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STATE OF ANTARCTIC PENGUINS 2018

MAPPPD

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ABSTRACT
This report comprehensively summarizes the status — population size and population trends — of Antarctica's five penguin species, continent-wide and in key regions. These species total at least 6.1 million breeding pairs nesting at 661 or more sites across the entire Antarctic continent. This report uses the most current scientific data, including 3,617 records from 108 sources of on-the-ground colony counts and satellite photo analyses. We continue to closely track the notable changes in the Antarctic Peninsula, which has undergone a well-documented period of warming over the last six decades. There, we have noted Adélie and chinstrap declines and gentoo increases; however, there are indications that the warming trend has leveled off in recent years with a concomitant stabilization of some Adélie populations. Our report relies on Oceanites' open access, publicly available MAPPPD tool and we encourage those who have not yet contributed to the MAPPPD database to do so.

We are pleased to present our 2nd *State Of Antarctic Penguins* report (SOAP), which, as we have noted previously, is intended to be is a living document buttressed by ongoing science. We trust it assists stakeholders everywhere, particularly the entire community of Antarctic interests — decision-makers and governments, scientists, NGOs, the private sector including fishing and tourism operators, and concerned citizens throughout the world.

For more than two decades, Oceanites Inc. has championed — and continues to champion — science-based conservation. One of its first programs was the Antarctic Site Inventory (ASI), which began in 1994. There was an initial focus on identifying potential penguin population changes from human activity, which has shifted to distinguishing the direct and interactive effects of climate change, fishing, tourism, and other human activities on the Antarctic Peninsula ecosystem. This past season marked the ASI's 24th season of field data collection, monitoring the entirety of the warmed Antarctic Peninsula.

In October 2016, the Mapping Application for Penguin Populations and Projected Dynamics (MAPPPD), another major initiative involving Oceanites, went live. 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 U.S. National Aeronautics and Space Administration (NASA) and Oceanites. MAPPPD intends to assemble penguin population data from *all* of Antarctica and to make it publicly available. We hope MAPPPD becomes *the* one-stop shop for scientific and other information about Antarctic penguins, integrating expert biological field surveys, satellite imagery analyses and citizen science.

Our goal is to keep everyone fully apprised of the latest, most accurate population data about Antarctic penguins — both continent-wide and regionally—, and trends in such numbers. Additionally, we will note key references and report on the latest scientific papers and publications relating to Antarctica's five breeding species of penguins.

While work on MAPPPD's predictive trend models continues, MAPPPD is currently using a population dynamics model recently published and described in Che-Castaldo et al. (2017). This model was developed for Adélie penguins and is being fine-tuned for use with chinstrap and gentoo penguins as well. We have not yet developed an emperor penguin population dynamics model but would welcome the submission of candidate models that could be incorporated into MAPPPD for this species.

We focus our summary of penguin populations and trends on three key regions, the Antarctic Peninsula (CCAMLR Areas 48.1, 48.2 and 48.5), the Ross Sea (CCAMLR Areas 88.1 and 88.2), and East Antarctica (CCAMLR Areas 58.4.1 and 58.4.2). Methodological details on data imputation and aggregation can be found in Che-Castaldo et al. (2017), while updated data can be searched and downloaded at http://www.penguinmap.com.

This report also may be accessed via the Oceanites website (https://oceanites.org/future-of-antarctica/penguin-conservation/state-of-antarctic-penguins-reports/), either online or through your mobile device, where we'll additionally post maps depicting sites from which MAPPPD would value the submission of more recent up-to-date data.

We trust that SOAP 2018 is useful to all of you! Please let us know and suggest what you might want to see in future issues.

Ron Naveen
Oceanites, Inc.

Heather Lynch
Stony Brook University

Grant Humphries
Black Bawks Data Science Ltd.

April 25, 2018

THE ANTARCTIC PENGUINS

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

Emperor Penguin

(Aptenodytes forsteri)

ANTARCTIC POPULATION SIZE

283,000 breeding pairs per Fretwell et al. (2012), data stored and displayed in MAPPPD.

ACCURACY

Satellite imagery analyses, as utilized in this survey, expand the capacity to discover previously undescribed emperor colonies and enable better estimates of species population size. Estimates are expected to change as analytical techniques for satellite imagery are refined and improved.

