Penguin monitoring and conservation activities in the Gulf St Vincent

July 2016 – June 2017

Report to the Adelaide and Mt Lofty Ranges Natural Resources Management Board

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inspiring achievement

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I. SUMMARY

This project further investigated little penguin (*Eudyptula minor*) population trends in the Gulf St Vincent with a focus on breeding performance and stress response to cats. Granite Island continued to have the highest breeding success (2.00 ± 0.19 fledgling per pair; n=8) while Emu Bay had the lowest (0.67 ± 0.33 fledgling per pair; n=13). Population censuses and night tours data showed stabilizing trends for Granite Island population since 2012, with 16-18 penguins present in 2016 on Granite Island. Population censuses on Kangaroo Island showed declining trends for Emu Bay and Antechamber Bay but potentially increasing trends at Kingscote. Population censuses showed increasing trends for Troubridge Island, with 466 penguins present at the time of the census. Althorpe Island population showed potentially stable or slightly decreasing trends since the 2013 census. However, the fact that no additional breeding area was located since 2013 suggests that the Althorpe Island population may have decreased significantly since the 132 penguins found in 2004. Finally, little penguins exhibited a stress response when hearing cat calls, even if they had never been exposed to cats previously.

II. INTRODUCTION

This project is an ongoing project monitoring the decline of little penguins (*Eudyptula minor*) in the Gulf St Vincent (South Australia). The work seeks to implement actions identified in a previous report on Conservation management priorities for little penguin populations in Gulf St Vincent (Wiebkin 2011). This project is supported by funding from the Adelaide and Mount Lofty Ranges Natural Resources Management Board, with support for additional investigations provided by Flinders University, Birds SA and the Nature Foundation.

The overall project aims to monitor targeted populations to collect baseline information and increase awareness of little penguin conservation issues with a particular focus on three main issues: (1) factors impacting breeding success, (2) factors impacting adults and sub-adults survival, and (3) differentiation and connectivity of the populations.

The report by Colombelli-Négrel (2016) showed stabilizing trends for both Granite and Troubridge Islands but declining trends on Kangaroo Island, with 84% decline since 2011. In 2015, Granite Island continued to have the highest breeding success while Emu Bay had the lowest with 25% of the burrows showing signs of predation (Colombelli-Négrel 2016). Blood parasites (*Haemoproteus* and *Plasmodium* spp.) were identified in 86% of the individuals sampled and individuals with multiple infections had longer bills than those with single infection or non-infected individuals (Colombelli-Négrel 2016). Finally, there were substantial morphological variation for bill measurements and body mass among the different breeding colonies (Colombelli-Négrel 2016).

The following report outlines the data collected between July 2016 and June 2017. This report continues long-term annual monitoring of targeted populations and further investigates breeding success for inter-annual variation. This report also develops a Monitoring Plan for estimating population trends in South Australia to get a better understanding of the little penguin status.

III. AIMS

The current funded project had the following objectives: (1) to continue breeding monitoring on Granite Island. Troubridge Island and at three colonies on Kangaroo Island (Emu Bay, Antechamber bay, Kingscote); (2) to conduct population surveys on Troubridge Island and on Granite Island; (3) to organise community events in the Victor Harbour area to educate public about the penguins; and (4) to establish a citizen science approach to collect regular nightly penguin data on Granite Island. This report also provides information on penguin response to cat intruders at burrows and develops a Monitoring Plan for estimating population trends in South Australia.

IV. MATERIALS AND METHODS

Study sites

This project was conducted during the 2016-breeding season between August 2016 and February 2017 on three islands in the Gulf St Vincent: (1) Granite Island (35°37'S, 138°36'E), in the Fleurieu Peninsula. Granite Island is a small island off Victor Harbour connected to the mainland by a bridge causeway open to pedestrians; (2) Troubridge Island (35°06'S, 137°49'E), in the Yorke Peninsula. Troubridge Island is a small sandy island about 7 km east of Sultana Point, which is only accessible by boat with restricted access; and (3) Kangaroo Island (35°47'S, 137°13'E), 112 km south-west of Adelaide. The island is accessible by ferry, is 150km long and includes several penguin colonies.

Colonies at Antechamber Bay (KI), Emu Bay (KI), Kingscote (KI), Granite Island and Troubridge Island were included in this study for breeding monitoring. Colonies at Antechamber Bay, Emu Bay, Kingscote, Vivonne Bay (KI), Granite Island, Althorpe Island (35°22'S, 136°51'E, Yorke Peninsula) and Troubridge Island were included for population surveys and/or trends. Preliminary data for Wardang Island (34°28'S, 137°18'E, Yorke Peninsula) are also presented.

Breeding monitoring

On Kangaroo and Granite Islands, little penguins use both naturally excavated burrows and artificial nest boxes, while on Troubridge Island, they use scrapes under the vegetation or naturally excavated burrows. For consistency of the terminology, all nesting sites are referred to as burrows. All Search for active burrows started around mid-August and monitoring was carried out until November on Kangaroo and Troubridge Islands and until February on Granite Island. A burrow was recorded as active if it contained either eggs, chicks or adults or had clear evidence of penguin presence, such as fresh droppings or a strong penguin smell. Once found active, burrows were checked every 10-15 days.

To assess breeding success, the number of adults, eggs and chicks present in each burrow was recorded during each visit. A chick was considered as fledged when it disappeared from the burrow at about eight weeks of age and was not found depredated nor in any of the other burrows. Breeding success was defined as the number of chicks that fledged per breeding pair. If the outcome of a burrow was unknown at the end of the monitoring period (e.g., the burrow still had eggs and therefore it was unknown whether those eggs would hatch and produce fledglings), it was excluded from the analysis for breeding success. Microchip numbers of birds in burrows were also recorded to assess survival.

Predation was scored as suspected if eggs or chicks were damaged or removed between visits before the eggs were ready to hatch or before the chicks were ready to fledge, but only if adults were still attending the burrow and therefore had not abandoned the nest. Eggs were considered as abandoned if they were found unattended during two consecutive visits and felt cold to the touch.

Granite Island nightly counts

The nightly penguin counts report on the number of penguins counted by the Penguin Tour Guides and volunteers on the North shore. Counts are conducted within two hours after dark on a nightly basis.

Population Census

Penguin censuses were carried out on Troubridge Island (Yorke Peninsula), Althorpe Island (Yorke Peninsula), Granite Island (Fleurieu Peninsula) and Kangaroo Island. Wardang Island was also visited to estimate possible locations within the island for future censuses.

All censuses were conducted by a team of volunteers and the Penguin Ecologist, except on Althorpe Island, where the census was conducted by the Friends of Althrope Island Group. All censuses were conducted in October 2016 to align with previous years. An additional count was conducted on Althorpe Island in April 2016.

On Troubridge Island, repeated censuses (five times between August and November) within a small section were also conducted to estimate variation in penguin numbers between months and the accuracy of population estimates using a single count. An additional census in April 2017 was conducted within four 30x30m quadrats to estimate variation in numbers between times of the year. The four 30x30m quadrats were selected to reflect varying habitats and penguin densities (low, high). Finally, an acoustic survey using 32 playback point surveys was conducted on 5th of October 2016 along two transects as described in Colombelli-Négrel (2016).

On Kangaroo Island, the details of the sections surveyed are as follow: (1) *Emu Bay*: Boat Ramp (day 1), Whittle (day 1) and Playground (day 2); (2) *Antechamber Bay*: Cowry Beach, Post Point and Cape Coults; and (3) *Kingscote*: Hospital Beach. No census was conducted at Vivonne Bay but the section called Point Ellen North was extensively searched for active burrows.

Each colony was searched along transects for presence or absence of penguin burrows. Once a burrow was found, its status was noted as active or inactive. A burrow was recorded as active if it contained eggs, chicks or adults, or had clear evidence of penguin presence such as fresh droppings, a strong penguin smell or recent burrow excavation. A burrow was recorded as inactive if none of the above criteria was found or if it had cobwebs at the entrance indicating that no large animal was regularly entering/exiting the burrow. As per previous years, around 10% of Troubridge Island could not be accessed and was extrapolated. All active burrows were marked with GPS. On Granite Island, burrows were also marked with talcum powder to avoid double counting by different team of volunteers.

Additional data: Stress response to cats

These data were analysed as part of Rebecca Schaefer's Honours project (2016-2017) entitled "Naïve little penguins exhibited a stress response to predator cat calls" under the supervision of Dr Diane Colombelli-Négrel. This project was funded by Flinders University, Birds SA and the Nature Foundation. The aims of Rebecca's project were to determine: (1) whether little penguins were able to recognize cats as predators and (2) whether little penguins exhibited a stress response when presented with cat calls. Little penguins at Emu Bay and on Troubridge Island were presented with playback of cat or penguin calls during the incubation period. Each playback comprised 1 hour of pre-playback silence (pre-trial) followed by 1 minute of playback (trial) and 1 hour of silence (post-trial). The 1 minute of trial consisted of six evenly spaced (every 10 seconds) penguin or cat calls. Behavioural responses were recorded using a Sony AS20 Action Camera (Sony Corporation, Australia) placed in front of the burrow (approx. 30cm away). Physiological responses (heart rate) were recorded by replacing one of the egg with a dummy egg, containing an internal omnidirectional lavalier condenser microphone (WL183, Shure Inc., USA) and connected to either a Zoom Handy Recorder H4n (Zoom Corporation, Australia) or a Tascam DR-05 recorder (TEAC Corporation, USA). During the experiments, the real egg was held in a Janoel Model 12 Egg Incubator (Poultry Australia, Australia) at 38˚C (220-240V, 50-60Hz, <60W) located <10mins away. The egg was returned to its original burrow at the experiment. No difference in hatching success between experimental and control burrows was found ($t_{47} = 0.85$; $p = 0.40$).

Ethics

This project was approved by the Flinders University Animal Welfare Ethics Committee (Project numbers No. E388-348) and is also supported by a scientific permit to conduct the research (Y26040). Progress report on the numbers of animals that were used will be provided to DEWNR on 30/6/2017.

