Humboldt penguin (*Spheniscus humboldti*)
Population and Habitat Viability Assessment Workshop
Final Report

Workshop organized by: ACOREMA, Saint Louis Zoo, IUCN SSC Conservation Planning Specialist Group (CPSG).

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A contribution of the IUCN SSC Conservation Planning Specialist Group.

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2019

CONTENTS

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Final Report

Lima, Peru
October 17,18, 21-23
2019

Section 1
Executive Summary

Photo: J. Reyes

Executive Summary

Found on coastal islands and a few isolated peninsulas along 4,700 km of coastline in Peru and Chile, Humboldt penguins derive their name from the cold Humboldt current (aka Peruvian Current) that flows northward from sub-Antarctica along the west coast of South America. Humboldt penguins prefer nest sites in the guano deposited by the hundreds of thousands of seabirds that also inhabit the coastal islands. The species is listed as vulnerable and declining by the IUCN Red List (see Appendix I for all acronyms), while national legislation in Peru classified this species as "Endangered." A Population and Habitat Viability (PHVA) workshop in Chile in 1998, facilitated by (then) CBSG identified major threats to the population and recommended four key strategies:

- To begin long-term monitoring of the population through regular, systematic, standardized censuses;
- To decrease mortality due to entanglement in fishing nets and direct poaching;
- To increase reproductive success;
- To decrease the effects of El Niño events on adult mortality.

Twenty-one years later, in October 2019 (in Lima, Peru), a PHVA workshop, building upon the results from an immediately preceding Population Viability Analysis (PVA) workshop, reassessed the population, evaluated progress made towards the goals of the 1998 PHVA, and identified priority strategies and actions moving forward. (See Appendix VIII for PVA and PHVA agendas.)

The specific goals of the 2019 Humboldt penguin PVA/PHVA workshop included:

- To assemble all colleagues who work on or have influence over the future of Humboldt penguins;
- To assemble all the best data, published or unpublished, from both Chile and Peru, on population status and demography of Humboldt penguins;
- To create common understanding of current status of Humboldt penguins and projections for their future;
- To identify and fully understand the threats facing Humboldt penguin populations;
- To prioritize the threats that have the greatest negative impact on the populations;
- To develop strategies, action items and planned follow-up to:
    - Address the high priority threats
    - Identify and address gaps in knowledge;
- To identify and propose implementation of an approach for long-term monitoring of populations that can be used in both Peru & Chile; and
- To create a report from the workshop that can be used to inform agencies, NGOs and others who want to create action plans and other management tools that promote the conservation of Humboldt penguins.

The workshops, sponsored by the Peruvian Ministry of the Environment (MINAM), included diverse participants: scientists from Peru and Chile; representatives from the Ministries of Production and Agriculture, including their attached bodies; Peruvian NGOs; members of the IUCN Penguin Specialist Group; and representatives from zoos in the United States and Peru; among others. CPSG, CPSG North America, CPSG Mesoamerica, and CPSG Brazil assisted with population modeling and workshop facilitation. Julio Reyes, President of ACOREMA (Áreas Costeras y Recursos Marinos, a Peruvian NGO) coordinated all in-country logistics, guiding the planning through numerous unexpected changes. Julio's working mantra became *#we can work it out*. And he always did!

Systematic censuses in Chile between 2000 and 2008, and in Peru between 2009 and 2019 provided the basis for PVA modeling. The surveys have revealed some additional colonies of penguins (especially in Peru) that were not known during the 1998 PHVA and suggest that penguins move between sites more often than had been suspected. However, using the census data and other best estimates of demographic rates, the PVA projections also suggest that the overall population could be decreasing on average by 7% per year. Although some information on reproductive rates, chick survival and juvenile mortality was available, the paucity of this information highlights the difficulty of studying pelagic, island-nesting birds with extended breeding seasons in widely dispersed colonies scattered along a long coastline. Nonetheless, in hundreds of iterations of the baseline model, the mean time to extinction was 59 years, with the population expected to be extinct between 35 and 85 years. If the 7% annual decline is confirmed by additional census and/or demographic data, then Humboldt penguins meet the IUCN criteria for moving from its current threat category of “Vulnerable” to “Endangered” (Appendix V).

Overfishing, net entanglement, human disturbance and predation by native and introduced predators were identified as key drivers of mortality. Additionally, some discussions suggested that climate change and warming oceans may indirectly affect penguins and survival rates through changing ocean currents and food chain impacts. Efforts to regulate guano harvest have proved effective on the islands where they have been employed, but harvest on many islands remains unmonitored, and illegal harvest is known to occur in some parts of the range.

Specific conservation objectives resulting from the 2019 Humboldt penguin PHVA workshop included:

- Better understanding the food and energy requirements of Humboldt penguins as they relate to food availability;
- Improving the design of gill nets to reduce penguin mortality while maintaining the fishery catch;
- Promoting the spatial and temporal regulation of the gillnet fishery to minimize penguin bycatch;
- Developing and promoting the use of best practice guidelines for the gill net fisheries in Peru and Chile;
- Reducing predation and human disturbance, including from tourism;
- Decreasing the impacts of environmental contamination and disease;
- Continuing to refine sustainable guano harvesting practices in Peru and Chile, and reducing the impacts of illegal guano harvesting;
- Increasing the level of collaboration within the scientific community (short term);
- Educating the public about how they can help with Humboldt penguin conservation (mid- and long-term;)
- Developing long term research monitoring methods and implementation protocols across specific major breeding sites, with special emphasis on those demographic variables that drive population decline and need further verification (particularly fledging rate, juvenile survival, adult mortality).
- Consistently censusing across the range; and
- Increasing knowledge of juvenile and adult dispersal by defining where they go during life cycle stages, different times of the year, and across years (for example, during El Niño years).

Detailed actions, timelines, and responsible parties were identified for each goal found in the individual working group reports. A total of 14 goals were developed during the workshops and were prioritized by surveying participants in the PHVA. During the review process of the final document, relevant comments were provided that were additive to the content of the report but had not been vetted during the workshop; these comments were collected in Appendix IX. An oversight team was charged with monitoring progress towards the goals (Appendix X).

Humboldt Penguin
Population and Habitat Viability Assessment Workshop
Final Report

Lima, Peru
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2019

Section 2
History and Status Review

History and Status Review

The Humboldt penguin is endemic to the Humboldt Current (also known as the Peru Current) region and is restricted to more than 4,700 km along coasts and offshore islands of Chile and Peru (see maps Appendix II). The species' reproductive range includes Foca Island (5° 12'S) in Peru though Metalqui Island in Chile (42° 11'S) (Hiriart-Bertrand et al. 2010), which almost exactly matches the distribution of Peruvian anchovy (*Engraulis ringens*) and the upwelling ecosystem (Jahncke et al. 2004). The primary concentration of the species between Islas Guañape (8° 33'S) and Isla Pajaro Niño (33° 21'S).

Humboldt penguins breed in loose colonies on rocky coasts, in sea caves, among boulders, in burrows and occasionally on the surface. Historically there has been a strong association between these penguins and guano birds (Guanay cormorant (*Phalacrocorax bougainvillii*), Peruvian booby (*Sula variegata*), and Peruvian pelican (*Pelecanus thagus*), in part because of the richness of the Humboldt Current ecosystem and in part because deep guano deposits have made excellent substrate for burrows. Surface nesting has become more common over time, as the huge guano deposits of the 1800's were mined and sold as fertilizer. In Peru, to maintain guano production and the guano industry, these 'bird islands' (Murphy 1936) have been managed during the past century for sustainable populations of the guano-producing birds. This has conferred benefit on penguin populations because the guano sites have been legally protected, including having guards in place. Today in Peru, the association of penguins with protected sites is very strong (Figure 2.1). In Chile, deep guano deposits were not as widespread, commercial production of guano was never as intense as in Peru, islands have not been managed for sustainable guano bird populations, and penguins have used more diverse nest sites. In both countries, important bird areas (IBAs) have been designated by Bird Life International; the marine IBAs tend to include the important penguin sites because, at least in part, those sites present ecological conditions that favor the entire seabird guild. (See Appendix III).

The penguins are generally considered to be monogamous, having strong pair fidelity, with partner death or desertion the main causes of partner changes; however, success of the previous breeding season can also influence pair fidelity. While they may nest year-round, there are two distinct peaks with the larger peak in September-November (Spring) and a lesser peak in April-June (Fall). A single peak of nesting is generally a stronger phenomenon at higher latitudes. Females typically lay two eggs, which hatch after 39-42 days of incubation. A second clutch may be laid in the same year if the first clutch fails (Williams 1995). Parents often raise both chicks. Fledging into juvenile plumage is complete at about 3 months of age, and the juveniles retain the juvenile plumage until the next annual molt. Annual molt in Humboldt penguins is highly synchronous although it occurs slightly earlier further north in Peru than in Chile. Molt of most of the population occurs over approximately six weeks from mid-January through February (Wallace & Araya 2015), although this period may be somewhat longer in Peru (Paredes *et al*. 2003). Molt of each individual requires 21 days, during which time the penguins fast and stand on shore, usually in groups.

Diet for Humboldt penguins depends somewhat on location. Peruvian anchovy or anchoveta (*Engraulis ringens*) is the main prey item in Peru, while in Chile penguins in northern colonies consume primarily garfish (*Scomberesox saurus*), yet birds at the southern colony of Puñihuil fed primarily on anchovy, Araucanian herring (*Strangomera bentincki*) and silverside (*Odontesthes regia*) (Herling et al. 2005). Humboldt penguins historically have been considered to be sedentary, leaving their colonies at sunrise to forage diurnally close to the colony. However, as technology and data collection methodologies have advanced, recent studies have shown that Humboldt penguins may travel farther than previously thought (Simeone & Wallace 2014; Wallace et al. 1999; Culik & Luna-Jorquera 1997).

Ranges of Humboldt and Magellanic (*S. magellanicus*) penguins overlap over 1100 km along the southern Pacific coast of South America**.** Despite this overlap, inter-breeding appears to be rare, although hybrids in the wild have been documented (Simeone et al. 2011).

Humboldt penguin populations have declined over the past 5 decades. Murphy (1936) suggested that the species was already in decline from mid-19th century estimates of more than a million, down to hundreds of thousands in the early 20th century. Murphy observed that in Peru the destruction of nesting sites due to guano harvesting was causing the penguins to resort to precarious nesting sites. After the 1982-83 El Niño, the Peruvian population was estimated to have declined 65% to 2100-3000 adults (Hays 1986). The Chilean population of breeding adults (i.e., adults found in burrows or nests) following the 1982-83 El Niño event was estimated to be approximately 3000 birds in 1984, down from 10-12,000 in 1981 before the El Niño. However, by 1986 the population appeared to have rebounded to approximately 5-6000 birds in Chile (Araya & Todd 1988). This led to speculation that rather than a true population decline from death, the adults simply followed food sources to areas less affected by the warmer water temperature and did not return to reproduce in the reproductive seasons immediately following El Niño. Since 1970, seabird populations have declined globally at the same time that global annual fish catch has increased (Grémillet et al. 2018); these authors particularly noted this phenomenon in the 'Peru Current.'

During the 1998 Population and Habitat Viability Assessment (PHVA) for the Humboldt penguins, recommendations were made to conduct more frequent censuses, of molting birds, to better assess the total penguin population (Araya et al. 2000). Outside of the breeding season penguins can be fairly mobile and roost at various locations, (Wallace & Araya 2015; Vianna et al. 2014) therefore the censuses of birds in Chile and Peru ideally would be done simultaneously to account for interannual variations in populations found in either of the two countries.

Following the methodology specified in the 1998 PHVA, a count of molting penguins (excluding juveniles and chicks) at all known colonies along the Chilean coast from the Peruvian border to Islote Pájaro Niño, Algarrobo, Chile was performed from 2000-2008. Although the number of birds at individual locations could vary greatly from year to year, the overall population counted each year was relatively stable, averaging approximately 33,000-34,000 birds (Wallace & Araya 2015) (Appendix IV). Additionally, in 1999 an assessment of the Humboldt penguin population in the Coquimbo region, Northern Chile, between 29°10'S and 30°15'S, by combined terrestrial and at-sea counts, found an estimated 10,300 molting birds, exceeding all recent estimates at that time (Luna-Jorquera, et al. 2000). A more recent census performed in 2018 found, with different methodology, about 5,000-6,000 breeding pairs (adults). (https://www.emol.com/noticias/Nacional/2018/08/24/918134/Primer-censo-nacional-detecta-menos-pinginos-de-Humboldt-que-hace-10-anos.html).

Using the 1998 PHVA-recommended methodology, censuses were conducted irregularly in Peru between 2000 and 2010. Between 1999 and 2009, the molt censuses in Peru were irregular—some years were missed and in some years only major sites were counted (Appendix IV). Consistent Peruvian censuses of molting birds were conducted from 2010 – 2019; the total population of molting birds, while variable, showed a peak in 2015 and an overall downward trend from just under 20,000 birds in 2010, to fewer than 10,000 in 2019 (McGill et al. unpubl. data). Although the majority of penguins in Peru are found in protected and partially protected sites (Figure 2.1 and Appendix IV) and counts in most sites can vary between years, McGill and recent census teams regularly count even the lesser sites; dramatic declines between years (and failure to rebound) have been documented at some unprotected sites and it is important to understand the cumulative variability at such sites because together the impact may be important (see data in Appendix IV). Simultaneous censuses in Chile and Peru did not occur except for 2000, 2003 and 2004.

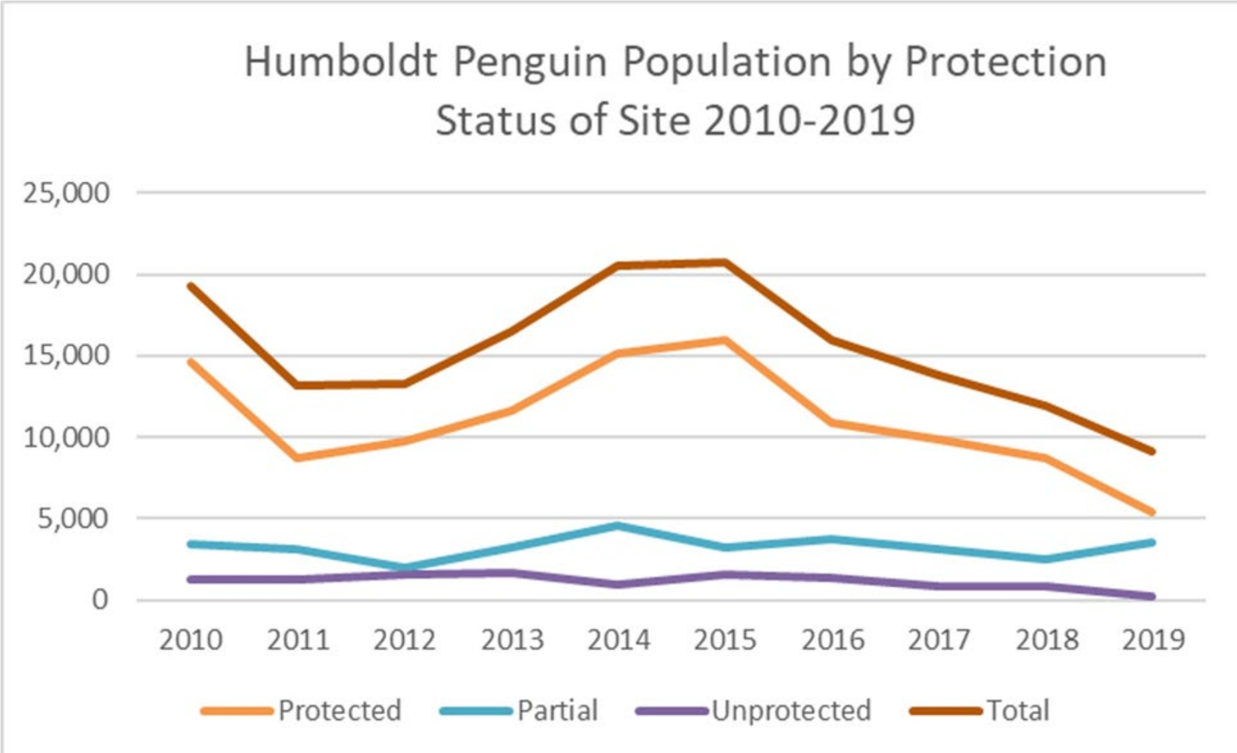

Figure 2.1. Census of molting birds in Peru (McGill, unpubl. data). Protected sites include those with legally protected status and typically with guards in place, i.e., Reserva Nacional Sistema de Islas, Islotes y Puntas Guaneras (RNSIIPG) as well as La Reserva Nacional de Paracas (RNP). Partially protected sites are those that lack national-level protection, but nonetheless require special permission to access, such as crossing mining or industrial property.

Although Humboldt penguin counts may vary widely among locations, between years, and different census methods, the general trend across the range appears to be that of a population in decline. The decline may be caused by many factors, including poor reproductive success, high chick mortality rates, entanglement in fishing nets, high mortality during El Niño years, and overfishing. Among the postulated main causes currently of concern are: climate change, including more frequent, stronger ENSO events, with heavy rainfall which in many regions results in nest destruction and the associated loss of eggs or chicks, and the movement of prey stocks away from established breeding colonies; decreased abundance of prey populations due to fishing activities (especially the collapse of the anchovy stocks), human disturbance, loss of habitat because of guano exploitation, and ocean disturbances. Secondary threats include: predation by introduced animals, and contamination from increased human activity in close proximity associated with urban development and inadequate planning (Wallace et al. 1999, Luna et al. 2002; De la Puente et al. 2013).

The Humboldt penguin is listed as vulnerable by IUCN, with the population considered to be decreasing (BirdLife International 2018), and listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES: https://cites.org/eng/app/appendices.php, 26.November.2019). The species is listed as vulnerable by the Chilean Environmental Ministry (Ministerio del Medio Ambiente (http://www.mma.gob.cl/clasificacionespecies/listado-especies-nativas-segun-estado-2014.htm) and as endangered in Peru (https://www.serfor.gob.pe/wp-content/uploads/2018/10/Libro-Rojo). Currently in Peru, SERFOR is finalizing a reassessment of the Red List status of the regional (Peruvian) population of Humboldt penguins.

Humboldt Penguin
Population and Habitat Viability Assessment Workshop
Final Report

Lima, Peru
October 17,18, 21-23
2019

Section 3
Plenary Discussion and Issue Identification

Photo: J. Reyes

Plenary Discussion and Issue Identification

A thorough understanding of factors that impact the viability of Humboldt penguin populations is critical in identifying and evaluating management strategies to address threats and promote viability. The 1998 Humboldt Penguin PHVA identified primary threats to penguin populations as climate change, especially heavy rainfall leading to nest destruction; decreased prey abundance due to fishing activities; entanglement in fishing nets; hunting of penguins for human consumption and use as bait; and loss of habitat due to guano exploitation and ocean disturbances. Secondary threats were predation on chicks by rat and introduced animals; and contamination from human activities associated with urban development and inadequate planning.

A group exercise was conducted at this stakeholder-diverse workshop to bring all of these threats and issues to the attention of all participants, to provide the participants with the opportunity to highlight additional threats, and to take advantage of their diverse expertise to identify potential causal relationships that may have implications for mitigation or management.

Workshop participants were asked to brainstorm challenges to Humboldt penguin conservation by writing each issue on a card and placing it on the wall. Next, the participants grouped related issues together, resulting in four primary focal areas:

- **Fisheries and fishing practices:** Ineffective management of fisheries results in high fishing pressure, reducing the food available to penguins. The use of gill nets in fisheries results in direct penguin mortality due to entanglement.
- **Population Biology and Demography:** Insufficient and inconsistent information on reproductive success, adult and juvenile dispersal, adult and juvenile mortality, sex ratios and population levels makes it difficult to produce accurate and stronger population projections (see Section 8 PVA).
- **Communications and Education:** Limited generation and dissemination of information leads to poor collaboration among penguin conservationists, researchers, managers and all who develop action links to the Humboldt penguin.
- **Human Disturbance:** Human influences including tourism, marine pollution, introduction of predators and guano harvest negatively impact penguin populations. Additionally, some fishing practices, e.g., crowding of boats near islands or use of the shore by line fishermen, can also contribute to human disturbance.

These focus areas served as a basis for the formation of working groups for further discussion. Each working group received all of the issues that fell under its primary topic. Over the course of the next several days, working group participants were asked to develop specific problem statements for each identified issue, and to articulate specific goals, objectives, and actions that would address each problem statement. Each working established its own timetable of target dates and durations. Reports from the working groups follow.

Humboldt Penguin
Population and Habitat Viability Assessment Workshop
Final Report

Lima, Peru
October 17,18, 21-23
2019

Section 4
Working Group Report: Fisheries

Photos: P. McGill

Photos: J. Reyes

Working Group Report: Fisheries

Working group participants: Guillermo Luna Jorquera (Universidad Católica del Norte, Chile), Maria Andrea Meza (IMARPE), Cynthia Romero (IMARPE), Alejandro Simeone (Universidad Andrés Bello, Chile), Lauren Waller (SANCCOB)

Two aspects of fish abundance impact Humboldt penguin populations. Humboldt penguins feed primarily on fish, especially anchovies, herring and smelt. When not rearing chicks, adult penguins are able to travel long distances when foraging. However, when rearing chicks, adults tend to forage in shallow waters close to their nesting burrows. The anchoveta population size in particular is closely tied to natural climate fluctuations in the eastern South Pacific and year-to year variation can be significant (Chavez et al., 2003). These variations in the abundance and distribution of fish play an important role in penguin survival and reproduction. Additionally, penguins depend on guano deposited by other seabirds for nesting sites. Seabird populations are also impacted by fish availability (Tovar and Cabrera, 1985), with a reduction in fish populations resulting in lower seabird populations and less seabird guano.

The commercial Peruvian anchoveta fishery is one of the largest fisheries in the world. As a result of heavy fishing pressure catches have decreased from an annual peak of 13 million metric tons in 1971, to recent averages between 4 and 8 million metric tons per year. The reduction in anchovetas has led the fishing industry to expand its effort to other fish species as well (Coull 1974, Chávez et al. 2020). In northern Chile anchoveta make up the majority of the tonnage landed by the industrial fisheries. (Fuente: http://www.sernapesca.cl/informes/estadisticas?qt-quicktabs_area_trabajo=5). Artisanal fisheries in both Peru and Chile also have a substantial impact on fish abundance.

Two issues related to industrial and artisanal fisheries surfaced as having significant impact on Humboldt penguin populations. The first was fish availability and the extent to which current fishing regulations and practices impact fish availability. Specific information on penguin food requirements makes it difficult to determine what impact the variation in different fish stocks has on penguin populations. The second issue revolved around the use of gill nets by artisanal fishermen. There have been observations of and scattered reports on penguin bycatch and entanglement, but this information has not been consolidated into range-wide or country-wide assessment of the population impact or key locations. In conjunction with the International Penguin Conference in 2016, penguin biologists from around the world met to assemble information about the frequency and impact of bycatch (Crawford et al. 2017). Additional sources of information on penguin bycatch include reports by groups documenting entanglement of sea turtles and dolphins in coastal Peru and Chile; additionally, these groups have examined the use of lights, pingers, etc. to reduce bycatch. Bycatch or entanglement may be particularly important where zones of gill net use overlap with zones that are important for penguins foraging in or transiting those areas. Additional focus on this information in Humboldt penguins would be useful in order to develop specific tangible priorities for conservation action.

Finally, there have been scattered reports of intentional use of nets to capture penguins, e.g., as they are swimming from sea caves; this issue is considered in the topic of human disturbance.

Problem Statement 1: The lack of information on penguin food requirements makes it difficult to assess how variations in specific fish stocks impact penguin populations. Better understanding of penguin food requirements will enable those departments responsible for fisheries management to develop models for sustainable fisheries that will meet both economic and ecological needs.

Goal 1: Determine the food and energetic requirements for penguins.
Objective 1: By 2022, determine the diet of Humboldt penguins in Chile and Perú.

Activity	Responsible	Target Date
Compile a literature review on Humboldt penguin diet.	G. Luna, A. Simeone, IMARPE, ACOREMA	December, 2021
Analyze the stomach contents of dead penguins.	G. Luna. A. Simeone, ACOREMA	June, 2022
Conduct stable isotope analysis.	G. Luna, A. Simeone	June, 2022
Deploy cameras on penguins.	G. Luna, A. Simeone	June, 2022

Objective 2: By 2022, develop an energetic model for the Humboldt penguin

Activity	Responsible	Target Date
Build a bioenergetic model using available information.	G. Luna	December, 2022
Publish a paper with the model outputs.	G. Luna	December, 2022

Objective 3: By 2023, convene all relevant stakeholders to communicate the results.

Activity	Responsible	Target Date
Identify the relevant stakeholders.	G. Luna, A. Simeone, IMARPE	January 2023
Present the results to relevant stakeholders (fisheries, guano harvesters, government agencies), considering different scenarios.	G. Luna, A. Simeone, IMARPE	June, 2023

Problem Statement 2: Gill nets are a cause of high penguin mortality. Penguin distribution and foraging areas overlap with fishing areas; penguins are unable to detect gill nets used by artisanal fisheries and are caught in them. There are no regulations governing the use of gill nets.

Goal 2: Improve the design of the gill nets to reduce penguin mortality while at the same time maintaining fishing efficiency.

Objective: Within the next eighteen months initiate a collaboration with relevant stakeholders to improve the design of gill nets.

Activity	Responsible	Target Date
Identify relevant stakeholders	G. Luna, IMARPE	September 2022
Compile a literature review on gill net designs.	L. Waller, A. Simeone, IMARPE	September 2022
Generate a technical document on ideal net design, including e.g., lights, pingers, silhouette.	A. Simeone, IMARPE	December 2022
Present a proposal to fisheries authorities.	A. Simeone, M.A. Meza	March 2023

Goal 3: Develop and promote the use of best practice guidelines for the gill net fishery.

Objective: Within the next 12 months initiate the development of a best practice protocol for the gill net fishery.

Activity	Responsible	Target Date
Compile a literature review on best practice information available on the gill net fishery	L. Waller, A. Simeone, IMARPE	January 2022
Generate a technical document on best practice for the gill net fishery.	M. Portflitt, C. Anguita, IMARPE	September 2022
Present a proposal to fisheries authorities.	A. Simeone, G. Luna, IMARPE	January 2023

Goal 4: Promote the spatial and temporal regulation of the gill net fishery to minimize overlap with peak penguin foraging periods.

Objective. Within the next 12 months generate a proposal that recommends measures for the spatial and temporal regulation of the gill net fishery.

Activity	Responsible	Target Date
Include the spatial and temporal management of the gill net fishery as an agenda item within appropriate agencies in Chile and Peru, for example the GT-AM Subpesca-Chile.	G. Luna, A. Simeone, Peruvian agency/partner[1]	Ongoing
Generate a technical document, with particular relevance for areas where bycatch is documented and significant, and also that provides recommendations for spatial and temporal management of gill net fisheries.	G. Luna, A. Simeone, PRODUCE[2]	December, 2022
Present a proposal to fisheries authorities.	G. Luna, A. Simeone, PRODUCE[2]	June, 2022

[1] The working group identified the need for an appropriate Peruvian partner, which still needs to be identified. Prodelphinus (NGO) works on gillnet issues; PRODUCE would be an appropriate Peruvian agency.

[2] Subsequent to the workshop, IMARPE has identified PRODUCE as the most appropriate party to engage in these regulatory activities

Humboldt Penguin
Population and Habitat Viability Assessment Workshop
Final Report

Lima, Peru
October 17,18, 21-23
2019

Section 5
Working Group Report: Population Biology and Demography

Photo: Julio Reyes

Working Group Report: Population Biology and Demography

Group Members: Carlos Zavalaga (UCSUR), Patricia McGill (St Louis Zoo), Roberta Wallace, Robert Lacy (Species Conservation Toolkit Initiative; CPSG), Caroline Cappello (University of Washington), Lizett Bermudez (Huachipa Zoo), Franco Fernandez (MINAM), Rosana Paredes (Oregon State University), Eve Gonzales (AGRO RURAL), Jorge Rodriguez (CPSG Mesoamerica), Victor Vargas (SERFOR).

Introduction

The Population Biology and Demography Working Group focused on threats to the population of the Humboldt Penguin as well as challenges resulting from an incomplete understanding of population dynamics.

Several threats to the population of Humboldt penguins identified during the 1998 PHVA (Araya et al., 2000) persist in 2019. The main threats affect adult and juvenile survival (e.g., entanglement in gill nets, illegal capture for food or pets (less impact than 1998), prey competition with fisheries, predators, and diseases). Anthropogenic factors affecting penguin reproductive rates include guano harvesting, weather, introduced predators e.g., rats. Climate change may affect any age group through impact on food availability. These specific risks were discussed in detail in other working groups. This Working Group focused on identifying data gaps in population numbers and demographic rates required to make predictions of Humboldt penguin population viability.

There is insufficient information on factors influencing Humboldt penguin population dynamics. Data have been collected in a few different places at different times using different methodologies. Given the high variability of the Humboldt (Peru) Current ecosystem, it may be likely that this species experiences real and substantial fluctuations in population size. Current information suggests that the penguin population is in serious decline (see Figure 2.1 and Appendix IV); however, the lack of precise and consistent census data in Peru and Chile makes it difficult to make accurate population projections (see PVA Section 8). Moreover, there is insufficient information on population parameters including reproductive success, adult and juvenile mortality, adult and juvenile dispersal, and unknown sex ratios across the Humboldt penguin distribution range. Finally, existent data sets are site-biased because they represent a single colony in Peru and few in Chile.

In summary, the Population Biology and Demography working group identified 3 main issues: 1) Lack of standardized data of the total population size; 2) Lack of representative data on breeding/demographic parameters; and 3) Lack of information about penguin movements (dispersal).

Data Needs	Why there are no data	Goal and objectives
Obtain standardized concurrent population counts in Chile and Peru (molting and breeding).	Lack of money, personnel, training, standardized methods. Lack of coordination among institutions of Peru & Chile.	Goal: Perform complete census every X years (coordinate) across range. Counting both breeding and molting. Obj: Determine interval for census based on past data and across years (climate change, El Niño).

