR x 1.283; MR to CPP x 1.153
Lilliput	Nuyts-Archipelago	2	2006.5	0	Count	Adjust Count to MR x 1.283; MR to CPP x 1.153
Lilliput	Nuyts-Archipelago	3	2008	70	CPP	
Lilliput	Nuyts-Archipelago	4	2009.5	0	Count	Adjust Count to MR x 1.283; MR to CPP x 1.153
Lilliput	Nuyts-Archipelago	5	2010.5	76	MR	Adjust MR to CPP x 1.153
Lilliput	Nuyts-Archipelago	6	2012	73	MR	Adjust MR to CPP x 1.153
Lilliput	Nuyts-Archipelago	7	2013.5	78	CPP	
Lilliput	Nuyts-Archipelago	8	2015	72	CPP	
Olive	Chain of Bays	1	2003.5	185	Count	Adjust Count to MR x 1.40; MR to CPP x 1.094
Olive	Chain of Bays	2	2005	201	Count	Adjust Count to MR x 1.40; MR to CPP x 1.094
Olive	Chain of Bays	3	2006.5	192	CPP	
Olive	Chain of Bays	4	2008	159	CPP	
Olive	Chain of Bays	5	2009.5	221	CPP	
Olive	Chain of Bays	6	2010.5	184	CPP	
Olive	Chain of Bays	7	2012	127	CPP	
Olive	Chain of Bays	8	2013.5	140	CPP	
Olive	Chain of Bays	9	2015	133	CPP	
Nicolas Baudin	Chain of Bays	1	2003.5	0	Count	

Site	Region	Season	Year	Count	Survey method	Notes
Nicolas Baudin	Chain of Bays	2	2005	0	Count	
Nicolas Baudin	Chain of Bays	3	2006.5	98	Count	
Nicolas Baudin	Chain of Bays	4	2008	0	Count	
Nicolas Baudin	Chain of Bays	5	2009.5	0	Count	
Nicolas Baudin	Chain of Bays	6	2010.5	0	Count	
Nicolas Baudin	Chain of Bays	7	2012	0	Count	
Nicolas Baudin	Chain of Bays	8	2013.5	57	Count	
Nicolas Baudin	Chain of Bays	9	2015	63	Count	
Ward	Chain of Bays	1	2003.5	0	Count	
Ward	Chain of Bays	2	2005	0	Count	
Ward	Chain of Bays	3	2006.5	45	Count	
Ward	Chain of Bays	4	2008	0	Count	
Ward	Chain of Bays	5	2009.5	0	Count	
Ward	Chain of Bays	6	2010.5	0	Count	
Ward	Chain of Bays	7	2012	0	Count	
Ward	Chain of Bays	8	2013.5	46	Count	
Ward	Chain of Bays	9	2015	44	Count	
Pearson	Chain of Bays	1	2003.5	29	Count	
Pearson	Chain of Bays	2	2005	35	Count	
Pearson	Chain of Bays	3	2006.5	0	Count	
Pearson	Chain of Bays	4	2008	0	Count	
Pearson	Chain of Bays	5	2009.5	0	Count	
Pearson	Chain of Bays	6	2010.5	0	Count	
Pearson	Chain of Bays	7	2012	0	Count	
Pearson	Chain of Bays	8	2013.5	27	Count	
Pearson	Chain of Bays	9	2015	30	Count	
Pt Labatt	Chain of Bays	1	2003.5	1	Count	
Pt Labatt	Chain of Bays	2	2005	6	Count	
Pt Labatt	Chain of Bays	3	2006.5	0	Count	
Pt Labatt	Chain of Bays	4	2008	0	Count	
Pt Labatt	Chain of Bays	5	2009.5	0	Count	
Pt Labatt	Chain of Bays	6	2010.5	0	Count	
Pt Labatt	Chain of Bays	7	2012	0	Count	
Pt Labatt	Chain of Bays	8	2013.5	2	Count	
Pt Labatt	Chain of Bays	9	2015	0	Count	Was surveyed but zero pups
Jones	Chain of Bays	1	2003.5	0	Count	
Jones	Chain of Bays	2	2005	15	Count	
Jones	Chain of Bays	3	2006.5	15	Count	
Jones	Chain of Bays	4	2008	15	Count	
Jones	Chain of Bays	5	2009.5	11	Count	
Jones	Chain of Bays	6	2010.5	12	Count	
Jones	Chain of Bays	7	2012	12	Count	
