Life Near Ever-Shrinking Sea Ice: A Penguin's Perspective

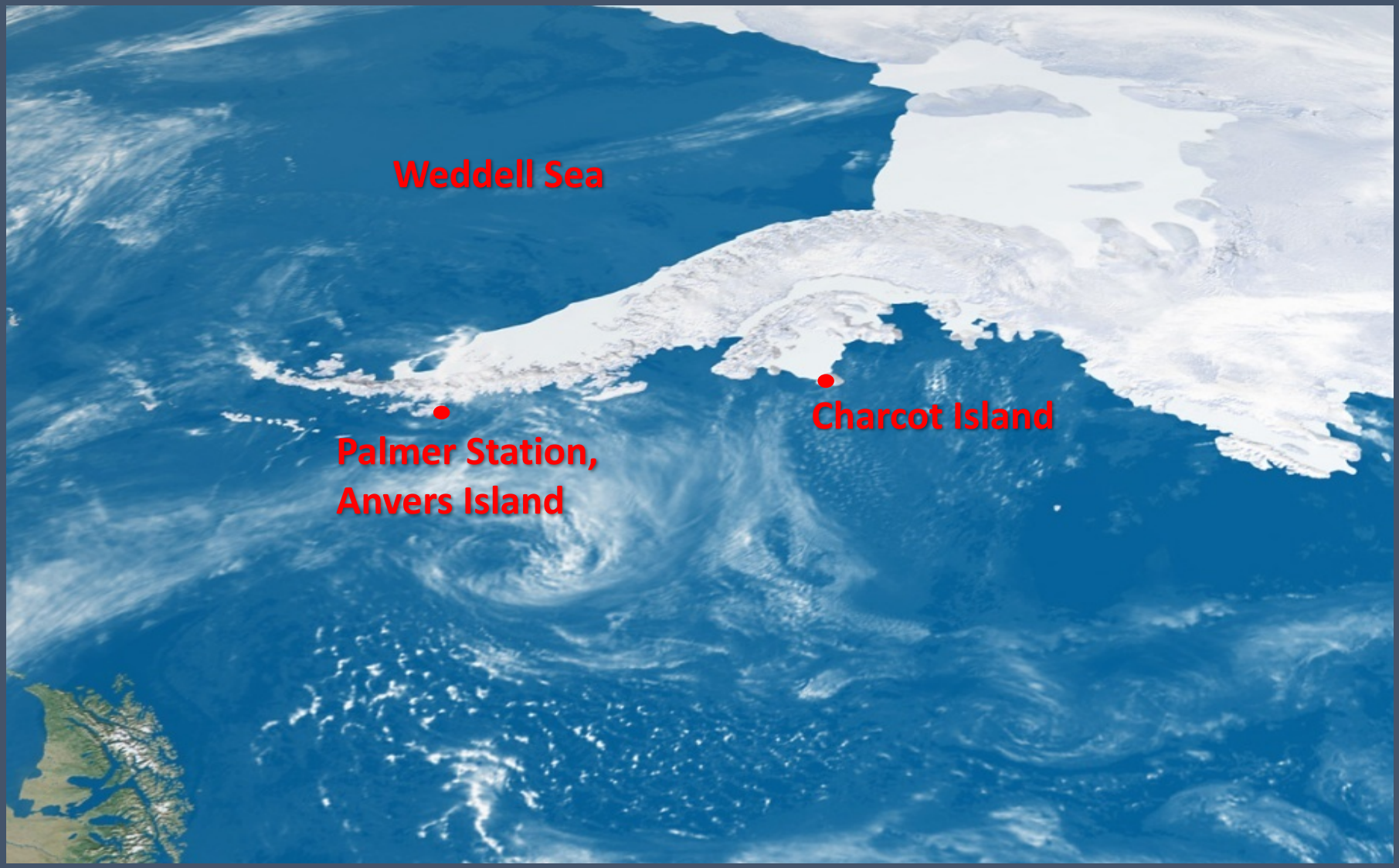
Bill Fraser, Polar Oceans Research Group, Sheridan Montana USA

PAL LTER Background and Operational Setting

Inception in 1990, associated seabird research began in 1974

10 investigators, 8 institutions, a marine sampling domain encompassing 150,000 km^2

Rate of regional warming ~ 5 times the global average, conspicuous sea ice loss



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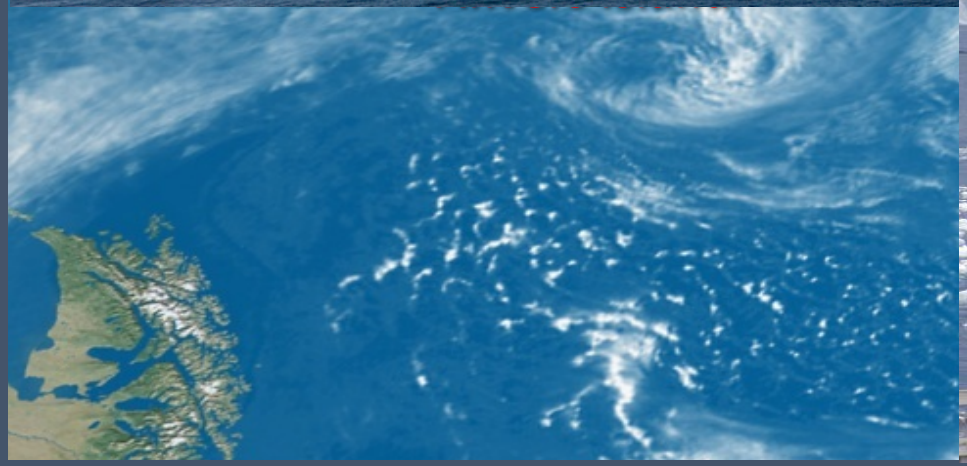


Understanding Our Ocean Connections through …A Penguin's Perspective?

"…ecosystems select the life histories of the species that populate them…" (Verity and Smetacek, 1996).