Increase representation in long-term monitoring of colonies in addition to Punta San Juan, Peru, regarding reproductive success and other key demographic parameters in Chile and Peru.	Peru and Chile: Few seabird ecologists and specialists. Restricted funding, personnel, access to sites. Lack of standardized protocols, materials, training and relationships with governments.	Goal in Peru & Chile: To develop long-term research monitoring methods on 3-4 sites to obtain specific data from major breeding colonies of penguins. Objectives: How many and which sites? What is 'long-term,' i.e., how many years? Objective in Peru: identify sites where guards can be trained in a few techniques and data methods.
Unknown juvenile and adult dispersal	Peru: Funding. Lack of specialized researchers for data analyses. Colony access (for long-term studies by trained personnel).	Goal: Define where penguins are going during life-cycle stages and different times of the year. Objective: develop methods on questions to be answered.

Issue 1. Lack of standardized data on the total population of Humboldt penguins

Background

During the 1998 PHVA a consistent method (count molting rather than breeding birds, twice during each molt season) was proposed for both Chile and Peru, but it was not possible to maintain that methodology long term in both countries. Prior to 1999, a complete census along the entire distribution of Humboldt penguins had never been conducted; during the past 20+ years, much has been learned about the time, logistics and funding needed for such an endeavor. Whereas a complete count of molting penguins, based on the assumption that ALL penguins must molt annually but not all necessarily breed, would give a good count of total numbers, it is presently impossible to use the many years of census to obtain such a total population estimate. The key challenges have been both the expense and the time it takes to conduct the census at all sites once (and ideally, per the 1998 guidelines, count each site twice 3 weeks apart). However, further assessment of the existing molt census data may allow use of these data as an index of the population, even if not a total population count.

The molt counts of the Humboldt penguin population in Chile between 2000 and 2008, and in Peru between 2009 and 2019 were used in the PVA population analysis (Section 8); this showed that the mean population decline is 7% and could be as much as 10% per year in recent years. The high level of ecosystem variability in the range of Humboldt penguins is an additional confounding factor and may indicate that very long-term consistent censuses are needed to truly understand patterns of population variability. Thus, the 20-year database is not yet sufficient to provide either a definitive estimate of the population changes or the causes of any such trends. Therefore, there is a critical need for consistent molt censuses with well-articulated methods and explicit assumptions, across the entire range of the species long-term to monitor overall trends.

In addition, no correlation between molting numbers and breeding numbers has been determined; although it seems that many penguins molt at their breeding colonies, the many years of molt counts have definitely shown that molting penguins are also found in sites unsuitable for breeding (McGill et al. unpubl. observations; see also Appendix IV). Counting breeding penguins or active nest sites misses birds that do not breed in any given year. At lower latitudes where there are two peaks of breeding numbers per year, the portion of breeders which have two breeding attempts in a year is also not known. Through more intensive monitoring of population sizes throughout the year these uncertainties could potentially be resolved. For example, on a few guano islands in Peru, monthly counts of penguins could be made by trained guards that already monitor the guano bird populations. These data would allow calculation of the ratio of molt census numbers to peak population sizes and breeding populations, and thereby provide a means to estimate the total number of Humboldt penguins in Peru and in Chile each year. However, specific logistical challenges would need to be resolved such as regular access, by boat or land, to areas where the penguins breed and/or molt; currently most of the guano guards do not have such access. At the same time, there is no guano reserve system in Chile thus other parks or reserves where personnel could access the penguin areas regularly need to be identified.

It has been suggested that perhaps a few key sites could be monitored and counted annually. One of the true challenges of a total count versus a partial count for purposes of monitoring trends is that there is high variability in numbers of penguins using smaller or unprotected sites. While it would be logical to monitor the larger more significant sites, if smaller sites are not also monitored or counted, it is possible that these large changes in local numbers could go undetected and local threats could likewise be undetected. In order to find the best census method, it is important to articulate the uses for the data and therefore the intensity and precision needed.

Problem Statement: During the 1998 PHVA a consistent method was proposed for both Chile & Peru, but it was not possible to maintain that methodology long term in both countries; additionally, the census counted only molting penguins and a correlation between molting numbers and neither breeding numbers nor total numbers has not been established. Census methodology needs to be reviewed and revised to accomplish specific and explicit goals so that the variation can be better understood as real variation in penguin numbers or differences in methods and timing. Challenges in achieving this include availability of trained personnel, sufficient time, regular funding, and storage/management of a long-term database.

Goal 5: Consistent census across range.

Objective: Census methodology developed and coordinated for breeding and molting birds.

Activity	**Responsible**	**Target Date**
Update and refine methodology (calibrating one vs two counts) and protocols for counts; articulate specific goals (e.g., total count vs count of breeding population vs population index or trends); establish sites for consistent monitoring	P. McGill (molt) A. Simeone (breeding) C. Zavalaga, M. Cardeña, Franco Sandoval & others for advice re drones	September 2022
Create technical document on best practices for censusing Humboldt penguins; compare methods with those used for other *Spheniscus* species	P. McGill, A. Simeone	September 2022
Write proposal for funding	P. McGill, A. Tieber for Peru; A. Simeone, G. Luna, T. Mattern for Chile[1]	June 2022
Coordinate with partners along the coast.	P. McGill, Julio Reyes, L. Amaro A. Simeone	September 2022
Secure Permits	P. McGill, J. Reyes	Annual

	A. Simeone	
Acquire equipment	P. McGill A. Simeone	Ongoing
Train personnel	P. McGill, J Reyes, A. Tieber A. Simeone	January 2023 (Peru) February 2023 (Chile)
Surveys, data collection	P. McGill and others A. Simeone and others[1]	2021-2022 then ongoing
Establish data repository	P. McGill A. Simeone	December 2022

[1] Counts at 8 key sites in Chile (Cachagua, Pan de Azucar, and other sites in N. Central Chile (mostly Zone 2) are planned in 2021, 2023, and 2025.

Issue 2. Lack of representative data on breeding and demographic parameters

Background

The breeding season of Humboldt penguins varies across their latitudinal range; it occurs consistently between April and December in Peru and northern Chile but has a strong seasonality in central/southern Chile. Penguin productivity, survival and ultimately population numbers are closely linked to the oceanographic conditions (i.e., prey availability), weather, and threats associated with colony location and time of reproduction.

Population viability analyses were conducted during the PVA workshop and subsequently discussed and refined at the PHVA workshop. The analyses showed that nesting rates, fledging rates, post-fledging survival of juveniles, and adult survival might all be too low to allow for consistent population growth. The PVA model (see Section 8) points in particular to fledging rate (best estimate 0.5/nest), juvenile survival (best estimate 33%), and adult mortality (estimated at 5%) as contributors to population decline. However, these demographic rates are also all very uncertain because they have been estimated from only a few sites (Peru: Punta San Juan; Chile: Algarrobo), over few years (Chile), and with different methodologies. Therefore, it is difficult to know whether the high variability of parameter estimates found among sites is the result of above caveats or truly represent differences among sites.

Increasing the number of sites for monitoring key parameters across penguin range would help to reduce uncertainties, to obtain more accurate predictions, and to prioritize conservation actions. Likewise, standardizing methods among sites will also reduce variability and uncertainty in the data.

Problem Statement: There are not good estimates of factors determining reproductive success including nest occupation rate, the percent of females breeding, hatching success, and fledging success; data that were collected regarding breeding parameters were collected at one colony, PSJ, in south central Peru and at one colony, Algarrobo, in south central Chile. Therefore, there is high variability among estimates of these parameters, and it is not known with confidence whether this variability reflects differences among sites, differences due to oceanographic variability or other factors. It is particularly important to improve estimates of fledging rate, juvenile survival and adult mortality, if possible, to improve population projections as well as population success. Adult mortality is particularly difficult to assess in long-lived marine birds, such as Humboldt penguins.

Both in Peru and in Chile, there are few seabird specialists and study sites in situ for long-term data collection of breeding biology. Funding is unstable across years. Also, trained personnel are lacking, and sites are logistically difficult to access and therefore expensive to carry on studies. Humboldt penguins are notably disturbed by human activity and are best studied where nest sites are secure, and observers do not risk alarming the birds and affecting results. There is a lack of standardized protocols, materials, and training within and between countries. Finally, there is a lack of collaboration with government agencies.

Goal 6: Increase representation of other colonies, in addition to Punta San Juan (Peru) and Algarrobo (Chile), in long-term monitoring of reproductive success and other demographic parameters in Chile and Peru.

Objective 1: To develop a program to work in collaboration with scientists, universities, and/or professionals from government agencies to collect specific long-term data regarding breeding success in other sites in Peru (3-4) and Chile (2 or more).

Peru: Develop a program to work with guards from AGRO RURAL to collect specific data on breeding biology and numbers by 2022.

Chile: Develop a program to work in collaboration with universities to collect specific data regarding breeding success at selected sites.

Activity	Responsible	Target Date
Develop a general protocol for data to be collected in both Chile and Peru; confer with scientists collecting long-term data on other *Spheniscus* species (e.g., Lauren Waller re African penguins; Caroline Cappello re Galapagos or Magellanic penguins)	C. Zavalaga, Universidad Científica del Sur (UCS) A. Simeone, Universidad Andrés Bello G. Luna, Universidad Católica del Norte	August 2022
Develop specific protocols for data collection[1]	C. Zavalaga A. Simeone G. Luna PSJ	August 2022
Develop standardized database for both countries	C. Zavalaga PSJ A. Simeone G. Luna	December 2022
Cultivate shared goals and standards for data collection and use; formal signed agreements with government agencies (Peru)	C. Zavalaga AGRO RURAL SERNANP	December 2022
Write proposals for funding	C. Zavalaga A. Simeone G. Luna PSJ	October 2022
Equipment acquisition as needed	C. Zavalaga A. Simeone, G. Luna	March 2023
Train personnel	C. Zavalaga A. Simeone	March 2023
Data retrieval and analysis	C. Zavalaga PSJ	October 2023
Periodic review at 12-month intervals; reports.	C. Zavalaga PSJ	Every 12 months

[1] Milagros Ormeño and Franco Sandoval: plans developing for Islas Ballestas Centro; Fernando Nishio for Punta San Juan, Peru. Alejandro Simeone and Guillermo Luna: plans developing for Islas Chañaral and Chorros, Chile.

Issue 3. Lack of information about penguin movements (dispersal)

Background

Methods to track individual birds with new technologies such as RFID microchips/transponders or satellite tags are being used to study *Spheniscus* species and should be further explored for Humboldt penguins (Ludynia *et al*. 2019, Quispe *et al*. 2020). Studies of juvenile and adult dispersal are important for revealing where penguins go during different life stages, at different times of the year, and across years such as during El Niño events. Together, such data will provide critical information about the causes of population fluctuations and the threats that the species faces.

There are very few studies of at-sea movements of adults and none of juveniles. Data of foraging ranges and diving behavior of breeding adults originates from a single site in Peru (Punta San Juan). The few data that exist on adult penguin movements during the non-breeding season were collected using a variety of methods, in very few sites (1 in Peru and 2 in Chile) along the distribution of over 4000 km kilometers (5º12' to 42º11' S) and with minimal ability to detect movement between Peru and Chile.

Problem Statement: There are very few data about juvenile dispersal, adult long-distance nor foraging movements; the few data that exist were collected using a variety of methods, in very few sites (1 in Peru and 2 in Chile) over the distribution of 4,700 kilometers and without the ability to detect movement between Peru and Chile. Failure to understand movement patterns impairs the ability to understand whether movement or mortality causes local fluctuations in penguin numbers; whether movements at sea are associated with mortality patterns is also unknown and therefore impairs our ability to understand all threats..

There are several challenges in studying penguin movements. Bio logging can be very expensive depending on the type of data being collected therefore funding is a big limitation. The least expensive tags are those that require retrieval after deployment to obtain the data, so birds need to get captured twice. At many colonies there is low availability of covered, protected nest sites where trained personnel can access penguins without excess disturbance for long-term studies. There is also lack of specialized researchers for analysis of spatial data. Finally, accurately assessing movement among colonies and dispersal, e.g., from natal colonies, would require a significant tagging, identification and data-recording effort.

Goal 7: Increase knowledge of individual dispersal during the breeding season, non-breeding season, dispersal of juveniles (birds in juvenile plumage), and across years (e.g., El Nino/ENSO cycles).

Objective: Determine dispersion rates at different stages of the penguin's life cycle (reproductive period, non-reproductive period, juveniles) and across several years.

Actions:

What	**Who**	**Target date**
Identify breeding colonies where to work in Peru and Chile (besides Punta San Juan).	C. Zavalaga A. Simeone G. Luna	April 2022 (Peru)
Monitor potential study sites to select biologging studies	C. Zavalaga A. Simeone	December 2022 (Peru)
Develop protocols for each type of tags: GPS loggers, GLS, GPS-satellites	C. Zavalaga Rosana Paredes A. Simeone	July 2022

	G. Luna	
Submit proposals	C. Zavalaga PSJ Rosana Paredes A. Simeone	September 2022 (Peru)
Permit requests	C. Zavalaga	February 2023 (Peru)
Acquire equipment	C. Zavalaga Rosana Paredes A. Simeone	February 2023 (Peru)
Data collection	C. Zavalaga Rosana Paredes	July 2023 (Peru)
Data analysis	C. Zavalaga A. Simeone Rosana Paredes	June 2024 (Peru)
Project and Data Review	C. Zavalaga A. Simeone Rosana Paredes	Every 12 months


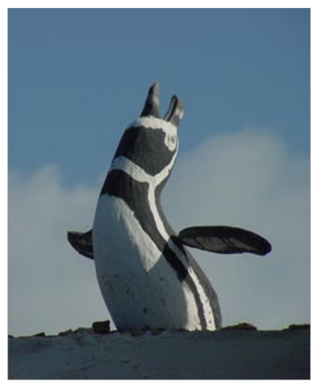
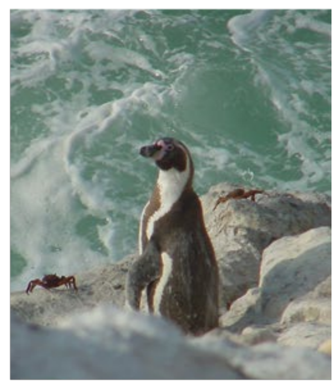
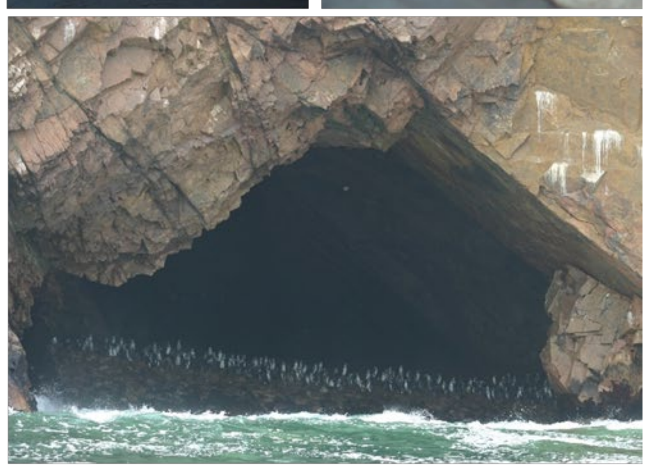

Photo: J. Reyes   2 Photos top right: R. Tardito   Photo: P. McGill

Humboldt Penguin
Population and Habitat Viability Assessment Workshop
Final Report

Lima, Peru
October 17,18, 21-23
2019

Section 6
Working Group Report: Communication and Education

Photos: ACOREMA

Working Group Report: Communication and Education

Working group participants: Alex Waier (Milwaukee County Zoo); Frida Rodriguez (MINAM), Edward Gutiérrez, Helbert Anchante (SERFOR), Vicky Segura (Dirección Medio Ambiente-PNP), Marco Cardeña, Carlitos Sánchez, Lyanne Ampuero (Programa Punta San Juan-CSA-UPCH), Milagros Ormeño, Julio Reyes (ACOREMA).

Introduction

Ensuring a future for Humboldt penguins will require collaboration and cooperation among government departments, scientists, conservation biologists, and non-governmental organizations. Collaboration and cooperation are possible only when there is good communication among all parties about the current state of knowledge, current government policies that impact the penguins, and engagement of those directly connected to penguin conservation. Concern about the conservation status of Humboldt penguin dates back to the 1980s; the censuses for those times revealed the dramatic decline in penguin numbers and the several threats responsible for this situation. In the ensuing years, scattered efforts were made to reach the different actors/stakeholders (fishermen, guano harvesters, authorities, general public) involved in both the generation and mitigation of the threats. During the 1998 Humboldt penguin PHVA in Chile the need to develop strategies to reach the several publics involved was discussed, and recommendations were proposed. While there was some increased effort to create more of a comprehensive conservation agenda for Humboldt penguins, the level of achievement in raising awareness for Humboldt penguins is still low. The need for focusing on an educational/informative approach parallel to the gathering of scientific information is important to address.

The Communication and Education Group focused on the mechanisms through which information about Humboldt penguin is: 1) available to and shared among stakeholders involved in identifying and ameliorating the main threats to this species, and 2) communicated by researchers with each other and to managers and decision makers. Group members also discussed the level of public knowledge about the current situation of Humboldt penguin, the causes of decline, work done to the present, and the involvement of official entities and the civil society. There was a rapid review of sample educational materials produced and currently available and a review of institutions, individuals, with past and current initiatives intended to raise awareness about Humboldt penguin. Also, regarding Humboldt penguin researchers, the Group attempted to identify people in both Peru and Chile conducting research on the species, how these investigators interact, what opportunities exist to meet and share information from their studies, agree on standardized methods for data collection, or discuss research approaches. The Group explored and discussed the needs and the possible funding sources to accomplish the goals identified.

Issue 1. Limited information for the general public regarding the threats facing Humboldt penguins

Background

Those organizations or individuals capable of addressing this problem lack a specialized platform or database to review what has been done in terms of educational/informative materials or communication strategies applicable at the local, regional or national level. The lack of economic resources further constrains public education efforts. The educational policies managed by the government pay little attention to such awareness efforts, lack skilled education personnel, and show little interest in collaboration with organizations outside of the government. Enhancing public knowledge and engagement can be addressed through strategies directed to children and youngsters at schools (and through them to their parents) as well as to adult audiences.

Problem statement:

The general public receives little information on the current conservation status and threats facing Humboldt penguins.

Goal 8: Educate and engage the public about the threats to Humboldt penguins and how individuals can help conserve them.

Objective 1: Prepare a proposal with themes/contents about Humboldt penguin to be inserted in the school curriculum.

Action	Responsible	Target date
Identify members of the National School Curriculum Review Committee	E. Gutiérrez (SERFOR), MINAM representative	June 2022
Review the National School Curriculum.	M. Ormeño, J. Reyes, M. Cardeña (Peru)	August 2022
Prepare the proposal of themes/contents to be inserted in the National School Curriculum.	ACOREMA, SERNANP and Planeta Océano	December 2022
Submit the proposal to the proper division at the Peruvian Education Ministry (MINEDU).	ACOREMA, Programa Punta San Juan, SERFOR, SERNANP	January 2023

Objective 2: Produce educational materials and tools in support of programs on Humboldt penguin conservation directed to all publics.

Action	Responsible	Target date
Diagnosis and review of the available materials and tools used for conservation actions for Humboldt penguin.	M. Ormeño, J. Reyes, Programa Punta San Juan, Planeta Océano, Milwaukee County Zoo, SERNANP, SERFOR, Huachipa Zoo	June 2022
Workshop on strategies for Humboldt penguin awareness programs.	Programa Punta San Juan, ACOREMA, MINAM, SERFOR	September 2022

Issue 2. Limited exchange of scientific information and collaboration among researchers, managers and decision-makers.

Background

Through the years, studies on Humboldt penguin have been carried out by a small group of national researchers in both Peru and Chile. Funding for these studies is always limited and results from the efforts of individuals that search for and apply to financial sources; they must also organize and staff the fieldwork and reporting. In most cases, funding is restricted to a period of one or two years, after which a researcher needs to start all over again to search for funding. This results in short-term projects, separated by long periods during which many researchers switch to other studies where resources are available. Opportunities for researchers to meet are also limited, as they work in remote areas in each country. Scientific fora are separated in time and space and thus, unless a forum is near a researcher's location and known well in advance, few researchers from Chile and Peru will have the chance to attend, meet their peers, and be able to discuss their experiences in the wide array of approaches, methods, results, etc. On the other side, little exchange of information exists between researchers and personnel from official management agencies such as fisheries, guano management, tourism, endangered species, etc. Because there is little interaction between managers, agencies and researchers, there is also little opportunity for researchers to hear what data the managers would like to have in order to make informed decisions.

Problem statement
There is limited interchange of information and scientific collaboration because Humboldt penguin specialists are not known to each other, there are no opportunities and places to meet together; also, there are limited funds for research and attendance at scientific meetings. Examples from the marine mammal scientific community may be useful to consider; over many years, the international collaboration and communication has proved very useful. In addition, there is a separation between the work of researchers and managers from public entities; therefore, in many cases, decisions about management are not based on solid, verifiable scientific data.

Goal 9: Increase the level of collaboration among Humboldt penguin researchers.

Objective 1: Compile a directory of researchers by January 2022

Action	Responsible	Target date
Identify key persons working on the species.	A. Waier, C. Zavalaga, M. Cardeña, Programa Punta San Juan, A. Simeone, CONAF, Subsecretaría de Pesca (Chile) SERNANP, SERFOR, MINAM, IMARPE (Peru)	November 2021
Identify governmental agencies relevant to research and conservation of Humboldt penguin and the person in charge to be included in the directory.	SERFOR (Dirección de Estudios e Investigación), J. Reyes (Peru), A. Simeone (Chile)	November 2021
Develop a researcher and manager registration form, validate the format, distribute the form, consolidate the information, elaborate and distribute the directory.	SERFOR (Dirección de Estudios e Investigación), J. Reyes, M. Cardeña, SERFOR	September 2021

Objective 2: Identify opportunities for collaboration and discussion between researchers and managers/agencies.

Action	Responsible	Timeline
Screen and follow up all events related to marine birds.	A. Waier, L. Ampuero	November 2021 (updated every 2 months)
Disseminate the information to the researchers in the directory.	L. Ampuero, SERFOR	February 2022 (updated every 2 months)

Objective 3: Identify potential financial sources

Action	Responsible	Timeline
Screen institutions (private, charities, governmental) financing research and conservation projects.	L. Ampuero, A. Waier, A. Simeone	December 2021
Develop a list of entities, organizations, etc. already financing research and conservation projects relevant to Humboldt penguin[1].	L. Ampuero, A. Waier, A. Simeone, SERNANP, SERFOR, CONAF	December 2021
Disseminate the information about potential financial sources throughout the members in the directory.	J. Reyes	February 2022

[1]The Global Penguin Society, Penguin Specialist Group, and International Penguin Conference have together recently established a small fund to support attendees, primarily students, attending the International Penguin Conference (IPC). The next IPC (IPC XI) will be held in Chile in 2022.

Photos: J. Reyes

Humboldt Penguin
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Section 7
Working Group Report: Human Disturbance

Photos: R. Tardito

Photo: R. Tardito

Photo: P. McGill

Working Group Report: Human Disturbance

Working group participants: Mike Adkesson (Chicago Zoological Society), Patricia Saravia (Paracas National Reserve), Enzo Pino (AGRO RURAL), Roberto Paredes (AGRO RURAL), Manuel Sovero (AGRO RURAL), Nelida Torres (SERNANP), Ali Altamirano (ACOREMA), Anne Tieber (Saint Louis Zoo), Fernando Nishio (Programa Punta San Juan)

Humboldt penguins face diverse threats, many of which are human-driven issues. From the earliest native people or explorers who hunted penguins for their meat and eggs to today's ecotourism operators, fishermen and local communities, the birds experience the pressure of human encroachment into their areas.

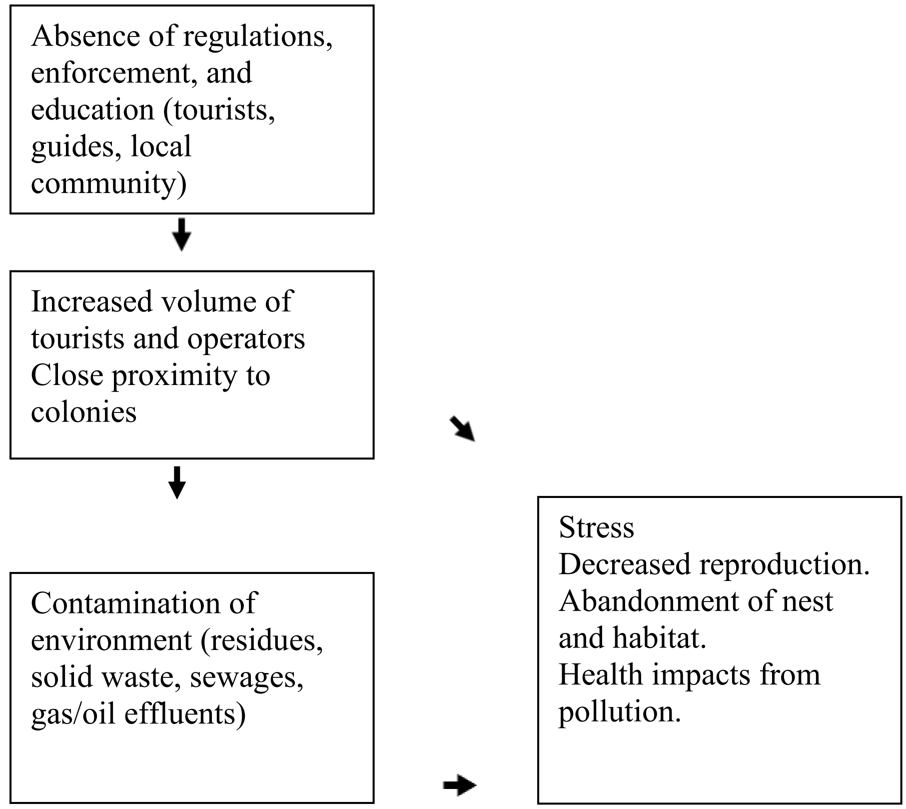
Penguins are iconic species and draw people from around the world to see them in their natural habitat. Now more than ever tourism to these "wild places" is common. This can have negative impacts on seabird colonies and the penguins themselves. The presence of people in their areas can lead to collapsed nests (Simeone and Bernal 2000), abandonment of nest sites due to regular disturbance, introduction of pest species such as cats, rats and goats (Simeone & Schlatter 1998) and the potential for environmental contamination and infectious disease introduction. A full list of current threats can be found in Appendix VI (De la Puente et al. 2011).

The Human Disturbance working group focused on human-derived threats to the Humboldt penguin population in the following categories:

1. Tourism,
2. Predation and human disturbance,
3. Penguin health (environmental contamination and infectious disease), and
4. Guano harvesting activities.

Issue: Tourism

One of the largest threats to the birds is unregulated tourism at colony sites. Tourism appears to be increasing at many sites in Peru and Chile; the absence of regulatory enforcement for tourist operators and their activities can have negative impacts for the birds. The close proximity of tourist boats to penguin colonies and some boats allowing tourists to disembark, and even swim, at some sites (Tieber and McGill, personal observation) may disrupt breeding, and eventually drive to site abandonment. (Unlike some penguin species that appear in photos and movies and appear to tolerate human proximity well, Humboldt penguins are typically quite nervous in the presence of humans.) Some penguin sites in Peru, such as Islas Ballestas in the Reserva Nacional Sistema de Islas, Islotes y Puntas Guaneras (RNSIIPG) and Punta San Juan (PSJ) in Marcona, have longer histories with tourist operations and have developed guidelines, whereas other sites have not. For example, the RNSIIPG Site Plan for the Islas Ballestas (SERNANP 2012) provides a thorough and thoughtful assessment of the area along with benefits and challenges of tourism, provides micro-zoning of the area for different types of tour activities, and lays out a management action plan designed to protect biodiversity, manage touristic activities, provide quality experience and education for tourists, and implement training for guides and operators. Also in Peru, SERNANP is considering increased tourism activity for other sites within the RNSIIPG, but guidelines to minimize negative human impacts are not yet complete.



Problem statement
The absence of regulation, enforcement, and education (for tourists, guides, and local community) results in a high volume of tourists and boats operating with a lack of respect for and/or proximity to the penguins. This causes environmental contamination (sound, solid waste, petroleum effluents) that results in higher stress on penguin populations and subsequently lower reproductive rates and abandonment of nests and colony.

Goal 10: Decrease tourism impacts on Humboldt penguins

Objective 1:
Improve regulation and enforcement of tourism activities that exist for tourist sites to control number of boats and distance from colonies.

Activity	Responsible	Target Date
Develop a list of current and proposed sites with tourism activities	SERNANP	December 2022
Provide at least one enforcement official at each tourism site (at least during peak tourist season) to improve regulation	SERNANP	December 2025

Establish regulations and a mechanism to fine tourism operators that violate boundaries and licensing.	SERNANP	December 2025
Establish research program to provide data on influence of tourism to evaluate safe distances	SERFOR (Dirección de Estudios e Investigación) SERNANP ACOREMA (J. Reyes)	December 2024
Educate tourism operators on issues related to penguin conservation	SERFOR (H. Anchante) ACOREMA (J. Reyes) PSJ staff	December 2024

Objective 2:
Provide protocols and educational materials related to penguin and ocean conservation for tourism operators, tourists, and local communities to improve their understanding of the importance of regulations and to improve the educational experience they provide to visitors.

