Antarctic Science 18 (2), 171–174 (2006) © Antarctic Science Ltd Printed in the UK DOI: 10.1017/S0954102006000198

Recent decrease in gentoo penguin populations at Iles Kerguelen

AMÉLIE LESCROËL* and CHARLES-ANDRÉ BOST

Centre d'Etudes Biologiques de Chizé – CNRS, UPR 1934, F-79360 Villiers en Bois, France
**lescroel@cebc.cnrs.fr*

Abstract: Several sub-Antarctic penguin populations have exhibited decreasing trends in the last 5–20 years. At Iles Kerguelen, the gentoo penguin (*Pygoscelis papua*) has decreased by approximately 30% over the last 15 years. This decrease is likely to be related to reduced food availability for this coastal species. We discuss this decrease with regard to the impact of overfishing and to the potential effects of climate changes on marine food webs.

Received 23 May 2005, accepted 24 October 2005

Key words: global warming, population trend, *Pygoscelis papua*, Southern Ocean, sub-Antarctic

Introduction

Over the past 50 years, the Southern Ocean has undergone a warming trend (Gille 2002), and recent studies have highlighted profound functional modifications in many systems leading to a probable major ecosystem shift (Reid & Croxall 2001, Weimerskirch *et al.* 2003). The regional impact of these climate changes remains poorly documented, but in the last 5–20 years all the monitored penguin populations, except for the king penguin (*Aptenodytes patagonicus* Miller), seem to be decreasing in the sub-Antarctic area (Woehler *et al.* 2001, Delord *et al.* 2004). In this context, there is an urgent need for additional data concerning the population trends of sub-Antarctic penguins within their major breeding grounds.

As the sensitivity to climate increases with increasing trophic level (Voigt *et al.* 2003), marine top predators may be viewed as reliable indicators of the state of their biological and physical environments (Bost & Le Maho 1993). Until now, most monitoring studies have focussed on pelagic seabirds, few being dedicated to coastal species. Since species respond individually to climate change (Voigt *et al.* 2003), it is unlikely that all seabird species will exhibit trends similar to those of pelagic seabird populations. Moreover, due to their restricted foraging range, coastal seabirds are very dependent on local resources and any regional change would have a greater impact on these birds as they would not be able to reach other favourable areas.

Gentoo penguins (*Pygoscelis papua* Forster) are coastal inshore foragers. Data from South Georgia, Marion and the Falkland Islands suggest a recent and unexplained decrease over the last 5 to 20 years (reviewed in Woehler *et al.* 2001). At present, nothing is known about the status of gentoo penguins at Iles Kerguelen (48°45'–50°00'S, 68°45'–70°58'E), one of its three major breeding grounds (Woehler 1993). The aim of this paper is to give the first multi-year censuses of gentoo penguins at Iles Kerguelen and discuss possible reasons for the observed changes.

Methods

Population censuses were carried out on the coast of the Courbet Peninsula, Iles Kerguelen in 1987, 2002 and 2004 during the breeding season, by two observers. During the colony occupation peak (28 September–12 October in 1987, 13–26 October in 2002, 11–24 October in 2004), colonies were visited once and the number of occupied nests was taken as the number of breeding pairs. As the number and location of colonies of gentoo penguins vary from year to year, counts were grouped in four geographical areas along the coast (Fig. 1). Two colonies (Pointe Guite and Pointe Suzanne) were not counted in 2004 for logistical reasons, and were subsequently considered separately in analyses. During 1987 and 2002, the breeding success of gentoo penguins was assessed for two colonies, by dividing the number of chicks at fledging produced by the colony by the number of incubating pairs. For both colonies, chicks were directly counted prior to their departure to sea (26 November–18 January in 1987, 1–7 December in 2002).