Translation…Life History Strategies Are Essentially Skill Sets, The Factors That Allow A Species To Survive And Reproduce

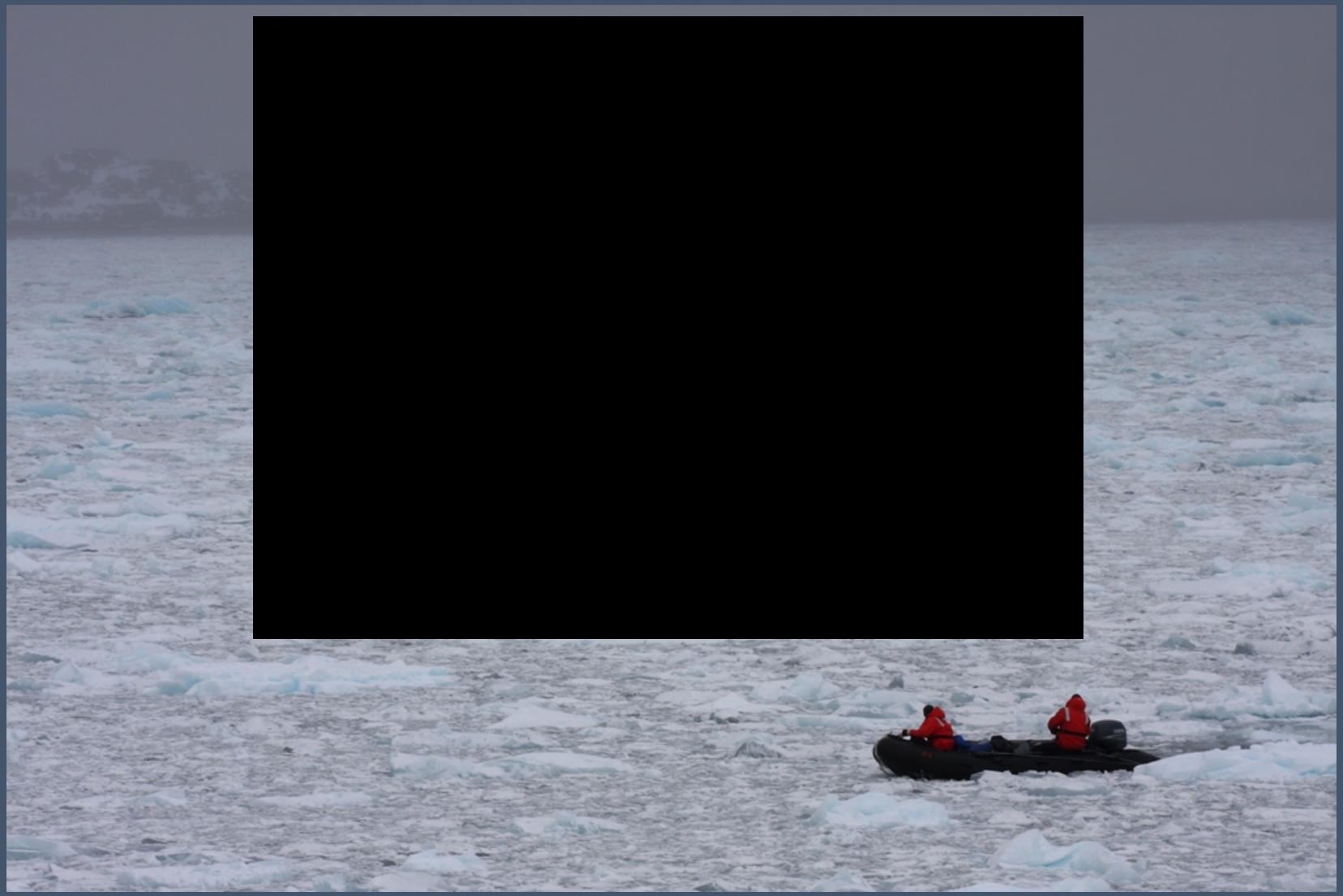
Implications…When These Skill Sets Fail, They Are Almost Always Indicative Of A Changing Ecosystem

Adélie Penguin
Polar Ecosystem

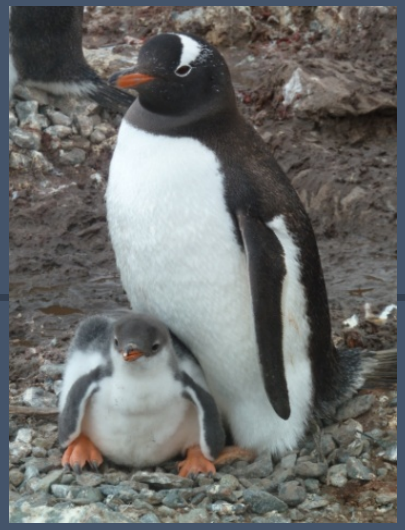
Gentoo Penguin
Sub-Polar Ecosystem

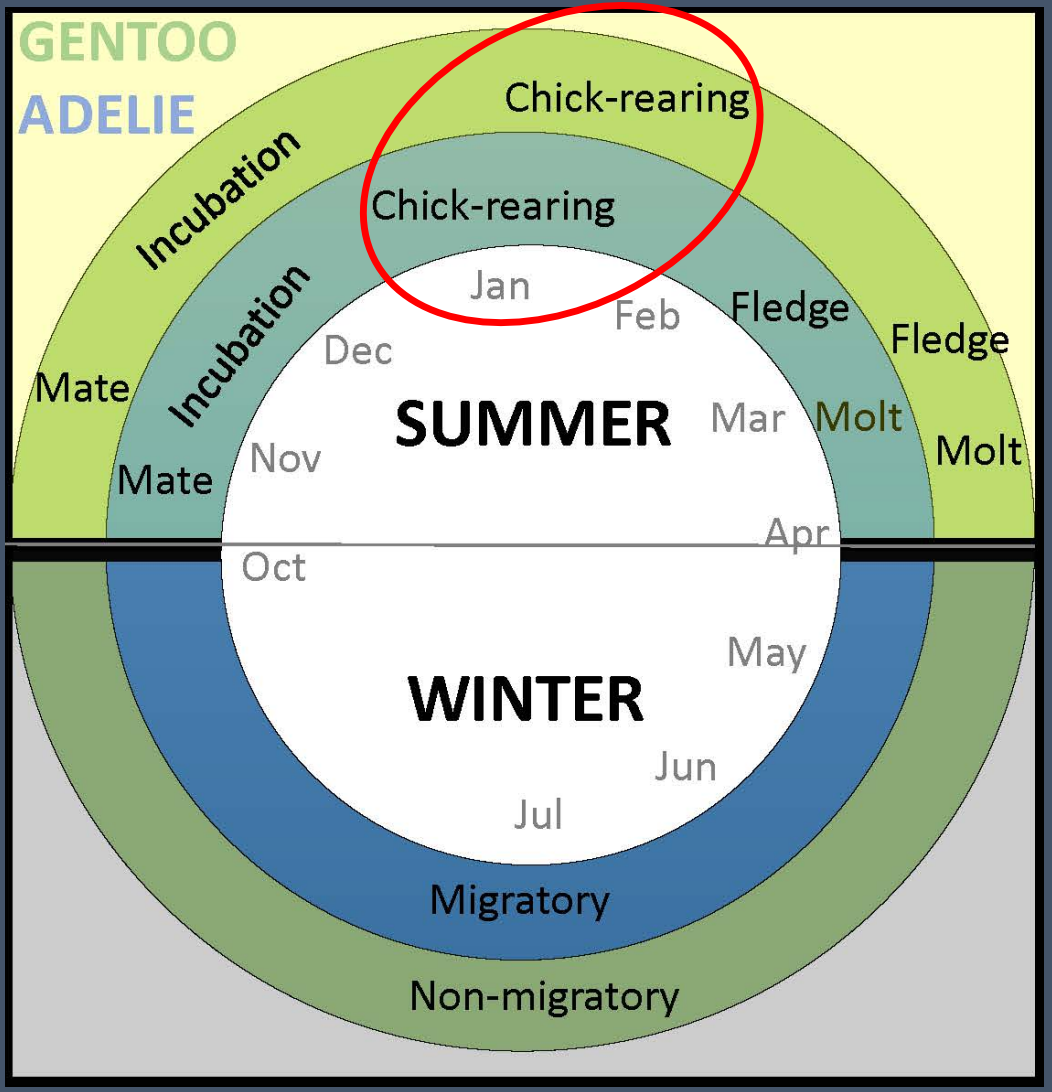
Understanding
Our Ocean Connections
through