Activity	Responsible	Target Date
Provide a training campaign for the tourism guides	SERFOR (H. Anchante) ACOREMA (J. Reyes) PSJ staff	December 2023
Review existing education materials. Decide if information needs further developing and then distribute material for the local communities, focusing on restaurants and tourism operators/agencies.	SERFOR (H. Anchante) ACOREMA (J. Reyes)	December 2023
Develop video/educational materials that the tourists would view before getting on the tourist boats before each trip.	SERFOR (H. Anchante) ACOREMA (J. Reyes) PSJ staff	December 2024

Objective 3:
Work with tourism operators to develop mitigation plans to reduce the amount of contaminants (oil, gas, trash) that are discharged into the ocean around tourist sites.

Activity	Responsible	Target Date
Improve regulatory enforcement of tourist watercraft to reduce amounts of contaminants released into the water	SERNANP SERFOR	December 2024

Issue: Predation and human disturbance.

The group considered there were two types of predation occurring to penguin adults, chicks and eggs.

1) Invasive species (rats, dogs, cats)
2) Native predators (fox, falcons, gulls, otters, sea lions).

It was also felt that humans play an indirect role in the predation of the penguins at colony sites, by inadvertently (rats) or intentionally (dogs, cats) bringing animals onto the islands and by generating garbage that attracts pest species. In addition, human activity and disturbance can frighten adults from their nests, allowing predators to take eggs or chicks; this is especially important where penguins nest in surface sites due to insufficient burrows.

While many of the important breeding sites for penguins are islands, where terrestrial native predators are uncommon, there are a few key breeding sites that are on mainland points and peninsulas. In these sites, native terrestrial predators may disrupt or prey upon penguins, eggs and chicks. In the past, when penguin populations were very large and thriving, a modest level of predation by native predators may have been sustainable. However, with current low and declining populations, the impact of any predation must be minimized.

Punta San Juan (Marcona, Peru) has a program for rat mitigation, but it is not fully known whether other sites have implemented programs for monitoring and controlling rats and other introduced predators.

Problem statement
The absence of long-term mitigation programs for predator removal and lack of effective barriers to prevent introduction (e.g., walls for mainland sites, or exclusion devices to prevent rats from accessing boats and island sites) allows the introduction and maintenance of native and introduced predator species, as well as humans, that results in penguin mortality and decreased reproductive success. By utilizing exclusion techniques or barriers, this would help keep predators out and minimize any changes to the composition and richness in the environment near the penguin colonies.

Rats have a relationship with food and available resources. They arrive onto the islands with boats—either of fishermen, guano extractors, or tourists. This, along with lack of garbage removal service from the points and islands, leads to accumulation of trash that attracts rats and predators. Once established, rat populations are extremely difficult to eliminate.

Goal 11: Reduce predation impacts and human disturbance on Humboldt penguin colonies

Objective 1:
Exclude feral animals, predators and disruptive human activities from penguin colonies; in Peru, improve wall maintenance and restoration; in Chile, evaluate use of fences and other methods to protect penguin colonies.

Activity	Responsible	Target Date
Evaluate the condition of existing walls and needs for restoration in Peru. Prepare report.	AGRO RURAL (E. Gonzalez), SERNANP, E. Rivera, PSJ, Mining companies	December2023
Evaluate the impact of shell fishermen on breeding islands and peninsula beaches.	AGRO RURAL (E. Gonzalez), SERNANP, E. Rivera, PSJ, Mining companies	December 2024
Identify and prioritize top sites that need additional protection in Peru. Prepare report.	AGRO RURAL (E. Gonzalez), SERNANP, E. Rivera, PSJ, Mining companies	December 2023
Identify organization in Chile to help with assessment of Chilean sites that need additional protection.	Chilean partner [1]	December 2023 for contact
Develop cost estimates and a proposed schedule for repairs and installation	AGRO RURAL, SERNANP, Chilean partner [1]	May 2024
Secure funding and implement plans	AGRO RURAL, SERNANP, Chilean funding source? [1]	May 2025

[1] There was not a Chilean representative in this group at the workshop but would be valuable to identify one

Objective 2:
Develop rat-mitigation programs for sites; share with tour operators, guano companies and researchers and ensure maintenance of those programs.

Activity	Responsible	Target Date
Evaluate locations with rat problems in Peru	AGRO RURAL (M. Sovero), SERNANP	December 2023
Use published information on rats and penguins in Chile (Simeone and Luna-Jorquera 2012) and other reports to prioritize rat control in Chile.	A. Simeone, Chilean partner[1]	December 2023
Host a workshop and meeting to create an integrated program to address rat mitigation and prevention (methods to be applied)	AGRO RURAL (M. Sovero), SERNANP (P. Saravia), Chilean partner[1] , DIGESA, CPSG to facilitate meeting	June 2024
Create a capacity-building program for AGRO RURAL staff/guards on how to prevent/mitigate rats	DIGESA, SERNANP (P. Saravia)	June 2024
Evaluate options for removal of rats from locations with problems (ensure methods do not adversely impact wildlife.)	M. Cardeña, M. Sovero, SERNANP, DIGESA, Chilean partner [1]	June 2024
Secure funding and implement programs (AGRO RURAL will supply equipment; SERNANP and AGRO RURAL implement together)	AGRO RURAL, SERNANP	December 2025

[1] **There was not a Chilean representative in this group at the workshop but would be valuable to identify one**

Issue: Penguin health - marine environmental contamination and infectious disease
The Group performed a review of the factors that may have an impact on the health status of the Humboldt penguin population. After a recent outbreak of Avian Influenza reduced key populations of the already declining and endangered African penguin, the working group agreed that introduced pathogens and infectious disease sources is a heavy concern for Humboldt penguins. Ongoing health population assessments have been underway at Punta San Juan (south central Peru) since 2007 and some historical information is also available for Algarrobo (Chile). The experience in these two sites could be used as platform to launch similar studies along the main sites in both Chile and Peru for better understanding of disease and its impacts. The reproductive success of penguins could be improved from such programs.

Another issue of concern is the impact of environmental contaminants on population health. Industrial development and mining operations in coastal regions raise concern about toxicant exposure and its impacts on health and breeding. Agricultural runoff and direct discharge of sewage into the ocean are additional routes of potential toxicant and infectious disease exposure. Research to date at Punta San Juan has found little impact from environmental toxicants despite the close proximity to large-scale mining operations. However, toxicant exposure and contamination are highly site specific and additional monitoring is needed throughout the Humboldt penguin's range.

The potential for oil and other chemical spills has not been identified as a high risk. However, with increased coastal development and larger ports, the absence of local and regional response plans and rescue centers for recovery of penguins is a concern. In contrast, for African penguins an international network centered in South Africa has been developed and is being strengthened to be prepared for and able to respond quickly and efficiently to any disaster; a similar action plan to be prepared for any type of urgent response is recently launched for Namibia (J. Phillips, Maryland Zoo; SANCCOB South Africa unpubl. report). While the specifics of these various disasters may vary widely, the approaches to planning, preparedness and rescuing penguins may be quite similar among types of disasters.

A wide array of environmental contaminants may present challenges to Humboldt penguin populations. The main sources identified during discussions are listed below; these threats are very similar to those identified for seabirds globally (Grémillet et al. 2018). Although all of the issues listed pose threats to Humboldt penguins, the group felt that the three (3) top priority issues were Mining effluents, Plastics and marine debris and Infectious disease sources.

- i. Mining effluents
  - a. It is unclear if mining waste is a large-scale problem
  - b. Uncertainty over what is being released due to lack of transparency, monitoring, and enforcement
  - c. In Chile, not much coastal mining (but further inland close to Andes); however, thermoelectric plants are built along the coast, increasing commercial traffic which can impact penguin populations by warming nearby waters
- ii. Plastics and marine debris.
- iii. Infectious disease sources
  - a. Major potential disease risks from coastal poultry farming.
  - b. Additional potential disease risks from co-mingling of penguins with feral animals, pets (pet penguins with pet chickens), and wildlife.
- iv. Dynamite fishing.
- v. Gas, oil, petroleum
  - a. Major sources spills, pipeline leaks
  - b. Lesser sources: boat discharges
- vi. Agricultural runoffs
  - a. Pesticide residues in agricultural runoff into river outlets
- vii. Chemical residues (organochlorines, flame retardants, etc. (e.g. CP, PCB, PBDE, PFOS))
  - a. Released into rivers that outlet to ocean, as well as direct ocean release, from human population center refuse, agriculture, and industrial sources.
  - b. These compounds can result in mortality or lead to decreased reproductive success
- viii. Solid waste.

Problem statement
There is an absence of data on Humboldt penguin health, disease, and exposure to environmental contaminants, except at Punta San Juan. This limits our understanding of the impacts of disease on penguin mortality and reproductive success. The lack of data is due to a lack of resources, infrastructure/technology, and researchers in range countries experienced in this type of wildlife research. Additionally, specific mitigation plans for disease outbreaks and/or large-scale pollution events (e.g., oil spills) are absent.

Goal 12: Decrease the impacts of environmental contamination and disease on Humboldt penguin populations

Objective 1:
Develop and implement research programs to collect data and biological samples (live and deceased penguins) from the primary breeding colonies (both Chile and Peru) on a rotating basis to evaluate exposure to contaminants and disease. Collaborate with existing teams and entities along the coast to

assemble risk information and data on colonies close to environmental hazards, such as near smelters or close to shipping terminals, etc.

Activity	Responsible	Target date
Establish methods for collecting data and samples coordinated with efforts to evaluate breeding success at major sites.	SERNANP, SERFOR, IMARPE, Universities, Chicago Zoological Society (M. Adkesson), Programa Punta San Juan, Cayetano Heredia University	July 2022
Secure research permits to collect samples from penguins at multiple sites in Peru and Chile	SERNANP, SERFOR, IMARPE, Universities (A. Simeone), Chicago Zoological Society (M. Adkesson), Programa Punta San Juan (F. Nishio), Cayetano Heredia University, CONAF (Chile), R. Wallace	December 2022
Secure funding for sample collection	Chicago Zoological Society, Saint Louis Zoo, Milwaukee County Zoo (Adkesson, Tieber, Waier)	June 2023
Discuss working plans to include collaboration for sample collection by Peruvian biologists and reserve guards	AGRO RURAL, SERNANP, Chicago Zoological Society (M. Adkesson), Programa Punta San Juan (F. Nishio) SERFOR	June 2023
Train personnel in sample collection methods	AGRO RURAL, SERNANP, CONAF, Programa Punta San Juan (F. Nishio), Chicago Zoological Society (M. Adkesson) A. Simeone, R. Wallace, SERFOR (Dirección de Estudios e Investigación)	November 2023
Start collection of samples in coordination with other research (census and breeding evaluation)	AGRO RURAL, SERFOR (Dirección de Estudios e Investigación) SERNANP, CONAF, Programa Punta San Juan (F. Nishio), Census teams (P. McGill and A. Tieber; A. Simeone and G. Luna-Jorquera) Chicago Zoological Society (M. Adkesson), R. Wallace	November 2023
Laboratory testing and analysis of data	SERNANP, Programa Punta San Juan, Chicago Zoological Society (M. Adkesson)	June 2024

Objective 2:
To improve data on mortality and disease, disseminate protocols for collection of data and post-mortem biological samples from penguins to all major breeding colonies.

Activity	Responsible	Target date
Coordinate with current PSJ and Chilean researchers (in their respective countries) to	Universities, Programa Punta San Juan (F. Nishio), Cayetano Heredia University	December 2022

facilitate diagnostic testing using consistent methodology	A. Simeone to help identify Chilean partners	
Elaborate, validate and disseminate protocols for data collection. Recruit guards, researchers, NGOs, students to procure samples and send for analysis per protocols; conduct training as needed.	Same as above, SERFOR (Dirección de Estudios e Investigación)	December 2022
Recruit pathologist/ pathology lab to analyze tissue samples.	Programa Punta San Juan, Chicago Zoological Society (M. Adkesson), University of Illinois Zoological Pathology Program, Saint Louis Zoo	December 2022
Secure necessary permits in coordination with Objective 1, step 2.	SERNANP, SERFOR, IMARPE, Universities, Chicago Zoological Society M. Adkesson), Programa Punta San Juan (F. Nishio), Cayetano Heredia University, CONAF (Chile) (A. Simeone, R. Wallace)	June 2022
Secure funding for sample collection	Chicago Zoological Society, Saint Louis Zoo, Milwaukee County Zoo (Adkesson, Tieber, Waier)	June 2022
Laboratory testing and analysis of data	SERNANP, Programa Punta San Juan, Chicago Zoological Society (M. Adkesson)	June 2024

Objective 3:
Develop penguin-specific preparedness and mitigation plans for the major breeding colonies that address potential oil spills or major contamination or disease outbreak events.

Activity	Responsible	Target date
Coordinate contingency plans for hazardous spill mitigation for Humboldt penguins in both Peru and Chile; reach out to the South African penguin group for their protocols. Identify funding to purchase equipment and conduct training as required by plan.	SERNANP, SERFOR (Dirección de Estudios e Investigación), PRODUCE, AGRO RURAL, Programa Punta San Juan (F. Nishio), M. Cardeña, Chilean partner [1]	December 2023
Identification of facilities with potential use as penguin rescue and rehabilitation sites	SERFOR, SERNANP, F. Nishio, M. Cardeña, SERFOR (Dirección de Estudios e Investigación), Chilean partner [1] CONAF	December 2023
Develop plans for response to a disease outbreak in a Humboldt penguin colony that allows for rapid sample collection (and funding) and export of samples for laboratory testing as indicated	SERNANP, SERFOR, Programa PSJ (F. Nishio), M. Adkesson, Chilean partner [1]	June 2023

[1] There was not a Chilean representative in this group at the workshop but would be valuable to identify one

Issue: Guano-harvesting activities

Photo: R. Tardito

The harvesting of guano for fertilizer has taken place for centuries in Peru and in the most recent century has been regulated and managed to maintain sustainable populations of guano birds (Peruvian boobies, pelicans and guanay cormorants). The legal harvesting within the reserve sites is managed by government agencies such as AGRO RURAL in Peru. In contrast, in Chile guano was never as abundant; in the north, there was a modest guano extraction industry. Currently, guano collecting in Chile is forbidden, with a few permits issued for small scale harvest issued by the Ministerio de Minas and supervised by the Servicio Agrario y Ganadero (SAG). However, in both countries, it is unclear how widespread the problem of non-regulated and illegal guano harvesting outside the protected reserves areas may be. Both legal and illegal guano harvesting can be disruptive to penguin nesting and limit reproduction. The stealthier illegal harvest may also be associated with illegal hunting of birds and eggs.

Problem statement:
Non-regulated and illegal guano harvesting in Peru and in Chile disrupts penguin nesting habitat and limits reproduction; similar to previous issues, the low level of illegal guano activity might not present a conservation problem to a thriving penguin population, but under the current circumstances of an unstable population of Humboldt penguins, this issue should also be considered. Additionally for existing legal guano operations, refinement of the guidelines may enhance sustainability for penguins while maintaining protection of guano birds and profitable guano operations. Some work on developing a Best Practices document for sustainable harvests has been drafted at Punta San Juan; biologists at Punta San Juan have collected data and worked with the guano entities (formerly PROABONOS and now AGRO RURAL) to develop sustainable strategies for guano harvests (Cárdenas-Alayza et al. 2019). Continued close collaboration between biologists/researchers and AGRO RURAL will produce the most successful guidelines.

Goal 13: Continue refinement of sustainable guano harvesting practices in Peru and Chile and research how granza might be utilized.

Objective:
Develop strategies for AGRO RURAL and SERNANP to continue implementing sustainable harvesting methods and plans at the guano reserves that consider mitigation distances, timing of harvests, and use of granza to encourage new nesting sites.

Activity	Responsible	Target Date
Strengthen enforcement of timelines for guano extraction (i.e., eliminate extensions of harvest durations)	AGRO RURAL, SERNANP	Continuous
Develop site plans according to SERNANP guidelines. Engage guano-harvest stakeholders in development of site plans.	AGRO RURAL, SERNANP	November 2024
Develop ongoing penguin conservation metrics and monitoring.	AGRO RURAL, SERNANP	November 2024
Expand the sustainable harvesting methods used as PSJ to other reserve locations. Secure funding to	AGRO RURAL, SERNANP, Programa Punta San Juan	November 2024

facilitate external observers during harvest activities and research on success of sustainability measures.		
Identify appropriate sites for use of granza (previously used for nesting by penguins and correct microclimate/geography for granza to compact)	AGRO RURAL, SERNANP, Programa Punta San Juan (F. Nishio)	November 2023
Create a committee and meeting to establish research program on the use of granza (including examination of features such as microclimate, structural stability of nests, tick concentrations, etc.)	AGRO RURAL, SERNANP, F. Nishio Programa Punta San Juan	November 2023
Conduct a research experiment with granza at selected site(s)	AGRO RURAL, SERNANP, Programa Punta San Juan (F. Nishio)	December 2023
Update guano harvest management plans to include the use of granza to increase appropriate superficial areas for penguin nesting	AGRO RURAL, SERNANP	December 2024

Goal 14: Reduce the impacts of illegal harvesting of guano.

Objective:
Develop strategies to monitor and reduce illegal harvesting of guano

Activity	Responsible	Target Date
Establish a meeting to plan a campaign	AGRO RURAL SERNANP (P. Saravia), SERFOR (H. Anchante)	June 2024
Create a campaign targeting fishermen to diminish the amount of illegal guano extraction that occurs during periods of low fish availability	AGRO RURAL SERFOR, DICAPI, Policía Ambiental, ACOREMA (J. Reyes, M. Ormeno) Chilean partner [1]	October 2024
Establish a hotline for reporting illegally harvested guano	AGRO RURAL SERFOR (H. Anchante), SERNANP (P. Saravia) DICAPI, Policía Ambiental	December 2024

[1] **There was not a Chilean representative in this group at the workshop but would be valuable to identify one**

Photos: P. McGill

Humboldt Penguin
Population and Habitat Viability Assessment Workshop
Final Report

Lima, Peru
October 17,18, 21-23

Section 8
Working Group Report: Population Viability Analysis (PVA)

Photo: M Cardeña

Working Group Report: Population Viability Analysis (PVA) workshop

Participants: *Helbert A. Anchante Herrera; Anne Baker; Alonso Bussalleu, Caroline Cappello; Marco Cardeña Mormontoy; Robert Lacy; Guillermo Luna Jorquera; Patricia McGill; Fernando Nishio Lúcar; Julio Reyes Robles; Fabiana Lopes Rocha; Jorge Rodríguez Matamoros; Alejandro Simeone; Anne Tieber; Alex Waier; Roberta Wallace; Lauren Waller; Carlos Zavalaga Reyes. Report authors: R. Lacy & J. Rodríguez Matamoros.*

Introduction

The PHVA workshop is a highly participatory and dynamic species risk assessment process involving participation by all interested parties (e.g., researchers, government, community) with a stake in the development of management plans for the species or population in question. The workshop integrates the biological information required to assess the probability of persistence of the species, based on the knowledge of the different parties that bring together multiple disciplines and sectors that are concerned with the conservation of the species. The objective is to create a realignment of priorities among different individual stakeholder groups to take into account the needs, views, and initiatives of other groups (Miller *et al*. 2007).

Central to this workshop process is the use of a PVA simulation modeling approach, *Vortex* being the most common software of choice of CPSG, a package written by Robert Lacy of the Chicago Zoological Society and JP Pollak of Cornell University (Lacy & Pollak, 2020). *Vortex* serves as an exceptionally valuable tool to help stimulate discussion around population data collection and the assumptions being made, to integrate diverse biological and even social science-based data sets, and to evaluate—without prior judgment or bias—a set of proposed management alternatives. In this way, the software unites PHVA workshop participants in a common activity, leading to a greater degree of buy-in to the process among participating stakeholders and, consequently, a greater likelihood for positive action following the meeting. *Vortex* is available for free at https://scti.tools.

Understanding population dynamics is fundamental for the conservation and management of wildlife, since it provides the most direct measures of the situation and trends of populations (Block et al. 2001). However, the long-term studies necessary to identify the most important factors in the long-term viability of species are scarce and laborious (Block et al., 2001, Lindenmayer & Likens 2010, Lindenmayer *et al*. 2012, Clements et al. 2015). The population-based computational modeling assessments known as Population Viability Analysis (PVAs) are a key element of a PHVA (Miller et al. 2007, Lacy et al. 2018) and may help to identify the most important factors in the population growth of wildlife species. Models can also be used to assess the effects of alternative management strategies to identify the most effective conservation actions for a population or species and to identify research needs (Akçakaya & Sjögren-Gulve 2000, Ellner et al. 2002, Fessl et al. 2010, Wakamiya & Roy 2009).

Vortex uses a Monte Carlo simulation to model the effect of deterministic and stochastic factors on wild and captive populations. Deterministic events are constant over time (i.e. harvest, habitat loss, contamination and habitat fragmentation); whereas stochastic events are linked to a probability of occurrence and are classified as demographic (i.e. probabilities of survival, reproduction, sex determination), environmental (fluctuations in demographic rates caused by fluctuations on weather, competition, food supply, diseases), catastrophes (i.e. hurricanes, prolonged droughts, oil spills, epidemic diseases) and genetic (i.e. genetic drift, inbreeding). Initially, the program generates individuals to form the initial population, then each animal moves through different life cycle events such as birth, mate selection, reproduction, mortality and dispersion, which are determined by the probability of occurrence that are entered into the model. Consequently, each simulation run (iteration) of the model gives a different result. By allowing random variables to vary within identified limits, the program predicts at the end of the simulation: the extinction risk, the average size of the surviving populations, and genetic diversity retained by the population, among other statistical results. By running the model hundreds of times, it is possible to examine the probable outcome and range of possibilities (Lacy 1993, Lacy 2000, Lacy et al. 2018).

PVA methods do not pretend to give absolute and precise “answers” about what the future will bring for a given wild species or population. This limitation arises from two fundamental facts about the natural world: (1) the detailed behavior of many biological processes is inherently unpredictable and (2) rarely do we comprehend completely all of the factors and the precise mechanisms through which they act. Consequently, many researchers have warned against the exclusive use of absolute results of a PVA in order to promote specific management actions for threatened populations.

The true value of a PVA lies in the compilation and critical analysis of the available information about a species and its ecology, the identification of gaps in the data and the ability to compare quantitative metrics of population performance in simulation scenarios. For a more detailed explanation of Vortex and its use in PVAs see the software manual (Lacy et al. 2018) or visit https://scti.tools and www.cpsg.org.

The relation between PHVA and PVA

In summary, Population Viability Analysis (PVA) and Population and Habitat Viability Analysis (PHVA) refer to an array of interrelated and evolving techniques for assessing the survival probability of a population and possible conservation actions. Although the terms PVA and PHVA are sometimes used almost interchangeably, it might be useful to restrict the term PVA to its original meaning: the use of quantitative techniques to estimate the probability of population persistence under a chosen model of population dynamics, a specified set of biological and environmental parameters, and enumerated assumptions about human activities and impacts on the system. PHVA extends this approach and refers to a workshop approach to conservation planning, which elicits and encourages contributions from an array of experts and stakeholders, uses PVA and other quantitative and non-quantitative techniques to assess possible conservation actions, and strives to achieve consensus on the best course of action from competing interests and perspectives, incomplete knowledge, and an uncertain future.

Many of the components of PVAs and PHVAs, even when used in isolation, can be effective educational and research tools. To be a useful framework for advancing the conservation of biodiversity, however, PHVA must incorporate all of: (1) collection of data on the biology of the taxon, status of its habitat, and threats to its persistence, (2) quantitative analysis of available data, (3) input of population status and identifiable threats to persistence into analytical or simulation models of the extinction process, (4) assessment of the probability of survival over specified periods of time, given the assumptions and limitations of the data and model used, (5) sensitivity testing of estimates of extinction probability across the range of plausible values of uncertain parameters, (6) specification of conservation goals for the population, (7) identification of options for management, (8) projection of the probability of population survival under alternative scenarios for future conservation action, (9) implementation of optimal actions for assuring accomplishment of conservation goals, (10) continued monitoring of the population, (11) reassessment of assumptions, data, models, and options, and (12) adjustment of conservation strategies to respond to the best information available at all times. The PVA is a valuable methodology to reach objectives 1-5 and 8.

Introducción

El PHVA es un proceso de evaluación de riesgos de especies altamente participativo y dinámico que involucra las diferentes partes (investigadores, gobierno, comunidad…) que muestran interés en el desarrollo de planes de manejo para la(s) especie(s) o población(es) en cuestión. El taller equilibra la integración de la información biológica requerida para evaluar la probabilidad de persistencia de la especie a partir del conocimiento de las diferentes partes que reúnen múltiples disciplinas y sectores que se ocupan de la conservación de la(s) especie(s). El objetivo es crear una realineación de prioridades entre los grupos de distintas partes individuales interesadas para tener en cuenta las necesidades, puntos de vista e iniciativas de otros grupos (Miller et al. 2007).

Un elemento central de un PHVA es el uso de modelaje de poblaciones de un Análisis de Viabilidad de Poblaciones (PVA, por sus siglas en inglés), siendo *Vortex* el software de elección más común de CPSG, un paquete escrito por Robert Lacy de la Sociedad Zoológica de Chicago y JP Pollak de la Universidad de Cornell (Lacy & Pollak 2020). *Vortex* sirve como una herramienta excepcionalmente valiosa para ayudar a estimular la discusión sobre la recopilación de datos de la población y los supuestos incorporados en ese proceso, para integrar diversos conjuntos de datos basados en la ciencia biológica e incluso social, y para evaluar, -sin juicio ni sesgo-, una serie de alternativas de manejo propuestas. De esta manera, el software une a los participantes del taller de PHVA en una actividad común, lo que lleva a un mayor grado de participación en el proceso entre las partes interesadas participantes y, en consecuencia, una mayor probabilidad de acción positiva después de la reunión. *Vortex* está disponible de forma gratuita en https://scti.tools.

Comprender la dinámica poblacional es fundamental para la conservación y manejo de la vida silvestre, dado que proporciona las medidas más directas de la situación y las tendencias las poblaciones (Block *et al*. 2001). Sin embargo, los estudios a largo plazo necesarios para identificar los factores más importantes en la viabilidad de las especies son escasos y laboriosos (Block et al. 2001, Lindenmayer & Likens 2010, Lindenmayer et al. 2012, Clements et al. 2015). Las evaluaciones hechas con un PVA pueden ayudar a identificar los factores más importantes en el crecimiento poblacional de especies de vida silvestre. Los modelos también se pueden utilizar para evaluar los efectos de estrategias de manejo alternativas para identificar las acciones de conservación más eficaces para una población o especie e identificar las necesidades de investigación (Akçakaya & Sjögren-Gulve 2000, Ellner et al. 2002, Fessl et al. 2010, Wakamiya & Roy 2009).

Vortex utiliza una simulación Monte Carlo para modelar el efecto de los factores determinísticos y estocásticos sobre poblaciones silvestres y en cautiverio. Los eventos determinísticos son constantes en el tiempo (p. ej. cacería, pérdida de hábitat, contaminación y fragmentación del hábitat); mientras que los eventos estocásticos están relacionados con una probabilidad de ocurrencia y se clasifican como demográficos (p. ej. las probabilidades de supervivencia, reproducción, la determinación del sexo), ambientales (p. ej. las fluctuaciones en las tasas demográficas causadas por las fluctuaciones en el tiempo climático, la competencia, el suministro de alimentos, enfermedades), catástrofes (p. ej. huracanes, sequías prolongadas, derrames de petróleo, enfermedades epidémicas) y genética (p. ej. la deriva genética, la endogamia). Inicialmente, el programa genera individuos para formar la población inicial, a continuación, cada animal se mueve a través de eventos diferentes del ciclo de vida, tales como nacimiento, selección de pareja, reproducción, mortalidad y dispersión, que se determinan de acuerdo a la probabilidad de ocurrencia que se introduce en el modelo. Como resultado, cada simulación del modelo (iteración) da un resultado diferente. Al permitir que las variables aleatorias cambien dentro de ciertos límites, el programa predice al final de la simulación: el riesgo de extinción, el tamaño medio de las poblaciones supervivientes y la diversidad genética retenida por la población, entre otros resultados estadísticos. Mediante la ejecución del modelo cientos de veces, es posible examinar el resultado probable y un ámbito de posibilidades (Lacy 1993, Lacy 2000, Lacy et al. 2018).

Los métodos de PVA no pretenden dar "respuestas" absolutas y precisas a lo que el futuro traerá para una determinada especie o población de vida silvestre. Esta limitación surge de dos hechos fundamentales sobre el mundo natural: (1) el comportamiento detallado de muchos procesos biológicos es inherentemente impredecible y (2) raramente comprendemos completamente todos los factores y los mecanismos precisos a través de los cuales actúan. En consecuencia, muchos investigadores han advertido contra el uso exclusivo de resultados absolutos de un PVA con el fin de promover acciones de gestión específicas para las poblaciones amenazadas.

El verdadero valor de un PVA radica en construir y el análisis crítico de la información disponible sobre la especie y su ecología, la identificación de lagunas de datos y la capacidad de considerar y comparar las métricas cuantitativas del rendimiento de la población en escenarios simulados. Para una explicación más detallada de *Vortex* y su uso en PVAs consulte el manual del software (Lacy et al. 2018) o visite https://scti.tools y www.cpsg.org.

La relación entre PHVA y PVA

En resumen, el Análisis de viabilidad de la población (PVA) y el Análisis de Viabilidad de la población y el hábitat (PHVA) se refieren a una serie de técnicas interrelacionadas y en evolución para evaluar la probabilidad de supervivencia de una población y las posibles acciones de conservación. Podría ser útil restringir el término PVA a su significado original: el uso de técnicas cuantitativas para estimar la probabilidad de persistencia de la población según un modelo elegido de dinámica de la población, un conjunto específico de parámetros biológicos y ambientales, y supuestos enumerados sobre las actividades humanas e impactos en el sistema. Mientras que un PHVA se refiere a un enfoque de taller para la planificación de la conservación, que obtiene y alienta las contribuciones de una variedad de expertos y partes interesadas, que utiliza el PVA y otras técnicas cuantitativas y no cuantitativas para evaluar posibles acciones de conservación, y se esfuerza por lograr un consenso sobre el mejor curso de acción desde intereses y perspectivas en competencia, conocimiento incompleto y un futuro incierto.

