Independent report on the risk assessment for little penguins in South Australia including management recommendations and priorities

DEWNR report

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Department of Environment, Water and Natural Resources

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Report prepared for Department of Environment, Water and Natural Resources (DEWNR)

by

Peter Dann (PhD)
Research Manager
Phillip Island Nature Parks
Phillip Island, Victoria. 3991.

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Executive summary
Sixty percent of the world's penguin species are classified as threatened and the little penguin *Eudyptula minor* is facing increasing threats across its range in southern Australia. The conservation status of little penguins in South Australia has come into focus over recent years as some colonies have significantly decreased in size while others have disappeared. Accordingly, DEWNR has provided a framework and facilitated a process to synthesize published and collective knowledge of stakeholders to allow an assessment of the status of penguins and to evaluate the risks facing penguins in South Australia over the next five years.

The purpose of this report is to provide an independent view of the risk assessment process and outcomes as well as recommend management actions and priorities.

This risk assessment process identified a number of high and very high risk pressures that are likely to have an influence on the distribution and abundance of little penguins in South Australia and associated socio-economic values over the next five years. The suite of pressures and threats identified through the workshop process was comprehensive and corresponded well with threats identified for little penguins elsewhere in Australia. The relative ratings level of risks was sound.

The rating of land-based predation, marine-based predation and socio-economic risks as very high-risk pressures is appropriate as the first two are capable of shaping the distribution and abundance of penguin populations and the latter is a consequence of these.

Land-based predation of penguins by introduced mammalian carnivores rated a significant pressure and one that requires management if penguins are to persist. There are examples where these predators have been greatly reduced in number or, in some cases, eliminated entirely.

Predation by long-nosed fur seals (LNFS) will be an important driver of penguin population dynamics in some parts of South Australia in the next five years. It cannot be predicted what kind of LNFS/penguin equilibrium will be reached in the longer-term based on our current understanding of the interaction between these two species. However there is some genetic evidence that suggests penguins may not have been present in some parts of South Australia historically when LNFS were much more abundant.

The socio-economic consequences of the changing abundance of penguins will obviously be dependent upon the outcomes of a suite of drivers; however it appears there are still penguins in low numbers at each of the three main tourism sites. Addressing the land-based risk pressures at these sites will improve the penguins' chances of persisting there in the longer term.

Two of the four high-risk pressures are reflections of higher risk pressures at a smaller scale, one highlights the potential loss of habitat through erosion while the final high-risk pressure

encapsulates various processes and events associated with penguin "food availability". The latter is highly complex, usually poorly understood and rarely dealt with to everyone's satisfaction.

There are data deficiencies related to penguin colony size, trends in abundance and threats that need to be addressed before a clearer picture of what the future distribution and abundance of penguins in South Australia will look like. Quantifying the rates of predation by LNFS on penguins and the nature of the seal/penguin interaction will be pivotal in making predictions about the rate and extent of change in patterns of penguin distribution and abundance in South Australia.

Priorities for management are the removal or reduction of introduced mammalian predators wherever possible; a public communication plan of our understanding of the interaction between long-nosed fur seals and penguins; and site-specific plans to protect penguins at the three tourism sites and the colonies in the South-east.

It is recommended that consideration be given to monitoring focal penguin colonies across South Australia in the longer-term and to conduct a state-wide penguin census and inventory of colonies and their threats. Further studies are recommended to address some of the key questions about LNFS such as their predation rates on penguins and more detail on where, how and by what LNFS the penguins are being predated.

Introduction

Sixty percent of the world's penguin species are classified as threatened (Birdlife International 2012). The reasons for their decreasing conservation status are varied but in a review of anthropogenic threats facing the world's penguins, Trathan et al. (2015) identified habitat loss, pollution and fishing as the primary threats with climate change emerging as a future threatening process. In addition they noted that any resilience of penguin populations to further climate change impacts will depend on the extent to which current terrestrial and marine threats are addressed (Trathan et al. 2015).

Taxonomy of Little Penguins in southern Australia

Little Penguins *Eudyptula minor* breed across southern Australia and around the islands of New Zealand (Stahel and Gales 1987). It is likely that *E. minor* will be split into two species in the near future and most of the Little Penguins in New Zealand elevated to specific status with the exception of the population in Otago in the south-east of the South Island which will remain conspecific with the Australian population (Grosser et al. 2015). Across southern Australia, studies of spatial structuring of genetic variation identified an eastern and a western form which were not sufficiently differentiated to be considered species (Overeem et al. 2008, Peucker et al. 2009). Both forms occur in South Australia and there is a very narrow zone of contact between the two forms between Troubridge and Granite Islands (Burridge et al. 2015). The nature of this zone suggests that the two forms may have come into secondary contact in this area relatively recently rather than a hard barrier having limited genetic exchange across the zone in the longer term (Burridge et al. 2015). The presence of this contact zone could be interpreted to mean that historically there may not have been Little Penguins in some parts of

the area currently occupied in South Australia.

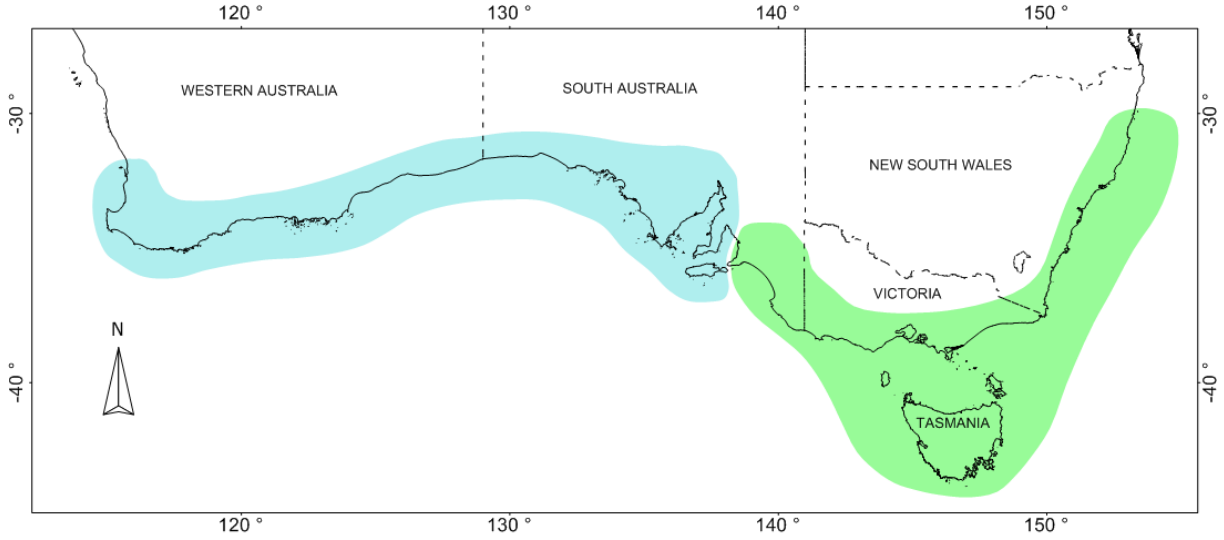

Figure 1: The geographical ranges of the western (aqua shading) and eastern (light green shading) "lineages" of little penguins in South Australia (drawn after Burridge et al. 2015).

World population size and trends of little penguins (updated from Dann 2013)

General trends: Overall numbers of little penguins appear to have declined in some parts of Australia, particularly on mainland south-eastern Tasmania and in some parts of South Australia as well as on the south Island of New Zealand. In both New Zealand and Australia there have been little apparent change on most offshore islands, although quantitative data are lacking. While decreasing numbers have been documented at some sites in southern Australia, significant downward trends have not been reported in Bass Strait where the majority of the species occurs. In addition increases have been reported at some sites, and in one case, an increase of almost 20,000 breeding birds has been recorded over several decades. A conservative assessment is that the nett population number is decreasing slowly. While trends in population numbers are influenced by significant increases at some colonies as a result of threat management, the trend in the number of penguin breeding sites is much more obvious as few new sites have been established while significantly more breeding sites have ceased to be used by penguins. Hence the number of sites used by penguins for breeding has clearly decreased overall in Australia, particularly mainland Tasmania and in South Australia and, in New Zealand, on the South Island.

The world breeding population is thought to be ~600,000 birds, comprising ~500,000 in Australia (Ross et al. 1995, Dann et al. 1996) and ~50,000 to 100,000 in New Zealand (estimated from Robertson and Bell 1984). These figures are underestimates as new colonies are still being found and many have not been adequately surveyed. Numbers of pre-breeding individuals are unknown and would vary dramatically in concert with breeding productivity and post-fledging survival rates (Dann 2013). In South Australia it has been estimated that there are 36,600 breeding individuals, unevenly distributed at approximately 100 colonies (Wiebkin 2011). The locations and population estimates of South Australian colonies are summarised in DEWNR (2016).

