Nature-based tourism impacts on yellow-eyed penguins *Megadyptes antipodes*: does unregulated visitor access affect fledging weight and juvenile survival?

Maureen R. McClung [1], Philip J. Seddon *, M. Massaro, A.N. Setiawan

Department of Zoology, University of Otago, P.O. Box 56, Dunedin, New Zealand

Abstract

The Otago Peninsula, South Island, New Zealand offers tourists opportunities for unregulated access to breeding sites of the yellow-eyed penguin (*Megadyptes antipodes*). The presence of people on beaches delays post-foraging landing by penguins, which in turn may affect the amount of food delivered by parents to their chicks, with consequences for chick growth and fledging mass. This study explored the relationship between human disturbance and yellow-eyed penguin chick fledging weight and survival by comparing five yellow-eyed penguin breeding areas with different levels of visitor frequency. We investigated whether chick fledging weights vary between breeding areas, and whether fledging weight is a predictor of juvenile survival. In 2002, chicks at Sandfly Bay, an area with high numbers of tourists, had significantly lower fledging weights than chicks at Highcliff, an area with no tourist visitors. An analysis of sightings of 2125 yellow-eyed penguin chicks banded between 1981 and 2000 indicated probability of survival was positively associated with mass at fledging. Thus lower fledging weights may have long-term population consequences. Fledging weight is influenced by many factors, however the results suggest the possibility of an effect of tourist numbers on chick fledging weight. This is noteworthy, especially in light of the rapid rate at which wildlife tourism is increasing in coastal areas of southern New Zealand.
© 2003 Elsevier Ltd. All rights reserved.

Keywords: Yellow-eyed penguin; Ecotourism; Human impact; Fledging weight; Juvenile survival

1. Introduction

There are many ways in which the presence of even well-meaning tourist visitors may affect an environment and its organisms. For instance, disturbance by visitors during periods of breeding and rearing young, particularly in seabirds, has been documented in several studies (Geise, 1996; Robertson, 1997). Visitor approach or presence may prompt breeding birds to move away from nests, leaving eggs open to attack by predatory gulls (Edington and Edington, 1986; Bolduc and Guillemette, 2003); may cause territorial displacement, resulting in the destruction of eggs and young (Anderson and Keith, 1980), and can modify nesting behavior and nest placement (Burger and Gochfeld, 1993).

In assessing tourism-related disturbance, an indicator of human impact must be chosen for analysis. Often effects upon key parameters such as mortality rate and population size are considered to be the ultimate criteria for identifying negative impacts (Nimon and Stonehouse, 1995), however, a decrease in population numbers reflects an extreme impact. Increasing attention is being paid to the possible presence of subtle and hidden environmental impacts of tourism (Buckley, 2001), including the identification of sublethal physiological effects, such as increased heart rate and decreased body mass, which may reduce individual fitness and could ultimately have population-level consequences.

---

* Corresponding author. Tel.: +64-3-479-7029; fax: +64-3-479-7584.
 E-mail address: philip.seddon@stonebow.otago.ac.nz (P.J. Seddon).
[1] Present address: 319 AGRI Building, University of Arkansas, Fayetteville, AR 72701, USA.

In New Zealand, the tourism market relies heavily on wildlife attractions (Page and Dowling, 2002). On the Otago Peninsula, near Dunedin in New Zealand's South Island, commercial operations provide tourists with interpreted viewing of wildlife such as the royal albatross (*Diomedea epomorphora*) and the yellow-eyed penguin (*Megadyptes antipodes*). In addition, a number of locations on the Otago Peninsula are promoted for unregulated visitor access where tourists can view wildlife free of charge.

The endemic yellow-eyed penguin, or hoiho, is an iconic species for coastal Otago, a flagship for regional conservation efforts, and an important contributor to the success of ecotourism ventures. With a total world population estimated to be less than 2000 breeding pairs, the Otago Peninsula supports the most significant mainland yellow-eyed penguin breeding sites (Department of Conservation, 2000). The yellow-eyed penguin is listed by the IUCN as endangered (IUCN (World Conservation Union), 2002). The birds have a restricted distribution and in certain areas they have experienced periods of dramatic population decline in the recent past (Department of Conservation, 1991). In light of the rise in wildlife tourism on the Otago Peninsula (Ratz and Thompson, 1999), there is a clear need to monitor the health of penguin colonies on the Otago Peninsula.

