



Bayesian data-model synthesis for biological conservation and management in Antarctica

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Oceanites

Remote sensing provides perhaps the only method to study the largest and most remote penguin colonies.



Remote sensing of penguins by satellites: A paradigm shift

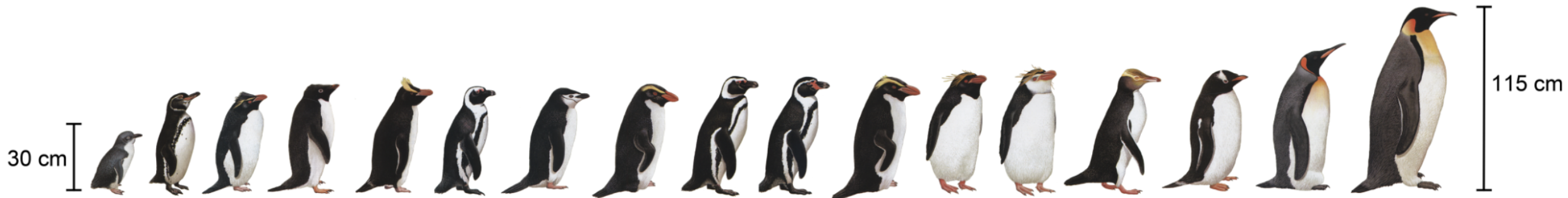
Why Antarctica? Antarctica remains one of the planet's most challenging environments for biological survey. Recent developments in remote sensing have radically expanded the opportunities for regular, high-quality biological surveys at the continental scale. As a result, Antarctica has become a model system for the use of remote sensing for biological conservation.



Drawings from del Hoyo et al. 1992

Remote sensing of penguins by satellites: A paradigm shift

Why now? With the support of the Southern Ocean Observing System, we have the opportunity to help develop a regional biodiversity observing network (BON) in the Antarctic. Additionally, there is currently an effort to assess how we can meet the 2020 Aichi biodiversity targets for Antarctica. **Our decision-support tool is a critical component to these important international efforts.**



Drawings from del Hoyo et al. 1992

Remote sensing of penguins by satellites: A paradigm shift

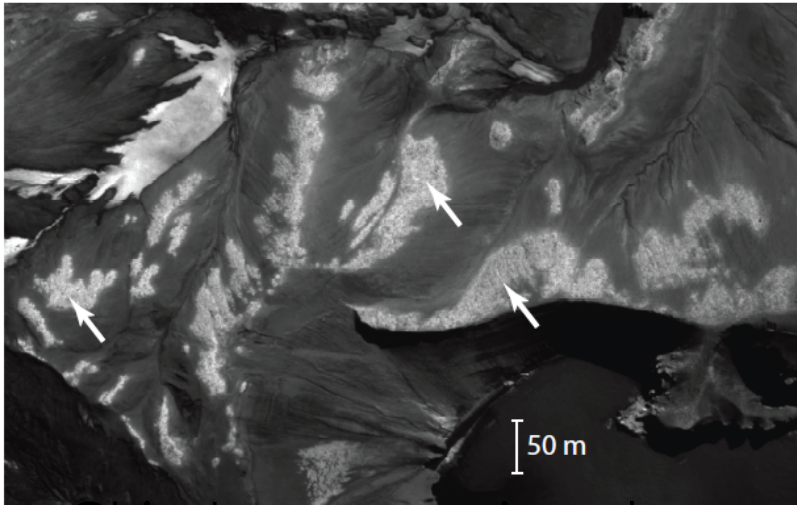
Big questions

1. Can we detect penguins?
2. Can we differentiate different species of penguins?
3. Can we estimate abundance?
4. Can we assess changes in abundance?
5. Can we start doing global/regional censuses?
6. Can we learn something new about penguin biology?
- 7. Can we improve the decision-making process for conserving Antarctic marine living resources?**



Drawings from del Hoyo et al. 1992

The mission: To create a publicly-accessible, easy-to-use, browser-based application that provides Antarctic biodiversity data at any user-defined spatial and temporal scale



Chinstrap penguin colony
in Quickbird imagery

NASA

Landsat-4

30m multispectral

Landsat-5

30m multispectral

Landsat-7

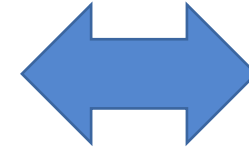
15m panchromatic

30m multispectral

Landsat-8

15m panchromatic

30m multispectral



Merger of
commercial and
NASA satellite
imagery products

Commercial

Quickbird

2.4m multispectral)