The conservation status of little penguins across their range is currently "least concern" (Birdlife International 2012), however this is under review and may be upgraded to "near threatened" in the light of recent trends in population numbers and numbers of sites (Dann 2013). For the majority of little penguin colonies there are insufficient data to determine trends accurately and the indications of population change are usually derived from anecdotal

information of drastic changes in distribution or abundance. There are regions such as northern Tasmania and a few colonies in south-eastern Australia and New Zealand where populations have increased in size in recent decades in response to management (Dann 2013). However there are obvious trends too, often regionally-based, that suggest widespread population decline in areas such as south-east Tasmania (Stevenson and Woehler 2007), Otago region of South Island, New Zealand (Dann 1994) or South Australia (Wiebkin 2011, DEWNR 2016).

In South Australia, as elsewhere, many colonies have not been surveyed sufficiently for trends to be established while, for those where some data exist, some appear stable and others decreasing (Wiebkin 2011, DEWNR 2016). In 2015 a Threatened Species Schedule Review workshop assessed the conservation status of little penguins in South Australia to be "*Near Threatened NT (A2ae) for little penguin – because the status could be said to be approaching Vulnerable A2ae"* (Gillam *unpubl*. 2016). The status may be reviewed pending the finalisation of this risk assessment.

Community and nature-based tourism concerns have accompanied several well-documented declines at little penguin colonies in South Australia and a variety of factors have been proposed for these declines. The Department of Environment, Water and Natural Resources (DEWNR) has conducted a risk assessment process to identify, analyse, and evaluate risks to little penguins in South Australia (DEWNR 2016).

As a first step in an ecological risk assessment of little penguins in South Australia, DEWNR compiled a list of all known penguin colonies in South Australia. Subsequently, DEWNR compiled and updated what has been documented about relative numbers and current trends within each colony (where documented), identified the various threats and pressures operating on each colony and then prepared a draft risk assessment for each colony based on the assessed likelihood and consequence of each pressure (threat) effecting that colony. A draft background report identified physical drivers, pressures and existing management on little penguin colonies. The report included a first-attempt at completing the risk assessment spreadsheet which was then forwarded to a range of experts and interested stakeholders for their input. They were asked to provide their own risk assessment(s) for any colony (-ies) that they were familiar with and to return these prior to the workshop held on 24 May 2016. These stakeholders were invited to participate in the workshop to compare and assess the risk assessments made for each colony by other attendees. The risk assessment scores were then used to identify where there were differences of opinion about risks at different colonies, to help guide discussions in the workshop. Once the relative risks were identified for different little penguin colonies, options for the management of pressures and socio-economic values were then discussed and evaluated for their feasibility during a risk assessment workshop. As a result of the risk assessment workshop, two reports are being produced. The first is an expansion of the background report incorporating workshop outcomes (namely results of the risk analysis and summaries of management options discussed) to form a final background report and the second report, an independent review of the process and future options and priorities.

This report is the independent review of this process and a consideration of research, monitoring and management options and priorities for little penguins in South Australia. It is informed by the background report (DEWNR 2016) and is designed to provide evidence-based policy advice. Its recommendations are intended to inform state level policy and management, after consideration of resource constraints, evidence uncertainties and broader public values.

Results and outcomes of the risk assessment workshop for little penguins in South Australia

Summary of key messages from background report and workshop

Data for Little Penguin distribution and population sizes in South Australia vary spatially, temporally and in method of collection and quality.

- Few long-term time series
- Extensive geographical gaps
- Inconsistency in type and quality of data collected between studies and sites
- No data for many colonies
- Studies have increased in last decade

Spatial and temporal trends in population data

- Spencer Gulf to SA/WA border: data deficient in Spencer Gulf, some stability in population size on the west coast of Eyre Peninsula. Only one colony known to be declining (Flinders Island)
- Kangaroo Island & Encounter Bay: declines evident
- Baudin Rocks to Cape Northumberland: few sites (5), some declines probable

General patterns of risk/threats to penguins in South Australia

- Conservation status varies by region in SA -critically endangered (1), endangered (1), Vulnerable (1) & Data deficient (2)
- Risk/threats are multifactorial (often no single threat/risk evident)
- Spatial variation of threats (threats or combinations of threats vary between sites)
- Temporal variation in threats (suite of threats & presence/intensity of threats has changed since European Settlement)
- Suite of threats identified in South Australia similar to those for little penguins elsewhere (exception is predation by Rosenberg's goannas)
- Broad association between geographic region in SA and suite of threats
- Insufficient data available to assess threats empirically

Site-specific risk/threats/issues to penguins

- Granite Island: chick productivity was high & increased after rat control, but survival estimates of adults unsustainably low
- Kangaroo Island, Emu Bay: Rosenberg's goanna photographed killing penguin chicks & estimated proportionally high rate of penguin predation, brush-tailed possums visited burrows but no predation observed, cat predation likely to be significant.
- Troubridge Island: habitat loss due to storm surge erosion
- Olive & Pearson Islands & Granite Island: there appears to have been a shift in breeding phenology (becoming later)

Long-nosed fur seal

- Sub-adult males come inshore during winter
- Incidence of feathers in scats suggests unrealistic predation rates (trophic modelling suggests 50x consumption of penguins than exist)
- Incidence of feathers in scats highly variable between sites
- Penguins more prevalent in scats where they are less abundant
- LNFS impacts on penguins east of a nominal line south of the tip of Eyre Peninsula are high and are low west of the same line.
- 80% of the LNFS Australian population is in SA
- Penguin and LNFS foraging areas overlap south of KI particularly
- Population is recovering post-harvesting in early 1800s.

Workshop proceedings and risk ratings

The risk ratings are a product of likelihood and consequence and theoretically could range from 0 to 16 (remote score-0 to likely-score 4 x negligible consequence-score 0 to catastrophic consequence-score 4). In this exercise the risk ratings ranged from 0 to 12. Importantly in this process the consequence ratings are based on the outcome of the risk if there are no controls in place i.e. no management actions implemented.

Evaluation of workshop proceedings and outcomes

This process had two elements that contributed significantly to the outcomes: a draft document on penguin distributions, threats and trends and a risk assessment workshop. Importantly the draft document collated available information and was circulated prior to the workshop. This document served as a basis for the discussions at the risk assessment and ensured all participants were well informed. The risk assessment process of harnessing collective knowledge in a workshop provided a viable means of predicting likely trends and pressures where information was patchy or in the absence of extensive datasets. Confidence about trends and threats was strengthened when sites were considered regionally as some common themes emerged. The consensus of local knowledge generally concurred with experience about likely trends and the drivers of penguin population pressures elsewhere. The risk assessments was simplified by maintaining a focus on the next five years and hence potential climate change effects were not included in this time frame. The outcomes of the workshop provided sufficient evidence to drive policy and management in the short-term, particularly on land, and identified significant knowledge gaps.

Main threats to Little Penguins identified in a review of Australian and New Zealand populations (modified from Dann 2013)

This section on the threats to little penguin populations in Australia and New Zealand is included to place the threats listed for South Australian penguin colonies in a broader setting. The substantial overlap and priorities for threat management between the workshop and from this review (Dann 2013), also provides additional confidence in the outcomes of this risk assessment process.

In an analysis of little penguin colonies along the Victorian coast in Australia, Dann and Norman (2006) concluded that available breeding area as well as food supply during breeding may be involved in the regulation of little penguin populations locally. The relationship between population sizes and available breeding area suggested that little penguin numbers

may be limited on smaller islands by area but clearly are not on larger islands. Breeding success is related to the foraging area available around breeding colonies (Chiaradia et al. 2007) and colony size (Dann and Norman 2006). Changes in adult survival have a much greater impact on the size of little penguin populations than do changes in juvenile survival or breeding productivity (Dann 1992) and, therefore, factors effecting adult survival are likely to be more significant threats. The main threats to little penguins vary between colonies and the following is a brief review of known and potential threats.

Introduced mammalian predators: Introduced mammalian predators in Australia (foxes [*Vulpes vulpes*], dogs [*Canis familiaris*] and cats [*Felis catus*]) and in New Zealand (ferrets [*Mustela furo*], stoats [*Mustela erminea*], cats and dogs) have been reported taking eggs, chicks or adult penguins (Stahel and Gales 1987, Dann 1992, Taylor 2000, Challies and Burleigh 2004).

