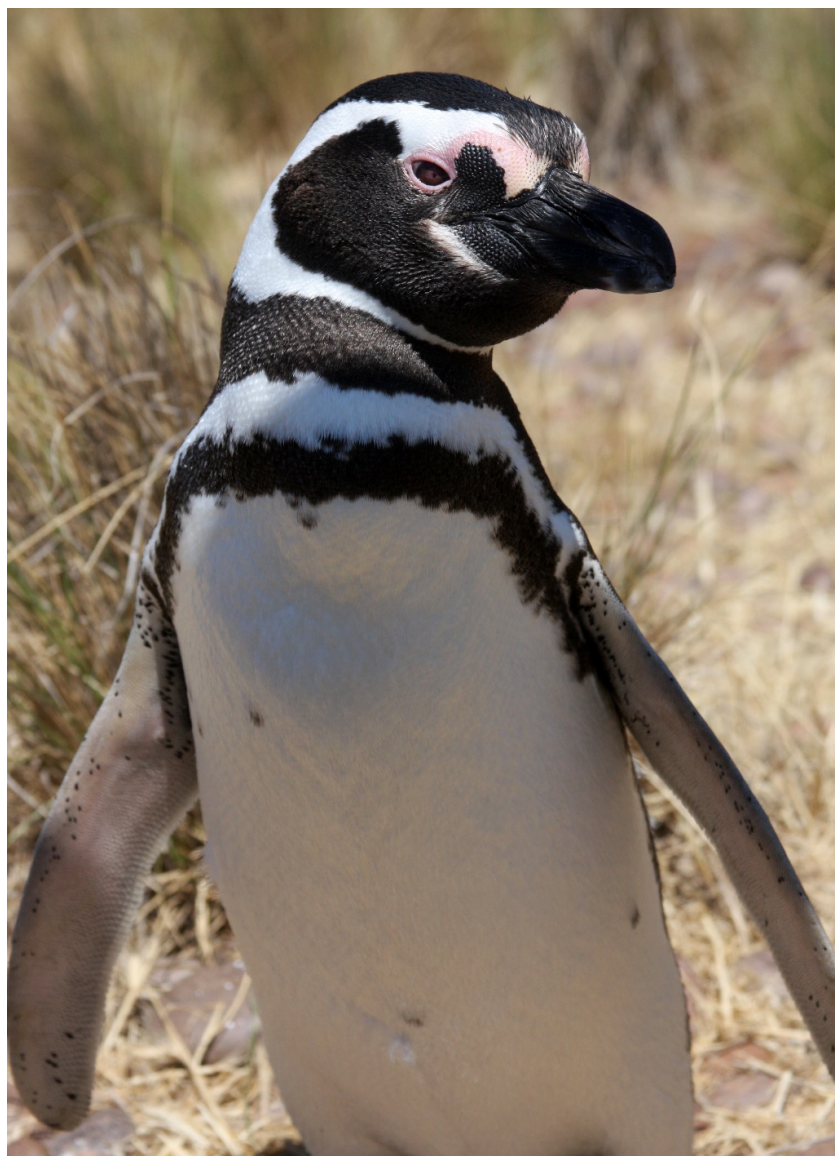


Earthwatch 2018 and 2019 Field Report

Trailing Penguins in Patagonia

At-sea behavior and breeding biology of Magellanic Penguins



Picture: Anne-Sophie Page

Gabriela S. Blanco, PhD y Flavio Quintana, PhD
Instituto de Biología de Organismos Marinos (IBIOMAR-CONICET)



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Puerto Madryn, April 1st, 2020

Dear Volunteers:

I finally finished processing some of the data from the past two years. I am so sorry that took so long. These seasons (as always) was very successful in terms of data collection and that was because of all your hard work! We have had the most amazing teams of volunteers working tireless hours.

Below I will describe the results from the two last seasons (2018 and 2019). Even though numbers do not look that good for our colony, you have to keep in mind that our colony is located in the center of the distribution of Magellanic penguins (as you may recall we talked about this when you guys were here). For a while the colonies in the center of the distribution have been decreasing but, good news is that colonies located in the north (Península Valdés) are increasing a lot. Remember also, that these facts are the reason why we are working in this colony, to try to understand the reasons and effects of this distributional change.

I hope you have enjoyed working with us and the penguins! We did enjoy a lot your company.

Thank you so much for the hard work and tons of fun!

A handwritten signature in black ink, appearing to read 'G. Blanco', written in a cursive style.

Dr. Gabriela S. Blanco IBIOMAR-CONICET

Summary

Total number of breeding pairs estimated during the 2018 and 2019 breeding seasons were: 8,397 and 5,585 respectively. Penguins occupied an area of 22.1 ha, with an estimated nest density of 3.3 in 2018 and 2.9 nests/100m² during the last year.

Hatching success for experimental nests was 0.7 and 0.6 for 2018 and 2019 respectively. Breeding success during 2018 breeding season was 0.01, where only 0.2 chicks/nest survived until fledging. As for 2019, 0.5 chicks/nest survives until fledging (BS: 0.25). Depredation events (total or partial) occurred in approximately 60% of the surveyed nest for both years.

Foraging trips during early chick rearing period, lasted approximately 1 day, where in 2018 the area where penguins found food for them and their chicks was at 46 km from the colony. Interestingly in 2019 they foraged in a closer area (22 km from the colony). Although total distance traveled in one foraging trip was similar for both years (mean: 110 km)

Goals, Objectives, and Results

Magellanic Penguin (MP, *Spheniscus magellanicus*) colonies are distributed along the coasts of South America, from 41°S to the Falkland Islands (Malvinas) (Schiavini et al. 2005). The estimated population in Argentina is approximately 950,000 pairs. Although numbers are increasing at some colonies and decreasing at others, the overall world population shows a decreasing trend, for this reason the IUCN consider this species as "Near Threatened" (IUCN 2017, see www.iucn.org).

