Ecology and Management of the Little Penguin *Eudyptula minor* in Sydney Harbour

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ABSTRACT

In 1998 we commenced the first formal study of the Little Penguin *Eudyptula minor* population in Sydney Harbour. Prior to this study there was limited and inaccurate information about the population's size and distribution, and no information relating to the breeding biology or foraging ecology of these birds. This study has revealed that the population is small (60-70 breeding pairs) and restricted to 2 km of foreshore within the busy port of Sydney Harbour. The Little Penguins in Sydney Harbour have adapted their nesting behaviour to the urban habitat. In response to the lack of tussock grass, sandy soils or other suitable habitat on the Hawkesbury sandstone foreshores of Sydney, the Manly colony of Little Penguins nest mostly in rock crevices and human-made structures that offer protection from the weather, tidal action, predators and human disturbance. The Sydney Harbour population of Little Penguins has an extended breeding season (July to February), high breeding success (averaging 48.76% over the three years of the study) and a high rate of double brooding (averaging 12.53%). Despite the high level of breeding success, the Little Penguins in Sydney Harbour are subject to a relatively high level of adult mortality, especially on land. This exemplifies many of the major issues faced by managers of wildlife in urban environments, yet offers a model for the cohabitation of wildlife and humans. Recent legislation and implementation of cooperative management strategies aim to generate a coordinated approach across jurisdictional boundaries that will mitigate many of the threats to the colony, including loss of breeding and foraging habitat, predation from domestic pets, direct human disturbance and indirect disturbance from human activities such as movement, light and noise from boats and fishermen, and pollution.

Key words: Ecology, management, Little Penguin, *Eudyptula minor*, Sydney Harbour, distribution, habitat, breeding, diet, foraging, mortality.

Introduction

Weighing approximately 1 kg and standing 30-40 cm tall, the Little Penguin *Eudyptula minor* is the smallest of all the 17 penguin species and is the only penguin species to breed on the Australian mainland (Reilly 1994). Although a relatively common species, individuals are particularly vulnerable to predators on land so almost all breeding populations in Australia are restricted to coastal islands along the southern coast from Fremantle in Western Australia to Port Stephens in NSW and on islands around Tasmania (Stahel and Gales 1987; Klomp *et al.* 1991).

The Sydney Harbour colony is the only known mainland population in NSW, although there are several breeding colonies in Tasmania and South Australia (Klomp and Wooller 1991; NPWS 2000). Little Penguins generally nest in rock crevices, within grass tussocks and other coastal vegetation, or under the ground in true burrows along the foreshores. In Sydney Harbour, Little Penguins also nest in artificial structures such as boat sheds, back-yard gardens and under houses. These modifications to their nesting behaviour have enabled the Little Penguins to persist in the densely urbanised environment of Sydney Harbour.

The Little Penguin population at Manly is an exceptional model of cohabitation between humans and wildlife, while exemplifying many of the problems of conservation and management in an urban environment. The colony presents all the challenges of managing a population across multiple jurisdictional boundaries and minimising a variety of threats, especially those generated by human activities.

The Little Penguin population in Sydney Harbour was formerly more extensive, with birds once breeding at Manly Point, Spring Cove, Store Beach and Cabbage Tree Bay (NPWS 2000). It is now a tiny, disjunct population, restricted to a small area of Australia's largest city and busiest harbour. Since January 1997, a series of legislative controls and management plans have been implemented in an attempt to ensure the population's survival.

This paper presents preliminary results of the first formal study of the Little Penguin population in Sydney Harbour. This study commenced in 1998 and has provided much information in the form of data and internal reports required for management policies and plans, including the Little Penguin Recovery Plan, to achieve long-term conservation and protection of the population.

Historical and contemporary population distributions

"Historically, Little Penguins have nested on the mainland at several sites around NSW. A sizeable colony used to exist at Cape Banks, Botany Bay, until 1958. At the time,

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the land was managed by the military[1] and public access was restricted. The military left in 1958 and fishermen moved in and established huts after which the Little Penguins disappeared" (NPWS 2000). Historic records and remains found in Aboriginal middens (Stahel and Gales 1987; Fortescue 1991) indicate that Little Penguins were once much more common in Sydney Harbour. As late as 1954 the *Sunday Telegraph* reported 300 shot at North Head (NPWS 2000).

