

# HUMBOLDT PENGUIN *SPHENISCUS HUMBOLDTI* POPULATION IN CHILE: COUNTS OF MOULTING BIRDS, FEBRUARY 1999–2008

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## SUMMARY

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We conducted annual counts of moulting Humboldt Penguins roosting on the mainland coast and on offshore islands in north and central Chile during 1999–2008. The census area included the known major breeding colonies in Chile, where many penguins moult, as well as other sites. Population size was relatively stable across years, with an average of 33 384 SD 2 372 (range: 28 642–35 284) penguins counted, but the number of penguins found at any individual site could vary widely. Shifting penguin numbers suggest that penguins tend to aggregate to moult where food is abundant. While many of the major breeding sites are afforded some form of protected status, two sites with sizable penguin populations, Tilgo Island and Pájaros-1 Island, have no official protection. These census results provide a basis upon which future population trends can be compared.

Key words: penguin, *Spheniscus humboldti*, census, Chile

## INTRODUCTION

The Humboldt Penguin *Spheniscus humboldti* is a species endemic to the nutrient-rich waters of the Humboldt Current that flow northward along the west coast of South America. The species' current distribution extends from La Foca Island, Peru (5°12'S), to Puñihuil and Metalqui islands, Chile (41°55'S, 42°12'S) (Hays 1984, Araya & Todd 1987, Wilson *et al.* 1995, Simeone *et al.* 1997). Once considered abundant, the population has decreased since the end of the 19th century because of changes to habitat (Coker 1919, Murphy 1936) and commercial activities, and it is now listed as *Vulnerable* by the IUCN (2013). We assessed the Humboldt Penguin population in Chile annually from 1999 to 2008 during the austral summer to determine current trends and status for a significant part of its range.

Because of the remote and inaccessible nature of the species' roosting and nesting islands and of its burrow-nesting behavior, it is difficult to determine a reliable population estimate. The Conservation Assessment and Management Plan (CAMP) held in Cape Town, South Africa, in 1996 (Ellis *et al.* 1998) and the Population and Habitat Viability Assessment (PHVA) workshop held in Chile in 1998 (Araya *et al.* 2000) recommended that a simultaneous census be conducted in Peru and Chile during the moulting period. This method developed for African penguins *Spheniscus demersus* provides a better estimate of the population than other methods (Randall *et al.* 1986, Crawford & Boonstra 1994).

In adult Humboldt Penguins, the moulting period extends from late January to early March. In Punta San Juan, central Peru, it normally occurs in late January (Paredes *et al.* 2003), and in Algarrobo, central Chile, peak moult occurs in late February (Simeone *et al.* 2002). While birds within a population are fairly synchronous, the moulting season lasts approximately six weeks, with an individual

penguin taking less than three weeks to moult (Paredes *et al.* 2003). Penguins remain on land during moult, and they return to sea immediately after moulting (Zavalaga & Paredes 1997). Field surveys in Chile were initiated during 1999 (Luna *et al.* 2002), and subsequent annual censuses were conducted using two surveys 2–3 weeks apart to count different populations of synchronously moulting penguins, according to methodology recommended at the PHVA.

This paper provides annual census results of Humboldt Penguins from 1999–2008 in Chile, from Iquique, in the Tarapacá Region, to Pájaro Niño island, near Algarrobo in the Valparaíso Region, covering roughly 1 800 km of coastline. This area comprises the largest breeding colonies of Humboldt Penguins in Chile and all the roosting sites mentioned by Araya (1983) as well as other sites that have been reported in the literature.

## METHODS

### Study area

The study area included the principal breeding colonies and roosting sites of Humboldt Penguins in Chile (Fig. 1) (Araya 1983). In 1999, counts were made from just north of Iquique to the Puñihuil Islands, to the south. Given the small number of penguins found at the Puñihuil Islands (0.02% of the total found in 1999), their absence on Mocha Island, the islands' relative inaccessibility and the long distance to the nearest colony in central Chile, these sites were not included in subsequent years, i.e. the 2000–2008 counts were done only as far south as Pájaro Niño island near Algarrobo.