Jones	Chain of Bays	8	2013.5	16	Count	
Jones	Chain of Bays	9	2015	19	Count	
West Waldegrave	Chain of Bays	1	2003.5	157	Count	

Site	Region	Season	Year	Count	Survey method	Notes
West Waldegrave	Chain of Bays	2	2005	104	Count	
West Waldegrave	Chain of Bays	3	2006.5	0	Count	
West Waldegrave	Chain of Bays	4	2008	0	Count	
West Waldegrave	Chain of Bays	5	2009.5	0	Count	
West Waldegrave	Chain of Bays	6	2010.5	0	Count	
West Waldegrave	Chain of Bays	7	2012	0	Count	
West Waldegrave	Chain of Bays	8	2013.5	91	Count	
West Waldegrave	Chain of Bays	9	2015	89	Count	
Cap	SW Eyre	1	2005	0	Count	
Cap	SW Eyre	2	2006.5	0	Count	
Cap	SW Eyre	3	2008	0	Count	
Cap	SW Eyre	4	2009.5	0	Count	
Cap	SW Eyre	5	2010.5	0	Count	
Cap	SW Eyre	6	2012	38	Count	
Cap	SW Eyre	7	2013.5	0	Count	
Cap	SW Eyre	8	2015	31	Count	
Rocky North	SW Eyre	1	2005	0	Count	
Rocky North	SW Eyre	2	2006.5	0	Count	
Rocky North	SW Eyre	3	2008	0	Count	
Rocky North	SW Eyre	4	2009.5	0	Count	
Rocky North	SW Eyre	5	2010.5	34	Count	
Rocky North	SW Eyre	6	2012	44	Count	
Rocky North	SW Eyre	7	2013.5	47	Count	
Rocky North	SW Eyre	8	2015	35	Count	
Rocky South	SW Eyre	1	2005	0	Count	
Rocky South	SW Eyre	2	2006.5	0	Count	
Rocky South	SW Eyre	3	2008	0	Count	
Rocky South	SW Eyre	4	2009.5	0	Count	
Rocky South	SW Eyre	5	2010.5	0	Count	
Rocky South	SW Eyre	6	2012	12	Count	
Rocky South	SW Eyre	7	2013.5	0	Count	
Rocky South	SW Eyre	8	2015	11	Count	
Four Hummocks	SW Eyre	1	2005	0	Count	
Four Hummocks	SW Eyre	2	2006.5	0	Count	
Four Hummocks	SW Eyre	3	2008	0	Count	
Four Hummocks	SW Eyre	4	2009.5	0	Count	
Four Hummocks	SW Eyre	5	2010.5	14	Count	
Four Hummocks	SW Eyre	6	2012	9	Count	
Four Hummocks	SW Eyre	7	2013.5	0	Count	
Four Hummocks	SW Eyre	8	2015	6	Count	
Little Hummock	SW Eyre	1	2005	0	Count	
Little Hummock	SW Eyre	2	2006.5	0	Count	
Little Hummock	SW Eyre	3	2008	0	Count	
Little Hummock	SW Eyre	4	2009.5	0	Count	
Little Hummock	SW Eyre	5	2010.5	0	Count	

Site	Region	Season	Year	Count	Survey method	Notes
Little Hummock	SW Eyre	6	2012	10	Count	
Little Hummock	SW Eyre	7	2013.5	0	Count	
Little Hummock	SW Eyre	8	2015	4	Count	
Price	SW Eyre	1	2005	0	Count	
Price	SW Eyre	2	2006.5	0	Count	
Price	SW Eyre	3	2008	0	Count	
Price	SW Eyre	4	2009.5	0	Count	
Price	SW Eyre	5	2010.5	0	Count	
Price	SW Eyre	6	2012	0	Count	
Price	SW Eyre	7	2013.5	0	Count	
Price	SW Eyre	8	2015	32	Count	
Liguanea	Spencer Gulf	1	2000.5	0	Count	
Liguanea	Spencer Gulf	2	2002	0	Count	
Liguanea	Spencer Gulf	3	2003.5	0	Count	
Liguanea	Spencer Gulf	4	2005	43	Count	
Liguanea	Spencer Gulf	5	2006.5	0	Count	
Liguanea	Spencer Gulf	6	2008	0	Count	
Liguanea	Spencer Gulf	7	2009.5	0	Count	
Liguanea	Spencer Gulf	8	2010.5	0	Count	
Liguanea	Spencer Gulf	9	2012	0	Count	