Since the 1960s, urban expansion along Sydney's foreshores has been rapid and extensive. This urban expansion and increased recreational activity may have rendered many former Little Penguin breeding areas around the harbour inactive and probably led to the decline of other areas through continued disturbance and/or predation. Cunningham *et al.* (1993) attributed the historical decrease in the size of the Manly population as part of a wider decline of Little Penguins in the Sydney area due to loss of habitat, predation, disturbance and indirect impacts to food supplies.

The Little Penguin colony in Sydney Harbour is now restricted to approximately 2 km of foreshore extending from Manly Point to Cannae Point (Figure 1). Habitat in these areas is limited by the availability of adequately protected rock crevices and suitable landing sites. As one of the only known mainland colonies in Australia, and owing to its small size and location within Australia's largest city and busiest port, the Sydney Harbour population has been listed as an endangered population on Part 2 of Schedule 1 of the NSW *Threatened Species Conservation Act 1995*. A copy of this listing is included in Appendix 1.

Lack of information has resulted in most initial research of the Little Penguin colony in Sydney Harbour focusing on obtaining basic ecological data. Particular attention has been paid to the foraging ecology of Little Penguins, to provide information about the potential impacts of commercial fishing in Sydney Harbour. Commercial fishing, including haul netting, occurs in many parts of the harbour. Commercial catches include small schooling fish, such as whitebait, and occur between October and April (pers. comm., NSW Fisheries). These are the very species sought by Little Penguins breeding in the harbour at the same time of year. The potential and realised effects of predation, pollution, urban development and human recreational activities have been monitored and recorded in breeding and mortality data.

Habitat

One of the first priorities of the research and monitoring project was to identify and map the extent and range of the breeding colony of Little Penguins in Sydney Harbour. During the 1998 breeding season all known and potential areas of foreshore were surveyed and all active burrows tagged and mapped. An 'active' burrow was one which contained eggs, chicks or adults, or showed signs of recent occupation, such as fresh excreta or nesting material (after Dann 1992). Nests were marked with an individually numbered stainless steel disc glued onto exposed rock outside the burrow entrance. Each burrow was then photographed and entered onto a digitised mapping database. These data are updated each breeding season as new burrows are located.