Muchos de los componentes de los PVA y PHVA, incluso cuando se usan de forma aislada, pueden ser herramientas educativas y de investigación efectivas. Sin embargo, para ser un marco útil para avanzar en la conservación de la biodiversidad, un PHVA debe incorporar: (1) recopilación de datos sobre la biología del taxón, el estado de su hábitat y las amenazas a su persistencia, (2) análisis cuantitativo de datos disponibles, (3) ingresar el estado de la población y amenazas identificables para la persistencia en modelos analíticos o de simulación del proceso de extinción, (4) evaluación de la probabilidad de supervivencia en períodos de tiempo específicos, dados los supuestos y limitaciones de los datos y el modelo utilizados, (5) pruebas de sensibilidad de las estimaciones de probabilidad de extinción en el rango de valores plausibles de parámetros inciertos, (6) especificar objetivos de conservación para la población, (7) identificar opciones de manejo, (8) proyección de la probabilidad de supervivencia de la población en escenarios alternativos para futuras acciones de conservación, (9) implementación de acciones óptimas para asegurar el cumplimiento de los objetivos de conservación, (10) monitoreo continuo de la población, (11) reevaluación de supuestos, datos, modelos y opciones, y (12) ajuste de las estrategias de conservación para responder a la mejor información disponible en todo momento. El PVA es una metodología valiosa para lograr los objetivos 1-5 y 8.

Description of demographic rates used in the Vortex PVA modeling

Estimates of population sizes, reproductive rates, and survival rates were obtained by:

- Questionnaire distributed to penguin biologists several months prior to the workshops in Lima. The questionnaire was distributed to those biologists who participated in the PVA workshop, and several others (Dee Boersma, Hernán Vargas, Pablo Garcia Borborgulu) who were not able to attend the workshop. The questionnaire solicited any available information on populations of Humboldt penguins, as well as data on the three other *Spheniscus* species. Both published and unpublished data were requested from research teams.
- Reviewing published literature on *Spheniscus* species.
- Tallying population counts and estimates from censuses that had been conducted in Peru and Chile over various years.
- Reviewing the data providing in the above activities with all participants in the PVA workshop, obtaining any additional data, insights about the applicability of the available data, and expert opinion regarding key variables for which we had no quantitative estimates from field surveys.

We used the available population data to:

- Characterize as a "baseline" scenario the current conditions for typical populations of Humboldt penguins. This baseline case provides our best estimate of the average present status of the populations, rather than a description of the best years or worst years, or the most stable local populations or the most vulnerable ones. However, it should be noted that the data on demographic rates are obtained from just a few populations, and those populations are among the largest populations. Thus, the data might not be representative of the many smaller populations that have not been monitored as closely. It is also important to note that our "baseline" scenario includes current levels of fishing net entanglement and other threats. Thus, it will lead to estimates of population growth and viability that are less than the maximum growth that the species could attain if all anthropogenic threats were removed.
- Identify any known differences between populations, such as might exist between the populations in Peru vs Chile.
- Identify ranges of plausible values for population rates that were very imprecisely known. We later tested the effect on population projections of choosing different possible values, in order to characterize our uncertainty in the future of the species and to identify which inadequately described population rates are the largest causes of that uncertainty.

<u>General settings for the PVA model</u>

We repeated the simulation of population trajectories 1,000 iterations for each scenario that was tested. This is sufficient to characterize both the mean expected performance and the range of possible trajectories.

We projected the population dynamics for 100 years to show the long-term consequences of currently estimated conditions or alternative scenarios. However, we also examined the population performance through 30 years to present the projections over a timescale that might be the focus of planned management actions.

We omitted any impacts of inbreeding from the PVA model. Census results show that local populations fluctuate up and down in size more than can be accounted for by fluctuations in local breeding and survival rates, indicating that there must be significant exchange of penguins between populations. This is consistent with genetic evidence that shows little genetic divergence between populations (see below). The total numbers of penguins within regions that are likely to exchange individuals are currently sufficiently large so that inbreeding is not likely to affect population growth and viability. However, if the populations decline to small size (for example, to fewer than 50 breeding pairs in a set of interconnected breeding populations), then the damaging effects of inbreeding on reproduction and survival might accelerate declines toward extinction compared to what is projected in our PVA models.

We defined "extinction" in our model as a population declining to fewer than 10 penguins. The final ultimate biological extinction (no individuals) is difficult to predict and is perhaps less meaningful than collapse to the last few individuals, because a few isolated birds can survive for 20 years or more even after the breeding population is no longer functional. In addition, estimates of mean population growth become very imprecise when they include years with only a few individuals.

We assumed that, except in El Niño years, there is low (0.05) correlation between annual breeding rates and annual survival rates for adults. Even in years with poor reproduction, adult penguins can forego breeding or abandon breeding attempts. In El Niño years, we assumed that reproduction is severely reduced and survival rates are moderately reduced (see below). In metapopulation models, we assumed that there is a moderate correlation (0.50) between local populations in the annual fluctuations in reproduction and survival, as both region-wide and local factors would drive temporal variation in rates.

<u>Reproductive rates</u>

Breeding system: Humboldt penguins primarily form long-term monogamous pair-bonds. A small rate of mate-switching would not affect the population projections, and therefore we modeled the species as maintaining monogamous pairs. New breeders and those that lost a mate will select a new mate from among the pool of unpaired adults. We also assumed that all adult males are capable of breeding.

Age of first breeding: African penguins (Whittington et al. 2005) and Magellanic penguins (PD Boersma in litt, in Whittington et al. 2005) have been reported to start breeding at 4 years of age. At Pájaro Niño in Central Chile, Humboldt penguins age at first breeding ranges from 3.6 to 6.1 years, with a mean of 5±1 year (n = 7) (Simeone, unpubl. data in De la Puente et al. 2013, Simeone & Wallace 2014). At Punta San Juan, the mean age of first nesting for Humboldt penguins is 3.6 years, and a 1992-1996 study (Zavalaga, unpubl.) reported that females start breeding at 3 years and males as early as 2 years of age. In the previous PHVA, this parameter was thought to be between 3-4 years (Araya et al. 2000). In the present PVA model, we assumed that Humboldt penguins can start breeding at age 3. However, because only an estimated 75% of adult females nest each year, this would lead to some penguins not breeding until age 4, and a few not breeding until age 5 or later.

Maximum age: No banded Humboldt penguins have been monitored long enough to provide a good estimate of maximum age. Among the Magellanic penguins, the oldest observed breeder was 28 years (Cappello, unpubl.). In the smaller and presumably shorter-lived Galápagos penguin, the oldest known age animal was 18 years (Jimenez-Uzcategui & Vargas 2019). In zoos, captive Humboldt penguins typically breed into their mid-20s, and occasionally are still breeding when older than 30 years. In our modeling, we assumed that Humboldt penguins in the wild can survive and breed up to 25 years of age.

Percent breeding each year: The percent of adult females that nest each year is unknown. In zoos, typically 75% to 85% of pairs that are given an opportunity to nest will produce chicks. In Galápagos penguins (Vargas *et al*. 2007) 56.7% (SD = 13) of adult females successfully fledged chicks during the 2003-2004 breeding season, but this would under-estimate the number that produced chicks. In Magellanic penguins (C. Cappello pers. comm.), a mean of 81% of pairs that nested in one year will nest again the next year. On Robben Island, 70-100% of sexually mature individuals of African penguins nest each year (Crawford *et al*. 1999), with females usually breeding every year and males skipping years at about 19% of times (B. Barham, L. Waller pers. comm.). In the 1998 PHVA for Humboldt penguins, a guess was made that only 25% (in Chile) or 50% (in Peru) of adult females, nest in an average year (Araya et al. 2000). Given the uncertainty in this rate, our baseline model used an estimate of 75% of adult females (those 3 years and older) producing a brood in an average year. We later tested values ranging from 65% to 85%.

Number of broods per year: Humboldt penguins have two primary breeding seasons (Paredes et al. 2002), but the percentage of pairs that produce a brood in both seasons might vary between areas. At Islote Pájaro Niño, Chile, pairs have been observed to produce only a single brood per year, whereas at Punta San Juan, Peru, some pairs have two broods per year. Paredes et al. (2002) reported that an average of 53%, 43%, and 4% had one clutch, two clutch and three clutches each year, respectively, at Punta San Juan (PSJ). Of pairs that had two clutches per year, 73% were double brooders and 27% replacement brooders. Of the few pairs that had three clutches per year (n = 7) most were replacement brooders during their second (86%) and third breeding attempt (71%). Thus, an estimated 65% of pairs produce one brood (53% a single nest, plus 27% x 43% = 12% replacement broods) and 35% produce two broods in an average year.

Sex ratio of chicks: The sex ratio of chicks of 44% males has been observed at PSJ, although higher mortality among females observed in Magellanic penguins indicates that there might be a more equal breeding sex ratio or even an excess of males (Gownaris & Boersma 2019).

Eggs per brood: Humboldt penguins lay 2 eggs per brood. For the demographic model, however, we described the “brood size” as the number of chicks fledged per nest, after any nestling mortality.

Fledging rates: Paredes *et al*. (2002) reported that from 1992-1999 at PSJ, single brooders fledged an average of 0.98 chicks, while double brooders fledged a total of 2.61 chicks (across both broods). Thus, we can estimate that during those years, first broods fledge about 1 chick and second broods fledge about 1.6 chicks. However, since 2000 (observations in 2001-2007, 2011, and 2012), the research team of the PSJ Program has observed a 36% hatching rate and 66% survival from hatching to fledging, thus yielding an average of about 0.48 fledglings per nest. On Islote Pájaro Niño, Chile (Wallace, unpubl.), from 1994-1998 (including an El Niño year), there was a mean of only 0.15 fledglings per nest, although in next two years (after El Niño) pairs produced about 1 fledgling per nest. Overall, from 1994-2000 the average number of fledglings/nest on Islote Pájaro Niño including El Niño years was about 0.5 (Wallace, unpubl.). In the other *Spheniscus* species, fledging rates vary greatly between sites, ranging from 0.15 to 0.70 (mean of 0.54, Sherley 2012) per nest in African penguins, and 0.16 to 1.96 among 11 colonies of Magellanic penguins (mean at Punta Tombo of about 0.5 across years). In the baseline model, we assume a mean number fledged per brood of 0.5, but we later tested scenarios with either the higher fledging rates observed in the 1990s at PSJ or the very low rates observed at Islote Pájaro Niño, Chile, in the 1990s. Given the high variation observed in fledging rates between years and between sites, in sensitivity testing we examined a range from 0.25 to 1.75 fledglings per nest.

Mortality rates

Accurate estimation of mortality requires monitoring tagged birds over a number of years. Even when this is possible by banding chicks at the nest, the return rates of banded birds in subsequent years will underestimate survival because they do not include birds that dispersed from the area and did not return to the population under observation. Estimates of mortality rates in *Spheniscus* penguins vary widely between sites, years, and studies. Return rates PSJ from chicks first banded at the nest (which would over-estimate mortality) range from 67% loss (in 2007, the year with the best sample size) to 81% loss (2003, a year with smaller sample size). Among other *Spheniscus* species, estimates of first year mortality for several period of years and sites include: for African penguins, a range from 11% to 69% (mean of 29%) at Namibia (Kemper 2006); 47% to 90% (mean of 62%) at Dassen Island (Whittington 2002), and 56% to 83% (mean of 81%) at Robben Island (Whittington 2002); for Magellanic penguins, and 88% for females and 83% for males in the most recent summary of long-term census data at Punta Tombo (Gownaris &Boersma 2019). The 1998 PHVA for Humboldt penguins (Araya *et al*. 2000) estimated first year mortality as 80%. The PHVA for Galápagos penguins (Matamoros *et al*. 2006) used an estimate of 67% first year mortality. Recognizing the very wide range of estimates, in our baseline model we assumed an annual first year mortality rate of 67%, but subsequently tested a range from 33% to 83%.

Mortality estimates for later age classes include an estimate of 18% based on return rates at PSJ from 2000-2010; for African penguins, 9% to 45% annual mortality from a variety of studies, including recent years during which the population has been in rapid decline (Randall 1983, La Cock & Hänel 1987, Whittington 2002, Kemper 2006, Ludynia et al. 2014, Sherley et al. 2014); for Magellanic penguins, 13% (Gownaris & Boersma 2019); and for Galápagos penguins, 11% (Boersma 1977). The 1998 PHVA used an estimate of 5% annual adult mortality as a baseline, but added to that 1%, 3%, or 5% mortality due to net entanglement. Estimated levels of net entanglement for Humboldt penguins in different years and sites range from 0% to 10%, with a mean estimate of 4.5% at PSJ from 1991-1998. Our baseline model includes the current level of entanglement as one cause of mortality, and we set the annual adult mortality to 10%, with later sensitivity tests of a range from 5% to 15% annual adult mortality.

Impacts of El Niño and La Niña events

Catastrophes are rare events with severe impacts. Therefore, the frequency of occurrence and severity of impacts on reproduction and survival are difficult to estimate from observations over only relatively recent years. Severe El Niño events have been occurring about once every 15 years, as have the converse – strong La Niña events, although the frequency of such events might be increasing (Vargas et al. 2006). Weaker El Niño events have been occurring about once every 6 years on average, although the weaker events do not seem to have a large effect on the penguins. Severe El Niño events occurred in 1982-1983, 1997-1998, and 2015-2016. A decline of 65% was observed across a number of sites in Peru following the 1982-1983 El Niño (Hays 1986), and high mortality was suspected. During the 1998 El Niño, no reproduction was observed at PSJ, very few birds (about 15% of normal) attempted to breed at Islote Pájaro Niño (Chile), and there was about a 25% decline in adult penguins at Islote Pájaro Niño (Simeone et al. 2002). For the PVA, we assumed that strong El Niño events would cause almost complete failure of reproduction (set in the model to be 0.05 times the normal nesting rate) and 25% mortality (implemented in the model as survival being 75% of normal).

La Niña events can be treated as "good catastrophes" in the Vortex model. In Pajaro Niño Island, the 1995-1996 and 1998-1999 La Niña events were linked to the highest number of breeding pairs and successful breeding events compared to normal years (Simeone et al. 2002); in the spring of 1998 there was an increase of 58% in the number of breeding pairs and a 42% increase in the fall of 1999. Also, in

1998 there were 1.4 fledglings per nest. We modelled this beneficial effect as a 1.5-fold increase in nesting pairs during La Niña years.

Population sizes

Local population sizes at the 9 primary molt sites in Peru range from about 400 at Islote San Francisco to about 3,200 at PSJ (2011 to 2019 census counts), with a total mean across the last 8 years of 11,542. There are large fluctuations at individual sites from year to year, and the count at the largest site (PSJ) declined in recent years and was 1,293 in 2019, while the total across all sites recorded in the 2019 molt census was 6,290 – a reduction of more than 60% since 2014 (when the total was 16,274). (See census report from McGill for more details, Appendix IV.) From 2011 to 2019, the census counts in Peru declined an average of 10% per year.

The Chilean populations were censused regularly from 1999 through 2008 (Wallace & Araya 2015). The mean total counts across those years were 34,383. Although counts fluctuated widely between years at individual sites, the total count was steadier, ranging from 25,490 to 35,284. A more recent count in 2017 tallied only 10,134 breeding Humboldt penguins in Chile, but that count focused on breeding birds, and it is unknown how it compares to the molt counts from prior years.

The large fluctuations in numbers across years at some sites, with relatively low correlations in these fluctuations across sites, suggest that the penguins occasionally move between sites. For example, some Peruvian populations decreased by more than 2/3s in some years and increased by more than 3-fold in other years. Although some of the variation over time would have been due to incompleteness of counts (caused by variations in weather conditions and timing of counts), the magnitude of fluctuations at local sites seems too large to be accounted for by local demography. Indeed, penguins completely disappeared for a few years from a few of the local populations in Chile (e.g., El Chango Islet), but then repopulated the site in subsequent years. Moreover, genetic studies have found high genetic variation within colonies and low divergence between colonies, indicative of at least occasional exchange between sites (Schlosser et al. 2009). However, Dantas et al. (2019), with more sampling, found evidence for restricted recent gene flow over long distances, and they grouped the populations into three clusters.

Considering that we do not know to what extent the breeding colonies are demographically and genetically isolated, and evidence suggests that at least within regions the populations are connected, we chose not to model each population in isolation. Moreover, data on demographic rates are available only from PSJ in Peru and (to a lesser extent) from Islote Pájaro Niño in Chile, so we do not have the information necessary to predict the dynamics of other specific populations. We therefore tested scenarios with a range of initial population sizes (100; 500; 1,000; 2,000; and 4,000), as well as testing some scenarios with numbers approximating the populations in Chile and Peru.

For projections of the Peruvian population, we used an initial population size of 6,290 (the 2019 molt census count). However, because the molt census counts likely underestimate the total population size, we also tested models with 1.5x and 2x initial numbers or with an adjusted count of 15,266. The adjusted count scaled the molt count by a factor that was the ratio of maximum number in weekly counts at PSJ to the annual molt count at that site. We also tested a Peru metapopulation scenario in which the total count for Peru (mean across 2011-2019 of 11,542) was divided into the 9 local populations.

For the projections of the Chilean population, we tested a starting population of 15,000 (approximate maximum size of the largest colony, at Chañaral Is.), and a starting population of 34,383 (total mean count over 1999-2008) divided into either 3 populations representing 3 zones (South, Central, and North Chile) or into the 25 local populations that were censused. Finally, we also tested some metapopulation scenarios intended to encompass the entire species range: a total of 45,925 (mean across all censuses in each area) divided into 3 zones in Chile and 1 zone for Peru. In these metapopulation scenarios, we tested annual rates of dispersal between each pair of populations of 0%, 1%, 2%, and 3%.

Carrying capacity

The total number of penguins that could be supported currently in any one area or across the species range is unknown, but the numbers had been much higher in the past. We set an upper limit on population size in the PVA model of twice the initial size of each population that was being modeled. If the projections show that under some scenarios the populations would grow to this limiting carrying capacity in the model, then we would be confident that the populations were projected to be viable and healthy, even though we do not know how large the populations might become.

Although the number of penguins in each population, the exchange between populations, the total census size for the species, and the carrying capacity of the habitat are all uncertain, our focus in the PVA modeling was on the rate of population growth or decline, rather than on the numbers that might be achieved if the populations grow.

Data availability

The input file used for the Vortex modeling is available on the Zenodo data repository at https://zenodo.org/record/5113516.

Model Results

Baseline model

The simulation of the initial baseline model, when started with N = 1,000 penguins, projected a declining population. The trajectories of a sample of 100 iterations are shown in Figure 8.1. With the demographic rates estimated in the baseline model, the population is projected to decline at an average rate of 7% per year. As shown in Figure 8.1, there is a lot of variability in the population change from year to year, even increasing in some years, but is virtually certain to be functionally extinct within 100 years. The median time to extinction (defined as fewer than 10 penguins remaining) was 59 years, with the population projected to be extinct within 35 to 85 years.

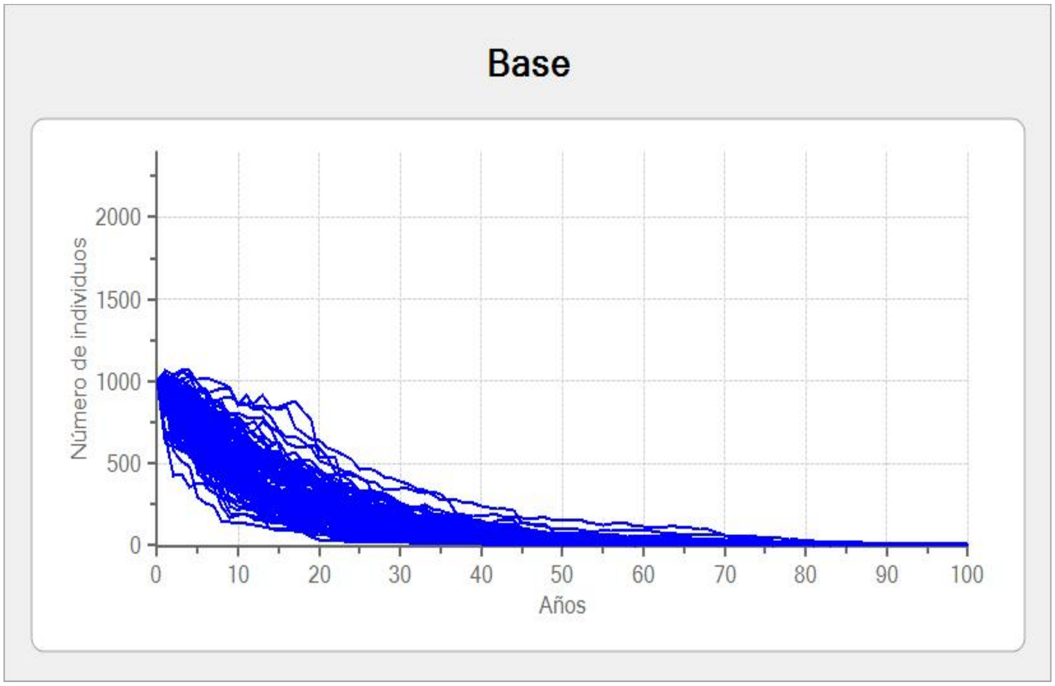


Figure 8.1. Sample of 100 iterations of the simulation of the baseline scenario for a population starting with 1000 individuals

Figure 8.2 shows a sample of simulation trajectories over the first 30 years. Over that time span, a population of initially N = 1,000 is projected to decline to an average size of N = 125 (SD among simulation iterations = 75), but never go completely extinct. The mean genetic diversity remaining at 30 years was 98.6% of the starting level, indicating that loss of genetic variation (or inbreeding) was not a cause of the decline in the simulation. Instead, the estimated reproductive success is not sufficient to offset the estimated mortality.

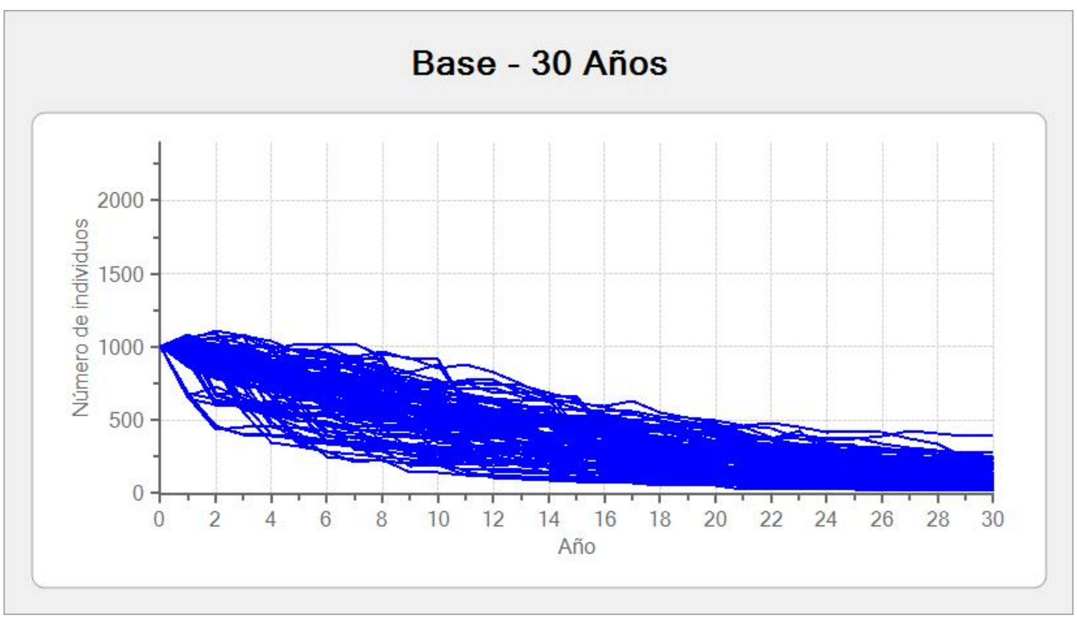


Figure 8.2. Sample of 100 iterations of the simulation of the baseline scenario over 30 years

The projected 7% annual decline is cause for concern about the future of the species, and the model prediction might seem to be overly pessimistic. However, it is not inconsistent with the mean rate of decline of 10% in census counts for Peru since 2010, and the lack of parallel census estimates in Chile over the recent years leaves open the possibility that Humboldt penguins are in decline there as well. The relative concordance between the projected decline and the recent census data indicates that the demographic rates applied in baseline model, although based on few data and therefore very uncertain, are not inconsistent with observed population trends. In addition, other *Spheniscus* species (especially, African penguins) have been reported to be declining as fast or faster.

Given the considerable fluctuations in numbers from year to year – in both the census counts and in the simulation model – it is difficult to know if a short-term decline is indicative of a long-term trend. However, the model does show us that if the demographic rates that have been observed in recent years continue into the future, the species will continue a downward trajectory toward extinction.

<u>Varying starting population sizes</u>

Smaller populations are expected to experience greater random fluctuations due to various stochastic processes, while larger populations are more predictable demographically. If random processes are strong determinants of population dynamics, then smaller populations can decline faster and become extinct sooner than do initially larger populations (Lacy 2000). Figure 8.3 shows the mean trajectory for the baseline model for populations that initially have N = 100 to N = 4,000 penguins. Across these population sizes, the projected rate of decline is similar, indicating that the predominate threats to the populations are not the random processes that can threaten small populations, but instead the negative mean growth rate caused by inadequate reproductive success and too high mortality.

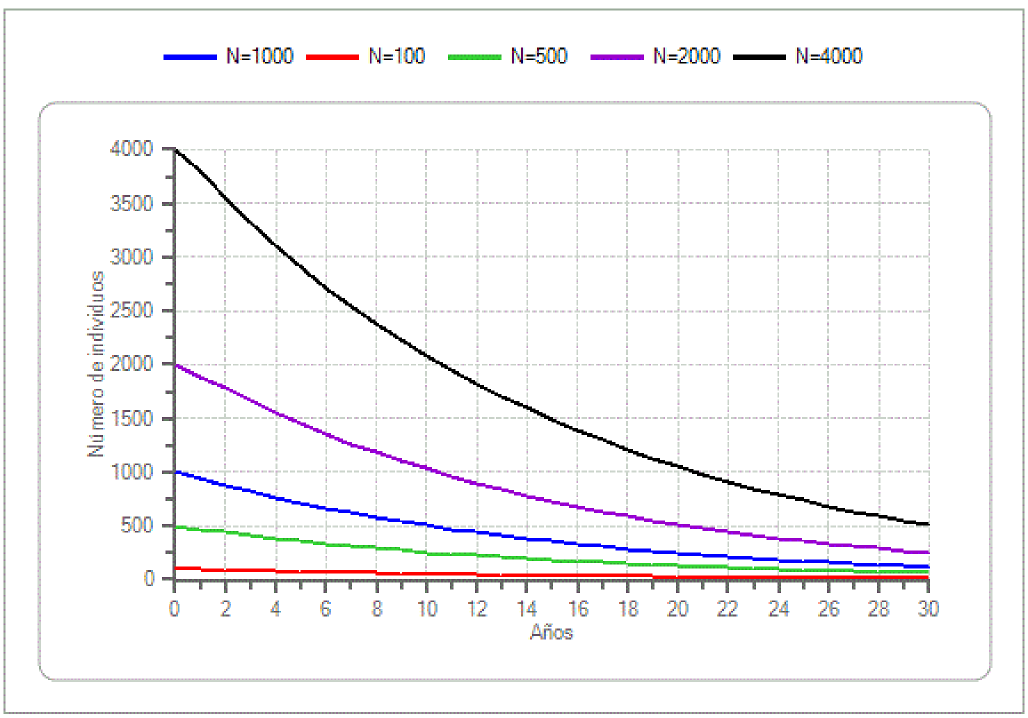


Figure 8.3. Mean projected sizes for populations starting with N = 100, 500, 1000, 2000, or 4000 penguins, each averaged across 1,000 iterations

The molt census counts probably underestimate the total numbers, because some penguins would have molted earlier or later, or not been observed by the research team. Figure 8.4 shows the mean projections for the baseline compared to a population starting at the most recent census estimate from Peru (N = 6,290), a size typical of the largest population, Isla Chañaral, in Chile (N = 15,000), a size 1.5x the census estimate for Peru, a size double the census estimate for Peru, and a size that scales the Peru census upwards by the ratio of the maximum counts at PSJ to the census estimate at PSJ. With increased initial population sizes, the projected size in 30 years is larger, but still only about 1/8th the initial size.