During the breeding period MPs (and seabirds in general) are central place foragers (Orlans and Pearson 1979) meaning that they are constrained to return to the colony since their eggs and hatchlings are left ashore. Consequently, males and females take shifts during incubation and chick rearing period. During this time, energy optimization is crucial, as they must obtain food for themselves and their hatchlings. MPs perform foraging trips of approximately 30 hours with some variations between different colonies (Sala et al. 2012a). They forage in areas relatively close to their breeding sites, traveling between 30 and 280 km (Sala et al. 2012a). MP foraging trip characteristics (duration, distance from the coast, diving depth) vary among colonies. This variation is explained by the abundance and prey type around the breeding sites (Sala et al. 2012b). Thus, individuals from different colonies will invest different effort in foraging which would be reflected in breeding parameters and ultimately in population trends of the colony.

Cabo dos Bahías, (CDB, *Reserva Faunística Provincial Cabo dos Bahías*, 44°54'30"S; 65°32'24" W) is a small colony that hosts approximately 12,000 breeding pairs (Pozzi et al. 2015) in an area of 0.25 km². This colony is located in the middle of the MPs range of distribution. Interestingly colonies located in the north and south of the MP distribution are increasing in numbers; on the contrary, colonies located in the middle of their distribution are stable or decreasing (Pozzi et al. 2015). Thus, the goal of this study is to understand the sources of these variations, focusing mainly in the relationship between the breeding biology of this particular colony (i.e. breeding success, hatchling success, etc.) and the at-sea foraging effort of adult breeders. Additionally during 2019 we started to monitor health parameters of the penguins to 1) analyze hematological parameters of penguin chicks from different age groups and to 2) analyze hematological parameters of breeding adults (those receiving GPS behavioral loggers)

Methodology

BREEDING BIOLOGY

We selected 17 areas spread along the colony to represent different nests characteristics (i.e. nests built in burrows, nests under bushes, and eggs laid in the shelter of rocks) before egg laying started. Each area comprised between 5 and 15 nests adding 170 marked nests (Figure 1). From those, 130 were marked permanently in previous seasons. Experimental nests were checked daily to record egg laying. In addition, we randomly selected control nests within the 17 areas of the colony. Those ~ 40 nests were checked once every 15 days to record number of eggs and/or chicks, and no manipulation was performed. Additionally, each nest was mapped and a GPS location (latitude and longitude) was recorded.

To identify individuals for long term monitoring, 260 adults were marked using Passive Integrated Transponders (PIT tags) from 2015 to 2019 breeding seasons.

During daily monitoring, date of laying of first and second eggs were recorded, eggs were also marked and measured. Nest monitoring continued daily until chicks fledged. When egg hatching started, dates were recorded, as well as egg loss if that was the case (Frere et al. 1998). Egg volume was calculated following Boersma et al. (1990). In addition, we estimated nest predation by recording the “disappearance” of eggs and/or chicks as a proxy of depredatory events (Yorio and Boersma 1994).

MEASUREMENTS OF CHICKS

Chicks were gently removed from the nest, weighted, and morphometric measurements were recorded every three days to document growth rates. Morphometric measurements were taken following (Yorio et al. 2001).

CENSUS OF THE COLONY

Colony size was estimated using circular plots considering only active nests (see (Gandini et al. 1996, Pozzi et al. 2015)). The census was carried out during mid-November: to that date all active nests were occupied for the season.

AT-SEA BEHAVIOR

- **Incubation:** Adult penguins (N=19, six females and 13 males) were equipped with data loggers that record location, temperature and depth (AxyTreck Max, TechnoSmart, Italy) during the incubation period. Because foraging trips during incubation could last more than 20 days, GPSs were programmed to record 1 data point/15 minutes to extend battery life.
- **Early chick rearing period:** Adult penguins (N=25, 14 females and 11 males) were equipped with AxyTreck Max during the early chick rearing period. During this time, male and female perform short foraging trips (~24 h).

To deploy devices, penguins were carefully removed from the nests using an adapted clipboard for that purpose (Wilson 1997). Loggers were attached to penguins' feathers on their lower backs using overlapping strips of tesa tape following Wilson et al. (1997). For details see Sala et al. (2012a). Once penguins returned to their nests, the logger was removed to download data, recharged and deploy again in a different individual.