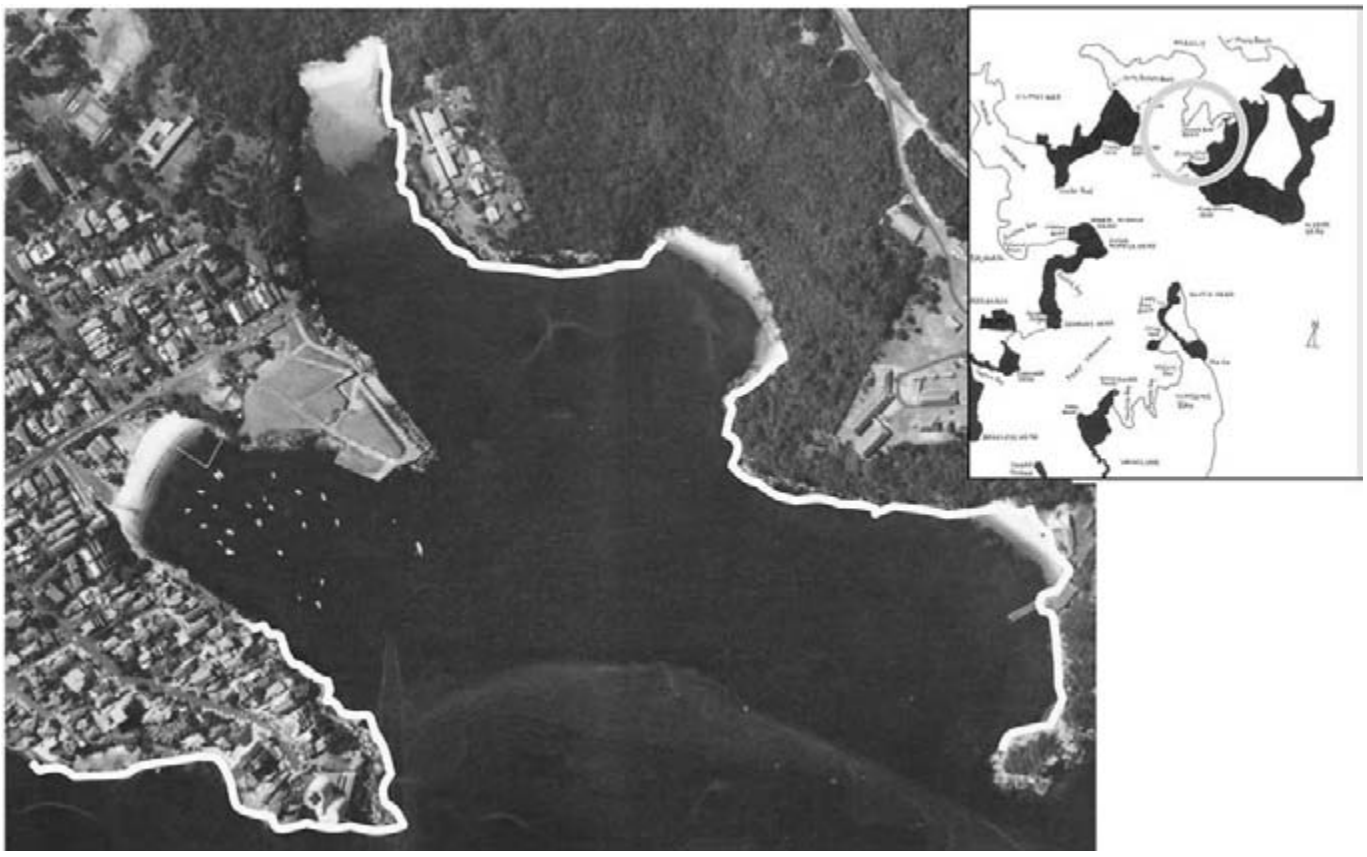

Figure 1. The current breeding distribution of the endangered population of Little Penguins in Sydney Harbour.

The initial results of burrow surveys led to the expansion of the known breeding habitat of the population and a subsequent amendment of the population's listing on the *Threatened Species Conservation Act 1995*. Positive identification of breeding burrows, known and potential habitat, has also resulted in tighter development controls being implemented by Manly Council.

By the end of 2001, 18 artificial burrows ('nest boxes') had been installed in known and potential breeding areas. All six of the nest boxes installed in 1996 were used for breeding in 1998, 1999, 2000 and 2001, six of the eight deployed in May 2000 were used for breeding in 2000 and 2001, and three of the four installed in August 2001 had been visited by prospecting birds in 2001. The rapid occupation rates of these nest boxes may indicate that nesting space is a limiting factor for the Sydney Harbour colony. Disturbance (predation and high levels of human activity) near nesting habitat may be preventing the occupation of 'apparently suitable' breeding areas at Store Beach, although 12 of the 18 nest boxes were installed adjacent to Store Beach in an area subject to the same amount of human disturbance from boats, bushwalkers and occasionally dogs. Also, the Little Penguin burrows located within highly disturbed residential areas on Manly Point constitute about half the total population and many consistently record a higher than average breeding success. The combination of historical distribution, access to foreshore, presence of suitable burrows that provide adequate protection from the weather and predators, and the acclimation of some birds to disturbance probably all interact to determine the breeding population in these areas.

Breeding timing and success

Information on breeding biology was obtained by surveying all known burrows each season for signs of breeding activity. Adult and juvenile Little Penguins were captured by hand during these surveys and morphometric data obtained. Adults were banded with uniquely numbered flipper bands, to allow individuals to be identified throughout the study, and chicks were banded prior to fledging to allow individuals to be monitored (for survival and recruitment rates) in subsequent years. Such morphometrics provide a great deal of information about the age-structure and sex-ratio of the population, as well as overall health and condition of the penguins.

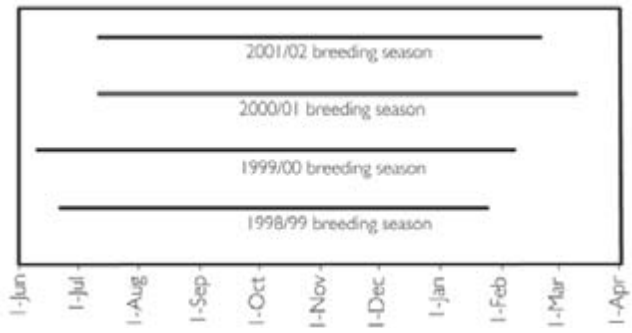

Figure 2. The period of nesting (eggs or chicks present in a nest) in the Sydney Harbour Little Penguin colony in four different breeding seasons.