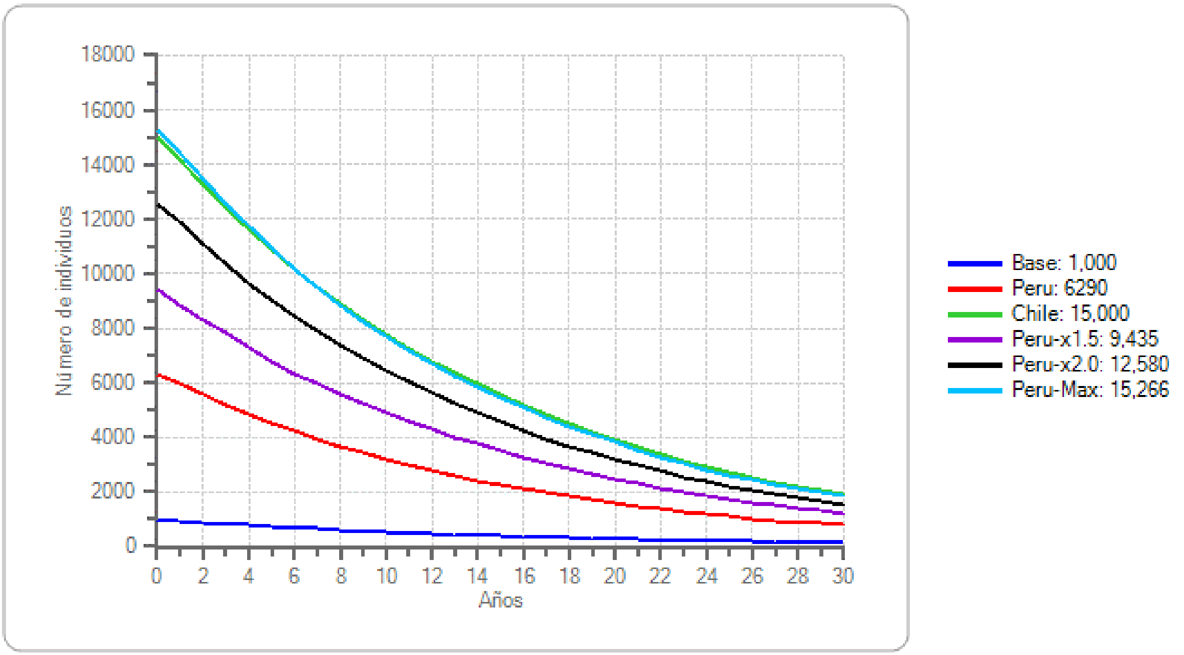


Figure 8.4. Mean projected sizes for populations starting at several estimates for current population sizes

<u>Projections with reproductive rates from alternative time spans and populations</u>

Although data exist for only a few populations from studies over different periods of time, the reported demographic rates, especially reproductive success, vary considerably between locations and between years. Reported fledging rates at PSJ, Peru, from the 1990s were much higher than observed since 2000. Conversely, the fledging rates at Islote Pájaro Niño, Chile, were very low when monitored from 1994 to 2000. Figure 8.5 compares the baseline model (blue line) to the predicted trajectories for scenarios with the low reproductive success of the Islote Pájaro Niño population (with starting size of 2,540, based on the mean size from 1999-2008), the very high reproductive success at PSJ in the 1990s (with starting N =1,293, the most recent census count), and the lower reproductive success observed at PSJ since 2000 (used also in the baseline model). The low reproductive success at the Chilean population leads to a projection of very rapid decline (if the population is not reinforced by immigrants from other populations with better reproduction), while the fledging rates reported from PSJ in the 1990s would result in positive population growth.

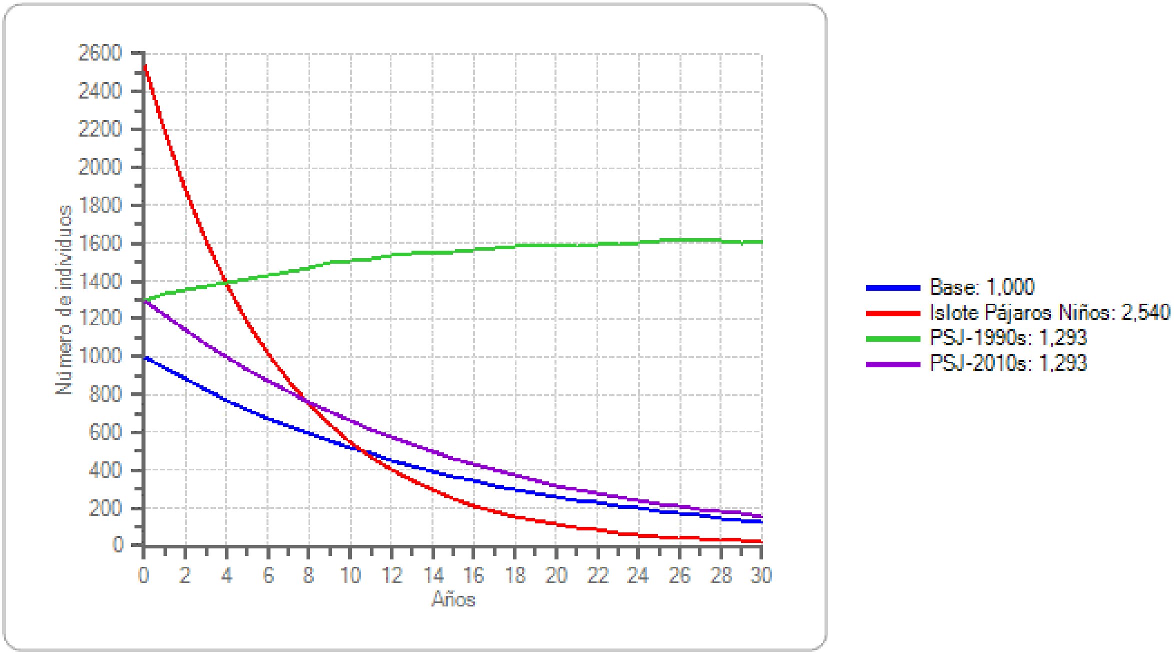


Figure 8.5. Mean projected sizes for scenarios with reproductive success and initial population sizes reported for Islote Pájaro Niño, Chile, and PSJ, Peru, at different time periods

<u>Which demographic rates could be causing the projected population decline?</u>

Key demographic rates are variable among sites, variable across years, and only imprecisely estimated. An important part of PVA is sensitivity testing, the examination of projections under the range of plausible values for model parameters that are uncertain (Manlik et al. 2018). We therefore tested a range of plausible values for the % of adult females breeding per year, the number of young fledged per nest, the survival rate from fledging to 1 year, and the survival rate of adults in order to determine the influence of each of these variable and uncertain rates have on population projections.

Figure 8.6 compares mean population projections (starting with N = 1,000) for the percent of adult females nesting each year ranging from low (60%) to high (85%) estimates. Changing this one demographic rate, within the range considered plausible, had relatively small effect on population trajectories.

Figure 8.7 compares projections for the fledging rate (number of fledged young per nest) ranging from low (0.25) to high (1.75) estimates. We tested a very wide range of values to encompass much of the range that has been reported for different populations of *Spheniscus* penguins. Across this wide range of fledging rates, there is a dramatic impact on the population growth, with the best to worst scenarios having mean population growth rates from +6% to -12% per year. This indicates that the range of fledging rates observed among sites and years can result in populations that experience dramatically different growth. Importantly, if the other demographic rates remain as estimated in our baseline model, then the fledging rate must be greater than 1 per nest to result in positive population growth.

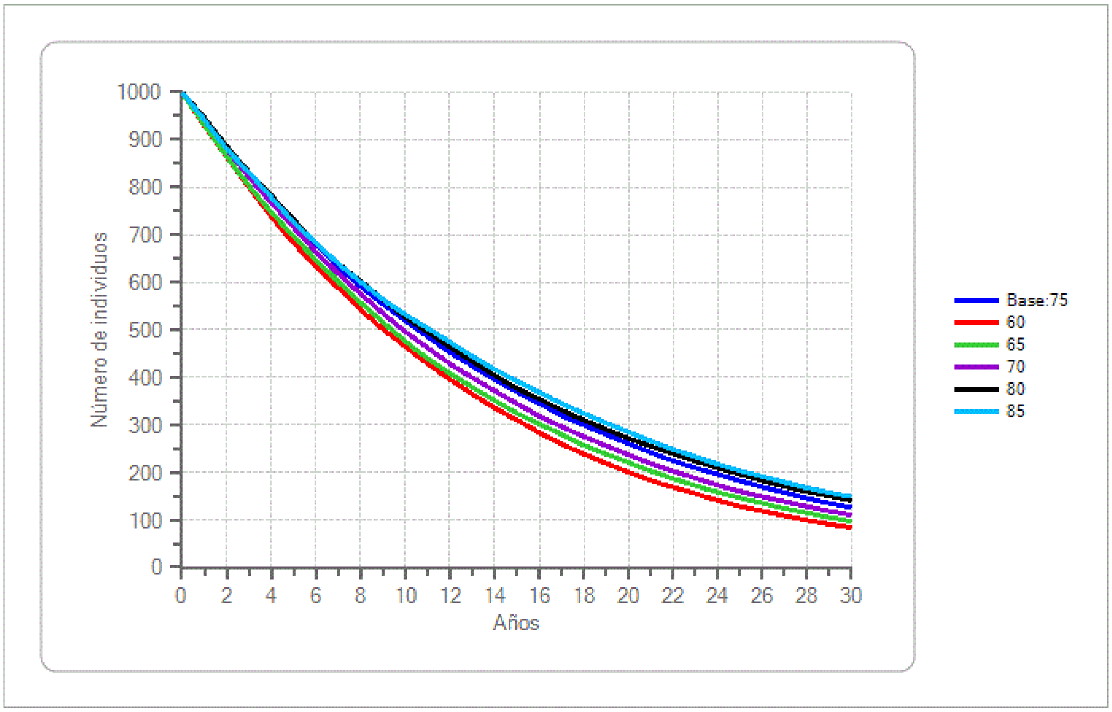


Figure 8.6. Mean projected sizes for scenarios with percent of adult females breeding set at 60%, 65%, 70%, 75%, 80%, or 85% per year (bottom to top lines)

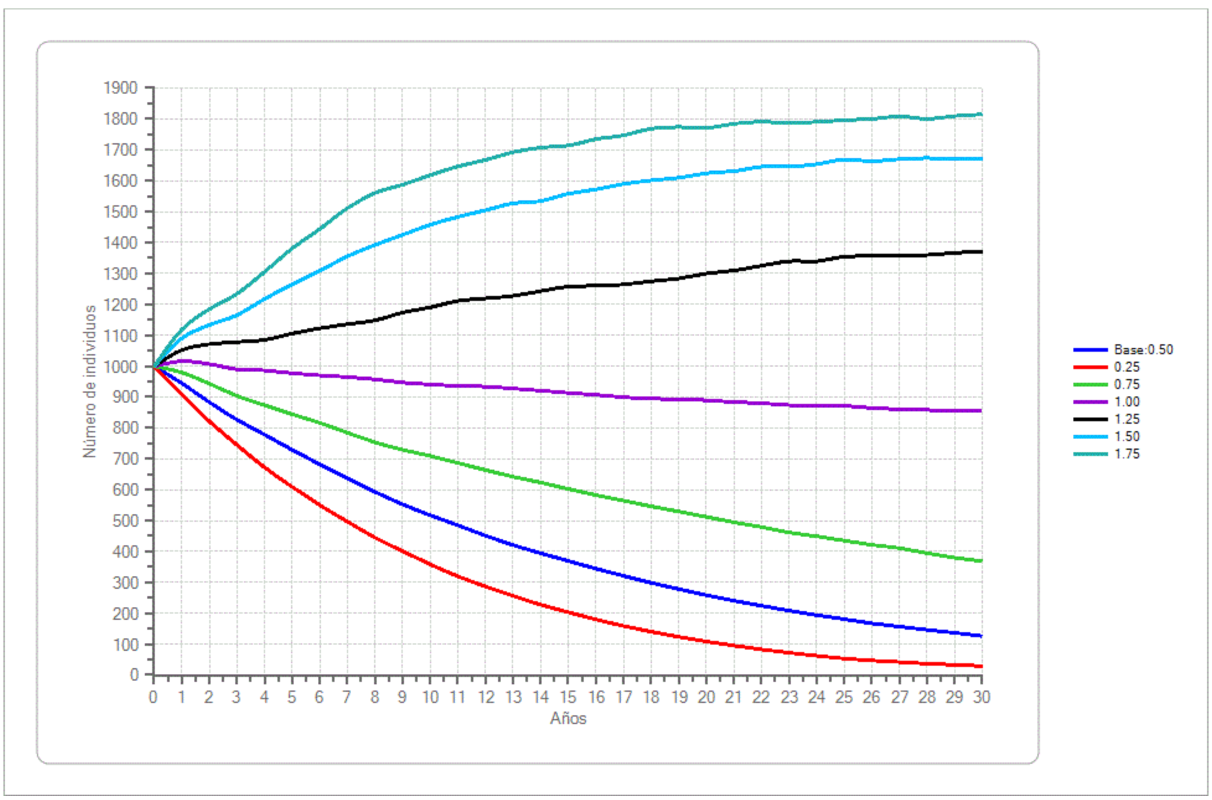


Figure 8.7. Mean projected sizes for scenarios with fledging rate set at 0.25, 0.50 (baseline), 0.75, 1.00, 1.25, 1.5, or 1.75 per nest (bottom to top)

Figure 8.8 compares projections for juvenile mortality (survival from fledging to 1 year) ranging from low (33.5%) to high (83.5%) estimates. Demographically, increasing juvenile survival has the same effect as increasing fledging rate, as the two factors together determine the reproductive success per nest. However, within the range of plausible values for juvenile mortality, even the best rate did not achieve a positive population growth when all other parameters (especially fledging) were at the baseline values.

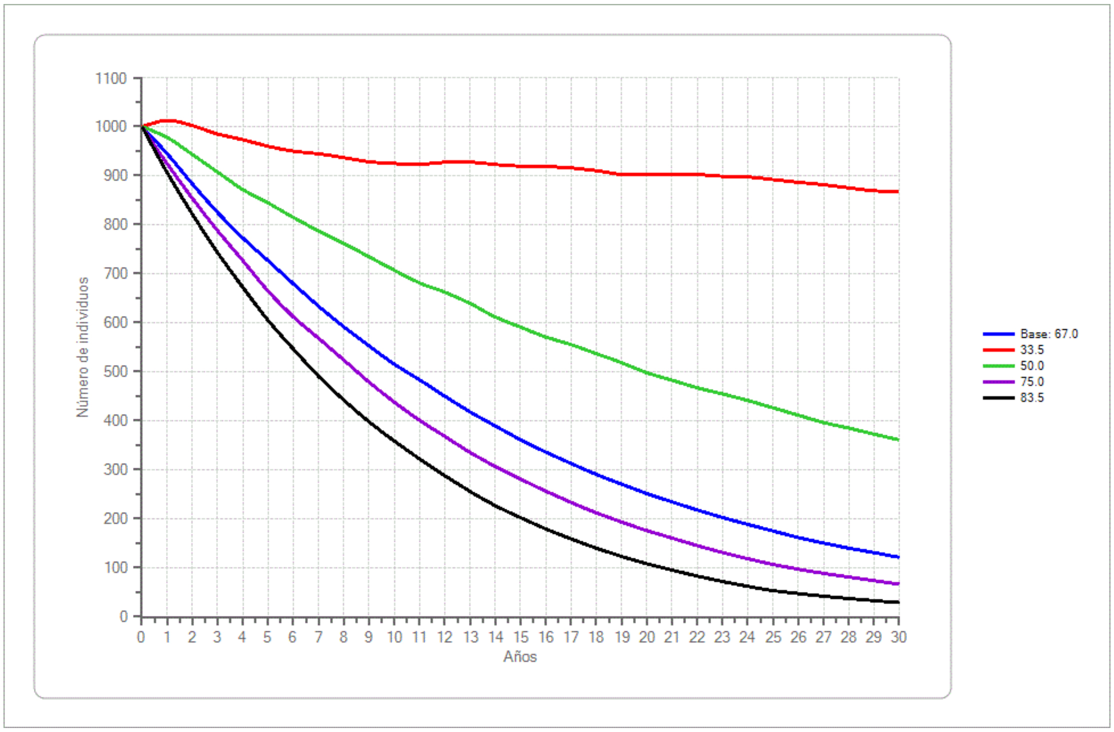


Figure 8.8. Mean projected sizes for scenarios with juvenile mortality rates set at 33.5%, 50%, 67% (baseline), 75%, or 83.5% (top to bottom)

Figure 8.9 compares projections for annual adult mortality ranging from low (5%) to high (15%) estimates. For long-lived species such as penguins, adult survival is often assessed to have the greatest impact on population growth. Adult mortality is imposed at each year, so the cumulative effect can be very large compared to, for example, a one-year impact of juvenile mortality. However, in our sensitivity tests, varying the adult mortality rate had a slightly lesser impact than did variation in juvenile mortality and much lesser impact than variation in fledging rate. This is because the range of plausible values for adult mortality is much less than the range of values reported for fledging rate and juvenile mortality in *Spheniscus* populations. Importantly, even if the adult mortality is at the lowest level that has been considered likely for *Spheniscus* penguins (5%, a rate that might be achieved in the absence of net entanglements or other human-caused mortality), the populations are projected to decline if reproductive success and other demographic rates are not improved above the values estimated for Humboldt penguins.

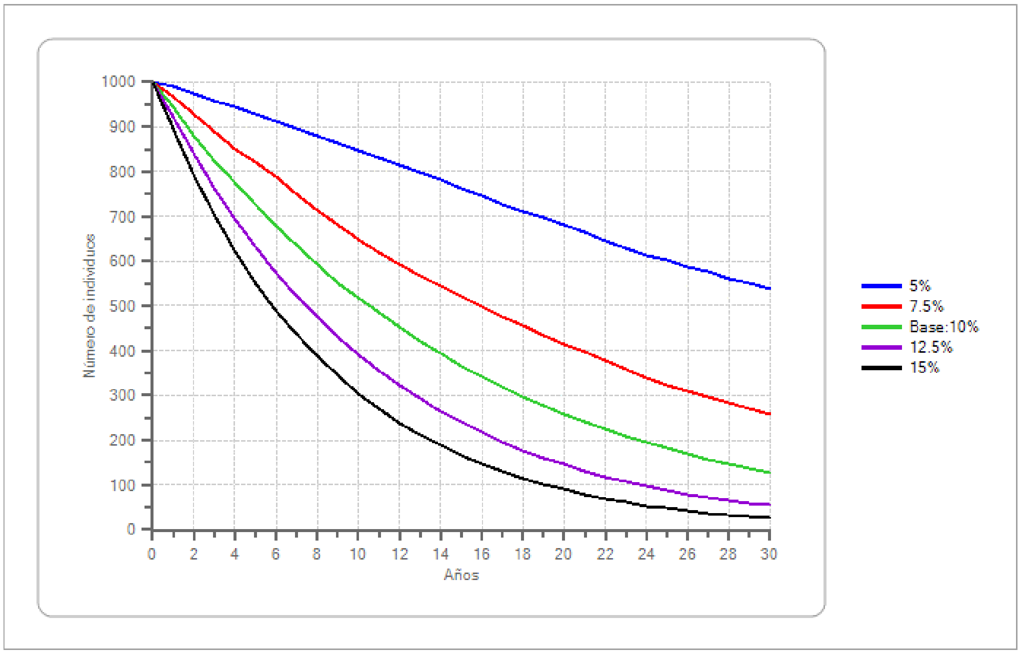


Figure 8.9. Mean projected sizes for scenarios with adult mortality set at 5%, 7.5%, 10%, 12.5%, or 15%

It is unknown if strong El Niño events cause significant adult mortality, or instead most penguins fail to nest or successfully raise young but still survive, perhaps by changing or extending foraging areas. Figure 8.10 compares projections with adult survival during strong El Niño events is reduced (down to 65%) or increased (up to 95%) of survival during non-El Niño years. Across this range, the impact on long-term mean population growth is small, because strong El Niño events are (currently) infrequent.

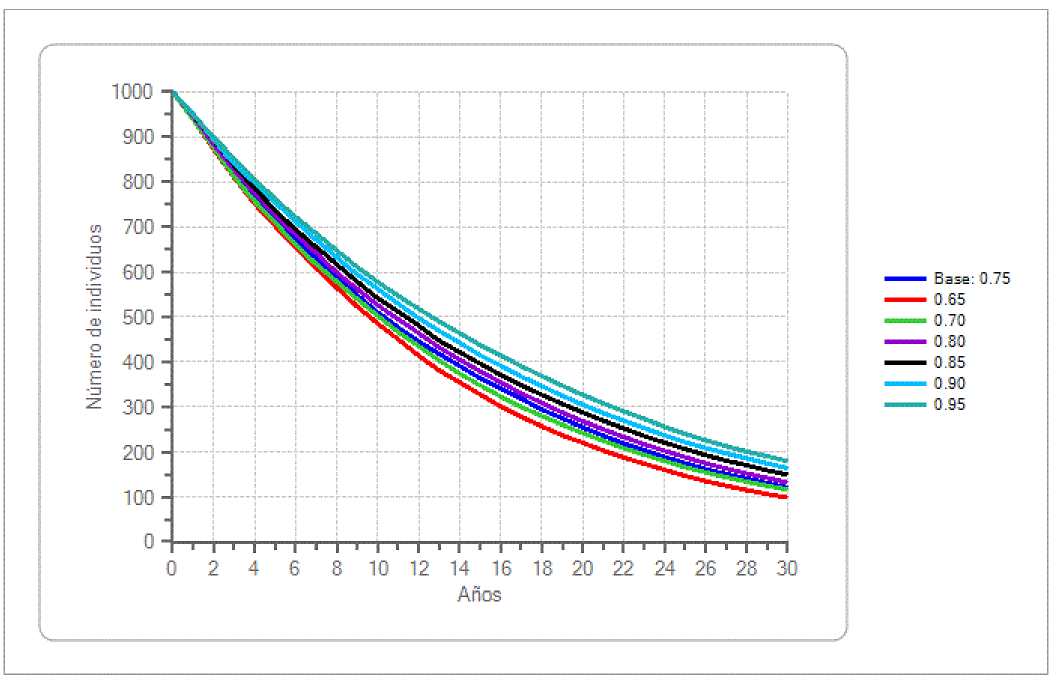


Figure 8.10. Mean projected sizes for scenarios with adult survival set at 65%, 70%, 75% (baseline), 80%, 85%, 90%, or 95% of the rate in non-El Niño years

We also tested all 1,050 combinations of the values of breeding rate, fledging rate, juvenile survival, and adult survival that are discussed above. We will not present all of the results here, but a sample of the scenarios is shown in Figure 8.11. In this sample of tested combinations of parameter values, the only scenarios that had positive population growth were three that had fledging rates of 1.25 or greater. Across all combinations of values for the demographic rates, positive population growth was achieved with the baseline rate of 0.50 fledglings / nest only if several of the other rates were set to optimistic values. For example, a growth rate of almost 4% could be achieved if juvenile mortality is 33.5% and adult mortality is 5%. If fledging rate is 1.0 or higher, then many combinations of other rates would result in positive population growth. With all four rates set to their most optimistic values (85% breeding, 1.75 fledglings/nest, 33.5% juvenile mortality, and 5% adult mortality), the populations could achieve 25% growth per year. This perhaps indicates an upper bound on the potential population growth in the best of years. Observed annual increases above 25% in some populations in some years were likely due to penguins immigrating from other colonies.

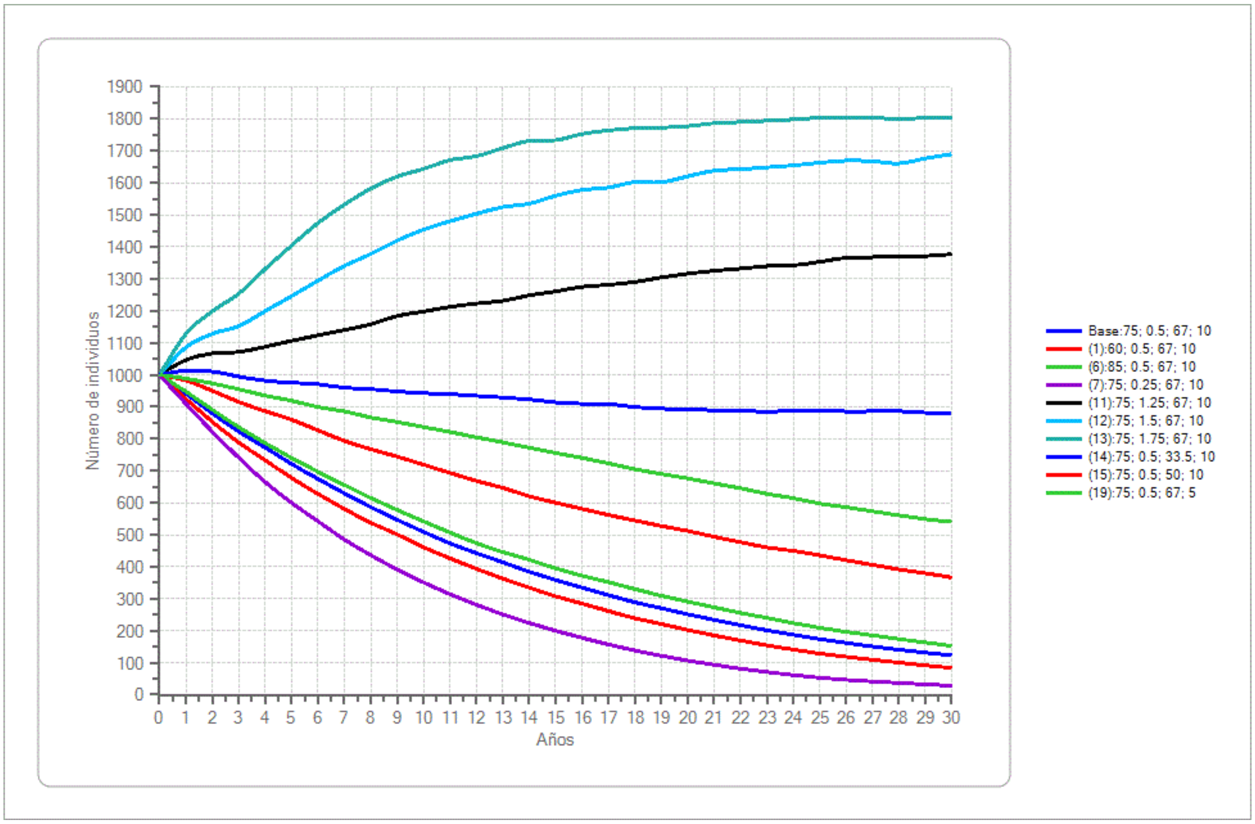


Figure 8.11. Population projections under various combinations of values for four uncertain demographic rates. The labels in the legend specify the tested values for % breeding (60% to 85%), fledging rate (0.25 to 1.75), juvenile mortality (33.5% to 67%), and adult mortality (5 or 10% in the displayed scenarios).

Figure 8.12 shows the full set of 1,050 scenarios with combinations of input parameter values. The separate lines are not distinguishable, and the legend is not shown. However, the wide range of possible outcomes illustrates that the current uncertainty in demographic rates and the variation among local populations and across years leaves us, at present, unable to confidently predict the fate of any given Humboldt penguin population.

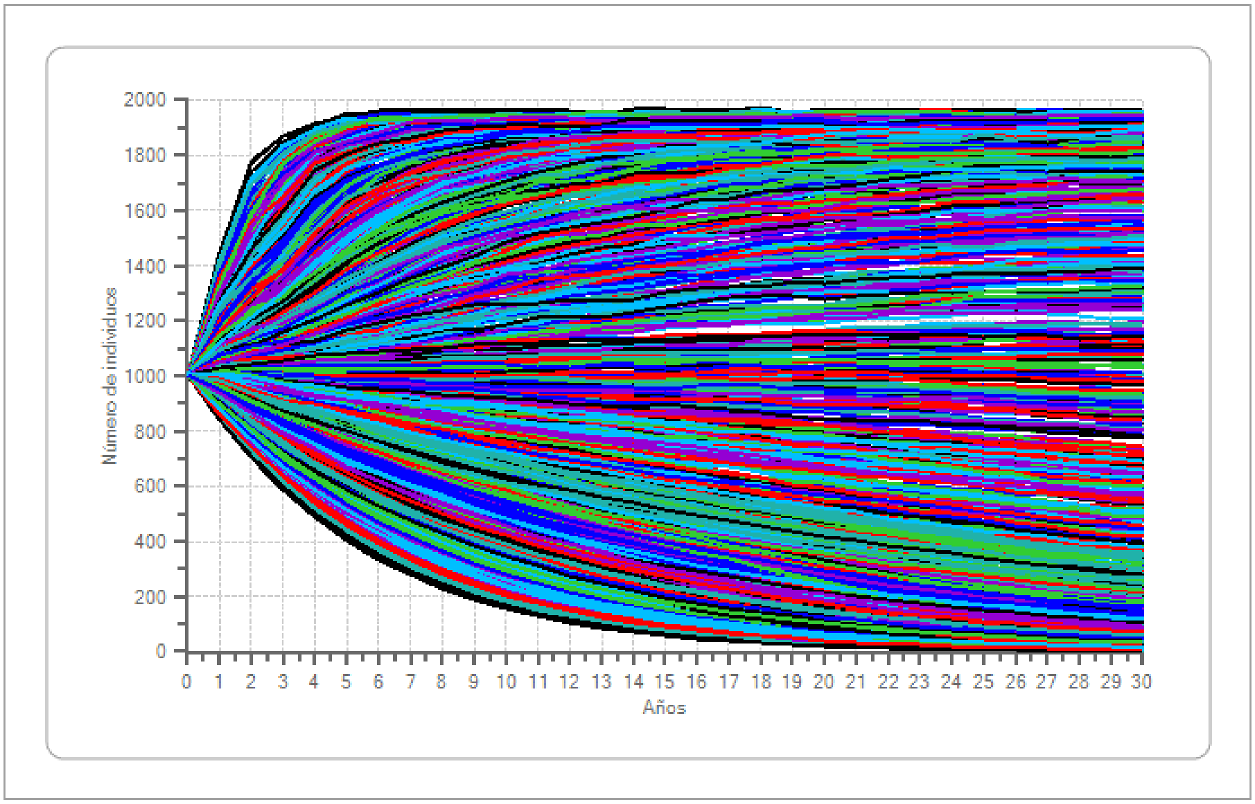


Figure 8.12. Population projections under all combinations of tested values for four uncertain demographic rates: % breeding (60% to 85%), fledging rate (0.25 to 1.75), juvenile mortality (33.5% to 83.5%), and adult mortality (5% to 15%).

<u>Metapopulation models</u>

Humboldt penguins use a number of breeding and molting sites along the Chilean and Peruvian coastal islands and peninsulas, with unknown rates of movement between colonies. We modeled some scenarios with the metapopulation divided into local populations and tested the impact of a range of dispersal rates. However, we have very few data on the differences in demographic rates between sites. Therefore, in these initial metapopulation models we applied the same (baseline) demography to all local populations. A few sample results are shown below, simply to illustrate the kind of metapopulation models that can be explored. More informative metapopulation models will require more specific data on the demographic differences among sites.