0.6m panchromatic

Worldview-1

0.5m panchromatic

Worldview-2

1.6m multispectral

0.4m panchromatic

Geoeye

1.6m multispectral

0.4m panchromatic

IKONOS

4m multispectral

1m panchromatic

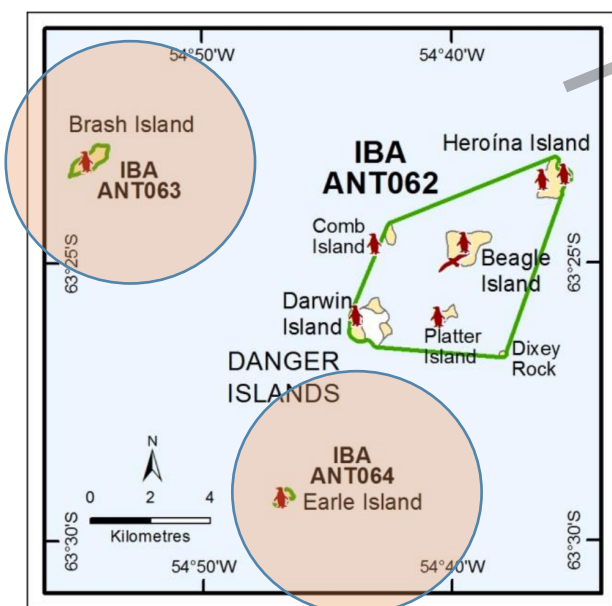
Worldview-3

1.24m multispectral

0.31m panchromatic

“Data-to-knowledge pipeline”

Danger Islands



A large number of Adélie Penguins breed in the Danger Islands group, with between 285 115 and 305 165 Adélie Penguin nests estimated in 1996 (Naveen & Lynch 2011). Breeding occurs on slopes and ridges across most of the islands in the group (Elliott *et al.* 1978; Naveen & Lynch 2011; Lynch & LaRue 2014; Lynch & Schwaller 2014). Brash and Earle islands possess breeding colonies of Pygoscelid penguins of sufficient size and distance from each other and the other islands to warrant qualification as IBAs in their own right, and these are described in IBAs ANT063 and ANT064. Numbers of breeding pairs of Pygoscelid penguins on the remaining islands were estimated by Lynch & LaRue (2014) and Lynch & Schwaller (2014) (Table 062.1).

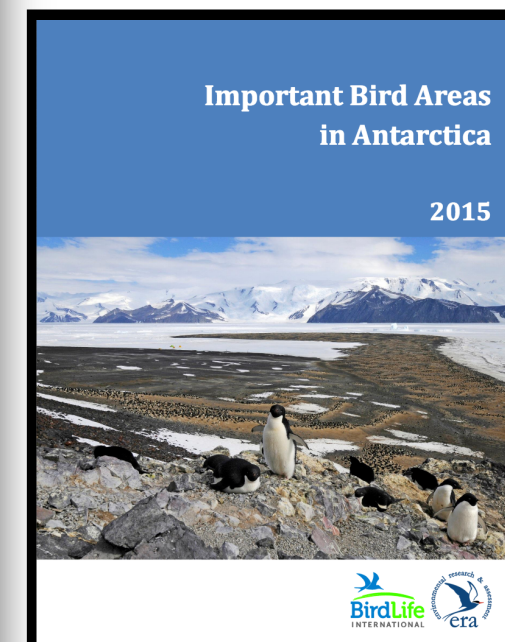
Table 062.1: Estimates of the number of breeding pairs of Pygoscelid penguins on northeastern Danger Islands

Island	Species	Breeding Pairs	95% CI	Source
Heroína	<i>Pygoscelis adeliae</i>	51 358	31 184, 83 938	Lynch & LaRue 2014
Beagle	<i>Pygoscelis adeliae</i>	96 892	59 507, 158 260	Lynch & LaRue 2014
Comb (Peine ¹)	<i>Pygoscelis adeliae</i>	3 311	1805, 5564	Lynch & LaRue 2014
Platter (Plato ¹)	<i>Pygoscelis adeliae</i>	27 902	16 876, 45 600	Lynch & LaRue 2014
Darwin	<i>Pygoscelis</i> sp.	7 419	5384, 9931	Lynch & Schwaller 2014
Totals		186 882		

¹ Geographical name used in Lynch & LaRue 2014.

Gentoo Penguins (*Pygoscelis papua*) also breed on the Danger Islands in small numbers, with 215 pairs present on Heroína Island in 1996 and 173 chicks counted in late Jan 2009, reported by the Antarctic Site Inventory (Naveen & Lynch 2011; Lynch *et al.* 2013).

Other birds thought to breed at the site include the Cape Petrel (*Daption capense*), Snowy Sheathbill (*Chionis albus*), Kelp Gull (*Larus dominicanus*), Brown Skua (*Catharacta antarctica*), Wilson's Storm-petrel (*Oceanites oceanicus*) and Antarctic Tern (*Sterna vittata*). Occasional visitors include Chinstrap Penguin (*Pygoscelis antarctica*), Southern Giant Petrel (*Macronectes giganteus*), Snow Petrel (*Pagodroma nivea*), Imperial Shag (*Phalacrocorax [atriceps] bransfieldensis*) and South Polar Skua (*Catharacta maccormicki*) (Naveen & Lynch 2011).