The topography of the coast investigated varies considerably and can be divided into three zones. In Zone I, from Arica, located just south of the Peruvian border, to Iquique, the coast is characterized

by high cliffs and a rocky coastline with deep gorges falling vertically into the sea (Araya 1983); Cueva del Caballo and Punta Pierna Gorda are located in this area. Farther south, the coast is flatter with some rocky outcroppings and small islets. In this area, we saw small flocks of penguins at sea and penguins moulting in small groups on shore, by sea caves, on headlands and on small rocks and coastal islets, some of which are used as rookeries, but some open nests and chicks have also been seen in these locations (Araya 1983). For the purposes of this study, Zone I extends south to Tórtolas Islets (Appendix 1, available on the web site).

We considered Zone II to be in north-central Chile, where a series of medium and large islands comprise the larger breeding colonies. These include Pan de Azúcar, Grande, Chañaral, Choros, Tilgo, Pájaros 1, as well as Lengua de Vaca point. Zone III is located in central Chile and includes the breeding colonies of Cachagua, Concón and Pájaro Niño islands. There are other colonies and small breeding localities both outside and within the study area (Araya 1983), but, with the exception of Pájaros 2 in 1999, these were not surveyed because some are too small, far away, relatively inaccessible or required too much travel time to be reached.

### Surveys

A vehicle was used to access remote places on the mainland, and rented fishing boats were used to access the islands. While on land during moult, penguins congregate in groups mainly along landing

beaches and rocks both in islands and near mainland, allowing for direct counting of roosting birds from suitable vantage points (Bibby *et al.* 2000) such as tops of elevated sea cliffs, which allowed us to see groups of birds on beaches and rocky shores. On some islands, such as Tilgo and Chañaral Islands, which are partially covered by vegetation, we walked regular inland transects of 20 m, in a slow pass to minimize disturbance, in order to count birds in burrows and under vegetation. In some respects, the mountainous shape of some islands with high terraces and coastal cliffs facilitated the counts, but it did not permit access to numerous large coastal caves. Depending on ocean conditions, penguins at the peripheries of islands were counted from boats, and, therefore, counts included only birds seen at cave entrances. From a boat travelling at low speed, we surveyed inaccessible islands, getting as close as ocean conditions allowed and recording birds both at sea and on shore. At all locations, penguins moulting in burrows on cliffs, within sea caves or under vegetation or in burrows on inaccessible islands could not be counted.

Counts usually began on 31 January and ended on 28–29 February and were conducted from 09h00 to 18h00. To include as many penguins as possible during 2000–2008, two counts were done approximately two weeks apart (15.1 SD 1.7 d), both following the same route from north to south.

Observations were made using both a Nikon 7 × 50 binocular and a 60× Swift Telemaster Spotting Scope as well as a manual tally-

