MARINE MANAGEMENT SUPPORT:
LEEUWIN-NATURALISTE

# STATUS OF LITTLE PENGUINS IN WESTERN AUSTRALIA: A MANAGEMENT REVIEW

**Report: MMS/LNE/SIS-40/2001**

**Prepared by**
**Dr Belinda Cannell**

**For**
**the Department of Conservation and Land Management**

**April 2001**

Marine Conservation Branch
Department of Conservation and Land Management
47 Henry St
Fremantle, Western Australia, 6160

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**This report may be cited as:**

Cannell B. (2001): Status of little penguins in Western Australia: A management review. Report: MMS/LNE/SIS-40/2001. April 2001. (Marine Conservation Branch, Department of Conservation and Land Management, 47 Henry St., Fremantle, Western Australia, 6160). Unpublished report.

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## EXECUTIVE SUMMARY


The status of Little Penguin populations on 168 islands from Perth to the Recherché Archipelago in Western Australia was determined. No information is available for 84 of the islands. Only three of the remaining islands are reported to have colonies of more than 200 penguins and the Penguin Island colony is the only one with more than 500 penguins.

Available information on various aspects of this colony’s terrestrial and aquatic biology was reviewed and summarized. Due to various features of this colony, it has been awarded the highest conservation status of Little Penguin colonies in Australia and there is evidence that this colony may merit sub species status.

Existing and potential anthropogenic and natural threats, onshore and offshore, for the Penguin Island colony of Little Penguins were determined. The threatening processes were ranked on the basis of relative risk that established that disturbance of the whitebait nursery at Becher Point, recreational boat use and overfishing were the most significant.

Developing strategies to address these threats must be supported by an effective base upon which outcomes of strategies can be measured. Whilst several such strategies have been identified, a better basis to measure the effectiveness of these strategies is required. Rigorous baseline monitoring needs to be established as a high priority to achieve this outcome. Nevertheless, several lagging indicators have been identified, and would serve as the basis for reflecting the effectiveness of these management strategies, once baseline monitoring establishes reliable targets. These indicators include the numbers of penguins arriving on Penguin Island, the breeding success, adult mortality, body condition of the penguins at various stages throughout the year and mortality of moulting birds.

In order to establish a rounded management system for the Penguin Island colony, focusing on lagging indicators is insufficient. Several leading indicators have been suggested (strength of Leeuwin Current and El Nino/Southern Oscillation (ENSO), baitfish biomass etc) which can establish a more proactive basis for management action that complements strategies typically measured through lagging indicators. The greatest use of these leading indicators will be through the development of predictive models to aid establishment of reliable performance targets.

# TABLE OF CONTENTS

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**LIST OF TABLES**



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# 1 SUMMARY OF THE STATUS OF LITTLE PENGUIN (*EUDYPTULA MINOR*) IN WESTERN AUSTRALIA

## 1.1 DISTRIBUTION OF LITTLE PENGUINS IN WESTERN AUSTRALIA

Various sources of information were used to assess the location and size of populations of Little Penguins in Western Australia. Most importantly were works by Burbidge *et al*. 1996, the Seabird Island Series published in Corella, and personal communications from Peter Collins (CALM Wildlife Officer) and Dr Nick Dunlop. Little Penguin colonies are typically located on islands. Where there were several references to an island, the latest reference was used.

One hundred and sixty eight islands were assessed between Carnac Island and Twilight Cove (not including the unnamed islands). Of these, it appears that Penguin Island is the only island with a population of 500 – 1000 penguins. The next largest colony is on Breaksea Island (in King George Sound near Albany, approximately 600 km away), with an estimate of 500 individuals. There is no information for 84 of the 168 islands. Of the remaining islands, nearly half are not inhabited by penguins. Two thirds of the islands with population estimates appear to have less than 50 penguins (Table 1, see Appendix 1 for detailed information). Much of this information was collected more than 15 years ago, and for many islands, their entire fauna and flora survey was conducted within a matter of hours.

**Table 1. Population estimates on islands from Carnac Island to the Recherché of the Archipelago.**

| Population estimate | Number of islands |
|---|---|
| No penguins | 37 |
| < 50 | 19 |
| 50-100 | 6 |
| 100-200 | 3 |
| 200-500 | 2 |
| > 500 | 1 |
| No estimate | 16 |
| No information | 84 |
| Total | 168 |

## 1.2 LITTLE PENGUINS ON PENGUIN ISLAND

Penguin Island is a 12.5 ha limestone island that lies 600 m offshore from a rapidly expanding urban area. It is joined to the mainland by a sandbar that is at least partially submerged, and the low spring tides allow easy access for visitors across the sandbar (Wienecke *et al.* 1995). It has a thin coverage of Holocene aeolian sand in places and bears low bushes and shrubs (Chape 1984). Few penguins dig burrows, and most nest under bushes and shrubs and in limestone crevices. Penguins can be found over the majority of the island, but the highest density occurs on the Tombolo area (Dunlop *et al.* 1988). Apart from the few penguins on Carnac and Garden Islands just north of Penguin Island, this colony is at the northern and western limits of its range.

In 1986, 55 identical plywood nest boxes were placed on the island in the Tombolo region, either under, or adjacent to, *Tetragonia* bushes (Klomp *et al.* 1991). Since then, the nest boxes have been checked at least fortnightly, and the birds inhabiting the boxes have formed the basis of several studies on various aspects of penguin biology.

### 1.2.1. Population estimates

From various sources, the population of penguins on Penguin Island is estimated to be between 500 and 1000 individuals (Dunlop *et al.* 1988, Klomp & Wooller 1991, Wienecke 1993, Wienecke *et al.* 1995). These figures were based on monthly retrap rates of marked individuals during various intensive studies on the colony. Population estimates from 1987 – 1991 appeared to show a declining trend (Wienecke 1993). There have been no recent attempts to estimate the population. From the nest box population information has been gained on mate and site fidelity, breeding success and its annual variation, chick growth and the affects of human disturbance. The checking of the nest boxes alone cannot be used as a means of monitoring the population.

## 1.3 TERRESTRIAL LIFE OF LITTLE PENGUINS ON PENGUIN ISLAND

### 1.3.1. Daily cycle

Peak numbers of penguins leave the island before dawn and they forage at sea all day. They usually begin to return to the island 45 minutes after dusk, with peak numbers arriving one to two hours after dusk. Individuals use the same point for entry and departure, and while partners do not generally arrive together, they do use the same landfall point (Klomp & Wooller 1991).

### 1.3.2. Annual cycle

Little Penguins leave Penguin Island when they have finished moulting, around December/January, and return to the island around March to begin their pre-breeding activities. It is not known where the penguins go between moulting and pre-breeding, and therefore the potential threats the penguins are exposed to during this time are also unknown. Breeding is unusually protracted in this colony, lasting from April to December (Wienecke 1993, Nicholson 1994, Cannell pers. obs.). Time of egg laying varies between years, but can begin anywhere from April to August (Wienecke 1993, Nicholson 1994). However the main peak of egg laying is generally in June, with a smaller peak in September (Dunlop *et al.* 1988). Generally 2 eggs are laid and incubated for 5 weeks. Both parents share the incubation and chick rearing, which lasts for about 8 weeks. After hatching, the parents guard the chicks for an average of 17 days. The importance of this nurturing behaviour is evident from the fact that successful breeders guard their chicks for 5 days longer than failed breeders (Chiaradia 1999). Parents feed their chicks for a total of 7 – 8 weeks before the chicks leave the nest. Time of breeding appears to coincide with an abundance of food for hatchlings (Wienecke 1993). Depending on the date of laying, some pairs will lay 2 clutches of eggs in a season (Wienecke 1993). Once the chicks fledge they leave the island. They generally return to the island to breed when they are 2-3 years of age (Reilly & Cullen 1982, Wienecke 1993).