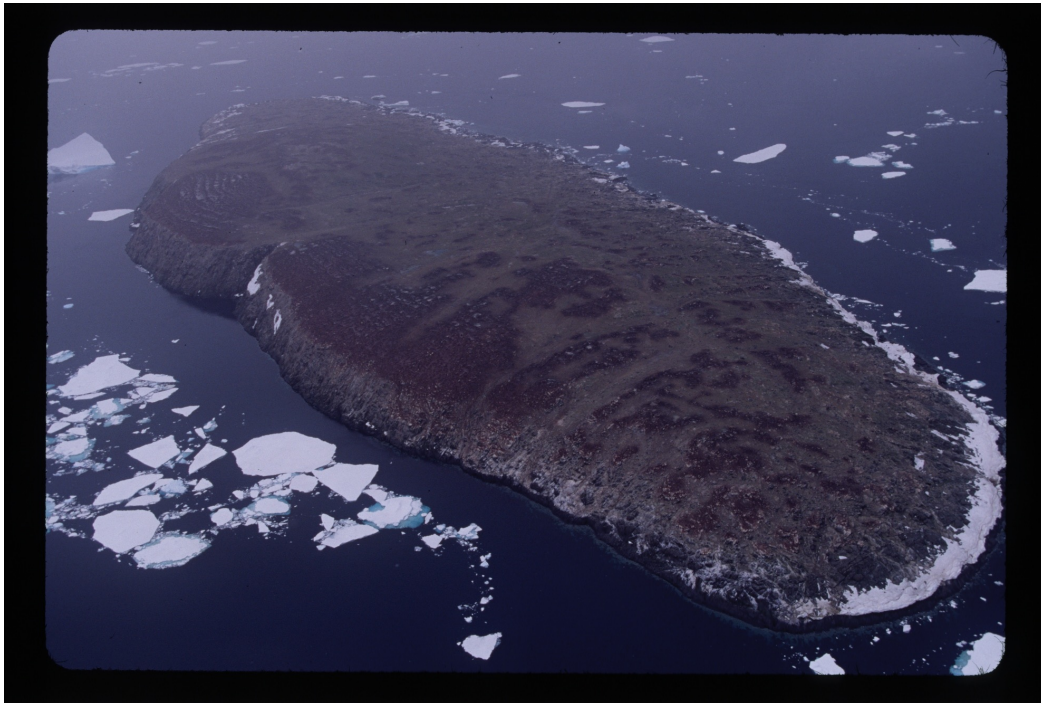
Harris et al. 2015

Danger Islands Expedition

Dec 2015-Jan 2016



Some populations known only from helicopter survey – the rest recently discovered by Landsat imagery



Need to automate image interpretation, but both medium- and high-resolution imagery presents challenges