…Collecting Life History Data, A Human's Perspective



The Annual Breeding Chronology Of Adélie And Gentoo Penguins

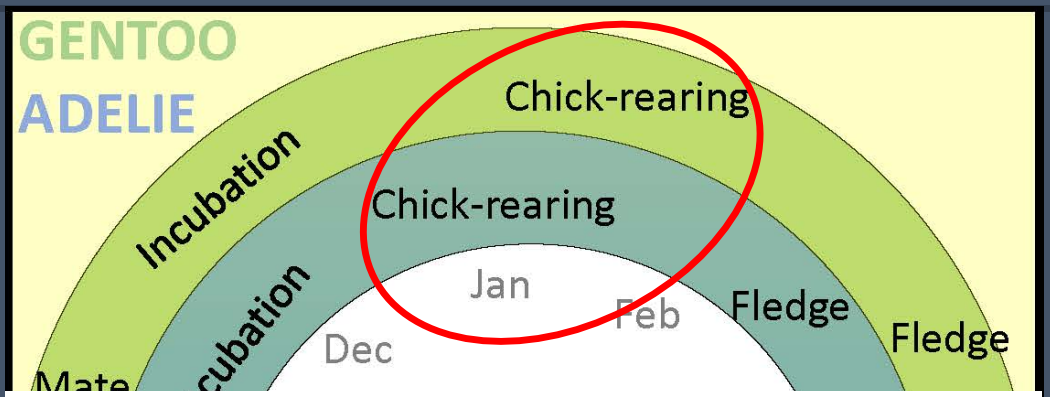


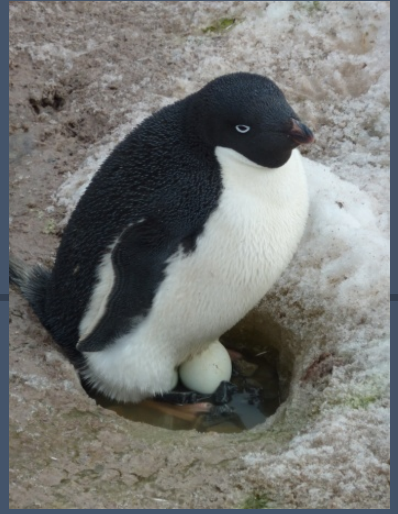


The Timing Of Gentoo Breeding Events Occurs 2-4 Weeks Later On Average Than Those Of Adélies

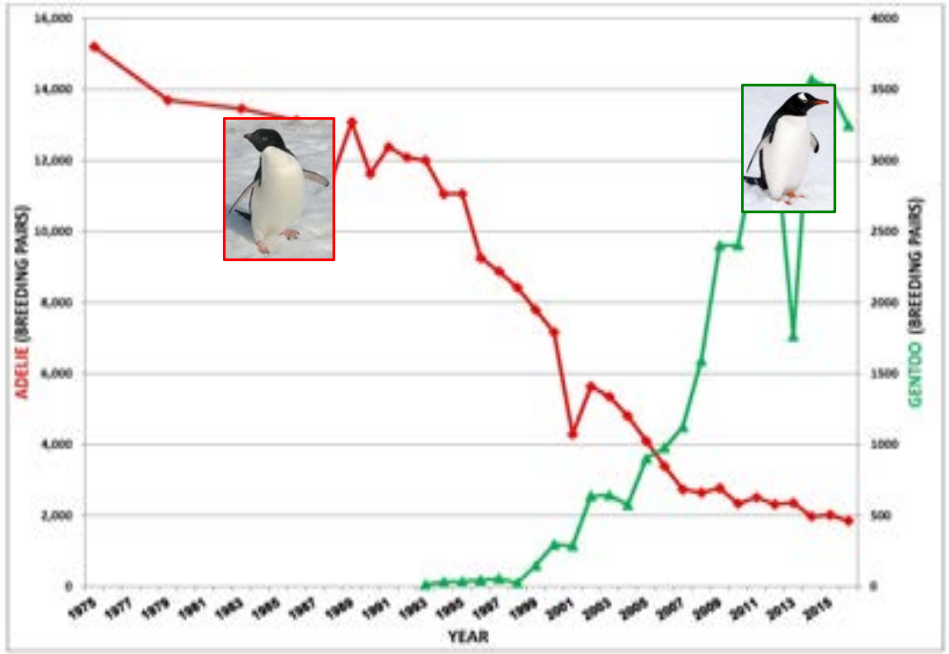
Why Should This Be Important?