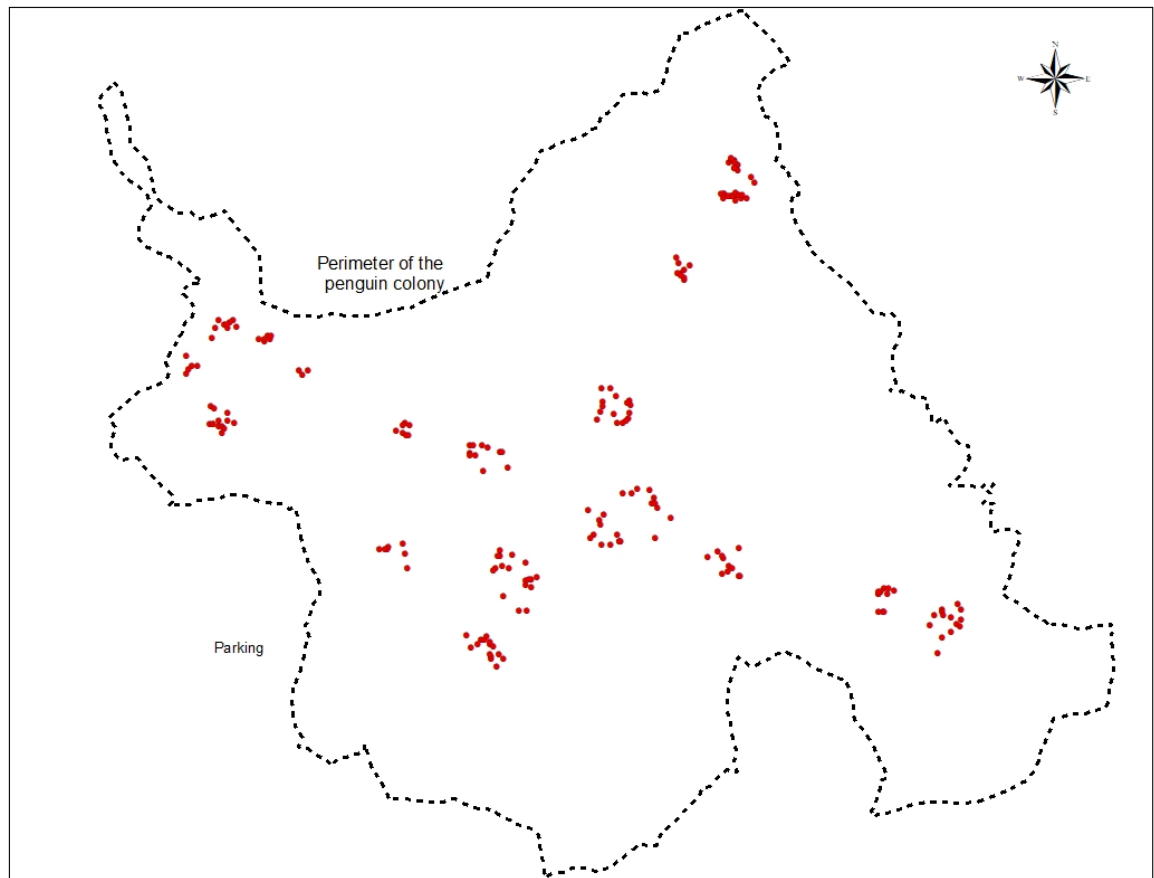


Figure 1: Magellanic Penguin colony at Cabo dos Bahias. Red dots indicate active marked nests monitored through the season (N=191). Dotted line shows the perimeter of the colony for 2019 breeding season.

HEMATOLOGICAL PARAMETERS OF CHICKS AND ADULTS

Blood samples were collected from 153 chicks in six age groups. With the exception of some of the younger chicks for which it was not possible to obtain sufficient blood, these blood samples were used to estimate the packed cell volume and plasma protein analysis from 122 chicks. Additionally, for 55 chicks it was also possible to obtain a plasma sample, which will allow for future analyses of the immunoglobulin concentration and plasma chemistry.

Preliminary results

BREEDING BIOLOGY

During several years it has been believed that mate-fidelity in sea birds increases breeding success, even though some researchers suggest that mate fidelity in penguins is due to avoid the costs of finding a new mate (Dubois et al. 1998, Croxall and Davis 1999). Our data indicated that 14% of the breeding pairs got “divorce” and in half of those cases mate switching was produced by the absence of one of the breeding pairs. Moreover, 10% of the nests monitored with ID animals did not reproduce because one of the pair was not at their nest (or in the vicinities of the area), which may suggest the costs of switching pairs during different breeding seasons.

We estimated 8,400 breeding pairs in Cabo dos Bahías during 2018 and 5,585 in 2019, spread in an area of 22.1 ha, with a nest density of 3.3 and 2.8 nests/100m² for 2018 and 2019 respectively. Previous estimates indicated that CDB hosts approximately 12,000 breeding pairs (Pozzi et al. 2015), based on these five years of study (see table 1, Figure 2) and previous records for this colony, our results demonstrate the need to continue to research the causes of this changes in number of breeding pairs throughout the years.

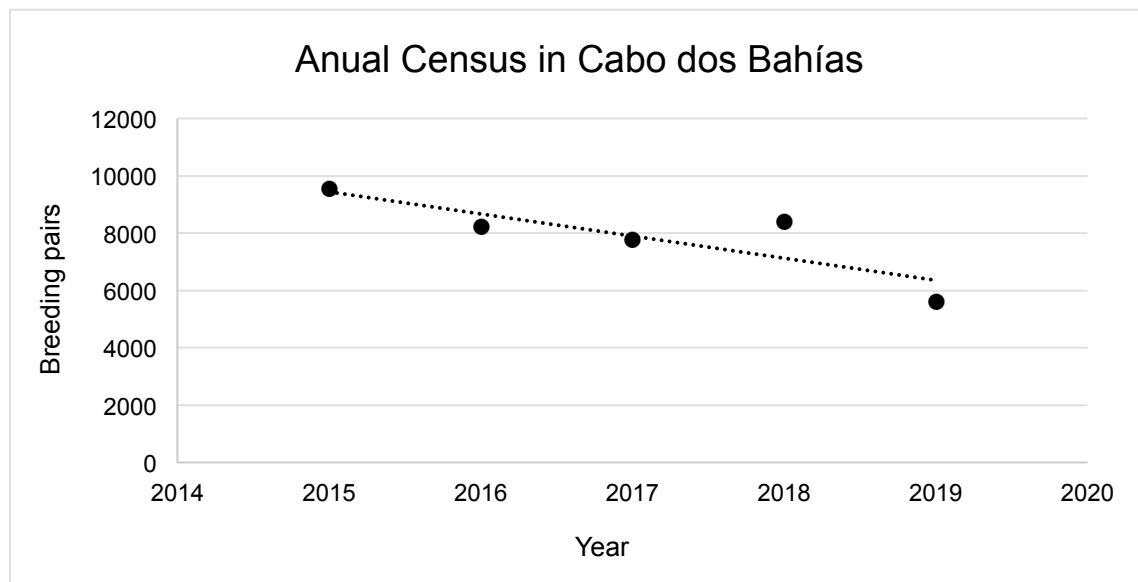


Figure 2: Population estimates of breeding pairs nesting in Cabo dos Bahías.