Results

There was a strong decrease in the gentoo penguin breeding population on the eastern part of Iles Kerguelen between 1987 and 2004. In 1987 there were 7907 breeding pairs in 48 colonies on the Courbet Peninsula (Table I), decreasing by 30.3%, to 5512 pairs in 38 colonies in 2002. For regions that were counted, there was an additional decrease of 3.5% by 2004. The decrease was more pronounced on the eastern part of the peninsula (Pointe Morne–Cap Ratmanoff and Cap Ratmanoff–Cap Digby areas) with up to 45% less breeding pairs in 2002. In 2004, the number of breeding pairs increased slightly within the Cap Ratmanoff–Cap Digby area, but remained much lower than in 1987. Furthermore, the largest colony of gentoo penguins on the Courbet Peninsula, located on its eastern part, showed a dramatic decrease, from 2150 breeding pairs in 1987 to 478 in 2002 and 374 in 2004. On the north of Golfe du

https://doi.org/10.1017/S0954102006000198 Published online by Cambridge University Press

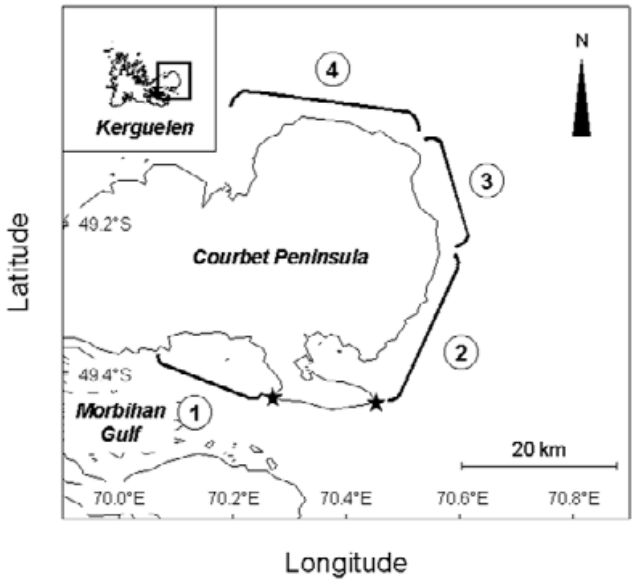


Fig. 1. Map of the study site (Courbet Peninsula, Iles Kerguelen) showing the four areas where counts of breeding gentoo penguins (*Pygoscelis papua*) were performed in 1987, 2002 and 2004: (1) North of Golfe du Morbihan, (2) Pointe Morne–Cap Ratmanoff, (3) Cap Ratmanoff–Cap Digby, (4) Cap Digby–Rivières des Cataractes. Stars indicate the Pointe Guite and Pointe Suzanne colonies, from left to right respectively.

Morbihan, the south part of the peninsula, and on the Rivières des Cataractes–Cap Digby area, the north part of the peninsula, the number of breeding pairs remained stable between 1987 and 2004.

Contrasting with the overall trend in numbers of breeding birds, the breeding success was quite similar or increasing between 1987 and 2002. Gentoo penguins were able to rear 0.64 and 0.71 chicks per pair on the North of Golfe du Morbihan in 1987 and 2002 respectively, and 0.50 and 0.70 on the Pointe Morne–Cap Ratmanoff area.

Table I. The number of breeding pairs and colonies of gentoo penguins (*Pygoscelis papua*) on the Courbet Peninsula, Iles Kerguelen, during 1987, 2002 and 2004.

Sector	Number of breeding pairs			Number of colonies		
	1987	2002	2004	1987	2002	2004
North of Golfe du Morbihan	100	160	134	2	2	2
Pointe Guite	330	297	nc	1	1	nc
Pointe Suzanne	410	0	nc	1	0	nc
Pointe Morne–Cap Ratmanoff	2348	1786	1575	15	12	15
Cap Ratmanoff–Cap Digby	3328	1542	1909	10	10	13
Cap Digby–Rivières des Cataractes	1391	1727	1392	19	13	16
Subtotal	7167	5215	5032	46	45	46
Total	7907	5512	-	48	38	-

nc = not counted, subtotal = total number without Pointe Guite and Pointe Suzanne.

Discussion

Our study showed a dramatic decrease of numbers of gentoo penguins breeding at Iles Kerguelen during the last 15 years. Our censuses covered only part of the archipelago but the Courbet Peninsula is representative of the entire archipelago as about one third of the Kerguelen population breed in this area (Weimerskirch *et al.* 1989) and this region corresponds to 15% of the archipelago's surface area. The decrease of this population seems to be part of a more general decrease at sub-Antarctic breeding localities (Woehler *et al.* 2001). Over the last 10–20 years substantial decreases have been reported at almost all the other breeding localities of the south Indian Ocean, i.e. Marion and Prince Edward Islands (Cooper 2003), Iles Crozet (Bost, unpublished data) and Heard Island (Woehler in press), as well as at South Georgia (Woehler *et al.* 2001, CBSG 2004) and the Falkland Islands (Bingham 1998, Woehler *et al.* 2001). The only sub-Antarctic exception might occur at Macquarie Island, where a suggested increase needs confirming (Ellis *et al.* 1998).

