Seabird Research at Admiralty Bay, King George Island, Antarctica

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Abstract

Land-based seabird data were collected between October 2010 and March 2011 at the Admiralty Bay penguin colonies. Main results include:

- Populations of Adélie, gentoo, and chinstrap penguins experienced 20-32% increases in numbers relative to the 2009/10 season. However, these increases were largely a rebound from the abnormally low counts in the prior year, when heavy snowfall precluded breeding by all penguin species in our colonies;
- Mean fledgling masses of Adélie (3330 ± 284 g, n = 153) and gentoo (4989 ± 579 g, n = 100) penguins were the highest in 20 years; and
- All skua pairs had much higher breeding success in the 2010/11 season than their long-term means, with south polar and hybridizing pairs fledging about twice as many chicks per pair in 2010/11 as they fledged per year over the last decade of study.

Introduction

The U.S. Antarctic Marine Living Resources (AMLR) Program completed its 15th field season of joint NSF/AMLR land-based seabird research at the Copacabana (Copa) Field Camp on King George Island, Antarctica (62º 10'S, 58º 30'W), during the austral summer of 2010/11. The western shore of Admiralty Bay is an Antarctic Specially Protected Area (ASPA #128) and long-term monitoring of predator populations are conducted there in support of U.S. participation in the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR).

The objectives of the seabird research program for the 2010/11 season were to collect the following long-term monitoring data (CCAMLR 2004):

1. To estimate Adélie (*Pygoscelis adeliae*), chinstrap (*P. antarctica*), and gentoo (*P. papua*) penguin breeding population sizes (CCAMLR Ecosystem Monitoring Program (CEMP) Standard Method A3);
2. To band 250 Adélie and 250 gentoo penguin chicks for demography studies (CEMP Std. Method A4);
3. To determine Adélie and gentoo penguin foraging trip durations during the chick-rearing stage of the reproductive cycle (CEMP Std. Method A5);
4. To determine Adélie, chinstrap, and gentoo penguin breeding success (CEMP Std. Methods A6a, b, & c);
5. To determine Adélie and gentoo penguin chick weights at fledging (CEMP Std. Method A7c);
6. To determine gentoo and chinstrap penguin diet compositions, meal sizes, and krill length–frequency distributions (CEMP Std. Methods A8a, b, and c); and
7. To determine Adélie and gentoo penguin breeding chronologies (CEMP Std. Method A9).

Methods

We arrived at Admiralty Bay on 9 October 2010 via the National Science Foundation's ARSV *Laurence M. Gould*. We conducted research until we closed camp on 9 March 2011. The AMLR-chartered R/V *Moana Wave* provided logistical support and transit back to Punta Arenas, Chile, at the field season's conclusion.

Breeding Biology

We conducted nest censuses for Adélie penguins on 5 November 2010, for gentoo penguins on 1 November 2010, and for chinstrap penguins on 29 November 2010. Chick censuses were conducted for Adélie penguins on 5 January 2011, for gentoo penguins between 5 and 12 January 2011, and for chinstrap penguins on 3 February 2011. All chick census dates were approximately one week after mean crèche for each species. The range of dates for the counts for gentoo penguin chicks was due to the asynchrony in chick crèche dates among the different breeding groups within the colony.

Detailed reproductive success was measured by following 100 banded pairs of breeding Adélie penguins and 100 pairs of gentoo penguins that had one member of each pair banded. These nests were followed from clutch initiation through crèche formation (Std. Methods 6b). In addition, all known-age penguins that initiated clutches were also followed to crèche. Chick mortality is typically low after reaching crèche age, thus these numbers were also used to estimate fledging success.

A sample of 250 Adélie and 250 gentoo penguin chicks was banded for future demographic studies. The banded chicks that survive and return to the colony as adults will be observed for age-specific survival and reproductive success.