The only critical event for penguins each year is their annual moult, an intense physiological effort for the penguins during which they replace all their feathers over a two to three week period. The penguins have an increased metabolic rate, body temperature and energetic demands associated with new feather growth (Stahel & Gales 1987). They are confined to land during the entire moult and an individual can only survive the moult period if its' body mass is great enough to endure the long fast. Depending on the time of breeding, some birds may need to abandon their chicks in order to build up their own reserves. The penguins are often emaciated after moulting (Stahel & Gales 1987). For the Little Penguins on Penguin

Island, moulting occurs in December/January and thus coincides with high daily temperatures and peak numbers of tourists on Penguin Island. As the penguins are confined to land they are unable to escape these stresses.

### 1.3.3. Mate and site fidelity

Little Penguins appear to be highly faithful to their natal colony with little evidence of immigration or emigration (Wienecke 1993), i.e. there is little interaction with other colonies. Indeed, Little Penguins have a high site fidelity, with penguins returning to a nest site within $5m^2$ of the nest site they had occupied during the previous year or where they were raised (Nicholson 1994). Experienced males generally return first to the island following their post-moult exodus, and are more faithful to a site than females (Wienecke 1993, Nicholson 1994). Mate fidelity is high, at least within years (Wienecke 1993, Nicholson 1994). However the number of birds remaining together over successive years drops each year (Wienecke 1993). Breeding success is related to the stability of the pair-bond (Wienecke 1993)

### 1.3.4. Breeding success

Breeding success varies yearly. The success of the nest, defined as raising a chick until it fledges, appears to be associated with breeding experience of the parents, their body mass at the start of the breeding season, and the availability of food (Wienecke 1993, Chiaradia 1999). Food shortage delays laying, reduces the period over which the penguins will lay and reduces the number of penguins attempting to breed (Wienecke 1993). Daily terrestrial temperatures also affect nest attendance during pre-laying and the onset of breeding, the latter being delayed with high temperatures (Wienecke 1993, Nicholson 1994).

The nest site itself also appears to affect breeding success. Nest sites that have a higher percentage of cover are more successful (Wienecke 1993). Human disturbance appears to affect the site chosen and the subsequent breeding success. Studies using the nest boxes showed more nest boxes are used in areas with the least human disturbance. Hatching rate and fledgling success is also greater in undisturbed areas (Klomp *et al.* 1991). Access to a nest site also affects breeding success. Following storm events, access to burrows is reduced due to eroded and damaged paths such as severe cut backs in dune slopes. As the parents cannot return to their chicks during such times, breeding success is reduced (Nicholson 1994). From 1987 – 1991, only 21 – 40% of eggs laid in the nest boxes resulted in fledged chicks (Wienecke 1993).

### 1.3.5. Survival

Survival estimates of Little Penguins from 1986 – 1991 varied from 2 years to 12 years with an average of 5 years. Over the six year study period, it was estimated that 75% of the adult population survived from year to year (Wienecke 1993). The survival rate of fledglings after leaving the nests was unknown, but on Phillip Island it has been estimated that 33.3% of birds banded as chicks survived to their first birthday (Dann & Cullen 1990).

### 1.3.6. Effect of the Leeuwin Current

The Leeuwin Current is a pole ward flowing current along the Western Australia coast that brings warm, tropical waters of low salinity. Its flow and strength are affected by the El Nino/Southern Oscillation (ENSO) events (Wienecke *et al.* 1995). Thus during an ENSO year, the Leeuwin current is weaker and the southward penetration of tropical waters is reduced allowing the northern flowing Capes Current to reach further north. As a result the waters surrounding Penguin Island are cooler. ENSO years have been associated with good body condition of the penguins on Penguin Island and a longer laying period (Wienecke 1993, Nicholson 1994). Conversely, when the Leeuwin Current flows strongly, the water temperatures are warmer and the salinity is reduced. The effect this has on the local fish populations is still largely unknown. However data on the annual and mean catches per boat of sandy sprat (*Hyperlophus vittatus*) and pilchard (*Sardinops neopilchardus*) from 1976-1991 show that their abundance was markedly reduced in inshore waters from Fremantle to Mandurah when the current flowed strongly (Wienecke 1995).

### 1.3.7. Morphometrics and comparison with other populations

The penguins on Penguin Island are heavier and larger than penguins found in Albany, Phillip Island Tasmania and Jarvis Bay. Preliminary results suggest that the Penguin Island population is also genetically separate from the other populations studied (Wienecke 1993).

## 1.4 AQUATIC LIFE OF LITTLE PENGUINS FROM PENGUIN ISLAND

### 1.4.1. Foraging ranges and diet

From a radio-tracking study conducted in 1996/1997, it was found that the penguins all headed south and tended to forage within 10 km of the coastline, remaining between the coast and the Garden Island Ridge. Thus, the birds all pass through the narrow stretch of water in the morning, bordered by Becher Point on one side and the Murray Reefs on the other, in order to reach their foraging grounds. Before dusk, they swim along the same route back to Penguin Island (Wooller *et al.* in prep.).

During the breeding period, the penguins are mostly found in Comet Bay, and their foraging range decreases when they are rearing chicks (a few were found throughout the day in Warnbro Sound). There is evidence that the breeding success decreases with increasing foraging range (Wooller *et al.* in prep).

From diet studies conducted in four different years (1986, 1988, 1995 and 1996/97), it is evident that Little Penguins feed mainly on sandy sprat , pilchard and garfish (*Hyporhamphus melanochir*). However, sandy sprats comprise 60% of the penguins diet while rearing chicks (Klomp & Wooller 1988, Wienecke 1989, Connard 1995 and Wooller *et al.* in prep). A study of inshore waters at 14 different sites covering 55 km of the coastline (north and south of Penguin Island) revealed that the highest densities of 20 – 35 mm sandy sprat were found inshore at Becher Point. The average size of sandy sprats taken by the penguins was 40 – 50 mm in length, although sprats between 30 – 60 mm in length were found in the dietary samples (Wooller *et al*. in prep).

Assemblages of fish that have grown up in different areas can be identified by differences in the ratios of isotopes of Carbon and Oxygen incorporated into their ear bones (otoliths). These ratios in the otoliths from sandy sprats taken from penguin diet samples were compared with those found in sandy sprats caught at various sites along the coast. It was determined that the sandy sprat the penguins ate originated from the nursery at Becher Point (Bastow *et al.* in prep)

### 1.5 CONSERVATION STATUS OF LITTLE PENGUINS

Even though not listed in the Wildlife Conservation Act or the Environmental Protection and Biodiversity Conservation Act, the Little Penguin population on Penguin Island has been given the highest conservation status of 256 colonies of Little Penguin around Australia studied (Dann *et al.* 1996). This study used several criteria to make this assessment. These included

- *Population size* – populations of greater than 1000 individuals were regarded as having conservation significance;
- *Location* – it is the only colony of significant size on the west coast; the nearest colonies of comparable size are on Breaksea Island, more than 600 km away. Isolated sites may assume greater significance in the maintenance of biodiversity.
- *Vulnerability* – sites of high conservation significance were those where current threats were minimal, or where steps could be realistically taken by the relevant management agency to reduce further damage.
- *History in scientific research* – the Penguin Island colony has been the subject of long-term study by scientists from Murdoch University who have collected data weekly for the past 14 years from 50 - 55 nest-boxes and from a number of banded individuals with known reproductive histories. Recently, several individuals from the colony have been radio-tracked to determine where they feed and, during 1999, the annual reproductive patterns have been studied with the help of a Small ARC Grant (University of WA and Murdoch University).
- *Special features* – the Penguin Island birds differ from those in other colonies in several ways: first, they are substantially larger (Klomp & Wooller 1988b, Wienecke 1993); second, they nest under bushes and in limestone rocks, rather than in excavated burrows; and third, they have an unusually long breeding season, often laying two clutches of eggs between April and December, rather than a single clutch laid in spring-summer (Wienecke 1993). Preliminary results show they may be genetically separated from other colonies of Little Penguins (Wienecke 1993)