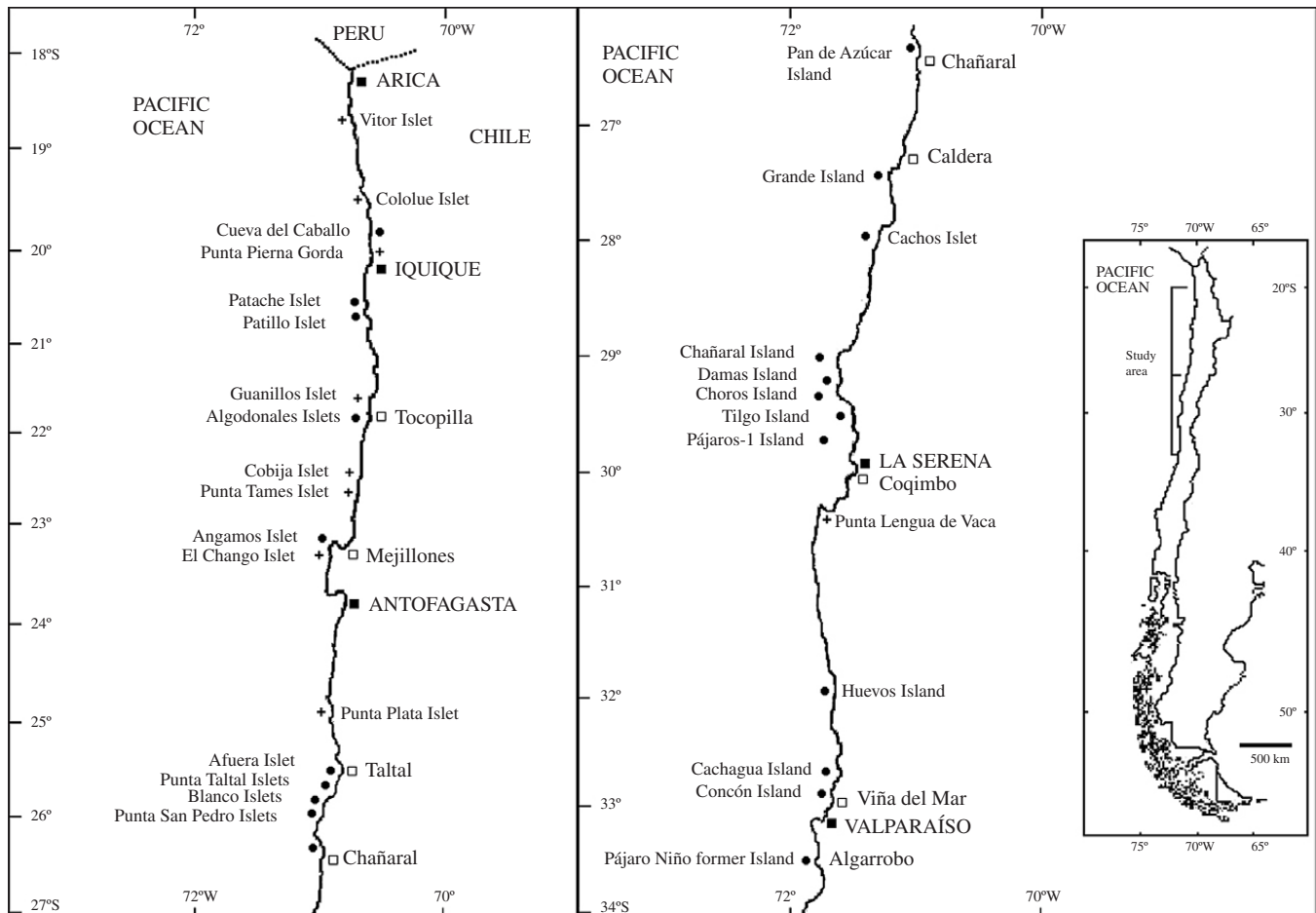


Fig. 1. Study area for Humboldt Penguin population census 2000–2008.

counter. A Garmin eTrex Global Positioning System (GPS) was used to determine the coordinates of the locations. Two observers made counts simultaneously, and if the results varied more than 5%, new counts were done, and the mean of the two closest counts was adopted.

We categorized the number of birds in the following stages of moult, based on the proportion of old feathers lost:

Stage 0 — not yet moulting, with worn and brownish plumage;

Stage 1 — moult has already begun, with small patches of old feathers missing;

Stage 2 — moult is almost concluded, with only a few old feathers remaining on the head and;

Stage 3 — moult concluded, new plumage.

To estimate the total, we used the higher of the first or second counts. If the total of the first count was used, we added the number of birds in stages 0 and 1 of the second count to this total, since these birds were probably not yet on land and had not started moulting during the first count. If the total of the second count was used, we added the number of birds in stages of 2 and 3 of the first count, because they most likely had finished moult and were at sea by the time the second count was done. Only birds with adult plumage and juveniles moulting into adult plumage were included. We assumed that juvenile numbers were not representative of the total juvenile population, because the peak moult for juveniles occurs earlier, i.e. in late January at Pájaro Niño Island, Chile, and at locations in Peru (Simeone *et al.* 2002, Paredes *et al.* 2003).

In 1999, only one count was done, and in 2000, it was impossible to make both counts at some locations because of rough sea conditions. Data from these years were tabulated but not used to calculate the overall mean or median population numbers.

## RESULTS

### Population status

In the surveys of 1999 and 2000, respectively, 25 490 and 28 268 Humboldt Penguins were counted (Appendix 1, available on the web site). For the surveys performed during 2001–2008, counts ranged from 28 642 to 35 284, with an average of 33 284 SD 2 372 (Appendix 1).

Penguins were found throughout the area surveyed and used different places to moult across years (Appendix 1). Based on the average across years for each location, Zone I represented 12.9% of the total. The Algodonales Islets had the highest number, with a mean of 1 781.9 birds (5.2%), followed by islets near Punta Taltal with 886.3 birds (2.6%), Blanco islets with 329.6 birds, Punta San Pedro with 261.1 birds, islet at Punta Patache with 242.8 birds and islets at Punta Tames and south of Cobija with 216.3 and 214.0 birds, respectively. Finally, Angamos Islet, with an average of 173.5 birds, represented a new breeding site.

