



STATE OF ANTARCTIC PENGUINS
2020

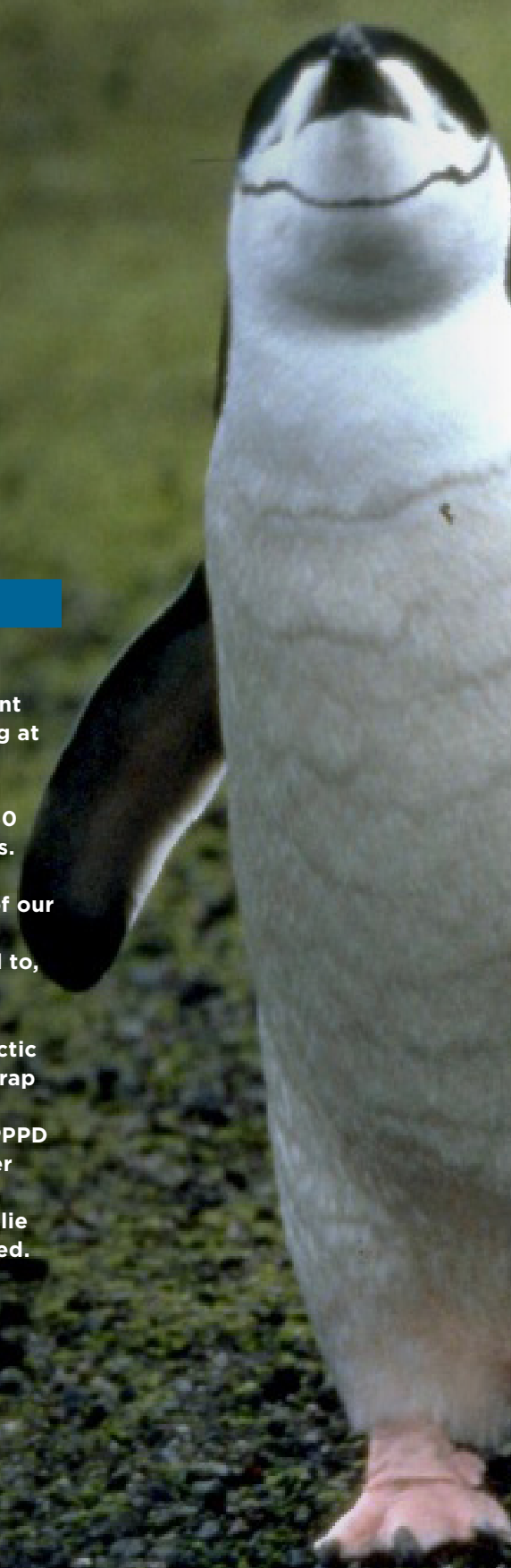


SOAP 2020

ABSTRACT

This report comprehensively summarizes the status of Antarctica's five penguin species, outlining the population size and trends for the continent and in key regions. These species total 5.77 million breeding pairs nesting at 698 sites across the entire Antarctic continent. This report uses the most current scientific data in the Antarctic continent-wide penguin MAPPPD Database that Oceanites maintains, which contains 4,010 records from 130 data sources of on-the-ground colony counts and satellite photo analyses. This year, the number of records in MAPPPD has increased by 7% and the number of data sources by 12%. We greatly appreciate the growing use of our open-sourced, publicly available data repository by the entire Antarctic community. And we again encourage those who have not yet contributed to, or utilized MAPPPD, to do so.

This year's report highlights continuing population declines in two Antarctic penguin species, with new and critical data documenting a further chinstrap penguin population decline in the Antarctic Peninsula (specifically, at Elephant Island). We note key papers that recently have utilized the MAPPPD Database; identify key data needs; and describe climate change and other factors being examined to assist a better understanding of penguin population changes in the vastly warmed Antarctic Peninsula, where Adélie and chinstrap penguins have declined and gentoo penguins have increased.