There is no direct evidence of rats *Rattus spp*. taking eggs or chicks but penguin breeding success increased in association with rat control on Granite Island in South Australia (Bool et al. 2007, Colombelli-Negrel pers. comm.). Increases in numbers of Rakali (water-rat) (*Hydromys chrysogaster*) have been implicated in chick deaths at St. Kilda, Victoria (Preston 2008) and King's skink (*Egernia kingii*) were thought to take eggs in Western Australia (Meathrel and Klomp 1990). Pacific gulls (*Larus pacificus*) and white-bellied sea-eagles (*Haliaeetus leucogaster*) take chicks and adults in Australia (mainly at sea or on water's edge) (Wiebkin 2011, Dann pers. obs.) and brown skuas (*Catharcta skua lonnbergi*) also take chicks and adults crossing wave platforms in the Chatham Islands (Houston pers. comm.). Tiger snakes (*Notechis ater*) take eggs and chicks (Serventy et al. 1971), Rosenberg's goanna takes chicks (Colombelli-Négrel pers. comm.) and little ravens (*Corvus mellori*) take eggs (Ekanayake et al. 2015) and chicks (Renwick, pers. comm.). Long-nosed fur seals take adults in New Zealand and Australia (Notman 1985, Page et al. 2005) and a leopard seal (*Hydrurga leptonyx*) also took adults (and one newly-fledged bird with a PIT-tag) during a stay of some months on Phillip Island at the northern limit of its range (Renwick and Kirkwood 2004).

Climate variation: Overall there are a number of aspects of the biology of penguins that are likely to be affected, some positively and some negatively, by predicted climate change over the next 100 years (Dann and Chambers 2009). Breeding productivity and juvenile survival seem likely to improve with increasing sea temperatures in south-eastern Australia (Cullen et al. 2009, Sidhu 2007), although this may not be the case for Penguin Island in Western Australia (on the northern limit of the range), where chick mass has decreased with increasing sea temperatures (Cannell et al. 2012). By contrast, the direction of the response of adult survival to increasing ocean temperature appears to vary between months (Sidhu 2007) while the feeding behaviour of penguins may experience both negative and positive impacts as a consequence of climate change (Dann and Chambers 2009, Ropert-Coudert et al. 2009). Some of the negative impacts, particularly those resulting from expected changes to the terrestrial environment, can be addressed on small scales in the short-term by habitat management, particularly fire and vegetation management (Dann and Chambers 2009). Sea-level rise and increased storm surges may reduce available breeding habitat on low-lying islands (Dann and Chambers 2009).

Historical or current harvest: Latham (1802) noted that New Zealand Maori killed little penguins with sticks and ate them, considering them a delicacy. However, there is little

indication that adults have ever been taken in numbers for food by humans in Australia; eggs and chicks are presumed to have been taken in both countries but evidence is lacking. Generally little penguins co-habit breeding areas with more abundant, and possibly more palatable, shearwaters (*Ardenna* spp.).

Fisheries: Penguins being taken for crayfish bait are thought to have reduced 'alarmingly' the population of De Witt Island in Tasmania during the 1950s and 60s (White 1980). Although this practice may have once been widespread, it now appears rare. Inshore fishing nets have been the source of some mortality for little penguins in New Zealand (Tennyson pers. comm.), at Victor Harbor and Nepean Bay in South Australia (Copley 1996), in Corner Inlet and Corio Bay in Victoria (Norman 2000) and in south-eastern Tasmania (Stevenson and Woehler 2007). The extent of this type of mortality is not known as reporting rates are likely to be low. This netting practice is more widespread in New Zealand than Australia and, of all the Australian States; it is most commonly deployed in Tasmania (Woehler pers. comm.).

A number of important prey species of little penguins are taken commercially in Australia and New Zealand including sardine (*Sardinops sagax*) and Australian anchovy (*Engraulis australis*) (Klomp and Wooller 1988, Gales and Pemberton 1990, Cullen et al. 1992, Chiaradia et al. 2012). However, the direct impacts of these fisheries on penguin breeding success and survival are unknown.

Habitat degradation: Introduced mammalian predators such as foxes and dogs are the most significant threat to penguins on land in Australia (Dann 1992) and ferrets, stoats (Hocken 2000, Challies and Burleigh 2004) and dogs in New Zealand, are implicated in a number of colony extinctions or declines. For example, an estimated 500 little penguins were killed by foxes over six years in a colony in western Victoria (Overeem and Wallis 2007). The role of cats in determining the distribution and abundance of penguins varies, being relatively unimportant on Phillip Island (Dann 1992) but significant on Wedge Island in Tasmania (Stahel and Gales 1987) until they were eradicated (Vertigan pers. comm.).

Penguins are killed, or have been killed in the past, by cars at a number of places where they cross coastal roads at night to reach their burrows, notably Phillip Island and Portland in Victoria, Bruny Island and Lillico Beach in Tasmania, and Oamaru, Wellington and on the west coast of the South island in New Zealand (see Hodgson 1975, Dann 1992, Hocken 2000, Heber et al. 2008). The effects on the population sizes at each site vary and, in some cases, road mortality has contributed to declines in breeding numbers locally. At its worst, traffic mortality killed an estimated 180 adult penguins per year on Phillip Island before traffic management measures eliminated this cause of death. Penguins have also been killed by trains in Oamaru in New Zealand (Hocken 2000) and at Penguin in Tasmania (Dann pers. obs).

Deliberately lit fires are believed to have caused declines in numbers of penguins breeding on De Witt Island between 1975 and 1977 (White 1980). Fortunately the deliberate burning of islands around the Australian coast seems to becoming uncommon but it is likely to have contributed to declines in numbers at some sites. Little penguins are particularly susceptible to being killed or injured by fires in their breeding areas (Chambers et al. 2009).

Indirect threats, such as habitat loss through weed invasion, erosion, grazing and housing developments remain a concern (Harris and Bode 1981, Dann 1992, Fortescue 1995, Priddel et al. 2008) and impact the distribution and abundance of penguins in some areas. Habitat loss is particularly a problem at mainland sites or on islands that are intensely settled. Trampling of burrows by humans and stock is a contributor to habitat loss, particularly where erosion

develops as a consequence. Fire and rabbits can be a danger by destroying the above ground vegetation where nests are situated reducing soil support and fostering burrow collapse.

Some introduced weeds cause severe loss of breeding area, e. g. Kikuyu Grass (*Pennisetum clandestinum*), which form dense patches that penguins find difficult to penetrate. On Bowen and Montagu Islands, kikuyu is recognized as a serious pest for seabirds and measures are in place to eliminate it (Fortescue 1995, Weerheim et al. 2003).

Coastal developments: Coastal developments can also have potential impacts on the marine environment as well as the terrestrial one through disturbance at fish nursery sites or through increased access by watercraft to marine areas also used by penguins. For example, the penguins on Penguin Island, Western Australia, feed mainly on sandy sprat when raising chicks (Wooller et al, unpublished data). The sandy sprat originate from a highly productive nursery (Lenanton et al. 2003), adjacent to which a boat ramp was constructed in 2010. The impact of this construction on both the abundance of the sandy sprat and the reproductive success of the penguins is being studied 2010-2013 (Cannell pers. comm.). Increasing human access to marine areas used by little penguins could also result in more injuries/deaths associated with collisions with watercraft.

Pollution: Little penguins are the most likely seabirds in southern Australia to come into contact with oil spills at sea (Dann 1994b). Approximately 10-20,000 little penguins were affected in the Iron Baron oil spill in northern Tasmania in 1995 (Goldsworthy et al. 2000). Oil spills have the potential to reduce little penguin populations significantly, and if frequent enough, entirely. Recent advances in less invasive and potentially more effective techniques for cleaning oiled penguins may improve post-oiling survival (Orbell et al. 2005, Van Dao et al. 2006) but cleaning is an ineffective and costly mitigation tool.

Organochlorine and heavy metal accumulations at levels typical for temperate latitude seabirds are found in little penguins living near Sydney and at Phillip Island (Gibbs 1995) but it is not known whether these levels interfere with the penguin's health or breeding success.

Disease: The immunological penalty of malnutrition is poorly understood, but is reflected in severe internal helminth parasitic disease in starved birds (Harrigan 1992). Similar burdens of helminth parasites may not be as pathogenic in adult birds in good condition, suggesting helminths must be regarded as opportunistic pathogens (Norman 2006). Ectoparasites, protozoa, bacteria and fungi are a primary causes of death, or as agents contributory to multifactorial deaths in individuals (Harrigan 1988, Norman 2006). There is no indication that anthropogenic sources are contributing to penguin diseases. The role of known bacterial and viral pathogens in birds in the epidemiology of mortality of penguins, or the costs of morbidity or reproductive wastage have not been investigated or have only been superficially and unsystematically examined.

Disease has indirectly affected little penguins through a viral outbreak amongst one of their main prey species; sardine (Murray et al. 2003). In 1995, and, to a lesser extent, in 1998, there was a widespread die-off of sardine that was first reported on both occasions at Port Lincoln in South Australia and spread east and west around southern Australia, and to the North Island of New Zealand (in 1995) (Griffin et al. 1997). This sardine die-off was associated with reduced survival and breeding success of little penguins at a number of colonies in Victoria (Dann et al. 2000), and caused fundamental changes in the diet of penguins (Chiaradia et al. 2003) that have

remained until the present time (Chiaradia et al. 2010). The cause of the viral outbreak was undetermined but one hypothesis was that the viral disease came from infected pilchard, imported to supply tuna farms at Port Lincoln in South Australia.