V. RESULTS

Breeding monitoring

Between August and February, 71 burrows were monitored on Granite, Kangaroo and Troubridge Islands (Table 1). Out of the 71 monitored burrows, 54 (76%) showed signs of breeding activity such as eggs or chicks present in the burrow. Breeding success on Granite Island was the highest with 2.00 (± 0.19) fledglings per pair (n=8) while breeding success at Emu Bay (KI) was the lowest with 0.67 (± 0.33) fledglings per pair (n=13) (Table 2; Figure 1).

No burrow showed evidence of abandonment or predation. Breeding success at Antechamber Bay could not be estimated because the only two breeding burrows contained either unhatched eggs or very young chicks during the last visit and thus their likelihood of survival to fledgling stage was too uncertain to estimate. One burrow on Granite Island was vandalised and one chick (> 6 weeks old) was stolen. As a result, the remaining chick was abandoned by the adults and rescued by the Animal Welfare Rescue Team but released to the wild in March 2017.

Survival: A total of five individuals that were previously microchipped were re-sighted in 2016: three on Troubridge Island and two at Emu Bay. No microchipped individual was re-sighted on Granite Island. The full list of re-sighted individuals is presented in Appendix 1.

Penguin colonies	Burrow monitored	Breeding burrows	Eggs	Chicks	Fledglings	Groups with 2nd clutch	Burrows predated
Troubridge	31	31	59	51	32	0	0
Antechamber Bay (KI)	3	2	4	2	0	0	0
Kingscote (KI)	8	3	6	2	2	0	0
Emu Bay (KI)	18	13	26	17	6	0	0
Granite	11	8	18	18	16	1	0
Total	**71**	**54**	**113**	**90**	**56**	**1**	**0**

Table 1*. Number of eggs, chicks and fledglings produced in total per penguin colony. The table also presents the number of burrows with suspected predation.*

Penguin Colonies	2016 Eggs/ Pair (SE)	2016 Chicks/ Pair (SE)	2016 Breeding success (SE)	2015 Eggs/ Pair (SE)	2015 Chicks/ Pair (SE)	2015 Breeding success (SE)
Troubridge	1.90 (0.05)	1.65 (0.13)	1.03 (0.18)	2.14 (0.10)	1.04 (0.19)	0.43 (0.16)
Kingscote (KI)	2.00 (0.00)	1.50 (0.50)	1.00 (1.00)	2.33 (0.33)	1.20 (0.37)	0.50 (0.50)
Emu Bay (KI)	1.44 (0.22)	1.21 (0.26)	0.67 (0.33)	2.20 (0.14)	1.55 (0.23)	0.29 (0.13)
Granite	2.25 (0.25)	2.25 (0.25)	2.00 (0.19)	2.00 (0.00)	1.00 (0.45)	1.00 (0.45)

Table 2*. Breeding success for each penguin colony monitored during the 2016 and 2015-breeding seasons*

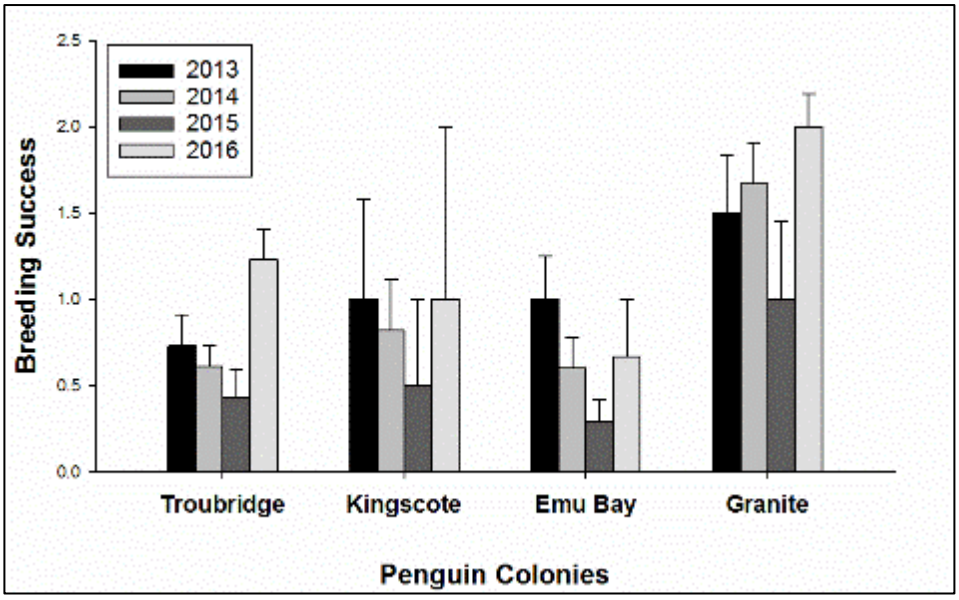

Figure 1. *Breeding success across all the penguin colonies monitored between 2013 and 2016*

Granite Island nightly counts

The daily attendance for the night tour counts occurring on the North Shore is presented in Figure 2. The night tour counts confirmed stabilising trends on Granite Island since 2012 as evidenced by the highest number of adults seen during the tours (Figure 3).

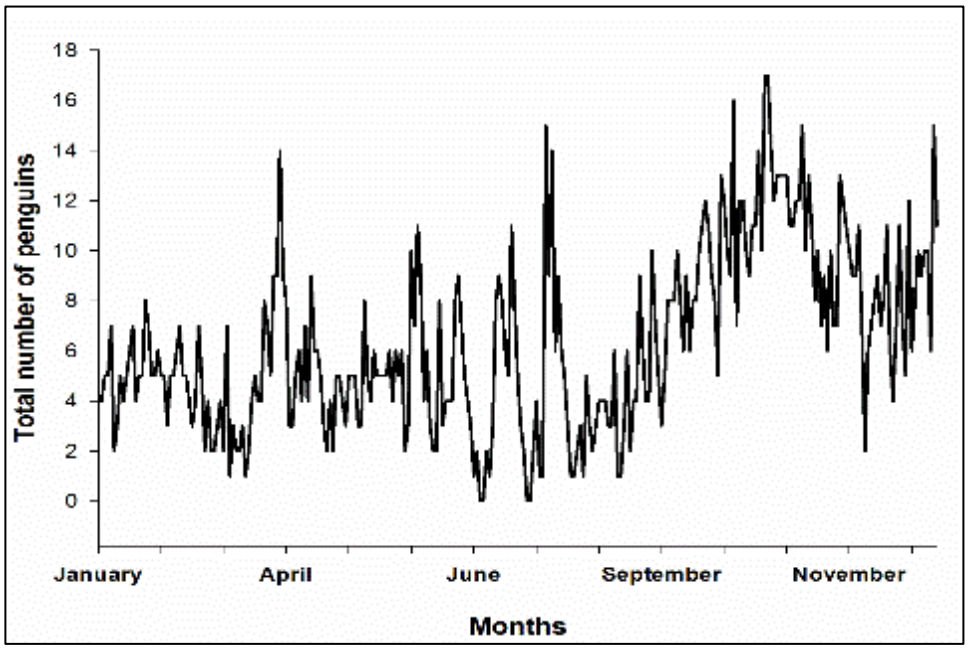

Figure 2. *Daily attendance of little penguins on Granite Island during the 2016 night tours (North Shore)*

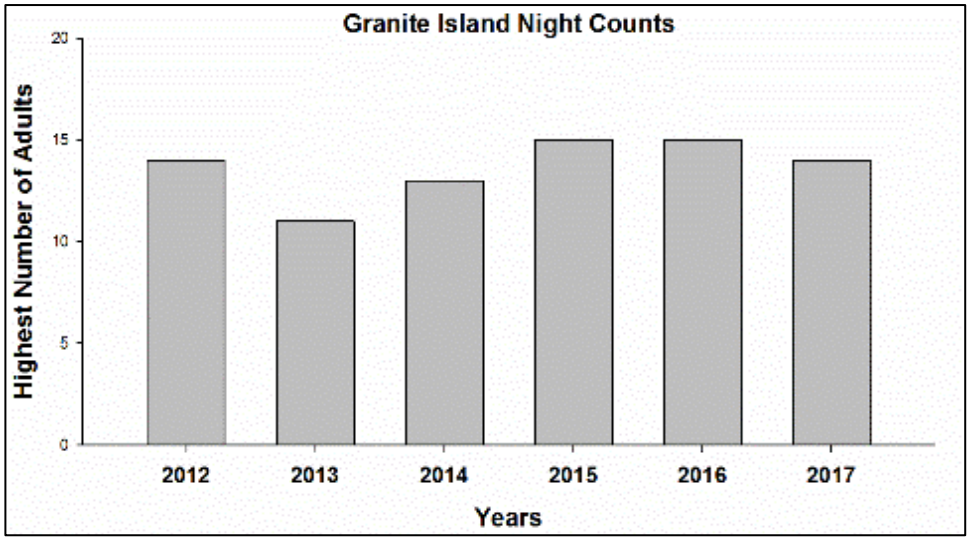

Figure 3*. Highest number of adult little penguins seen on Granite Island during the night tours (North Shore) between 2012 and 2016*

Population Census

Granite Island

Population census on Granite Island was conducted on the 10th of October 2016 by 18 volunteers and two penguin researchers. Five active burrows (mostly on the North Shore) were found on the day of the census and the population estimation for Granite Island at the time of the census was 10 adult penguins. Out of the five occupied burrows, all showed signs of breeding activity (Table 3). However, since the census date, three additional burrows were found active with birds preparing for breeding. Therefore, the Granite Island population is estimated at 16 adult penguins (Figure 4), which is confirmed by the regular night tour counts occurring on the North Shore (see Figure 3).