Liguanea	Spencer Gulf	10	2013.5	17	Count	
Liguanea	Spencer Gulf	11	2015	25	Count	
Curta	Spencer Gulf	1	2000.5	0	Count	
Curta	Spencer Gulf	2	2002	0	Count	
Curta	Spencer Gulf	3	2003.5	0	Count	
Curta	Spencer Gulf	4	2005	0	Count	
Curta	Spencer Gulf	5	2006.5	0	Count	
Curta	Spencer Gulf	6	2008	0	Count	
Curta	Spencer Gulf	7	2009.5	0	Count	
Curta	Spencer Gulf	8	2010.5	0	Count	
Curta	Spencer Gulf	9	2012	0	Count	
Curta	Spencer Gulf	10	2013.5	0	Count	
Curta	Spencer Gulf	11	2015	7	Count	
Williams	Spencer Gulf	1	2000.5	0	Count	
Williams	Spencer Gulf	2	2002	0	Count	
Williams	Spencer Gulf	3	2003.5	0	Count	
Williams	Spencer Gulf	4	2005	0	Count	
Williams	Spencer Gulf	5	2006.5	0	Count	
Williams	Spencer Gulf	6	2008	0	Count	
Williams	Spencer Gulf	7	2009.5	0	Count	
Williams	Spencer Gulf	8	2010.5	0	Count	
Williams	Spencer Gulf	9	2012	0	Count	
Williams	Spencer Gulf	10	2013.5	0	Count	
Williams	Spencer Gulf	11	2015	5	Count	
Lewis	Spencer Gulf	1	1999	0	Count	

Site	Region	Season	Year	Count	Survey method	Notes
Lewis	Spencer Gulf	2	2000.5	0	Count	
Lewis	Spencer Gulf	3	2002	0	Count	
Lewis	Spencer Gulf	4	2003.5	0	Count	
Lewis	Spencer Gulf	5	2005	0	Count	
Lewis	Spencer Gulf	6	2006.5	149	Count	
Lewis	Spencer Gulf	7	2008	0	Count	
Lewis	Spencer Gulf	8	2009.5	0	Count	
Lewis	Spencer Gulf	9	2011	0	Count	
Lewis	Spencer Gulf	10	2012.5	79	Count	
Lewis	Spencer Gulf	11	2014	82	Count	
East	Spencer Gulf	1	1999	0	Count	
East	Spencer Gulf	2	2000.5	0	Count	
East	Spencer Gulf	3	2002	0	Count	
East	Spencer Gulf	4	2003.5	0	Count	
East	Spencer Gulf	5	2005	14	Count	
East	Spencer Gulf	6	2006.5	0	Count	
East	Spencer Gulf	7	2008	0	Count	
East	Spencer Gulf	8	2009.5	0	Count	
East	Spencer Gulf	9	2011	0	Count	
East	Spencer Gulf	10	2012.5	0	Count	
East	Spencer Gulf	11	2014	9	Count	
South Neptune	Spencer Gulf	1	1999	0	Count	
South Neptune	Spencer Gulf	2	2000.5	0	Count	
South Neptune	Spencer Gulf	3	2002	0	Count	
South Neptune	Spencer Gulf	4	2003.5	0	Count	
South Neptune	Spencer Gulf	5	2005	0	Count	
South Neptune	Spencer Gulf	6	2006.5	6	Count	
South Neptune	Spencer Gulf	7	2008	0	Count	
South Neptune	Spencer Gulf	8	2009.5	0	Count	
South Neptune	Spencer Gulf	9	2011	0	Count	
South Neptune	Spencer Gulf	10	2012.5	7	Count	
South Neptune	Spencer Gulf	11	2014	0	Count	
Albatross	Spencer Gulf	1	1999	0	Count	
Albatross	Spencer Gulf	2	2000.5	0	Count	
Albatross	Spencer Gulf	3	2002	0	Count	
Albatross	Spencer Gulf	4	2003.5	0	Count	
Albatross	Spencer Gulf	5	2005	0	Count	
Albatross	Spencer Gulf	6	2006.5	0	Count	
Albatross	Spencer Gulf	7	2008	0	Count	
Albatross	Spencer Gulf	8	2009.5	69	Count	
Albatross	Spencer Gulf	9	2011	69	Count	
Albatross	Spencer Gulf	10	2012.5	0	Count	
Albatross	Spencer Gulf	11	2014	0	Count	