Few studies have examined the effects of human presence on yellow-eyed penguins, and the results are equivocal. Roberts and Roberts (1973) showed that sites experiencing more unregulated human traffic had a lower egg and chick survival rates, although it is possible these differences were due more to predation and farming practices. Ratz and Thompson (1999) detected no difference in either breeding success or the rate of food transfers in a comparison between a colony that was part of a commercial ecotourism venture and another that was closed to the public. However, they did remark that a power analysis showed the differences would have to be large to be detected. Wright (1998) explored the effects of human presence in delaying the landing times of penguins returning from their daily foraging at sea, and showed that if people were present on areas of the beach closest to penguin landing sites, penguins were less likely to come ashore.

During the post-guard phase, parents forage at sea daily and return in the early evening to regurgitate meals for their young (Williams, 1995). If a parent's return is delayed, the meal intended for its chick(s) will have been subject to more digestion, perhaps resulting in smaller meal sizes for chicks. If the effect is severe enough, chicks may experience retarded weight gain or weight loss and thus fledge at a lighter mass than chicks reared in areas with fewer human visitors. Many avian studies have linked fledging weight to juvenile survival. Heavier chicks have an increased survival rate in great tits (*Parus major*) (Garnett, 1981), kittiwakes (*Rissa tridactyla*)

(Coulson and Porter, 1985), sooty shearwaters (*Puffinus griseus*) (Sagar and Horning, 1998), and grey-headed albatrosses (*Diomedea chrysostoma*) (Reid et al., 2000). Yellow-eyed penguins have high site fidelity (Richdale, 1957), therefore if a certain site consistently fledges lighter chicks and if lighter chicks have lower post-fledging survival, then even with apparently high levels of breeding success, the population of penguins in that area may decline over time.

This study aims to determine if yellow-eyed penguin chick fledging weight is affected by unregulated tourist visitors on landing beaches, and whether chick fledging weight is a predictor of post-fledging survival.

2. Methods

2.1. Study sites

This study was conducted on the Otago Peninsula on the South Island of New Zealand (Fig. 1), along two adjacent stretches of coast that serve as breeding grounds for yellow-eyed penguins, Boulder Beach and Sandfly Bay. Boulder Beach (45°50′S and 170°30′E), about 3 km in length, is divided into four areas: Double Bay (DB), Midsection (MS), A1, and Highcliff (HC). Sandfly Bay (SB) (45°50′S and 170°36′E) lies east of Boulder Beach and stretches about 1 km.

Sandfly Bay has high visitor numbers; between 80 to in excess of 200 people per day depending on weather conditions, based on counts at Sandfly Bay in 2002 and 2003 (Seddon et al. in lit.). Double Bay, Midsection and A1 beaches receive low (less than 10 people per day) to moderate (less than 20 people per day) levels of visitation, derived from counts conducted during February and April 2002. Highcliff has negligible visitors (less than one per day on average); no visitors were sighted in the Highcliff section during sample counts in February and April 2002.