The Annual Breeding Chronology Of Adélie And Gentoo Penguins





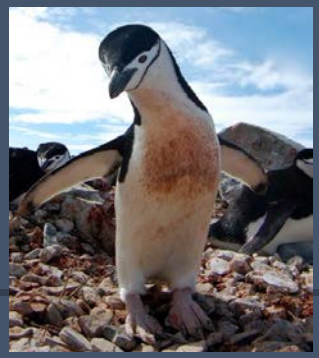
Adélie and Gentoo Penguin Population Trends, 1974-2017



A Subtle Life History Difference, Breeding Later Than Adélies, Allows Gentoo Penguins To Largely Avoid The Melt-Induced Mortality Events That Adélies Experience

This Life History Strategy Is Now Favored By The Warmer, Snowier, Wetter Ecosystem Of The Western Antarctic Peninsula

When Life History Strategies Begin To Fail, The Connections To The Ocean Are Not Always Obvious



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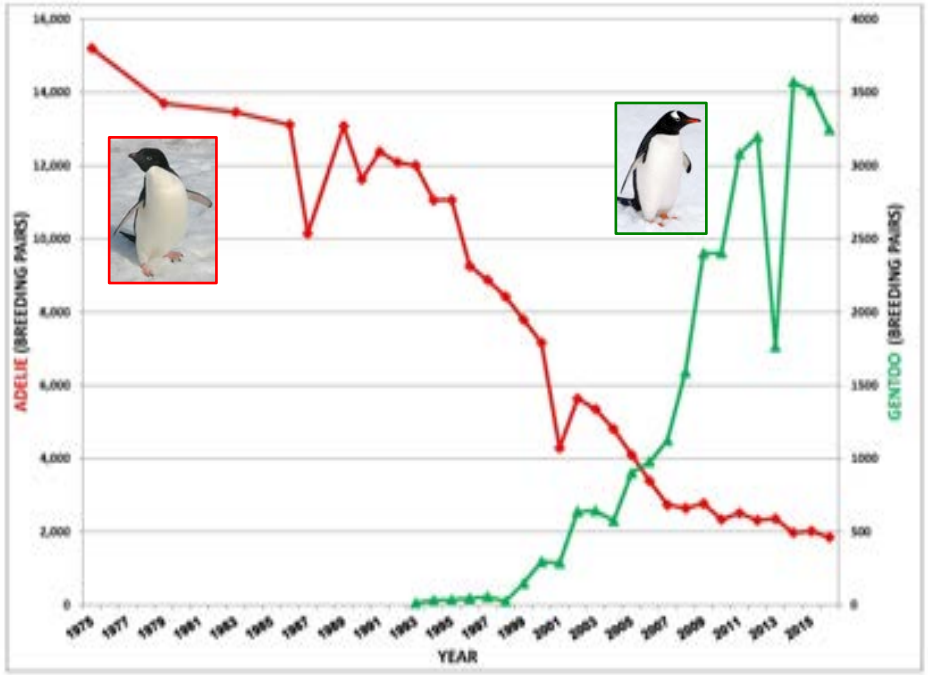
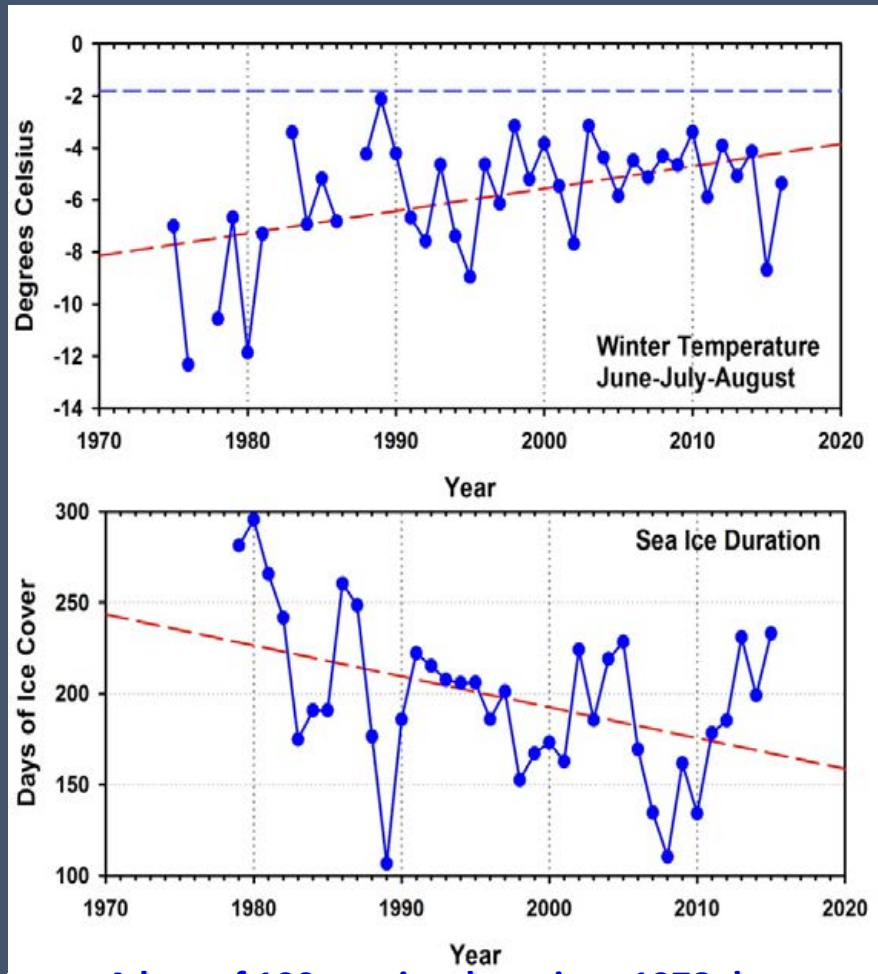


Ice-Dependent

Ice-Intolerant



A loss of 100 sea ice days since 1978 due to warming mid-winter temperatures

A Main Problem Has Been That We Have Been Unable To Sample The Ocean On The Scales That Penguins Perceive It

Emphasis on Terrestrial Studies, but Penguins Spend 70-90% of Their Lives at Sea

Unavailable Appropriate Technologies

Penguins Operate Over Smaller Scales Compared to Oceanographic Surveys

The Palmer Deep Canyon

…Developing Long-Term Life History Data On How And Where Penguins Use The Ocean

Joubin Islands

Palmer Station

Anvers Island

Biscoe Point

The Palmer Deep Canyon

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…Taking Advantage Of Sea Ice Variability To Guide Field Experiments And Scale Analyses