## 2 THREATS

There are various potential threats to the viability of penguin populations. In order to identify those threats that may impact on the long-term survival of the Little Penguins, it is necessary to evaluate the significance of each threat. Natural mortality such as parasitism, in itself, is not a threatening process unless humans have changed its frequency or intensity. Management of Little Penguins is mainly concerned with controlling mammalian predators (i.e. dogs, cats and foxes), protecting nesting habitats and minimising various kinds of human (anthropogenic) disturbance, including tourism (Dann *et al.* 1996)

### 2.1 ANTHROPOGENIC EFFECTS OFFSHORE

#### 2.1.1. Food availability

A reduction of the food supply of penguins, whether by natural events, overfishing or other anthropogenic causes (such as declining water quality), has serious consequences for Little Penguins. While they take a variety of fish, they are selecting for particular species during different stages of their cycle. For example, they appear to be targeting pilchards in the early part of their breeding season and sandy sprat during chick rearing. Furthermore, as the distance travelled by the penguins is related to breeding success (Collins *et al* 1999), a nearby, plentiful supply of sandy sprat is essential. Anything that is likely to disturb the availability of these species of fish is likely to have an impact on the breeding success, and therefore population size, of Little Penguins on Penguin Island. The seriousness of the impact will obviously be dependent on the magnitude of the affect on fish availability. This was evident in 1987-88 in the Little Penguin colony at Phillip Island. A reduction in the overall food availability and a shift in diet to an increased composition of krill and squid led to later onset of breeding, reduced hatching and fledgling success and reduced mean weight of chicks at banding (which resulted in decreased chance of survival). The number of pairs laying single egg clutches also increased (Cullen at al. 1992). Another example is the mass pilchard mortality in Victoria in 1995, which resulted in an immediate increase in adult mortality, a delay in egg laying, a decrease in breeding success and a marked increase in the mortality of first year birds the following year (Dann *et al.* 2000).

### 2.1.2. Commercial fishing

*Disturbance of whitebait nursery*

Whitebait (i.e. sandy sprat) are largely caught commercially from shore based nets (there is one purse seine net operator), and most of the whitebait is caught from the Bunbury region (Fisheries Dept of W.A. 1996). Sandy sprat are the most important prey item of the penguins while they are rearing chicks (Wooller *et al.* in prep.), and chemical analyses of otoliths from diet samples taken from penguins in 1997 showed that the penguins ate sandy sprat that originated from the nursery site at Becher Point. As the largest proportion of the annual commercial catch is taken from the Bunbury region, it would appear that the relatively small current commercial catches of whitebait taken from Becher Point are not a direct threat to Little Penguins on Penguin Island. However, the total annual catches are reduced for one to two years following large catches from the Bunbury region (Fisheries Dept. of WA. 1999) i.e. there may be an effect on the total population available. Evidence suggests that the distribution of sandy sprat is largely restricted to nearshore waters and that the nursery areas are restricted to protected inshore marine areas and major estuaries. The total stock size between Fremantle and Busselton is not large (< 1000 tonnes) and is patchily distributed (Gaughan *et al.* 1996), and sandy sprats live to a maximum of three, and possibly four, years. This short life span, in conjunction with the fact that the majority of the catch from Warnbro Sound consists of fish less than two years of age, results in this species being particularly vulnerable to overfishing (Gaughan *et al*.1996).

Given that the penguins generally remained within 20 km of Penguin Island during chick rearing (Wooller *et al.* in prep) and as breeding success is related to foraging distance from the nest site (Collins *et al.* 1999), any development at Becher Point is likely to have an adverse effect on the breeding success of the penguins and ultimately the number of penguins in the colony.

*Fin Fishing*

Pilchards are an important prey item for Little Penguins (Klomp & Wooller 1988b, Wienecke 1989, Connard 1995). They predominate the penguins' diet in autumn and early winter (Klomp and Wooller 1988b, Connard 1995), i.e. the beginning of the breeding season, which also coincides with the most productive season of the Fremantle commercial pilchard fishery

(Fletcher 1991). At this time, between spawning seasons, the adult pilchards have a particularly high oil content (Blackburn 1950). Pilchards have been implicated as the proximate cause for the onset of breeding in Little Penguins (Montague and Cullen 1988). The pilchard biomass is carefully monitored however, thus the risk of population reduction from commercial overfishing would appear to be minimal.

The commercial catch of southern sea garfish has significantly reduced since 1975, when 15 545 kg were caught, to only 5 kg being caught from Warnbro Sound/Comet Bay in 1999/2000 (W.A. Fisheries pers. comm.). This is probably due to a reduction in fishing effort rather than a marked decrease in the population (Lenanton pers. comm.).

*Rock Lobster and Crab Fishing*

There are approximately 300 licenses for rock lobster fishing in zone C, but the number fishing in the Comet Bay area is much smaller than this. Most of the fishing is concentrated on the west side of the Murray Reef system, and therefore would not appear to impact on the penguins. There have been no records of penguins being caught in lobster pots or entangled in their lines.

There are only two crab boats licensed to fish in the open ocean of Comet Bay, and one in Warnbro Sound. The impact of these fishers on penguins is unknown but thought to be minimal.

*Southwest Trawl Fishery*

There are only two boats trawling in the marine park. The trawling involves sea floor and benthic fauna disturbance, but the low number of trawlers operating would presumably not impact on the penguins.

### 2.1.3. Recreational fishing

Recreational fishing is one of the most popular leisure activities in Western Australia (Sumner and Williamson 1999). In 1996/97, an estimated 10 626 boats fished in the southern half of Warnbro Sound and Comet Bay (Williamson pers. comm.). It is difficult to estimate the effect recreational fishers are having on the populations of fish in the area. However, the recreational fish catch of skipjack trevally is greater than the reported commercial catch, and recreational catch of southern sea garfish forms a significant proportion of the total catch (Summer and Williamson 1999). The catch of both these species from the Perth South and Mandurah regions (which incorporate Warnbro Sound and Comet Bay), were amongst the highest recorded. These two species have been found in the diet of Little Penguins, and garfish composed significant proportions of the diet in 1986, 1989 and 1995. The fish caught by the recreational fishers are, on average, larger than those taken by penguins (Sumner and Williamson 1999), but the larger fish taken represent the mature breeding population. Consequently the number of smaller juveniles on which the penguins prey is likely to be affected. Currently there is no research on the biomass of garfish in Warnbro Sound and Comet Bay. Nevertheless, competition between the fishers and the penguins is undoubtedly occurring, and is likely to be increasing with the increasing number of recreational fishers.

### 2.1.4. Recreational boat use

From 1981 to 1999, the population of Rockingham has grown from 25,000 to 70,000 people. Although there is no published evidence of increasing recreational boat numbers in this area, it is expected to have increased also. Penguins forage in Comet Bay (and occasionally in Warnbro Sound) and travel daily through Warnbro Sound and the connecting stretch of water less than 2 km wide between Becher Point and the Garden Island Ridge. They also sleep at sea, on the water surface. Thus interactions between penguins and boats are unavoidable. The interactions are multi-tiered. Firstly is the risk of injury from birds being struck by boats/propellers/fins. Secondly is the interruption of foraging bouts by boats, and thirdly is competition between penguins and fishers for fish.