REFERENCE:

Fretwell et al. (2012)

Gentoo Penguin

(Pygoscelis papua)

ANTARCTIC POPULATION SIZE

119,216 breeding pairs per the MAPPPD database, an increase of 44% from an estimated 80,645 breeding pairs per Naveen (1997). The worldwide population is estimated at 387,000 breeding pairs per Lynch (2013).

ACCURACY

MAPPPD data are comprised almost entirely of recent ground counts, which are very accurate.

REFERENCES:

Woehler (1996); Naveen (1997); Naveen & Lynch (2011); Lynch et al. (2008, 2009, 2012); Lynch (2013)

Adélie Penguin

(Pygoscelis adeliae)

ANTARCTIC POPULATION SIZE

3,790,000 breeding pairs per Lynch & LaRue (2014), which is larger than an estimate from more than 20 years ago of 2,465,800 breeding pairs per Woehler (1993). The estimate from the MAPPPD database is 4,224,071, breeding pairs; which includes the latest counts obtained from Borowicz et al. (2018) on the Danger Islands. This is approximately 2% higher than 2017.

ACCURACY

Many sites were last counted in the 1980s, however we continue to add new counts through estimates in the published literature (e.g. Borowicz et al. 2018 and Southwell et al. 2017), and the Antarctic Site Inventory. The increase we note from SOAP 2017 may not represent an actual increase in the population, but, rather, reflects in part new data from several large colonies in the Danger Islands, not previously known to contain breeding populations.

REFERENCES:

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

Chinstrap Penguin

(Pygoscelis antarctica)

ANTARCTIC POPULATION SIZE

1,559,896 breeding pairs per the MAPPPD database; however, many sites have not been counted since the 1980s. Existing estimates of the worldwide population range from 4-7.5 million breeding pairs, which includes the large colonies found in the South Sandwich Islands that are not included in the MAPPPD database.

ACCURACY

The Antarctic estimate is expected to be revised by: a new survey presently underway, using satellite imagery analyses; updated colony counts; and MAPPPD predictive trend models, which are still being developed.

REFERENCES:

Woehler (1993); Naveen et al. (2012)

Macaroni Penguin

(Eudyptes chrysolophus)

ANTARCTIC POPULATION SIZE

13,249 breeding pairs estimated in the Antarctic Peninsula per Crossin et al. (2013). The worldwide population is believed to have declined 30% to an estimated 6,300,000 breeding pairs (Crossin et al. 2013).

ACCURACY

These data come from counts made in the 1980s, which makes it difficult to establish recent trends.

REFERENCES:

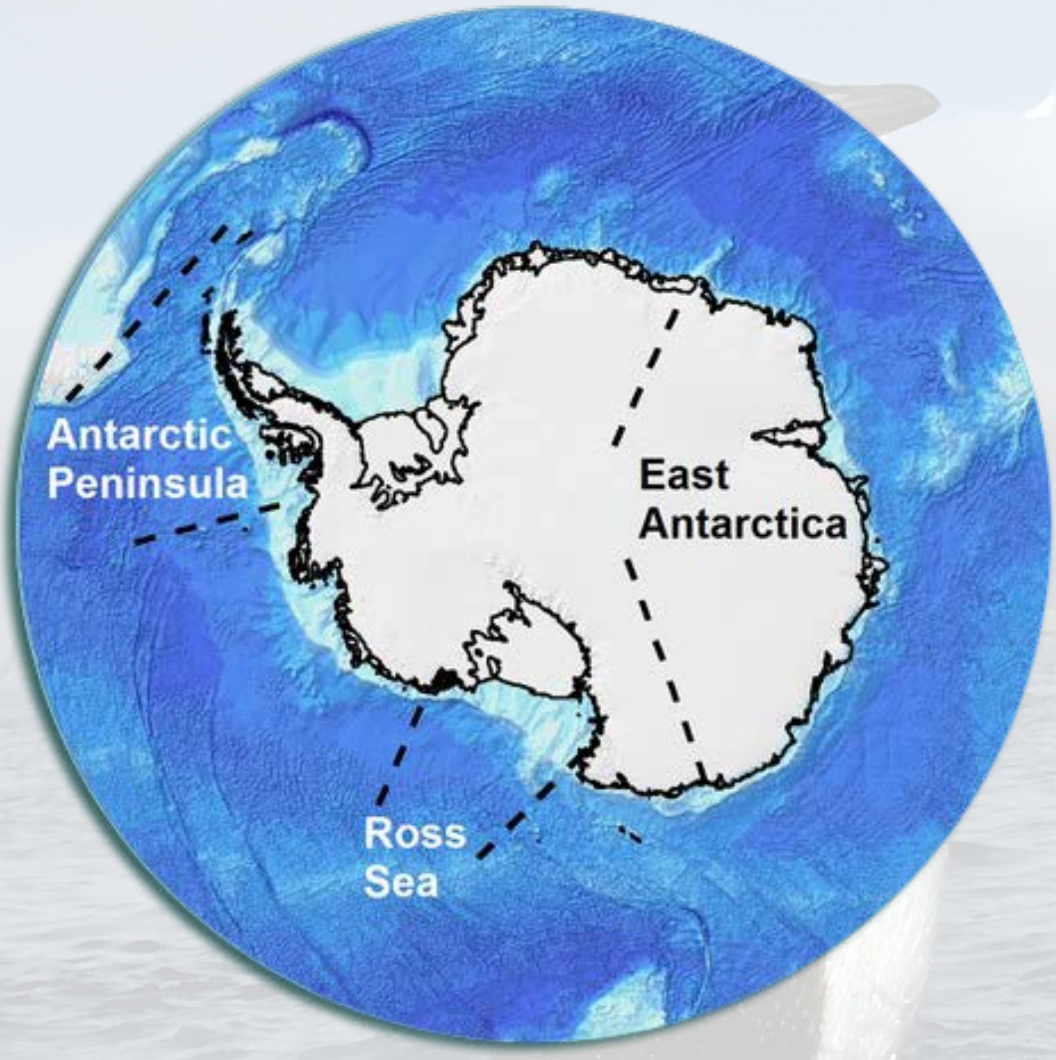
Woehler (1993); Woehler & Croxall (1996); Convey (1999); Crossin et al. (2013)

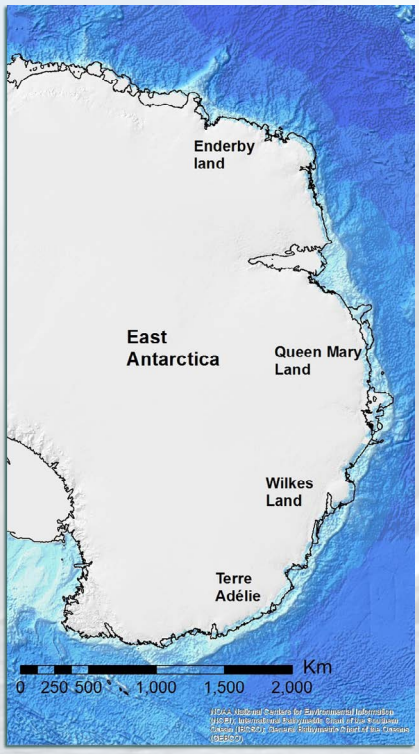
KEY ANTARCTIC REGIONS

As per the inaugural *State Of Antarctic Penguins Report 2017*, we focus on three key regions — the Antarctic Peninsula, comprising Areas 48.1, 48.2 and 48.5 demarcated by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR); Ross Sea, comprising CCAMLR Areas 88.1 and 88.2; and East Antarctica, comprising CCAMLR Areas 58.4.1 and 58.4.2.

The Antarctic Peninsula is where Oceanites' Antarctic Site Inventory concentrates and has collected data from 223 sites over 24 field seasons. This region had warmed considerably over more than six decades, year-round by 2˚C / 5˚F and in winter by 5˚C / 9˚F, but the warming trend appears to have slowed over the last decade. By contrast, in East Antarctica and the Ross Sea, there has been a cooling trend (Turner et al. 2005, 2013, 2016). In contrast to some site-specific Adélie penguin declines in the Antarctic Peninsula, Adélie populations in East Antarctica and the Ross Sea appear to be increasing.