English	Spencer Gulf	1	1999	0	Count	
English	Spencer Gulf	2	2000.5	0	Count	

Site	Region	Season	Year	Count	Survey method	Notes
English	Spencer Gulf	3	2002	32	Count	
English	Spencer Gulf	4	2003.5	0	Count	
English	Spencer Gulf	5	2005	27	Count	
English	Spencer Gulf	6	2006.5	0	Count	
English	Spencer Gulf	7	2008	23	Count	
English	Spencer Gulf	8	2009.5	39	Count	
English	Spencer Gulf	9	2011	34	Count	
English	Spencer Gulf	10	2012.5	0	Count	
English	Spencer Gulf	11	2014	0	Count	
Dangerous Reef	Spencer Gulf	1	1999	487	MR	Adjust MR to CPP x 1.146
Dangerous Reef	Spencer Gulf	2	2000.5	543	Count	Adjust Count to MR x 1.205; MR to CPP x 1.146
Dangerous Reef	Spencer Gulf	3	2002	588	Count	Adjust Count to MR x 1.205; MR to CPP x 1.146
Dangerous Reef	Spencer Gulf	4	2003.5	581	MR	Adjust MR to CPP x 1.146
Dangerous Reef	Spencer Gulf	5	2005	658	MR	Adjust MR to CPP x 1.146
Dangerous Reef	Spencer Gulf	6	2006.5	831	CPP	
Dangerous Reef	Spencer Gulf	7	2008	543	CPP	
Dangerous Reef	Spencer Gulf	8	2009.5	629	CPP	
Dangerous Reef	Spencer Gulf	9	2011	413	CPP	
Dangerous Reef	Spencer Gulf	10	2012.5	0	Count	
Dangerous Reef	Spencer Gulf	11	2014	485	CPP	
North	Spencer Gulf	1	1999	0	Count	
North	Spencer Gulf	2	2000.5	0	Count	
North	Spencer Gulf	3	2002	0	Count	
North	Spencer Gulf	4	2003.5	0	Count	
North	Spencer Gulf	5	2005	28	Count	
North	Spencer Gulf	6	2006.5	0	Count	
North	Spencer Gulf	7	2008	0	Count	
North	Spencer Gulf	8	2009.5	0	Count	
North	Spencer Gulf	9	2011	21	Count	
North	Spencer Gulf	10	2012.5	0	Count	
North	Spencer Gulf	11	2014	0	Count	
Peaked Rocks	Spencer Gulf	1	1999	0	Count	
Peaked Rocks	Spencer Gulf	2	2000.5	0	Count	
Peaked Rocks	Spencer Gulf	3	2002	0	Count	
Peaked Rocks	Spencer Gulf	4	2003.5	0	Count	
Peaked Rocks	Spencer Gulf	5	2005	0	Count	
Peaked Rocks	Spencer Gulf	6	2006.5	0	Count	
Peaked Rocks	Spencer Gulf	7	2008	0	Count	
Peaked Rocks	Spencer Gulf	8	2009.5	0	Count	
Peaked Rocks	Spencer Gulf	9	2011	58	Count	
Peaked Rocks	Spencer Gulf	10	2012.5	0	Count	
Peaked Rocks	Spencer Gulf	11	2014	0	Count	
North Casuarina	Kangaroo Island	1	1985.5	0	Count	
North Casuarina	Kangaroo Island	2	1987	0	Count	
North Casuarina	Kangaroo Island	3	1988.5	0	Count	

Site	Region	Season	Year	Count	Survey method	Notes
North Casuarina	Kangaroo Island	4	1990	0	Count	
North Casuarina	Kangaroo Island	5	1991.5	0	Count	
North Casuarina	Kangaroo Island	6	1993	0	Count	
North Casuarina	Kangaroo Island	7	1994.5	0	Count	
North Casuarina	Kangaroo Island	8	1996	0	Count	
North Casuarina	Kangaroo Island	9	1997.5	0	Count	
North Casuarina	Kangaroo Island	10	1999	0	Count	
North Casuarina	Kangaroo Island	11	2001	0	Count	
North Casuarina	Kangaroo Island	12	2002.5	0	Count	
North Casuarina	Kangaroo Island	13	2004	0	Count	