Fledging weights were collected from Adélie and gentoo penguin chicks as a measure of chick condition. Banded Adélie penguin chicks from the demography study were captured on the beach as they were about to fledge and weighed to the nearest 25 g with hand-held Pesola scales. A non-banded Adélie chick was also captured and weighed at the same location and time to increase sample sizes. Gentoo penguin chicks are provisioned by their parents after they begin making trips to sea, so it is not possible to obtain definitive fledging weights by catching and weighing chicks prior to departure. Instead, gentoo penguin chicks were weighed 85 days after their mean clutch initiation date, at approximately the age when other *Pygoscelis* chicks fledge.

Foraging Ecology Studies

Diet samples were collected from 30 gentoo and ten chinstrap penguins between 20 December 2010 and 3 February 2011. Adults were captured at their nest sites upon returning from foraging trips, to assure they were feeding chicks, and the stomach contents were collected using the wet-offloading technique (Wilson 1984). Full stomach loads were collected from chinstrap penguins. However, for gentoo penguins, samples were confined to the fresh portion of the stomach samples only to avoid undue stress associated with handling these larger birds. A sub-sample of 50 individual Antarctic krill from each diet sample was measured and sexed to determine length and sex frequency distributions of the krill selected by foraging penguins.

Radio transmitters were deployed on 13 Adélie and 20 gentoo penguins during the chick-rearing phase in order to determine their foraging trip durations. Colony attendance was logged between 24 December 2010 and 8 February 2011 using a remote receiver and data collection logger.

Gentoo and chinstrap penguins were instrumented with satellite transmitters (PTTs) to provide geographic data on adult foraging locations during the chick-rearing period. A total of 14 PTTs were applied to gentoo penguins during three separate deployments between 4 January and 15 February; the first deployment was during the brood stage, the remaining two deployments during the crèche phase. Five PTTs were deployed on chinstrap penguins on 26 January 2011, during their chick crèche stage. Two of the instruments were recovered seven and ten days later, while the other three PTTs were not recovered and will continue to provide us with novel information about the foraging areas used by chinstrap penguins post-chick rearing, when they are at sea acquiring food in preparation for their annual molting fast in late February. The PTT data are awaiting analysis.

Other Seabirds

The reproductive success of brown (*Catharacta antarctica lonnbergi*), south polar (*C. maccormicki*), and hybridizing skua pairs breeding along the western shore of Admiralty Bay was followed over the course of the summer season via weekly surveys and nest checks. The reproductive performance of southern giant petrels (*Macronectes giganteus*) was also followed over the austral season via nest checks following egg laying and chick hatching, and a final nest check in late February when all surviving giant petrel chicks were banded in their natal colonies.

Diets of the at-sea foraging south polar and hybrid skua pairs were followed by collecting fecal samples, which will be sorted later for evidence of fish and other prey species. These samples were collected four times during the breeding season on the skuas nesting territories; once each during courtship and incubation and twice during the chick-rearing period. All skua reproductive data await analysis and the fecal samples have been sent to Pomona College, where they will be sorted and analyzed by Dr. N. Karnovsky as part of an ongoing collaboration.

Early Season Studies

Upon arrival at the field camp on 9 October, we found the Norwegian (Aker Marine) krill fishing vessel, *Saga Sea*, trawling for krill in Admiralty Bay and learned that they had been fishing in this vicinity for the past three weeks. The following day, the fishery was closed because the provisional krill catch-limit was reached. In response to this unanticipated event, we collected 10 early season diet samples from foraging, pre-breeding gentoo penguins and analyzed these samples as per the chick-phase samples: the samples were sorted for prey types and 50 krill were selected from the fresh contents of each stomach and sexed and measured to the nearest 1 mm in length. We also attached PTTs to five female Adélie penguins prior to their first departures to sea following clutch completion. The PTTs were deployed between 27 October and 2 November 2010 and retrieved in mid-November when the females returned to their respective nest sites to relieve the males that were incubating the eggs.