No gentoo or chinstrap penguins appear to be breeding in East Antarctica or the Ross Sea. These two species breed in West Antarctica, but with different responses to the warmed, regional climate: gentoos are increasing, while chinstraps appear to be declining, although many sites lack enough data to draw firm conclusions.





Map Sources: NOAA National Centers for Environmental Information (NCEI); International Bathymetric Chart of the Southern Ocean (IBSCO); General Bathymetric Chart of the Oceans (GEBCO)

ANTARCTIC PENINSULA

(CCAMLR Areas 48.1, 48.2 and 48.5)

Emperor Penguin

(Aptenodytes forsteri)

REGIONAL POPULATION SIZE

48,343 breeding pairs in the Weddell Sea per Fretwell et al. (2012), data stored and displayed in MAPPPD.

ACCURACY

Counts are from seven sites in 2009, of medium to high accuracy and are reported in Fretwell et al. (2012).

TREND

Appears to be extirpated from its former breeding site in the Dion Islands. Satellite imagery analyses expand the capacity to discover previously undescribed emperor colonies and enable better estimates of species population size and regional trend. This estimate has not changed since 2017 due to a lack of new census data. Estimates are expected to change as analytical techniques for satellite imagery are refined and improved.

Adélie Penguin

(Pygoscelis adeliae)

REGIONAL POPULATION SIZE

1,473,875 breeding pairs per the MAPPPD database.

ACCURACY

Counts are from 112 sites, 72 counts are of high accuracy, 67 of medium accuracy, 47 are estimates from satellite imagery, and most were accomplished in the last decade.

TREND

In this region, we have noted significant Adélie declines at specific locations, some of which declines now appear to be flattening out. Our 2018 estimate is 7% higher than 2017, mostly due to our new baseline information from the Danger Islands expedition (Borowicz et al. 2018).

Chinstrap Penguin

(Pygoscelis antarctica)

REGIONAL POPULATION SIZE

1,559,896 breeding pairs per the MAPPPD database.

ACCURACY

Of 291 sites, mostly counted within the last decade, 97 are of high accuracy ground counts, 167 involve medium accuracy estimates, and 27 involve satellite imagery analyses. Some key, large sites lack updated counts, and many lack complete time series. This estimate is expected to be revised by a new survey, presently underway and using satellite imagery analyses; updated colony counts; and MAPPPD predictive trend models, which are still being developed.

TREND

At Deception Island, declines have been significant, with populations at neighboring chinstrap penguin breeding sites also declining, though to a lesser degree. The new survey, presently underway and using satellite imagery analyses, will enable the regional trend to be reassessed. Our estimate for 2018 is 3% lower than our estimate for 2017.

Gentoo Penguin

(Pygoscelis papua)

REGIONAL POPULATION SIZE

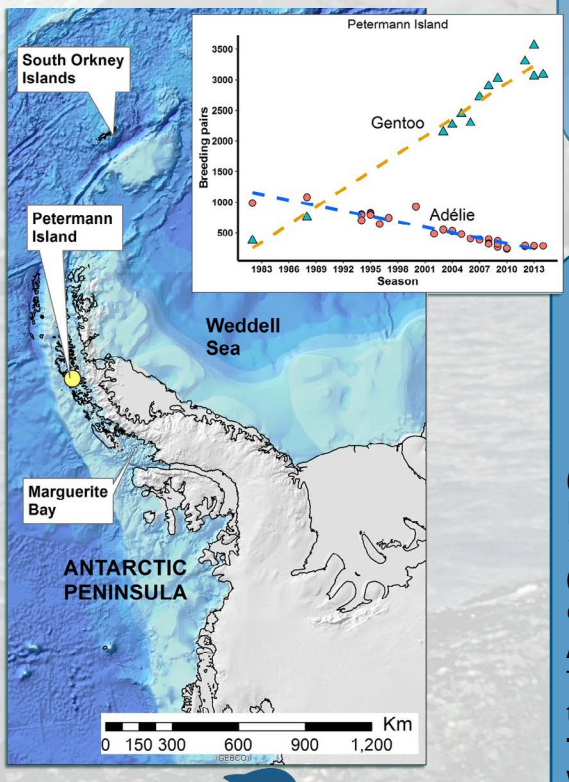
119,216 breeding pairs per the MAPPPD database.