North Casuarina	Kangaroo Island	14	2005.5	0	Count	
North Casuarina	Kangaroo Island	15	2007	0	Count	
North Casuarina	Kangaroo Island	16	2008.5	0	Count	
North Casuarina	Kangaroo Island	17	2010	0	Count	
North Casuarina	Kangaroo Island	18	2011.5	0	Count	
North Casuarina	Kangaroo Island	19	2013	11	Count	
North Casuarina	Kangaroo Island	20	2014.5	0	Count	
Cape Bouguer	Kangaroo Island	1	1985.5	0	Count	
Cape Bouguer	Kangaroo Island	2	1987	0	Count	
Cape Bouguer	Kangaroo Island	3	1988.5	0	Count	
Cape Bouguer	Kangaroo Island	4	1990	0	Count	
Cape Bouguer	Kangaroo Island	5	1991.5	0	Count	
Cape Bouguer	Kangaroo Island	6	1993	0	Count	
Cape Bouguer	Kangaroo Island	7	1994.5	0	Count	
Cape Bouguer	Kangaroo Island	8	1996	0	Count	
Cape Bouguer	Kangaroo Island	9	1997.5	0	Count	
Cape Bouguer	Kangaroo Island	10	1999	0	Count	
Cape Bouguer	Kangaroo Island	11	2001	0	Count	
Cape Bouguer	Kangaroo Island	12	2002.5	0	Count	
Cape Bouguer	Kangaroo Island	13	2004	0	Count	
Cape Bouguer	Kangaroo Island	14	2005.5	0	Count	
Cape Bouguer	Kangaroo Island	15	2007	0	Count	
Cape Bouguer	Kangaroo Island	16	2008.5	0	Count	
Cape Bouguer	Kangaroo Island	17	2010	0	Count	
Cape Bouguer	Kangaroo Island	18	2011.5	0	Count	
Cape Bouguer	Kangaroo Island	19	2013	9	Count	
Cape Bouguer	Kangaroo Island	20	2014.5	0	Count	
Cave Point	Kangaroo Island	1	1985.5	0	Count	
Cave Point	Kangaroo Island	2	1987	0	Count	
Cave Point	Kangaroo Island	3	1988.5	0	Count	
Cave Point	Kangaroo Island	4	1990	0	Count	
Cave Point	Kangaroo Island	5	1991.5	0	Count	
Cave Point	Kangaroo Island	6	1993	0	Count	
Cave Point	Kangaroo Island	7	1994.5	0	Count	
Cave Point	Kangaroo Island	8	1996	0	Count	

Site	Region	Season	Year	Count	Survey method	Notes
Cave Point	Kangaroo Island	9	1997.5	0	Count	
Cave Point	Kangaroo Island	10	1999	0	Count	
Cave Point	Kangaroo Island	11	2001	0	Count	
Cave Point	Kangaroo Island	12	2002.5	0	Count	
Cave Point	Kangaroo Island	13	2004	0	Count	
Cave Point	Kangaroo Island	14	2005.5	0	Count	
Cave Point	Kangaroo Island	15	2007	0	Count	
Cave Point	Kangaroo Island	16	2008.5	0	Count	
Cave Point	Kangaroo Island	17	2010	0	Count	
Cave Point	Kangaroo Island	18	2011.5	0	Count	
Cave Point	Kangaroo Island	19	2013	0	Count	
Cave Point	Kangaroo Island	20	2014.5	0	Count	
Seal Bay	Kangaroo Island	1	1985.5	359	Live count	Adjust Live count to CPP x 2.334
Seal Bay	Kangaroo Island	2	1987	387	Live count	Adjust Live count to CPP x 2.334
Seal Bay	Kangaroo Island	3	1988.5	317	Live count	Adjust Live count to CPP x 2.334
Seal Bay	Kangaroo Island	4	1990	378	Live count	Adjust Live count to CPP x 2.334
Seal Bay	Kangaroo Island	5	1991.5	299	Live count	Adjust Live count to CPP x 2.334
Seal Bay	Kangaroo Island	6	1993	357	Live count	Adjust Live count to CPP x 2.334