Results

Breeding Biology Studies

The penguin colony at Copa consists of a dozen Adélie and many loosely defined gentoo penguin sub-colonies. In addition, there are several nesting chinstrap penguin pairs that usually breed within one of the Adélie penguin sub-colonies. There are additional colonies of chinstrap penguins at three other locations along the western shore of Admiralty Bay: the DeMay, Uchatka, and Patelnia colonies. There were 2793 Adélie penguin breeding pairs at the Copa colony and 5330 pairs at the nearby Pt. Thomas colony in 2010/11. The Copa colony Adélie penguin count increased almost 700 pairs above the census figures from the 2009/10 season, a 32% increase from last year. Gentoo penguins at Copa began breeding in October, even before the Adélie penguins in some areas. A total of 4814 gentoo penguin nests were counted in 2010/11, an increase of 1325 nesting pairs from the previous year. Interestingly, in spite of the traditional beach colony nesting areas being snow-free in October 2010 when we arrived, gentoo penguins that moved to new, higher ground last season (2009/10) in response to the deep snow on the beach areas returned to these new, higher sub-colonies in 2010 and bred there. A total of 1017 chinstrap penguin nests were counted in the three colonies along the western shore of Admiralty Bay, an increase of nearly 200 pairs following the decline reported in the prior season. (Figure 6.1).

The Adélie penguin chick count was 2755 at Copa and 4982 at the Pt. Thomas colony, the gentoo penguin chick count was 5773, and the cumulative chinstrap penguin chick count from the three colonies we surveyed was 944. Based on census data, Adélie penguins fledged 0.99 chicks per breeding pair at Copa and 0.94 chicks per pair at Pt. Thomas. Gentoo penguins fledged 1.20 chicks per pair, while chinstrap penguins had a fledging success of 0.93 chicks per pair, similar to the overall Adélie penguin rate of 0.95 chicks per pair.

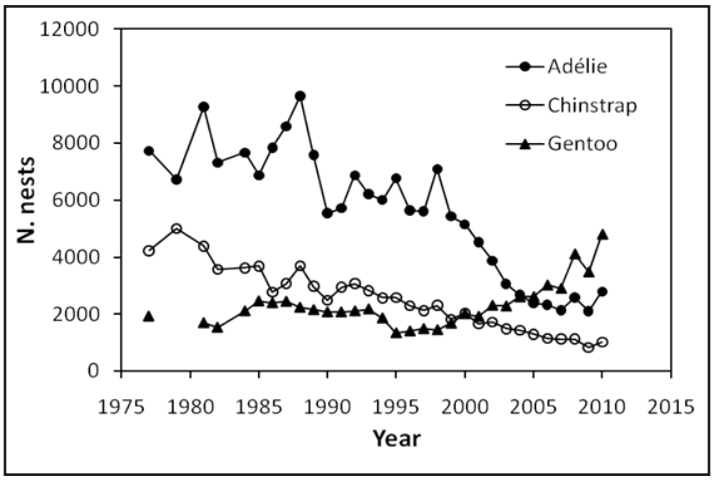

Figure 6.1. Long-term trends (1977-2011) in Adélie, gentoo and chinstrap penguin populations in Admiralty Bay, King George Island, South Shetland Islands, Antarctica.

Based on the banded sample of 100 nesting pairs in the reproductive study, Adélie penguins fledged 1.19 chicks per pair, 20% above the estimate derived from the census data and the highest reproductive success for Adélie penguins in the last decade of study. Gentoo penguins in the reproductive study fledged 1.27 chicks per pair (versus 1.20 from the census data). The high reproductive success observed, relative to the long-term mean for Adélie penguins, was most likely due to the low percentage of egg loss during the incubation period. Adélie penguins hatched 1.50 chicks per pair, suggesting they arrived in good condition and had favorable foraging success in the early spring following clutch completion. We do not follow chinstrap penguins on a daily basis, as their colonies are located 6-10 km from our primary study site.

Thirty-two known-age Adélie penguins (4 – 9 years of age), including 11 first-time breeding four-year-olds, fledged 0.71 chicks per pair this season, a vast improvement over the 0.17 chicks per pair produced by 23 similarly aged Adélie penguins in 2009/10. However, when data analysis was limited to just first-time, four-year-old breeders, reproductive success declined to only 0.45 chicks fledged per pair. This season, 87 known-age gentoo penguins were breeding in the colony, including 21 that bred for the first time. Breeding success among all known-age gentoo penguins was 1.17 chicks fledged per pair, slightly lower than the reproductive success of the banded population success rate of 1.27. This was primarily due to the lower reproductive success of the first-time breeding birds, which constituted approximately 25% of the known-age population and had a breeding success rate of only 0.52 chicks fledged per pair; similar to the success rate of the inexperienced Adélie penguins.