During 1998 - 2002, the Sydney Harbour colony had relatively protracted breeding seasons with nesting commencing in June and the last chicks fledging in February. This was followed by moulting in March. This extended breeding season allowed some birds to double brood. There was, however, a low level of synchronisation of breeding with some birds first nesting in October. Those birds nesting in June or July were usually successful and make up the average 12.53% of the population that double brood. Those birds not nesting until September or October did not double brood (although replacement clutches are laid), and were more likely to be unsuccessful.

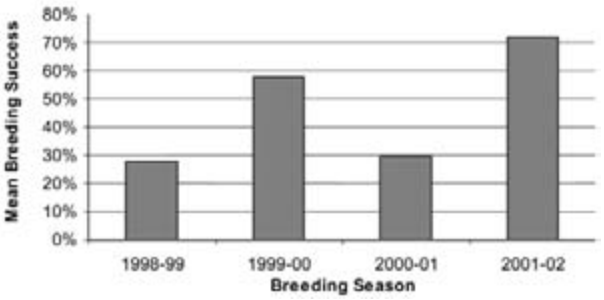

Figure 3. Mean breeding success (percentage of chicks fledged from eggs laid) in each year of the study.

Counts of birds arriving on land at different parts of the colony were conducted a few times each season. These landing counts included local residents and community educators to increase community awareness while providing additional information on population size. Counts were conducted from the same locations and at the same time each year, and volunteers were given training prior to participation to ensure that reliable and comparable data were obtained. Observations made during these counts suggested disrupted rafting[2] behaviour and delayed or asynchronised shore landing resulting from unusual disturbance patterns from recreational boats anchored offshore or human foreshore activity. Little Penguin rafts were observed coming ashore comparatively later on occasions when human or other disturbances were present on the foreshore or on nearby boats. More comprehensive comparative observations of Little Penguin rafting and landing behaviour will be required to determine the effect of such disturbance on breeding penguins.

Diet and foraging

Radio-tracking commenced in October 1999 and was undertaken at the beginning, middle and end of each breeding season (1 July to 28 February). Ten birds were fitted with specially adapted transmitters and tracked from two mobile receiver towers, one on North Head and one on South Head, to record penguin movements within and outside the harbour. Radio-tracking was undertaken with the assistance of volunteers from the National Parks and Wildlife Service (NPWS), Taronga Zoo, Manly Council and other volunteers. Ten birds per month were also captured as they returned to shore and examined for stomach contents for subsequent diet analysis, using the harmless and non-invasive water off-loading technique (Gales 1987).

Preliminary analysis of radio-tracking data indicate that during the breeding season the birds spend most of their time foraging within Sydney Harbour. This correlates with preliminary dietary analysis, which indicates a prevalence of small Sea Mullet *Mugil cephalus* and other species commonly found in the shallow waters of the Harbour (Kuiter 1996). The results of these dietary and foraging studies will be further analysed in the light of the commercial fishing activity within Sydney Harbour.

Mortality

All Little Penguins found dead within the Sydney region in the past few years have been entered on a database set up to record mortality. The collation of mortality and burrow survey data led to identifying many of the causes of death of individual penguins in the Little Penguin colony in Sydney Harbour. An analysis of mortality statistics shows that predation by dogs and foxes is the most common cause of death of Little Penguins in Sydney Harbour, followed by various fatal trauma related injuries and disease.

Several injuries and fatalities from fishing line, netting and hooks have also been recorded in Sydney Harbour. Stahel and Gales (1987) reported that fishing line and hooks are a significant cause of mortality of Little Penguins at Philip Island, Victoria.