Most penguins die at sea and the chances of recovering them are small (Wienecke 1993). However, penguins have been collected with propeller/fin wounds across the upper middle of their body (Mayes pers. comm.). In attempt to limit the impact of boats on wildlife in the marine park, motor driven vessels within the Shoalwater Bay Special Purpose Zone are recommended to limit their speed to 8 knots within 200 metres of the island or mainland shores (CALM in prep.). Windsurfers pose a significant risk to Little Penguins as they are quieter than motor powered vessels and their skegs can vary in length, anywhere from 29 – 54 cm in length. Little Penguins studied in Tasmania remained within the top 1 – 2 m while travelling to their foraging sites (Bethge *et al*. 1997), and in Comet Bay they are foraging in waters that range from 3 – 12 m in depth (Wooller *et al.* in prep.). It is recommended in the Shoalwater Islands Marine Park Management Plan 2001 – 2011 that sail powered vessels be encouraged to conform to the speed regulations. However these are often observed to be travelling at much greater speeds in the Special Purpose Zone. A recent study on whales struck by boats found that they were unable to escape from boats traveling at speeds above 14 knots (Laist *et al.* 2001). Little is known about the depths at which penguins from Penguin Island travel or forage, the length of time for each foraging bout, their acceleration rate, or the interval between foraging bouts spent at the water surface. The probability of penguins being able to escape from boats travelling at various speeds therefore cannot be determined, nor can the potential disturbance boats have on penguins foraging. However, the increasing number of people using recreational vessels in the same waters the penguins travel and forage in is likely to be having an increasing impact on the penguins.

### 2.1.5. Plastic pollution

Penguins can get entangled in plastic pollution such as discarded fishing line or the yokes from cans and bottles, or they may swallow it. Usually a penguins' flippers, feet or bill is entangled, and the bird can either not feed, or it drowns (Dann 1990). Recently a penguin was found entangled with fishing line to a bush on Penguin Island. Although released it had lost body condition, and was found dead the following day (Mitchell pers. comm.). Given the level of recreational fishing in the marine park, the potential threat from entanglement in fishing lines would be expected to be quite high.

### 2.1.6. Toxic contamination

The most recent study of levels of pesticides, polychlorinated biphenyls, hydrocarbons, organotin compounds and heavy metals in sediments from coastal waters between Fremantle and Mandurah is detailed in the DEP 1996 Southern Metropolitan Coastal Waters Study report. Arsenic was found to be elevated in Warnbro Sound, DDT was widespread in Warnbro Sound and Comet Bay, with storm water drains thought to be the principal source for both compounds. In a recent report on Arsenic levels in nearshore sediments, there was an of wet weight of fat were higher than levels previously reported for other seabirds. It is unclear the implications such levels have on the health of the penguins (Gibb 1995).

DDT is known to cause thinning of eggshells, particularly in birds of prey and those that eat fish (CSIRO 1979). Currently there have been no studies undertaken to determine the levels of these compounds in penguins, and from the nestbox data there is no evidence to suggest that eggs are accidentally broken during incubation (an indicator that egg shells are thinner and weaker than normal (CSIRO 1979)).

Tributyltin (TBT), the active ingredient in certain marine anti-fouling paints has been banned in WA since 1992 on vessels under 25 m in length. It is extremely toxic to marine life, and causes a sexual deformity (imposex) in marine snails. In birds it has been found to reduce fertility and hatching success (Schlatterer *et al.* 1993). In 1994, concentrations of 1-10 ìg TBT $kg^{-1}$ were found throughout sediments in Warnbro Sound and the northern half of Comet Bay. However, in various coastal areas, including Becher Point, sediment concentrations of 10 – 20 ìg TBT $kg^{-1}$ were found, and a hotspot of 20 – 40 ìg TBT $kg^{-1}$ was found in northern Comet Bay (DEP 1996). Sandy sprat taken by Little Penguins during their chick rearing season originate from Becher Point (Wooller *et al.* in prep, Bastow *et al.* in prep), and the penguins commonly forage in Comet Bay. The "penguin highway" to and from their daily foraging grounds goes through these waters. However levels of TBT in the sediment do not necessarily indicate levels of TBT in the water column. A recent survey of the rate of imposex in the whelk, *Thais orbita,* from various study sites showed that the rate had decreased around Penguin Island and the Sisters Reef (Reitsema *et al.* in prep.). It would therefore appear that levels of TBT would not be of a great immediate concern to the Penguin Island colony. However, bioaccumulation up through the food chain does not preclude the penguins being affected by TBT if it is still apparent in the areas in which their prey forage. Also, 100% of the whelks examined from Colpoys Point (within 50 m of a naval berthing facility) on Garden Island exhibited imposex, and therefore the Little Penguins on Garden Island may be affected by TBT (Reitsema *et al.* in prep.).

Copper is used as an antifouling agent on smaller craft and its effects are currently unknown.

### 2.1.7. Oil spill

Oil spills have the potential to elicit major, even catastrophic, effects on penguin populations (Dann 1996). Not only do they have immediate and devastating effects on Little Penguins, but oiled and rehabilitated Little Penguins show a delay in egg-laying the following season and they have an overall reduced egg success. For at least two seasons after the oiling event, the masses of their pre-fledglings is significantly lower. The survival rate of these chicks would therefore be reduced (Giese *et al.* 2000).

Currently the Australian Maritime Safety Authority (AMSA) has a National Plan for oil spills, and a contingency plan for wildlife during oil spills (available on their website). However, a review of the National Plan response to the Iron Baron Oil spill recommended that a National Wildlife Response Plan should be pursued as a matter of priority. The AMSA has also distributed Oiled Wildlife Response Kits to 4 locations around Australia, one of which is at The State Operations Headquarters of CALM in Kensington. The State Marine Pollution Committee and associated agencies holds primary responsibility for the response and planning of oiled wildlife. In the event of an oil spill in the state, CALM would be responsible for coordinating resources in terms of equipment, personnel and volunteers for the rescue and rehabilitation of oiled wildlife. However, there are no courses for the treatment of oiled wildlife for CALM staff or CALM volunteers. Nor is there any specific training for the handling of oil-affected wildlife for wildlife carers (Smith pers. comm.).

According to the Department of Transport, the risk of an oil spill affecting Penguin Island is extremely low. The large ships using bunker oil are well offshore. Those travelling northwards towards Fremantle pass approximately seven to eight nautical miles to the west of Penguin Island.

#### 2.1.8. Sewage outfall

The Woodman Point treatment Plant discharges primary treated effluent into the Sepia Depression at the Cape Peron outfall. This is the largest single point source of nutrients into the region. In 2002, the treatment will be upgraded to a secondary level. There is a commitment to maintain levels of outputs to 1994 levels.

#### 2.1.9. Industrial waste

Currently, industrial waste is either released into Cockburn Sound, following treatment, via the industry's own outlet (e.g. BP, CSBP). The industries themselves are responsible for monitoring their own outputs. Smaller industries treat their waste and then send it to the treatment plant. The threat this outfall poses is conditional on the output meeting standards proposed by the Water Corporation.

### 2.2 ANTHROPOGENIC EFFECTS ON PENGUIN ISLAND

#### 2.2.1. Disturbance of nesting sites

Trampling, destruction of habitat and disturbance of flora and fauna are noted as the more severe impacts of humans on Penguin Island. Since the construction of the walkways on Penguin Island, public access to many areas used by the penguins has been restricted. However, other activities such as swimming and picnicking on the beaches also affect the penguins (Wienecke *et al.*1995). A study of the breeding success of the nest boxes in different areas of the Tombolo region showed that the occupancy, hatching and breeding success was reduced in those areas closest to human disturbance (Klomp *et al.* 1991). Penguins will abandon their nest sites if disturbed and King Skinks may take unprotected eggs. While the island is closed from June until September, the second peak of breeding occurs from September to November/December (Wienecke *et al.* 1995, Cannell, pers. obs.), followed by the moult period. This also coincides with warmer weather and school/Christmas holidays, and represents the only time in the annual cycle that the penguins are restricted to land. The number of people visiting the island during November- January is very high. The presence of the CALM Ranger and CALM volunteers on the island aids in the reduction of disturbance by visitors. However there are reports of tourists and bus operators removing penguins from accessible caves in order to take photographs. Unfortunately, stressed penguins are not easily discerned. A study on Adelie penguins showed that their heart rates can double with no evidence of posture change (Culik *et al.* 1990). Therefore, the tourists do not know of the possible deleterious affect they have on the penguins. Direct disturbance of the penguins' nesting sites is conditional on people remaining on the walkways.