The main aggregations of penguins were found in Zone II, on islands with active breeding colonies. This zone contributed 81.3% of the census population, led by Chañaral with 12 768.3 birds

(37.2%), Pan de Azúcar with 4 584.5 (13.3%), Grande 3 922 (11.4%), Pájaros 1 2 540.1 (7.4%), Tilgo 2 267.2 (6.6%), Choros 1 818.8 (5.3%) and others described in Appendix 1. Lengua de Vaca Point is the only place on the mainland in this zone where penguins were seen moulting. The remaining 5.9% of the population was found in Zone III, where Cachagua led with 1 332.7 penguins (3.9%), followed by Pájaro Niño Island with 570.5 (1.7%) and Concón with 109.5 (0.3%).

Of the 14 sites in Zones II and III surveyed during at least one census, 12 sites are considered major breeding grounds (underlined in Appendix 1), including Pájaros 2 (Araya, 1983). Eleven sites were confirmed to have breeding activity (Appendix 2) — breeding activity at Pájaros 2 could not be confirmed because the island was visited only once, and counting was done from a distance (Araya 1983). In Zone I, there is one regular breeding location, and 10 locations appear to be irregular breeding sites with only occasional presence of chicks. The four remaining sites were deemed to be used for roosting only, or the use was undetermined.

### Comparison between surveys

In the 2001–2008 surveys, the relative distribution of moulting penguins among the locations shifted from island to island across years (Fig. 1). Fluctuation was greatest among Chañaral, Grande, Pan de Azúcar and Pájaros 1 islands (Appendix 1, Fig. 2). In Zone I, Algodonales islets had the highest number of moulting penguins during 2006–2008, peaking at 3 299 individuals in 2007. Punta Taltal and Punta San Pedro showed a slight increase during 2005–2007, while Blanco Islets peaked at 1 972 birds in 2006 before returning to more typical numbers the following years (Appendix 1).

In Zone II, numbers of moulting penguins at Pan de Azúcar shifted from about 3 000–4 000 in the 2001–2005 to more than 6 000–7 000 birds during the 2006–2008 visits. Grande Island increased from about 3 000 to more than 5 000 birds in 2004 and 2007, then fell to 4 000 in 2006 and 2008.

Chañaral Island has always had the largest aggregation of penguins. A total of nearly 15 000 birds were found annually from 2001 to 2004, reaching a maximum of 19 132 in 2003 and decreasing to 8 319–8 671 during 2007–2008. Roughly 3 000–4 000 birds were present on Pájaros 1 during 2002–2004, decreasing to 2 000 in 2006–2007, then recovering to nearly 3 000 in 2008 (Appendix 1).

Choros Island, situated between the islands above, had about 2 000 birds in 2002 and again from 2005 to 2008. Tilgo Island had under 2 000 birds in 2004, but spiked at more than 2 750 in 2007 (Appendix 1).

In Zone III, central Chile, the counts at Cachagua varied from 568 in 2002 to 1 624 and 1 879 in 2006 and 2007, respectively, and at Pájaro Niño from a low of 278 in 2004 to 778 and 898 in 2006 and 2007, respectively. Concón Island had low numbers, from 20 to about 130, during 2001–2007, reaching its highest count of 225 in 2008 (Appendix 1).

## DISCUSSION

During the 1980s, the Chilean Humboldt Penguin population was initially estimated as 8 800 breeding birds, with a total of up to 10 000–12 000 during the 1981/1982 breeding seasons (Araya

1983). The same places were visited in 1984, 1985 and 1986, when 5670 birds were seen, leading to a population estimate of 5000–6000 penguins (Araya & Todd 1987). The 1982/1983 El Niño–Southern Oscillation (ENSO) apparently caused a temporary reduction in the number of breeding birds in Chile, but not in total penguin numbers since there was no evidence of dead or malnourished birds (Araya & Todd 1987), which contrasted with the situation in Peru, where adult mortality was reported by Hays (1986).