Seal Bay	Kangaroo Island	7	1994.5	289	Live count	Adjust Live count to CPP x 2.334
Seal Bay	Kangaroo Island	8	1996	338	Live count	Adjust Live count to CPP x 2.334
Seal Bay	Kangaroo Island	9	1997.5	348	Live count	Adjust Live count to CPP x 2.334
Seal Bay	Kangaroo Island	10	1999	345	Live count	Adjust Live count to CPP x 2.334
Seal Bay	Kangaroo Island	11	2001	315	Live count	Adjust Live count to CPP x 2.334
Seal Bay	Kangaroo Island	12	2002.5	343	Live count	Adjust Live count to CPP x 2.334
Seal Bay	Kangaroo Island	13	2004	221	CPP	
Seal Bay	Kangaroo Island	14	2005.5	272	CPP	
Seal Bay	Kangaroo Island	15	2007	219	CPP	
Seal Bay	Kangaroo Island	16	2008.5	254	CPP	
Seal Bay	Kangaroo Island	17	2010	268	CPP	
Seal Bay	Kangaroo Island	18	2011.5	267	CPP	
Seal Bay	Kangaroo Island	19	2013	249	CPP	
Seal Bay	Kangaroo Island	20	2014.5	259	CPP	
Seal Slide	Kangaroo Island	1	1985.5	0	Count	
Seal Slide	Kangaroo Island	2	1987	0	Count	
Seal Slide	Kangaroo Island	3	1988.5	0	Count	
Seal Slide	Kangaroo Island	4	1990	0	Count	
Seal Slide	Kangaroo Island	5	1991.5	0	Count	
Seal Slide	Kangaroo Island	6	1993	0	Count	
Seal Slide	Kangaroo Island	7	1994.5	0	Count	
Seal Slide	Kangaroo Island	8	1996	0	Count	
Seal Slide	Kangaroo Island	9	1997.5	0	Count	
Seal Slide	Kangaroo Island	10	1999	0	Count	
Seal Slide	Kangaroo Island	11	2001	0	Count	
Seal Slide	Kangaroo Island	12	2002.5	9	Count	
Seal Slide	Kangaroo Island	13	2004	11	Count	

Site	Region	Season	Year	Count	Survey method	Notes
Seal Slide	Kangaroo Island	14	2005.5	10	Count	
Seal Slide	Kangaroo Island	15	2007	15	Count	
Seal Slide	Kangaroo Island	16	2008.5	12	Count	
Seal Slide	Kangaroo Island	17	2010	10	Count	
Seal Slide	Kangaroo Island	18	2011.5	13	Count	
Seal Slide	Kangaroo Island	19	2013	10	Count	
Seal Slide	Kangaroo Island	20	2014.5	8	Count	
The Pages	Kangaroo Island	1	1985.5	0	Count	
The Pages	Kangaroo Island	2	1987	0	Count	
The Pages	Kangaroo Island	3	1988.5	0	Count	
The Pages	Kangaroo Island	4	1990	522	Count	
The Pages	Kangaroo Island	5	1991.5	431	Count	
The Pages	Kangaroo Island	6	1993	448	Count	
The Pages	Kangaroo Island	7	1994.5	439	Count	
The Pages	Kangaroo Island	8	1996	381	Count	
The Pages	Kangaroo Island	9	1997.5	445	Count	
The Pages	Kangaroo Island	10	1999	438	Count	
The Pages	Kangaroo Island	11	2001	461	Count	
The Pages	Kangaroo Island	12	2002.5	609	Count	
The Pages	Kangaroo Island	13	2004	490	Count	
The Pages	Kangaroo Island	14	2005.5	543	Count	
The Pages	Kangaroo Island	15	2007	403	Count	
The Pages	Kangaroo Island	16	2008.5	478	Count	
The Pages	Kangaroo Island	17	2010	478	Count	
The Pages	Kangaroo Island	18	2011.5	0	Count	
The Pages	Kangaroo Island	19	2013	0	Count	
The Pages	Kangaroo Island	20	2014.5	0	Count	