### 2.2.2. Introduced predators

Currently there are no introduced predators on Penguin Island. Cats are very efficient predators, with a report of feral cats killing approximately 20 penguins in three days on Wedge Island, Tasmania (Stahel and Gales 1987), and a cat released onto an island near Albany killed 19 penguins (Wienecke 1993). Dogs and foxes are also efficient predators, being implicated in several extinctions and declines of penguin colonies (Dann 1996). The probability of such predators making their way to the island is remote, however there is anecdotal evidence of surfers taking a dog to Penguin Island on their surfboard. When the tides are low, the water level above the sandbar connecting Penguin Island and the mainland can be as low as a few centimeters. Full exposure of the sandbar would be a threat to the penguins, and would need to be assessed at the time of occurrence.

### 2.2.3. Fire

While the probability of a fire on Penguin Island is low, the impact on Little Penguins is potentially very high. A reduction in the numbers of penguins breeding on De Witt Island in southwest Tasmania is thought to be the result of deliberately lit fires (White 1980). The main fire risks occur where the dry grassy weeds have invaded and where the densest and woodiest vegetation occurs i.e. adjacent to the south-eastern walkway, the eastern side of the main dune, and the dunes behind the tourist centre. This latter area represents that of highest penguin population in the nest boxes. As recently as last year, a fire was observed on the north-eastern beach in the evening during the Ranger's absence (Mitchell pers. comm.).

## 2.3 NATURAL EFFECTS

### 2.3.1. ENSO and the Leeuwin Current

During an ENSO year, the Leeuwin Current is weaker, thus the water temperature is reduced. During such years, the body conditions of the Little Penguins improve, their food is seemingly more abundant and the laying period is protracted. Conversely, during a strong Leeuwin Current the body condition of the penguins is reduced, their laying period is delayed and is shorter. The number of birds attempting to breed is also reduced. The Leeuwin Current appears to positively affect the number of whitebait available in the year following a strong Leeuwin Current (Gaughan *et al*. 1996).

### 2.3.2. Diseases from feral pigeons

Avian Paramyxovirus incorporates several strains of the virus, both pathogenic and non-pathogenic, and includes Newcastle disease virus (NDV). Some of the strains, including NDV are carried by pigeons, and are transmitted via faeces. The clinical presentations may vary in severity and include:

- Peracute death
- Acute gastrointestinal disease
- Acute respiratory disease

- Acute gastrointestinal and respiratory disease
- Chronic central nervous system disease (Gerlach 1994)

Antibodies to Newcastle disease have been previously demonstrated in the serum from Little Penguins but their significance is uncertain. However, the disease has occurred in Adelie penguins, which were thought to have been infected in the wild (Clarke & Kerry 1993 and refs within). A large flock of pigeons inhabit Penguin Island, but the threat of NDV or other pathogenic Paramyxoviruses to Little Penguins is currently unclear.

#### 2.3.3. Storms

Storm events can cause cut backs in the dune slopes limiting adult penguin access to their nest sites. This can result in incubating partners abandoning eggs or chicks starving. The number of storm events is expected to increase with the change in climate as a result of the Greenhouse Effect. The effect of storm events can be minimized by sandbagging penguin access areas eroded during storms.

#### 2.3.4. Natural predators

The only natural predators on Penguin Island are the King Skinks, which take abandoned eggs. Therefore the effect natural predators have on Little Penguins is dependent on the level of disturbance by humans at the nest site.

#### 2.3.5. Cormorants

The numbers of Pied Cormorants breeding on the northern end of Penguin Island has increased from no nests in 1998 to 400 nests in 1999 and 2000. This has resulted in a loss of native vegetation due to heavy trampling during nesting and the increased guano deposition. Invasion of weeds has subsequently occurred on other islands once the rookeries have become deserted (Rippey *et al.* in prep.). Although it is unlikely that the cormorants will be in direct competition with penguins for nesting habitat on Penguin Island, they have had a negative impact on the penguins on Carnac Island using the same nesting areas (Dunlop pers. comm.). An increase in the number of weeds may also increase the fire risk on Penguin Island.

### 2.4 CURRENT MAJOR THREATS

There are three main current threats to the Little Penguin colony on Penguin Island. These are:

- Disturbance of whitebait nursery.
- Recreational boat use.
- Over fishing, particularly from the recreational fishers.

### 2.5 RANKING THE THREATENING PROCESSES

The following matrix was constructed using the likelihood of the threat and the impact of that threat on the Little Penguin colony should it occur. The sum of these factors yields relative importance, and thus the priority from a management perspective. The following table summarises this approach. For both parameters, a rating of 1-3 is used, with 1 being least likely or little impact.

**Table 2. A revised/proposed threatening process matrix**

| Threat | Likelihood | Impact | Sum | Priority |
|---|---|---|---|---|
| ENSO and Leeuwin Current | 3 | 3 | 6*** | H |
| Disturbance of whitebait nursery | 3 | 3 | 6 | H |
| Rec. fishing | 3 | 3 | 6 | H |
| Disturbance of nesting sites | 2 | 3 | 5 | H |
| Recreational boat use | 3 | 2 | 5 | H |
| Arsenic | 2* | 2# | 4 | M |
| DDT | 2** | 2 | 4 | M |
| Fin fishing | 2 | 2## | 4 | M |
| Fire | 1 | 3 | 4 | M |
| Industrial waste | 2 | 2 | 4 | M |
| Introduced predators | 1 | 3 | 4 | M |
| Oil Spill | 1 | 3 | 4 | M |
| Plastic pollution | 2 | 2 | 4 | M |
| TBT | 1 | 3 | 4 | M |
| Pied Cormorants | 1 | 2 | 3 | M |
| Rock lobster and crab fishing | 2 | 1 | 3 | M |
| Sewerage outfall | 2 | 1+ | 3 | M |
| Storms | 1 | 2 | 3 | M |
| SW Trawl Fishery | 2 | 1 | 3 | M |
| Natural predators | 1 | 1 | 2 | L |
| Diseases from feral pigeons | 2 | ? | | ? |

* - dependent on more rigorous test results.
\# - needs information on levels that are likely to cause an effect, and magnitude of effect
** should reduce over time
\## - dependent on commercial catch of sandy sprat.
\+ - provisional on industrial waste maintaining current standards (or better)
*** - only negative impact during times of strong Leeuwin Current
? – currently we have no idea about the impact of diseases from feral pigeons on the Little Penguins, and thus are unable to prioritise this threat.

## 3 MANAGEMENT OBJECTIVES

To ensure that Little Penguin populations at breeding and feeding sites in the park, are not significantly disturbed by human activities. To ensure that landing sites are functional and not significantly disturbed by human activities.