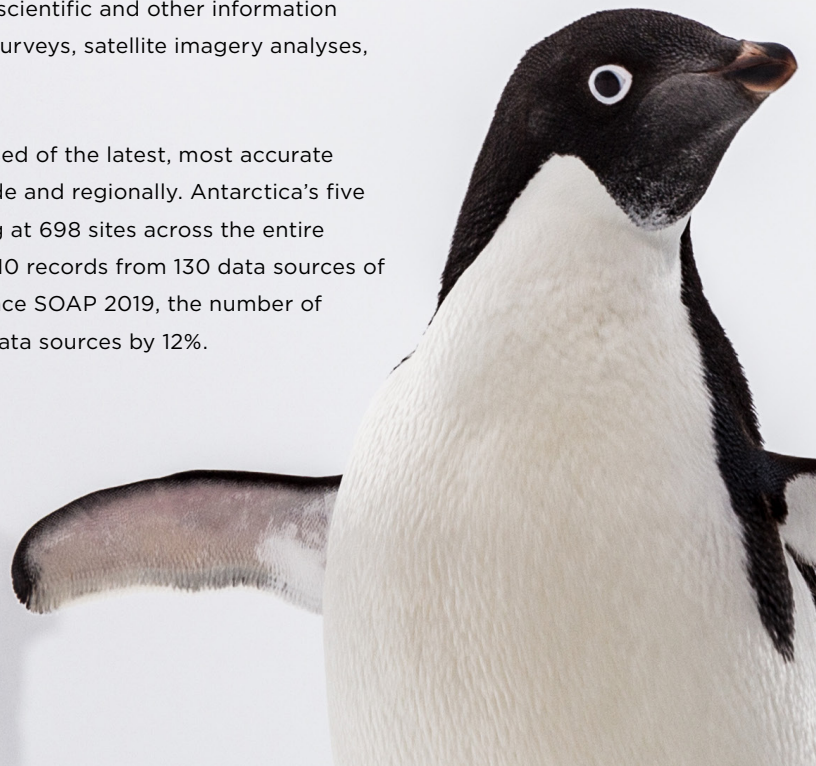
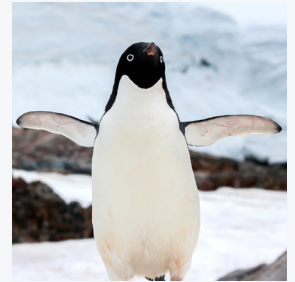
OUR DEAR FRIENDS,

We are pleased to present our 4th State Of Antarctic Penguins Report (SOAP), which, as noted previously, is intended to be a living document buttressed by ongoing science. We trust it provides a robust evidence base for decision making and management that assists all Antarctic stakeholders, including governments, scientists, NGOs, the private sector (fishing and tourism operators), and concerned citizens. Oceanites has championed — and continues to champion — science-based conservation (www.oceanites.org), with the firm view that long-term conservation in Antarctica cannot be achieved without ongoing and regular monitoring and assessment (Benninghoff & Bonner, 1985). To this end, we are doing all we can to ensure that the most current and accurate penguin population data are freely, readily, and publicly available.

Part of this monitoring and analytical effort is Oceanites' long-term Antarctic Site Inventory (ASI) project. The 2019/2020 season marked the 26th consecutive field expedition for the ASI, which began in 1994 and continues to monitor the entirety of the vastly warmed Antarctic Peninsula. Through February 2020, the ASI now has made 2,100 census visits and collected data at 258 Antarctic Peninsula locations. The present focus is on distinguishing the direct and interactive effects of climate change, fishing, tourism, and other human activities on the Antarctic Peninsula ecosystem. The complications of this analysis are described herein.

Another aspect of our monitoring and analytical effort is maintaining and upgrading the Antarctic continent-wide penguin database, MAPPPD (Mapping Application for Penguin Populations and Projected Dynamics), which was launched and went live in 2016 (<http://www.penguinmap.com>). MAPPPD is an open access decision support tool that was designed by the Lynch Lab for Quantitative Ecology at Stony Brook University and Black Bawks Data Science Ltd., with support from the US National Aeronautics and Space Administration (NASA) and Oceanites. MAPPPD assembles penguin population data from all of Antarctica and makes it publicly available. Over the past four years, MAPPPD has become a primary resource for scientific and other information about Antarctic penguins, integrating expert biological field surveys, satellite imagery analyses, and citizen science.