Penguin Colonies	No. Active Burrows	No. Burrows Breeding	No. Burrows with Adults	No. Burrows with Eggs	No. Burrows with Chicks
Troubridge	229	89 (39%)	163 (71%)	43 (19%)	46 (20%)
Granite	5	5 (100%)	0 (0%)	0 (0%)	5 (100%)

Table 3. *Percentage of burrows showing signs of breeding activity and number of burrows with adults, eggs and chicks for the 2016-census on Granite and Troubridge Islands*

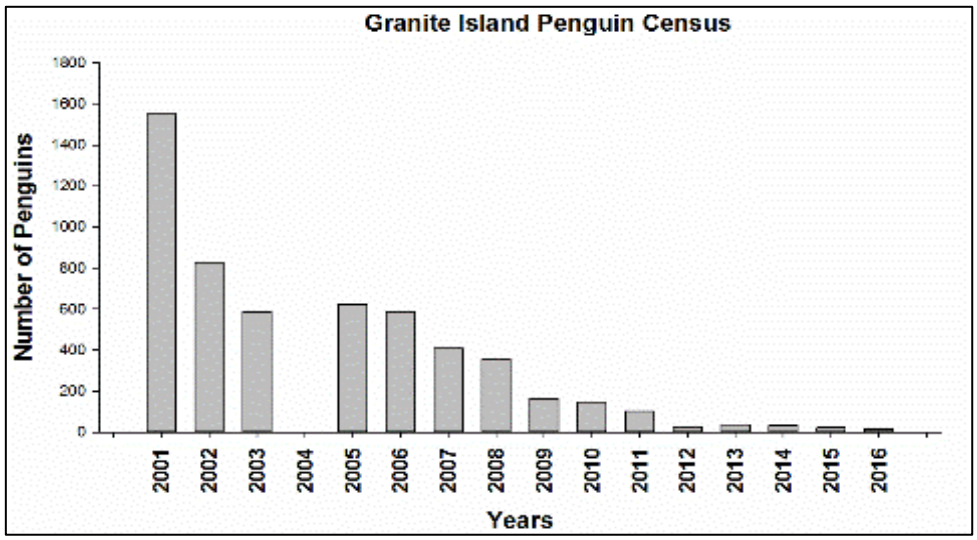

Figure 4. *Estimated population size of little penguins on Granite Island between 2001 and 2016*

Troubridge Island

Population census on Troubridge Island was conducted over three days (5-7th of October 2016) by a team of five people. A total of 229 occupied burrows and 311 empty burrows were found. As per previous years, 10% of the island could not be accessed and had to be extrapolated. With the estimation, this brings the population to 233 occupied burrows (466 penguins present on the island at the time of the census) and 318 empty burrows (total 551 burrows) (Figure 5). Out of the 229 occupied burrows that were found, 39% showed signs of breeding activity (89 burrows; Table 3). No additional burrows were found during the acoustic playback surveys, suggesting that penguin numbers did not increase during night time in 2016. Figure 6 shows the variation in spatial distribution of the active burrows found between 2013 and 2016.

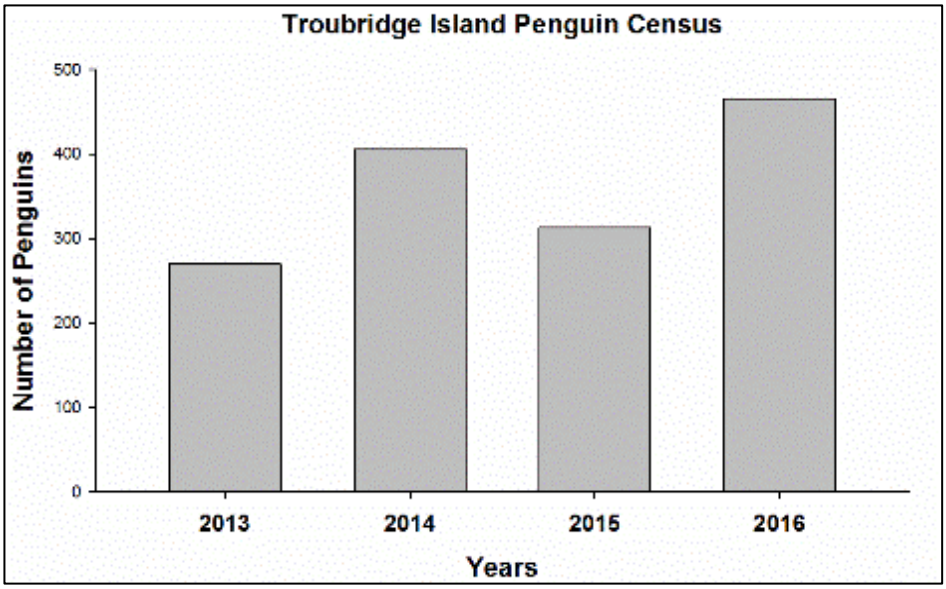

Figure 5. *Estimated population size of little penguins on Troubridge Island between 2013 and 2016*

Repeated censuses within a small section of Troubridge Island were conducted on the 17th of August, 16th of September, 26th of September, 5th of October and 9th of November by a team of three people. The number of active burrows found varied between visits, even within the same month, and fewer active burrows were found in November (Figure 7). However, the number of breeding burrows within this section remained the same (n = 6) since the 16th of September and less non-breeding burrows were found in November than in other months (Figure 7).

The second census (within four 30x30m quadrats) was conducted on the 23rd and 24th of April 2017 by a team of two people. During the October census, 5, 9 15 and 17 active burrows were found in each of the quadrat (46 active burrows in total). During the April census, 8, 13, 9 and 16 active burrows were found in each of the quadrat respectively (46 active burrows in total and 64 empty burrows). Only 3% of the burrows showed signs of breeding activity compared to 39% in October 2016.

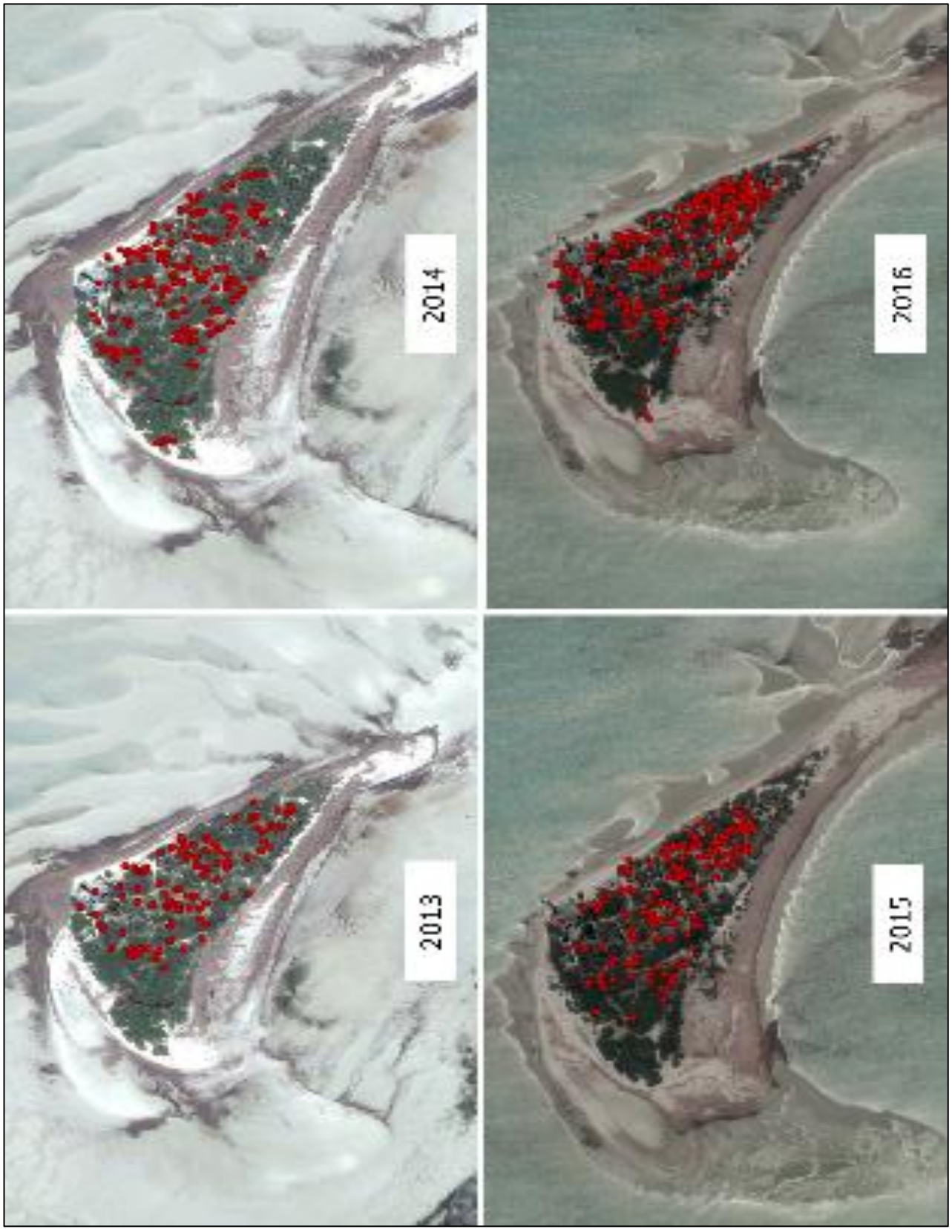

Figure 6. *Spatial distribution of the active burrows found on Troubridge Island in 2013, 2014, 2015 and 2016.*

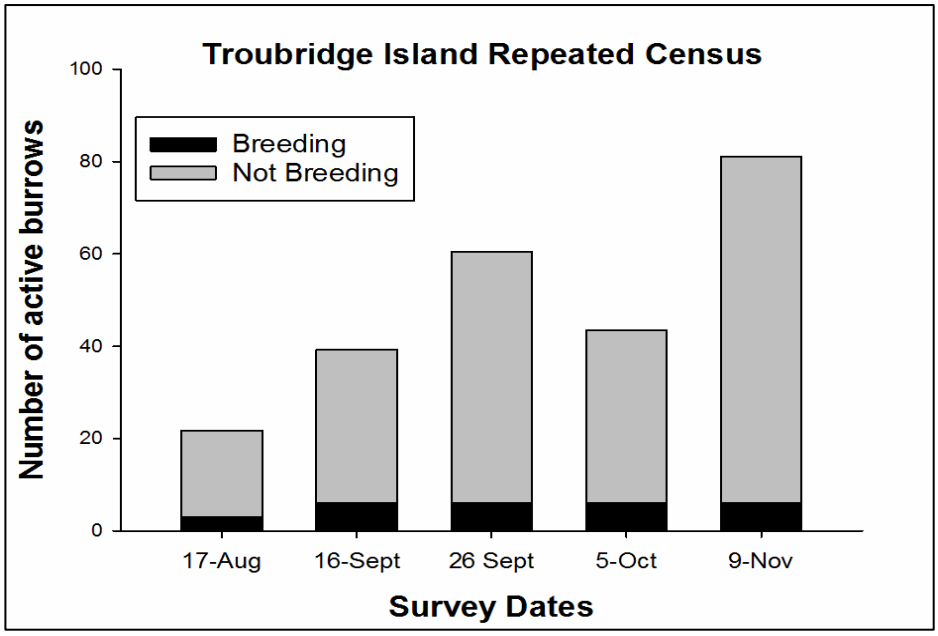

Figure 7. *Numbers of active burrows found within a small section of Troubridge Island surveyed five times between August and November 2016. The data are presented for the number of active breeding burrows (in black) and the number of active non-breeding burrows (in grey).*

Kangaroo Island

Population census at Emu Bay (sections Boat Ramp and Whittle) was conducted on the 19th of September by a team of three people. A total of 17 active and 42 inactive burrows were found (34 penguins estimated to be present in the colony; Figure 8). A night count was also conducted on the night of the 12th of October in the Playground section. An additional nine active burrows were found on this night and 14 adult penguins were seen. This brings the population of Emu Bay to 56 adult penguins.