The mean fledging mass for Adélie penguin chicks in 2010/11 was 3330 ± 284 g (n = 153). This was 449 g (15.5%) heavier than last year's mean fledging mass of 2881 g and was the highest fledging mass for Adélie penguin chicks in the last 20 years A similar result was found in the fledging mass of gentoo penguin chicks this year. Gentoo penguin chicks were weighed on 20 February 2011 and had an average mass of 4989 ± 579 g (n = 100). This is the highest fledging mass since we began recording this parameter in 1997/98 and is more than 500 g above the previous 12-year mean (Figure 6.2).

Foraging Ecology Studies

Antarctic krill (*Euphausia superba*) was present in all

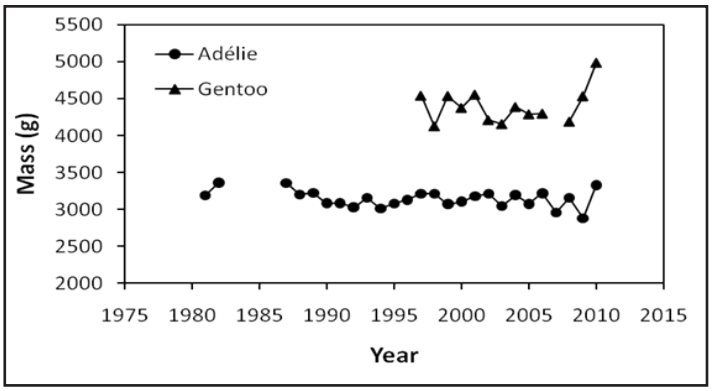

Figure 6.2. Annual mean fledgling weights (± 95% CI) for Adélie and gentoo penguin chicks at Admiralty Bay, King George Island, Antarctica 2010/11.

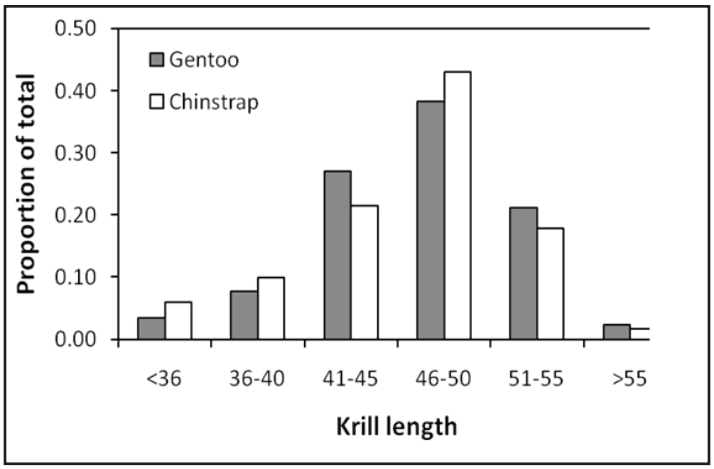

Figure 6.3. Krill length-frequency distribution from gentoo and chinstrap penguin diets at Admiralty Bay, King George Island, Antarctica in 2010/11.

stomach samples and comprised the majority of the diet in all 40 samples collected from gentoo and chinstrap penguins during their respective chick-rearing phases of the breeding cycle. *Thysanoessa macrura* was found in one of the 10 stomach samples collected from chinstrap penguins, but was not seen in any of the 30 gentoo penguin stomach samples. Gentoo penguins had evidence of fish in their diets (e.g., otoliths, scales, and hard parts) in five of the 30 samples, although only one of the five samples had more than trace amounts of fish. Chinstrap penguins also had evidence of fish in their diets in five of the 10 samples, but in each case, this was limited to just one to three otoliths per stomach sample, with no measureable amounts of fish tissue in any sample. Amphipods were also found in the stomach samples of gentoo penguins, but represented less than 0.1% of all prey items. Chinstrap penguin mean stomach mass was 638 g, 70 g greater than last season's mean stomach mass and nearly 50 g heavier than the long-term mean for this species.