The goal of our SOAP reports is to keep the world fully apprised of the latest, most accurate population data about Antarctic penguins, both continent-wide and regionally. Antarctica's five breeding species now total 5.77 million breeding pairs nesting at 698 sites across the entire Antarctic continent. The MAPPPD database now contains 4,010 records from 130 data sources of on-the-ground colony counts and satellite photo analyses. Since SOAP 2019, the number of records in MAPPPD has increased by 7% and the number of data sources by 12%.



As is custom, SOAP 2020 also elaborates penguin population data in three key regions that have been the focus of conservation management efforts by the member countries of the Commission for the Conservation of Antarctic Marine Living Resources, or CCAMLR — the Antarctic Peninsula (CCAMLR Areas 48.1, 48.2 and 48.5); the Ross Sea (CCAMLR Areas 88.1 and 88.2); and Eastern Antarctica (CCAMLR Areas 58.4.1 and 58.4.2).

Additionally, SOAP 2020 notes new scientific papers that have utilized the MAPPPD database and key data needs that will assist a better understanding of penguin population changes, particularly in the vastly warmed Antarctic Peninsula where Adélie and chinstrap penguins have declined and gentoo penguins have increased.

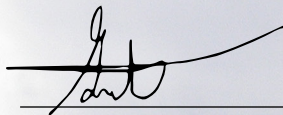
This report may be accessed and downloaded via the Oceanites website (<https://oceanites.org/wp-content/uploads/2020/10/SOAP-2020.pdf>).

We trust SOAP 2020 is useful to all of you!

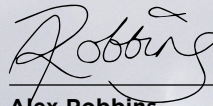
Please let us know and suggest what you might want to see in future issues.



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October 12, 2020

(This version of SOAP 2020 corrects numerical errors that appeared when the report was first posted online. We apologize for any inconvenience or difficulties this may have caused; R.N., G.H., A.R.)





THE ANTARCTIC PENGUINS

There are five penguin species breeding in Antarctica: emperor, Adélie, chinstrap, gentoo, and macaroni. Emperor and Adélie penguins only breed in Antarctica and are the only two Antarctic species that breed around the entire continent. The other species are restricted to the northern sections of the Antarctic Peninsula in addition to also breeding north of the Antarctic continent.

For this report, per the Antarctic Treaty, Antarctica is defined as all of the land and ice shelves south of 60°S latitude, which excludes penguins nesting at South Georgia and the South Sandwich Islands. Also, note that below, “N” refers to the number of nesting pairs.

The total of 5,771,543 breeding pairs nesting at 698 sites across the entire Antarctic continent represents a 6.03% decline from the total reported in SOAP 2019.

ANTARCTICA N TOTALS	N 2020	N 2019	N CHANGE	% CHANGE
EMPE (Emperor)	238,340	238,000	340	0.14%
ADPE (Adélie)	4,001,631	4,211,530	-209,899	-4.98%
CHPE (Chinstrap)	1,395,774	1,563,119	-167,345	-10.71%
GEPE (Gentoo)	122,549	116,083	+6,466	+5.57%
MCPE (Macaroni)	13,249	13,249	0	0.00%
TOTAL	5,771,543	6,141,981	-370,438	-6.03%

EMPEROR PENGUIN (*Aptenodytes forsterii*)

EMPE (EMPEROR) N	N 2020	N 2019	N CHANGE	% CHANGE
ANTARCTIC PENINSULA	53,114	48,343	+4,771	+9.87%
ROSS SEA	83,546	90,851	-7,305	-8.04%
EASTERN ANTARCTICA	58,092	58,092	—	—
WORLD WIDE TOTAL N	238,340	238,000	340	0.14%
ANTARCTIC TOTAL N	238,340	238,000	340	0.14%
WW% IN ANTARCTICA	100.0%	100.0%		
% OF ANTARCTIC TOTAL IN ANT PENINSULA	22.3%	17.1%		
% OF ANTARCTIC TOTAL IN ROSS SEA	35.1%	32.1%		
% OF ANTARCTIC TOTAL IN EASTERN ANTARCTICA	24.4%	20.5%		

• TRENDS, NOTES:

The newly discovered emperor colonies in the Antarctic Peninsula establish new baselines that will assist future, retrospective analyses. Estimates are expected to change as analytical techniques for satellite imagery continue to improve.