Figure 8.13 shows the projections for the 9 local populations in Peru, under the assumption that there is no exchange of penguins among sites. Given that we assume the same demography across the populations, the result that all would decline at the same rate is fully expected. Figure 8.14 shows the projections for the Chilean populations aggregated into three zones (south, central, and north Chile).

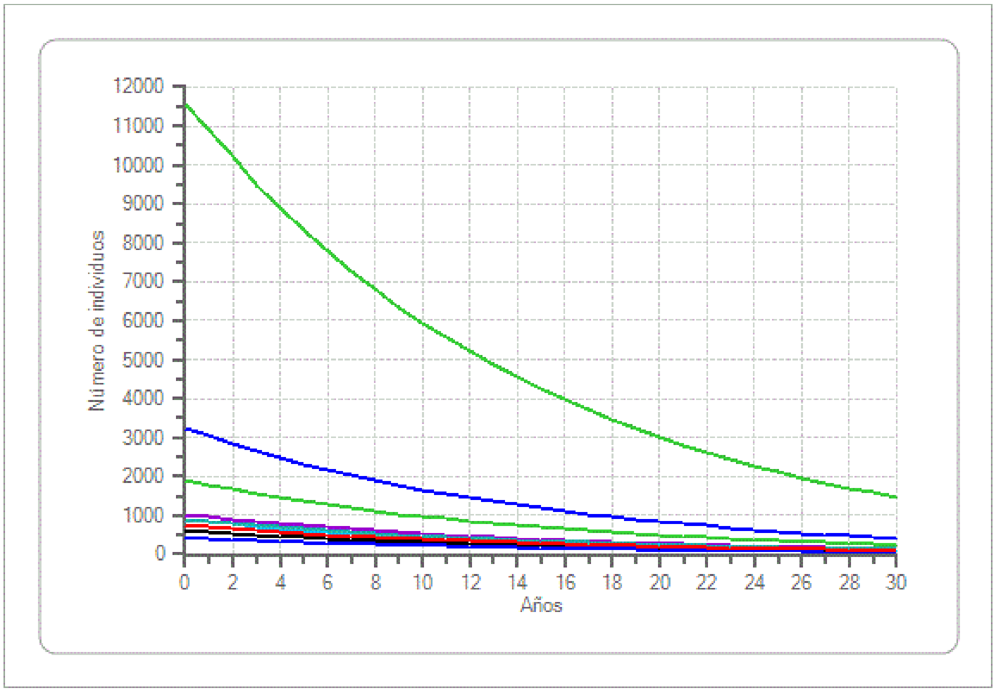


Figure 8.13. Projections of 9 local populations in Peru (with the metapopulation shown in green), under an assumption of no dispersal between sites

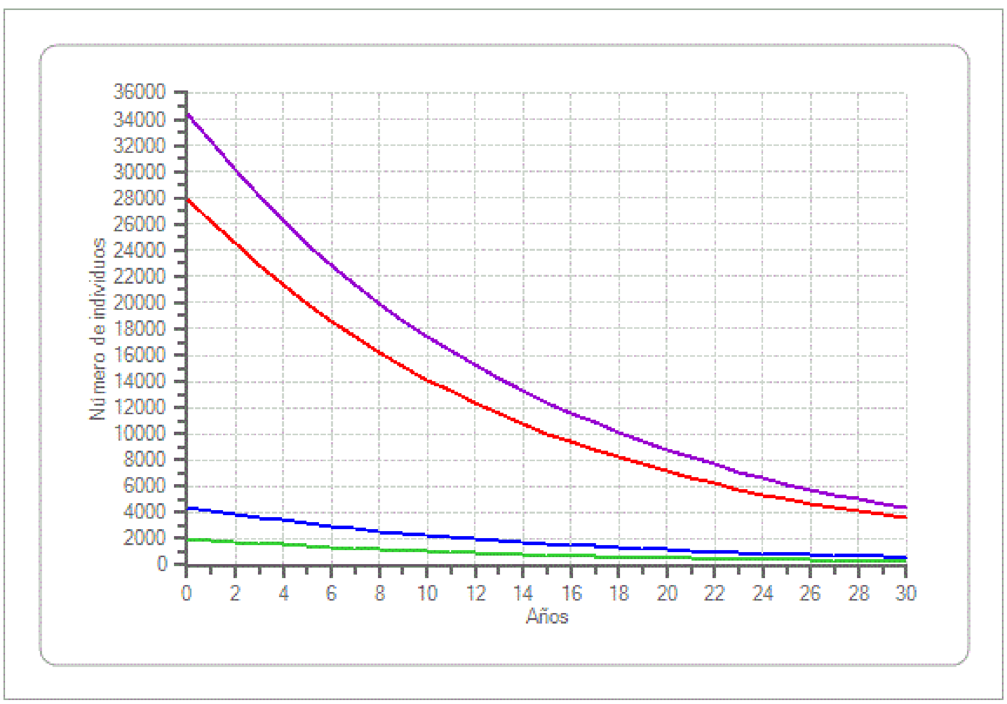


Figure 8.14. Projections of three regional populations in Chile (from top to bottom: metapopulation in purple, central Chile in red, north Chile in blue, and south Chile in green), under an assumption of no dispersal between regions

Figure 8.15 shows projections from a metapopulation model that partitions the species range into three zones of Chile and one combined Peruvian population, with dispersal rates between each pair of regions set at 0%, 1%, 2%, or 3% per year. The total metapopulation size is unaffected by the dispersal rates, and the lines for those 4 scenarios are superimposed. Among the individual regions, the largest population (central Chile) declines slightly faster if there is higher dispersal, because it is acting as a source for the other populations. The two smallest populations (south Chile and north Chile) benefit from dispersal, because they are net recipients of immigrants. The Peruvian population is unaffected by dispersal in this model, because it receives about the same number of immigrants as it loses as emigrants.

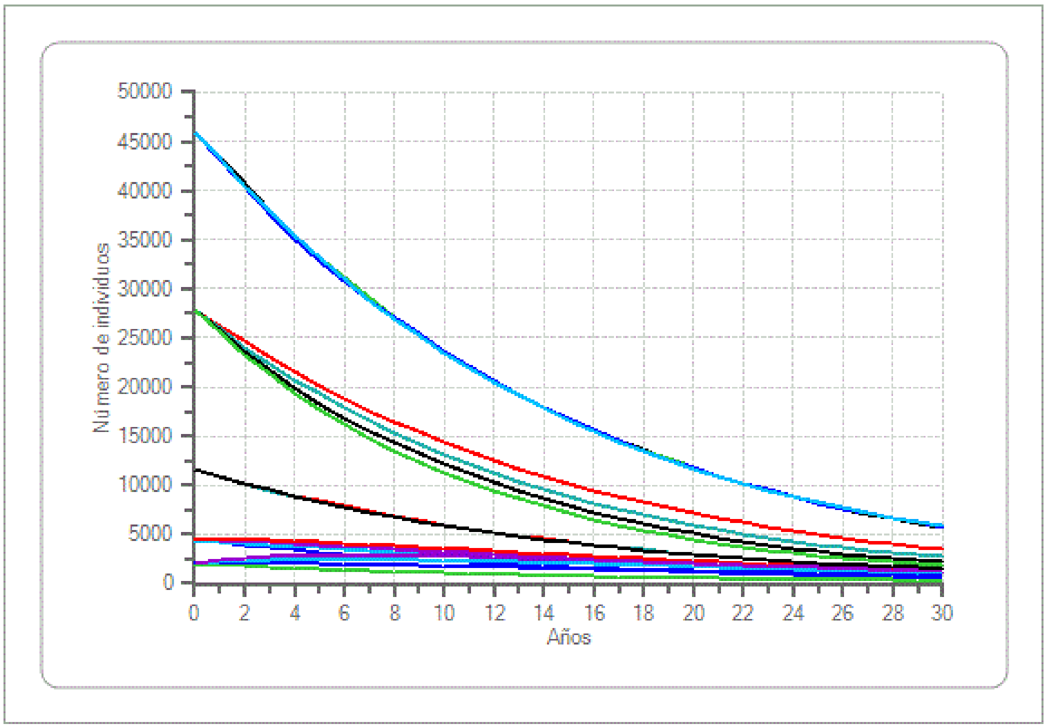


Figure 8.15. Projections of regional populations, with 0%, 1%, 2%, or 3% dispersal between regions. Metapopulation, top lines, with the four lines superimposed and indistinguishable; central Chile, next set of lines, with the order within that set being increasing dispersal from top to bottom; Peru, next set of lines, with the four dispersal rates indistinguishable; north Chile, next set of lines, with the order within that set being decreasing dispersal from top to bottom; south Chile, bottom set of lines, with the order within that set being decreasing dispersal from top to bottom

Examining conservation needs and management options

The baseline scenario that included the best estimates of current demographic rates projects population decline of 7% per year. This projection is not inconsistent with recent census trends. Alternative possible values of demographic rates that could occur in some populations or in some years do yield projections of positive growth. However, overall, the findings of the PVA modeling indicate that the species is probably facing threats that must be addressed.

Implications for Red List assessment

If the projected annual decline of 7% is confirmed by either further census data or by more precise estimates of demographic rates, the species would meet the IUCN criteria A3 (IUCN 2012) for moving from its current threat category of "Vulnerable" (BirdLife International 2018) to "Endangered". With respect to a national assessment for Peru, the country for which we have the more recent estimates of breeding, fledging, and survival rates (from Punta San Juan) and the more complete recent census data (estimated at N = 6,290 in the 2019 molt census), the estimated probability of extinction (defined here as falling below N = 30 penguins) at 3 generations (37.5 years), 5 generations (62.5 years), and 100 years was approximately 0%, 25%, and 98%, respectively. For our analyses, we chose to define "extinction" as the population falling below 30 penguins, because the population would likely be functionally extinct even if a few birds remained. Moreover, the population model did not include factors such inbreeding depression and difficulty finding mates that would make the population highly unstable and unpredictable after it falls below a small number of adult birds. Using the above estimates, the Peruvian population would meet IUCN Criterion E for classification as Endangered. If we instead assess "extinction" as the death of the last penguin, then the model projects 0%, 6%, and 87% probability that no penguins would remain in Peru after 3 generations, 5 generations, or 100 years, respectively. The delay to extinction (with 10% probability reached after 55 years) occurs because, even with the projected decline of 7% per year, a remnant of the current population would persist for about 4 to 6 generations. The projected median population size after 3 generations, 5 generations, and 100 years is about 400 penguins, 60 penguins, and 1 penguin, respectively.

Management needs

After projecting the future trajectory of Humboldt penguin populations under scenarios that represent best estimates of demographic rates and population sizes, further goals for the Population Viability Analyses include identifying the primary threats to the populations and evaluating management options for ameliorating those threats sufficiently to ensure long-term population stability or growth. The PVA modeling results provide indications of the likely primary threats. The recently estimated fledging rate (0.50 / nest) is well below the level (1.0 / nest) that would assure population growth. Reductions in juvenile mortality to less than 33% or adult mortality to substantially less than 5% could result in positive population growth, even without any improvement in the fledging rate. Achieving healthy population growth through improvement of any one factor will be difficult, as the reproductive success would need to be doubled or the mortality rates reduced by half (relative to current estimates) to ensure success. Therefore, management actions might focus first on improving fledging rates, because that is the rate that has varied the most among sites and years and appears to have the greatest influence on variation in the projected rates of population growth. However, the most feasible path to successful protection of the species will likely involve actions that improve all three factors: fledging rate, juvenile survival, and adult survival.

The working groups in the full PHVA workshop identified the kinds of actions that could ameliorate threats, improve demographic trends, and help ensure long-term viability of the species in Peru and Chile. However, given the uncertainty in the current rates and the ecological and anthropogenic drivers of those rates, the PVA workshop did not attempt to model specific management options that might be proposed to achieve the above benefits for the Humboldt penguin populations. Moreover, we do not yet have quantitative estimates of the extent of improvement in demography that might be achieved by any specific management action, and therefore it is not yet possible to predict accurately the likely impacts. It will be important to monitor the responses of the penguin populations both to management actions and to changes in the environment, and then to adjust conservation strategies as necessary to reverse the decline in the species. Therefore, within the Research & Monitoring working group of the PHVA, the focus was on reviewing the PVA models, identifying the key demographic rates that need to be measured in the populations, and planning for a more comprehensive census across the species range.

Summary

- Data on demographic rates (breeding rate, fledging rate, juvenile survival, and adult survival) and population sizes were gathered from published literature and from unpublished data made available by workshop participants and their colleagues.
- Comparable data on the other three *Spheniscus* species were used to help validate information on Humboldt penguins and to provide reasonable estimates when data on the Humboldt penguins was lacking.
- Data from different studies, on different populations, or in different time periods were compared in order to identify plausible ranges of values for demographic rates.
- A population model, using the Vortex PVA simulation software, in which the best estimates of current demographic rates were entered, projected that populations of Humboldt penguins would decline, on average, at 7% per year. This rate of decline is not inconsistent with recent census data.
- The projected rate of population decline and the probability of extinction over the next 5 generations suggest that a change in the IUCN Red List status from Vulnerable to Endangered might be warranted.
- However, both the census data and the uncertainty in demographic rates leave open the possibility that the species is declining faster or more slowly than projected. Moreover, recent trends might not be indicative of long-term patterns, and population trends might be very different in different parts of the species range.
- The fledging rate has been highly variable among studies, sites, and time periods. The highest fledging rates reported (1 chick per nest at PSJ in the 1990s) would result in positive population growth. More recent estimates (0.5 chicks per nest since 2000) result in predictions of population decline. The worst rates observed at a local population (Islote Pájaro Niño, Chile, in 1994-1998, which includes an El Niño year) would result in rapid population decline.
- Positive population growth requires either fledging rates of at least 1 / nest, or reduced juvenile mortality (< 50%) and reduced adult mortality (e.g., 5%), or a combination of improved breeding success and reduced mortality.
- The largest local breeding populations can serve as a source for reinforcing or even recolonizing small populations, but projecting the metapopulation dynamics will require information on site differences in demography and on dispersal rates between sites.
- Although management actions can and should be taken now to improve the prospects for the Humboldt penguin, quantitative analysis of the expected outcomes of specific actions will require additional field studies of the key demographic rates, studies of the differences in rates among colonies, documentation of the changes in rates across years (including El Niño and La Niña years) and understanding of the causes of differences and changes in demography.
- Validation of population trends, any population predictions, and the consequences of management actions will require regular censusing across the species range.

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Humboldt Penguin
Population and Habitat Viability Assessment Workshop
Final Report

Lima, Peru
October 17,18, 21-23
2019

Section 9
Priority Goals and Actions

Photo: J. Reyes

Priority Goals and Actions

During the opening plenary session, the workshop participants brainstormed possible threats to the conservation and population security of Humboldt penguins. During the working group sessions, these were discussed and vetted.

The Fisheries Working Group identified two issues related to industrial and artisanal fisheries as having significant impact on Humboldt penguin populations. The first was fish availability and the extent to which current fishing regulations and practices impact fish availability; lacking specific information on penguin food requirements makes it difficult to determine what impact the variation in different fish stocks has on penguin populations. The second issue revolved around the use of gill nets by artisanal fishermen.

The Population Biology & Demography Working Group focused on identifying data gaps in population numbers and demographic rates required to make predictions of Humboldt penguin population viability. There is insufficient information on factors influencing Humboldt penguin population dynamics; specifically, reproductive success, adult and juvenile mortality, adult and juvenile dispersal, and unknown sex ratios across the Humboldt penguin distribution range. Existent data sets are site-biased because they represent a single colony in Peru and one in Chile. In summary, this working group identified 3 main issues: 1) Lack of standardized data of the total population size; 2) Lack of representative data on breeding/demographic parameters; and 3) Lack of information about penguin movements (dispersal). These data deficiencies are important to address because they create uncertainties about whether current data accurately forecast future population trends.

Ensuring a future for Humboldt penguins will require collaboration and cooperation among government departments, scientists, conservation biologists, and non-governmental organizations. Collaboration and cooperation are possible only when there is good communication among all parties about the current state of knowledge, current government policies that impact the penguins, and engagement of those directly connected to penguin conservation. Group members discussed inadequate levels of public knowledge about the current situation of Humboldt penguin, key causes of decline, work done to the present, and lack of collaboration among different stakeholders. The Communication and Education Working Group focused on creating solutions when information about Humboldt penguin fails to be: 1) available to and shared among stakeholders involved in identifying and ameliorating the main threats to this species, and 2) communicated by researchers with each other and to managers and decision makers.

Humboldt penguins face diverse threats, many of which are human-driven. From the earliest native people or explorers who hunted penguins for their meat and eggs to today's ecotourism operators, fishermen and local communities, the birds experience the pressure of human encroachment into their foraging, breeding and molting areas. The Human Disturbance Working Group focused on human-derived threats in the following categories: tourism; predation and human disturbance; penguin health, marine environmental contamination and infectious disease; and guano harvesting activities.

The four working groups of the Humboldt penguin PHVA collectively developed 14 goals. Because we did not have time during the in-person workshop, we polled the workshop participants through on-line survey to establish priorities among the goals. Each participant was given five votes to distribute among the goals based on which ones they felt would have the greatest impact on conservation of Humboldt penguins. The pattern of votes caused the goals to cluster into three groups: higher, medium and lower priority. (See Figure 9.1 and Table 9.1.)

Although criteria for establishing priorities were not stated prior to voting, those goals receiving the highest number of votes were either already in progress in one form or another or could be implemented relatively quickly. Goals receiving lower numbers of votes were more complex and likely to be realized over a longer time frame or may be narrow in scope.

The higher priority goals include educating the public and engaging them in actions to conserve Humboldt penguins, performing consistent censuses and population monitoring across the range, plus reducing direct ongoing threats to the penguin population, i.e., relieving impacts of predation and human disturbance, and reducing incidental take of penguins in gill nets. However, it must also be noted that some high priority goals were given long timelines for completion; while this may reflect some practical challenges in completing the goal, every consideration should be given to possibilities for shortening timelines for these highest priority goals.

The medium priority goals each build on some existing effort. Goals 6 and 13 build on work being conducted on behalf of Humboldt penguins, whereas Goals 2 and 3 could build upon work being conducted on behalf of sea turtles and dolphins, at least in Peru.

The lower priority goals sorted in such a way that they included longer-term efforts and research projects that will ultimately provide needed information to make future conservation decisions.

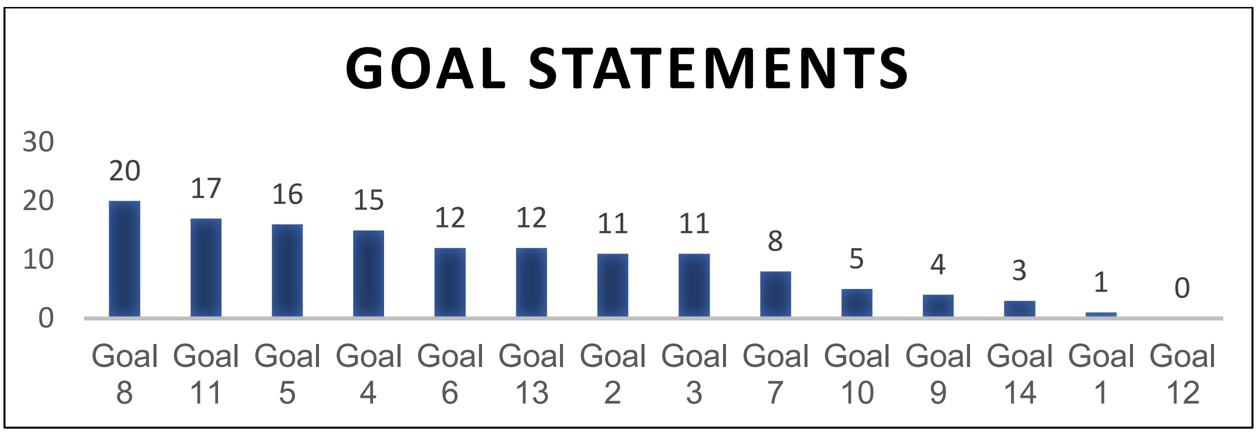


Figure 9.1. Distribution of votes for PHVA working group goals for conservation of Humboldt penguins.

In the process of voting for priority goals, respondents were also asked to indicate their professional affiliations. The 27 PHVA workshop participants who voted on priorities of the conservation action goals were evenly divided among government agencies (9), NGOs (9), and universities or zoos/aquariums (9) (Figure 9.2). This balance provides some assurance that different backgrounds, experiences and expertise were brought to the priority ranking of the goals.

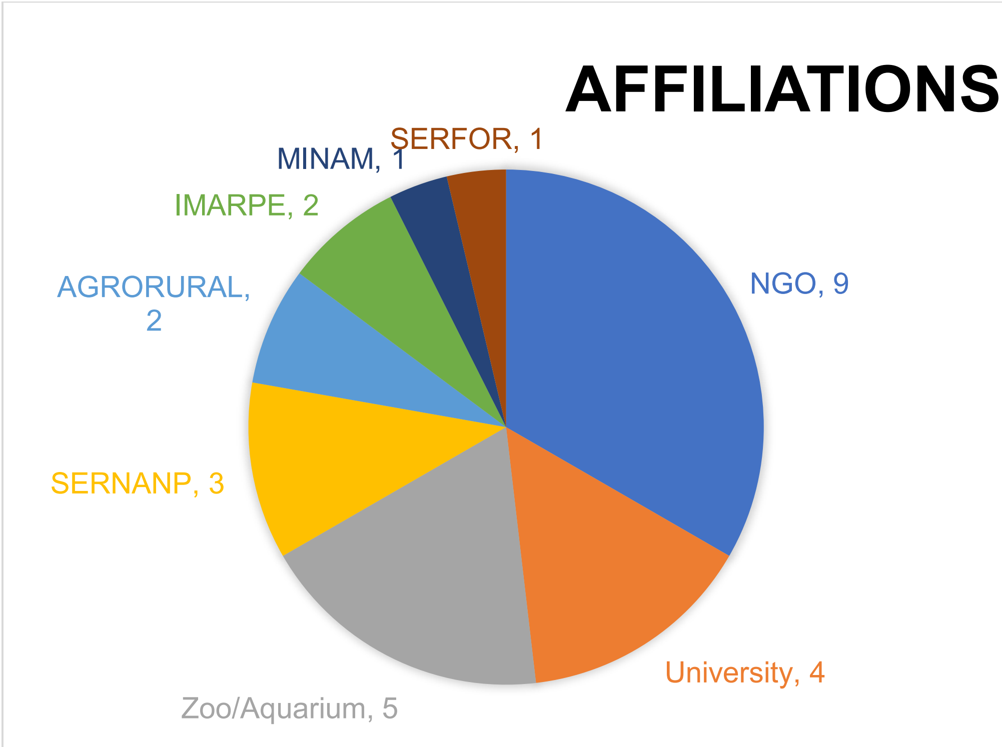


Figure 9.2. Affiliations of online voters among participants in the Humboldt penguin PHVA workshop.

In addition to establishing priorities for the working group goals, we also examined the categories of activities that will be needed in order to accomplish each goal (Table 9.2). For each of the 14 goals, activities were categorized as policy, regulation and management; education; communication and networking; research and investigation; field conservation action; or financial support. In order to make this assessment, all of the objectives and activities under each goal were examined and type of action categorized. Each goal typically involves more than one category of activity in order to fully execute it.

From examining Table 9.2, it is clear that most of the goals (13 out of 14 goals) require communication and networking with stakeholders. This is a skill set in which CPSG specializes and provides training; many groups and persons also have clear skill in communication and collaborative problem-solving. In addition to finding best practices in research and conservation action, skill among stakeholders in the interpersonal work should be recognized and endorsed; fine-tuning skill within stakeholders could enhance conservation progress.

Other underlying skills are also needed, as seen in Table 9.2. Ten goals will need at least some research or background/topic investigation; 7 goals involve policy, regulation and management activities. Eight of the goals list finding financial support among the needed activities.

Another way to assess the work needed to conserve Humboldt penguins is to examine the priority goals that are intended for completion within the next two years—both important and urgent. Goals 4, 5, 8, 2 and 3 fall in this group. Three of these (4, 2, and 3) involve threats and solutions around the gill net fishery. Also important and urgent are educating and engaging public audiences and developing a consistent, effective census. Goal 9, collaboration and networking among researchers/managers, was considered lower priority but has a short timeline to implementation; this goal also deserves immediate attention because it could greatly facilitate accomplishing other goals, particularly if biologists working on other *Spheniscus* species were also invited to share their expertise and solutions.

As described in Appendix IX, an oversight and monitoring team will communicate with working groups to monitor progress and promote reporting among the parties.

A careful review of both Tables 9.1 and 9.2 will be effective in directing or suggesting productive approaches to conservation of Humboldt penguins. Stakeholders interested in promoting such conservation can examine the tables, study the priority goals and see where their own talents, expertise and abilities may be best applied. Additional volunteers for the conservation priorities are encouraged and may contact PHVA participants to become involved; in each of the working group sections the participants in the working group are listed, the key persons responsible for each objective are provided in the tables, and contact information is provided in Appendix VII.

Photo: P. McGill

Table 9.1. Results of voting on priority goals from Humboldt penguin PHVA, October 2019. Of 44 participants in the workshop, 27 votes were received in the online vote.

GOALS DEVELOPED DURING HUMBOLDT PENGUIN PHVA WORKSHOP, OCTOBER 2019	VOTES	% OF 27 RESPONSES
Higher priority		
Goal 8: Educate and engage the public about the threats to Humboldt penguins and how individuals can help conserve them. Meta 8. Educar e involucrar al público sobre las amenazas al pingüino de Humboldt y cómo las personas pueden ayudar a conservarlo.	20	74.04%
Goal 11: Reduce predation impacts and human disturbance on Humboldt penguin colonies. Meta 11. Reducir los impactos de la depredación y la perturbación humana sobre las colonias de pingüinos.	17	62.96%
Goal 5: Consistent census across range. Meta 5. Censos consistentes a lo largo del rango.	16	59.26%
Goal 4: Promote the spatial and temporal regulation of the gill net fishery to minimize overlap with peak penguin foraging periods. Meta 4. Promover una regulación espacial y temporal de la pesquería con redes agalleras para minimizar la superposición con los picos de periodos de alimentación de los pingüinos.	15	55.56%
Medium priority		
Goal 6: Increase representation of other colonies, in addition to Punta San Juan (Peru) and Algarrobo (Chile) in long-term monitoring of reproductive success in Chile and Peru. Meta 6. Incrementar la representación de otras colonias, además de Punta San Juan (Perú) y Algarrobo (Chile) en monitoreos de largo plazo del éxito reproductivo en Chile y Perú.	12	44.44%
Goal 13: Continue refinement of sustainable guano harvesting practices in Peru and Chile and research how granza might be utilized. Meta 13. Continuar mejorando las prácticas de extracción sostenible de guano en Perú y Chile, e investigar formas de utilización de la granza de guano.	12	44.44%
Goal 2: Improve the design of the gill nets to reduce penguin mortality while at the same time maintaining fishing efficiency. Meta 2. Mejorar el diseño de las redes agalleras para reducir la mortalidad de pingüinos sin afectar la eficiencia de la pesca.	11	40.74%
Goal 3: Develop and promote the use of best practice guidelines for the gill net fishery. Meta 3. Desarrollar y promover el uso de guías para mejores prácticas en la pesquería con redes agalleras.	11	40.74%

Table 9.1 continued		
Lower priority		
Goal 7: Increase knowledge individual dispersal during the breeding season, non-breeding season, dispersal of juveniles (birds in juvenile plumage), and across years (e.g., El Nino/ENSO cycles). Meta 7. Incrementar el conocimiento sobre dispersión de individuos durante las épocas reproductiva y no reproductiva, así como la dispersión de juveniles (aves con plumaje juvenil) y entre años (por ejemplo, durante los ciclos de eventos El Niño/ENSO).	8	29.63%
Goal 10: Decrease tourism impacts on Humboldt penguins Meta 10. Disminuir los impactos del turismo sobre los pingüinos de Humboldt.	5	18.52%
Goal 9: Increasing the level of collaboration among Humboldt penguin researchers. Meta 9. Incrementar el nivel de colaboración entre los investigadores del pingüino de Humboldt.	4	14.81%
Goal 14: Reduce the impacts of illegal harvesting of guano. Meta 14. Reducir los impactos de la saca ilegal de guano.	3	11.11%
Goal 1: Determine the food and energetic requirements for penguins. Meta 1. Determinar los requerimientos alimenticios y energéticos de los pingüinos.	1	3.70%
Goal 12: Decrease the impacts of environmental contamination and disease on Humboldt penguin populations. Meta 12. Disminuir los impactos de la contaminación ambiental y enfermedades en las poblaciones de pingüino de Humboldt.	0	0.00%

Total Respondents: 27

Table 9.2. CATEGORIES OF ACTIVITY required in order to successfully complete goals for conservation of Humboldt penguins. Policy, Regulation & Management (**PRM**), Education (**Ed**), Communication & Networking (**CN**), Research & Investigation (**RI**), Financial Support (**FS**), Field Action (**FA**) such as repairing walls, controlling predators, etc. TARGET DATES are designated by quarter of the year (Q1= January-March, Q2=April-June, etc.)