Population census at Antechamber Bay (sections Cowry Beach, Post Point and Cape Coults) was conducted on the 1st of October by a team of three people. A total of three active and 38 inactive burrows were found (six penguins estimated to be present in the colony; Figure 8).

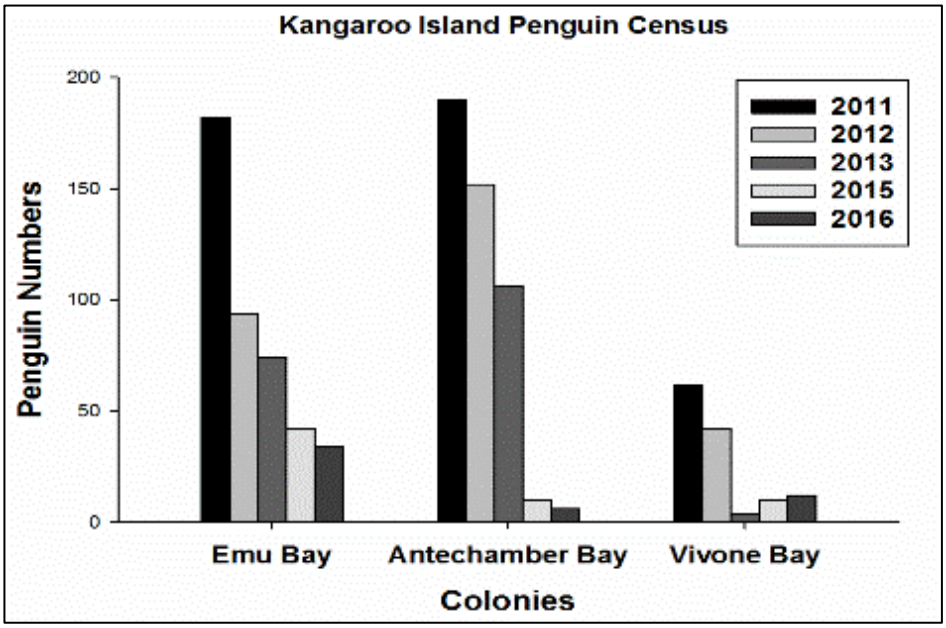

Figure 8. *Estimated population size of three little penguin colonies on Kangaroo Island between 2011 and 2016*

The section called Point Ellen North (Vivonne Bay) was extensively searched for active burrows on the 25th of October 2016 by a team of four people. Six active burrows were found on the day with only 1 burrow showing signs of breeding (1 adult and 2 eggs; Figure 7). Six adults were reported dead in early October with no mark from predation. An additional two chicks and one adult were found dead during the visit to the colony on 25/10/16 (Figure 9).

Figure 9. *Little penguin carcasses found at Vivonne Bay in October 2016*

Population census at Kingscote (Hospital Beach section) was conducted on the 1st of October by a team of three people. A total of five active and 90 inactive burrows were found on the day; however, four more active burrows were found on the other side of the jetty in subsequent searches. This brings the population of Kingscote/Hospital Beach to 18 adult penguins (Figure 10).

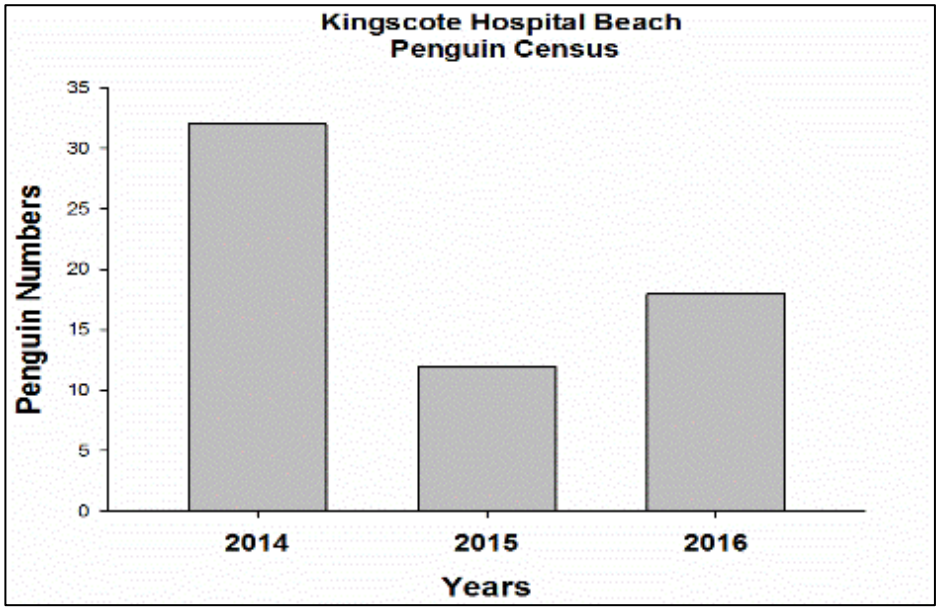

Figure 10. *Estimated population size of little penguins at Kingscote Hospital Beach between 2013 and 2016*

Althorpe Island

Althorpe Island was visited in October 2016 by the Friends of Althrope Island Group and a penguin survey was undertaken on the 31st of October 2016 in the area previously surveyed in 2013 by the Penguin Ecologist (circled in red in Figure 11). A total of 18 active burrows, 17 adults, four chicks and three eggs were found during this census (compared to 21 active burrows in the same area in 2013; Figure 11). Another census was conducted on the 17th of April 2016 by the Friends of Althrope Island Group in the same area. On this day, seven active burrows were found in the section, as well as one dead chick and evidence of moulting birds.

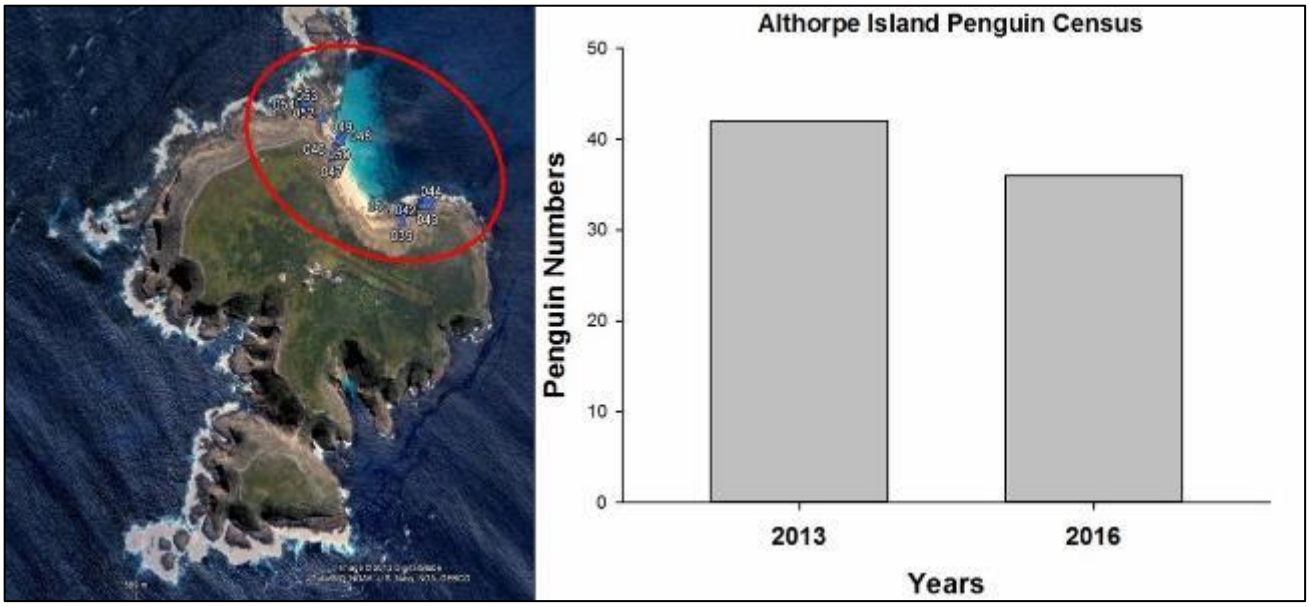

Figure 11. *Population census on Althorpe Island. On the left, map showing the location of the breeding area surveyed (circled in red). On the right, estimated population size of little penguins on Althorpe Island in 2013 and 2016*

Wardang Island

Four locations had previously been identified as potential little penguin breeding areas by Deborah Furbank (Natural Resources Northern and Yorke) in 2015: (1) Boat rock at the north, (2) Flatman beach near the lighthouse on the west coast, (3) below Bird point on the east coast and (4) Fossil beach at the south (Figure 12). Fossil beach was visited on the 19th of October 2016 by a team of six people and surveyed for active burrows. Forty-nine burrows were found on the day in this 1km long section: 16 were definitively active, 17 were inactive and the remaining 16 had evidence of activity earlier in the season (Figure 12). Flatman beach and Boat rock were visited on the 2nd and 10th of November respectively and surveyed for active burrows. Only three burrows were found at Flatman beach (2 active, 1 inactive). Thirty-three burrows were found at Boat rock, of which only nine were active (Figure 13).