The mean krill size in gentoo penguin stomach samples was 47.5 mm, slightly larger than the mean chinstrap penguin krill size of 46.2 mm. Of the krill eaten by the two species, 65% were between 41-50 mm in length, with 23% greater than 51 mm in length. Krill sex ratios in the diets of both gentoo and chinstrap penguins were similar; 55.2% of the krill were female, 40.4% were male, and 4.4% juvenile (Figure 6.3).

Due to an oversight in our ACA permit request, we reached the requested number of adult Adélie penguin "takes" prior to the beginning of the diets study and could not amend the permit request in time to collect diet samples in 2010/11. In addition, we also were unable to examine foraging trip locations in Adélie penguins using satellite tags (PTTs). However, we did put radio transmitters on 13 Adélie penguins feeding chicks shortly after chick hatching and were able to document foraging trip durations throughout the chick rearing period. Mean Adélie penguin foraging trip durations were 14.8 ± 2.3 hours (n = 13). This was less than the mean 17.5 hour foraging trips made by Adélie penguins in 2008/09 and 2009/10, but still an hour longer than the mean 13.6 hour trips made between 2005/06 and 2007/08. These results for Adélie trip lengths should be considered preliminary until we can check our daily logbooks to confirm these birds were not seen during several long (24 hours or longer) foraging trips during daily nest checks. In addition, we placed radio transmitters on gentoo penguins for the first time. Gentoo penguins spent an average of 12.4 ± 1.9 hours (n = 20) foraging at sea while provisioning chicks. This was two hours less than was spent by Adélie penguins foraging at this same time; however, this is the first year we have collected data on gentoo penguin foraging trip durations and thus have no historical data with which to compare this season for the gentoo penguin.

Other Seabirds

Brown skua pairs fledged a mean of 1.07 chicks per breeding pair, south polar skuas fledged 1.27 chicks per pair, and hybrid skua pairs had the highest reproductive success with a fledging rate of 1.3 chicks per pair. All skua pairs had much higher breeding success in the 2010/11 season than their long-term means, with south polar and hybridizing pairs fledging about twice as many chicks per pair in 2010/11 as they fledged per year over the last decade of study. This high productivity was likely due to an abundance of silverfish (*Pleuragramma antarcticum*) in Admiralty Bay and the nearby Bransfield Strait. We found large numbers of fresh silverfish lying around on many skua nesting territories in January and February 2011, meaning they had col-

lected more than they or their chicks could eat. One territory had 240 fresh fish on the territory and another had 165 fish during a single weekly visit (Figure 6.4). We have rarely witnessed this phenomenon over the last three decades.

The southern giant petrel (*Macronectes giganteus*) population has been expanding recently at our study site and many known-age birds have returned to breed in the colonies. However, the 2010/11 season saw a decline of approximately 20% in the number of breeding pairs that laid an egg, relative to last season. In contrast to the decrease in breeding attempts, those pairs that did breed raised a mean 0.71 chicks fledged per pair in 2010/11, slightly above the long-term average of 0.67.

Early Season Studies

Upon discovering the krill fishing ship, *Saga Sea*, trawling in Admiralty Bay in early October, we collected diets samples from 10 pre-breeding gentoo penguins that were making daily feeding trips to sea at that time, and we placed satellite tags (PTTS) on five female Adélie penguins with completed clutches and tracked them during their first foraging trip to sea in late October. All stomach samples had 100% krill in them by mass, while two of the 10 individuals had trace amounts of fish. Measurements of individual krill consumed by the gentoo penguins found 75% of the krill in the 41-50 mm size range with approximately equal sex ratios. Examinations of the satellite-tagged Adélie penguin females' tracks are under analysis. However, preliminary examination of the PTT tracks revealed that only one penguin remained in the vicinity of King George Island, foraging in the mouth of Admiralty Bay and King George Bay to the NE, while the other four tagged birds went across the Bransfield Strait to the Western Antarctic Peninsula region or into the upper Weddell Sea. These latter trips are the normal patterns seen in earlier tracked birds at this time of year (Trivelpiece, unpublished data).