GOALS DEVELOPED DURING HUMBOLDT PENGUIN PHVA WORKSHOP, OCTOBER 2019	TARGET DATE	CATEGORIES OF ACTIVITY
Higher priority		
Goal 8: Educate and engage the public about the threats to Humboldt penguins and how individuals can help conserve them. Meta 8. Educar e involucrar al público sobre las amenazas al pingüino de Humboldt y cómo las personas pueden ayudar a conservarlo.	Q1, 2023	Ed, CN, FS
Goal 11: Reduce predation impacts and human disturbance on Humboldt penguin colonies. Meta 11. Reducir los impactos de la depredación y la perturbación humana sobre las colonias de pingüinos.	Q4, 2025	FA, FS, CN, RI
Goal 5: Consistent census across range. Meta 5. Censos consistentes a lo largo del rango.	Q4, 2022	FA, FS, CN
Goal 4: Promote the spatial and temporal regulation of the gill net fishery to minimize overlap with peak penguin foraging periods.	Q2, 2022	CN, RI, PRM

Meta 4. Promover una regulación espacial y temporal de la pesquería con redes agalleras para minimizar la superposición con los picos de periodos de alimentación de los pingüinos.		
Medium priority		
Goal 6: Increase representation of other colonies, in addition to Punta San Juan (Peru) and Algarrobo (Chile) in long-term monitoring of reproductive success in Chile and Peru. Meta 6. Incrementar la representación de otras colonias, además de Punta San Juan (Perú) y Algarrobo (Chile) en monitoreos de largo plazo del éxito reproductivo en Chile y Perú.	Q4, 2023	RI, CN, FS
Goal 13: Continue refinement of sustainable guano harvesting practices in Peru and Chile and research how granza might be utilized. Meta 13. Continuar mejorando las prácticas de extracción sostenible de guano en Perú y Chile, e investigar formas de utilización de la granza de guano.	Q4, 2024	FA, PRM, RI, CN
Goal 2: Improve the design of the gill nets to reduce penguin mortality while at the same time maintaining fishing efficiency. Meta 2. Mejorar el diseño de las redes agalleras para reducir la mortalidad de pingüinos sin afectar la eficiencia de la pesca.	Q1, 2023	CN, RI, PRM
Goal 3: Develop and promote the use of best practice guidelines for the gill net fishery. Meta 3. Desarrollar y promover el uso de guías para mejores prácticas en la pesquería con redes agalleras.	Q1, 2023	CN, RI, PRM
Lower priority		
Goal 7: Increase knowledge individual dispersal during the breeding season, non-breeding season, dispersal of juveniles (birds in juvenile plumage), and across years (e.g., El Nino/ENSO cycles). Meta 7. Incrementar el conocimiento sobre dispersión de individuos durante las épocas reproductiva y no reproductiva, así como la dispersión de juveniles (aves con plumaje juvenil) y entre años (por ejemplo, durante los ciclos de eventos El Niño/ENSO).	Q2, 2024	RI, FS
Goal 10: Decrease tourism impacts on Humboldt penguins Meta 10. Disminuir los impactos del turismo sobre los pingüinos de Humboldt.	Q4, 2025	CN, PRM, RI, Ed
Goal 9: Increasing the level of collaboration among Humboldt penguin researchers. Meta 9. Incrementar el nivel de colaboración entre los investigadores del pingüino de Humboldt.	Q1, 2022	CN, FS
Goal 14: Reduce the impacts of illegal harvesting of guano. Meta 14. Reducir los impactos de la saca ilegal de guano.	Q4, 2024	CN, PRM
Goal 1: Determine the food and energetic requirements for penguins. Meta 1. Determinar los requerimientos alimenticios y energéticos de los pingüinos.	Q2, 2023	RI, CN, FS
Goal 12: Decrease the impacts of environmental contamination and disease on Humboldt penguin populations. Meta 12. Disminuir los impactos de la contaminación ambiental y enfermedades en las poblaciones de pingüino de Humboldt.	Q2, 2024	RI, FS, CN

Humboldt Penguin
Population and Habitat Viability Assessment Workshop
Final Report

Lima, Peru
October 17,18, 21-23
2019

Appendix I
Glossary of Acronyms, Agencies and Organizations

ACOREMA	Áreas Costeras y Recursos Marinos, Peru.
AGRO RURAL	Programa de Desarrollo Productivo Agrario Rural.
CONAF	Corporación Nacional Forestal, Chile.
CSA-UPCH	Centro para las Sostenibilidad Ambiental-Universidad Peruana Cayetano Heredia, Peru.
CPSG	International Union for Conservation of Nature, Species Survival Commission, Conservation Planning Specialist Group (formerly called CBSG, Conservation Breeding Specialist Group).
CZS	Chicago Zoological Society, USA.
DICAPI	Dirección de Capitanías y Guardacostas, Peru.
DIGESA	Dirección General de Salud Ambiental, Ministerio de Salud, Peru.
IMARPE	Instituto del Mar del Peru.
IUCN	International Union for the Conservation of Nature; also UICN La Unión Internacional para la Conservación de la Naturaleza.
MINAM	Ministerio del Ambiente, Peru.
MINEDU	Ministerio de Educación, Peru.
PNP	Policía Nacional del Peru.
PROABONOS	El Proyecto Especial de Promoción del Aprovechamiento de Abonos provenientes de Aves Marinas (now replaced by AGRO RURAL).
PRODUCE	Ministerio de la Producción, Peru.
PSJ	Proyecto Punta San Juan, located at Reserva Punta San Juan, Marcona, Peru; office at UPCH (above).
RNP	La Reserva Nacional de Paracas.
RNSIIPG	Reserva Nacional Sistema de Islas, Islotes y Puntas Guaneras.
SERNANP	Servicio Nacional de Áreas Marinas Protegidas, Peru.
SERFOR	Servicio Nacional Forestal y de Fauna Silvestre, Peru.
UCSUR	Universidad Científica del Sur. Peru.

Humboldt Penguin
Population and Habitat Viability Assessment Workshop
Final Report

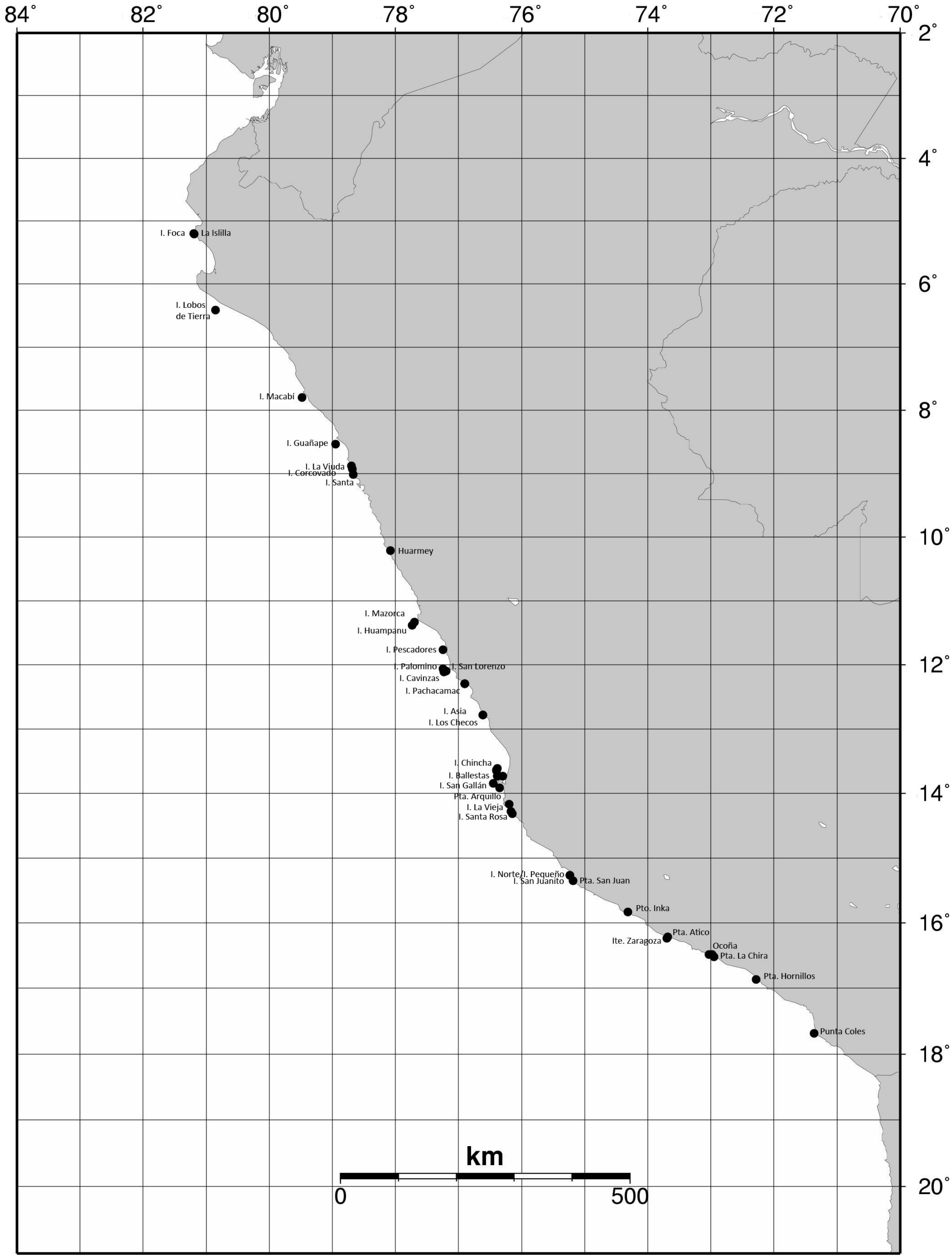
Lima, Peru
October 17,18, 21-23
2019

Appendix II
Maps

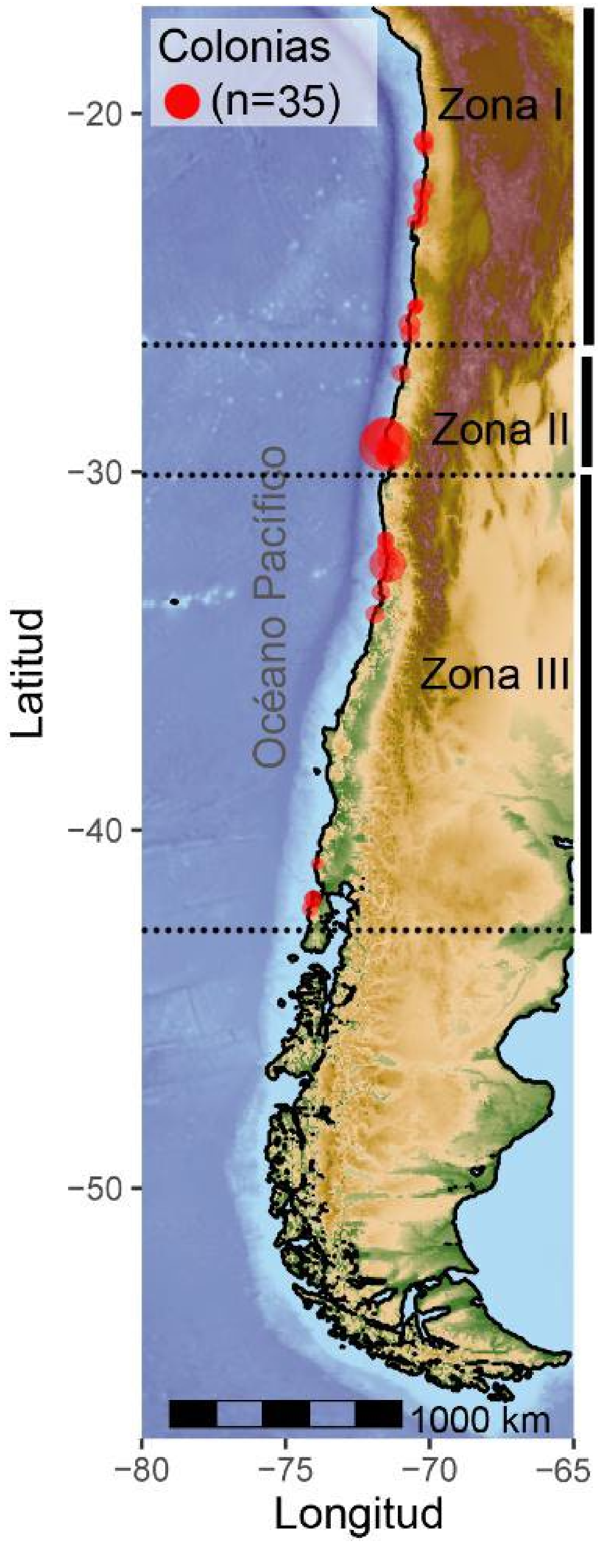
Google Earth, imagery date 12/13/15

Peru: Islas, Islotes & Puntas Guaneras Reserve: stronghold of Humboldt penguin distribution
Source: SERNANP

Peru: Map with penguin sites from 2018 molt census



Distribution of Humboldt penguins in Chile.
Relative abundance of penguins at each site is indicated by size of red circle.
Source: Simeone et al. 2018.



Humboldt Penguin
Population and Habitat Viability Assessment Workshop
Final Report

Lima, Peru
October 17,18, 21-23
2019

Appendix III
Seabird Important Bird Areas (IBAs) in Peru & Chile

Photo: P. McGill

Data Zone

Search terms
Country/Territory = Peru
Marine sites only;
Ordered by Country, Site Name

Number of sites 8

Country/Territory	Site name	IBA Criteria	Final Code
Peru	Isla Foca	A1, A4ii	PE011
Peru	Isla Lobos de Afuera	A1	PE015
Peru	Isla Lobos de Tierra	A1, A4ii	PE014
Peru	Isla Pachacámac	A1, A4ii	PE035
Peru	Laguna de Ite	A1, A2, A3, A4i, A4iii	PE048
Peru	Pantanos de Villa	A4i	PE034
Peru	Reserva Nacional de Paracas	A1, A2, A3, A4i, A4ii	PE038
Peru	Río Tambo y Lagunas de Mejía	A1, A2, A3, A4iii	PE046

http://datazone.birdlife.org/site/results?cty=166&fam=0&gen=0&stmar=Y Peru

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Data Zone

Search terms
Country/Territory = Chile
Marine sites only;
Ordered by Country, Site Name

Number of sites 58

Country/Territory	Site name	IBA Criteria	Final Code
Chile	Acantilados de Arica/ Guaneras de Camaraca	A1, A4ii	CL008
Chile	Acantilados de la Quirilluca	A4ii	
Chile	Bahía de Mejillones	A1, A4i	CL017
Chile	Chacalluta	A1, A4i	
Chile	Chepu River Reserve	A4i	
Chile	Costa sur de Arica	A1, A4i	CL005
Chile	Cuevas de Anzota	A1	
Chile	Desembocadura del Río Lluta	A1, A4i, A4iii	CL003
Chile	Estero Compu	A4i	
Chile	Estero Mantagua y Desembocadura del Río Aconcagua	A1, A4i	CL035
Chile	Estuario de Maullín y Cerro Amortajado	A1, A4i	CL075

Chile	Guamblin Island	A1, A4ii, A4iii	
Chile	Guaneras de Camaraca	A1	
Chile	Guaneras de Cutipa	A1	
Chile	Guaneras sur de Camarones	A1	
Chile	Isla Alejandro Selkirk (Parque Nacional Archipiélago de Juan Fernández, Isla Alejandro Selkirk IBA)	A1, A2, A3, A4ii, A4iii	CL043
Chile	Isla Chañaral	A1, A4ii	CL026
Chile	Isla Diego de Almagro	A1, A4ii	CL097
Chile	Isla Doña Sebastiana Punta Chocoi y Roqueríos adyacentes	A1, A4i	CL077
Chile	Isla Grande de Atacama	A1, A4ii	CL023
Chile	Isla Guafo	A1, A4ii, A4iii	CL093
Chile	Isla Magdalena National Park	A1, A4i, A4ii, A4iii	CL103
Chile	Isla Maiquillahue	A1, A4i	CL069
Chile	Isla Mocha	A1, A2, A4ii	CL061
Chile	Isla Noir	A1, A2, A3, A4ii, A4iii	CL109
Chile	Isla Pájaro Niño de Algarrobo	A1, A4ii	CL038
Chile	Isla Sala y Gómez	A1, A4i, A4ii	
Chile	Isla Santa María	A1, A4i	
Chile	Isla Tilgo	A1, A4ii	CL028
Chile	Islas Desventuradas	A1, A4ii	CL019
Chile	Islas Diego Ramírez y Rocas Norte	A1, A4ii, A4iii	CL112
Chile	Islas Ildefonso	A1, A4ii, A4iii	CL111

Chile	Islote Albatros - Seno Almirantazgo	A1	CL110
Chile	Islote Huentellao	A1	
Chile	Islote Leonard	A1	CL108
Chile	Islote Pupuya	A1	
Chile	Islotes Evangelistas	A1	CL099
Chile	Islotes Pajaros	A1, A4, B1a, B3b	CL029
Chile	Monumento Natural Isla Cachagua	A1, B1a	CL034
Chile	Monumento Natural Isla Contramaestre	A1	
Chile	Nigue	A1, A4i	
Chile	Parque Nacional Archipiélago de Juan Fernández: Islas Robinson Crusoe and Santa Clara	A1, A2, A3, A4ii	CL044
Chile	Parque Nacional Cabo de Hornos	A1, B1a	CL113
Chile	Parque Nacional Hornopirén	A1	
Chile	Parque Nacional Pan de Azúcar	A1, A4, B1a, B3a	CL020
Chile	Parque Tumbes Talcahuano	B1a	CL051
Chile	Pingüinera del Seno Otway	A1, A2	CL104
Chile	Playa Hornitos	A1	CL016
Chile	Playa las Machas	A1, A4i	
Chile	Puaucho	A1, A4i	
Chile	Puerto de Arica	A1, A4i, A4iii	
Chile	Puerto Viejo	A1	CL024
Chile	Punta Corona	A1, A4i	CL079

Chile	Punta Ronca	A1, A4i	CL068
Chile	Quinchele Inland and surrouding sea	A1	
Chile	Reserva Nacional Pingüino de Humboldt - Isla Choros, Damas y Punta de Choros	A1, A3, A4, B1a, B3a	CL027
Chile	Santuario de la Naturaleza Península de Hualpén	A4, B1a	CL053
Chile	Santuario de las Aves Bahía de Caulín	A1, A4i	CL080

http://datazone.birdlife.org/site/results?cty=43&fam=0&gen=0&stmar=Y Chile

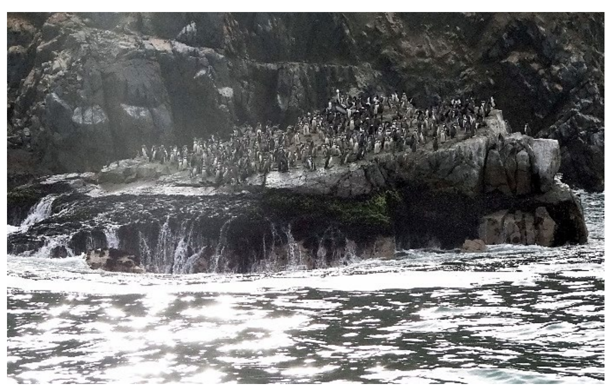
Humboldt Penguin
Population and Habitat Viability Assessment Workshop
Final Report

Lima, Peru
October 17,18, 21-23
2019

Appendix IV
Populations of Molting Humboldt Penguins in Chile and Peru

Photo: R. Tardito

Photo: ACOREMA. Team Paracas.



Photos: P. McGill

Humboldt Penguin counts conducted in the Chilean coast during February 1999-2008. Main breeding colonies underlined.

(Wallace and Araya 2015)

Location	Latitude	Longitude	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Mean	Range
Zone I														
Cueva del Caballo	20º07'44.2"S	70º08'04.8"W	152	143	19	88	18	175	2	--	--	45	57.8	0-175
Punta Pierna Gorda	20º06'28,6"S	70º07'49,3"W	0	15	74	57	77	0	95	--	--	33	56.0	0-95
Patillo Islet	20º44'57,9"S	70º11'49,3"W	0	0	54	0	18	14	30	75	113	96	50.0	0-113
Punta Patache, Islet	20º48'35,1"S	70º12'0,58"W	302	113	172	354	154	168	253	117	566	158	242.8	117-566
Guanillos Islet	21º58'11,6"S	70º11'02,7"W	19	21	32	13	19	2	0	27	21	0	14.3	0-32
Algodonales Islets	22º05'47,2"S	70º12'37,1"W	967	1,153	942	1,171	1,697	803	1,459	1,900	3,299	2,984	1,781,9	803-3,299
South of Cobija Islets	22º35'51,8"S	70º16'29,1"W	81	8	0	428	11	149	44	264	547	269	214.0	0-547
Islet in Punta Tames	22º40'55,7"S	70º16'43,2"W	29	113	94	166	67	320	322	215	323	223	216.3	67-323
Angamos Islet	23º01'06,5"S	70º31'14,4W	267	61	30	235	228	182	293	132	161	127	173.5	30-293
El Chango Islet	23º05'20,0"S	70º34'27,0"W	291	178	132	133	2	13	0	0	62	155	62.1	0-155
Punta Foque	23º08'52,0"S	70º34'19,7"W	38	21	0	0	0	0	0	--	--	--	0	--
off Punta Plata Islet*	24º43'02,9"S	70º34'40,7"W	114	107	84	42	114	--	--	--	--	--	80,0	42-114
Afuera Islet off Pta. Taltal	25º23'27,9"S	70º30'51,7W	78	8	29	55	26	21	24	14	15	15	24.9	14-55
Punta Taltal off Islets	25º23'22,3"S	70º30'57,3 W	0	8	166	1,280	593	838	1,164	1,312	1,022	715	886.3	166-1,312
Blancos Islets	25º28'53,7"S	70º33'14,3"W	571	453	21	116	12	35	228	1,972	101	152	329.6	12-1,972
Punta San Pedro Islets	25º30'40,9"S	70º37'55,2"W	27	103	78	243	113	117	344	570	351	273	261.1	78-570
Tórtolas Islets	25º31'30,4"S	70º38'31,0"W	0	1	0	0	0	0	0	0	0	0	0	--

Zone II													
Pan de Azúcar Is.	26º09'20"S	70º41'20"W	2,773	3,048	4,246	2,913	2,861	3,026	3,520	6,214	6,281	7,615	4584.5	2,861-7,615
Grande Is.	27º14'24,2"S	70º58'13,9"W	249	3,265	2,270	3,830	3,270	5,244	3,475	4,224	5,036	4,028	3922.1	2,270-5,244
Chañaral Is.	29º01'37,1"S	71º35'13,4"W	8,757	15,214	14,894	15,184	19,132	15,011	11,417	9,518	8,319	8,671	12,768.3	8,319-19,132
Damas Is.	29º13'40"S	71º32'00"W	1	25	58	19	23	8	28	6	4	2	18.5	2-58
Choros Is.	29º15'43,4"S	71º32'15,4"W	1,728	1,475	1,663	2,136	1,364	1,509	1,911	1,888	1,738	2,341	1,818.8	1,364-2341
Tilgo Is.	29º32'30,5"S	71º20'18,4" W	1,729	--	--	--	--	1,769	2,246	2,319	2,750	2,252	2,267.2	1,769-2750
Pájaros 2 Is.*	29º30'20"S	71º30'06"W	1,000											1,000*
Pájaros 1 Is.	29º35'39,1"S	71º28'18,5"W	3,640	--	1,007	3,426	4,014	2,855	2,597	1,906	1,595	2,921	2,540.1	1,007-4014
Lengua de Vaca Point*	30º14'S	71º37'30"W	100	--	--	--	--	--	--	--	--	--		100*
Zone III													
Cachagua Is.	32º35' S	71º27' W	1,452	1,093	1,737	568	--	1,041	981	1,624	1,879	1,499	1,332.7	568-1,879
Concón Is.	32º53'20"S	71º31'15"W	13	42	120	55	72	20	108	132	144	225	109.5	20-225
Pájaro Niño former Is.	33º21'21,5"S	71º41'07,6"W	1,018	1,600	740	461	443	278	481	778	898	485	570.5	278-898
Mocha Is.*	38º23'00"S	73º55'00"W	0	--	--	--	--	--	--	--	--	--	--	0*
Puñihuil Islets*	41º55'S	74º02'W	94	--	--	--	--	--	--	--	--	--	--	94*
Total 1999-2008			25,490	28,268	28,642	32,973	34,328	33,598	31,022	35,207	35,225	35,284	33,284.8	28,642-35,284

* Sites visited only once and no estimates were done. Averages were calculated only for 2001-2008 data.

-- Site not visited, not included in calculation of mean

Humboldt Penguin Molt Census: Peru 1999-2010--1
Single count each site
P. McGill, J. Reyes, A. Tieber, M. Cardeña, unpublished data.

Colonia/ Sitio de muda	Latitud (S)	Longitud (O)	Número de pingüinos 1999[1]	Número de pingüinos 2000[2]	Número de pingüinos 2003	Número de pingüinos 2004	Número de pingüinos 2007	Número de pingüinos 2008	Número de pingüinos 2009	Número de pingüinos 2010
Punta Coles	17º41.9'	71º22.5'	178	81	184	59				460
Platanales	17º23.8'	71º23.6'	0		0	0				
Cocotea	17º15.4'	71º33.1'	103	57	45	0				
Punta Cordel			21			48				
Punta Corio	17°14.9’	71°35.7’	9		0	0				
Isla Islay	17°00.6’	72º07.2'	0		NC	21				
Tarpuy	16º58.3'	72º12.4'	6	0		0				
Carrizales	16º54.6'	72º17.3'	23	0		14				
Punta Hornillos	16º52.3'	72º17.3'				102				46
Isla Hornillos	16º52.7'	72º17.2'	512	190		124				197
Honoratos	16º51.5'	72º17.4'	4	8		0				0
Caleta Quilca	16º42.8'	72º26.1'	15	0		8				
La Chilcanera	--	--								
Punta La Chira	16º31.1'	72º56.2'	6	0	0	0				
La Lancha	16º31.0’	72º57.8’								
Punta La Norte	16º30.9'	72º56.6'	4	0						
Punta Caleta	16º30.8'	72º59.0'	93	89	82	67				
Ocoña área (desde Caleta del Inca)	16º29.9'– 16º30.9'	72º59.1'– 73º02.7'								
Cueva Saltadero	16º29.9'	73º02.5'								

Humboldt Penguin Molt Census: Peru 1999-2010--2										
Colonia/ Sitio de muda	**Latitud (S)**	**Longitud (O)**	**1999[1]**	**2000[2]**	**2003**	**2004**	**2007**	**2008**	**2009**	**2010**
La Planchada	16º24.7'	73º13.4'								148
Islote Zaragoza	16º14.6'	73º42.2'								
Punta Atico	16º13.8'	73º41.8'		0	0	0				0
Sombrerillo	15º29.9'	74º56.8'	113	0	34	41				
El Submarino	15º29.3'	74º58.6'		0	0	0				
Puerto Inka	15º50.9'	74º19.4'								35
Punta San Juan	15º21.7'	75º11.3'	1631	1525	1545	627	630	1809	1504	3926
Islote San Juanito	15º16.4'	75º14.3'	505	468	532	378		225	788	2120
Islote Norte						308	256	88	354	947
Islote Pequeño	15º16.3'	75º14.5'						34		
Punta Gallinazo	15º09.4'	75º28.9'	0	2	9	4				
San Fernando Is.	15º09.0'	75º21.2'	3	12	NC	42				67
Punta Vera	15º08.8'	75º22.3'		0	1	3				
Pinguinera	15º03.2'	75º24.7'			0	0				
Santa Rosa	14º19.2'	76º09.5'	0	1	276	NC	212	771	1128	2335
Islote Pan de Azúcar	---	---								
Isla La Vieja	14º17.2'	76º10.6'	0	0	146	NC	60	60	165	349
Tres Puertas	14º10.4'	76º12.8'	220	450	110	NC	155	190	NC	112
Bajada Blanca	14º10.4'	76º12.8'							8	
Mendieta-Paracas	14º03.6'	76º16.4'	15	0	0			0		
Punta El Arquillo	13º55.3'	76º21.4'								183
Isla San Gallán	13º51.2'	76º27.7'	191	109	108	101	57	86	149	215
Tambillo	13º50.6'	76º23.2'	3	3	0	0				
Culebras	13º50.0'	76º22.8'	46		0	0				
Isla Blanca	13º44.2'	76º18.7'								

Humboldt Penguin Molt Census: Peru 1999-2010--3										
Colonia/ Sitio de muda	**Latitud (S)**	**Longitud (O)**	**1999[1]**	**2000[2]**	**2003**	**2004**	**2007**	**2008**	**2009**	**2010**
Isla Ballestas Sur	13º44.5'	76º23.8'							132	294
Isla Ballestas Centro	13º44.2'	76º23.7'					160	140	47	237
Isla Ballestas Norte	13º44.0'	76º23.8'	79	97	70	98	115	86	108	69
Isla Chincha Sur	13º38.9'	76º24.3'		73	0	31	88	78	185	85
Isla Chincha Centro	13º38.8'	76º24.1'		0	40	26	49	45	56	173
Isla Chincha Norte	13º37.9'	76º23.5'	0	18	44	111	327	527	810	810
Peru LNG breakwater										
Isla Asia	12º47.2'	76º37.4'	0		163	183		131	225	482
Islote Los Checos	12º47.2'	76º37.4'						29	0	144
Santa María	12º18.1'	76º54.0'	0	3						
Pucusana					17					
Isla Pachacamac	12º18.0'	76º54.2'	230	297	652			333	499	619
Islote San Francisco	12º18.0'	76º54.2'							65	494
Islote Farallones	12º18.0'	76º54.2'								
Isla San Lorenzo	12º04.0'	77º15.2'								462
Isla Las Cavinzas	12º06.9'	77º12.5'							487	23
Islas Palomino	12º07.7'	77º14.0'								
Islas Pescadores	11º46.3'	77º15.7'								
Isla Huampanú	11º20.0'	77º42.3'								
Isla Chuquitanta										
Islote Lobera										
Isla Mazorca	11º23’	77º44.7								
Huarmey (zona costera)	10º13' -	78º5.4' -							141	79
Huarmey (cueva)	10º16'	78º5.9'							78	118
Isla Chao										

Humboldt Penguin Molt Census: Peru 1999-2010--4										
Colonia/ Sitio de muda	**Latitud (S)**	**Longitud (O)**	**1999[1]**	**2000[2]**	**2003**	**2004**	**2007**	**2008**	**2009**	**2010**
Isla Santa	9º01.9’	78º40.6								
Islote Corcovado	8º56.5’	78º41.8’								
Isla de la Viuda	8º53.3’	78º42.5’								
Isla Guañape Sur										
Isla Guañape Norte	8º32.7’	78º57.8	20							
Islas Macabí	7º48.8’	79º29.9								
Isla Lobos de Afuera										
Isla Lobos de Tierra	6º25.7’	80º51.5’								
La Islilla										
Aguja	5º41'		20							
Isla Foca	5º12.6’	81º12.4’	20							
TOTAL			4070	3483	4058	2396	2121	4632	6929	15229
Date span for census			13-22 de enero	17-28 de enero	18-31 de enero	18-28 de enero	18-20 de febrero	16-23 de febrero	6-17 de febrero	15-29 de enero

1 Paredes, Battistini & Majluf, unpubl. data
2 Zavalaga, Paredes & Majluf, unpubl. data

Part 2: Humboldt Penguin Molt Census: Peru 2011-2020—1
Single count each site
P. McGill, J. Reyes, A. Tieber, M. Cardeña, unpublished data.