Figure 12. *Map of Wardang Island showing the different little penguin potential breeding sites (on the left) and the burrows found during the 2016 search at Fossil Beach (on the right)*

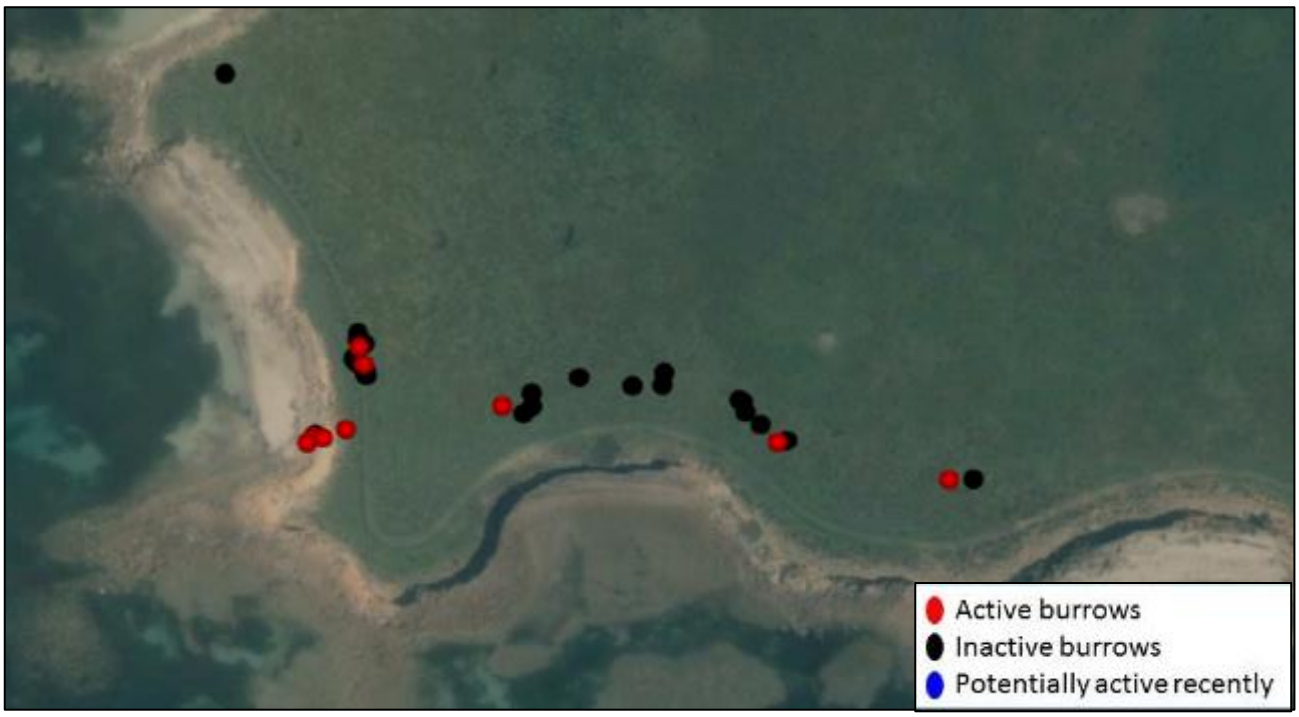

Figure 13. *Map of the burrows found during the 2016 search at Boat Rock*

Additional data: Stress response to cats

The study showed that little penguins exhibited the same responses after hearing some cat or little penguin vocalisations. Specifically, adults decreased their time spent resting, moving and preening, and increased their time spent in vigilance. They also trended to spend more time in distress behaviour in response to the cat playback but this was not significant. However, following the penguin playback, individuals remained more vigilant than following the cat playback. Little penguins also increased their heart rate in response to both playbacks but returned to baseline levels within few minutes following both playbacks. The study also highlighted some differences between the colonies. Individuals at Emu Bay showed a greater increase in vigilance and heart rate in response to both playbacks than those on Troubridge Island.

VI. DISCUSSION

The main findings of this study are: (1) Granite Island population continued to have the highest breeding success while Emu Bay population (on Kangaroo Island) continued to have the lowest; (2) Granite Island population showed stable trends since 2012; (3) Troubridge Island and Kingscote (KI) populations showed slightly increasing trends while Emu Bay (KI) and Antechamber Bay (KI) populations continued to show decreasing trends; (4) Althorpe Island populations showed potentially stable or slightly decreasing trends since the last census; and (5) little penguins exhibited a stress response when hearing cat calls, even if they had never been exposed to cats previously.

On Kangaroo Island, Emu Bay population continued to show decreasing trends since 2011. However, delayed arrival of adult birds may have biased the population count for 2016 as monitoring stopped in late October at this colony and breeding pairs were still forming and starting incubating at this time. Similarly, on Granite Island, only five breeding pairs were recorded during the census in October but three more pairs arrived afterward in November. Breeding activities of seabirds and daily attendance at the colony can vary significantly between months of the year (Figure 3) and years depending on weather and food availability (e.g., Mickelson et al. 1992; Fortescue 1999; Cullen et al. 2009). Such temporal variation means that considerable natural variation in the annual estimates of the penguin populations is to be expected. The timing of breeding activities can also vary spatially between colonies, as demonstrated on Wardang Island were 16 burrows were found recently active but not occupied. Therefore, a single count estimate could potentially underestimate the actual size of the breeding population (Reilly and Cullen 1981; Weerheim et al. 2003; this study).

Antechamber Bay (Kangaroo Island) also continued to show decreasing trends since 2011, which raises concerns that this population may become extinct in the near future. Out of the three burrows found active in this colony, only two burrows showed signs of breeding activities. Despite regular visits to the colony, no additional burrow was found during the 2016 breeding season, suggesting that delayed arrival of adult birds did not explain the observed low numbers. Vivonne Bay and Kingscote (Hospital Beach) colonies, on the contrary, showed slightly increasing or stable trends since the last census. However, further monitoring across the next years is necessary to confirm these trends as very few breeding pairs (three at Kingscote and only one at Vivonne Bay) were actually recorded in 2016.

In the Yorke Peninsula, Troubridge Island population showed slightly increasing trends since 2013 (see Colombelli-Négrel and Kleindorfer 2014) and one of the highest breeding success on record for this colony. The best breeding success for Troubridge Island was recorded in 2009 with 1.09 fledgling/breeding pair compared to 1.03 fledgling/pair in 2016. Their lowest breeding success on record was 0.16 fledgling/pair in 2006. In addition, hatching success in 2016 was the highest recorded, with 86% of the eggs hatching into chicks compared to 49% on average in other years. The repeated censuses showed that the numbers of active burrows found varied between visits, even within the same month, suggesting that a single count estimate could potentially underestimate the overall size of the population. The fact that the number of active burrows, but not the number of breeding burrows, varied between months suggests that some birds come ashore only for resting but do not breed, which aligns with previous finding that showed more birds present at night than during the day (Colombelli-Négrel 2016). However, the second census in 2017 showed that the overall number of birds present on the island remain similar across the two breeding seasons (April-July vs August-November), suggesting that the discrepancy between earlier censuses may be due to differences in methodology or reflect actual population decline.

On Troubridge Island, little penguins generally nest in shallow scrapes under thick vegetation rather than in burrows. Previous censuses estimated its population size based on presence/absence of scrapes, with 80% of the scrapes recorded as active being empty compared to only 23% on average in more recent censuses. Results of the repeated census of this study and the playback surveys of Colombelli-

Négrel (2016) suggest that ~40% of non-breeding individuals come ashore to rest but do not always remain in their burrow during the day. Based on this, Troubridge Island actual population size can be estimated between 466 and 652 adult penguins.

In addition, changes in the size of Troubridge Island (as a result of land erosion and sand movement) need to be considered. This is because sea-level rise and increase in the numbers of storm surges is predicted to reduce little penguin available habitats on low-lying islands (Dann and Chamber 2009). In 1838, Troubridge Island was estimated as 1.6 hectares in size while, in 1996, it was estimated as 2.9 hectares. In 2016, Troubridge Island is estimated to be approx. 1.2 hectares, which is a reduction of 59% of its size since the earliest little penguin censuses.

Population census on Althorpe Island seem to show stable trends (accounting for annual variation) since 2013 (Colombelli-Négrel and Kleindorfer 2014). In 2013, 42 adults were recorded in the breeding area surveyed in the north compared to 36 in the same area in 2016. However, it should be noted that the Friends of Althrope Island Group have not identified additional breeding areas within the island during their regular visits in 2014, 2015 and 2016. In 2013, only half of the potential breeding areas were visited and searched for active burrows (Figure 10) and the total population count was extrapolated for the whole island (Colombelli-Négrel and Kleindorfer 2014). If no other breeding area than the one located in 2013 exists, the Althorpe Island population would have decreased significantly since the 132 penguins found in 2004 (see Wiebkin et al. 2012). However, further monitoring, potentially at different times of the year (see above), is needed to confirm this trend.

On Wardang Island, 16 active burrows were found in 2016 at Fossil beach with another 16 suspected to have been recently active. This would bring the population count for this section to 64 adult penguins. Considering that the island has a coastline of approx. 24km, and that the area surveyed was 1 km long, one could extrapolate the population of little penguins to 1536 adults for the whole island. However, Deborah Furbank's searches in 2015 only showed four active breeding areas used by the little penguins on this island. This would reduce the estimated numbers to approx. 256 birds, which is much lower than the estimated number of 8000 penguins in 2004 (see Wiebkin 2011). Again, additional monitoring at different times of the year and across the whole island is needed to confirm population number for Wardang Island.

