Natural Foraging and Breeding Behaviours of the Little Blue Penguin *Eudyptula minor* Including Recommendations for a Captive Population

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1.0 Introduction

The Blue Penguin (*Eudyptula minor*) belongs to the family *Spheniscidae*, a distinctive group of flightless, pelagic seabirds that inhabit the Southern hemisphere. The smallest of the penguin species, the Blue Penguin weighs approximately one kilogram, stands around 40 centimetres tall (Stonehouse, 1975), and occurs naturally in southern areas of cooler waters off Australia and New Zealand. Blue Penguins are covered in dense waterproof plumage that ranges in colour from pale power-blue to dark slaty blue-grey on the dorsal side, and white on the ventral side acting as a form of counteractive camouflage.

There is ongoing debate as to the number of sub-species that occur within the extents of *E. minor*. Some experts believe that the White-flippered penguin (*E. minor ablosignata*) can be considered as a different species, not just as sub-species. These penguins are characterised by the presence of a white margin on both the front and rear sides of the flippers and paler plumage on their backs (Reilly, 1994).

The total population of Blue Penguins in Australia and New Zealand has been estimated to be somewhere between 350 000 and 600 000 breeding pairs (Dann, 2006). Although numbers are believed to be stable, there are concerns of decreasing numbers of breeding pairs in certain locations (Dann, 1992). The White-flippered penguin in New Zealand has recently been listed as 'endangered' by the International Union for the Conservation of Nature (IUCN), as the breeding population is measured to be only 2,200 pairs (Davis & Renner, 2003) and is restricted to parts of Banks Peninsula and Motunau Island off the eastern coast of Canterbury, New Zealand.

Threats to the Blue Penguin include predation by introduced species (predominantly foxes and dogs but also cats and stoats in New Zealand) and, locally, human disturbance through residential and farming developments (Reilly, 1994; Williams 1995). Perhaps the most detrimental influences however come from fluctuations in natural oceanic changes. Reilly (1994), states that if large-scale oceanic changes take place, there will be corresponding changes to fish populations, something that we can not deter, especially if the commercial fisheries continue to target the main prey species of Blue Penguins and exploit areas in which they forage.

In order to gain an accurate understanding of the long-term viability of the Blue Penguin, it is necessary to look at the breeding biology and foraging behaviours exhibited by this species. By investigating these aspects of the Blue Penguin, we can also make detailed choices in regard to the captive management of the species.

This paper aims to detail the breeding biology and foraging behaviours of *Eyduptula minor*, in Australia and New Zealand, with a more indepth coverage of the sub-species *E. minor albosignata.* The information highlighted will be used to construct some guidelines that may be considered when housing and breeding the Blue Penguin in a captive situation.

2.0 Distribution

Eudyptula minor breeds on the coastal mainlands and islands of Australia and New Zealand between 32° and 47° South. Blue Penguins are widely distributed in Australia (from Western Australia along the southern coast of Australia up to New South Wales) and in New Zealand (from Northland to Stewart Island and the Chatham Islands). Each of the sub species are found in different localities (Fig. 1): *novaehollandia* in Australia, *iredaei* in northern New Zealand, *variabilis* from Cook Strait, New Zealand, *albosignata* on Banks Peninsula and Motunau Island, *minor* in the lower part of the South Island, New Zealand, and *chathamensis* from the Chatham Islands (Davis & Renner, 2003).

Figure 1. Distribution of *Eudyptula minor* in Australia and New Zealand.

In Australia, Blue Penguins are found mostly on offshore islands, where the risk of predation and disturbance from introduced species is minimal (Dann, 1994). Along the coastline of New Zealand Little penguins are known to inhabit areas with natural cliffs that provide some protection from predators, with wildlife organizations increasing efforts to maintain colonies within predator-proof fencing in some areas.

Nesting is usually located in areas where soil type allows the penguins to burrow (Williams, 1995), or find shelter in caves or crevices on rocky shores. The introduction of rabbits to the New Zealand islands has made abandoned rabbit burrows a nesting option also, and penguins in the Otago region have been known to utilise this option (Perriman & McKinlay, 1995). Other nest locations include under rocks, in pipes and above ground but under vegetation as well as in man made boxes supplied at numerous breeding sites. Nesting is usually carried out within colonies situated up to 300m from the shore, and to the extent of 50m above sea level. Although some birds have been found breeding as solitary pairs (Reilly, 1994).