2.2. Study species

Adult yellow-eyed penguins are present at or near breeding grounds year round (Richdale, 1957). Adults form monogamous pair-bonds and individuals return to the same general area in successive seasons (Darby and Seddon, 1990). Two-egg clutches are laid in September–October and incubated by both parents (Seddon, 1989). After chicks hatch synchronously in November, parental duties continue to be shared until the chicks fledge in February–March (Darby and Seddon, 1990) at between 97 and 118 (mean 106) days of age (Richdale, 1957). Juveniles have a pelagic phase following fledging when they move north and probably spend most of their time at sea (Richdale, 1957). Mortality is high at this time
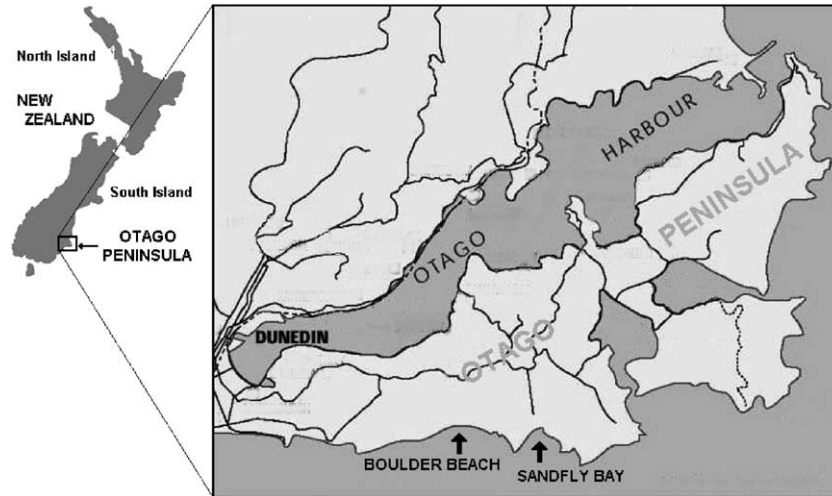
Fig. 1. Map showing the Otago Peninsula on the South Island, New Zealand, and the study sites of Boulder Beach and Sandfly Bay (both arrowed), which are breeding areas for yellow-eyed penguins.

with only 26% fledglings surviving to breeding (range 10–41%) (Richdale, 1957).

2.3. Data collection

Fledging weight was estimated by measuring chick weights within approximately 4 weeks before they first enter the sea, commencing their independent life. Estimates of chick fledging weight were obtained during February 2002. Penguin chicks were captured at or near their nests, placed in restraining bags, weighed with a Pesola spring balance (0.1 kg accuracy) and then banded with a single stainless steel flipper ring bearing a unique five digit number.

2.4. Data analysis

Chick fledging weight data were not normally distributed (Kolmogorov–Smirnov, $D = 0.085$, $n = 114$, $p = 0.042$), and this was not corrected by log transformation. In addition, heterogeneity of variances between breeding areas and unequal sample sizes meant the assumptions for parametric ANOVA were not met. Chick fledging weight data were therefore analysed using the non-parametric Kruskal–Wallis ANOVA on untransformed data for comparisons between breeding areas for the 2001–2002 breeding season. Other potential sources of variation in chick weight, such as brood size and parental experience were also examined. Brood size consisted of two levels: one and two chicks, and was analysed using a Mann–Whitney U test. Parental experience was calculated by combining the years of experience for both parents and was categorised as: none (0 years), low (1–4 years), and high (>4 years). The interval of 1–4 years was chosen for low parental experience because young birds (2–3 years

old) have significantly lower breeding success (63%) than older birds (89%) (Richdale, 1957). Levels of parental experience were analysed using a Kruskal–Wallis ANOVA.

Data for all yellow-eyed penguins chicks banded on the Otago Peninsula between 1981 and 2000 ($n = 2125$) were used to examine the relationship between fledging weight and post-fledging survival. Recoveries (sightings) data were obtained from nesting records and from sightings of juveniles and adults. It was assumed that sighting effort did not vary significantly between years. Logistic regression was used to explore whether heavier chicks were more likely to be recovered than lighter chicks after their first year at sea when mortality is highest.

3. Results

3.1. Fledging weight differences between breeding areas

Table 1 shows summary statistics for mean fledging weights among the five breeding locations. Because of the time required to locate chicks in the thick coastal scrub, it was not possible to weigh chicks in all study sites contemporaneously, so pre-fledging weights were obtained over a 3-week period. A linear regression showed no significant relationship between fledging weight and the date of sampling using data on 131 chicks banded at a single site (A1) in the years 1992–2001 ($t = 0.959$, $p = 0.339$). This is in accord with previous work (van Heezik, 1988) that indicated that mean chick weights do not fluctuate significantly during the last month before fledging. Nevertheless the slope of the resultant regression equation ($y = 0.0066x + 5.1038$; where y is mean fledging weight, and x is sampling date (day of year)) was