Peak laying period occurred between 15th and 25th October (Figure 3a). Most breeding pairs laid two eggs (clutch size: 1.95 ± 0.22 egg/nest) with 3.3 ± 1.1 days between egg 1 and 2. Incubation period was 40.4 ± 1.5 days for egg1 and 39.04 ± 1.4 days for the second egg. There were no statistical differences (ANOVA $p > 0.05$) in egg volume between first and second laid egg (Volume: egg1: 238.2 ± 18.8 cm³, egg2: 233.4 ± 20.02 cm³). Peak hatching period occurred between November 25th and 30th (Figure 3b). Hatching success was lower in 2019 than in previous seasons: 0.59 ± 0.5 (1.15 ± 0.9 eggs hatched/nest, Figure 4a). Breeding success was calculated as the number of chicks produced per nest and survived 60 days. In CDB, the breeding success for 2018 breeding season was 0.09 where only 0.5 chicks/nest fledge (lowest recorded for years of study), during 2019 the breeding success increased to 0.25 ± 0.4 , where 0.5 ± 0.7 chicks/nest fledge (Figure 4b). These breeding parameters were lower than in the previous season (see table 1). Even though some sections of the colony had higher breeding success, there were no significant differences in chick production along the colony.

Depredation events were observed along the season. Predators such as armadillos (*Chaetophractus villosus*) and Brown Skuas (*Stercorarius antarcticus*) forage on eggs during the incubation period. In addition, Kelp Gulls (*Larus dominicanus*) and skuas were registered foraging on penguin chicks. Moreover, a Geoffroy's cat (*Leopardus geoffroyi*) was observed during the season within the limits of the colony. During the 2018 and 2019 breeding season, egg predation (partially or totally) was observed in 27.5% and 41.5% of the nests, while predation on chicks was recorded in 34.5% and 16.4% of the nests (Table 1, Figure 5)

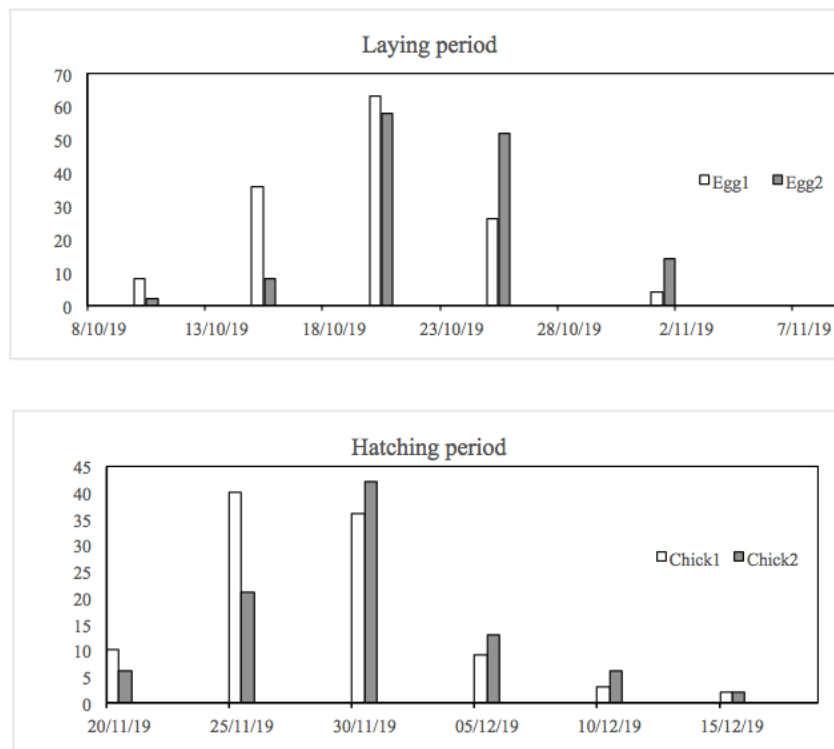


Figure 3: a) Laying period for penguins breeding at Cabo dos Bahias during 2019 breeding season. b) Hatching period of eggs laid at Cabo dos Bahias during 2019 breeding season.

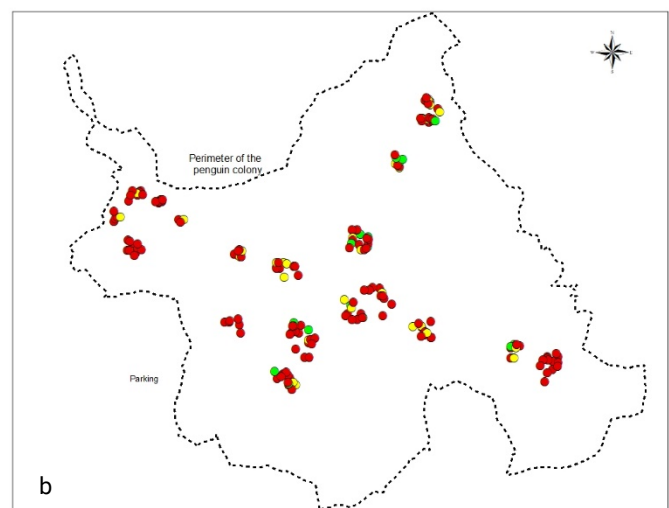
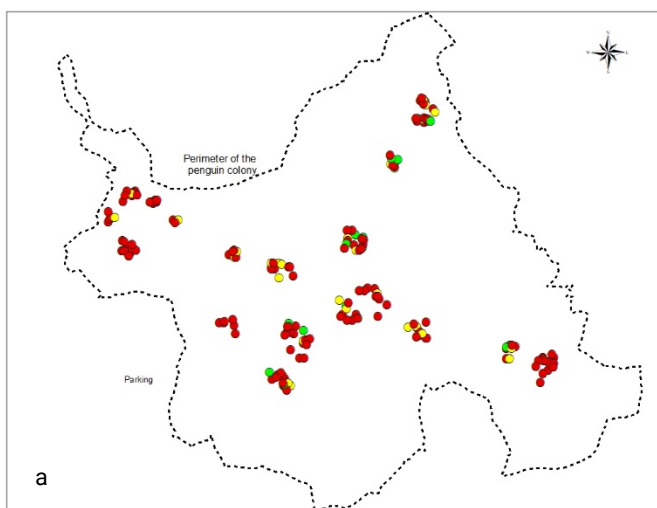


Figure 4: a) Hatching success and b) Breeding success of experimental nests marked in Cabo dos Bahias (2019). Green dots: 1, yellow dots: 0.5, red dots: 0.