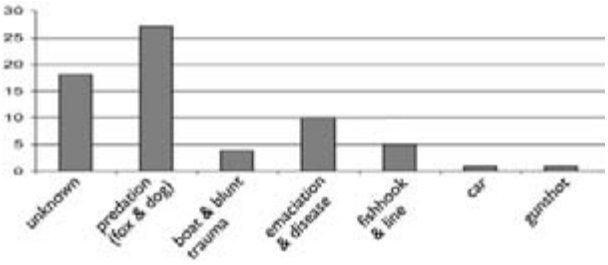

Figure 4. Causes of mortality of the endangered population of Little Penguins in Sydney Harbour from January 1995 to March 2002

Management

Following the establishment of Sydney Harbour National Park in 1989, the NPWS initially adopted a low-key management approach to the Little Penguins, working with the local community in an attempt to keep the exact location of the colony a secret from most of the four million residents of Sydney. The colony's listing as an endangered population in 1997, however, placed a greater responsibility on the NPWS to actively manage the colony, so in 1998 a Little Penguin Recovery Team was established. Information from the current study contributed to the Little Penguin Recovery Plan (NPWS 2000, 2002).

The objective of a Recovery Plan is to document the management actions required to promote the recovery of a threatened species, population or ecological community and to ensure its ongoing viability. The major conservation objective of the Little Penguin Recovery Plan is "to maintain and enhance the population of Little Penguins at Manly to a position of security in nature and have it de-listed as an endangered population from Part 2 Schedule 1 of the *Threatened Species Conservation Act, 1995*". To achieve the objectives in the plan, the recovery team and NPWS will continue to require scientifically-based information and recommendations.

One of the specific management objectives of the Little Penguin Recovery Plan is to identify and ameliorate the impacts of threats. In 2002 the NPWS listed much of the Little Penguin habitat in Sydney Harbour as critical habitat under Part 3 of the *Threatened Species Conservation Act 1995*. This listing incorporates land and water directly adjacent to known Little Penguin burrows, so it will provide greater legislative protection for the colony by requiring an environmental assessment of all activities undertaken within these areas.

However, legislative protection does not equal physical protection. This was evident in April 2001 when a dog killed eight Little Penguins in one night. Neither can human behaviour be curtailed by legislation alone; direct disturbance of burrows by local residents and other members of the public remains a major threat to the colony. Disturbances of nest boxes within the residential area are recorded in most surveys. Some nestbox lids left open have exposed adult birds and chicks to the weather and potential predation. Indirect human disturbances through vegetation removal, weed invasion, rubbish and pollution also adversely affected the population.

Foxes killed 12 adult Little Penguin in July 2000, resulting in a drop in breeding activity in the affected area (from 13 pairs to seven). Foxes have since been identified as a key threatening process of the Little Penguin population on North Head. The NPWS initiated a regional fox-baiting program in 2001 involving several councils and national parks in an area from Mosman to Brooklyn.

Little Penguins nesting within the urban environment are faced with constant disturbance. Incidental observations during this study suggest that noise and light from boats, vehicles, buildings and streets may disrupt Little Penguin rafts and delay them from coming ashore to their burrows. Although it has been documented that Little Penguins will habituate to constant light or noise (Shaughnessy *et al.* 1999), the flicker on and off of boat and porch lights and stereos is not constant. Boating activity in Sydney Harbour is predicted to double within the next 20 years (Boating Industry Association 2002) and areas of natural bushland, such as Spring Cove, will continue to be popular recreational areas. Further building and other developments are also unavoidable in such a populated area of a major city.

Local politicians and other members of the local community have attempted to argue that commercial fishing within Spring Cove, part of the North Harbour Aquatic reserve, is affecting the Little Penguin colony at Manly. Current research aims to determine if any correlation exists between commercial catch and Little Penguin diet and foraging behaviour. Entanglements in line and netting will also be examined in the area.

Three of the seven specific management objectives of the Little Penguin Recovery Plan (2000) relate to habitat conservation:

- to determine the current status of the population and extent of available habitat,
- to maintain the population at current levels and increase the limits of potential habitat, and
- to ensure the protection of the Little Penguin population at Manly and its habitat in the long-term.

Sixty-five percent of the known Little Penguin population in Sydney is on private property, 17% is located within lands managed by the Commonwealth and 18% is within Sydney Harbour National Park. Newman (1992) concluded that an increase in predators associated with ongoing development adversely affected breeding success and adult survival of Little Penguins at Philip Island, Victoria. Habitat reduction or modification was also found to affect that Little Penguin population by reducing available breeding habitat. Predation by domestic dogs was the primary cause of mortality of the Little Penguin population at Eagles Claw in southern NSW (NPWS 1989). Relentless urban pressure continues to force heightened property prices in Sydney and, despite increased development controls and legislation, renovations and redevelopments will continue to affect Little Penguin habitat within the urban area. Given this, the only long-term habitat available for the colony in the future may be the limited areas of foreshore within Sydney Harbour National Park. Over the past four breeding seasons (1998 – 2001) an increased number of breeding burrows has been recorded in this location, and further habitat enhancement and deployment of more nest boxes may augment this increase.