Table 1
Summary statistics for yellow-eyed penguin chick fledging weights at breeding areas on the Otago Peninsula, South Island, New Zealand, for the 2001–2002 breeding season

Category	Location	n	Mean	SD	Range
A	Sandfly Bay	30	5.32	0.602	4.11–6.11
B	Double Bay	22	5.52	0.629	4.12–6.46
B	Midsection	31	5.65	0.394	4.69–6.29
B	A1	16	5.75	0.271	5.43–6.13
C	Highcliff	15	6.08	0.794	4.70–7.05

Sample size (n) is number of yellow-eyed penguin chicks measured at each location. Mean fledging weight, standard deviation, and range given in kilograms. Categories relate to the degree of disturbance at landing sites due to the presence of people: A, high level of disturbance; B, low to moderate levels of disturbance and C, least disturbed (see text for descriptions of the levels of disturbance between areas).

used as a conservative correction for any temporal bias in fledging weight estimation. Paired weights of siblings were significantly correlated ($n = 46$, $r = 0.817$), so a weighted average was used for each two-chick nest in analyses involving single-chick nests.

Chick fledging weight varied significantly between locations (Kruskal–Wallis, $\chi^2 = 12.78$, df = 4, $p = 0.012$). A multiple comparisons test using equation 8.6 in Siegal and Castellan (1988) showed that there was a significant difference in mean fledging weight only between the areas of Sandfly Bay and Highcliff (mean rank difference (34.96) > critical difference (29.34), $p < 0.05$). The mean fledging weight of Sandfly Bay chicks was 0.76 kg lower than that of chicks at Highcliff.

Table 2 shows summary statistics for mean fledging weight for the variables of brood size and parental experience. A significant difference in mean fledging weight was found between one- and two-chick nests (Mann–Whitney U test, $z = -2.61$, $p = 0.009$), but weight did not vary due to parental experience (Kruskal–Wallis, $\chi^2 = 1.95$, df = 2, $p = 0.377$). Nonparametric tests did not allow for tests of interaction between variables, however, there was no significant difference in the frequency of occurrence of one- and two-chick nests between the breeding areas of Highcliff and Sandfly Bay ($\chi^2 = 3.46$, df = 1, $p > 0.05$).

3.2. Juvenile survival

Analysis of the relationship between fledging weight and the probability of recovery using logistic regression indicated that the observed data fit the regression model better when fledging weight and a constant were considered in predicting recovery. The estimated coefficients for fledging weight ($\beta = 0.51$) and the constant ($\alpha = -3.64$) were both valuable to the model, as indicated by their significant Wald statistic (*weight*: Wald = 50.50, $p < 0.001$; *constant*: Wald = 85.05, $p < 0.001$). These coefficients were inserted into the logistic regression model:

$$\text{logit}(p) = \ln \left\{ \frac{p}{1-p} \right\} = 0.51x' - 3.64,$$

where p is the probability of recovery and x' is the fledging weight. With the inclusion of the weight variable and the constant, the model correctly predicted the responses (whether a bird of a given fledging weight would survive or not) 70.8% of the time.

The predicted change in odds for a unit increase in the predictor is $\exp \beta$. Since $\exp \beta$ for fledging weights is greater than one ($\exp \beta = 1.66$), increasing values of the parameter of fledging weight correspond to increasing odds of recovery. As fledging weight increases, the

Table 2
Summary statistics for yellow-eyed penguin fledging weight based on (a) brood size and (b) parental experience for the 2001–2002 breeding season, Otago Peninsula, New Zealand

	n	Mean	SD	Range
(a) Brood size				
One-chick	22	5.92	0.421	5.29–7.05
Two-chicks	92	5.53	0.606	4.11–7.00
(b) Parental experience				
None	9	5.64	0.352	5.26–6.25
Low	24	5.46	0.585	4.11–6.45
High	81	5.65	0.615	4.12–7.05