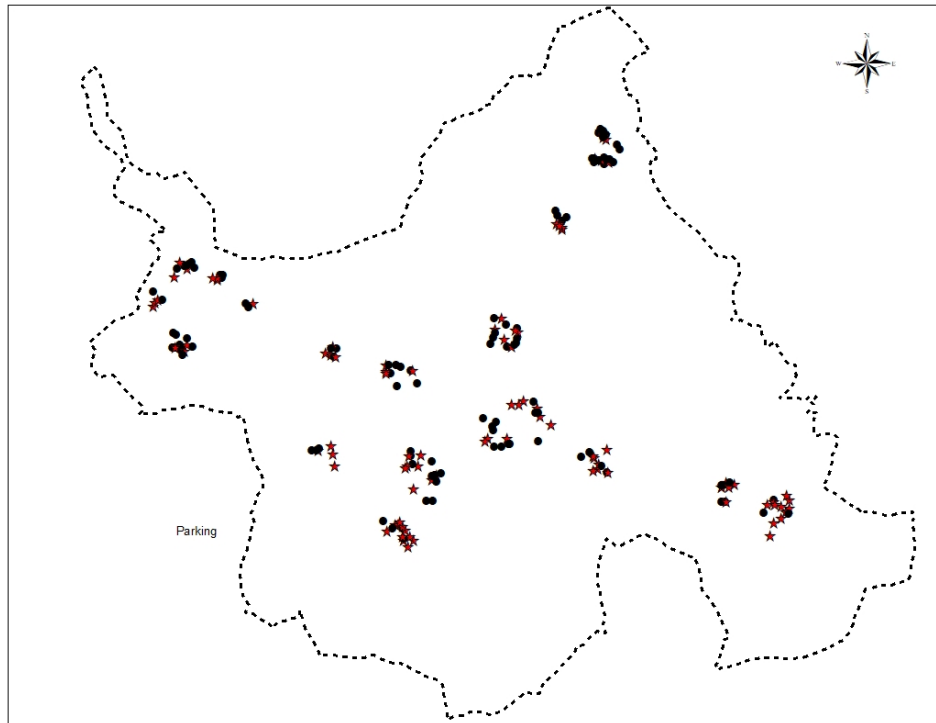


Figure 5. Depredation events (total or partial) recorded in the experimental nests monitored in Cabo dos Bahias during 2019. Red indicates depredates nests, black dots: monitored nests.