• KEY REFERENCES:

Fretwell & Trathan 2020; Fretwell et al 2012



ADÉLIE PENGUIN (*Pygoscelis adeliae*)

ADPE (ADÉLIE) N	N 2020	N 2019	N CHANGE	% CHANGE
ANTARCTIC PENINSULA	1,461,694	1,462,131	-437	-0.03%
ROSS SEA	1,461,213	1,486,335	-25,122	-1.69%
EASTERN ANTARCTICA	1,078,724	1,093,313	-14,589	-1.33%
WORLD WIDE TOTAL N	4,001,631	4,211,530	-209,899	-4.98%
ANTARCTIC TOTAL N	4,001,631	4,211,530	-209,899	-4.98%
WW% IN ANTARCTICA	100.0%	100.0%		
% OF ANTARCTIC TOTAL IN ANT PENINSULA	36.5%	34.7%		
% OF ANTARCTIC TOTAL IN ROSS SEA	36.5%	35.3%		
% OF ANTARCTIC TOTAL IN EASTERN ANTARCTICA	27.0%	17.1%		

• TRENDS, NOTES:

Many Adélie penguin sites in MAPPPD were last surveyed in the 1980s, and counts are expected to change as analytical techniques for satellite imagery continue to improve. Continent-wide, we note a 4.98% decline in nests, with declines in all three management regions.

• KEY REFERENCES:

Borowicz et al 2018; Southwell et al 2017; Casanovas et al 2015; Lynch and LaRue 2014; Lynch et al 2010; Woehler 1993



CHINSTRAP PENGUIN (*Pygoscelis antarctica*)

CHPE (CHINSTRAP) N	N 2020	N 2019	N CHANGE	% CHANGE
ANTARCTIC PENINSULA	1,395,750	1,563,119	-167,369	-10.71%
ROSS SEA	24	24	—	—
EASTERN ANTARCTICA	0	0		
WORLD WIDE TOTAL N	3,410,000	4- 7,500,000		
ANTARCTIC TOTAL N	1,395,774	1,563,119	-167,345	-10.71%
WW% IN ANTARCTICA	40.932%	20.9 to 39.1%		
% OF ANTARCTIC TOTAL IN ANT PENINSULA	99.998%	100.0%		
% OF ANTARCTIC TOTAL IN ROSS SEA	0.002%	0.0%		
% OF ANTARCTIC TOTAL IN EASTERN ANTARCTICA	0.000%	0.0%		

• TRENDS, NOTES:

New papers (Strycker et al, in review at *Polar Biology*; Strycker et al, in review at *Scientific Reports*) document a complete, updated penguin population census at Elephant Island and other locations in the northern Antarctic Peninsula, as well as a new and much improved estimate of the worldwide chinstrap penguin population. The chinstrap penguin decline at Elephant Island is significant and contributes to the 10.71% nest decline we note in the Antarctic Peninsula.

• KEY REFERENCES:

Strycker et al, in review at *Polar Biology*; Strycker et al, in Review at *Scientific Reports*; Casanovas et al 2015; Naveen et al 2012



GENTOO PENGUIN (*Pygoscelis papua*)

GEPE (GENTOO) N	N 2020	N 2019	N CHANGE	% CHANGE
ANTARCTIC PENINSULA	122,549	116,083	+6,466	+5.57%
ROSS SEA	0	0		
EASTERN ANTARCTICA	0	0		
WORLD WIDE TOTAL N	387,000	387,000	—	—
ANTARCTIC TOTAL N	122,549	116,083	+6,466	+5.57%
WW% IN ANTARCTICA	31.7%	30.0%		
% OF ANTARCTIC TOTAL IN ANT PENINSULA	100.0%	100.0%		
% OF ANTARCTIC TOTAL IN ROSS SEA	0.0%	0.0%		
% OF ANTARCTIC TOTAL IN EASTERN ANTARCTICA	0.0%	0.0%		

• TRENDS, NOTES:

122,549 breeding pairs per the MAPPPD database represents a 5.6% increase from 2019 and a 52% increase from an estimated 80,645 breeding pairs in 1997. The increase includes many newly reported nests from Elephant Island (Strycker et al, in review at *Polar Biology*).