Population census on Granite showed stable trends since 2012, which was confirmed by the nightly counts (Figure 4). There is therefore hope for the future of Granite Island population, particularly considering that the 2016-breeding season showed their best breeding success on record: 2.25 fledgling/breeding pair compared to 1.00 fledgling/pair in 2015 and 1.67 in 2014. Their lowest breeding success was 0.23 fledgling/pair in 2001 (Colombelli-Négrel 2015). However, urgent measures need to be taken to control disturbance from human activities on Granite Island. The effects of human disturbance on seabirds can vary from temporary stress to desertion of the nest or the colony (e.g., Buckley and Buckley 1972; Morris and Hunter 1976; Anderson and Keith 1980; Safina and Burger 1983; Burger and Gochfeld 1993) and has resulted in lower breeding success in several penguin species (e.g., Hockey 1981; Wilson et al. 1990; McClung et al. 2004; Ellenberg et al. 2007). Abandonment of the nest induced by human disturbance can lower breeding success by increasing the chance of predation on eggs or chicks (Hockey 1981; Bolduc and Guillemette 2003), increasing offspring mortality due to exposure to the environment (Hunt 1972) or by reducing important parental behaviours such as feeding (Hunt 1972; Hand 1980; McClung et al. 2004).

On Granite Island, human disturbance and burrow vandalism in 2016 has resulted in adults abandoning their chick, despite the chick being close to fledgling. Two weeks after the parents abandoned their chick, people were still seen harassing adult penguins at night. Such disturbances occur on a fairly regular basis, mainly due to the lack of closure of the island at night, and can have serious consequences for the long-term survival of the little penguin population on Granite Island.

In addition to the direct disturbance caused by humans, people regularly walk their dogs within little penguin colonies. This is particularly the case on Granite Island (despite the signs prohibiting dogs on this island) but also on Kangaroo Island (Diane Colombelli-Négrel, pers. obs.) and Troubridge Island (Chris Johnston, pers. obs.). While little penguins were not tested for a stress response to dog barks, the fact that they exhibited a stress response when hearing cat calls, even when they had never been exposed to cats previously, suggest that they would also exhibit a stress response to other predators such as dogs. Dog attacks have been reported in other penguin colonies (see Wiebkin 2011) and a single dog can kill up to 30 individuals in one night (e.g., Penneshaw; The Islander, 2003).

Constant exposure to stressful situations (such as human disturbance or predator intrusion within the colony) stimulates a physiological response in the brain called the 'stress response', which in turn activate the release of particular stress hormones and can have long-term detrimental consequences for the individuals and the colony (Cyr and Romero 2007; Viblanc et al. 2015). These detrimental impacts range from stress-related diseases (Vleck et al. 2000), disruption of foraging abilities (Angelier et al. 2008) to reduction in breeding success (Viblanc et al. 2015, 2016) in adults and can impair development in juveniles (Angelier et al. 2008; reviewed in Lupien et al. 2009).

Considering that little penguins are already under several identified risks (see the Risk Assessment by the Department of Environment, Water and Natural Resources 2016), the additional stress caused by constant human disturbance and dogs, particularly on Granite Island, could have important consequences for population trends, especially considering that managing land-based risk pressures can improve the chances of little penguins persisting in the long term (Dann 2016).

VII. PROPOSED MONITORING PLAN

On the 30th of November 2015, a little penguin meeting was held highlighting the urgent need for a Monitoring plan to fill out the existing knowledge gaps in South Australian little penguin populations trends. The participants agreed that (1) strategic sites should be selected and surveyed to fill out these knowledge gaps; (2) a unique method should be used across all colonies to obtain comparable data; and (3) careful consideration needed to be taken when selecting the timing for the surveys as little penguins do not breeding synchronously across their range. The key objectives of this Action Plan are to address these comments and provide some costings and timing for the implementation of the proposed Plan.

Background

Accurate assessment of population size, distribution and trends are critical for detecting relevant changes and implementing appropriate conservation measures (Marsh et al. 1997). Inaccurate estimates can underestimate the ecological role of a particular species or misguide management and waste limited conservation resources (Sillett et al. 2012).

Seabirds, and penguins in particular, are one of the most threatened of all bird groups (Croxall et al. 2012). Seabirds play an essential role in many terrestrial ecosystems due to the amount of nutrients they transport from sea to land (Fukami et al. 2006) and are often seen as excellent bio-indicators of marine ecosystems health (Piatt et al. 2007; Humphries et al. 2015). As a consequence, seabirds have been used in many studies to assess the biological consequences of environmental changes (Piatt et al. 2007; Humphries et al. 2015). But estimating seabird population trends remains challenging for many species, mainly because of the logistical constraints imposed by their breeding locations (often on inaccessible or remote islands) and the sensitivity of these species to direct human disturbance.

The nocturnal burrow-nesting behaviour of some seabirds can make estimation of population size even more challenging because they cannot be viewed from a distance and are typically active on land only at night. In such cases, population estimates are usually based on marking a large number of birds (Sutherland and Dann 2012) or on estimation from burrow occupancy (Pearson et al. 2013). But many studies assume 100% occupancy, use unreliable indices of occupancy or fail to account for uncertainty in detection probabilities of burrow occupants (reviewed in Rayner et al. 2007) making assumptions about population size unreliable and not comparable.

To reduce errors in estimating population size, it is critical to consider potential sources of errors within each methodology and select or develop methodologies that reduce the impacts of those errors on estimates (Parker and Rexer-Huber 2016). Errors generally arise as a result of detection probability and temporal or spatial variability (Wolfaardt and Phillips 2011). This Action Plan reviews the methods used to estimate population size of burrow-nesting seabirds with the aims to identify key errors impacting accuracy when survey data are extrapolated and to suggest a framework for future surveys of South Australian little penguin populations.

Survey Methods

A number of methods are currently used to estimate the abundance of burrowing seabirds, including counts of attending birds (e.g., Renner et al. 2011) or active nests (e.g., Schultz et al. 2005) and relative index of seabird density using colony mapping (e.g., Renner et al. 2006) or automated acoustic surveys (e.g., Buxton and Jones 2012). Counts of active nests or individuals can be conducted over the whole colony or within selected sections using quadrats/transects and extrapolation (e.g., Schumann et al. 2013), either via mark-recapture modelling (e.g., Sutherland and Dann 2012) or predictive habitat modelling (e.g., Rayner et al. 2007).

Surveys using automated acoustic recorders can provide reliable data more rapidly and accurately than human-based survey techniques (Kirschel et al. 2011). The advantages are that the devices can be easily deployed and retrieved (requiring only two brief visits to the colonies thus limiting disturbance), can simultaneously record at multiple sites (allowing spatial and temporal comparisons) and can record vocal activity over long periods of time (thus accounting for short-term variation in attendance or vocal activity patterns) (Buxton and Jones 2012). They also provide a permanent record for re-analysis by independent observers (Swiston and Mennill 2009) and can collect spatial and behavioural information that may be not observable directly in the field (Kirschel et al. 2011).

Because vocal activity has been shown to increase with colony size (Bretagnole et al. 2000; Oppel et al. 2014), automated acoustic recorders may thus offer a practical and feasible approach to monitor relative population changes of nocturnal burrow-nesting seabirds on remote islands (Buxton and Jones 2012; Oppel et al. 2014) and provide data on relative abundance (Buxton and Jones 2012) and estimate of colony size. However, vocal activity varies considerably with environmental parameters (such as moonlight, season and time) and over the breeding season (Bretagnolle et al. 2000; Granadeiro et al. 2009). Therefore, it is doubtful that the entire population size of burrowing seabirds can be estimated with sufficient accuracy based on automated acoustic recorders alone (Bolton et al. 2010; Oppel et al. 2014).

As a result, direct burrow count is the most commonly used method to assess burrowing seabird population sizes because it can also produce a direct estimate of the population at a relatively low cost. However, this method presents a number of problems, primarily due to the difficulty of finding burrows, the importance of the timing for the searches and the potential disturbance to the nesting birds (Thomas 1996; Lormée et al. 2012; Ellenberg et al. 2007). A significant number of burrows can be missed during the searches due to their concealment or variation in search efforts over difficult terrain (Walter and Rusch 1997; Moore et al. 2001). For example, Hegg et al. (2012) confirmed that a non-negligible number of yellow-eyed penguin (*Megadyptes antipodes*) nests were missed during a single search and that a single nest count provided an underestimate of the true number of nests.

The reliability of nest searches can be calibrated through the use of multiple counts (Morrison et al. 2008) and by having experienced leaders standardizing methodologies between years and sites (Bourgeois et al. 2013). At the same time, the number of repeated counts should be limited because searching for burrows is an intrusive activity (McClung et al. 2004; Ellenberg et al. 2007). More than two searches per season is often not required, as the additional number of nests found by increasing search effort is often negligible (Hegg et al. 2012), but search efforts may vary between colonies. Schumann et al. (2013) showed that the proportion of transects to survey little penguins could only be reduced at one of their site, with the remaining islands requiring that all transects be surveyed to achieve estimates within the recommended detection rate (20% per annum) for seabird populations (Hatch 2003).

Burrow Occupancy

To generate an accurate estimate of population size, it is important to not only count burrows but also to determine burrow occupancy. The most widely used methods to determine burrow occupancy are to use a burrowscope (e.g., Lavers 2015), to measure response (or lack of) to call-playback (e.g., Soanes et al. 2012) or to feel for an occupant by hand or with a probe (e.g., Schulz et al. 2005).

The usefulness of response to call-playback vary between species because response rates can vary between species, colonies, years or individuals (e.g., Ratcliffe et al. 1998; Berrow 2000), and even within the breeding season (Ryan et al. 2006). It can also be biased when individuals are aggregated under a single shrub or nest in adjacent burrows or crevices (Soanes et al. 2012). The probability of an individual responding is also influenced by factors such as breeding condition, time of day, sex and/or features of the calls used for the playback (such as type of calls used, volume and duration) (Berrow

2000; Soanes et al. 2012). But even when call-playback reliably indicates occupancy, it is important to distinguish between breeding birds and non-breeding birds when estimating population size, which cannot be achieved with call-playback alone.