Tourism: There are many kinds of human disturbance but a major challenge for the management of penguin colonies is the commercial pressure to allow public viewing without accompanying detrimental effects on the population. There are, or have been, at least 15 sites in Australia and New Zealand where organized viewing of wild little penguins occurs for commercial or community purposes. The most popular of these viewing sites, known as the "Penguin Parade" is on Phillip Island in south-eastern Australia and it currently attracts 650,000 tourists each year. Breeding productivity, philopatry and the movements of adults between areas were similar for birds breeding inside or outside the tourism area (Dann 1992). While tourism is often suspected of having detrimental effects on penguins at viewing sites, in reality, penguin numbers have increased substantially at four monitored and well-managed tourism sites in the last two decades years (Perriman and Steen 2000, Houston and Russell 2001, Preston et al. 2008, Sutherland and Dann 2014). Numbers at one viewing site declined and changes to the viewing behaviour of visitors were instigated to reduce disturbance (Shaughnessy and Briggs 2009).

Potential risks/threats listed elsewhere in little penguin range but not considered in workshop risk assessment–

There were three potential risks to little penguin survival and breeding success that weren't rated at the workshop that came up in my review of penguin management as potentially important issues elsewhere. These were: competition with fisheries, raven predation on penguin eggs and the potential relationship of Murray River outflows with Encounter Bay penguin survival and productivity is explored later in this review.

- Competition with industrial fisheries
  This has already been considered in depth in Wiebkin (2011). The main prey species in penguin diets in SA are in order of importance are: anchovy, garfish, sardine (Wiebkin 2011). The South Australian sardine fishery harvested up to 39, 000 tonnes of sardine per year (from a spawning biomass of ~220,000t, Ward et al. 2001b) and the fishery reports < 1 % anchovy by-catch (Ward et al. 2008). Based on this, little penguins are unlikely to be in competition with the fishery for anchovies, however, a quota of 1,000 tonnes of anchovy was allocated to SA sardine fishers in 2011 (Wiebkin 2011). This is a small proportion of the estimated spawning biomass of anchovies in the eastern GAB (~126,000t). Goldsworthy et al. (2011) examined the importance of sardine in the diet of marine predators in waters of the eastern Great Australian Bight and found no evidence of ecological impacts from the South Australian Sardine Fishery.
- Egg predation by little ravens *Corvus mellori* is an emerging threat to penguin breeding success on Phillip Island with up to 30% of eggs being taken in some areas (Ekanayake et al. 2015). Little ravens occur across coastal South Australia but this type of predation has not been reported in South Australian penguin colonies to my knowledge.
- Large-scale marine processes affecting local marine productivity that have been anthropogenically altered (Murray River estuarine flows- considered below).

Detailed evaluation of the highest risks identified in the workshop
The workshop identified three very high risk (risk score 12) pressures and four high risk (risk score 8) pressures.

Very high risk pressures

1. Land-based predation- feral cats, domestic dogs, foxes, black rats

Predation by introduced mammalian predators is a common theme in declines and extinctions of seabirds around the world. The distribution of many seabirds including penguins in particular has been restricted long ago to areas either inaccessible or with reduced accessibility to indigenous predators. The introduction of some novel predators into breeding areas of penguins has reduced their range worldwide as it inevitably leads to their extirpation from the site. Penguins often do not have appropriate responses to novel mammalian predators and consequently may suffer relatively high rates of mortality. In addition dogs and foxes engage in "surplus killing" behaviour wherein many more animals are killed than are required for immediate needs. Due to their small size, little penguins experience relatively more threats from predators than do other species. Their pre-European breeding distribution throughout southern Australia was a reflection of their use of breeding sites that are free of mammalian predators. These breeding sites are mainly on islands but also at the bases of sea cliffs inaccessible to mammals such as south-eastern South Australia and the Bunda Cliffs in the Great Australian Bight. In fact I'm unaware of little penguins persisting in the long-term in co-existence with an introduced or natural terrestrial mammalian predator at a breeding site.

All of the predators listed above are well-known predators of penguin adults with the exception of black rats. Rat predation on penguin adults has not been documented and their predation of eggs and chicks is often surmised but rarely is there enough evidence to determine if the rat killed the chick or has scavenged a dead chick. However rat control programs at Granite Island have been associated with a significant improvement in breeding success, which is gives some support for their role as predators of eggs and chicks (Bool et al. 2007, Diane Colombelli-Négrel, Risk assessment workshop).

There are numerous examples of foxes, dogs, cats and ferrets exterminating penguin colonies or reducing them greatly in size. Modelling has shown that predators that kill adults have the greater impact as adult survival is usually relatively high in little penguins (Dann et al. 1992, Sidhu et al. 2007). Foxes and dogs are the more damaging to penguin populations as these predators kill adults throughout the year and can "surplus kill" relatively large numbers. On Phillip Island in Victoria, one fox is believed to have killed up to 40 penguins in one night. In the absence of alternative and abundant prey, cats have less dramatic but significant long-term effects as has been seen on Wedge Island in Tasmania from whence they were recently removed to protect the penguin and shearwaters colonies.

In the light of substantial history of the extent and consequences of predation on penguins by introduced mammals throughout Australia and New Zealand, this is an entirely appropriate very high risk pressure and one that will shape and reduce the distribution and population size of penguins in South Australia if allowed to run its course.

In addition, evidence from Granite Island supports the inclusion of black rats as a very high risk pressure, particularly on breeding success on islands where alternative food sources for rats may be limited at some times of the year.

2. Marine-based predation – Long-nosed fur seals (LNFS)

LNFS numbers are recovering from severe harvesting in the 1800's with a few populations showing indications of levelling out (Shaughnessy et al. 2015). The increasing trend in South Australia is likely to continue over the coming decade, primarily by expansion in colonies on Kangaroo Island and by establishment of new colonies (Shaughnessy et al. 2015).

LNFS eat little penguins whereas Australian fur seals do not (Hume et al. 2004, Page et al. 2005) and Australian sea lions do so very rarely (McIntosh et al. 2006). In studies of the occurrence of little penguin remains in scats and regurgitates of LNFS, the % occurrence is around 30% in South Australia and western Victoria (Bool et al. 2007, Page et al. 2005, Rebecca McIntosh unpublished data). The rate at which penguins are predated by LNFS does not appear to be as intense as is suggested by the incidence of penguin feathers in LNFS scats. It has been demonstrated in preliminary experimental trials that penguin feathers from a single feeding episode may be passed in up to 6 scats over a period of 6 days (Simon Goldsworthy unpublished data) thus exaggerating the numbers of penguins consumed if assessed by scats containing feathers alone. The intensity of predation by LNFS on little penguins is possibly exaggerated by the spatial and temporal coincidences of declines of penguin numbers and increases in the sizes of LNFS colonies as it is suspected that not all LNFS eat penguins (perhaps particularly sub-adult LNFS), predation on penguins is not restricted to the vicinity of seal breeding areas (Simon Goldsworthy, workshop presentation) and both species appear to be co-existing over a wide range in New Zealand (Dann pers. observation).

However, there is some evidence implicating predation by LNFS in the disappearance of penguin colonies. For example, in the Cape Gantheaume Wilderness Protection Area on Kangaroo Island, annual monitoring of pup production has shown a remarkable recovery over a 26 year period from 1988/89 increasing at an average rate of 10% per year Throughout this period, the little penguin colony at Cape Gantheaume disappeared concurrently with recorded predation by LNFS (Simon Goldsworthy, workshop presentation).

However at some sites where penguin colonies have declined or disappeared, there are other risks, identified as high or very high in this assessment, which may be contributing factors in addition to seal predation. For example penguin populations in the group of islands in Encounter Bay where some of the more significant declines of penguin numbers have been reported in the past two decades and where LNFS do not yet breed but do haul-out nearby, may have been significantly impacted during this period by reductions in availability of penguin prey locally associated with severe reductions in Murray River outflows (see further comment on this under high risk pressures - Food Availability, below).

There is adequate evidence for LNFS to be considered a high risk pressure for penguins particularly around Kangaroo Island and Encounter Bay but also around the southern Gulfs. The question of most relevance in evaluating this risk is, given what we know, what are the long-term consequences for penguin distribution and population size in South Australia?

<u>Consequences of expansion of LNFS for Little Penguins in South Australia</u>
Given that the increasing trend in LNFS numbers in South Australia is likely to continue over the coming decade, primarily by expansion in colonies on Kangaroo Island and by establishment of new colonies (Shaughnessy et al. 2015), there are two aspects relating to the biology of penguins and LNFS that provide some insight as to what the penguin breeding

distribution in SA might look like in the future. Unfortunately they are somewhat contradictory.