• KEY REFERENCES:

Strycker et al, in review at *Polar Biology*; Lynch 2013; Lynch et al 2008, 2009, 2012; Naveen & Lynch 2011; Naveen 1997; Woehler 1996



MACARONI PENGUIN (*Eudyptes chrysolophus*)

MCPE (MACARONI) N	N 2020	N 2019	N CHANGE	% CHANGE
ANTARCTIC PENINSULA	13,249	13,249	—	—
ROSS SEA	0	0		
EASTERN ANTARCTICA	0	0		
WORLD WIDE TOTAL N	6,300,000	6,300,000	—	—
ANTARCTIC TOTAL N	13,249	13,249	—	—
WW% IN ANTARCTICA	0.2%	0.2%		
% OF ANTARCTIC TOTAL IN ANT PENINSULA	100.0%	100.0%		
% OF ANTARCTIC TOTAL IN ROSS SEA	0.0%	0.0%		
% OF ANTARCTIC TOTAL IN EASTERN ANTARCTICA	0.0%	0.0%		

• TRENDS, NOTES, REFERENCES:

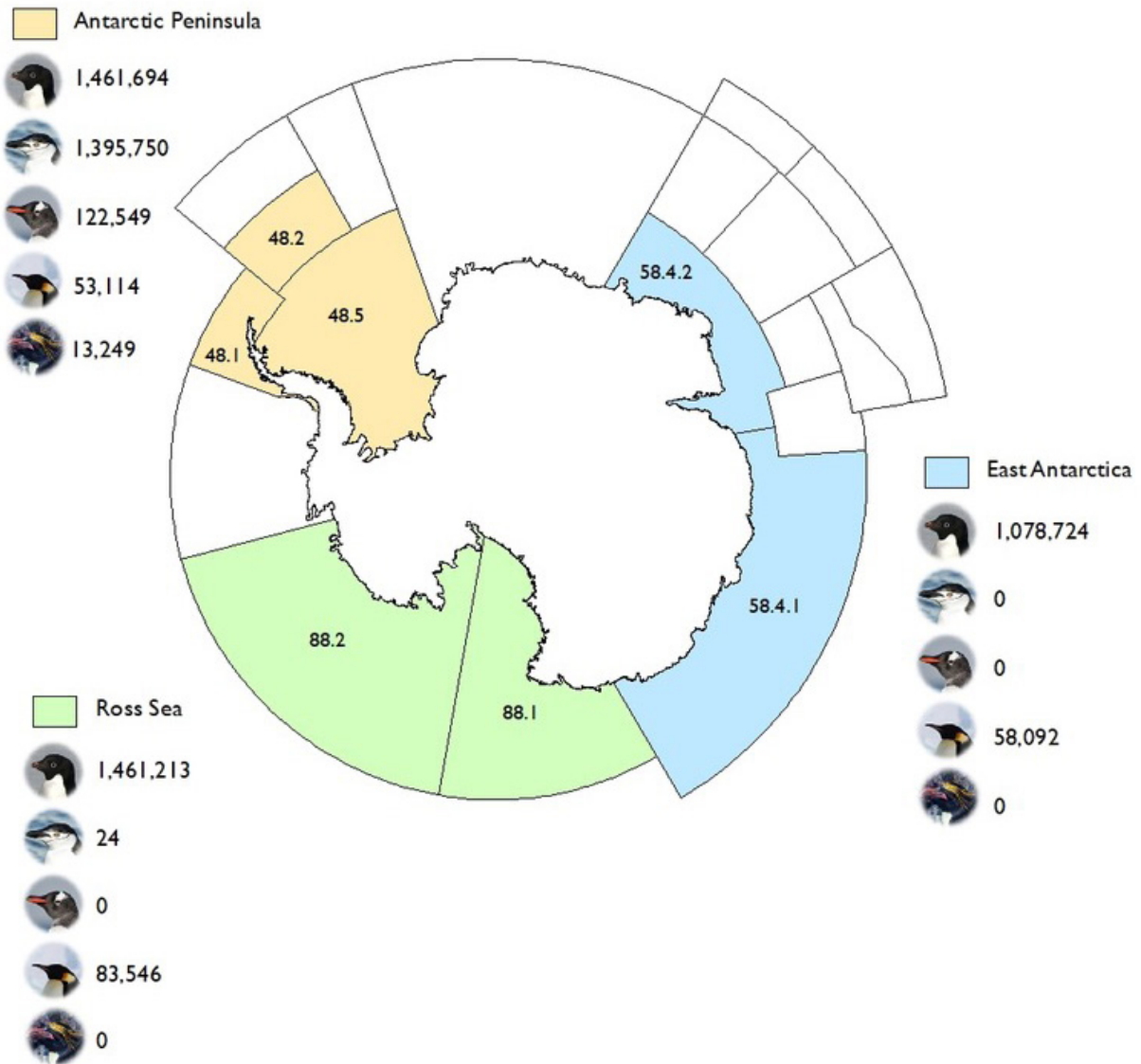
No new data to report. Per Crossin et al 2013, 13,249 breeding pairs are estimated in the Antarctic Peninsula and a worldwide population that is believed to have declined 30% to an estimated 6,300,000 breeding pairs. There are insufficient, recent surveys enabling an updated assessment of trends.