Sample size (n) is number of chicks measured in each type of nest. Mean fledging weight, sample standard deviation, and range given in kilograms. Parental experience calculated by combining the years of experience for both parents and categorized as: none (0 years), low (1–4 years), and high (>4 years).
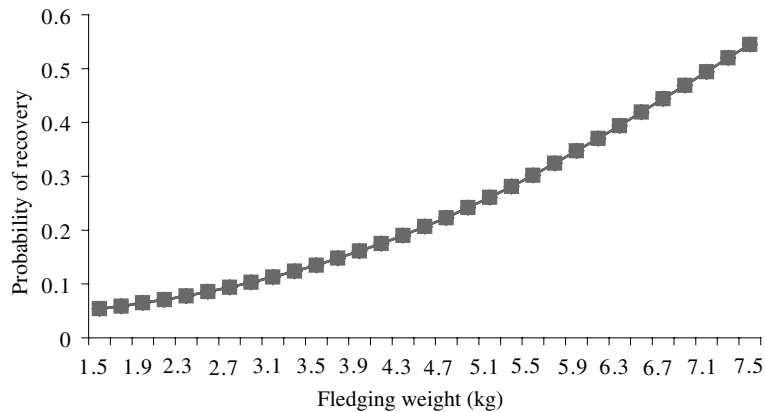
Fig. 2. Predicted probability of recovery (post-fledging survival estimated by a sighting one or more years after fledging) of yellow-eyed penguins based on fledging weight.

model predicts that the likelihood of recovery also increases (Fig. 2).

4. Discussion

Mean yellow-eyed penguin chick fledging weight was lower at Sandfly Bay compared to Highcliff, two breeding areas that experience very different regimes of tourist activity at penguin landing sites. Simulations from a modeling study on the factors affecting fledging weight of Adélie Penguins (*Pygoscelis adeliae*) showed that quantity, quality, and timing of food delivery to chicks by parents have large effects on chick mass (Salihoglu et al., 2001). The availability of food to Adélie Penguin chicks is most critical during the latter portion of chick development, when growth rates are high and a larger body mass means higher respiration demands. Salihoglu et al. (2001) suggest a threshold total energy value that is needed by an Adélie Penguin chick to maintain weight. With the delay or abortion of meal delivery to chicks, this threshold might not be met, leading to a decrease in chick mass. This effect may be exacerbated during years of poor food abundance or quality, when it is vital for parents to feed chicks more frequently, an adjustment they may not be able to make if post-foraging arrival patterns are disrupted.

Differences in tourist disturbance and its immediate effects at beaches are important to note also because of the long-term impacts they may have on yellow-eyed penguins. The mean fledging weight difference between Highcliff and Sandfly Bay was 0.76 kg. This mass may be significant to survival given that analyses indicated that heavier birds are more likely to be recovered (i.e., survive) than lighter birds. Generally in birds, larger individuals may be able to cope better with temporary periods of food shortage after fledging, reducing the chances of starvation (Magrath, 1991). Predation has been identified as a major cause of mortality in penguin chicks on land and at sea (Darby and Seddon, 1990;

Williams, 1995). In general, heavier chicks may be able to adopt foraging strategies that minimize predation, taking fewer risks than lighter chicks for which obtaining a meal is more critical (Magrath, 1991). Besides the obvious possibility for a total reduction of yellow-eyed penguin population numbers, there is also the possibility for changes in distribution of breeding pairs. Yellow-eyed penguins exhibit high nest site fidelity (Richdale, 1957; Darby and Seddon, 1990). If a breeding area consistently fledges lighter chicks, then there is potential for reduced recruitment to diminish or eliminate a colony at that location.

Impact assessment is complicated because of issues such as the linkage of environmental factors, natural changes in the environment, and the individuality of sites (Roe et al., 1997; Wright, 1998). There are potentially a number of other factors that may influence fledging weight. For instance, the features of Highcliff that make it unappealing to tourists may contribute to the breeding success and fledging weight of chicks via other mechanisms. The dense, low-lying scrub of Highcliff provides more shade to nests than the open flax and gorse habitats of other breeding areas. Thermal balance is critical for successful breeding and survival on land for yellow-eyed penguins, which suffer heat stress in warmer months (Seddon and Davis, 1989). Therefore, habitat such as Highcliff may be beneficial in preventing heat stress, resulting in higher levels of breeding success and survival (Darby and Seddon, 1990), although it is unclear how this may affect fledging weights.