Throughout the year when not breeding, Blue Penguins will travel offshore to forage, but will return to their nesting colonies during this period and spend time in and around prospective or previously used burrows (Reilly & Cullen, 1981) although rarely are both members of future breeding pairs present at the same time (Chiaradia & Kerry, 1999).

2.1 Banks Peninsula and Motunau Island Environment

Because the White-flippered Penguin is found exclusively on Motunau Island and the Banks Peninsula, it is important to discuss the environment that makes up these locations. Both areas are found along the Canterbury coast on the South Island of New Zealand. Motunau Island is classified as a natural reserve and lies approximately 1km offshore and 64km North of Christchurch. Around most of the island, slopes are broken by rocky bluffs that crop out below the plateau that forms the highest point of the island (Meredith, 1984). The base of these bluffs is an ideal habitat for the Blue Penguin to nest, and studies by Meredith (1984) found them to be abundant in these areas, however they are known to nest on all parts of the island.

The vegetation structure of Motunau Island consists of grasses and small bushes, with limited trees or large plants. The main cover is composed of silver tussock (*Poa caespitosa*), rush (*Juncus distegus*), sedge (*Scirpus nodosus*), bracken fern (*Pteridium aquilinum*) and ice plant (*Disphyma australe*). Harris Bay contains other plants such as Boxthorn (*Lycium ferocissimum*) and Boneseed (*Chrysanthemoides monilifera*) which are commonly used as nesting materials by the white-flippered Penguin (C. Challies, pers comm.).

White-flippered Penguins are found in small numbers around Banks Peninsula with the highest numbers in the remote south-eastern bays. They are mostly confined to inaccessible headlands, caves and rock jumbles and, in a few accessible places like Flea Bay and Harris Bay (refer to Figure 2). The White-flippered Penguin is most abundant on Motunau Island with around ¾ of breeding pairs inhabiting the island.

Figure 2: Typical Blue Penguin habitat at Harris Bay, Banks Peninsula (Newton, 2006).

3.0 Breeding and Life Cycle

There has been little work on what factors initiate breeding in penguins. It is likely, as for most birds (Cockrem, 1995), that photoperiod (day length) is one of the most important – if not *the* most important – proximal cues that penguins use to determine when to breed (Davis & Renner, 2003). Therefore we can assume that the breeding season for *Eudyptula minor* is extremely variable from place to place. The availability of food will also have an effect on the breeding period. Studies have shown that in years of poor food supply, the start date of breeding has been postponed (Numata, 2000).

Because of the long time that penguins have been studied at Phillip Island, the Blue Penguin colony there has been useful in determining the age at which *E. minor* breeds. Studies by numerous scientists (Dann, Cullen & Jessop, 1995; Dann & Cullen 1990) have indicated that 50% of penguins will attempt to breed at two years, and from three years on all birds normally attempt to do so.

The annual cycle of the Blue Penguin can be split up into four units; non-breeding, pre-breeding, breeding, and moulting. The non-breeding period for the Blue Penguin (in New Zealand) lasts from January to mid-July, and involves foraging, swimming, and general interaction between individual birds. The pre-breeding period incorporates the beginnings of breeding such as courtship, nest preparation and territorial establishment, and usually takes place from mid-July to mid-August. The actual breeding season last from August to mid-December, and involves egg-laying, incubation, hatching and rearing of the chick, and fledging of the chick. After adult birds have bred, moulting takes place from late December to March, with a peak in moulting between mid-January and March.

3.1 Courtship Behaviours and Displays

Blue penguins are known to spend nights ashore at their respective colonies throughout the non-breeding part of the year. According to Davis and Renner (2003), there is no distinct period of arrival of penguins back to the colony after moulting, however, by between late June and September most birds will have commenced breeding. There has been almost twice as many more male than female birds observed as first occupants of freshly cleared burrows in the lead up to nesting (Reilly & Cullen, 1981; Williams, 1995). Indicating that the male Blue Penguin may be primarily responsible for the digging or preparation of the burrow.

The presence of the male birds in nest sites earlier than the females also presents an opportunity for the male birds to advertise themselves for a suitable female. The ‘advertising display’ or ‘solo call’ is typically performed by unmated males outside the nesting area and involves the body being held erect, an outstretched neck, upward pointing bill, flippers being held above the back (refer to Fig. 2), and a loud braying call (Williams, 1995). This display can also be performed to advertise possession of territory by mated pairs and according to Jouventin (1982) this call seems to repel same-sex individuals and attract potential partners.