Conclusion

The preliminary results of this research have provided data and information for developing and implementing the objectives and management actions in the Little Penguin Recovery Plan and more substantial legislative controls to protect the colony. A greater achievement of this research, however, is the provision of information that has led to increased community understanding and awareness of Little Penguins in Sydney Harbour and prompted joint education programs with NPWS and Manly Council.

It is the intention of the Little Penguin Recovery Plan that a combined management approach of stronger legislation and increased community education will prevent much of the direct disturbance to birds and burrows and facilitate the conservation of this colony in the future. Continued research into the impact of threats, especially disturbance, on the breeding success and viability of the colony is essential to ensure that we achieve the primary objective of de-listing the population from Schedule 2 on the *Threatened Species Conservation Act 1995*. The research described in this paper was vital in identifying the threats, listing management options and engaging community support for management actions. Legislation alone will not provide adequate protection for this population.

Finally, this study highlights how urban wildlife presents specific challenges for wildlife managers. By allowing opportunities for human interaction with wildlife, we may be increasing the disturbance to this wildlife, but it could benefit from the raised public awareness of the need for conservation and management. The continuation of this study, and general monitoring of the population by the NPWS, will be an essential component of establishing the management boundaries required to achieve the balance between human needs for habitation and recreation and the conservation and protection needs of Little Penguins.

Acknowledgements

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APPENDIX

Appendix 1. Reasons for listing the Little Penguin population in Sydney Harbour as an endangered population on Schedule 2 of the *Threatened Species Conservation Act, 1995.*

"The NSW Scientific Committee listed the Manly Point population of Little Penguins as endangered on the *Threatened Species Conservation Act, 1995* on 31 January 1997 for the following reasons:

- the Little Penguin colony in Manly was formerly more extensive occurring at Manly Point, Spring Cove, Store Beach and Cabbage Tree Bay;
- the population is restricted to Manly Point and may be as small as 35 birds;
- the population is of significant conservation value given its disjunction from other populations and its occurrence in Sydney Harbour;
- the decline of Little Penguin populations in the Sydney region has been attributed to habitat destruction and predation from domestic and introduced animals. There is evidence that predation by dogs had been a significant factor in the decline of the Manly population; and that
- the numbers of Little Penguins in the Manly Point population have been reduced to such as critical level that it is in immediate danger of extinction" (NPWS 2000).

"The Manly population of Little Penguins represents only a small percentage of the States total population. However, the colony is of State significance as the only breeding colony on the NSW mainland. The colony contributes to the maintenance of genetic diversity, as losses of penguins from other localities may occur form natural or human induced disturbances. The presence of a wild population of penguins near a major urban centre has generated considerable community interest in the protection of the colony for its scientific, educational and general conservation values" (NPWS 2000).

Opposite page from left to right, top to bottom. One of 8 Little Penguins killed by a domestic dog in April 2001. Photo: Julie Bourne. NPWS staff collecting oiled Little Penguins for rehabilitation at Taronga Zoo after the Sydney Harbour oil spill. Photo: Julie Bourne. The Manly Ferry crash in 2001. Leaking oil into surrounding Little Penguin habitat. Photo: Julie Bourne. A 3 day old Little Penguin chick. Photo: Julie Bourne. NPWS staff studying Little Penguins. Photo: Nick Klomp. Boats at Store Beach, Sydney Harbour National Park. Photo: Julie Bourne. Dogs and human disturbance on Store Beach, Sydney Harbour National Park. Photo: Julie Bourne. NPWS staff undertaking Little Penguin monitoring. photo: NPWS. NPWS staff undertaking Little Penguin monitoring. Photo: NPWS. An adult and 2 seven week old chicks in an artificial nest box. Photo: Julie Bourne.

[1] The military refers to the Commonwealth Department of Defence located in NSW.

[2] Rafting is the term used to describe the behavior of penguins prior to coming ashore at night. Penguins will gather together in vocal groups on the water ('rafts') to facilitate a coordinated and simultaneous landing on the shore (Stahel & Gales 1987).

APPENDIX