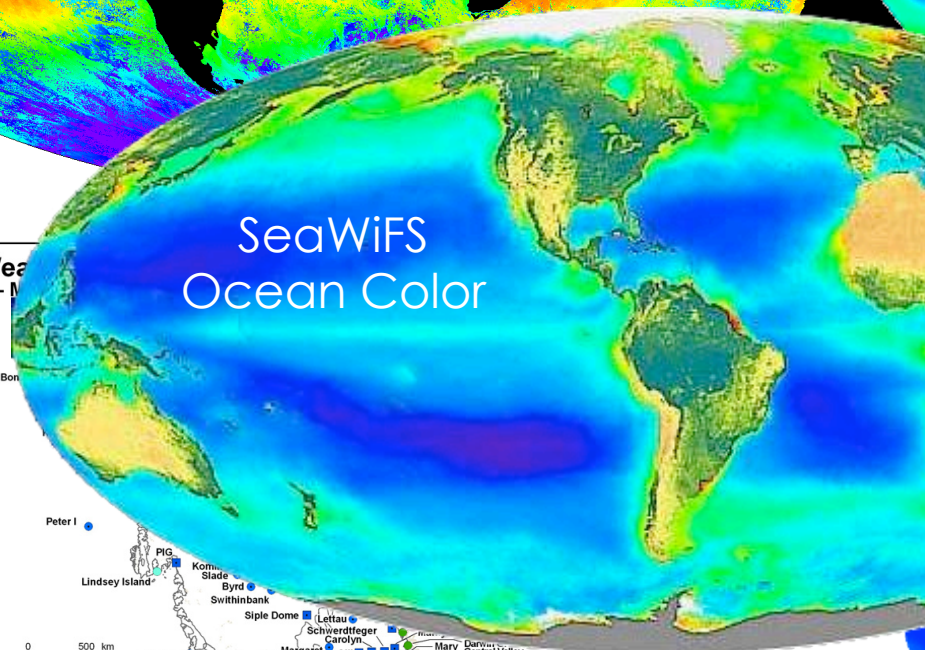
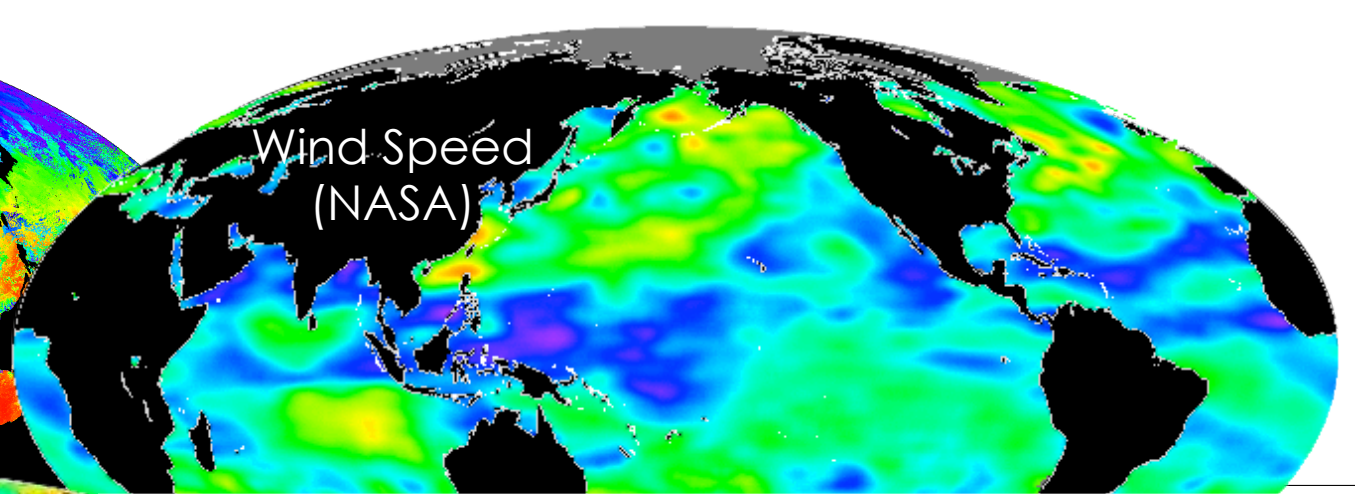
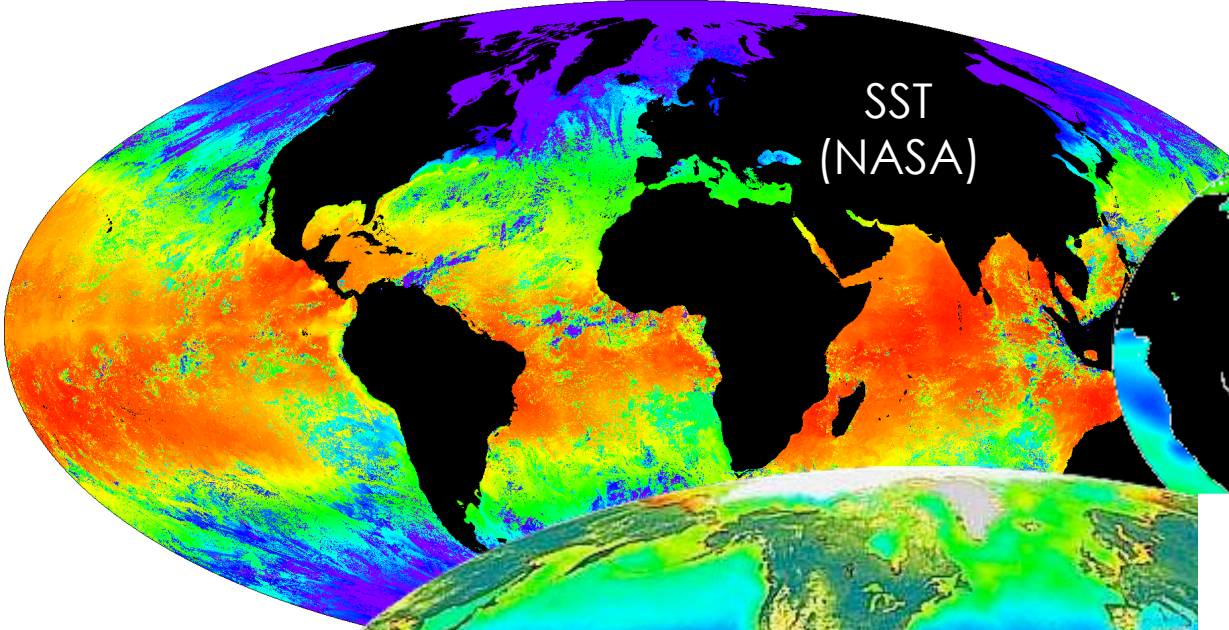


medium-resolution sensors
(e.g., Landat)