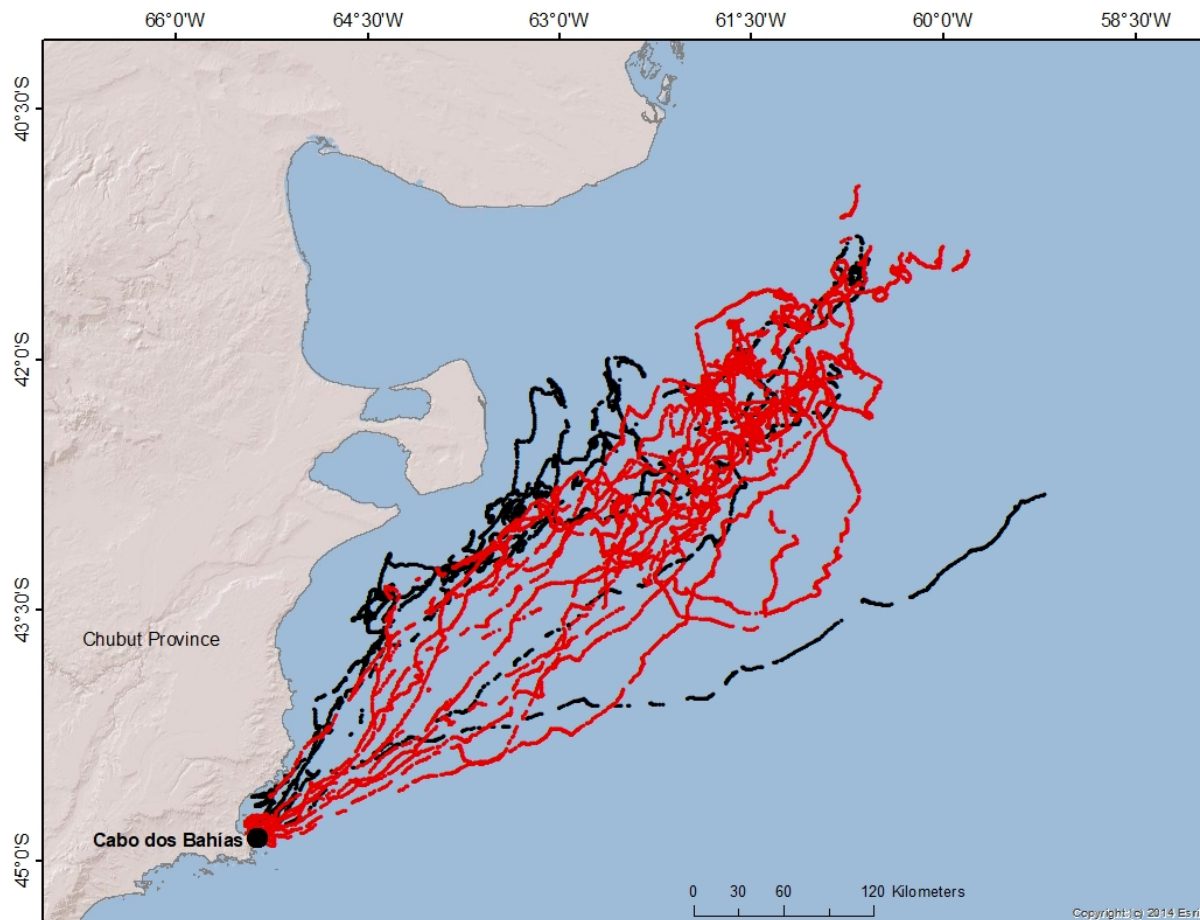
At-sea behavior

INCUBATION

Males and females during the incubation period performed foraging trips a mean duration of 17.7 ± 4 days for females and 19.9 ± 4 days for males. Our data showed significant differences between duration of trips between sexes ($p < 0.05$).

Although recording GPS locations for incubation periods remained being a challenge in terms of battery life, during the 2019 breeding season we recorded for the first time almost complete foraging trips of 9 males and 3 females. In addition three females and three males recorded partial trips. During incubation total distance traveled was 1544 ± 157 km in which males and females exploited similar areas, reaching maximum distances from the colony of approximately 500 km (Figure 6).

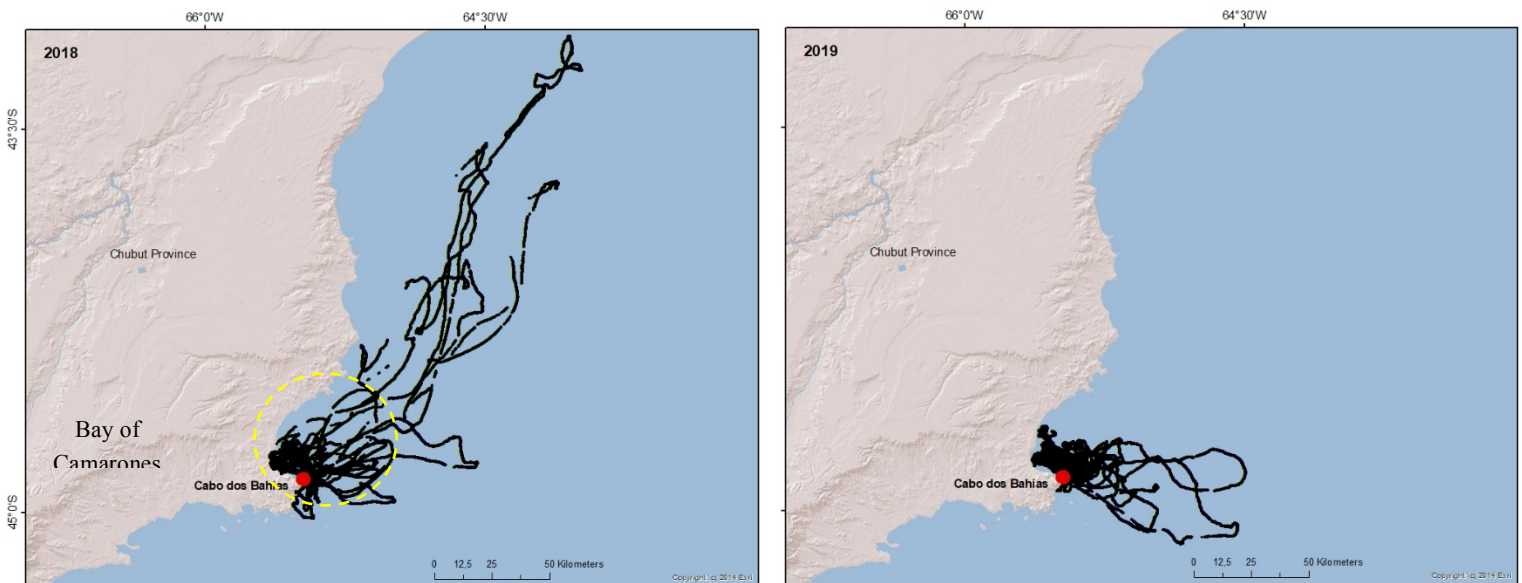
Figure 6: Movements of males (red lines) and females (black lines) during incubation foraging trips.



EARLY CHICK REARING PERIOD

During early chick rearing period duration of trips was similar for males and females in 2019. Adult penguins travel for an average of 23.7 ± 11 hours to find food for them and their chicks in an area 22 km away from the colony, traveling a total distance of 114 ± 56 km. Although the bay of Camarones remain being the most important area for penguins breeding in Cabo dos Bahías, strong differences were recorded between 2018 and 2019 foraging trips (Figure 7, see also Table 1). Those differences are attributed to the variation in the distribution of the prey that penguins are consuming, adding to the theory that this colony is exposed to strong inter-annual variations in prey availability.

Figure 7. Foraging trips of Penguins breeding at Cabo dos Bahías during early chick rearing period during 2018 (left) and 2019 (right). Red dot indicates location of the colony.



HEMATOLOGICAL PARAMETERS OF CHICKS AND ADULTS

Figures 8 and 9 show some of the preliminary results obtained, with a comparison of the packed cell volume and total plasma protein among the different age groups of chicks, including a comparison of chicks 1 and 2 (i.e. first and second hatched). The packed cell volume followed a gradual pattern of increase as the chicks grew older, however interestingly the rate of increase was steeper in chicks 1 than in chicks 2. This is consistent with the slightly smaller size at hatching but greater growth rate of chicks 1, which ultimately tend to experience a higher survival and greater body mass at fledging.