Numerous factors may regulate the number of breeding seabirds, the most important being food (Furness & Birkhead 1984) and nesting site availability (Ainley & Boekelheide 1990). Other regulating processes, such as predation or possible disturbance caused by human activities may also influence population dynamics on a smaller scale (Micol & Jouventin 2001). At Kerguelen, the two major colonies where scientific studies took place from 1987–2004 did not suffer decreases recorded elsewhere on the archipelago (from 330 to 297 pairs at the Pointe Guite colony and from 690 to 633 pairs at the Estacade colony in 1987 and 2002 respectively). Further, the population of the colonies close to the scientific base of Port-Aux-Français more than doubled between 1987 and 2004 (50–124 pairs), suggesting that station and scientific activities were unlikely to have influenced numbers during the study period. It is also unlikely that increased predation contributed to the population decrease. Penguin feathers were rarely recorded in the scats of Kerguelen fur seals (*Arctocephalus tropicalis* (Grey)) (Lea *et al.* 2002), suggesting they are not a target prey species. Gentoo penguin populations appear stable in the northern part of Courbet Peninsula, where large populations of fur seals are located. Predation by brown skuas (*Catharacta lönnbergi* Matthews) or giant petrels (*Macronectes* spp), is mainly directed towards chicks (Hunter & Brooke 1992, Phillips *et al.* 2004). Consequently, we would expect lower breeding success if predation had increased between surveys. However, we recorded higher breeding success in 2002 than in 1987, rejecting this hypothesis.

The most likely hypothesis to explain the 30% decrease of the gentoo penguin at Iles Kerguelen would be a decrease in food availability. As gentoo penguins forage close to their breeding grounds (Lescroël & Bost 2005), the different

https://doi.org/10.1017/S0954102006000198 Published online by Cambridge University Press

trends between sectors might be explained by a differential variation of local prey availability. Prey availability may be influenced either by competitors, fisheries or by environmental parameters. At Kerguelen, the only increasing species, antarctic fur seals and king penguins (Guinet *et al.* 1996, Chamaillé-Jammes *et al.* 2000), feed mainly on mesopelagic fishes of the family Myctophidae (Lea *et al.* 2002) whereas gentoo penguins feed mainly on crustaceans and benthic fishes (Lescroël *et al.* 2004). However, fur seals also feed on the mackerel icefish *Champsocephalus gunnari* Lönnberg (Lea *et al.* 2002), a dominant prey item in the diet of the gentoo penguin on the east of Courbet Peninsula (Lescroël *et al.* 2004). Icefish accounted for 18% by mass of the fur seal diet in 1998 but was no more present in the diet in 1999 and 2000 (Lea *et al.* 2002). Icefish was also the target of commercial fisheries in the Kerguelen region and its exploitation stopped after 1995 due to stock depletion (G. Duhamel, personal communication 2002). Since icefish represented about 40% by mass of the gentoo penguin diet during winter in 1987 (Lescroël *et al.* 2004), a depletion of icefish populations on the Kerguelen shelf may be implicated in the decrease of the eastern population of gentoo penguins.

Food availability may also be affected by long-term climate changes. The Indian Ocean sector of the Southern Ocean has been affected by increases in surface air and ocean temperatures during the 1970s (Levitus *et al.* 2000, Gille 2002, Weimerskirch *et al.* 2003), leading to a decline in chlorophyll *a* and zooplankton concentrations (Hunt *et al.* 2001). Recently, several authors published evidence for a major regime shift suggested to have occurred during the late 1980s over all the Southern Ocean sectors (Reid & Croxall 2001, Weimerskirch *et al.* 2003, Ainley *et al.* 2005). Since 1987, strong warm anomalies have been recorded more often in the Kerguelen zone, affecting population abundance or performances of several top predators (Weimerskirch *et al.* 2003, Guinet *et al.* 1998, Lea *et al.* 2002, Inchausti *et al.* 2003). At Marion and Prince Edward Islands, the decrease in the gentoo penguin population is supposed to have resulted from a reduced availability of food since the mid 1980s that may have resulted from altered environmental conditions, i.e. increased annual mean surface air and sea surface temperatures (Cooper 2003). Thus, given the regional-scale trend in sub-Antarctic populations of gentoo penguins, regional climatic changes are likely to have contributed to decrease prey availability and to affect gentoo penguin populations. However, at Kerguelen, additional censuses in subsequent years and demographic studies are clearly needed to determine whether the observed decrease is part of a long-term trend or circumstantial fluctuations.