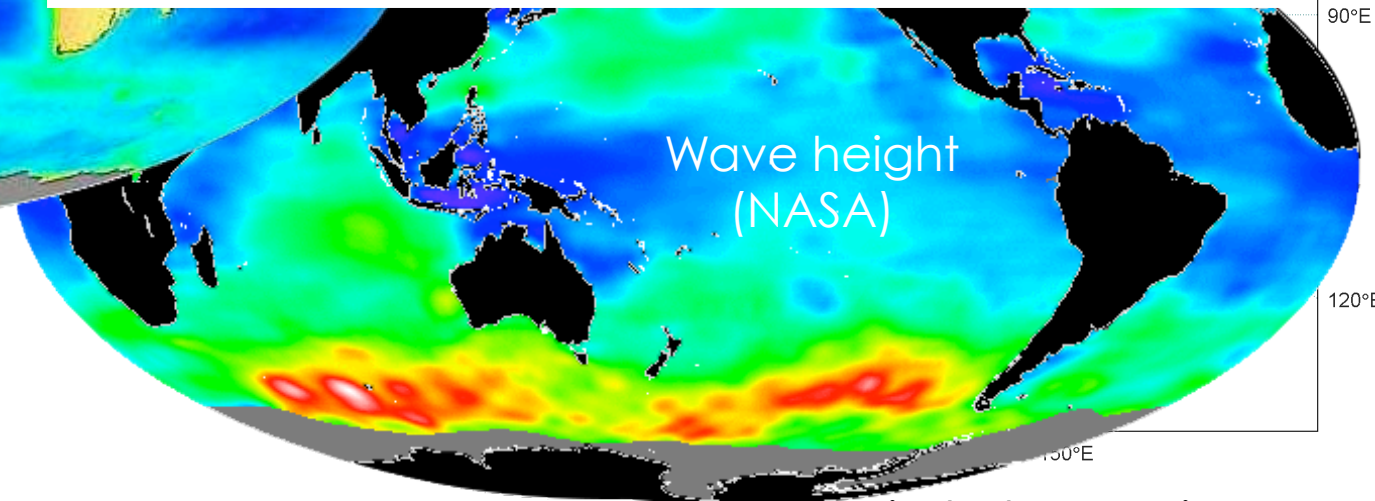


high-resolution sensors
(e.g., Worldview-3)

Need algorithms to automate the interpretation of both medium and high-resolution imagery



Lots of streaming data on environmental drivers but almost no comparable streaming datasets on wildlife abundance and distribution.



60°E

90°E

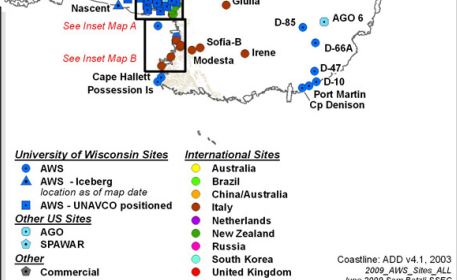
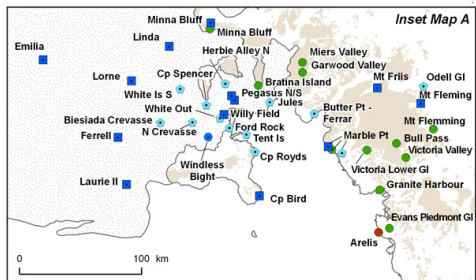
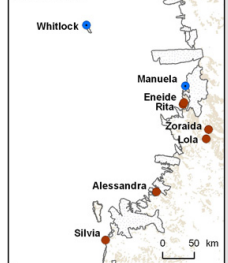
120°E

150°E

Li et al. In Review

2009 Automatic Weather Station Data
University of Wisconsin - Milwaukee

Inset Map B



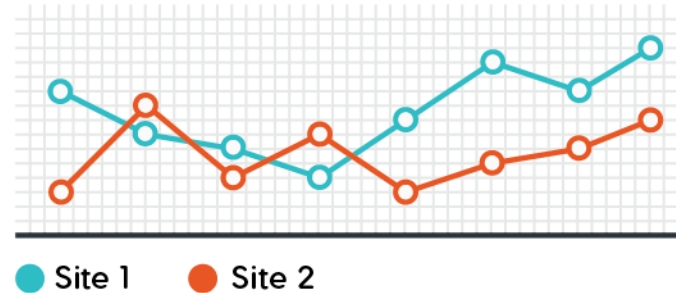
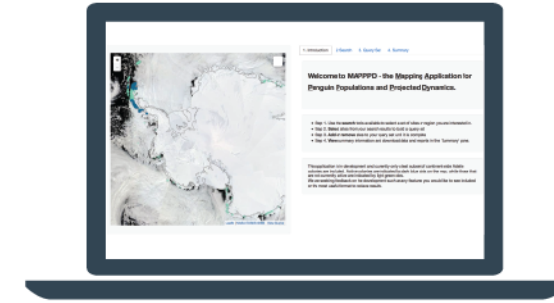
Coastline: ADD v4.1, 2003
2009_AWS_Sites_ALL
June 2009 Sam Batzi SSEC

Mapping Application for Penguin Populations and Projected Dynamics (MAPPPD)

Satellite imagery & Field counts



Map-based search engine for current abundance and predicted dynamics



Dynamic Naive Bayesian
Network Modelling

**“Data-to-knowledge”
pipeline**

MAPPPD (Mapping Application for Penguin Populations and Projected Dynamics) is an [open access](#) decision support tool designed for managers, scientists and the general public.