On the other hand, the total plasma protein showed a striking pattern wherein for both chicks A and B there was a gradual increase peaking at 20-days of age, but dropped abruptly in 21-to-25 days-old chicks, only to recover afterwards (with chicks 1 showing a better recovery than chicks 2). These patterns suggest that there is an immunological “window period” phenomenon, where the maternal immunity transmitted through the egg yolk expires but the chick immunity is still in development, with a corresponding drop in plasma protein concentration. However, an alternative explanation might be that the drop in protein concentration in the 21-25 days-old chicks could be related to nutritional stress during the transition from the guard stage (when one of the parents constantly remains at the nest to protect the chicks) to the post-guard stage (where both parents leave the nest to forage at sea), perhaps related to changes in diet composition or feeding schedule. In the coming months, we will analyze the blood smears collected during the field work and hopefully have further insight on the factors driving this dynamic.

Figure 8. Comparison of the packed cell volume among chicks of different age groups.

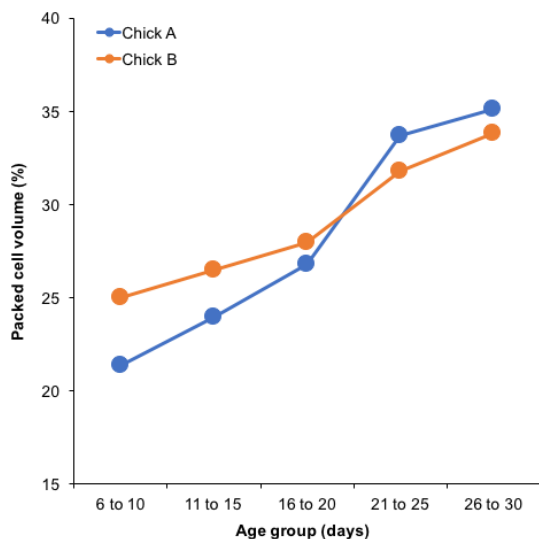


Figure 9. Comparison of the total plasma protein among chicks of different age groups.

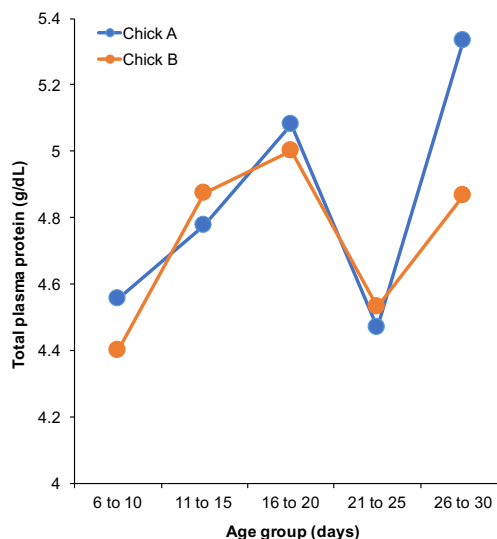


Table1. Breeding and foraging parameters estimated for five consecutive breeding seasons for Magellanic Penguins in Cabo dos Bahias.

Season	Estimated #Breeding pairs	Estimated nest density	#Nests surveyed	# Eggs	Peak laying	Time between laid (d)	Vol egg 1	Vol egg 2	Egg Predation %	Peak Hatching
2015-2016	9533		131	1,93	17-27 Oct	4,11	233,57	229,07	No Data	24-Nov/ 3-Dic
2016-2017	8230	3,86	199	1,93	15-25 Oct	3,5	240,75	240,87	28%	20-Nov/ 30-Nov
2017-2018	7750	3,50	156	1,95	15-25 Oct	2,14	238,2	233,4	25%	20-Nov/ 30-Nov
2018-2019	8397	3,30	170	1,95	10-20 Oct	3,97	221,4	201	27,50%	20-Nov/ 30-Nov
2019-2020	5585	2,87	191	1,97	15-25 Oct	3,29	235,56	233,64	41,50%	25-Nov /5Dic

Season	Incubation E1 (d)	Incubation E2 (d)	Eggs Hatched (mean)	Hatching success	Days between E1 and 2	Chick Predation %	# Chicks fledged (mean)	Breeding success	Total predated nests
2015-2016	40,77	38,38	1,19	0,6	1,24	No data	0,7	0,35	No data
2016-2017	38,91	38,05	1,43	0,75	2,15	20%	0,95	0,51	45%
2017-2018	40	39,04	1,45	0,74	2,14	47%	0,33	0,17	66%
2018-2019	41,15	38,97	1,41	0,71	1,99	34,50%	0,2	0,09	56,14%
2019-2020	40	39	1,15	0,6	1,41	27%	0,5	0,25	58,50%

Season	Mean Duration of trips (h)	Mean Max dist to colony	Mean Total distance traveled
2015-2016	24.68 ± 3.8	20.38 ± 5.9	99.64 ± 65
2016-2017	26.35 ± 2	36.05 ± 45	158.49 ± 118.6
2017-2018	No Data	No Data	No Data
2018-2019	30.75 ± 24.9	46.24 ± 56.3	106.8 ± 102
2019-2020	23,7 ± 10,1	22,2 ± 17,4	114,2 ± 52,9

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Project Impacts

Increasing Scientific Knowledge

TOTAL CITIZEN SCIENCE RESEARCH HOURS

Volunteers spent approximately 8 hours on the field every day collecting data. After that, volunteers contributed with data entry (~1 hour). Additionally, they helped in any other activity that was needed, such as help on fixing equipment, etc. Estimated total hours contributed for 2017: 1755.