## 4 MANAGEMENT STRATEGIES

Population monitoring is an essential part of management. Detailed monitoring is essential to provide the basis for sound management of the penguin population. It involves the collection of data on productivity, survival, habitat condition and geographic variation, as well as data on population size and trends. It is a long-term program (Taplin 1996). It is imperative to determine if the population of Little Penguins is increasing, decreasing or remaining constant. In attempt to determine the population size, a group of volunteers have, for several years, conducted monthly night counts of the penguins coming ashore. The night counts, in conjunction with past researchers, have identified the most common points of entry by the penguins onto the beaches. However large variances in the number of people attending the count, the skill level of individual observers, and the total length of time of each count reduce the viability of the data set. In order to obtain better estimates of the Little Penguin population, various steps need to be taken:

1. In the short term maintain the night counts of penguins coming ashore at several key points. Rather than performing a count every month, it is better to intensify the counts in a month where peak numbers are expected. Performing all night counts for five consecutive nights, around a new moon in June is suggested. Problems are encountered with visibility, differences in observers' skills, and ability to remain alert all night. Thus monitoring key sites using a night camera connected to a video unit (from which the number of penguins entering the site could later be determined from the video) would be invaluable. Such a count will give an index of the breeding population, composed of experienced regular breeders, occasional breeders (those birds who breed when conditions are favourable) and immediate pre-breeding birds. As juveniles return to breed 2-3 years after hatching, this will give some indication of the recruitment of penguins in the previous 2 – 3 years. **H**

2. Increasing the number of nestboxes monitored, and increasing the number of areas in which the boxes are placed. This will be likely to increase the proportion of the population monitored for breeding success and individuals recaptured between years. It will give an indication of the current season performance. **H**

3. Regularly catching penguins arriving on the beaches in the evening in order to monitor individuals present and to band unmarked individuals. This would serve to not only increase the number of individuals banded, but also to determine the proportion of marked and unmarked individuals. This would also give information on the number of individuals being recaptured, which is an essential parameter in the Manley and Parr estimate of population size (Blower *et al.* 1981). Such an exercise would have to be repeated at least three times a year. **H**

Using 1, 2 and 3 together, it will be possible to determine the number of fledglings returning to breed, the overall productivity of the monitored population, and would give a better indication of the survival of both adults and chicks. These three parameters are essential for the development of predictive models that can then be used to identify thresholds for a monitoring program (Taplin 1996). By looking at the trends from 1, 2 and 3 over several years, in relation to baitfish recruitment and the ENSO/Leeuwin Current, it will then be possible to determine the trigger points which will require attention/action.

4. As well as determining those individuals that are breeding in any particular year, it is also necessary to determine those individuals not breeding. Experienced, successful breeding birds are more likely to breed in a "poor" year, probably a reflection of better foraging skills. Therefore, by determining who is and isn't breeding can give insight to the cause of the "poor" year. **H**

5. Determine the mortality of moulting birds each year. This will give an indication of the penguins' body condition, thus prey availability in the premoult season as well as the level of threat processes occurring on the island during this time when the penguins are land-bound. **H**

6. From Wienecke (1993), it appeared that the population was declining. A model predicting the changes necessary to stabilize the Phillip Island penguin population utilized three factors to achieve this stability – an increase in chick production, and increase in juvenile survival and an increase in adult survival. The latter option is the most viable. Given that adult survival is dependent on food availability (Harrigan 1992), the management of anthropogenic effects on the fish populations the penguins rely on would appear to be the most effective method to improve their survival. **H**

7. Regular determination of body condition of penguins over a long term in order to determine the average condition and how this varies intra- and inter-annually. **H**

8. Determine the genetic relatedness between colonies using microsatellite analysis. This will give information on the degree of immigration or emigration between colonies, which is important for the type of response required if a change in population size or structure is detected. It is also imperative to determine the degree of genetic difference between populations in Western Australia. Absolute proof of genetic separation would increase the conservation value of this colony. **H**

9. To measure the effects of fishing on Little Penguins, information on the quantities of each prey species available to the penguins and relationships between penguin survival, breeding success and fish availability is imperative (Dann 1996). Therefore more information on the foraging ecology of Little Penguins in conjunction with data on fish availability is required. **H**

10. To determine the probability of efficacy boat usage and speeds within the park, information on the depths penguins travel and forage at, and the time they spend under water and resting the surface is needed. **H**

11. The implementation of a register for penguins found injured or dead, the development of a strategy for the collection of beach-washed birds and routine autopsy on dead birds to ascertain probable cause of death. Even though most penguins die at sea, this will give some indication of factors causing death and the effect of motor powered and sail powered vessels. **M**

12. Education of the public, particularly tourists, on the importance of the dune system, and the need to reduce direct interactions with the penguins. **M**

13. Dune stabilization, e.g. revegetation and sand bagging in order to reduce impact of storm events. **M**

14. Determination of presence of Avian Paramyxoviruses in penguins. **L-M**

15. Given that the levels of heavy metals from the Cape Peron outlet are expected to increase over the next 20 years it is important to obtain some baseline levels of arsenic in the Penguin Island population, and to monitor this on a regular basis. New methods involving analysis of heavy metals from moult feathers ensures that such analysis can occur easily and repetitively. **L**

# 5 PERFORMANCE MEASURES

Many readily identifiable measures could be used to assess the health of the Penguin Island Little Penguin population. A number of these measures are predictive (or are **leading** indicators). Typically, in themselves, they are unable to provide definite management guidance, but when aggregated with other like measures can signal effects or trends that could warrant action. Ordinarily these indicators would be measures of assessed threats.

A typical Performance Measurement approach involves the use of reactive or **lagging** indicators. Such measures tell us what has happened, not why or how.

We need a mix of both types of measures (leading and lagging) to provide an accurate overall picture:

- leading indicators to give us a sense of factors likely to impact the penguin colony.
- lagging indicators to subsequently verify that actions in response to leading indicators are achieving a positive effect.

Within this theoretical framework, a Performance Measurement System for Little Penguins at Penguin Island could be implemented (see next page).

## 5.1 INDICATORS

### 5.1.1. Lagging indicators

Leading and Lagging performance measures are of no use if the target condition or trend cannot be identified. In the case of the Little Penguins at Penguin Island, we hypothesize that the combination of Leeuwin/ENSO and Fish availability lead to variations in the population size. These impacts are evident through all of the suggested lagging indicators. To date however, although there is some information on the effect of the Leeuwin Current and ENSO events on the body condition, laying time and breeding success of the Little Penguins, this has not been sufficiently developed to be able to accurately predict the consequential impact on the penguin population. A predictive model factoring in a Leeuwin Current effect also exists for the annual commercial catch of Sandy sprat (Gaughan *et al.* 1996), but how this affects the penguins is also not accurately known.

Once a valid baseline dataset has been established, and with the benefit of a rigorous model that predicts the cumulative influences of Leeuwin/ENSO/Fish biomass we should be able, from year to year, to identify target conditions for each lagging indicator. Variations from these targets would trigger a response. Without such a framework, we have no objective basis upon which to assess whether changes in lagging indicators are reflective of expected population fluctuations, or the result of one or more other impacts. We would, in effect, be no further progressed than the current practice of subjectively seeking to reconcile population changes to potential causes. This must be addressed as a matter of priority as a crucial step in the establishment of an effective management strategy.

### 5.1.2. Leading indicators

To the extent that leading indicators identified in the Performance Measurement System are readily tracked, either directly by CALM or other government or research groups, then these in combination would provide intelligence in support of any excursion from lagging indicator targets, or perhaps could give pre-warning of issues likely to affect the penguin population outside of those built into predictive models. The important point to remember here is that cumulative effects, not necessarily once off events, are of most interest. Investigating the ease at which these indicators could be measured and reported should also be progressed as a matter of priority (Table 3).

## 5.2 SHORT AND LONG TERM TARGETS

Both short and long term targets with respect to the penguin population cannot be predicted until we have developed predictive models for the effects of the uncontrollable events on the population. It is of little benefit, for example, to say that breeding success should be increasing, body condition should be at least 1.15 or above, and that a specific number of penguins should be seen coming ashore, if we do not factor in the effect of the Leeuwin Current, ENSO and fish biomass.