Therefore, methods that visually inspect the burrow contents are necessary but studies have shown that using more than one methods can be more reliable (e.g., McKechnie et al. 2007; Bonnet-Lebrun et al. 2016). This is because visual inspection of burrow contents using hand, probe or a burrowscope may be difficult when species have multiple entrances and chambers or deviating tunnels (Hamilton 2000; McKechnie et al. 2007; Cuthbert et al. 2013). Alternatively, burrow occupancy may be determined via checks of the same burrows by different observers (Whitehead et al. 2014), repeated checks over a period of time (MacKenzie et al. 2006) or via a capture-mark-recapture model where burrows represent an 'individual' and the presence of an occupant over several checks is considered a 'capture - recapture' (Sutherland and Dann 2012; Whitehead et al. 2014).

Timing

Burrow occupancy and seabird population size can vary both spatially and temporally (e.g., Berrow 2000; Weerheim et al. 2003; Whitehead et al. 2014). Temporal variation should be accounted for in study designs (Sutherland and Dann 2012), especially when populations are surveyed infrequently (Parker and Rexer-Huber 2016). The ideal period for assessing population size in burrowing seabird species is immediately after the laying period (Schumann et al. 2013), as surveys before this period will likely underestimate the breeding population (Sutherland and Dann 2012). However, heterogeneous or asynchronous breeding could lead to considerable differences in population size estimates (Sutherland and Dann 2012). To account for this, it is suggested to conduct more than one search within a season as single nest count can result in 25-60% of a breeding population being missed because numerous individuals are still yet to start breeding or might have failed already (Frederick et al. 2006).

Extrapolation

Errors with extrapolation occur when researchers assume 100% occupancy for species that are patchily distributed or when the area sampled is not representative of the whole colony (reviewed in Rayner et al. 2007; Parker and Rexer-Huber 2016). Extrapolation errors can be reduced by using a categorisation design, where a colony is divided into several areas (with each area having similar vegetation and burrow distribution) and data collected within a particular area is extrapolated only to this area (Rayner et al. 2007; Charleton et al. 2009). However, this may require a priori knowledge of the species and its distribution as Schumann et al. (2013) showed that little penguin habitat preference, and consequently burrow characteristics and distribution, varied between islands.

Little Penguin Survey Methods

In little penguins, population trends and burrow occupancy are generally determined via manual counts either in line transects (Weerheim et al. 2003; Stevenson and Woehler 2007), quadrats (Sutherland and Dann 2012, 2014; Schumann et al. 2013) or over the whole island (Bool and Wiebkin 2013; Colombelli-Négrel and Kleindorfer 2014). Little penguins tends to nest near the ocean where they have suitable landing sites and walking paths to access inland areas, but vegetation preferences vary between islands (Schumann et al. 2013). Burrows occupancy is inferred from signs of recent occupation (such as the presence of fresh digging, excrement or feathers) or the presence of adults, chicks or eggs (Weerheim et al. 2003; Schumann et al. 2013; Colombelli-Négrel and Kleindorfer 2014).

The prolonged breeding season and timing of breeding of the little penguins make interpretation of a single count difficult (Reilly and Cullen 1981; Weerheim et al. 2003) and the optimal time to estimate population size vary between locations. Little penguins breed from September to January in the east

(Schumann et al. 2013; Sutherland and Dann 2012) and from April to November in the west (Klomp et al. 1991; Cannell et al. 2012). Therefore, to maximize detection in population size changes, Sutherland and Dann (2012) recommend that little penguin burrow surveys incorporate regular monitoring of "reference sites" to correct for spatial and temporal variations in burrow occupancy.

Recommendations

1. Framework for future surveys of the South Australian little penguin populations should include a pilot study to estimate penguin distribution and habitat preference over each colony. The pilot visit should assess accessibility and the time required for spatial coverage, and confirm the main laying period.
2. Population trends should be assessed via manual counts of occupied burrows using quadrats or transects (based on the landscape of the colony). If the whole colony cannot be surveyed due to time or accessibility constraints, counts should occur via quadrats or transects within smaller sections. Sections should represent different habitats and penguin densities, which would be determined during the pilot study.
3. Quadrats within selected sections should be revisited at a later time within the same breeding season to assess temporal variation. Hence, each colony should be visited twice.
4. Burrow occupancy should be determined with a probe (and a burrowscope for very deep burrows). Burrows should be recorded as active only if they have clear signs of activity such as presence of penguins or fresh poo or digging. Empty or inactive burrows should also be recorded, and all burrows should be marked with GPS for repeatability by other researchers and to create reference maps.

South Australian Strategic Sites

The list of all known SA little penguin colonies is presented in Appendix 2. The following strategic sites were identified following discussions with Peter Copley (Department of Environment, Water and Natural Resources), Simon Goldsworthy (SARDI), Peter Shaughnessy (SA Museum), Jasmine Swales (Natural Resources Northern and Yorke), Greg Kerr (Natural Resources Pt Lincoln), Mark Anderson (Natural Resources Streaky Bay) and Robbie Sleep (Natural Resources Ceduna). The colonies in bold were suggested as strategic sites to survey in Dann (2016). Potential timing/time to survey some of the colonies was discussed with local experts.

Little Penguins colonies	Location/island group	Current population	Year last surveyed	Population Trends	Timing	No. days
Franklin Islands	Far West Coast	2000	2004	Stable	May/June	~ 1 day
Olive Island	Far West Coast	2290	2006	Unknown (data deficient)	May/June	~ 1 day
St Francis Island	Far West Coast	ND	1988	Unknown (data deficient)	May/June	~ 2-3 days
St Peter Island	Far West Coast	1000	2005	Unknown (data deficient)	May/June	~ 4 days
Flinders Island	Western EP	20	2006	Declined	May/June	~ 4 days
Waldegrave Island	Western EP	500	2006	Stable	May/June	~ 1 day
Pearson Island	Western EP	12000	2006	Unknown (data deficient)	May/June	~ 3 days
Wedge Island	Southern EP	100	2004	Suspected declined	May/June	~ 1-2 days
Boston Island	Southern EP	100	2006	Unknown (data deficient)	May/June	~ 1-2 days
Thistle Island	Southern EP	ND	2006	Unknown (data deficient)	May/June	~ 2-3 days
Spilsby Island	SJBG	100	2010	Declined	May/June	~ 1 day
Hareby Island	SJBG	500	2008	Suspected stable	May/June	~ 1 day
Reevesby Island	SJBG	1857	2009	Suspected stable	May/June	~ 1 day
Goose Island	Spencer Gulf	20	2005	Unknown (data deficient)	June/Oct	~ 1 day
Wardang Island	Spencer Gulf	8000	2004	Unknown (data deficient)	June/Oct	~ 2-3 days
Baudin Rocks	SE Coast	<60	2006	Declined	Oct/Nov	~ 1 day
Penguin Island	SE Coast	19	2015	Unknown (Data deficient)	Oct/Nov	~ 1 day

Estimated Costs

Costs are estimated to survey each region alone, for two visits per colony by a team of 4 people. Helicopter rates are estimated at $1500 per hour, boat rate are estimated at $1200 per trip and aircraft rates are estimated at $600 per hour. Costs to survey approx. ten colonies on Kangaroo Island are also presented.

Items	Funding required
Ferry to Kangaroo Island x 2 trips (4 people + car @ $464/trip)	$1128
Petrol costs to and within Kangaroo Island (4 trips; 800km per trip) @1.0ct/km	$1600
Accommodation in Kingscote for 11 days ($230/night for 4 people) x 2	$5060
Total Far Kangaroo Island	**$7788**

Items	Funding required
Helicopter to Franklin Islands (~40m flight return; $1000 x 2) x 2 trips	$4000
Boat to Olive Island ($1200) x 2 trips	$2400
Helicopter to St Francis Island (~1.5h flight return; $2250 x2) x 2 trips	$9000
Boat to St Peter Island ($1200) x 2 trips	$2400
Accommodation in Ceduna for 11 days ($200/night for 4 people) x 2	$4400
Flights to Ceduna ($500/person for return) x 2	$4000
Total Far West Coast	**$26200**
Boat to Flinders Island ($1200) x 2 trips	$2400
Helicopter to Waldegrave Island (~30m flight return; $750 x 2) x 2 trips	$3000
Helicopter to Pearson Island (~1.5h flight return; $2250 x2) x 2 trips	$9000
Helicopter transfer to Elliston (~2h flight; $3000) x 2 trips	$6000
Accommodation in Elliston for 10 days ($200/night for 4 people) x 2	$4000
Flights to Port Lincoln ($300/person for return) x 2	$2400
Petrol costs Port Lincoln to Elliston (400km per trip @1.0ct/km) x 2	$800
Total Western EP	**$27600**
Boat to Boston Island ($1200) x 2 trips	$2400
Aircraft to Wedge Island (~1h flight; $600 x2) x 2 trips	$2400
Aircraft to Thistle Island (~30min flight; $300 x2) x 2 trips	$1200
Flights to Port Lincoln ($300/person for return) x 2	$2400
Accommodation in Port Lincoln for 9 days ($200/night for 4 people) x 2	$3600
Total Southern EP	**$12000**
Boat to Spilsby Island ($1200) x 2 trips	$2400
Boat to Hareby Island ($1200) x 2 trips	$2400
Boat to Reevesby Island ($1200) x 2 trips	$2400
Flights to Port Lincoln ($300/person for return) x 2	$2400
Accommodation in Port Lincoln for 4 days ($200/night for 4 people) x 2	$1600
Total SJBG	**$11200**
Boat to Goose Island @ $1200 per trip x 2	$2400
Boat to Wardang Island @ $1200 per trip x 2	$2400
Accommodation in Port Victoria for 5 days ($200/night for 4 people) x 2	$2000
Petrol costs Adelaide to Port Victoria (400km per trip @1.0ct/km) x 2	$800
Total Spencer Gulf	**$7600**
Boat to Baudin Rocks @ $1200 per trip x 2	$2400
Boat to Penguin Island @ $1200 per trip x 2	$2400
Accommodation in Robe for 4 days ($200/night for 4 people) x 2	$1600
Petrol costs Adelaide to Robe (680km per trip @1.0ct/km) x 2	$1360
Total SE Coast	**$7760**

TOTAL (inc GST)	**$92360**

VIII. DIRECTIONS FOR FUTURE RESEARCH

1) Continue long-term annual monitoring of populations trends, survival, threats and breeding success across targeted populations in the Gulf St Vincent to build reliable databases.