Figure 3. Sexual displays of *Eudyptula minor*

(Jouventin, 1982).

On Phillip Island unpaired males are often seen to dig burrows which they display infront of in order to attract a mate. On the Otago Peninsula however, males display on the rocky shoreline below the nesting area, and will only search for a burrow after pairing (Williams, 1995).

The most common form of sexual behaviour exhibited by *Eudyptula minor* consists of a display referred to in Williams (1995) as a 'mutual display', occurring between pairs during courtship, preceding copulation, and during nest reliefs. This display is initiated by one bird standing erect, followed by spreading flippers and a bowing of the head, with the partner copying the behaviour and repeating the display (refer to Fig 2). Both birds may then be seen to walk around the nest simultaneously in a tight circle whilst making a braying call. Males may also be observed vibrating a flipper on the females back (Williams, 1995).

The excessive noise heard each night as Blue Penguins return from foraging trips, is typical of the 'mutual display'. According to Jouventin (1982), the phrases of uniform syllables and pitch that are used for ecstatic and mutual display are noticeably different to the antagonistic brays that are used in defending territory or sexual partnerships. The acoustic activity of the Blue Penguin is remarkable, with high-pitched songs being easily distinguishable from the dull and monotonous sounds of the waves on the shore (Jouventin, 1982), an evolutionary trait that may affect the success of individual males in gaining a partner.

3.2 Nesting

As previously mentioned, the burrow used by a nesting pair of Blue Penguins may be excavated before or after pairing, depending on the location of the colony. Studies by Reilly & Cullen (1981) stated that although during their observations excavation was rarely seen, both birds are capable of digging, however it is typically carried out be the male bird, which agrees with what Williams (1995) indicates, stating that male birds may chose the nest site and carry out the majority of the digging.

Burrows are typically dug into soft, easily dug soils, usually in loose-knit groups where neighbours are within audible recognition of each other (Warham, Spurr & Clark, 1986). Burrow entrances are typically located slightly more than 2 metres apart (Reilly, 1994), as both parent birds defend small areas in front of the burrow during the breeding season. Cave dwelling Blue Penguins are known to exhibit contrasting behaviour to this and often nest within <2 m of other birds (Waas, 1988).

The depth and length of the burrow differs according to the location and ease of excavation. The excavation of a new burrow may take several weeks, and according to Williams (1995) burrows average 43 cm long (ranging from 15 – 100), with an entrance hole 14 cm high (7 – 40) and 22 cm wide (10 – 48). These dimensions differ slightly from the measurements taken by Challies (pers comm.) from the White-flippered Penguin colonies located along Banks Peninsula and Montunau Island. Here, because of the abundance of soft ground and previous occupation of the area by rabbits, burrows are commonly longer than an arms length. In areas where the ground is hard and stony and where there are few rock fissures, the burrows tend to be significantly shorter (C. Challies, pers comm.).

The use of artificial nest boxes has been prominent in Blue Penguin colonies for a number of years (Houston, 1999). The adoption of artificial nests is a result of growing concern in decreasing numbers of penguins breeding in areas such as Phillip Island, and a lack of natural environments suitable for nesting such as Oamaru.

Nest boxes are most commonly constructed with wood, as it is functional and relatively strong. During the 1980's, the design of the nest box was a similar shape to the shape of the letter 'T' without a removable lid. In recent years the box has been modified to aid with monitoring by humans and comfort of the penguins (Houston, 1999). The nest boxes used at Oamaru Blue Penguin colony can be seen in Appendix 1. This design includes adequate height and width allowance in the entrance, a removable lid for monitoring purposes, ventilation holes for air movement, and enough room in the nesting chamber to comfortably accommodate the nesting penguins.

Unfixed lids however are not without fault (Houston, 1999), with major problems arising from the issue of securing them. At the Blue Penguin colony at Oamaru, lids not fastened were prone to being dislodged by the penguins during courtship and territorial defence, as well as by animals such as dogs and stoats, which commonly prey on Blue penguins and their eggs. Most lids are currently held in place with stoppers and weighed down with rocks (Houston, 1999).