This study, which counted moulting birds, showed year-to-year variation in the timing of birds coming ashore, yet yielded similar counts across years and showed numbers that were consistent with the literature despite the different methodologies used (Mattern *et al.* 2004, Luna-Jorquera *et al.* 2000). At Chañaral Island, our estimate for 2002 and 2003 was 15 184 and 19 132 birds. Despite different methodology, in February 2003, Mattern *et al.* (2004) found the number of birds ranged from 15 269 to 16 947. Counts of birds on Choros, Tilgo and Pájaro 1 islands showed 1 479, 1 729 and 4 311 birds in February 1999 (Luna-Jorquera *et al.* 2000), similar to our counts during one pass that same year. We checked the Puñihuil islets in February 1999 only and found 94 birds (Appendix 1). For the same year a total of 150 breeding individuals were reported by Hennicke & Culik (2005) and Herling *et al.* (2005).

The population reported in this census is greater than previously estimated and remained about the same across years, with an average of 33 284 birds. This is undoubtedly a conservative estimate, as not every possible site could be visited and birds residing in burrows on cliffs or in sea caves would not have been seen. However, the study included the major breeding colonies and, thus, the majority of the Humboldt Penguin population in the species' range in Chile.

#### Concentration of moulting birds at certain locations

In this study, we found considerable local shifts in penguin numbers, which suggest that penguins aggregate to moult where food is abundant, both to allow them to store nutrients before the moult and to recuperate after the two-week moult fast (Culik 2001). Consequently, concentrations of moulting birds should occur in areas of higher productivity, such as the seasonal nutrient-rich cold-water upwelling centers along the coast of Chile. In the north-central zone, there are areas of upwelling south of Coquimbo (Lengua de Vaca), near Choros and near Caldera (Acuña *et al.* 1989, Weichler *et al.* 2004, Thiel *et al.* 2007). The Pájaros 1, Tilgo, Choros and Chañaral islands are situated just north of Coquimbo and near Choros, and Grande and Pan de Azúcar islands are near Caldera.