Scientists from all corners of the Antarctic have collaborated to create a database of penguin population counts with data from [four charismatic Sphenisciformes](#). Our tool takes penguin populations a step further by integrating advanced modeling techniques to detect and count penguin colonies from remote sensing data. MAPPPD also calculates occupancy probabilities and presents graphical output which projects how penguin populations will change in the future

Read More

Chinstrap penguin
(*Pygoscelis antarctica*)

Query by one of the four species of penguin in our database

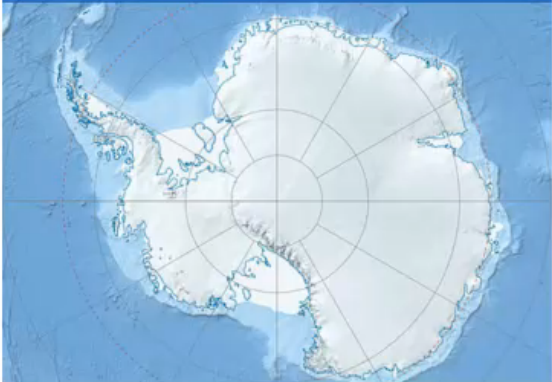
View Data

Adélie penguin
(*Pygoscelis adeliae*)

Penguin fact sheets




View Data



CLICK HERE to explore MAPPPD

Explore the MAPPPD data portal



View our species database

Four species of Antarctic penguins

Become a contributor

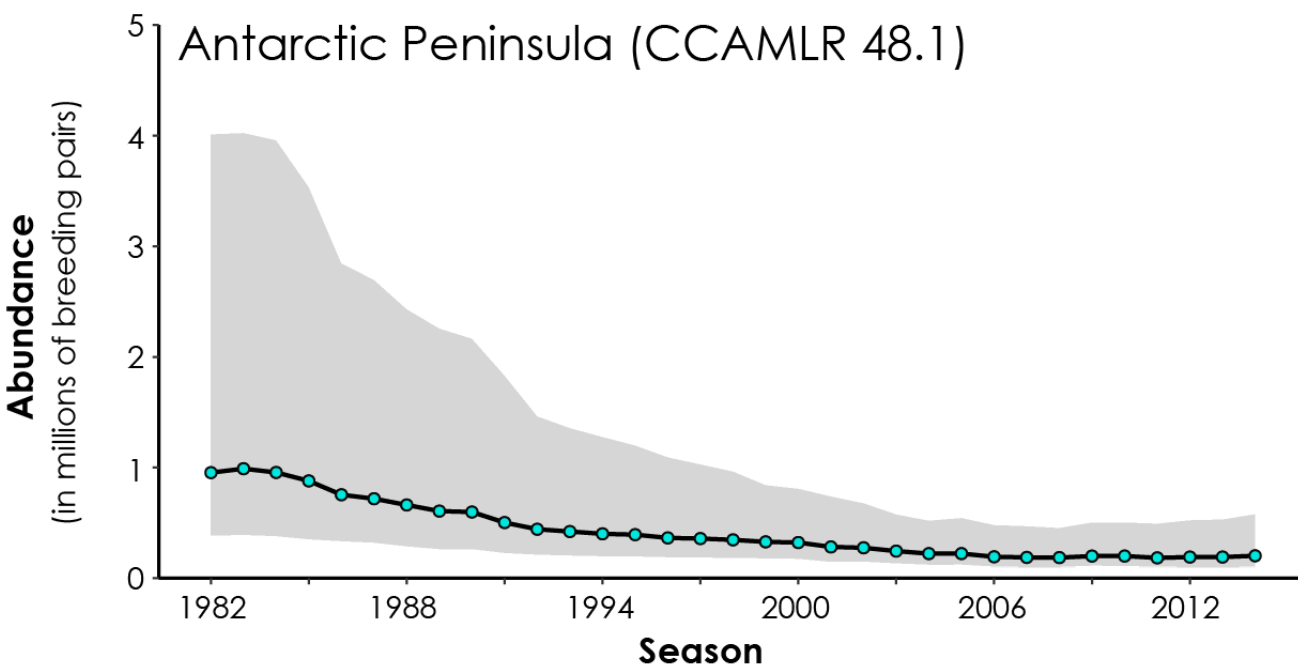
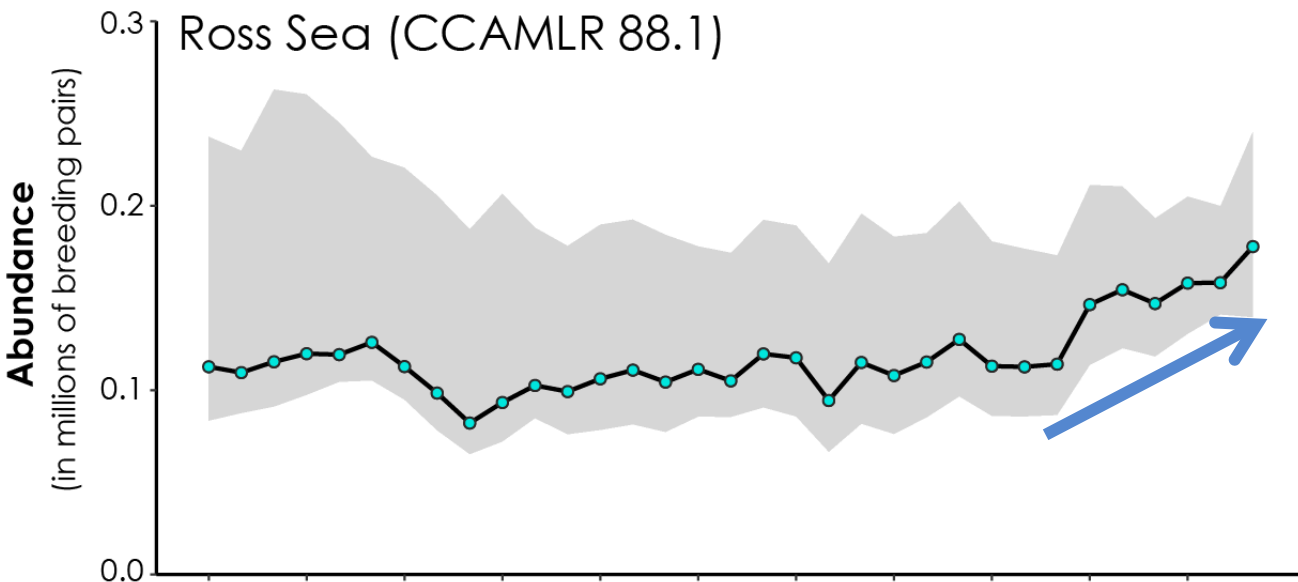
If you have data you would like to contribute to the database:

1. Read our [Terms of Use](#)
2. Download the [contributor's form](#)
3. Read the [instructions](#)
4. Submit your data to: info@penguinmap.com

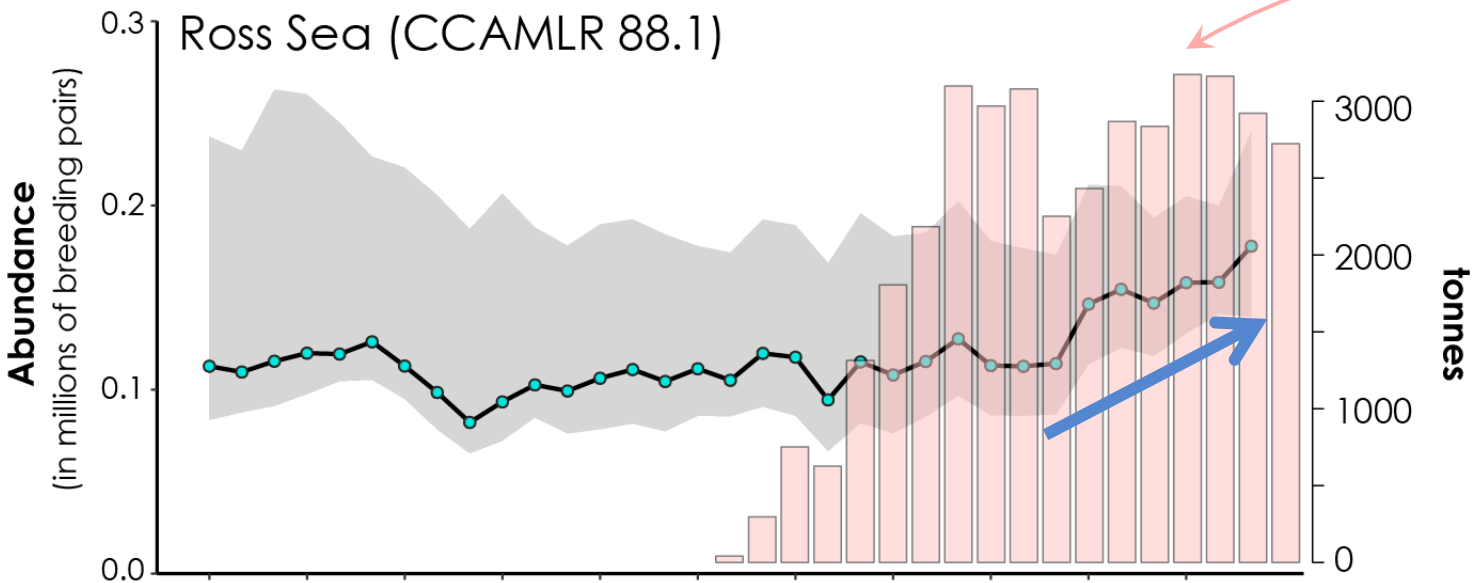
Instructions

Contributor form

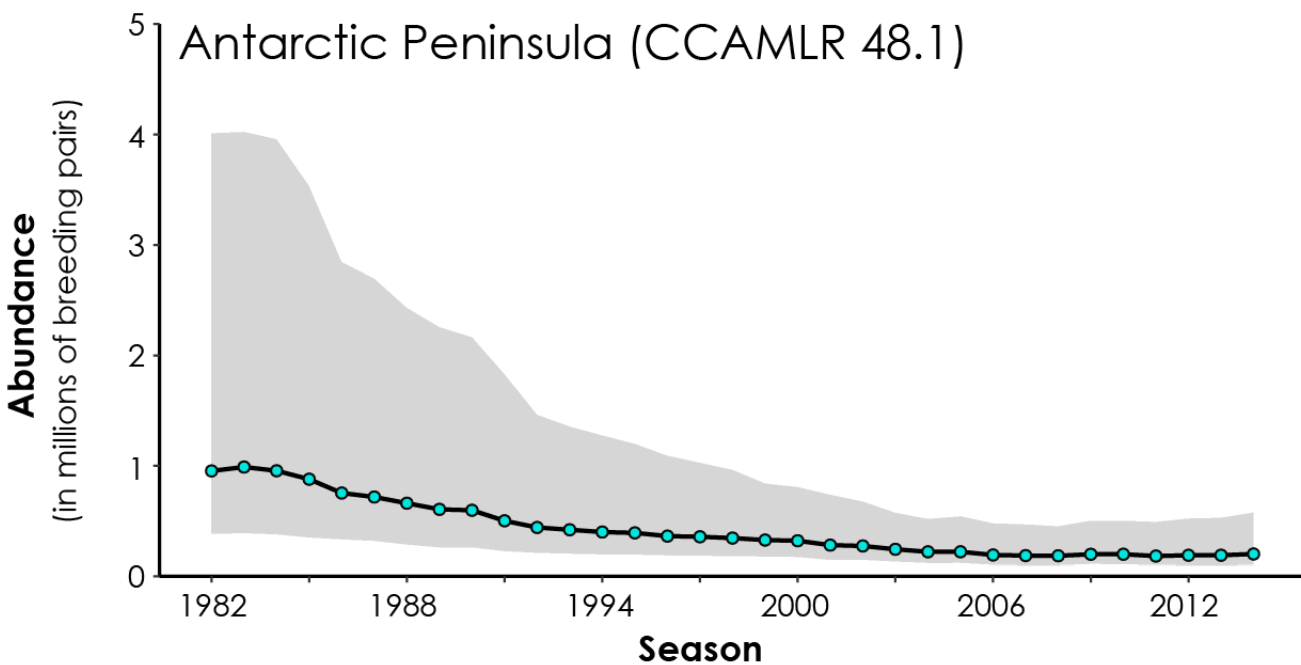




MAPPPD allows for easy analysis of entire regions.



MAPPPD allows for easy
analysis of entire regions.



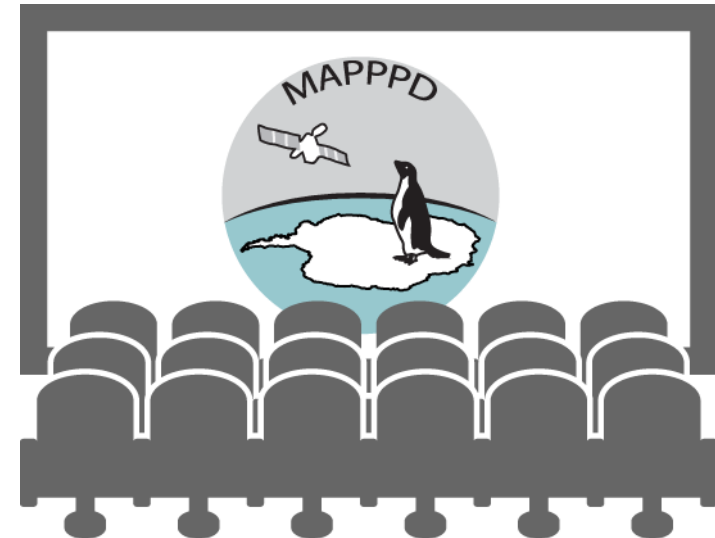
What we've completed to date:

- Underlying PostgreSQL database for all four Antarctic penguins
- 80-90% of the front end application GUI complete (MAPPPD "works" but lacks some features still in development)
- Underlying population dynamics model for Adélie penguins is complete
- Archival Landsat survey (L4,L5,L7,L8) complete
- Characterization of ground targets with field spectrometer complete
- Occupancy model for non-penguin Antarctic seabirds complete (but checklists not yet in MAPPPD)
- Initial beta-testing by community members underway

What we will do in the next year:

- Complete all remaining features of MAPPPD GUI (adding occupancy species checklists)
- Add tools for data input by the community
- Integrate Landsat retrievals
- Complete beta-testing

**MAPPPD premier at the Scientific Committee for
Antarctic Research Open Science Conference
Kuala Lumpur, Malaysia September 2016**



Student support

W. Burghardt Turner
Fellowship

Stony Brook University Graduate
Council Fellowship



Travel support

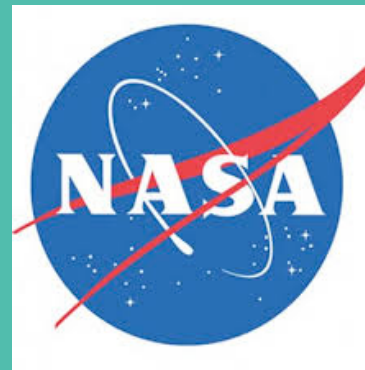
King-Miller Travel Award



Legacy Society Exploration Fund
Research Grant

Dalio Foundation

Equipment support



NASA NNX14AC32G