Interactions between seabirds, human activities and environmental changes are complex and multidisciplinary studies are required to identify the linkages (Micol and Jouventin, 2001). Initially, perceptible trends will aid in focusing future studies. The general trend from this study is that two breeding areas with very different levels of human visitation show a difference in yellow-eyed penguin chick fledging weight, in the year of the study.

If yellow-eyed penguins showed signs of habituation, an increase in visitor numbers might not be as detrimental.

However, yellow-eyed penguins appear to grow accustomed only to minimal and well-regulated exposure to humans (e.g., people in hides behind camouflage netting), but remain timid where the presence of unconcealed people is unpredictable, at close quarters, and with large groups (Ratz and Thompson, 1999).

One difficulty in drawing firm conclusions from ecotourism impact assessments is the number of variables that can have an effect on the identified impact. There is a lack of ecotourism impact studies based on systematic, ecologically informed assessments (Roe et al., 1997; Page and Dowling, 2002). Studies of foraging ranges and the effects of delayed landing on the digestion rates of yellow-eyed penguins would provide insight into whether there is a causal link between human presence on the beach, delayed landing, and reduced food intake by chicks.

There is currently little known of the effect of tourism on yellow-eyed penguins during the pre-laying and incubation phases. Adélie Penguins also show a delayed landing response to humans on a beach (Nimon and Stonehouse, 1995) and it has been suggested that if this delay occurs during the incubation phase, there may be higher rates of nest desertion because the incubation phase is marked by long fasts. Since the inability to continue incubating until the foraging partner returned accounted for 15.3% of nest desertion (Davis and McCaffrey, 1986), longer delays would increase desertion.

Seabirds have also been documented moving nests away from proximity to tourist access trails and viewing stations. New breeders of the Northern royal albatross (*Diomedea epomophora sanfordi*) chose nest sites and conducted breeding behaviour out of view from the public observatory at Taiaroa Head, despite the presence of suitable nest sites within view of the observatory (Robertson, 1997). It is possible that the behaviour responsible for changes in nest-site selection may also translate to changes in breeding area selection, whereby more disturbed areas receive fewer recruits.

Motivation for this study originated from observed trends in the growth of ecotourism and its potential for adversely affecting wildlife. Ironically, it is often the most sensitive habitats and most threatened wildlife that are the target of ecotourism activities. Nature-based tourism has numerous potential benefits for a wide range of stakeholders, from the local community to individual tourists to the targeted wildlife and environment. Realising these benefits must begin with understanding and mitigating the negative effects, both overt and subtle, of human activities.

Acknowledgements

References

Anderson, D.W., Keith, J.O., 1980. The human influence on seabird nesting success: conservation implications. Biological Conservation 18, 81–83.

Bolduc, F., Guillemette, M., 2003. Human disturbance and nesting success of Common Eiders: interaction between visitors and gulls. Biological Conservation 110, 77–83.

Buckley, R., 2001. Environmental impacts. In: Weaver, D.B. (Ed.), The Encyclopedia of Ecotourism. CAB International, Wallingford, UK, pp. 370–394.

Burger, J., Gochfeld, M., 1993. Tourism and short-term behavioral responses of nesting Masked, Red-footed, and Blue-footed, Boobies in the Galápagos. Environmental Conservation 20, 255–259.

Coulson, J.C., Porter, J.M., 1985. Reproductive success of Kittiwakes *Rissa tridactyla*: the role of clutch size, chick growth rates, and parental quality. Ibis 127, 450–466.

Darby, J.T., Seddon, P.J., 1990. Breeding biology of yellow-eyed penguins (*Megadyptes antipodes*). In: Davis, L.S., Darby, J.T. (Eds.), Penguin Biology. Academic Press, San Diego, pp. 45–62.

Davis, L.S., McCaffrey, F.T., 1986. Survival analysis of eggs and chicks in Adélie Penguins (*Pygoscelis adeliae*). Auk 103, 379–388.

Department of Conservation, 1991. Yellow-eyed Penguin Species Conservation Strategy. Department of Conservation, Dunedin, New Zealand.