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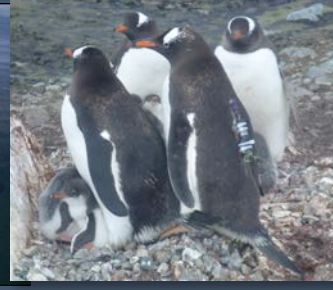
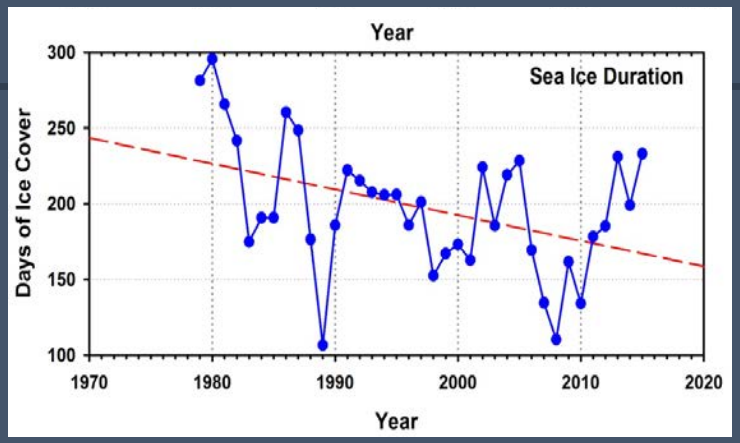
...Combining "Deep Ecology" With Advanced Robotic Technologies

Rutgers University Center for Ocean Observing Leadership (RU COOL)

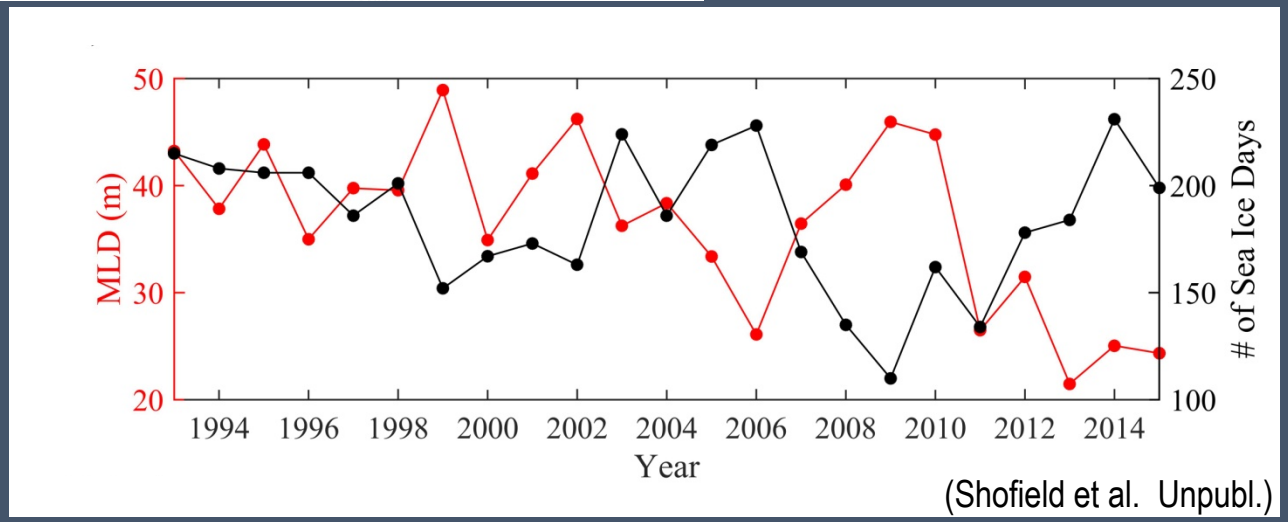
Oscar Shofield (Co-PI) and Josh Kohut (Collaborator)

Findings (In Progress)…And A New Paradigm For Future PAL LTER Synthesis?





An Ice-Free Ocean Becomes More Vulnerable to Wind-Driven Turbulence, Which Deepens The Mixed Layer (MLD)

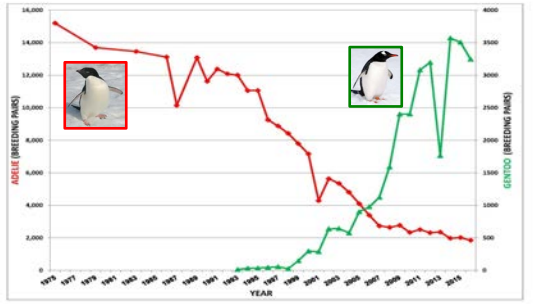


(Shofield et al. Unpubl.)

The Mixed Layer Boundary Determines The Depth Of The Food Web On Which Penguins Depend