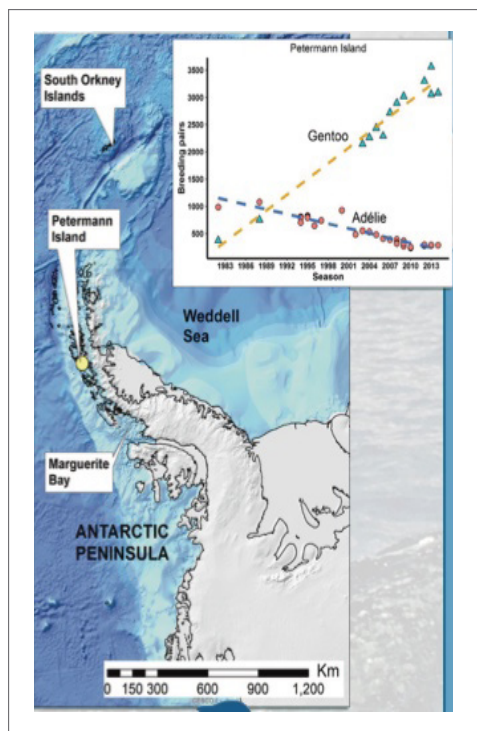
KEY ANTARCTIC REGIONS

As with previous *State Of Antarctic Penguins* reports, we elaborate penguin population data in three key regions that have been the focus of conservation management efforts by the member countries of the Commission for the Conservation of Antarctic Marine Living Resources, or CCAMLR – the Antarctic Peninsula (CCAMLR Areas 48.1, 48.2 and 48.5); the Ross Sea (CCAMLR Areas 88.1 and 88.2); and Eastern Antarctica (CCAMLR Areas 58.4.1 and 58.4.2).

Total number of breeding pairs in broad regions summarized in this report
 (Antarctic Peninsula = CCAMLR subareas 48.1, 48.2 and 48.5,
 Ross Sea = CCAMLR subareas 88.1 and 88.2,
 East Antarctica = CCAMLR subareas 58.4.1 and 58.4.2)



ANTARCTIC PENINSULA N TOTALS	N 2020	N 2019	N CHANGE	% CHANGE
EMPE (Emperor)	53,114	48,343	+4,771	+9.87%
ADPE (Adélie)	1,461,694	1,462,131	-437	-0.03%
CHPE (Chinstrap)	1,395,750	1,563,119	-167,369	-10.71%
GEPE (Gentoo)	122,549	116,083	+6,466	+5.57%
MCPE (Macaroni)	13,249	13,249	—	—
TOTAL	3,046,356	3,202,925	-156,569	-4.89%



• **TRENDS, NOTES:**

Over 26 consecutive seasons the Oceanites’ Antarctic Site Inventory has made 2,100 census visits and collected data at 258 Antarctic Peninsula locations. This region has warmed considerably over more than six decades, year-round by 3°C / 5°F and in winter by 5°C / 9°F, but the warming trend appears to have slowed (Turner et al 2005, 2013, 2016). In the same time frame, there has been a corresponding, significant increase in the regional gentoo penguin population and a significant decline in the regional populations of Adélie and chinstrap penguins.