Acknowledgements

This work was supported by the Institut Polaire Paul Emile Victor (IPEV, Programme No. 394), the Terres Australes et Antarctiques Françaises and the Centre National de la Recherche Scientifique. We would like to thank Alain Lamalle and the members of the 52th, and 54th missions at Kerguelen, especially V. Chartendrault, N. Delelis, E. Pettex, V. Marsaudon, F. Quemmerais, L. Bonnardot and F. Le Bouard for their help in the field. We also are grateful to R.J.M. Crawford, E. Woehler, H. Weimerskirch and N.D. Holmes for their helpful comments on the manuscript.

References

Ainley, D. & Boekelheide, R.J. 1990. *Seabirds of the Farallon islands: ecology, structure and dynamics of an upwelling-system community.* Stanford, CA: Stanford University Press, 349–380.

Ainley, D.G., Clarke, E.D., Arrigo, K., Fraser, W.R., Kato, A., Barton, K.J. & Wilson, P.R. 2005. Decadal-scale changes in the climate and biota of the Pacific sector of the Southern Ocean, 1950s to the 1990s. *Antarctic Science,* **17**, 171–182.

Bingham, M. 1998. The penguins of South America and the Falkland Islands. *Penguin Conservation,* **11**, 10–15.

Bost, C.A. & Le Maho, Y. 1993. Seabirds as bio-indicators of changing marine ecosystems: new perspectives. *Acta Oecologica*, **14**, 463–470.

CBSG. 2004. *Penguin Conservation Workshop Workbook*. Apple Valley, MN: IUCN/SSC Conservation Breeding Specialist Group, 12101 Johnny Cake Ridge Road, Apple Valley, MN 55124, USA.

Chamaillé-Jammes, S., Guinet, C., Nicoleau, F. & Argentier, M. 2000. A method to assess population changes in king penguins: the use of a Geographical Information System to estimate area-population relationships. *Polar Biology*, **28**, 545–549.

Cooper, J. 2003. Seabirds and seals at the Prince Edward Islands. *African Journal of Marine Science,* **25**, 415–564.

Delord, K., Barbraud, C. & Weimerskirch, H. 2004. Long-term trends in the population size of king penguins at Crozet archipelago: environmental variability and density dependence? *Polar Biology*, **27**, 793–800.

Ellis, S., Croxall, J.P. & Cooper, J. *eds*. 1998. *Penguin conservation assessment and management plan.* Apple Valley, MN: IUCN/SSC Conservation Breeding Specialist Group, 12101 Johnny Cake Ridge Road, Apple Valley, MN 55124, USA.

Furness, R.W. & Birkhead, T.R. 1984. Seabird colony distributions suggest competition for food supplies during the breeding season. *Nature*, **311**, 655–656.

Gille, S.T. 2002. Warming of the Southern Ocean since the 1950s. *Science*, **295**, 1275–1277.

Guinet, C., Cherel, Y., Ridoux, V. & Jouventin, P. 1996. Consumption of marine resources by seabirds and seals in Crozet and Kerguelen waters: changes in relation to consumer biomass 1962–85. *Antarctic Science*, **8**, 23–30.

Guinet, C., Chastel, O., Koudil, M., Durbec, J.P. & Jouventin, P. 1998. Effects of warm sea-surface temperature anomalies on the blue petrel at the Kerguelen islands. *Proceedings of the Royal Society London*, **B265**, 1001–1006.

Hunt, B.P.V., Pakhomov, E.A. & McQuaid, C.D. 2001. Short-term variation and long-term changes in the oceanographic environment and zooplankton community in the vicinity of a sub-Antarctic archipelago. *Marine Biology*, **138**, 369–381.