According to studies by the Department of Conservation (Houston, 1999), the optimal placement of the nest boxes is into a slope, with the entrance on the lower edge to permit water drainage if necessary. The use of artificial nest boxes does not seem to negatively affect the breeding performance of the Blue Penguin, in fact in most instances breeding success may actually increase (Houston, 1999). Numerous cases have been seen in which birds will choose artificial nest boxes over natural ones, although the cause of this selection is unknown (Perriman & McKinlay, 1995; Houston, 1999).

Blue Penguins do most of their nest building around the time the first egg is laid, although they will 'play' nest building briefly when ashore during the winter (C. Challies, pers comm.). The nest is usually located at the point furthest from the entrance, in order to avoid high levels of light and as a predator deterrent. Nests are often lined with vegetation and other materials that attribute to warmth or comfort (Williams, 1995). These range from small leaves and twigs, to bones and rocks, and there does not seem to be any particular preference for any one type of plant or grass. Blue penguins are assumed to opportunistic and simply use whatever materials are available close to the nesting area (Stonehouse, 1975).

In Harris Bay on Banks Peninsula, the White-flippered penguin commonly uses boxthorn and boneseed when they are available and on Motunau Island they use dried mallow sticks and some leaves (C. Challies, pers comm.).

3.3 Egg Laying, Incubation, Hatching and Rearing

The period of egg laying varies between locations and seasonal variation (Robinson, Chiaradia & Hindell, 2005); colonies in Western Australia may begin to lay as early as April, with the latest laying period in Australia being from September-October at Bruny Island which is also the case in some locations in New Zealand (Williams, 1995). The White-flippered Penguin also typically broods during September and October, producing a two-egg clutch (Waas, 1988; Reilly & Cullen, 1981). Blue Penguins exhibit a typical three-day laying interval, consistent with the physiological time in which it takes for the development of a second yolk after the first egg is laid (Astheimer & Grau, 1990).

Although *Eudyptula m. novaehollandia* is known to commonly produce second and sometimes third clutches, *Eudyptula m. albosignata* rarely produces a second clutch (Houston, 2006). This may be a result of the relatively short breeding season that the White-flippered Penguin undertakes in comparison with its Australian relatives. Gales (1984) suggests that the chance of a nest receiving a second clutch after at least one hatchling is successfully fledged decreases throughout the season.

Eggs are smooth in texture and white in colour, ovoide or ovate in shape and on average represent 4.2% of the female birds weight (Williams, 1995). The size of the egg varies slightly between breeding locations and can be seen in Table 1.

Table 1. Blue Penguin Egg Size (Marchant & Higgins, 1990)

Location	Length (mm)	Breadth (mm)	Weight (g)	*N*
Phillip Island	54.6 (49.5-61.5)	42.0 (38.6-44.3)	53 (40-60)	60
Wellington	56.4 (52.4-61.2)	43.1 (40.0-45.1)		41
Otago Peninsula	56.1 (53.2-59.6)	42.3 (40.0-44.5)	53.6	24

Eggs are incubated for five weeks by both parent birds. Kinsky (1960) found that birds incubated for 16 -17 hours and were relieved for 6 -7 hours at night. Females typically carry out more of the incubation duties. However, this is contradictory to findings by other studies by Marchant and Higgins (1990) and Williams (1995), who indicate that the duration of incubation shifts averages 3.4 days (varying between one and eight days). During incubation period, there is a marked reduction in aggressive behaviour, which is displayed during the pre-laying and guard stages (Waas, 1988).

After five weeks of incubation, chicks hatch synchronously, with both eggs in a clutch hatching over 24 hours (Williams, 1995). Chicks are hatched weighing a mere 36-48 grams, and both adults are immediately involved in the brooding of the chicks for a period of approximately 14 days (range 8 - 25 days) (Chiaradia & Kerry, 1999). After the brooding stage, both parents will forage each day, returning to the nest to feed the chick/s at dusk (Williams, 1995).

The entire guard stage lasts up to 30 days, however Chiaradia & Kerry (1999) suggest that the duration of this period may vary considerably with individual season and location of colony. The availability of food, it's proximity to the colony and the prevailing weather conditions presumably will all influence the duration for which the chick is guarded (Chiaradia & Kerry, 1999).

3.4 Fledging and Success

According to Reilly and Cullen (1981), Blue Penguin chicks become increasingly likely to wander out from the burrow at about five weeks old, which may indicate early stages of the fledging process. Fledging is the stage at which chicks depart from the colony and go to sea to forage for themselves (Davis & Renner, 2003). Timing of this process is in part influenced by the body mass of the individual chicks, which in turn is influenced by food availability (Bost & Jouventin, 1991). Studies by Davis and Renner (2003) indicated that most chicks fledge within the age period of seven and a half to ten weeks, closely corresponding with the 50 day time frame in which Fortescue (1995) reported the chicks at Bowen island fledging.