Department of Conservation, 2000. Hoiho (*Megadyptes antipodes*) Recovery Plan. Department of Conservation, Dunedin, New Zealand.

Edington, J.M., Edington, M.A., 1986. Ecology, Recreation, and Tourism. Cambridge University Press, Cambridge, MA.

Garnett, M.C., 1981. Body size, its heritability and influence on juvenile survival among great tits, *Parus major*. Ibis 123, 31–41.

Geise, M., 1996. Effects of human activity on Adélie Penguin *Pygoscelis adeliae* breeding success. Biological Conservation 75, 157–164.

IUCN, 2002. 2002 IUCN Red List of Threatened Species. Downloaded on 05 November 2003 from: <http://www.redlist.org/search/details.php?species=12943>.

Magrath, R., 1991. Nestling weight and juvenile survival in the blackbird, *Turdus merula*. Journal of Animal Ecology 60, 335–351.

Micol, T., Jouventin, P., 2001. Long-term population trends in seven Antarctic seabirds at Point Géologie (Terre Adélie). Polar Biology 24, 175–185.

Nimon, A.J., Stonehouse, B., 1995. Penguin responses to humans in Antarctica: some issues and problems in determining disturbance caused by visitors. In: Dann, P., Norman, I., Reilly, P. (Eds.), The Penguins: Ecology and Management. Surrey Beatty and Sons, Chipping Norton, NSW, pp. 420–439.

Page, S.J., Dowling, R.K., 2002. Ecotourism. Prentice-Hall, Harlow, England.

Ratz, H., Thompson, C., 1999. Who is watching whom? Checks for impacts of tourism on Yellow-eyed Penguins *Megadyptes antipodes*. Marine Ornithology 27, 205–210.

Reid, K., Prince, P.A., Croxall, J.P., 2000. Fly or die: the role of fat stores in the growth and development of Grey-headed Albatross *Diomedea chrysostoma* chicks. Ibis 142, 188–198.

Richdale, L.E., 1957. A Population Study of Penguins. Clarendon Press, Oxford, England.

Roberts, C.L., Roberts, S.L., 1973. Survival rate of Yellow-eyed Penguin eggs and chicks on the Otago Peninsula. Notornis 20, 1–5.

Robertson, C.J.R., 1997. Factors influencing the breeding performance of the Northern Royal Albatross. In: Robertson, G., Gales, R. (Eds.), Albatross Biology and Conservation. Surrey Beatty and Sons, Chipping Norton, NSW, pp. 99–104.

Roe, D., Leader-Williams, N., Dalal-Clayton, B., 1997. Take Only Photographs, Leave Only Footprints. Wildlife and Development Series, No. 10. International Institute for Environment and Development, London.

Sagar, P.M., Horning, D.S., 1998. Mass-related survival of fledgling Sooty Shearwaters *Puffinus griseus* at The Snares, New Zealand. Ibis 140, 329–339.

Salihoglu, B., Fraser, W.R., Hofmann, E.E., 2001. Factors affecting fledging weight of Adélie penguin (*Pygoscelis adeliae*) chicks: a modeling study. Polar Biology 24, 328–337.

Seddon, P.J., 1989. Patterns of nest relief during incubation, and incubation period variability in the Yellow-eyed Penguin. New Zealand Journal of Zoology 16, 393–400.

Seddon, P.J., Davis, L.S., 1989. Nest site selection by Yellow-eyed Penguins. Condor 91, 653–659.

Siegal, S., Castellan, N.J., 1988. Nonparametric Statistics For the Behavioral Sciences. McGraw-Hill, Singapore.

van Heezik, Y., 1988. Growth and diet of the Yellow-eyed penguin. PhD thesis. University of Otago, Dunedin, New Zealand.

Williams, T.D., 1995. The Penguins. Oxford University Press, Oxford.

Wright, M., 1998. Ecotourism on Otago Peninsula: Preliminary Studies of Hoihos (*Megadyptes antipodes*) and Hookers Sealion (*Photcartos hookerii*). Science for Conservation 68. Department of Conservation, Wellington, New Zealand.