ACCURACY

Of 158 sites, 90 involved high accuracy ground counts, the rest evenly spread between satellite imagery analyses or medium accuracy ground counts. About 65% of the latest counts were made in the last decade, and 40% within the last two seasons. Our 2018 estimate is 3% higher than that of 2017.

TREND

In this region, the gentoo penguin breeding population has increased significantly.



Macaroni Penguin

(Eudyptes chrysolophus)

REGIONAL POPULATION SIZE

13,249 breeding pairs per Crossin et al. (2013). Macaroni penguin data are not currently available in MAPPPD.

ACCURACY

These data come from counts made in the 1980s and need to be updated.

TREND

Worldwide, macaroni penguins appear to be decreasing (Horswill 2015). We are unable to update our assessment from 2017 because there are no recent surveys to report in the Antarctic Peninsula region.

ROSS SEA (CCAMLR Areas 88.1 and 88.2)

Emperor Penguin
(Aptenodytes forsteri)

REGIONAL POPULATION SIZE
90,851 breeding pairs per Fretwell et al. (2012), data stored and displayed in MAPPPD.

ACCACCURACY
Counts are from 12 sites, were made in 2009, and reported in Fretwell et al. (2012). All counts are medium to high accuracy.

TREND
Satellite imagery analyses expand the capacity to discover previously undescribed emperor 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.

Adélie Penguin
(Pygoscelis adeliae)

REGIONAL POPULATION SIZE
1,486,335 breeding pairs per the MAPPPD database.

ACCURACY
Estimates from 35 of the 54 sites in this region were high or medium accuracy, with 19 low accuracy estimates.

TREND
In the Ross Sea region, which has not experienced a regional warming trend like the Antarctic Peninsula, Adélie penguin populations appear to have increased. Estimates are expected to change as analytical techniques for satellite imagery are refined and improved. Our 2018 estimate is <1% higher than 2017.

EAST ANTARCTICA (CCAMLR Areas 58.4.1 and 58.4.2)

Emperor Penguin
(Aptenodytes forsteri)

REGIONAL POPULATION SIZE
58,092 breeding pairs per Fretwell et al. (2012), data stored and displayed in MAPPPD.

ACCURACY
Counts are from 16 sites and were made in 2009, and reported in Fretwell et al. (2012). All counts are medium to high accuracy.

TREND
Satellite imagery analyses expand the capacity to discover previously undescribed emperor 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.

Adélie Penguin
(Pygoscelis adeliae)

REGIONAL POPULATION SIZE
1,093,313 breeding pairs per the MAPPPD database.

ACCURACY
These estimates (78 of 88 sites) are made primarily using satellite counts from Lynch and LaRue (2014) for the year 2011. Few ground counts have been made at these sites due to their remoteness. Estimates are expected to be revised using refined satellite imagery analyses and updated ground surveys, augmented by the recent estimate, per Southwell et al. (2017), of East Antarctica breeding individuals.

TREND
In East Antarctica, which has not experienced a regional warming trend like the Antarctic Peninsula, Adélie penguin populations appear to have increased. Estimates are expected to change as analytical techniques for satellite imagery are refined and improved. No new data have become available since our 2017 report.

TRENDS, CONCERNS & FUTURE WORK

We again note that, over the past 60+ years in the warmed Antarctic Peninsula, gentoo populations have increased significantly; Adélie penguin populations in parts of this region have declined significantly; and chinstrap penguin populations have declined and, at some locations, significantly. By contrast, Adélie penguin populations in East Antarctica and the Ross Sea appear to be increasing.

The Peninsula continues to draw our attention knowing that warming in this region appears to have slowed, consistent with natural variability (Turner et al. 2005, 2013, 2016). And as noted in SOAP 2017, 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.

In 2017, the Lynch Lab, with Black Bawks Data Science Limited and Driven Data Limited hosted a data science competition with data from MAPPPD. The results were used to create an ensemble model of forecasts up to 2017 and is currently going through the peer-review process. To date, forecasts from these and the Bayesian Adélie penguin models are within 5–10% of those we present in this report, giving weight to the validity of our estimates for these populations.