Hunter, S. & Brooke, M.L. 1992. The diet of giant petrels *Macronectes spp.* at Marion island, southern Indian Ocean. *Colonial Waterbirds*, **15**, 56–65.

https://doi.org/10.1017/S0954102006000198 Published online by Cambridge University Press

INCHAUSTI, P., GUINET, C., KOUDIL, M., DURBEC, J.-P., BARBRAUD, C., WEIMERSKIRCH, H., CHEREL, Y. & JOUVENTIN, P. 2003. Inter-annual variability in the breeding performance of seabirds in relation to oceanographic anomalies that affect the Crozet and the Kerguelen sectors of the Southern Ocean. *Journal of Avian Biology*, **34**, 170–176.

LEA, M.-A., CHEREL, Y., GUINET, C. & NICHOLS, P.D. 2002. Antarctic fur seals foraging in the Polar Frontal Zone: inter-annual shifts in diet as shown from fecal and fatty acid analyses. *Marine Ecology Progress Series*, **245**, 281–297.

LESCROËL, A. & BOST, C.A. 2005. Foraging under contrasting oceanographic conditions: the gentoo penguin at Kerguelen Archipelago. *Marine Ecology Progress Series*, **302**, 245–261.

LESCROËL, A., RIDOUX, V. & BOST, C.A. 2004. Spatial and temporal variation in the diet of the gentoo penguin (*Pygoscelis papua*) at Kerguelen islands. *Polar Biology*, **27**, 206–216.

LEVITUS, S., ANTONOV, J.I., BOYER, T.P. & STEPHENS, C. 2000. Warming of the world ocean. *Science*, **287**, 2225–2229.

MICOL, T. & JOUVENTIN, P. 2001. Long term population trends in seven Antarctic seabirds at Pointe Géologie Terre Adélie. *Polar Biology*, **24**, 175–185.

PHILLIPS, R.A., PHALAN, B. & FORSTER, I.P. 2004. Diet and long-term changes in population size and productivity of brown skuas *Catharacta skua lönnbergi* at Bird Island, South Georgia. *Polar Biology*, **27**, 555–561.

REID, K. & CROXALL, J.P. 2001. Environmental response of upper-trophic level predators reveals a system change in an Antarctic marine ecosystem. *Proceedings of the Royal Society London*, **B268**, 377–384.

VOIGT, W., PERNER, J., DAVIS, A.J., EGGERS, T., SCHUMACHER, J., BÄHRMANN, R., FABIAN, B., HEINRICH, W., KÖHLER, G., LICHTER, D., MARSTALLER, R. & SANDER, F.W. 2003. Trophic levels are differentially sensitive to climate. *Ecology*, **84**, 2444–2453.

WEIMERSKIRCH, H., ZOTIER, R. & JOUVENTIN, P. 1989. The avifauna of the Kerguelen islands. *Emu*, **89**, 15–29.

WEIMERSKIRCH, H., INCHAUSTI, P., GUINET, C. & BARBRAUD, C. 2003. Trends in bird and seal populations as indicators of a system shift in the Southern Ocean. *Antarctic Science*, **15**, 249–256.

WOEHLER, E.J. 1993. *The distribution and abundance of Antarctic and sub-Antarctic penguins.* Cambridge: Scientific Committee on Antarctic Research, 76 pp.

WOEHLER, E.J. In press. Status and conservation of the seabirds of Heard Island. *In* GREEN, K. & WOEHLER, E.J. *eds. Heard Island: Southern Ocean Sentinel.* Chipping Norton: Surrey Beatty & Sons.

WOEHLER, E.J., COOPER, J., CROXALL, J.P., FRASER, W.R., KOOYMAN, G.L., MILLER, G.D., NEL, D.C., PATTERSON, D.L., PETER, H.-U., RIBIC, C.A., SALWICKA, K., TRIVELPIECE, W.Z. & WEIMERSKIRCH, H. 2001. A statistical assessment of the status and trends of Antarctic and sub-Antarctic seabirds. *Report on SCAR BBS workshop on Southern Ocean seabird populations.* Montana: SCAR, 45 pp.

https://doi.org/10.1017/S0954102006000198 Published online by Cambridge University Press