The recent penguin census at Elephant Island reports a significant decline at that location and, overall, the regional chinstrap penguin population has declined by 167,369 nests (10.71%).

In this region, Adélie penguin populations have, in general and as noted above, declined significantly. Frequently visited colonies like Petermann island have shown consistent year to year declines over the last two decades.

As noted in SOAP 2017, SOAP 2018, and SOAP 2019, there is the sharp transition zone at the northern boundary of Marguerite Bay in the southern Antarctic Peninsula, north of which are widespread declines in Adélie penguin populations and increasing populations of gentoo penguins, but south of which Adélie penguin populations have remained stable or increased (Casanovas et al 2015). This lends support to the hypothesis that ocean productivity and sea ice dynamics are critical factors regulating Adélie penguin abundance in this location. As emphasized below, it would be excellent to achieve new penguin census data from Marguerite Bay south.

By contrast, gentoo penguin numbers continue to increase, including many newly reported from Elephant Island (Strycker et al, in review at *Polar Biology*).

ROSS SEA N TOTALS	N 2020	N 2019	N CHANGE	% CHANGE
EMPE (Emperor)	83,546	90,851	-7,305	-8.04%
ADPE (Adélie)	1,461,213	1,486,335	-25,122	-1.69%
CHPE (Chinstrap)	24	24	—	—
TOTAL	1,544,783	1,577,210	-32,427	-2.06%

EASTERN ANTARCTICA N TOTALS	N 2020	N 2019	N CHANGE	% CHANGE
EMPE (Emperor)	58,092	58,092	—	—
ADPE (Adélie)	1,078,724	1,093,313	-14,589	-1.33%
TOTAL	1,136,816	1,151,405	-14,589	-1.27%

• **TRENDS, NOTES:**

In both regions, there are few new data to report. Satellite imagery analyses expand the capacity to discover previously undescribed colonies and enable better estimates of species population size and regional trend. Estimates are expected to change as analytical techniques for satellite imagery are refined and improved.

NEW PAPERS RELYING ON MAPPPD

Strycker, N., A. Borowicz, M. Wethington, S. Forrest, V. Shah, Y. Liu, H. Singh, H. J. Lynch. Decline in chinstrap penguin abundance on Elephant Island, South Shetland Islands, Antarctica: Results of the 2019-20 census. In review at *Polar Biology*.

Most chinstrap penguin colonies have not been directly surveyed for decades. This paper presents the results of the first comprehensive census of chinstrap penguins on Elephant Island since 1970-71, and documents a total of 53,087 breeding pairs of chinstrap penguins at 28 locations, which represents an overall decline of 56% over the past 50 years. Also observed was a sharp increase in the number of gentoo penguins breeding on Elephant Island, and a stable population of macaroni penguins. The dramatic decline in the population of chinstrap penguins on Elephant Island is consistent with trends reported elsewhere throughout the South Shetland Islands and associated portions of the western Antarctic Peninsula.

Strycker, N., M. Wethington, A. Borowicz, S. Forrest, C. Witharana, T. Hart, H. J. Lynch. A global population assessment of the Chinstrap penguin (*Pygoscelis antarctica*). In Review at *Scientific Reports*.

Using satellite imagery, drone imagery, and ground counts, this report establishes the first global estimate of chinstrap penguins at 3.41 million breeding pairs across 375 extant colonies. Limited historical data prohibit assessment of population change at 46.9% of all chinstrap penguin colonies. Of colonies for which a comparison can be made to counts in the 1980s, 38.0% have declined or probably declined, 17.3% increased or probably increased, 22.1% have not changed significantly, 9.6% have been extirpated or probably extirpated, and 13.0% represent previously unrecognized colonies. This report also discusses environmental drivers of penguin population dynamics in Antarctica.