The first is the presence of a zone of contact between the eastern and western 'lineages' of little penguin which is limited to a narrow zone in South Australia between Troubridge and Granite Islands (Burridge et al. 2015). The nature of this zone suggests that the two forms may have come into secondary contact in this area relatively recently, rather than a hard barrier having limited genetic exchange across the zone (Burridge et al. 2015). The implication is that, regardless of how wide this zone appears to be now, it strongly suggests that in the past there was a zone in the vicinity of Kangaroo Island and possibly Encounter Bay where penguins from further west and from further east were genetically isolated. One explanation for this may be that the population size of LNFS prior to the 1800's was large enough to inhibit populations of little penguins persisting in the area. Following the reductions in seal numbers in the 1800's, penguins may have colonized KI and Encounter Bay from the west and east correspondingly giving the pattern reported. The zone without penguins in this area may have been much wider than is suggested by the current zone of secondary contact and has been colonized from the west and east in the last 200 years. There are other possible explanations for this genetic pattern but none with any circumstantial support.

The second aspect relates to the distributions of penguins and LNFS in New Zealand.
The breeding distributions of little penguins and LNFS overlap around the three main islands of New Zealand. Predation of penguins by LNFS has been reported there (Notman 1985) and seal numbers are increasing. As far as I'm aware there has not been concern raised in New Zealand about effects of increasing LNFS numbers on penguin populations. A difference between penguin colonies in Australia and New Zealand is that there are relatively few large penguin colonies in New Zealand by comparison with Australia but many small ones. One explanation may be that where penguins breed in more dispersed and smaller aggregations, predation by LNFS is not as significant as it is at larger concentrations of breeding birds. This warrants further study but immediately suggests a mechanism by which penguins and LNFS may co-exist as their entirely overlapping ranges in New Zealand indicate that there must be some mechanism that has enabled their co-existence in the past.

In the light of the current trends and information, it is unlikely that penguins will persist on Kangaroo Island (and Encounter Bay) in the numbers apparent in the last 100 years due to LNFS predation. Whether or not penguins remain in small, scattered colonies away from LNFS activity or not is unknown but there are precedents for some co-existence elsewhere. Elsewhere in SA may experience reductions in penguin numbers where LNFS populations continue to expand. At sites where more than one high risk pressure or even other lesser anthropogenic source of mortality exists, penguin declines will be exacerbated.

3. Socio-economic risks – tourism and social values

It has been pointed out that the risk rating of consequence as (3) –major reduction of socio-economic pathways, seems high for Granite Island given the penguins are still present on the island, the tours are currently operating and there are alternate natural attractions that can be marketed in Encounter Bay if the penguins were to disappear. The likelihood recognises the declining trends in penguin numbers appropriately and the consequence gives a high weighting to the significance of the penguin tours to local economies. This applies to all three sites. There were 17,000 visitors in the last year of tours at Kingscote and presumably at least as many on Granite Island before the negative publicity. I have no visitor numbers for Penneshaw.

Considering these visitor numbers, there is a reasonable basis for weighting the significance as is if penguins were the reason (or part of the reason) that visitors went to these sites or stayed longer at these sites. Without more detailed information on visitor motivations and taking a conservative approach, the rating should stand.

Granite Island

Granite Island's penguin population has fallen from an estimated 1548 individuals in 2001 to only 32 individuals in 2014 (Bool et al. 2007, Colombelli-Négrel 2015a) and numbers seen on the nightly tour are low (10-12). A decrease in the number of people attending the tours has coincided with the dwindling penguin numbers and associated negative media stories. Breeding success is relatively high following rat control but survival of adults is very low (Colombelli-Négrel, workshop presentation). A simple explanation may be that food availability is adequate for breeding and predation is reducing adult survival to low and unsustainable levels. Fox and dog predation has been reported on Granite Island but infrequently and not recently. Little penguins are a relatively common occurrence in LNFS scats in Encounter Bay (Bool et al. 2007) and at a similar rate to KI (Page et al 2005) and Cape Bridgewater in Victoria (Rebecca McIntosh et al. unpublished data). Other significant predators of adult penguins have not been reported there.

Whatever the reasons for the decline in penguins, as the current population size stands at present, it is perilously close to losing its value as a tourist attraction and regional cultural icon. The private tours ceased 18 months ago for reasons other than penguin numbers (Paul Unsworth, risk assessment workshop) and DEWNR has been supporting the tours since. In the face of what appears to be a continuing decline, it is notable that some penguins have been seen on each tour night for the past six months (participant comments, risk assessment workshop). Granite Island penguins feature under several high risk pressures and several medium risk pressures and warrant site-specific co-ordinated attention.

Kangaroo Island-Penneshaw

Penguin tours continue at Penneshaw although the numbers of penguins have decreased and few are seen on some tours. Mortality caused by vehicles has been an issue there for many years and predation by dogs also. Both of these sources of mortality are capable to reducing small populations relatively quickly as they affect adults which have high survival rates under natural predator regimes in most places. Both are also manageable. There is a LNFS colony at Cape Hart not far away and possibly some haul-outs sites closer suggesting that LNFS predation is a possibility.

Kangaroo Island -Kingscote

Penguin tours ceased at Kingscote in 2013 associated with a decline in penguin numbers although the population estimate in 2014 was 128 breeding individuals. It is not clear if other factors were involved in the cessation of the tours but it appears that they may have continued beyond 2013 if sufficient interest was present. Dogs and disturbance have been listed as known causes of mortality and both of these are manageable. It is noteworthy that the Kingscote tour had 17000 visitors in its last year.

High risk pressures

4. Land-based predation
    i. Domestic dogs
    ii. Foxes

Granite Island

Predation on penguins by domestic dogs and foxes has been discussed above. They are a lesser risk at Granite Island because there have been few recorded events possibly due to the causeway being a deterrent. On occasions, low level but significant predation by foxes and dogs on penguins can be overlooked when evidence is removed by scavengers, when there are no systematic searches, the carcases deteriorate and the predator signs are lost or the kills are cached or out of view. The medium risk rating is appropriate.

iii. Goannas

Emu Bay, Kangaroo Island

Goannas are more common at the warmer sites on Kangaroo Island such as Emu Bay. Predation by LNFS, cats and dogs along this coast is highly likely too. A number of factors suggest that goanna predation on penguins may not be high. The goannas are decreasing in numbers and considered endangered. Compared to carnivorous mammals, reptiles consume relatively few prey and also may scavenge some of their food. An estimation of the rate of consumption of penguins by goannas at Emu Bay is required to evaluate this risk rating definitively and it may be rated too high at present.

5. Food availability –'natural' mass fish die-offs

Food availability underlies much of the distribution and demography of penguins in South Australia and elsewhere. There are processes that drive food availability that are essentially 'natural' and those that are anthropogenically-altered. There is little that can be done to manage natural cycles and processes governing fish die-offs and marine productivity in general, however if there is an anthropogenic element to the origin, frequency or extent of these events, then some management may be feasible. Here I consider a broader interpretation of processes that may affect penguin numbers to include two phenomena that that may fall into this category although both have probable anthropogenic components. These are the range-wide sardine mortality of 1995 and 1997 and drought-related reductions in marine productivity at the mouth of the Murray River.

Food availability-Sardine mortalities

Mass mortality events of sardine in 1995 and 1998 spread throughout the entire Australian range of sardine and are believed to have killed more fish over a larger area than any other single-species fish die-off recorded (Jones et al. 1997). Each of these mortalities is thought to have killed 70 % of the spawning stock of sardine in South Australia (Ward et al. 2001b). Characteristics of the mortalities suggest both were caused by an exotic pathogen to which Australian sardine were naïve (Jones et al. 1997).

In the past, increases in sardine harvest and mass mortalities of sardine in Victoria have coincided with decreases in sardines in penguin diets, increases in adult mortality and reductions in breeding success at Phillip Island (Cullen et al. 1992, Dann et al. 2000, Chiaradia et al. 2003). It is unknown if penguins in South Australia consumed more sardine prior to the sardine mortalities than they do now and little is known about the effects of the sardine mass mortalities on South Australian little penguins. If sardine were important in their diets prior to the mortalities, as they were in Victoria (Chiaradia et al. 2003), then it would be expected that the fish deaths would have some profound negative effects as they did in Victoria. Conversely the 1995 and 1998 mass mortality events facilitated the expansion of anchovy distribution and biomass (Ward et al. 2001a), currently the main prey of penguins in South Australia, thus likely benefiting local little penguin populations (Wiebkin 2011).

The source of the exotic pathogen that caused the sardine mortalities was never definitively identified although it is believed to have originated in the southern gulfs and potentially was of anthropogenic origin. The mortalities have not reoccurred and the sardine populations have recovered in South Australia. The prospect of a similar mortality occurring within the next five years seems remote as quarantine precautions are doubtless in place to protect the largest fin fishery in Australia.