During the time in which chicks are fledging, parent birds return to sea to forage, presumably increasing fat reserves before moulting (Waas, 1988), as fat provides 85% of the total energy expenditure for moulting penguins (Davis & Renner, 2003).

Moulting in penguins is characterised by all the feathers being simultaneously renewed, forcing the birds to stay ashore and fast for 2 – 5 weeks. The timing of this event is more consistent between years than timing of egg-laying, with the peak period of moult occurring between mid-January and March (Williams, 1990). However, the timing of the moult differs between locations; Phillip island moult begins around the last week in December, whereas in New Zealand it is known to begin in the first week of December in some locations (Reilly & Balmford, 1975) and last until March (Muller-Schwarze, 1984).

Most moulting by *Eudyptula minor* occurs in burrows, however, the burrows are not necessarily the ones which have been used by the same birds for breeding. Williams (1990) indicates that only 39% of birds will moult in the same area used for breeding, and of those, it is the successful breeders that are more likely to do so.

Breeding success is usually measured by the fledging success of each nest. Studies by Reilly and Cullen (1981) noted that for different seasons, the later the onset of breeding, the poorer breeding success was likely to be. This view was also maintained by Chiaradia and Kelly (1999), with findings that penguins which commenced breeding earlier in the season exhibit greater breeding success.

The relationship between breeding success and timing within the season is most likely due to food availability. Studies by Chiaradia and Kelly (1999) indicate that successful pairs had shorter incubation shifts and undertook more foraging trips than failed birds during incubation and guard-periods respectively. If birds are forced to forage offshore in times when intermediate foraging is no longer effective, the period of time away from the shore increases, resulting in increasing incidence of egg desertion (Davis & Renner, 2003) by parent birds.

Another factor influencing the success of a clutch is the delay between hatching of the two chicks, as hatching intervals influence the growth and subsequent survival of the younger chick (Lamey, 1990). Kinsky (1960) noted that a delay greater than one day put the younger chick at a disadvantage in competition for food, and may cumulate in brood reduction (Gales, 1987).

3.5 Fidelity

There are two types of fidelity that need to be considered when referring to Blue Penguins; mate fidelity and site fidelity. Nest or site fidelity is defined by Johannesen, Perriman and Steen (2002) as the possibility that a bird breeding in a given nest will return and breed in the same nest the next year, assuming it returns to the same colony. It was found that nest fidelity increased with the individual breeding success in the previous year. It was also found that there is a significant correlation between mate change and nest change (Johannesen, Perriman and Steen, 2002), which may also be dependent on breeding success.

According to Reilly and Cullen (1981), there seems to be strong fidelity to colonies, as 67.5% of male and 64.2% of female birds return to the same nest sites each year, however, birds are less likely to return to the same colony if breeding was unsuccessful in the previous year (Johannesen, Perriman and Steen, 2002). In established colonies, nest fidelity is higher where there are fewer suitable nesting burrows or sites available (Johannesen, Perriman and Steen, 2002).

4.0 Diet and Foraging

Eudyptula minor is identified as an intermediate forager, meaning that the majority of foraging time is concentrated in intermediate depth waters such as bays, harbours and estuaries (Chester, 1996). Foraging trips vary in duration according to the time of season, however two typical travelling patterns have been observed. Weavers (1992) categorises short-term foraging as localised trips of a single days duration, and long-term foraging as trips of several or many days in duration travelling up to hundreds of kilometres away from the burrow site. Blue Penguins typically only commence trips to sea in the early morning, and will come ashore again just after sunset (Klomp & Wooller, 1991).

There have been numerous studies (Gales, 1987; Cullen, Montague & Hull, 1992; Klomp & Wooller, 1988) aimed at determining the main prey items in the diet of the Blue Penguin. Studies by Cullen, Montague & Hull (1992) show that there is significant variation in the dietary components between colonies, however, most colonies show seasonal variation in prey items. Seasonal variation in the diet of Blue penguins suggests that they merely follow the changing availability of species in the foraging areas (Klomp & Wooller, 1988).