Oceanites and colleagues are proceeding with further work distinguishing climate change impacts from other factors potentially causing Antarctic penguin population changes (https://oceanites.org/future-of-antarctica/climate-challenge/), while keeping abreast of work by other researchers around Antarctica.

REFERENCES

Borowicz, A., P. McDowall, C. Youngflesh, T. Sayre-McCord, G. Clucas, R. Herman, S. Forrest, M. Rider, M. Schwaller, T. Hart, S. Jenouvrier, M. Polito, H. Singh, and H. J. Lynch, *2018*. Multi-modal survey of Adélie penguin mega-colonies reveals the Danger Islands as a seabird hotspot. Scientific Reports 8:3926.

Casanovas, P.V., R. Naveen, S. Forrest, J. Poncet, and H.J. Lynch. 2015. A comprehensive coastal seabird survey maps out the front lines of ecological change on the Western Antarctic Peninsula. Polar Biology 38: 927-940.

Che-Castaldo, C., Jenouvrier, S., Youngflesh, C., Shoemaker, K.T., Humphries, G., McDowall, P., Landrum, L., Holland, M.M., Li, Y., Ji, R. and Lynch, H.J., 2017. Pan-Antarctic analysis aggregating spatial estimates of Adélie penguin abundance reveals robust dynamics despite stochastic noise. Nature communications, *8*(1), p.832.

Clucas, G., J.L. Younger, D. Kao, A.D. Rogers, J. Handley, G.D. Miller, P. Jouventin, P. Nolan, K. Gharbi, K.J. Miller and T. Hart, 2016. Dispersal in the sub-Antarctic: king penguins show remarkably little population genetic differentiation across their range. BMC Evolutionary BiologyBMC: DOI: 10.1186/s12862-016-0784-z

Convey P., A. Morton, and J. Poncet J., 1999. Survey of marine birds and mammals of the South Sandwich Islands. Polar Rec 35:107–194 .

Crossin, G.T., P.N. Trathan, and R.J.M. Crawford, *Macaroni and Royal Penguin*, in Borboroglu, P. G., & Boersma, P. D. (2013). Penguins: Natural history and conservation. Seattle: University of Washington Press.

Fretwell, P. T., M. A. LaRue, P. Morin, G. L. Kooyman, B. Wienecke, N. Ratcliffe, A. J. Fox, A. H. Fleming, C. Porter, and P. N. Trathan, 2012. An Emperor Penguin population estimate: The first global, synoptic survey of a species from space. PLoS ONE 7:e33751.

Humphries, G.R.W., R. Naveen, M. Schwaller, C. Che-Castaldo, 2017. Mapping Application for Penguin Populations and Projected Dynamics (MAPPPD): data and tools for dynamic management and decision support. Polar Rec: DOI: 10.1017/S0032247417000055.

Horswill, C., 2015. The relative importance of opposing drivers in determining population change in macaroni penguins *Eudyptes chrysolophus* (Doctoral dissertation, University of Glasgow).

Kooyman, G.L. and and P.J. Ponganis, 2016. Rise and fall of Ross Sea emperor penguin colony populations: 2000 to 2012. Antarctic Science: DOI: 10.1017/S0954102016000559.

Levy, H. Hila Levy, G.V. Clucas, A.D. Rogers, A.D. Leaché, K.L. Ciborowski, M.J. Polito, H.J. Lynch, M.J. Dunn, and T.Hart, 2016. Population structure and phylogeography of the Gentoo Penguin *(Pygoscelis papua)* across the Scotia Arc. Ecol Evol. 2016 Mar; 6(6): 1834–1853.

Lynch, H.J., and M.A. LaRue, 2014. First global census of the Adélie Penguin. The Auk 131(4):457-466. 2014

Lynch, H.J., *Gentoo Penguin*, in Borboroglu, P. G., & Boersma, P. D. (2013). Penguins: Natural history and conservation. Seattle: University of Washington Press.

Lynch, H.J., R. Naveen, and W.F. Fagan. 2008. Censuses of Penguin, Blue-Eyed Shag Phalacrocorax Atriceps and Southern Giant Petrel Macronectes Giganteus Populations in the Antarctic Peninsula, 2001-2007. Marine Ornithology 36: 83–97.