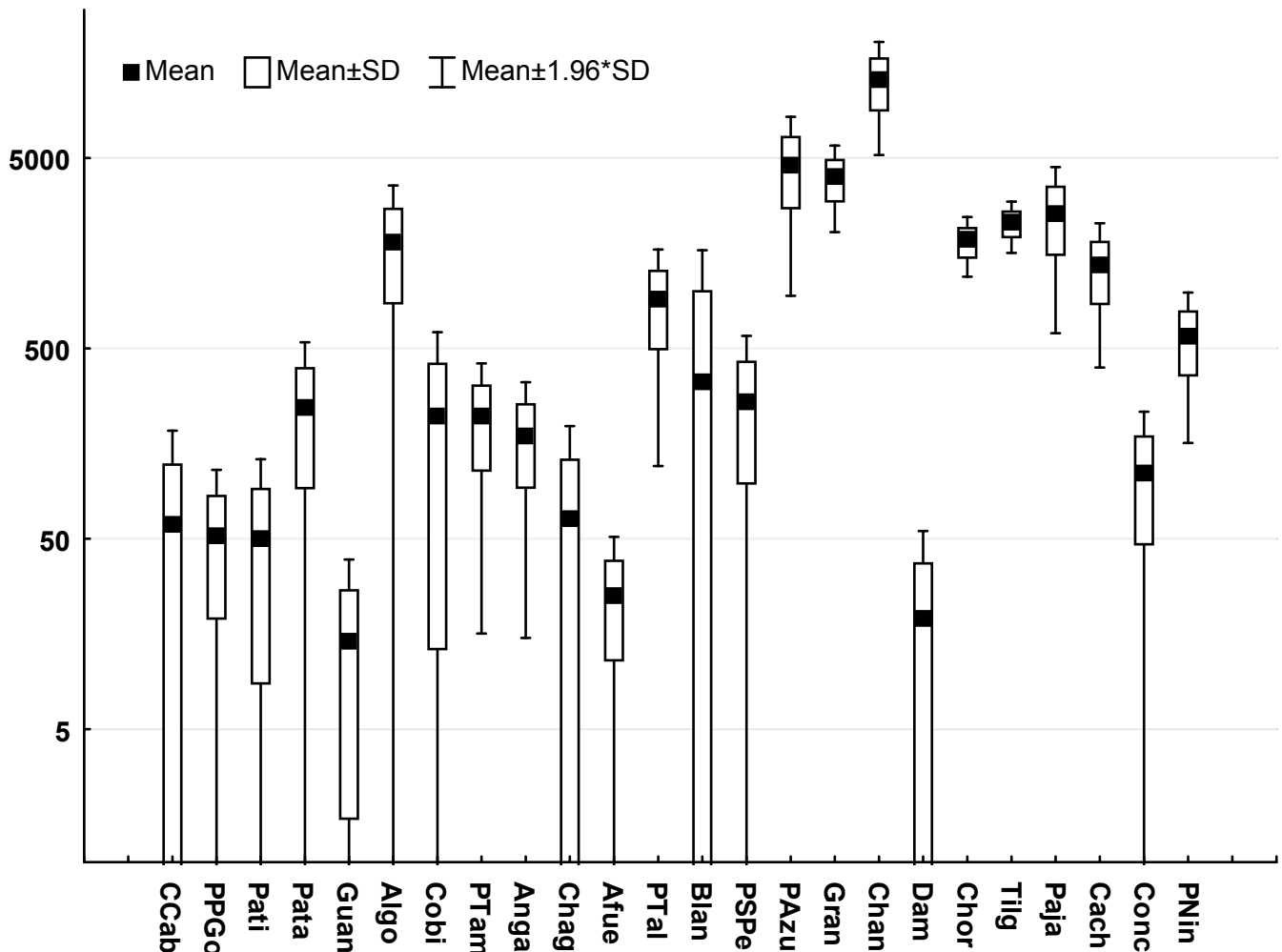


Fig. 2. Mean numbers of Humboldt Penguins counted at each site during the period of moult in 2001-2008. Values are shown on a log scale.

## Threats and conservation

The areas with the highest number of moulting birds mirror, for the most part, those islands that are known to have the largest number of breeding birds. Most conservation attention has focused on breeding colonies but, on occasion, these may differ from major moulting sites that could be equally as important. The small Algodonales islets are of particular importance for moulting birds (Appendix 1). Eight of 12 breeding colonies have some legal protection, so they also protect moulting birds. The Pájaros 1 and Tilgo islands, where both breeding activity and a significant number of moulting birds occur are not currently but should be protected. Of the 17 non-breeding sites used by moulting birds and sites where breeding occurs only occasionally, none have any degree of protection (Appendix 2, available on the web site).

Monitoring of Humboldt Penguin populations is critical to allow management responses to environmental threats that range from minor disruptions to potentially catastrophic events. Guano harvesting affects the population by both removing potential nest-sites and by disrupting nesting birds if harvest occurs during the breeding season. Small-scale illegal guano harvesting still occurs at some islets in the Tarapacá and Antofagasta regions, but it is regularly halted when detected by the Armada de Chile and Servicio Agrícola y Ganadero (SAG) (DIPROREN 2004). The extraction of both fresh guano (guano blanco) and ancient guano (guano rojo) is permitted mainly on mainland points under concession through the Ministerio de Minería and the SAG agencies. Legal guano harvesting was observed regularly on Guanillos Islet, and both new and old sacks full of guano were found in other sites (Appendix 2).

Unauthorized fishing camps and unregulated ecotourism providing tourists with access to breeding areas have been shown to increase trampled and collapsed burrows, leading to nest and chick abandonment. Introduced non-native animals, including domestic dogs, cats and goats, can also lead to burrow collapse or to direct mortality of penguins (Simeone & Schlatter 1998, Simeone *et al.* 2003). Mortality due to drowning in both artisanal and commercial fishing nets still occurs (Simeone *et al.* 1999). Large-scale threats include commercial fisheries, and associated port construction near breeding colonies and penguin foraging routes (Ellis *et al.* 1998), and pressure to develop tourist hotels on or near breeding colonies.

Overall, counting penguins during the moult season appeared to be a reasonable method to estimate the overall population and population trends, especially during ENSO years when penguins may defer breeding and practically disappear from their breeding colonies. However, moulting birds do not necessarily represent the breeding population. A predominance of post-reproductive individuals, a skewed sex ratio or the lack of suitable nesting sites to accommodate the number of breeding pairs would diminish the breeding population below what might be expected given the size of the general population. Determining the size of the actual breeding population across years would better assess the future stability of the overall Humboldt Penguin population. Methods to consistently and accurately assess and monitor the breeding population need to be developed. This may prove difficult given the length and ruggedness of the Chilean coast and off-shore islands, combined with the Humboldt Penguin's preference to nest in burrows, under rocks and in caves. Continued monitoring of the moulting population may be the only reasonable way to assess the general population trends.

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