PEER-REVIEWED PUBLICATIONS

- Yamamoto, T., Yoda, K., Blanco, G.S., Quintana, F. Female-biased stranding in Magellanic penguins. 2019. Current Biology 29, R1–R15.

In addition our team presented different aspects of the research at the Argentinean meeting of Ornithology:

- Gerez, N. A., Blanco G. S., Gallo, L., Quintana, F. 2019. Comportamiento de buceo del Pingüino de Magallanes en Cabo dos Bahías, Chubut.
- Blanco G. S., Gallo, L., Molina, G., Quintana, F. 2019. Ecología espacial del Pingüino de Magallanes en Cabo dos Bahías (Chubut) durante la temporada reproductiva

NON-PEER REVIEWED PUBLICATIONS: NONE

PRESENTATIONS

Progress of the penguin research at Cabo dos Bahías. Presentation to the community of Camarones (included Park rangers, tour guides, general public).

In addition we offered talks at the colony for groups of students (see below)

Mentoring

GRADUATE STUDENTS

There were no graduate students involved with the project during this year, although undergraduate students started collecting data for their thesis.

Genoveva Molina continued with her project, Movements and behavior of Magellanic Penguins.

Anabela Gerez finished an internship focused on diving behavior of Magellanic Penguins (University of Patagonia).

COMMUNITY OUTREACH-

Name of school, organization, or group	Education level	Participants local or non-local	Details on contributions/ activities
Local tour guides from Camarones	Local guides	Local	(see below) ⁽¹⁾
School of Sarmiento (Escuela Integral del Sur)	Primary school	Non-local	(see below) ⁽²⁾

⁽¹⁾ Together with the local tour guides we organized specific talks at the penguin colony. Every time that a group (different education levels) visits Cabo dos Bahias, staff from this project give a little presentation about the scientific work that is being carried out.



⁽²⁾ Starting in 2019, our Field Manager Ariel Serra, started an outreach program which main goal is to bring students from a school from Sarmiento (inland Chubut) to see penguins (most cases for the first time). This program will run every year.



Every other year, together with the National Park we organize a presentation to tell people from the community (tour guides, park rangers, and teachers from school, among others) the new information collected by the project.



Partnerships

Partner	Support Type(s) ¹	Years of Association
Parque Interjurisdiccional Marino Costero Patagonia Austral	Logistic	2015-Present
Centro Nacional Patagonico-CONICET	Logistics, academic support	2015-Present
Secretaria de Turismo y Áreas Protegidas	Permits	2015-Present
Dirección de Flora y Fauna Silvestre	Permits	2015-Present

Contributions to management plans or policies

Plan/Policy Name	Type ²	Level of Impact ³	New or Existing?	Primary goal of plan/policy ⁴	Stage of plan/policy ⁵	Description of Contribution

2. Type options: agenda, convention, development plan, management plan, policy, or other (define)

3. Level of impact options: local, regional, national, international

4. Primary goal options: cultural conservation, land conservation, species conservation, natural resource conservation, other

5. Stage of plan/policy options: proposed, in progress, adopted, other (define)



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Conserving natural and sociocultural capital

CONSERVATION OF TAXA

In the past year, has your project helped conserve or restore populations of species of conservation significance? If so, please describe below.

Species	IUCN Red List category	Local/regional conservation status	Local/regional conservation status source	Description of contribution	Resulting effect ⁶
Spheniscus magellanicus	Near Threatened	Vulnerable	Informe de Aves Argentinas y la Secretaría de Ambiente y Desarrollo Sustentable	We started to understand the threats affecting the penguin colony	Baseline for future studies and determine changes in their environment that can act as a conservation alert.

¹. Resulting effect options: decreased competition, improved habitat for species, range increased, population increase, improved population structure, increased breeding success, maintained/enhanced genetic diversity, other

CONSERVATION OF ECOSYSTEMS – IN THE PAST YEAR, HAS YOUR PROJECT HELPED CONSERVE OR RESTORE HABITATS? IF SO, PLEASE DESCRIBE BELOW.

Habitat type	Habitat significance ⁷	Description of contribution	Resulting effect ⁸
Nesting colony	Breeding ground	Baseline knowledge	Extent maintained

⁷. Habitat significance options: nursery, breeding ground, feeding site, corridor, migration path, refuge, winter range, summer range, spring range, fall range or other (define)

⁸. Resulting effect options: extent maintained, condition achieved, restored, expanded, improved connectivity or resilience

ECOSYSTEM SERVICES – INDICATE WHICH ECOSYSTEM SERVICE CATEGORIES YOU ARE DIRECTLY STUDYING IN YOUR EARTHWATCH RESEARCH AND PROVIDE FURTHER DETAILS IN THE BOX BELOW.

- ☐ Food and water ☐ Flood and disease control
☐ Spiritual, recreational, and cultural benefits ☐ Nutrient cycling

Details:

Magellanic Penguins are one of the most popular animals in the eco-tourism industry in Patagonia. By understanding their at sea-behavior, we provide novel information for management and new information for tourist visiting the area.



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Research Plan Updates

Report any changes in your research since your last proposal/annual report. For any 'yes' answers, provide details on the change in the 'Details' box.

1. Have you added a new research site or has your research site location changed? ☐ Yes ☐ No
2. Has the protected area status of your research site changed ☐ Yes ☐ No
3. Has the conservation status of a species you study changed? ☐ Yes ☐ No
4. Have there been any changes in project scientists or field crew? ☐ Yes ☐ No

Details – provide more information for any 'yes' answers

The project will included a Field Manager and new field assistants. Also, we included the collaboration of Dr. Ralph Vanstreels to start a health assessment study.

Acknowledgements

All this work was carried out with the collaboration in the field and data entry of Earthwatch volunteers. Field assistants of this were involved and helped in all aspects of the project. We thank park rangers of PIMCPA for their help. We also thank Dr. Giacomo dell'Omo for his help with devices.