Food availability – variations in productivity at the mouth of the Murray River

Breeding little penguins are central-place foragers with much of their prey being consumed within c.20 km of each colony during chick provisioning. As a consequence, penguins are very significant consumers of anchovy within relatively small areas and the medium and larger penguin colonies are frequently associated with areas of high productivity and food availability such as upwellings or freshwater inputs to provide adequate food supply. Tracking studies of penguins at Phillip and Rabbit Islands and at St Kilda breakwater in Victoria show that penguins breeding in these places show some propensity for foraging near freshwater inflows or estuarine environments during breeding and pre-moult foraging trips and in winter. Birds that breed at St Kilda spend much of their adult lives feeding in Hobsons Bay and the adjacent Yarra River estuary close to their breeding areas (Preston et al. 2008). Phillip Island birds often feed in the vicinity of estuaries in Port Phillip Bay in winter and early spring in association with anchovy schools (Dann unpublished) or along the coast between Port Phillip Heads and Cape Otway when fattening for moult (Collins et al. 1999). Rabbit Island penguins feed during chick-rearing periods in the area around the western entrance to Corner Inlet (Hoskings et al. 2008). All of these feeding grounds are known or thought to be associated with aggregations of anchovies probably for spawning (Preston et al. 2008, Kowalczyk et al. 2015, Dann unpublished). Kowalczyk et al. (2015) found that in drought years when Yarra River outflows drop, the penguins concentrated their foraging closer to the river mouth to take advantage of the increased fish productivity resulting from nutrients carried by the Yarra. In contrast, when outflow from the Yarra increased, the penguins ranged more widely in Port Phillip Bay to follow the dispersed nutrients and productivity, probably reflecting the movements and availability of anchovies. This emphasises the potential role of the river outflows in the availability of anchovies for penguins in general and underlines the substantial consequences of periods when the river flows to the sea cease.

Freshwater outflows from the Murray River into the sea have declined significantly in recent decades due to increasing extraction for human use and drought (South Australian Parliament Select Committee 2000). The Lower Murray now experiences drought-like flows in over 60% of years, compared with 5% under natural conditions. Flows to the lower reaches have been altered by significant changes in the annual flow, the distribution of flow through the year and the duration of low flow periods. Flows of seawater into the lower lakes in the opposite direction have also been identified as a component of the estuarine ecosystem (Walker 2002, South Australian Parliament Select Committee 2000). During the millennium drought (2002-2010), the lower lake system experienced greatly reduced flows of both freshwater from upstream and seawater although a dredge was employed to keep the mouth opened during this period (Murray Riverhttp://www.mdba.gov.au/river-information/running-river-murray/drought-river-murray-operations).

Anchovies are an important component of the diets of penguins at Granite and West Islands (Bool et al. 2007) and these along with two other known penguin prey (Blue *Sprat Spratelloides robustus* and Sandy Sprat *Hyperlophus vittatus*) have been recorded in the

Coorong and Lower Lakes system of the Murray River (Wedderburn and Suitor (2012). The mouth of the Murray is well within the daily foraging range of little penguins (Collins et al. 1999, Hoskins et al. 2006) from the islands in Encounter Bay and it is very likely this area is and has been an important feeding area for penguins in the past. It is positioned between two major coastal upwellings, both of which appear to be beyond daily foraging ranges of penguins breeding in Encounter Bay. Hence there is likely to be some dependence for the Encounter Bay penguins on Murray River estuary productivity. This possibility is supported by the reporting of Granite and West Islands penguins experiencing their major declines in numbers in the mid-2000s (Colombelli-Négrel 2015a) during the drought (2002-2010).

The relationship between penguin survival and productivity in Encounter Bay and the Murray River flows warrants further investigation although penguin numbers may now be too low to achieve any significant results. These observations highlight another potential factor in the demise of Encounter Bay penguins in addition to LNFS and introduced terrestrial mammals.

6. Habitat loss - Troubridge Island

The risk of habitat loss for Troubridge Island is rated "likely" and of "moderate consequence" in the next five years due to the low–lying nature of the island and the belief that storm surges will have significant effects on eroding the island's vegetation and sand base in the next five years. It is unlikely that storm activity will exterminate the colony in the next five years although it could reduce the available nesting areas substantially. This colony is the only one in the region where penguin abundance is considered stable or suspected of being stable and hence it has high conservation significance. The Troubridge Island colony has some other anomalous characteristics including being the easternmost known colony of 'western" Little Penguins (Burridge et al. 2015) as well as being genetically and morphologically different from Kangaroo Island penguins (Diane Colombelli-Négrel, workshop presentation) and a different diet (Wiebkin 2011). Curiously, penguins were not noted there on two visits in the early 1900s by S. A White, a prominent ornithologist, despite careful notes being taken on the birds present (White 1916). This begs the question: have penguins always been on Troubridge Island?

To my knowledge there are no obvious islands or man-made structures in Gulf St Vincent where penguins currently breed which could become alternative breeding sites for this colony.

7. Social values-various sites

A. <u>Baudin Rocks and Penguin Island, South East</u>

These penguin colonies appear to be in decline from a variety of sources including foxes, dogs and LNFS. They are in a region where penguin breeding habitat is relatively scarce but in close proximity to the Bonney upwelling suggesting that if predation issues can be resolved then the populations could persist, particularly if LNFS numbers remain low.

B. <u>Kangaroo Island colonies excluding Kingscote, Penneshaw and islets</u>

Penguins are deeply embedded in the social values of Kangaroo Island and there seems to be multiple threats to their continued presence there. The terrestrial threats at Kingscote (dogs) and Penneshaw (dogs and vehicles) are manageable but the long-term effects of LNFS may reduce their presence at these sites to scattered individuals at best and eliminate them at worst.

C. Althorpe Island, Southern Yorke Peninsula
D. Troubridge Island, Gulf St Vincent
E. Goose and Wardang Islands, Spencer Gulf
F. Reevesby and Spilsby Islands, Sir Joseph Banks Group
G. Boston, Thistle and Wedge Islands, Southern Eyre Peninsula
H. Flinders and Pearson Islands, Western Eyre Peninsula
I. St Peter Island, Far West Coast

The social values of sites C-I above are being treated as a group. I'm unsure why Boston, Troubridge, Reevesby, Pearson, St Peter & Goose Islands are on the list as there is no evidence of recent declines reported in the risk assessment. Althorpe, Spilsby, Thistle, Wedge and Flinders Islands all have some evidence or suspicion of declining numbers and hence their place in the fabric of local communities is at risk. Flinders and Wardang Islands appear to be the only one for which there is a suggested cause, namely cats and it is feasible to remove this threat from the islands. In the absence of suspected or known threats it is impossible to manage the threats or offer any explanations to the communities involved.

Management recommendations for high- and very high-rated risks

The highest risk scores obtained were:

1. Predation - Land-based

Feral predators have been removed from many islands around the world for conservation purposes and consequently the techniques of predator removal are well known. The extermination methods depend upon the complexity of the island's fauna particularly the presence of non-target species and the degree of human settlement or human activities on the island. If more than one pest species of concern is present on an island, they should be removed concurrently to avoid expansion of the other pest species population. Extermination generally involves broad-scale poison-baiting as a primary technique in conjunction with shooting, trapping, den fumigation etc. (Kirkwood et al. 2014). Tracker dogs may be used to enhance detection rates of the target species as was the case on Phillip Island with the fox eradication program.

Kirkwood et al. (2014) noted that a team dedicated solely to predator removal works better than personnel being drawn from other roles for periods of time. It is when the job is almost finished that other priorities develop greater importance and the gains can be lost. Extermination programs on islands have failed due to this in the past.

i. Feral cats
   - Flinders Island
   - Wardang Island
   - All colonies, Kangaroo Island (excluding islets)
   - Mainland colonies, South-East

Flinders and Wardang Islands: Removal of feral cats from Flinders (medium-sized colony, decline or suspected decline) and Wardang (large colony, unknown trend) Islands is highly desirable and achievable. The processes required for cat removal from islands are well-established and there have been successful eradications of cats in south-eastern Australia from Gabo Island in Victoria and Wedge and Tasman Islands in Tasmania. The removal of cats will likely have some positive impact on the black rat populations on both islands and rabbit

populations on Wardang Island which will require management, preferably in concert with cat eradication.

Kangaroo Island: The eradication or control of feral cats on Kangaroo Island has widespread support and is being planned under the National Threatened Species Strategy. Unlike Flinders and Wardang Islands, rat eradication on Kangaroo Island is not feasible for a variety of reasons including scale and non-target risk. Consequently rat control will need to be targeted to specific colonies where rats are considered a threat. An additional beneficiary of cat control/eradication on Kangaroo Island may be the threatened Rosenberg's Goanna (meso-predator release for goannas as has occurred under the western shield fox control program).