**Table 3. Little Penguin management strategy performance measurement system**

| Little Penguin Management Strategy Performance Measurement System | | | | | |
|---|---|---|---|---|---|
| **Leading indicators** | | | **Lagging Indicators** | | |
| **What** | **Measure** | **Target** | **What** | **Measure** | **Target** |
| Strength of Leeuwin Current# | Fremantle sea levels/Sea Surface Temp | **ACTUAL MEASURES WILL BE USED IN PREDICTIVE MODEL** | Numbers of penguins arriving | Counts at key landing points (Note: From previous night counts, there is a good indication of the beaches most used by the penguins for landing) | To be developed |
| ENSO# | Difference in mean sea level pressures between Darwin and Tahiti | Actual measures will be used in predictive model | Breeding success | Number of fledging chicks counted in nest boxes | To be developed |
| Bait Fish Biomass* | Sandy sprat – total stock can be estimated using predictive model, which then provides an indication of expected catch from Warnbro Sound.<br>Pilchard – biannual egg surveys and age structure information from commercial fishers to determine recruitment levels. | Actual measures will be used in predictive model | Adult Mortality | (1)Intensive counts<br>(2)Annual recapture by catching birds coming ashore at night several times a year | To be developed |
| No of visitors to Penguin Island (through ticket sales) | Monthly trend | Increasing trend likely to have negative impact | Body Condition at various stages of the year | $Log_{10}$ mass/$log_{10}$ (beak length *beak depth) | 1.15 – 1.16 at commencement of egg laying |
| Water quality | Develop in consultation with DEP | To maintain or improve water quality | Mortality of Moulting birds | Numbers counted in nest boxes and natural nests | To be developed |
| Other threats (eg Oil Spills) | | | | | |
| Increased Recreational fishing in Comet Bay | (1)Number licences issued<br>(2)Increases in bag limits<br>(3)Number of prosecutions for breaches of fishing licences | Increasing trend likely to have negative effect on penguins | | | |
| Numbers of Recreational boats | Registrations.<br>Surveys for areas of greatest use and times of use | | | | |

\# - not controllable – targets conditions are subjective
* - may be controllable, in part, through modification of commercial and recreational fishing strategies.

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## APPENDIX 1. ISLANDS ASSESSED FROM CARNAC ISLAND TO TWILIGHT COVE.

(E G) refers to islands belonging to the Eastern Group in the Recherche Archipelago

| Island | Location | Penguins | Number | Year | Number | Year | Number | Year |
|---|---|---|---|---|---|---|---|---|
| Bird | Perth to Augusta | yes | no estimate | no date | | | | |
| Garden | Perth to Augusta | yes | 10 to 40 | 1997 | | | | |
| Carnac | Perth to Augusta | yes | 11 to 100 | 1980 | | | | |
| Penguin | Perth to Augusta | yes | 500 | 1987 | 1000 | 1995 | | |
| Hamelin | Augusta to Pt D'Entrecasteaux | no | | 1977 | | | | |
| Sandy | Augusta to Pt D'Entrecasteaux | no | | 1981 | | | | |
| St Alouarn | Augusta to Pt D'Entrecasteaux | yes | 11 to 100 | no date | 100 | 1976 | | |
| Ledge | Pt D'Entrecasteaux to Albany | no info | | | | | | |
| Stony | Pt D'Entrecasteaux to Albany | no info | | | | | | |
| Chatham | Pt D'Entrecasteaux to Albany | no | | 1975 | | | | |
| Green | Pt D'Entrecasteaux to Albany | no | | 1975 | | | | |
| Saddle | Pt D'Entrecasteaux to Albany | no | | no date | | | | |
| Migo | Pt D'Entrecasteaux to Albany | yes | 20 to 40 | 2001 | | | | |
| Richards | Pt D'Entrecasteaux to Albany | yes | 2 to 10 | 2001 | | | | |
| Mistaken | Pt D'Entrecasteaux to Albany | yes | 35 | 1976 | 14 | 1990 | 60 to 100 | 1992 |
| Eclipse | Pt D'Entrecasteaux to Albany | yes | 11 to 100 | no date | < 200 | 1973 | | |
| Shelter | Pt D'Entrecasteaux to Albany | yes | 200 to 400 | 2001 | | | | |
| Flat | Pt D'Entrecasteaux to Albany | yes | 2 to 10 | 1982 | | | | |
| Mermaid | Albany to Bremer Bay | no info | | | | | | |
| Bald | Albany to Bremer Bay | yes | no estimate | 1971, 1976 | | | | |
| Coffin | Albany to Bremer Bay | yes | no estimate | 1979 | | | | |
| Michaelmas | Albany to Bremer Bay | yes | no estimate | no date | few | 1975 | | |
| Cheyne | Albany to Bremer Bay | yes | no estimate | no date | 100 to 200 | 2001 | | |
| Breaksea | Albany to Bremer Bay | yes | 100 to 1000 | 1975 | 6 | 1990 | 500 | 2001 |
| West | Bremer Bay to Stokes Inlet | no info | | | | | | |
| Rocky | Bremer Bay to Stokes Inlet | no | | no date | | | | |
| Doubtful | Bremer Bay to Stokes Inlet | yes | no estimate | no date | | | | |
| Anvil (E G) | Stokes Inlet to Twilight Cove | no | | 1992 | | | | |
| Archdeacon | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Arid | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Barely | Stokes Inlet to Twilight Cove | no | | 1992 | | | | |
| Barrier | Stokes Inlet to Twilight Cove | no | | 1990 | | | | |
| Beaumont | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Bellinger | Stokes Inlet to Twilight Cove | yes | 30 to 50 | 1986 | | | | |
| Ben | Stokes Inlet to Twilight Cove | yes | 60 to 100 | 1987 | | | | |
| Bishop Rock | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Black | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Black Rock | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Boxer | Stokes Inlet to Twilight Cove | yes | no estimate | no date | | | | |
| Brewis | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Broughton | Stokes Inlet to Twilight Cove | no | | 1992 | | | | |
| Burton Rocks | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Button | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Canning | Stokes Inlet to Twilight Cove | no | | 1987 | | | | |
| Cap | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Capps | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Carnard | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Cave | Stokes Inlet to Twilight Cove | no | | no date | | | | |
| Charley | Stokes Inlet to Twilight Cove | yes | 2 to 10 | 1982 | 1 | no date | | |
| Cliff | Stokes Inlet to Twilight Cove | no | | no date | | | | |

| Island | Location | Penguins | Number | Year | Number | Year | Number | Year |
|---|---|---|---|---|---|---|---|---|
| Cloud | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Combe | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Cooper | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Corbett | Stokes Inlet to Twilight Cove | no | | 1976 | | | | |
| Cornwall | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Cranny (E G) | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Creak | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Cull | Stokes Inlet to Twilight Cove | yes | 60 to 80 | 1981 | 1 | 1993 | | |
| Dailey | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Davy | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Daw (E G) | Stokes Inlet to Twilight Cove | yes | no estimate | no date | | | | |
| Dome | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Douglas | Stokes Inlet to Twilight Cove | no | | no date | | | | |
| Draper | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Figure of Eight | Stokes Inlet to Twilight Cove | yes | 2 to 10 | 1981 | | | | |
| Finger | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Foam Rocks | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Ford (E G) | Stokes Inlet to Twilight Cove | no | | 1992 | | | | |
| Forrest | Stokes Inlet to Twilight Cove | yes | 2 to 10 | 1986 | | | | |
| Frederick | Stokes Inlet to Twilight Cove | no | | 1981 | | | | |
| Free | Stokes Inlet to Twilight Cove | no | | no date | | | | |
| Fur Rock | Stokes Inlet to Twilight Cove | no info | | | | | | |
| George | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Giant Rocks | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Gig Rocks | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Glennie | Stokes Inlet to Twilight Cove | no | | 1990 | | | | |
| Godman | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Goose | Stokes Inlet to Twilight Cove | yes | no estimate | no date | | | | |
| Gould | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Gulch | Stokes Inlet to Twilight Cove | no | | 1987 | | | | |
| Gunton | Stokes Inlet to Twilight Cove | no | | 1992 | | | | |
| Harlequin | Stokes Inlet to Twilight Cove | no | | 1987 | | | | |
| Hasler | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Hastings | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Hector Rock | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Helby | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Hendy | Stokes Inlet to Twilight Cove | no info | | | | | | |
| High | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Hood | Stokes Inlet to Twilight Cove | yes | 2 | 1981 | no estimate | 1977 | | |
| Hope | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Howe | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Hugo | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Hull | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Inshore | Stokes Inlet to Twilight Cove | yes | 2 to 10 | 1986 | | | | |
| John | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Kermadec | Stokes Inlet to Twilight Cove | yes | no estimate | no date | | | | |
| Kermadec Rocks | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Kimberley | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Libke | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Lichen | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Limpet Rock | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Lion | Stokes Inlet to Twilight Cove | no | | 1970,92 | | | | |
| Little | Stokes Inlet to Twilight Cove | no | | 1987 | | | | |
| Long | Stokes Inlet to Twilight Cove | no | | 1981 | | | | |
| Lorraine | Stokes Inlet to Twilight Cove | yes | no estimate | 1981 | 1 | 1983 | | |
| MacKenzie | Stokes Inlet to Twilight Cove | yes | 10 to 20 | 1981 | | | | |
| Magistrate Rocks | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Manicom | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Marts | Stokes Inlet to Twilight Cove | yes | no estimate | no date | | | | |
| Middle | Stokes Inlet to Twilight Cove | no | | 1950,76 | | | | |
| Middle Rock | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Miles | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Mondrain | Stokes Inlet to Twilight Cove | yes | no estimate | 1976 | | | | |
| Murray Rock | Stokes Inlet to Twilight Cove | no info | | | | | | |