Figure 6.4. Regurgitated Antarctic silverfish (*Pleurogramma antarcticum*) remains on a south polar skua breeding territory. This phenomenon, which is rare and only documented a few times in the last 30 years, was seen on many territories in 2010/11, a year of high skua breeding success.

Discussion

This season marked the 35th anniversary of the onset of seabird studies in Admiralty Bay in 1976. This research has been focused at the Copacabana colony since 1984 and has allowed us to assess trends in penguin demography, breeding biology, and foraging ecology among the three sympatric *Pygoscelis* species.

Breeding population counts were significantly higher for all three penguin species in 2010/11. The increase in breeding numbers is largely a reflection of a rebound by breeders that abandoned breeding attempts due to unusually high snow deposition in the colonies in 2009/10. Reproductive success for Adélie penguins was well above their long-term mean and the highest success rate in more than 20 years. These results were likely due to a very high krill biomass in Admiralty Bay in the early season and to the warm snow-free spring that allowed Adélie penguins to begin breeding earlier than usual in October. The Adélie penguin population counts increased 32% over the number of breeding pairs in 2009/10; however, much of the increase can be attributed to a return to more normal conditions and breeding attempts following the very cold, snowy 2009/10 season when large numbers of Adélie penguins deserted their nesting attempts due to snow covering their nest sites well into December 2009.

Reproductive success among the banded sample of Adélie penguins was the highest in a decade and considerably higher than the estimate of breeding success derived from the census data. The higher estimates of chick production from the individually monitored nests may be due to selecting only breeding birds to follow in the reproductive study while the census data likely included young birds (pairs) that did not reproduce, yet were occupying nest sites at the time of the census in the colony. It is normal for many young pre-breeding-age Adelie penguins to migrate to their natal colonies in the spring when conditions are favorable (Trivelpiece et al. 2011). All indicators suggest this was such a season and the presence of these young penguins in the census data, but not in the breed-

ing population, is the most likely explanation for the lower breeding success estimates derived from census counts.

Fledging weights of Adélie penguin chicks also reflected the abundance of krill in the local area, with chick fledging masses at the highest levels we have recorded in 20 years. These results are in sharp contrast to the fledging masses of chicks last season, when we recorded the lowest ever fledging weights since we began measuring this parameter in 1981. Moreover, this season reverses a trend in declining masses of chicks at fledging that has been evident since 2005.

Diet composition for gentoo and chinstrap penguins was comparable to previous seasons, with krill accounting for the majority of prey biomass. However, Adélie penguins were not sampled in 2010/11 and thus we have no corollary data on food loads, prey composition, or krill size for Adélie penguins in 2010/11. Gentoo and chinstrap penguin diets were similar to past years, with krill in the 41-50 mm size range accounting for 65% of all krill in the diets. Krill sex ratios among all penguin samples were similar and exhibited a familiar trend towards more female krill found in the samples than male krill (55.2% vs. 40.4%, respectively).

The mean foraging trip duration of Adélie penguins (14.4 h) was approximately the same as the long-term mean for this species, but about three hours less than the 17-plus hour trip lengths of the last two seasons. Gentoo penguin foraging trips were two hours less than the trips of Adélie penguins this season, but as this was the first season of data collected on this parameter for gentoo penguins, we have no reference point for comparisons to other years.

Protocol Deviations

Adélie penguin diet samples were not collected in 2010/11 due to permit restrictions. Likewise, we were not able to track Adélie penguin foraging trips to sea during the chick-rearing period. We added gentoo penguin foraging trip duration data collection to our normal suite of predator parameters in 2010/11 and plan to continue this in future years.

Disposition of Data

Land-based seabird data are available from Dr. Wayne Trivelpiece, NOAA Fisheries, Antarctic Ecosystem Research Division, 8901 La Jolla Shores Dr., La Jolla, CA 92037. Ph: 858-546-5607, Fax: 858-546-7003.

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