Predation by feral cats at mainland penguin colonies in the South-East is rated as a high risk. While cats can be exterminated from islands, to date there have been no methods developed other than electric fencing which will stop them moving back into mainland sites. Predator control programs for cats, foxes and dogs will be required at these sites if penguins are to persist there. The risk of cats wiping out these penguin colonies is less than the risk of foxes and dogs doing so in the short-term. Maremma guard dogs are used in Warrnambool, Victoria to exclude foxes and dogs from the Middle Island penguin colony which is accessible at low tide. This approach is working well but uses considerable resources on a continuing basis and may not be appropriate for the colonies in the South-East.

ii. Domestic dogs
    - Kangaroo Island (in particular, Kingscote, Penneshaw, Vivonne Bay)
    - Mainland colonies, South-East

Fencing domestic dogs out of these colonies may be an unrealistic management action due to the cost and situation of the colonies. Generally public education and enforcement of regulations prohibiting dogs in penguin areas afford some protection to penguins but is seldom 100% effective in deterring predation. Widespread advertising of 1080 poisoning programs for other pest species can be an effective deterrent for uncontrolled dog incursions into penguin breeding areas. In my experience dogs usually operate in pairs or small groups, often without their owner's knowledge, and coupled with their habit of surplus killing penguins, are capable of doing a lot of damage. In the absence of effective management, it is inevitable that penguins will be eliminated from vulnerable sites close to human habitation.

iii. Foxes
    - Mainland colonies, South-East

Foxes will eventually remove penguins from sites to which they have access. Penguins appear to have no defences against canids, either indigenous or introduced. The mainland penguin colonies in the South-East have either had their accessibility to mammalian predators altered since European settlement or have established colonies there since dingos have been removed from the landscape.

There are well-known effective designs for fox-exclusion fences. However fencing foxes out of penguin breeding sites is very difficult, often requires electric fencing and frequent maintenance. Snaring and shooting are time-consuming and not always effective in achieving the management goals (Kirkwood et al. 2014). Currently 1080 poisoning is in widespread use for fox control and there are some landscape-scale baiting programs in the three southern

mainland States that maintain foxes at relatively low levels. It has been the primary technique used in the eradication of foxes from Phillip Island in Victoria (Kirkwood et al. 2014). There are delivery systems for 1080 such as M-44s which reduce risk to non-target species (van Polanen Petel et al. 2004) and a fox birth-control agent is currently being refined in Victoria (Dann unpublished).

iv. Black rats
- Flinders and Thistle Islands

Remove rats from Granite and Flinders Islands. The benefits to penguins vary but the removal of cats from Flinders Island will see the rat population increase rapidly and negative effects on penguins may increase correspondingly. Other wildlife values of these two islands will be enhanced if rats are eradicated.

2. Predation - Marine-based
   i. Long-nosed fur seals
      - Encounter Bay / Victor Harbor islands
      - Kangaroo Island and islets
      - Islands of the southern gulfs

Reducing or eliminating perceived and actual seal impacts on other vertebrates is an issue for wildlife and fisheries managers throughout the southern hemisphere and in parts of the northern hemisphere. Proposed management techniques (Wursig and Gailey 2002) include culling of significant proportions of the seal population (Sorenson 1969), culling particular individuals identified as "rogues", translocation of individuals identified as "rogues" (DEPWE- Tasmania), the use of deterrents to scare seals away from fisheries operations (Shaughnessy et al. 1981), the animals requiring protection or the use of barriers to keep seals out of aqua-culture pens (Pemberton and Shaughnessy 1993).

In short, only the use of physical barriers has been proven to be effective in permanently deterring or excluding seals from fisheries operations or aqua-culture (Pemberton and Shaughnessy 1993). Culling requires a large proportion of the population to be culled initially with annual culls to maintain the reduction; targeting individuals only works if a few individuals are taking the species to be protected and in this case, relatively large numbers of individuals are involved in penguin predation; translocated animals return to the areas from which they were removed and, to date, deterrents work for limited times and the seals eventually become accustomed to them. There is insufficient information available on when and where LNFS take little penguins to know if strategic placement of rigid mesh barriers in the sea off from penguin landing sites would allow penguins to get through safely to their breeding sites while excluding foraging seals. In summary, with the current lack of knowledge of the nature of LNFS predation on penguins and in the absence of effective seal deterrents that may be applied to reducing their predation on penguins, there is not a clear mechanism for directly managing this high-rated risk. Building resilience in the penguin populations by reducing or eliminating other threats is the best management strategy for this risk.

3. Socio-Economic Risks
   i. Tourism values
      - Granite Island
      - Kingscote, Penneshaw
   ii. Social values

- Granite Island
- Kingscote, Penneshaw

It appears that penguins may still be at all three of these sites in numbers that would support tourism although only two currently have tours (Granite Island & Penneshaw). Accepting that there is no immediate socially-acceptable and cost-effective management actions known to reduce LNFS predation at these sites but that there are a number of site-specific terrestrial risks that can be managed; it is a matter of some urgency to address these while penguins persist at the sites. Management actions related to the tourism and social values of these three sites will apply to both social and economic values as they depend on the continuance of penguins at the sites. Some recommended actions will specifically relate to penguins at a site whereas others will be more generic such as managing socio-economic impacts by diversifying visitor experiences and creating resilience in regional nature-based tourism (see South Australian Nature-based Tourism Strategy 2016).

Granite Island

Although the prognosis does not look favourable for penguins on Granite Island, there are a number of terrestrial management options which should be pursued/continued while the penguins persist. It is noteworthy that visitors seeing 10-12 penguins a night is not an uncommon occurrence on some of the boutique, guided penguin tours elsewhere in Australia and New Zealand and expectations of visitors can be managed accordingly. It has already been recommended that a fox, cat and dog-proof gate be installed on the causeway, cats be removed, rat control be continued and dogs prohibited from the island at all times (if not already).

The penguin tours should continue to be supported with a view to becoming financially self-supporting (the tour should also continue its monitoring function with standardised monitoring protocols - duration of counts, same route if possible etc.).

Translocation of penguins has been raised in the Granite Island context as a means of increasing penguin numbers. This technique has been achieved successfully at Phillip Island in Victoria and Manly in New South Wales (Dann unpublished data, Carlile et al. 2015). It involves the movement of chicks at the point of fledging and requires large numbers of chicks to be moved because survival is low in the first two years of a penguin's life (Sidhu et al. 2007). While it is an option for boosting the size of a colony, in this instance there is no point in investing resources in the exercise if the translocated individuals are at risk of predation by LNFS.

Other nature-based experiences could be considered for Granite Island such as pelican feeding and translocation of appropriate nocturnal mammals to Granite Island as an adjunct to penguin tours. These would build some resilience into the local nature-based tourism experiences by lessening the emphasis on penguins.

There has been a captive population of penguins on Granite Island in the past, and if this option were to be considered again as a means of supplementing or replacing the penguin tour, the captive population should not be on the island as it could put the wild penguins at increased risk of disease.

Expert opinion should be sought on whether there is an optimal landing place and approach route to Granite Island for penguins to reduce predation by LNFS (e.g. side furthest from LNFS

haul-outs, waters less frequented by seals etc.). However it is likely that where the penguins are currently is the optimal site for avoiding predation.

Kangaroo Island - Penneshaw

Penguin tours continue in Penneshaw at present and a plan to eliminate the road and dog mortalities of penguins would be the most effective management action to build resilience into the local population.

Kangaroo Island - Kingscote

It is unclear if penguins are still present in Kingscote although they were when tours ceased there in 2013. If they are still present then a dog management strategy is urgently required.

4. Land-based predation (risk score of 8)
    i. Domestic dogs
        - Granite Island
    ii. Foxes
        - Granite Island

Installing a dog and fox-proof gate on the causeway to Granite Island effectively eliminates the risk of predation by these two predators. It would need to be closed during hours of darkness. A general daylight ban on dogs on Granite Island is also important if not already in place. Neither foxes nor dogs are likely to access the island by swimming across a stretch of water of this extent with its accompanying currents and without the predators having a compelling motivation.

    iii. Goannas
        - Emu Bay, Kangaroo Island

Predation of penguin chicks by goannas, an endangered and declining species, at Emu Bay is a recent discovery (Colombelli-Négrel workshop presentation). It is occurring at a site on a 100 km stretch of coastline characterised by penguin colonies that are decreasing or suspected of decreasing in number. Goannas were presumably an apex predator on Kangaroo Island in the past but there is no way of knowing if the two species have coexisted at small or large-scales on Kangaroo Island. The rate of predation by goannas is likely to be relatively low and given the threatened status of goannas, no penguin-related management of this species is recommended at this site.

5. Food availability (‘natural’ mass fish die-offs)
    - State-wide

There are no new practical management actions that can be offered here to reduce either the likelihood of fish die-offs in South Australia nor to influence the environmental flows in the lower Murray River that have not be considered by DEWNR previously.

6. Habitat loss
    - Troubridge Island

Loss of breeding habitat due to storm surges on Troubridge Island will undoubtedly reduce the size of what appears to be a habitat-limited colony. Little penguins show a remarkable propensity to nest in man-made structures such as breakwaters, rock walls and under buildings.