Lynch, H.J., R. Naveen, and W.F. Fagan. 2009. Population trends and reproductive success at a frequently visited penguin colony on the western Antarctic Peninsula. Polar Biology 33(4): 493-503.

Lynch, H.J., R. Naveen, P.N. Trathan and W.F. Fagan. 2012. Spatially integrated assessment reveals widespread changes in penguin populations on the Antarctic Peninsula. . Ecology 93(6): 1367-1377.

Lynch, H.J., R. White, R. Naveen, A. Black, M.S. Meixler, and W.T. Fagan, 2016. Polar Biol 39: 1615. DOI:10.1007/s00300-015-1886-6

Naveen, R. 2003. Compendium of Antarctic Peninsula Visitor Sites (2d edition): A Report to the United States Environmental Protection Agency, US Environmental Protection Agency.

Naveen, R. and H.J. Lynch. 2011. Antarctic Peninsula Compendium, 3rd Edition. Environmental Protection Agency, Washington, D.C. Naveen, R. and H.J. Lynch. 2011. Antarctic Peninsula Compendium, 3rd Edition. Environmental Protection Agency, Washington, D.C.

Naveen, R., 1997. Compendium of Antarctic Peninsula Visitor Sites: A Report to the Governments of the United States and the United Kingdom, US Department of State and UK Foreign and Commonwealth Office.

Naveen, R., H. J. Lynch, S. Forrest, T. Mueller, and M. Polito. 2012. First, complete site-wide penguin survey at Deception Island, Antarctica reveals massive declines consistent with climate change. Polar Biology 35(12): 1879-1888.

Smith, R.C., Stammerjohn, S.E., 2001. Variations of surface air temperature and sea ice extent in the western Antarctic Peninsula (WAP) region. Annals of Glaciology 33, 493–500.

Southwell, C., Louise Emmerson, Akinori Takahashi, Christophe Barbraud, Karine Delord, Henri Weimerskirch, 2017. Large-scale population assessment informs conservation management for seabirds in Antarctica and the Southern Ocean: A case study of Adélie penguins. Global Ecology and Conservation 9, 104–115.

Turner J, Barrand NE, Bracegirdle TJ, Convey P, Hodgson DA, Jarvis M, Jenkins A, Marshall GJ, Meredith MP, Roscoe HK, Shanklin JD, French J, Goosse H, Guglielmin M, Gutt J, Jacobs SS, Kennicutt MCI, Masson-Delmotte V, Mayewski P, Navarro F, Robinson S, Scambos T, Sparrow M, Speer K, Summerhayes CP, Klepikov AV, 2013. Antarctic Climate Change and the Environment - An Update. Polar Rec: DOI:10.1017/S0032247413000296.

Turner, J., .R. Colwell, G.J. Marshall, T.A. Lachlan-Cope, A.M. Carleton, P.D. Jones, V. Lagun, P.A. Reid, and S. Iagovkina, 2005. Antarctic climate change during the last 50 years. *Int. J. Climatol*. 25: 279–294.

Turner, J., Hua Lu, Ian White, John C. King, Tony Phillips, J. Scott Hosking, Thomas J. Bracegirdle, Gareth J. Marshall, Robert Mulvaney & Pranab Deb, 2016. Absence of 21st century warming on Antarctic Peninsula consistent with natural variability. *Nature* 535 (7612).

Woehler, E. J. and J. Croxall, eds., 1996. The Status and Trends of Antarctic and Subantarctic Seabirds. Scientific Committee on Antarctic Research, Subcommittee on Bird Biology, Cambridge, Eng¬land.

Woehler, E. J., 1993. The Distribution and Abundance of Antarctic and Subantarctic Penguins. Scientific Committee on Antarctic Research, Cambridge, Eng¬land.

Oceanites, Inc.
PO Box 15259
Chevy Chase,
MD 20825 USA
202-237-6262

CREDITS
State Of Antarctic Penguins Report 2018

Contributors:
Grant Humphries, Ron Naveen, Heather Lynch

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For further information, contact:
Ron Naveen, Oceanites, Inc.
oceanites@icloud.com

Grant Humphries, Black Bawks Data Science Ltd.
grwhumphries@blackbawks.net

Heather Lynch, Stony Brook University
heather.lynch@stonybrook.edu