Fretwell, P.T., Trathan, P.N. 2020. Discovery of new colonies by Sentinel2 reveals good and bad news for emperor penguins. *Remote Sensing in Ecology and Conservation*. doi: 10.1002/rse2.176

The distribution of emperor penguins is circumpolar, with 54 colony locations currently reported of which 50 are currently extant as of 2019. This paper reports on eight newly discovered colonies and confirms the rediscovery of three breeding sites only previously reported in the era before very high resolution satellite imagery was available, making a total of 61 breeding locations. This represents an increase of ~20% in the number of breeding sites, but, as most of the colonies appear to be small, they may only increase the total population by around 5–10%. Some of the colonies exist in offshore habitats, something not previously reported for emperor penguins. Comparison with recent modeling results show that the geographic locations of all the newly found colonies are in areas likely to be highly vulnerable under business-as-usual greenhouse gas emissions scenarios, suggesting that population decreases for the species will be greater than previously thought.

Santora, J.A., LaRue, M.A., Ainley, D.G. Geographic structuring of Antarctic penguin populations. *Global Ecol Biogeogr.* 2020;00:1–13. <https://doi.org/10.1111/geb.13144>

The working hypothesis was that regional spatial organization of Antarctic penguin breeding populations was affected by social factors, that is, proximity and size of adjacent colonies, and by physical factors, that is, availability of breeding habitat and proximity of polynyas and submarine canyons where prey is abundant. New data on foraging areas and colony size are now available following 20 years of frequent biologging and real-time satellite data on colony locations and sizes. This paper reports that equal spacing of emperor penguin colonies was constant, with spacing a function of foraging range. In contrast, colonies of other penguin species were clustered, with small colonies adjacent to one another and within the outer edge of the foraging area of large colonies. The main conclusion is that inter- and intraspecific trophic competition affects the geographic structuring of colony distribution and size, although not necessarily in the same way among species. Results are relevant to assessing effects of climate, ecosystem dynamics, fisheries and other factors on penguin population trends at regional scales. Importantly, it is suggested that considering penguin colony distribution and abundance at the regional or cluster level is necessary to understand changes in these attributes.

Krüger, L., Huerta, M.F., Santa Cruz, F. et al. Antarctic krill fishery effects over penguin populations under adverse climate conditions: Implications for the management of fishing practices. *Ambio* (2020). <https://doi.org/10.1007/s13280-020-01386-w>

Fast climate changes in the western Antarctic Peninsula are reducing krill density, which along with increased fishing activities in recent decades, may have had synergistic effects on penguin populations. We tested that assumption by crossing data on fishing activities and Southern Annular Mode (an indicator of climate change in Antarctica) with penguin population data. Increases in fishing catch during the non-breeding period were likely to result in impacts on both chinstrap (*Pygoscelis antarcticus*) and gentoo (*P. papua*) populations. Catches and climate change together elevated the probability of negative population growth rates: very high fishing catch on years with warm winters and low sea ice (associated with negative Southern Annular Mode values) implied a decrease in population size in the following year. The current management of krill fishery in the Southern Ocean takes into account an arbitrary and fixed catch limit that does not reflect the variability of the krill population under effects of climate change, therefore affecting penguin populations when the environmental conditions were not favorable.

DATA GAPS

The recent, comprehensive survey at the Elephant Island and Low Island vicinity of the Antarctic Peninsula have filled some critical gaps for chinstrap penguins, but a number of key, under-surveyed areas should be considered high priorities for future data collection; for example, large chinstrap colonies in the South Orkney Islands; the South Sandwich Islands, and Cape Garry (Low Island). With regard to Adélie penguins, it would be helpful to have updated census data from Marguerite Bay south to the Red Rock Ridge and the Rhyolite Islands, which would further inform the differences in trends we have noticed north and south of Marguerite Bay.

CLIMATE ANALYSES

Oceanites collaborators, as well as many other researchers, are focused on distinguishing the interactive effects of climate change vis-à-vis human activities and other causes that might definitively explain penguin population changes that are being detected. Strycker et al in review at Scientific Reports, noted above, examines a suite of potential factors being examined in this regard, including: a potentially shifting or shrinking krill stock; the amount of krill fishing and higher exposure to fishing interference during the penguin breeding season; competition for krill with whales and seals; penguins' winter foraging ranges and other nonbreeding season impacts; and rising temperatures and retreating sea ice due to global warming.



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