4.1 Prey Species

Studies by both Klomp and Wooller (1988) and Cullen, Montague & Hull (1992) show that *Eudyptula minor* is a generalist predator feeding mostly on small schooling prey, mainly fish, but also including squid and crustaceans. The varieties of prey fish found by studies on Australian based Blue Penguins included Pilchards (*Sardinops neopilchardus*), Australian Anchovy (*Engraulis australis*), Sandy Sprat (*Hyperlophus vittatus*), Garfish (*Hyporhamphus melanochir*), Red Cod (*Pseudophycis bachus*), and Barracouta (*Thyrsites atun*).

In Oamaru, New Zealand, the Slender sprat (*Sprattus antipodum*) accounts for more than half of the diet throughout most of the year while Graham's gudgeon (*Grahamichthys radiata*) and arrow squid (*Nototodarus sloanii*) are also important seasonally (Fraser & Lalas, 2004). The size of prey items taken is relatively consistent between locations (Montague & Cullen, 1988), with nearly all pilchards taken by penguins being under 10cm. However, there have been samples collected with prey items up to 30cm in length (Cullen, Montague & Hull, 1992).

Blue penguins catch their prey through pursuit diving in depths of up to 15 meters (Williams, 1990). There has been some observations made in regard to foraging patterns. Schultz (1987) observed a solitary penguin foraging and reported this behaviour; the penguin locates a school of fish, accelerates and proceeds to swim around the school in a diminishing circle, then swims through the centre of the school grabbing fish as it passes. In shallower water, penguins may not circle the school, but simply accelerate rapidly and pursue the school in a straight line (Schultz, 1987).

Eudyptula minor is known to prey on squid and crustaceans to some extent, but they only account for a small proportion of the diet (14% and 3% respectively) (Cullen, Montague & Hull, 1992). Studies in Victoria by Cullen, Montague & Hull (1992) indicate that the euphausiid Krill (*Nyctiphanes australis*) is the highest ranking crustacean component in food samples retrieved during their studies. Although crustaceans only account for 3% of the overall catch, there are times when Krill appears to be the only food source available for the Little Penguins.

4.2 Foraging Effort

The catch effort of the Blue Penguin varies throughout the year, in synchrony with breeding and moulting activities. Studies of the penguins at Phillip Island by Cullen, Montague & Hull (1992) indicated a peak in the amount of food taken by penguins during the breeding season. This rise in the weight of food samples brought ashore was also seen by Klomp & Wooller (1988), and was attributed to the increasing food requirements of growing chicks in the nest.

It is interesting to note that although the weight of food brought ashore increases during the breeding season, there is a significant decline in the average weight of adult birds during the later part of the breeding season, perhaps as a result of cumulative demands of feeding young (Klomp & Wooller, 1988). After the conclusion of breeding, adult birds go to sea in order to gain weight before the moult begins. During this period there is a marked peak in the size of food samples caught (Klomp & Wooller, 1988).

4.3 Commercial Fishing Influence

The Blue Penguin preys on certain fish species that are commonly also targeted by commercial fishery practices. Penguins from Australia's Phillip Island colony regularly forage in Port Phillip Bay, which is also a commercial hub for the fishing of Australian Anchovy and Pilchard, which are dominant prey species of the Blue Penguin in this area. Studies by Weavers (1992) noted that although the fishing industry to date has taken larger fish than do the Blue Penguins, dispersal of schools, or reductions in numbers and disruption of the breeding populations of these fish are still risks to the birds. The geography of Port Phillip Bay also implicates problems associated with oil and chemical spillages near the entrance to the bay. As this entrance is the sole way in and out of the bay, the penguins must pass through it in order to return to Phillip Island, posing potential hazards during the event of any spillage.

Weavers (1992) outlined three important areas (Figure 4) in which all penguins from Phillip Island were likely to forage in, and recommended that these areas be deemed areas of special consideration and protection from damaging activities, in order to ensure the future of the Blue Penguin at Phillip Island.

Figure 4. Foraging Ranges of *Eudyptula minor* on Phillip Island; Areas of Special Consideration (Weavers, 1992).

5.0 Discussion and Recommendations for Captivity

While ecotourism is becoming increasingly popular, the majority of people will only have contact with penguins through captive displays (Bell, 2001). Therefore it is important to construct an accurate representation of the birds' natural habitat and behaviours whilst providing a safe and visitor friendly exhibit.