<table>
<tr><th>Colonia/ Sitio de muda</th><th>Número de pingüinos 2011</th><th>Número de pingüinos 2012</th><th>Número de pingüinos 2013</th><th>Número de pingüinos 2014</th><th>Número de pingüinos 2015</th><th>Número de pingüinos 2016</th><th>Número de pingüinos 2017</th><th>Número de pingüinos 2018</th><th>Número de pingüinos 2019</th><th>Número de pingüinos 2020</th></tr>
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<tr><td>Carrizales</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Punta Hornillos</td><td>50</td><td></td><td>133</td><td>79</td><td rowspan="2">403</td><td>99</td><td>49</td><td>41</td><td>54</td><td></td></tr>
<tr><td>Isla Hornillos</td><td>172</td><td>337</td><td>331</td><td>273</td><td>261</td><td>211</td><td>133</td><td>150</td><td></td></tr>
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<tr><td>El Submarino</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Puerto Inka</td><td>7</td><td>11</td><td></td><td>12</td><td>10</td><td>5</td><td>13</td><td>15</td><td>15</td><td></td></tr>
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<tr><td>Islote Norte</td><td>1238</td><td rowspan="2">1089</td><td>404</td><td>114</td><td rowspan="2">717</td><td>523</td><td>528</td><td>358</td><td>337</td></tr>
<tr><td>Islote Pequeño</td><td>75</td><td>84</td><td>13</td><td>82</td><td>74</td><td>69</td><td>110</td></tr>
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<tr><td>Isla San Gallán</td><td>NC</td><td>443</td><td>383</td><td>406</td><td>377</td><td>485</td><td>451</td><td>300</td><td>NC</td><td>746</td></tr>
<tr><td>Tambillo</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Culebras</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Isla Blanca</td><td></td><td></td><td></td><td></td><td></td><td></td><td>73</td><td>63</td><td>45</td><td>35</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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Part 2: Humboldt Penguin Molt Census: Peru 2011-2020—3

Colonia/ Sitio de muda	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Isla Ballestas Sur	99	86	153	8	11	3	12	14	14	13
Isla Ballestas Centro	252	240		72	56	109	49	114	44	97
Isla Ballestas Norte	286	328	203	25	19	1	2	0	0	1
Isla Chincha Sur	274	203	225	80	31	8	14	15	16	23
Isla Chincha Centro	151	274	164	127	57	1	9	8	19	20
Isla Chincha Norte	1045	936	981	1130	119	136	106	107	133	110
Peru LNG breakwater										1785
Isla Asia	801	816	824	855	1230	946	790	467	571	603
Islote Los Checos	184	294	370	342	653	590	388	456	537	421
Santa María										
Pucusana										
Isla Pachacamac	485	667	528	976	650	1034	1291	583	855	566
Islote San Francisco	223	206	353	641	197	666	261	209	586	521
Islote Farallones		56	41	24	25	65	0	91	63	37
Isla San Lorenzo	664	720	1417	1195	1069	1309	1192	738	637	931
Isla Las Cavinzas	39	100	104	171	69	91	100	69	102	91
Islas Palomino						36	34	28	34	99
Islas Pescadores					563	512	455	297	348	451
Isla Huampanú					62			1407		
Isla Chuquitanta					507					
Islote Lobera					13			78		
Isla Mazorca					133			55		
Huarmey (zona costera)	207	197	242	389	243	608	161	439		
Huarmey (cueva)	51	177	167		214	106	113	85		
Isla Chao					598					

Part 2: Humboldt Penguin Molt Census: Peru 2011-2020—4										
Colonia/ Sitio de muda	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Isla Santa								42		
Islote Corcovado								26		
Isla de la Viuda								40		
Isla Guañape Sur					362			361		
Isla Guañape Norte					347			457		
Islas Macabí					375			377		
Isla Lobos de Afuera					198			NC		
Isla Lobos de Tierra								173		
La Islilla					30			16		
Aguja										
Isla Foca					98			65		
TOTAL	13,423	14,424	16,461	20,558	20,738	15,922	13,615	11,936	9,130	10,050
Date span for census	21 de enero - 11 de febrero	21-27 de enero	16-30 de enero	14 de enero - 2 de febrero	7-23 de enero	16-30 de enero	16-30 de enero	14-28 de enero	13-27 de enero	19-27 de enero
					Excluding northern sites not counted prior to 2015= 17,452			Excluding northern sites not counted prior to 2015= 8,542		

Humboldt Penguin
Population and Habitat Viability Assessment Workshop
Final Report

Lima, Peru
October 17,18, 21-23
2019

Appendix V
IUCN Red List Assessment Based on Humboldt Penguin PVA[1]

Implications of the PVA modeling for a National Red List Assessment for Humboldt penguins in Peru

The population projections that were done for the PVA provide estimates that can be used for evaluating some of the criteria specified for determining Red List Threatened categories – Critically Endangered (CR), Endangered (EN), Vulnerable (VU), or Least Concern (LC). In particular, the following criteria can be evaluated with data generated from the PVA model:

Criterion	Critically Endangered	Endangered	Vulnerable
A3 – projected decline	≥ 80% in 3 generations	≥ 50% in 3 generations	≥ 30% in 3 generations
C1 – small size and in decline	N < 250 and 25% decline in 1 generation	N < 2,500 and 20% decline in 2 generations	N < 10,000 and 10% decline in 3 generations
E – quantitative analysis (i.e., PVA)	≥ 50% probability of extinction in 3 generations	≥ 20% probability of extinction in 5 generations	≥ 10% probability of extinction in 100 years

Other criteria are also used for assessing Red List Threatened categories (such as B – related to geographic range, and D – related to very small populations), but they are not informed by PVA population projections, and criteria B and D also would not result in a threatened category for Humboldt p

penguins (which do not currently have restricted distribution or very small population size).
The overall Threatened status for a species is the one that is the most threatened category across the various criteria. For example, if a species is determined to be Endangered by any of the criteria, then overall it is categorized as Endangered.

When evaluating the above criteria for Threatened categories for Humboldt penguins, we included in the PVA model an assumption that inbreeding depression would reduce survival if the population became very small and inbred, with the severity of inbreeding impacts quantified by 6.29 lethal equivalents, the mean effect reported in a review (O'Grady *et al*. 2006, "Realistic levels of inbreeding depression strongly affect extinction risk in wild populations." Biological Conservation 133:42-51). In the PVA workshop, we did not include inbreeding depression in the model, because the Humboldt penguin population is large enough that inbreeding would be very rare, except when the species is in the final years of a terminal decline. However, recognizing that population projections become unreliable as populations become so small and dispersed that animals might have difficulty finding mates, in the PVA we looked at the likelihood of "quasi-extinction" – the population falling below 30 animals – as our measure of when the species would no longer have a functioning breeding population. The IUCN Red List criteria, however, refer to expected times to complete extinction of the species. Below, we present probabilities of both quasi-extinction and final extinction.

There is uncertainty about the current total population size of Humboldt penguins in Peru. To evaluate threatened status, we therefore examined population projections based on several possible starting numbers. At the most pessimistic extreme, we used the number of penguins (6290) tallied in the 2019 censuses. However, it is known that the census counts miss some penguins. At the optimistic end, therefore, we estimated that the total population might be about 15,000. We also examined scenarios with intermediate starting sizes of 7500 and 12000.

The Red List criteria specify time periods of 1, 2, 3, or 5 generations, or 100 years, for the estimated rates of decline and probabilities of extinction. The global assessment estimated the mean generation time for Humboldt penguins as 12.5 years. We therefore used this estimate, corresponding to 13y, 25y, 38y, and 63y for 1, 2, 3, and 5 generations, for our assessment.

The estimated rate of decline (about 7% per year) is not affected by the starting population size. As shown in the table below, for any of the plausible estimates of current population size, the Humboldt penguin in Peru might be categorized as being Critically Endangered, because of the high rate of population decline (criterion A3).

Current N	Median N at 1, 2, 3, or 5 generations, or 100y					% Decline through 1, 2, 3, or 5 generations, or 100y					Quasi-extinction N < 30			Prob. Extinct N = 0			Red List criteria			Red List category
	13y	25y	38y	63y	100y	13y	25y	38y	63y	100y	38y	63y	100y	38y	63y	100y	A3	C1	E	
6,290	2544	1010	376	51	0	60	84	84	99	100	0	29	99	0	1	71	CR	VU	VU	CR
7,500	3030	1256	450	63	1	60	84	94	99	100	0	24	98	0	1	66	CR	VU	VU	CR
12,000	4796	1922	692	100	2	60	84	94	99	100	0	10	96	0	0	51	CR	LC	VU	CR
15,000	6049	2441	928	139	4	60	84	94	99	100	0	6	92	0	0	40	CR	LC	VU	CR

It is important to note that the assessment above should be considered only preliminary, providing useful information to the Red List assessment team. The Red List assessors will need to evaluate the uncertainties around the data that were used in the PVA, and also consider all of the Red List criteria, in order to make the final determination of Red List category for the species in Peru.

[1] Based on the PVA analysis conducted during these workshops, R. Lacy provided this Red List Assessment for a Red List re-evaluation being conducted by SERFOR for Peru. December 2020.

Photo: J. Reyes

Humboldt Penguin
Population and Habitat Viability Assessment Workshop
Final Report

Lima, Peru
October 17,18, 21-23
2019

Appendix VI
Threats to Humboldt Penguins

<u>From</u>: De la Puente, S., Bussalleu, A., Cardeña, M., Valdés-Velasquez A., Majluf, P. & Simeone, A. 2013. Humboldt penguin (*Spheniscus humboldti*). IN: *Penguins: Natural History and Conservation*, Garcia-Borboroglu, P., Boersma P.D. (editors). Seattle, WA: University of Washington Press, pp 265–283.

TABLE 15.7 Main threats for wild Humboldt populations

reference	en	gw	ep	ha	p and z	B	cf	hd	hl	iaS	th
Murphy (1936)	x		x (h)	x (h)	x (h)	x	x	x			
Duffy (1983)			x (h)	x (h)		x	x				
Duffy et al. (1984)			x (h)	x (h)		x	x	x	x	x	
Hays (1984)											
Hays (1986)								x			
Culik and Luna-Jorquera (1997a)							x				
Battistini (1998)											
Paredes and Zavalaga (1998)	x										
Araya et al. (2000)	x	x				x	x	x	x		
Simeone and Schlatter (1998)			x	x						x	x
Simeone et al. (1999)						x					
Wallace et al. (1999)						x					
Culik et al. (2000)	x										
Simeone and Bernal (2000)										x	
Majluf et al. (2002)	x	x				x					
Simeone et al (2002)	x										
Taylor et al. (2002)						x	x				X
Cushman (2003)			x (h)	x (h)				x			X
Paredes et al. (2003)	x		x (r)	x (r)	x (r)	x	x	x			
Simeone et al. 2003				x						x	X
Herling et al (2005)							x				
Ellenberg et al. (2006)								x			X
Boersma et al. (2007)						x	x				
BirdLife International (2008)	x	x		x		x	x	x			
Skewgar et al. (2009)						x				x	X

Note: Threats include EN: El Niño; GW: global warming; EP: Egg poaching; HA: Hunting of adult birds; P and Z: Capturing birds for pets and zoos; B: By-catch and drowning by net entanglement; CF: Competition with commercial fisheries; HD: Habitat degradation and reproductive failure from Guano harvests; HL: Loss of nesting sites and reproductive habitat due to coastal development; IAS: Introduction of alien species; TH: Tourism and human presence. "x" denotes the mentioning or discussing of the threat in the references, (h) stands for historical threat and (r) for recent threat.

From: Simeone, A., Aguilar, R., and Luna, G. 2018. Informe Final Proyecto FIPA Nº2016-33: "Censo de Pingüinos de Humboldt." Consultor: Corporación CULTAM. Santiago, julio 2018.

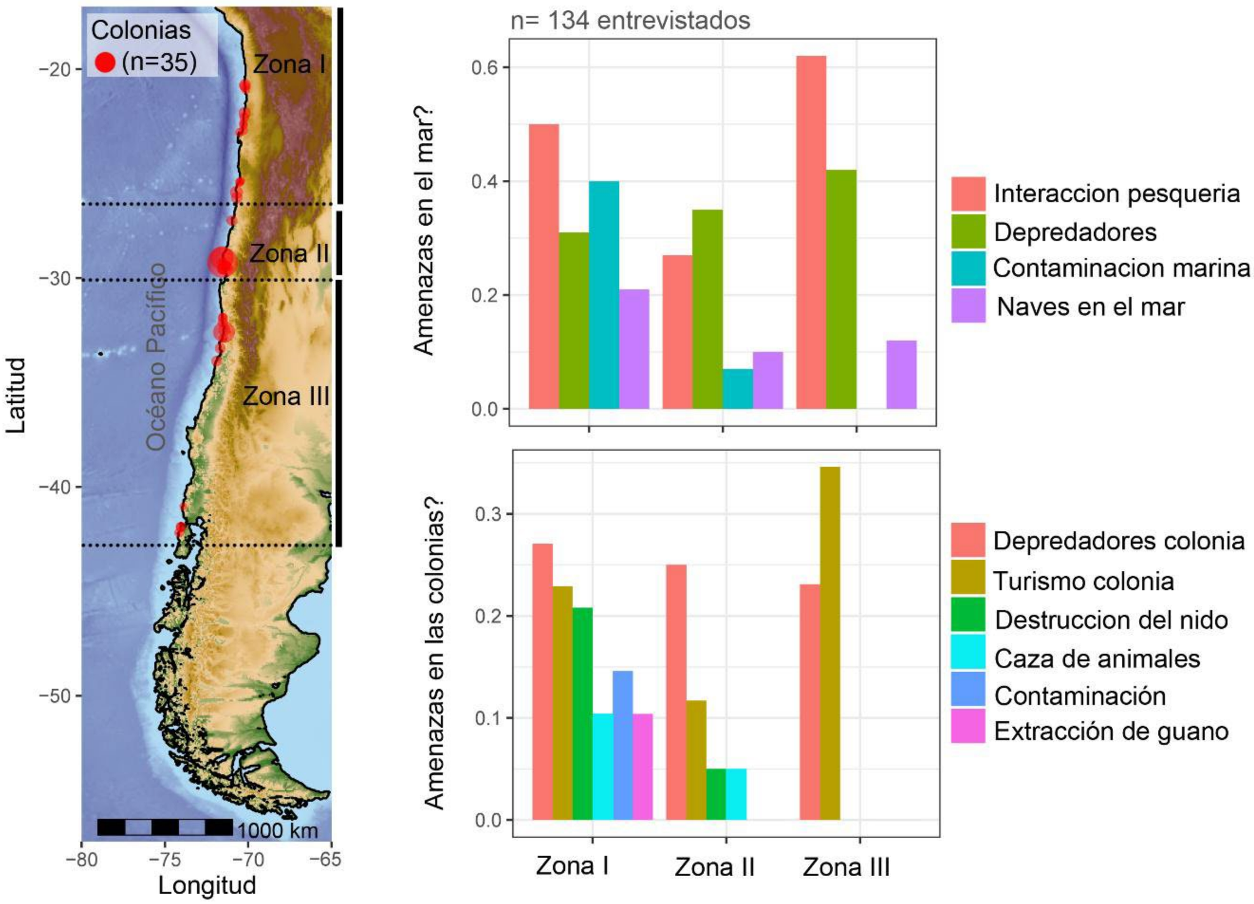

Figura 8. Reconocimiento de los usuarios sobre amenazas en el mar (superior) y en tierra (inferior) para el pingüino de Humboldt.

Figure 8. User's perception about threats to Humboldt penguins at sea (top) and on land (bottom) in the three zones of the Chilean coast with penguin populations. From the top, the cited threats are:

- At sea: Interaction with fisheries, primarily artisanal gillnets
  - Predation
  - Marine pollution/contamination
  - Ships or boats
- On land: Predators
  - Tourists and other human activity
  - Destruction of nesting habitat
  - Hunting
  - Contamination or pollution, primarily from coastal litter and sewage
  - Guano harvest

Humboldt Penguin
Population and Habitat Viability Assessment Workshop
Final Report

Lima, Peru
October 17,18, 21-23
2019

Appendix VII
Workshop Participants at PVA and PHVA

Photo: J. Reyes

Photos: J. Reyes. These participants had also been at the 1998 PHVA.

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Photos: J. Reyes

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Photos: J. Reyes

Humboldt Penguin
Population and Habitat Viability Assessment Workshop
Final Report

Lima, Peru
October 17,18, 21-23
2019

Appendix VIII
PVA & PHVA Agendas

Photo: J. Reyes

Population Viability Analysis Working Session for the Humboldt Penguin

Purpose: Develop models of the breeding populations of Humboldt penguins that summarize the knowledge about the current state of the populations and the primary threats to the populations, for use in the Population and Habitat Viability Assessment (PHVA) workshop.

Facilitator roles:

Bob – Lead discussions

Jorge – provide explanations in Spanish, as needed; enter values into Vortex model

Anne B or Fabiana – Record on flipcharts decisions, issues that need to be resolved, and topics or conclusions to be brought to the PHVA workshop

Anne B or Fabiana – Record in computer decisions made, uncertainties, assumptions, issues

Thursday, October 17

9:00 Participant Introductions

9:30 Brief overview of the Vortex PVA model

10:00 Identification of populations (location, size, amount and kinds of information available)
Peru; Chile; Ex situ

11:00 Development of basic demographic model of a typical or representative wild population
Step through Vortex input screens for Reproductive System; Reproductive Rates; Mortality Rates; Catastrophes; etc.
Review estimates provided in advance; determine if they need to be revised
Document sources of data
For each input value, note any uncertainty or alternative estimates
Note which rates will likely differ among populations

13:00 Lunch

14:00 Run initial, baseline model
Examine short-term trends and long-term projections (population growth rate; population fluctuations; loss of genetic diversity; probability of extinction)
Discuss level of confidence in the baseline model: Does it seem reasonable?

15:00 Sensitivity Testing (ST) of uncertain input values
Introduction to methods available in Vortex
Alternate scenarios; automated ST; inclusion within one model as sampled values
Identify ranges to be tested

16:00 Start Sensitivity Tests running
Discuss ways to present ST results

16:30 Questions, concerns, suggestions

Friday, October 18

9:00 Review initial ST results
What variables are most important to population viability?
Which uncertainties have the largest effect on our predictions?

10:00 Metapopulation model for Peru
Which populations form distinct demographic units? Genetic units?
Dispersal rates between populations
Different demographic rates among populations
Start model running

11:00 Metapopulation model for Chile

12:00 Examine metapopulation projections

12:30 Initial identification of primary threats to be explored in PVA models
What threats need to be examined? What are their impacts?

13:00 Lunch

14:00 Build a "Threats-Baseline" template model that includes threats

14:30 Review projections for each type of threat

15:00 Population-specific threats
Put threats into either individual population models, or all in the metapopulation model

16:00 Review projections of impacts of threats to populations

16:30 Discussion of PVA results to be presented to PHVA workshop
What are the largest uncertainties?
What aspects of the PVA do we need to refine with further insights from the PHVA participants?
How can we use the PVA model to examine conservation options during the PHVA?

Population & Habitat Viability Analysis Workshop

Monday, 21 October

8:30 – 9:00 Registration

9:00 – 9:15 Welcome (MINAM)

9:15 – 10:00 Introductions (all)

10:00 – 10:15 CPSG and the Workshop Process (Anne Baker)

10:15 – 10:30 Workshop Goals (Patty McGill)

10:30 – 10:45 Break

10:45 – 12:30 Presentations[1] (limit to 15 min)

- **Penguin biology – breeding, foraging, nesting patterns, disease issues** (Marco Cardeña)
- **1998 PHVA results and recommendations** (Alejandro Simeone)
- **Penguin population trends from census data**
  1. Peru –(Patty McGill, with Anne Tieber)
  2. Chile – (Alejandro Simeone with Roberta Wallace)
- **Prey density – Oceanographic activity and fish population trends** (Marilu Bouchon, IMARPE)

12:30 – 1:30 Lunch

1:30 - 2:15 Presentations[1] Continue

- **Seabird population trends** (Manuel Sovero Camac)
- **Impact of guano harvest and management on penguin populations**
  3. Punta San Juan (Marco Cardeña)
  4. Isla Santa Rosa (Carlos Zavalaga)
  5. **Long term impacts on penguin populations** (Lady Amaro)
- **Health Considerations in Conservation Planning for Humboldt Penguins** (Roberta Wallace, Mike Adkesson)

2:15 –2:45 **Population Viability Analysis – how does it work and what does it tell us?** (Bob Lacy/Jorge Rodriguez)

2:45 – 3:30 Preliminary results of the 2019 Humboldt penguin PVA (Lacy/Rodriguez)

3:30 – 3:45 Break

3:45 – 4:00 **Humboldt Current Ecosystem Dynamics** (Guillermo Luna Jorquera)

4:00 – 5:15 Plenary: Identification and prioritization of issues impacting long-term persistence of Humboldt penguin populations (Baker)

5:15 – 5:45 **African Penguin Biodiversity Management Plan: Findings and Lessons for Conservation Planning** (Lauren Waller)

5:45 Adjourn for the day

Tuesday, 22 October

8:30 – 9:15 Presentations[1] – Learning from the Work of Others: Humboldt penguins and other *Spheniscus* species

- **African Penguin Research in Support of Conservation** (Waller)
- **Consequences of climate-driven changes in the breeding phenology of Magellanic penguins (*Spheniscus magellanicus*)** (Caroline Capello)
- **Using Research to Inform Humboldt Penguin Conservation Action: Past & Present** (Rosana Paredes)
- **Galapagos penguin nest building project** (Capello)

9:15 – 9:30 Working group introduction (topics and instructions) (Fabiana Lopes Rocha)

9:30 -10:30 Working groups: Issue evaluation

- Group convenes, assigns roles, defines scope
- Further issue description (clear definition of issue, why is it an issue,)
- Identification of facts vs hypotheses and data gaps
- Identification of intervention opportunities

10:30 – 10:45 Break

10:45 – 12:00 Issue Evaluation working groups continue

12:00 – 12:05 Housekeeping – flights/airport transport

12:05 – 1:00 Lunch

[1] All presentations are available at www.CPSG.org

1:00 - 2:00 Plenary: Working group reports and discussion (Lopes Rocha)
Identification of additional modeling questions

2:00 – 4:30 Working Groups – Goals and Objectives (Break as needed)

- Generation of long-term goals that address issues
- Identification of SMART short-term objectives (**S**pecific, **M**easurable, **A**chievable, **R**elevant, **T**ime-oriented)
- Identification of potential actions needed to meet objectives

4:30 – 5:00 Plenary session - Working group reports, discussion, recommendations

5:00 Adjourn for the day

<u>Wednesday, October 23, 2019</u>

8:30 –9:00 Results of additional modeling work (Lacy)

9:00 – 11:30 Working groups (Break as needed)

- Analysis of proposed actions, benefits, costs, likelihood of success
- Evaluation and prioritization of proposed actions

11:30 – 12:30 Plenary session (Lopes Rocha)

- Working group reports, discussion, recommendations
- Development of suggested timeline for actions

12:30 – 1:30 Lunch

1:30 – 2:00 Working groups – revisions (as needed to goals, objectives and recommended actions)

2:00 – 2:30 Plenary: Final working group recommendations

2:30 – 2:45 Break

2:45 – 4:00 Plenary (Baker)

- Group consensus on major program components, workshop outcomes and recommendations
- Identification of next steps, responsible parties and communications

4:00 – 4:30 MINAM remarks

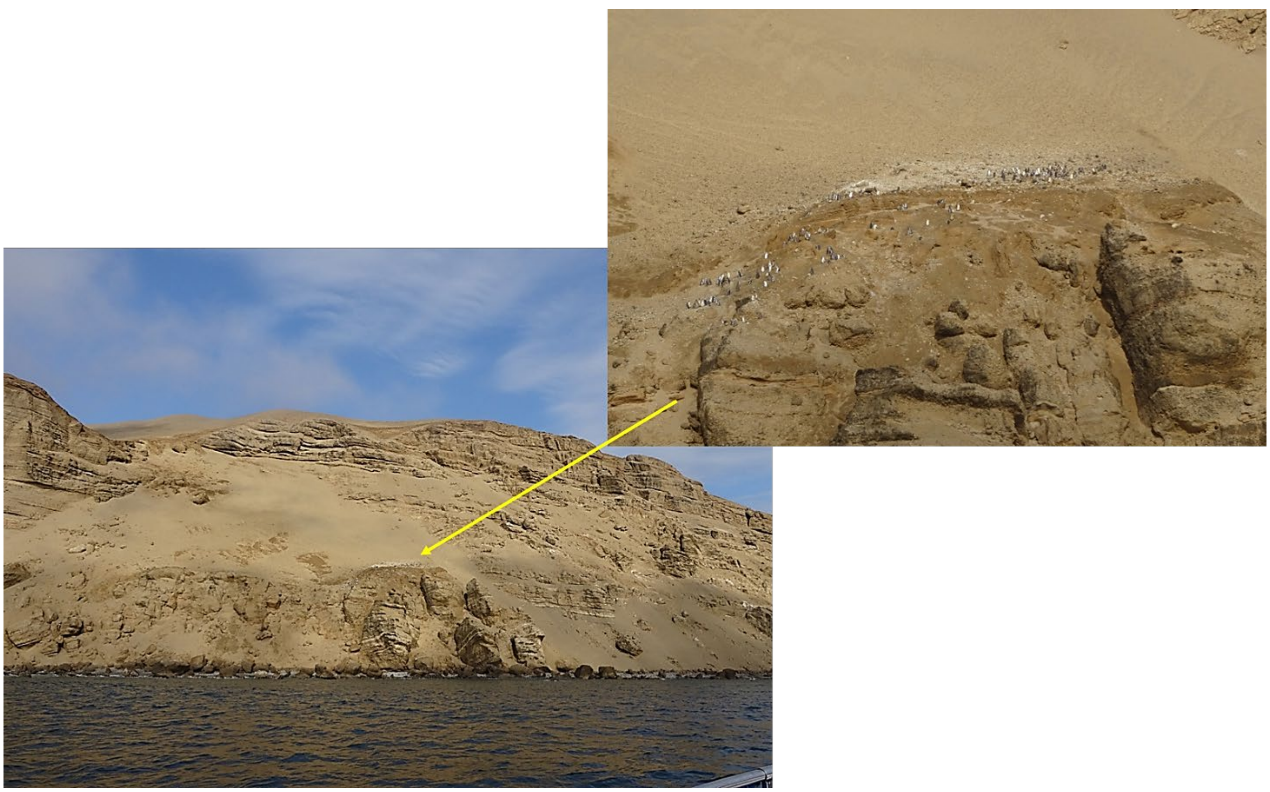
4:30 – 5:00 Closing remarks

5:00 Workshop adjourns

Humboldt Penguin
Population and Habitat Viability Assessment Workshop
Final Report

Lima, Peru
October 17,18, 21-23
2019

Appendix IX
Oversight, Monitoring and Follow up



Photos: P. McGill

Oversight, Monitoring & Follow-up

The PHVA final report serves as a valuable conservation document in several ways. The goals, actions and outcomes of the workshop set the stage for achieving:

- A common understanding of the current status of Humboldt penguins and projections for their future;
- Enhanced networking and collaboration among colleagues who work on or have influence over the future of Humboldt penguins;
- An assemblage of all the best data, published or unpublished, from both Chile and Peru, on population status, demography of and threats to Humboldt penguins; from this is derived a shared understanding of key gaps in knowledge;
- A prioritization of the threats that have the greatest negative impact on penguin populations along with strategies and action items to address the high priority threats;
- Standardized, international methodology/ies for monitoring population levels of Humboldt penguins (and potentially other *Spheniscus* species);
- Curricula for educating and engaging tourists, resource stakeholders and general populace in saving Humboldt penguins and taking action on their behalf;

The report from the workshop can be shared among workshop participants and non-participants alike, in order to inform agencies, NGOs and others who want to create action plans that promote knowledge about and conservation of Humboldt penguins.

Additional focus on the issues outlined in this report will produce some important measurable outcomes that further document the value of the PHVA and report:

- Reinforce & clarify important research priorities (metric: # of research studies identified and undertaken)
- Emphasize funding priorities (metric: # of priority projects funded)
- Provide significant input for conservation action plans metric: (metric: # of cp's that refer to PHVA)
- Articulate important policy and regulatory issues for species conservation (metric: # of policy & regulatory discussions that refer to PHVA)
- Influence other penguin (species) work (metric: # of penguin species action or work plans that consider or build upon PHVA)

In the past, a shortcoming of many conservation plans has been inconsistent follow-through on items listed in the plan. In order to build momentum and develop synergy among projects, the initial activities of the oversight team are to work to ensure that the report is widely distributed and widely known. The team will then follow up with various parties responsible for specific actions via regular surveys. Results will be assembled into annual reports available to participants, CPSG, relevant agencies and NGOs. The report will focus on updates on species issues (based on survey results), quantifiable progress on action items, challenges encountered, and metrics that document the value of the report as noted above.

The Oversight, Monitoring & Follow-up team initially includes Patty McGill, Julio Reyes and Alejandro Simeone.

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Appendix X
Key Reference Literature

Photo: R. Tardito

Key Reference Literature

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