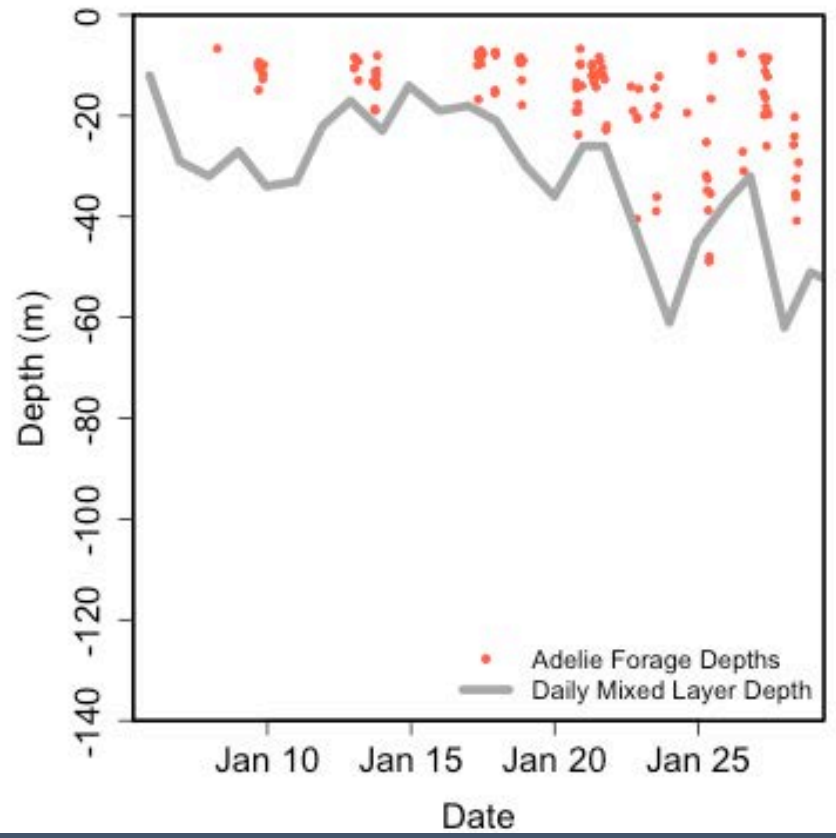
The Role Of Life History

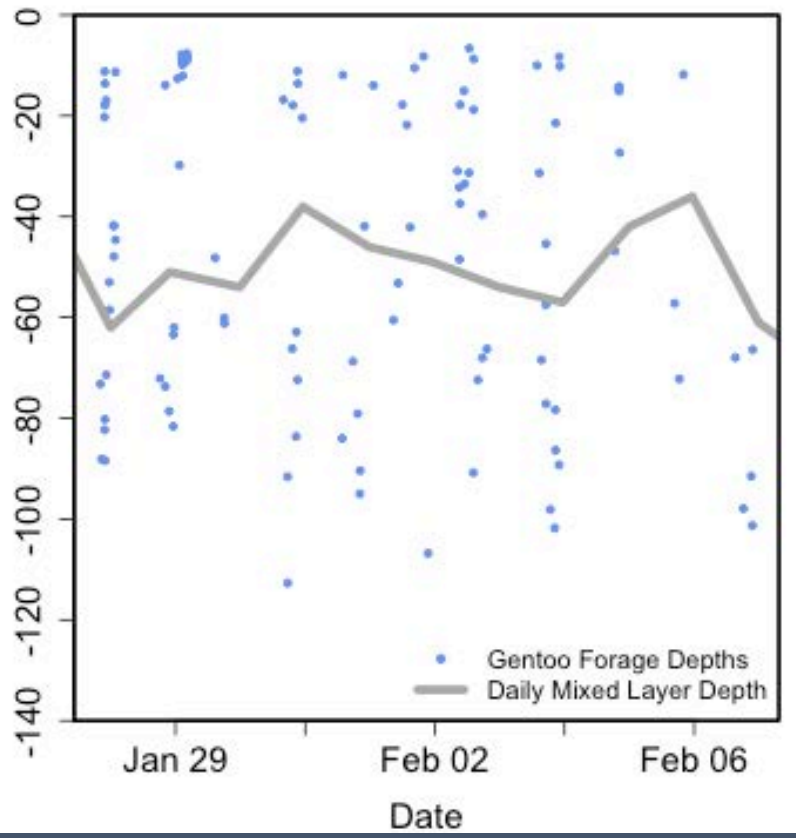
Why Is Mixed Layer Depth Important To Adélie And Gentoo Penguins?



An Ice-Free, Wind-Mixed Ocean With A Deeper Mixed Layer Favors The Diving Capabilities Of Gentoo Penguins Over Those Of Adélies.

Adélie and Gentoo Diving Profiles Relative to Mixed Layer Depth (Oliver et al. Unpubl.)





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Summary

- As Sea Ice Decreases, The Western Antarctic Peninsula Is Becoming Warmer And Wetter, And Its Marine Environment More Subject To Wind-Mixing
- These Changes Are Impacting Both The Landscapes On Which Penguins Breed And The Seascapes In Which They Forage
- Increasing Environmental Variability Is Favoring More Flexible Life History Strategies, With Current Penguin Population Trends Indicating Adélies Are Being Replaced By Gentoos

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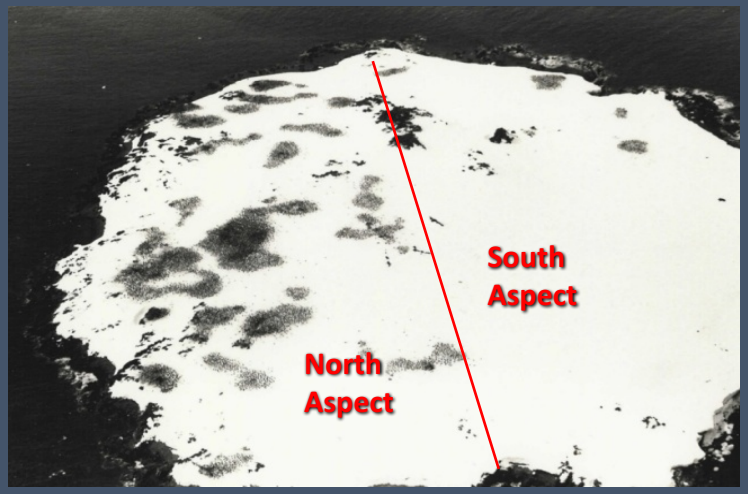
- D.G. Ainley, H.T. Harvey & Assoc
- Southern Ocean GLOBEC Program, ODU
- The CONVERGE Program, Rutgers

Logistics.

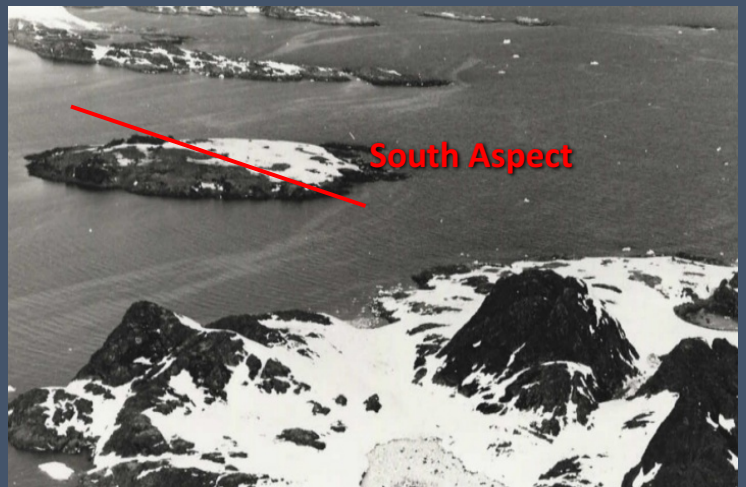
- Holmes & Narver
- ITT Antarctic Services
- Antarctic Support Associates
- Raytheon Polar Services Company
- Antarctic Support Contract
- RV Hero, Rieber Shipping and Edison Chouest