| Island | Location | Penguins | Number | Year | Number | Year | Number | Year |
|---|---|---|---|---|---|---|---|---|
| Nares | Stokes Inlet to Twilight Cove | yes | no estimate | no date | no | 1982 | | |
| New | Stokes Inlet to Twilight Cove | no info | | | | | | |
| New Year (E G) | Stokes Inlet to Twilight Cove | no | | 1980 | | | | |
| North Twin Peak | Stokes Inlet to Twilight Cove | yes | no estimate | no date | | | | |
| Observatory | Stokes Inlet to Twilight Cove | yes | 40 to 60 | 1981 | | | | |
| Owen | Stokes Inlet to Twilight Cove | no | | no date | | | | |
| Pasco | Stokes Inlet to Twilight Cove | no | | 1988 | | | | |
| Pasley | Stokes Inlet to Twilight Cove | no | | no date | | | | |
| Pearson | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Pointer (E G) | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Rabbit | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Ram | Stokes Inlet to Twilight Cove | yes | 2 to 10 | 1981 | | | | |
| Red | Stokes Inlet to Twilight Cove | no | | 1990,91,92 | | | | |
| Remark | Stokes Inlet to Twilight Cove | yes | 2 to 10 | 1981 | | | | |
| Rob | Stokes Inlet to Twilight Cove | yes | no estimate | no date | | | | |
| Rodondo | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Round | Stokes Inlet to Twilight Cove | yes | no estimate | no date | | | | |
| Roy | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Ruby | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Rug Rock | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Russel Rock | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Sail Rock | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Salisbury | Stokes Inlet to Twilight Cove | yes | 1 | 1992 | | | | |
| Sandy Hook | Stokes Inlet to Twilight Cove | yes | no estimate | no date | | | | |
| Seal Rock | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Six mile | Stokes Inlet to Twilight Cove | yes | 60 to 80 | 1985 | | | | |
| Skink | Stokes Inlet to Twilight Cove | yes | 20 to 50 | 1987 | | | | |
| Slipper | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Smith Rock | Stokes Inlet to Twilight Cove | no info | | | | | | |
| South Twin Peak | Stokes Inlet to Twilight Cove | no | | no date | | | | |
| Spindle (E G) | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Square Rock | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Stanley | Stokes Inlet to Twilight Cove | yes | 100 to 200 | 1982 | | | | |
| Station | Stokes Inlet to Twilight Cove | yes | no estimate | no date | | | | |
| Steep Rocks | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Swell Rocks | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Table | Stokes Inlet to Twilight Cove | no | | 1972 | | | | |
| Taylor | Stokes Inlet to Twilight Cove | no | | 1990 | | | | |
| Thistle Rock | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Thomas | Stokes Inlet to Twilight Cove | no | | no date | | | | |
| Tizard | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Tory | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Tunney | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Twin Rocks | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Waterwitch Rocks | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Wedge | Stokes Inlet to Twilight Cove | no | | 1993,98 | | | | |
| Westall | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Whale Rock | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Whalebeck (E G) | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Wharton | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Wickham | Stokes Inlet to Twilight Cove | yes | 10 to 20 | 1987 | | | | |
| Wilson | Stokes Inlet to Twilight Cove | no info | | | | | | |
| Woody | Stokes Inlet to Twilight Cove | yes | no estimate | no date | 10 to 12 | 2000 | | |
| York | Stokes Inlet to Twilight Cove | no info | | | | | | |

## APPENDIX 2. LATITUDE (D.M.S.) AND LONGITUDE (D.M.S.) OF ISLANDS INHABITED BY LITTLE PENGUINS.

| Island Name | Latitude | Longitude |
|---|---|---|
| Bald | 34 55 00 S | 118 27 48 E |
| Bellinger | 33 53 17 S | 123 38 16 E |
| Ben | 33 54 00 S | 122 45 08 E |
| Bird | 32 16 36 S | 115 41 18 E |
| Boxer | 34 00 04 S | 121 40 36 E |
| Breaksea | 35 03 42 S | 118 03 12 E |
| Carnac | 32 07 24 S | 115 39 48 E |
| Charley | 33 55 24 S | 121 52 32 E |
| Cheyne | 34 36 12 S | 118 45 06 E |
| Coffin | 35 00 06 S | 118 12 48 E |
| Cull | 33 55 23 S | 121 54 08 E |
| Daw | 33 50 56 S | 124 08 05 E |
| Doubtful | 34 22 30 S | 119 34 42 E |
| Eclipse | 35 10 54 S | 117 53 00 E |
| Figure of Eight | 34 01 42 S | 121 36 19 E |
| Flat (near Windy Harbour) | 34 50 12 S | 116 01 24 E |
| Forrest | 33 54 04 S | 122 42 30 E |
| Garden | 32 12 12 S | 115 40 30 E |
| Goose | 34 04 59 S | 123 10 56 E |
| Hood | 34 08 35 S | 122 02 54 E |
| Inshore | 33 55 01 S | 122 49 39 E |
| Kermadec | 34 05 22 S | 122 49 59 E |
| Lorraine | 33 57 01 S | 122 33 47 E |
| Mackenzie | 34 11 54 S | 122 06 14 E |
| Mart | 34 00 09 S | 122 37 49 E |
| Michaelmas | 35 02 36 S | 118 02 12 E |
| Migo | 35 04 18 S | 117 38 54 E |
| Mistaken | 35 03 42 S | 117 56 36 E |
| Mondrain | 34 08 12 S | 122 14 41 E |
| North Twin Peak | 33 59 41 S | 122 49 39 E |
| Observatory | 33 55 28 S | 121 47 32 E |
| Penguin | 32 18 18 S | 115 41 24 E |
| Ram | 34 01 56 S | 122 08 30 E |
| Remark | 34 03 53 S | 121 59 04 E |
| Richards | 35 04 24 S | 117 38 54 E |
| Rob | 34 02 03 S | 122 13 56 E |
| Round | 34 06 22 S | 123 53 12 E |
| Salisbury | 34 21 30 S | 123 33 06 E |
| Sandy Hook | 34 02 05 S | 121 59 33 E |
| Shelter | 35 03 00 S | 117 41 30 E |
| Six Mile | 33 38 26 S | 123 57 57 E |
| Skink | 33 59 15 S | 123 08 50 E |
| St Alouarn | 32 24 12 S | 115 11 48 E |
| Stanley | 35 04 00 S | 117 09 12 E |
| Station | 33 57 41 S | 122 31 17 E |
| Wickham | 34 01 17 S | 123 17 24 E |
| Woody | 33 57 44 S | 122 00 41 E |