There are breeding penguin colonies in breakwaters at numerous sites in southern Australia and New Zealand (Dann 1992, Preston et al. 2008). They also readily take to nest-boxes in which they breed at least as successfully as birds breeding in natural burrows (Sutherland et al 2014). Thus the option exists for either the protection of existing breeding habitat on the island, enhancing breeding habitat at higher/more stable parts of the island or the consideration of translocating some of the fledglings from Troubridge Island to a suitable alternative if one exists in the vicinity.

7. Social Values

The management of sites listed here with known risk pressures have been addressed under other headings. The remainder are a number of data deficient sites some for which there are no trend data and many of which there are no threats identified. A baseline population survey of penguins at these data deficient sites together with a threat inventory would provide a basis for proceeding to the next step of considering management options.

- Baudin Rocks and Penguin Island, South East
- Kangaroo Island colonies excluding Kingscote, Penneshaw and islets
- Althorpe Island, Southern Yorke Peninsula
- Troubridge Island, Gulf St Vincent
- Goose and Wardang Islands, Spencer Gulf
- Reevesby and Spilsby Islands, Sir Joseph Banks Group
- Boston, Thistle and Wedge Islands, Southern Eyre Peninsula
- Flinders and Pearson Islands, Western Eyre Peninsula
- St Peter Island, Far West Coast

Priorities for management

There are two key factors influencing the prioritising of management recommendations for little penguins in South Australia. The first is that terrestrial threats are more manageable and cost effectively managed than marine threats and the second is that penguin populations are most affected by threats that increase adult mortality.

Predator management

The management of introduced predators is crucial to efforts to improve the conservation status of penguins in South Australia. The best opportunities for controlling this risk occur where penguins are breeding on islands as the risk of re-invasion of the predators is minimal. A prioritised order for control/ eradication of penguin terrestrial predators in order of their impact on penguin colonies is: fox, then dog & then cat. Rats should be controlled where they are suspected of being an issue and it is likely that they will become an issue once cats are removed from sites were both occur.

Accordingly

- Ensure there are no resident foxes and cats on Granite Island and provide a fox/cat-proof gate that is locked at night
- Prohibit dogs from Granite Island (if not already so)
- Cats should be removed from Flinders and Wardang Islands
- Control/eliminate cats on Kangaroo Island in the vicinity of penguin colonies

- Control rats on Granite Island and eradicate them from Flinders Island and Wardang Islands

South-east mainland sites

Mainland sites require more complicated and often site-specific solutions for predator management and usually involve fencing to exclude foxes, dogs and cats.

- Develop a management strategy for the south-east mainland penguin colonies that prioritises protection of the colonies from fox, dog and cat activity
- Local communities should have a role in ensuring everyone understands the issues and supports the management actions particularly associated with dog attacks.

LNFS predation

Predation by LNFS is altering the distribution of little penguins in South Australia. However in some cases there are multiple factors involved. It is likely that penguins have and will disappear from some parts of their range in central and possibly south-east South Australia due to increasing levels of predation. It is unclear to what extent penguins west of Eyre Peninsula will be affected. There are no known management actions that have been effective in Australia or elsewhere in the world that will address this issue satisfactorily. The best course of action for penguin populations in the face of LNFS predation is to increase the resilience of penguin populations by reducing and removing controllable anthropogenic risks such as predation by introduced mammals.

- Produce a communication plan to inform the public of what are the best prospects for improving the conservation status of penguins in South Australia. Including what is known about LNFS historical and current population trends, their predation of penguins, lack of effective, socially-acceptable and economically justifiable management options, knowledge gaps, together with the other issues penguins face in South Australia (and across southern Australia) and proposed actions to increase resilience in these populations.

The three tourism sites

In this assessment, Granite Island penguins feature under several high risk pressures and several medium risk pressures and warrant site-specific co-ordinated attention to all of these pressures in a management plan

- Develop a site-specific management plan for Granite Island penguins that includes consideration of socio-economic values.
- Penneshaw: Develop a dog and road mortality management plan
- Kingscote: Determine if penguins are still present and, if so, implement a dog management plan.

Monitoring and research gaps

Research and monitoring gaps:

1. Population monitoring. 60% of islands in South Australia are data deficient for penguin population estimates. It would be in the long-term interests of penguin management in South Australia to conduct surveys of these data deficient islands at least once to establish the current size of the population and to make an inventory of likely threats.

- Survey the entire little penguin breeding population of South Australia
- Conduct a threat inventory of each breeding site during the population surveys
- Select focal colonies from each region (west of Eyre Peninsula, southern Gulfs, Kangaroo Island, Granite Island and South-East) and conduct population surveys at least every three-five years or more frequently if resources permit.

2. Long-nosed fur seal impacts. An assessment of the rate of predation by LNFS on penguins is required from five key regions at Kangaroo Island, southern Gulfs, Granite Island, western side of Eyre Peninsula and in the South-East which would allow the number taken to be assessed with time and related to the known regional population size. It would be instructive to know whether a particular age/gender cohort of penguins is targeted or more vulnerable to predation or is it a random process as this will affect the rate of penguin decline significantly. These studies combined with an identification of whether specific age/gender cohorts of seals are taking penguins will allow modelling of the population trends of penguins in each region.

- Quantify the number of penguins being consumed by LNFS from regurgitates and scats (in progress SARDI/Flinders)
- Estimate the rate (seasonal & compared with local penguin population size) of LNFS predation on penguins at key sites (west of Eyre Peninsula, southern Gulfs, Kangaroo Island, Encounter Bay and in the South-East).
- Determine age/gender cohorts of penguins predated (studies underway in South Australia, Cape Bridgewater and The Skerries in Victoria, Phillip Island Nature Parks)
- Determine age/gender cohorts of LNFS consuming penguins
- Determine where and when penguins are taken by seals (i.e. near penguin colonies, near haul-out sites or offshore)
- Estimate the historical range of LNFS in South Australia to inform predictions of the impact of LNFS on penguin distribution and numbers
- Evaluate the relationships between LNFS and little penguins in Australia and New Zealand with a view to determining if co-existence exists in New Zealand and, if so, what the mechanisms are (in progress, Phillip Island Nature Parks).

3. Threats to little penguins other than mammalian land-based predators and LNFS. The risk assessment process has identified site-specific threats for a number of breeding sites and the impact of some of these can be gleaned from local knowledge or experience elsewhere e.g. fox and dog predation. There are two threats considered high to medium during this risk assessment process that warrant further evaluation: predation by black rats and goannas. Rats are assumed to be predators of seabird eggs and chicks universally but rarely are they proven to be so. There is good circumstantial evidence that rat control was associated with increased breeding success on Granite Island and that is a good enough reason to continue to control rats there. However, to my knowledge, rats have not been observed taking attended eggs or chicks of little penguins and native rats are present at some stable penguin breeding colonies suggesting that their predation may not be a population pressure but rather an incidental source of mortality of eggs and chicks.

   Predation by goannas on penguin chicks at Emu Bay on Kangaroo Island has been identified in this risk assessment as a medium risk pressure. Based on limited existing

evidence, this requires further evaluation to determine if it is a threat to the penguin population there and on Kangaroo Island generally.

4. Role of the Murray River outflows in the survival and breeding productivity of penguins in Encounter Bay. It has been hypothesized here that there is likely to be a strong relationship between the outflows of the Murray River and the survival and breeding productivity of penguin populations in Encounter Bay. The penguin population of the area is probably too small now to do an intensive study but there may be sufficient existing data to examine if any relationship can be found between the outflows and penguin breeding and survival for the years that these data exist on Granite Island. This might be suitable for an MSc.

Conclusions

The risk assessment process has identified a number of high and medium risk pressures that are likely to have an influence on little penguins and the socio-economic values associated with them in South Australia over the next five years. Land-based predation of penguins by introduced mammalian carnivores is a significant pressure and one that can be managed and, in some cases, eliminated entirely. Predation by LNFS will be an important driver of penguin population dynamics in some parts of South Australia in the next five years. It cannot be predicted what kind of LNFS/penguin equilibrium will be reached in the longer-term based on our current understanding of the interaction between these two species. However there is some genetic evidence that suggests penguins may not have been present in some parts of South Australia historically when LNFS were much more abundant. The socio-economic consequences of the changing abundance of penguins will obviously be dependent upon the outcomes of a suite of drivers; however it appears there are still penguins in low numbers at each of the three main tourism sites. Addressing the land-based risk pressures at these sites will improve the penguins' chances of persisting there in the longer term.

There are data deficiencies related to penguin colony size, trends in abundance and threats that need to be addressed before a clearer picture of what the future distribution and abundance of penguins in South Australia will look like. Quantifying the rates of predation by LNFS on penguins and the nature of the seal/penguin interaction will be pivotal in predictions of the rate and extent change in patterns of abundance of penguins in South Australia.

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Government of South Australia
Department of Environment,
Water and Natural Resources