Palmer Station Field Teams

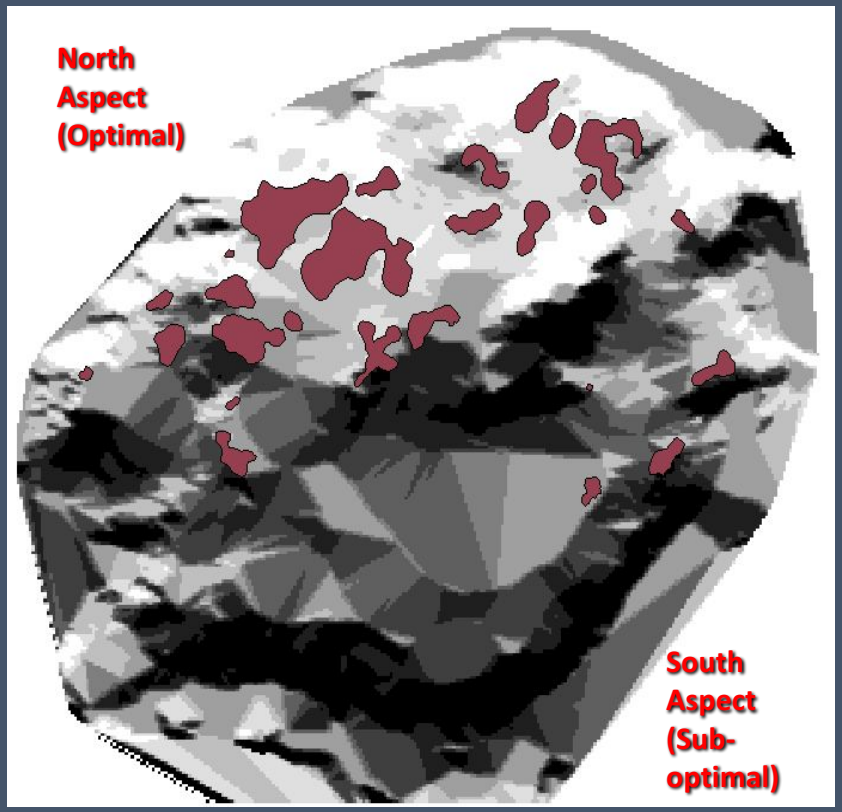
Adélie colonies are aggregated on the landscapes where snow melts off early