The White-flippered Penguin is found exclusively along the Canterbury Coast, and if being kept in captivity, should be housed in an environment that mimics that of their natural habitat. Components such as vegetation, and ground substrates suitable for use in an enclosure are an important consideration. The shoreline along Banks Peninsula is predominantly made up of medium to large rocks, which may be easily replicated in a captive situation. However, the ease of cleaning needs to be considered when building such structures into an enclosure, as does the inclusion of softer substrates to eliminate the occurrence of foot conditions such as bumblefoot (Bell, 2001).

Although vegetation is a major part of the natural environment along Banks Peninsula and Motunau Island, there needs to be careful consideration regarding maintenance of the enclosure and welfare of the penguins before they are included in a captive situation. Grasses such as silver tussock and sedge would add both enrichment and nesting material for the penguins and aesthetics to the enclosure. The inclusion of permanently planted grasses may prove to be a challenge, as penguins will readily destroy a plant in a short period of time. Perhaps small tussocks could be planted in pots, and inserted into tubes in the floor of the enclosure and replaced as necessary. That way the enclosure will remain visually attractive and functional in terms of enrichment and nesting material.

The enclosure should include either artificial nest boxes, and/or suitable substrate for the penguins to dig their own burrows. When encouraging penguins to excavate burrows, the soil in the enclosure needs to be 20% clay in order to prevent the possibility of the cave in of nests (PTAG, 2005). In the wild Blue Penguins will actively defend a territory of approximately one metre in front of the entrance to its nest, therefore entrance holes to artificial burrows should be placed at least two metres apart in order to decrease aggressive behaviour. Because the entrance to nests is often longer than one metre in natural situations, the length of the entrance is not likely to be an issue in captivity (C. Challies, pers. Comm.). However, the height and width of the entrance and size of the nest chamber should allow for ease of movement by the birds, and practicality of cleaning.

In order to stop the penguins nesting in the entrance chamber, artificial lighting may be introduced to the entrance, so that the nest is the darkest part of the burrow. As blue Penguins will instinctively nest in the darkest part of the burrow (C. Challies, pers comm.), this should influence their nesting position.

Nest boxes similar to those already used at various penguin colonies such as Oamaru are suitable to be used in a captive situation, although the issue of drainage, ventilation and cleaning needs to be addressed before they are incorporated into an enclosure. Artificial boxes used at Harris Bay (C. Challies, pers. comm.) have a nesting chamber that is the square equivalent of a natural nest, measuring 32.5 x 32.5 cm. According to Challies (pers comm.) there should be at least 20-25 cm clearance at the centre of the chamber taking into account any nesting materials.

In the situation where artificial nests are provided, it is important that penguins collect their own nesting materials from the environment they are in. Suitable nesting material should be introduced during July, as this is the time that penguins are preparing to breed and kept in the enclosure until the chicks are hatched, as the penguins may not make use of the materials until later in the season. Nesting material is not always used by birds, and the use of some materials such as hay or straw can cause severe respiratory infections (Houston, 1999), so it is important to provide only appropriate vegetation. The choice of material must also take into account the ease of acquiring and availability of the material and ability to clean or dispose of the material when it is soiled.

During the breeding season, the amount of food given to the penguins should be increased, so that adults can easily provide for the needs of growing chicks. During this time, it may be beneficial to provide smaller fish (>10cm) for ease of feeding the young chicks. Chicks usually fledge around the 50 day mark, and this is a suitable time for the young to be removed from the enclosure and relocated to an existing colony such as Harris Bay and Motunau Island. There have been several successful relocations of birds to the Harris Bay area (Christchurch City Council), and this area is likely to remain a good site for release of White-flippered Penguins.

6.0 Conclusion

The breeding cycle and life of the Blue Penguin is unique in many ways. Not only does this bird, the smallest of the penguin species, partake in a breeding schedule restrained by seasonal affects and body condition, but they also undertake a fasting of several weeks in order to undergo moulting, during which they are increasingly vulnerable to predation. Along with all this, they are faced with the ever growing problem of human encroachment into select areas in which the Blue Penguins breed, bringing new challenges for their survival.

With the White-flippered Penguin already considered endangered, it is critical that we act towards preserving *Eudyptula minor* for future years. There are still many gaps in the knowledge about these birds, which may play an important towards their conservation. Perhaps the captive management of the species can aid towards the education of the public on issues that are faced by the Blue Penguin, prompting further studies into areas such as feeding ecology and distribution of birds throughout the non-breeding season.

7.0 Acknowledgements

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8.0 Appendix One