2) Conduct population surveys and identify threats at strategic sites to get a better understanding of the little penguin status in South Australia as outlined in Dann (2016).

3) Assess spatial variation of predation by long-nosed fur seals across more colonies within South Australia to measure the long-term impacts for little penguin population trends as outlined in Dann (2016).

4) Identify parasite infections and vectors across colonies with different population trends to better assess their impact on population trends.

5) Investigate variation in food availability, foraging effort and resource use between colonies and their impact on population trends.

6) Determine to which extent little penguins can respond to environmental change (i.e., introduced predators, disturbance from human activities and climate change).

7) Develop population viability analysis models to explore how variation in each of the parameters listed above affect population trends and population vulnerability.

IX. MANAGEMENT RECOMMENDATIONS

1) Continue rat control on Granite Island to maintain high breeding performance as rat numbers seem to be increasing recently according to night tour guides.

2) Increase/improve security on Granite Island to prevent unauthorised public access at night. This could be achieved by installing a proper gate on the causeway and additional security cameras along the tram line.

3) Consider intensive cat and dog control and increase public awareness about the impact of pets on Kangaroo Island to improve long-term persistence of colonies.

X. COMMUNITY ENGAGEMENT

Eighteen volunteers participated in the Granite Island penguin census in October 2016. An additional twenty-one volunteers participated in field trips to collect the data and helped with penguin census on the other islands. One Honours student worked on a little penguin related project (specifically investigating stress response to cat).

Diane Colombelli-Négrel gave a presentation to the public on Granite Island on the 10th of October 2016 for the census and an article calling for community volunteers to join the Granite Island Penguin count was released in September 2016 in the Victor Harbour Times. Diane Colombelli-Négrel gave three radio interviews to ABC News on the 10th and 11th of October 2016 and on the 30th of January 2017, one TV interview to Channel 7 News on the 2nd of March 2017 and prepared two media releases regarding the Granite Island population, which were published in (1) the Victor Harbour Times on the 2nd of February 2017 and (2) the Advertiser on the 10th of March 2017. Research assistant Vanessa Owens raised public awareness about little penguin conservation issues and presence of little penguins on Granite Island to 72 people.

XI. ACKNOWLEDGEMENT

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XIII. APPENDIX 1 - List of microchipped individuals that were re-sighted in 2016

Island	Reference Number	Year Microchipped
Troubridge Island	982000063644673	2014
Troubridge Island	157468403	unknown
Troubridge Island	982000063645151	2014
Emu Bay	982000063644178	2014
Emu Bay	982000063644657	2014

XIV. APPENDIX 2 - List of the little penguin colonies in South Australia

Little Penguins colonies	Location group	Population size	Year last visited	Suspected Population Trends
Franklin Islands (E and W)	Far West Coast	2000	2004	Stable
Blefuscu Island	Far West Coast	ND	1981	Unknown (data deficient)
Bunda Cliffs/Nullarbor Cliffs	Far West Coast	100	2006	Unknown (data deficient)
Dog Island	Far West Coast	ND	1982	Unknown (data deficient)
Egg Island	Far West Coast	ND	1982	Unknown (data deficient)
Evans Island	Far West Coast	500	2005	Unknown (data deficient)
Eyre Island	Far West Coast	ND	1982	Unknown (data deficient)
Fenelon Island	Far West Coast	ND	1982	Unknown (data deficient)
Freeling Island Nuyts Arch	Far West Coast	ND	1982	Unknown (data deficient)
Goat Island, off St Peter Island	Far West Coast	ND	1982	Unknown (data deficient)
Lounds Island	Far West Coast	ND	1982	Unknown (data deficient)
Olive Island	Far West Coast	2290	2006	Unknown (data deficient)
St Francis Island	Far West Coast	ND	1988	Unknown (data deficient)
St Peter Island	Far West Coast	1000	2005	Unknown (data deficient)
Flinders Island	Western EP	20	2006	Declined
Nicolas Baudin Island (CP)	Western EP	ND	2005	Not a breeding colony
Waldegrave Island	Western EP	500	2006	Stable
Greenly Island	Western EP	1500	2004	Suspected stable
Dorothée Island	Western EP	200	2004	Unknown (data deficient)
North Veteran Island	Western EP	ND	1980	Unknown (Data deficient)
Pearson Island	Western EP	12000	2006	Unknown (data deficient)
Rabbit Island, Coffin Bay	Western EP	ND	2008	Unknown (data deficient)
West (Little) Waldegrave island	Western EP	ND	2013	Unknown (data deficient)
Neptune Island	Southern EP	0	2014	Extinct
Wedge Island	Southern EP	100	2004	Suspected declined
Albatross Island	Southern EP	ND	1982	Unknown (data deficient)
Avoid Island (Sudden Jerk Is.)	Southern EP	ND	1981	Unknown (data deficient)
Black Rocks	Southern EP	ND	1981	Unknown (data deficient)
Boston Island	Southern EP	100	2006	Unknown (data deficient)
Curta Rocks - North	Southern EP	ND	1982	Unknown (data deficient)
Curta Rocks - South	Southern EP	ND	1982	Unknown (data deficient)
Four Hummocks	Southern EP	ND	1980	Unknown (data deficient)
Lewis Island	Southern EP	100	2006	Unknown (data deficient)
North Islet (north of Wedge Island)	Southern EP	ND	2005	Unknown (Data deficient)
Owen Island	Southern EP	ND	1982	Unknown (data deficient)
Rabbit Island, Pt Lincoln	Southern EP	ND	2008	Unknown (data deficient)
Smith Island	Southern EP	ND	1982	Unknown (data deficient)
Thistle Island	Southern EP	ND	2006	Unknown (data deficient)
Spilsby Island	SJBG	100	2010	Declined
Dangerous Reef	SJBG	0	2010	Not a breeding colony
English Island	SJBG	0	2011	Suspected Extinct
Hareby Island	SJBG	500	2008	Suspected stable
Reevesby Island	SJBG	1857	2009	Suspected stable

Blythe Island	SJBG	ND	2009	Unknown (data deficient)
Boucaut Island	SJBG	ND	1980	Unknown (data deficient)
Dalby Island	SJBG	ND	1980	Unknown (data deficient)
Duffield Island	SJBG	ND	1990	Unknown (data deficient)
Kirkby Island	SJBG	ND	1980	Unknown (data deficient)
Langton Island	SJBG	ND	1980	Unknown (data deficient)
Lusby Island	SJBG	ND	2009	Unknown (data deficient)
Marum Island	SJBG	ND	1980	Unknown (data deficient)
Partney Island	SJBG	ND	2009	Unknown (data deficient)
Roxby Island	SJBG	ND	2009	Unknown (data deficient)
Sibsey Island	SJBG	10	2004	Unknown (data deficient)
Stickney Island	SJBG	ND	1980	Unknown (data deficient)
Winceby Island	SJBG	ND	2009	Unknown (data deficient)
Lipson Island	Spencer Gulf	52	2011	Stable
Goose Island	Spencer Gulf	20	2005	Unknown (data deficient)
Green Island	Spencer Gulf	ND	1981	Unknown (data deficient)
Wardang Island	Spencer Gulf	8000	2004	Unknown (data deficient)
Althorpe Island	Southern YP	84	2013	Suspected declined
Chinaman’s Hat Island	Southern YP	ND	1982	Unknown (data deficient)
Middle Island	Southern YP	ND	1982	Unknown (data deficient)
Royston Island	Southern YP	ND	1982	Unknown (data deficient)
Seal Island, Althorpe group	Southern YP	ND	1982	Unknown (data deficient)
Troubridge Island	N Gulf St Vincent	466	2016	Suspected stable
Antechamber Bay	KI	6	2016	Declined
Cape Cassini	KI	12	2013	Declined
Emu Bay	KI	56	2016	Declined
Kingscote	KI	128	2014	Declined
Penneshaw	KI	112	2013	Declined
Snellings Beach	KI	4	2013	Declined
Stokes Bay	KI	8	2013	Declined
Vivonne Bay	KI	68	2013	Declined
Busby Islet	KI	0	2014	Extinct
Ravine des Cassoars	KI	0	2006	Extinct
Cape Gantheaume	KI	0	2004	Extinct
Western River Cove	KI	0	2013	Extinct
Harvey's Return	KI	0	2006	Suspected Extinct
American River	KI	ND	2010	Unknown (data deficient)
Beatrice Island	KI	ND	1970	Unknown (data deficient)
Breakneck river	KI	ND	1970	Unknown (data deficient)
Browns Beach	KI	32	2008	Unknown (data deficient)
Cape Willoughby	KI	116	2008	Unknown (data deficient)
Cape Younghusband	KI	ND	1989	Unknown (data deficient)
Christmas Cove	KI	140	2008	Unknown (data deficient)
Maupertuis Bay	KI	ND	1970	Unknown (Data deficient)
Nobby Islet	KI	ND	1982	Unknown (Data deficient)
Pelorous Islet	KI	ND	1982	Unknown (Data deficient)

Rocky River	KI	ND	1970	Unknown (Data deficient)
Seal Bay	KI	32	2010	Unknown (Data deficient)
Granite island	FP	16	2016	Declined
South Page Island	FP	10	2009	Declined
Hindmarsh Island	FP	0	1970	Extinct
Pullen Island	FP	0	2013	Extinct
West Island	FP	0	2013	Extinct
Wright Island	FP	0	2013	Extinct
Seal Island/rocks, Encounter Bay	FP	0	2013	Not a breeding colony
North Page Island	FP	ND	2004	Unknown (Data deficient)
Baudin Rocks	SE Coast	<60	2006	Declined
Port MacDonnell	SE Coast	10	2016	Suspected declined
6km NW Cape Martin	SE Coast	ND	1978	Unknown (data deficient)
Cape Banks	SE Coast	16	2015	Unknown (data deficient)
Penguin Island	SE Coast	19	2015	Unknown (Data deficient)