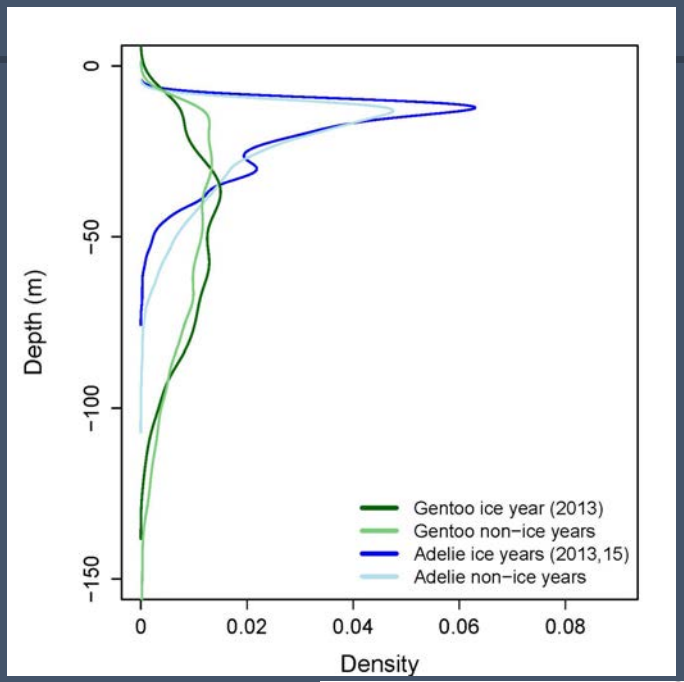
6 Nov. 1989, peak arrival

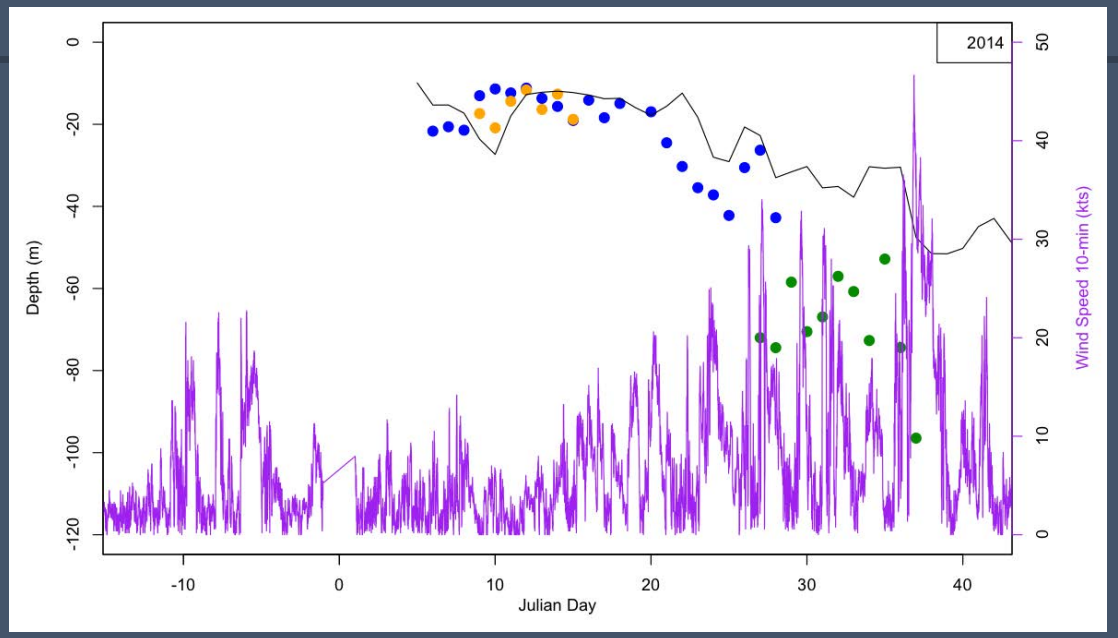


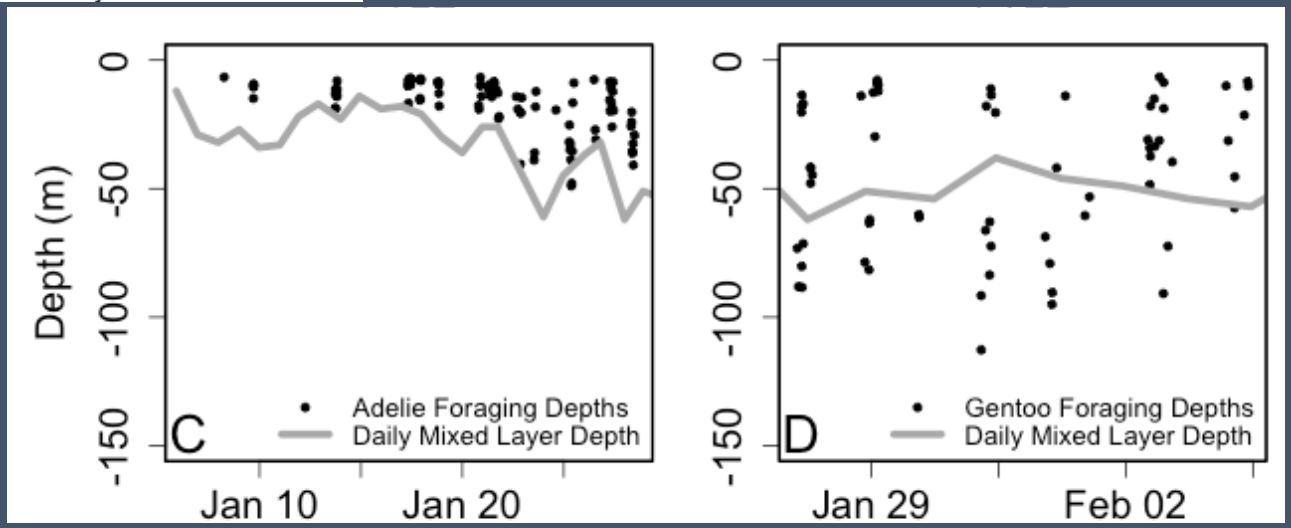
6 Dec. 1989, peak laying



Effects of Sea Ice on Foraging Costs, Depth Over Which Predators Must Search for Prey…and a new discovery?





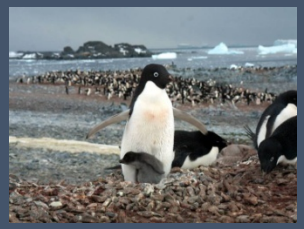


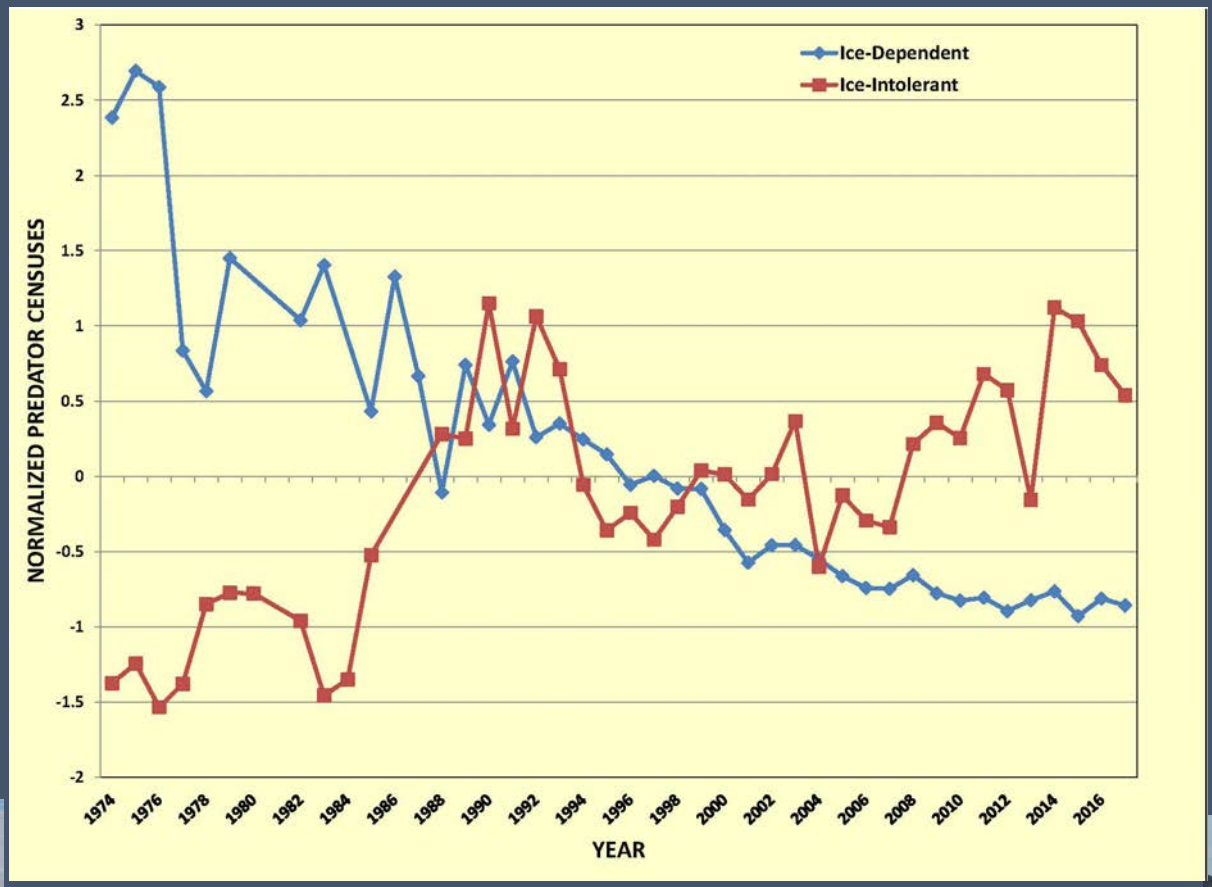
Population Trends Of Ice-Dependent Versus Ice-Intolerant Top Predators, Anvers Island, 1974-2017.

Ice-dependent

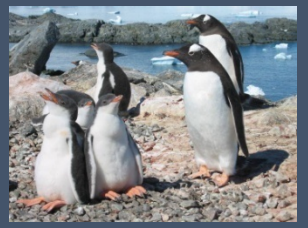
A transition between dominant life history types begins in 1988.

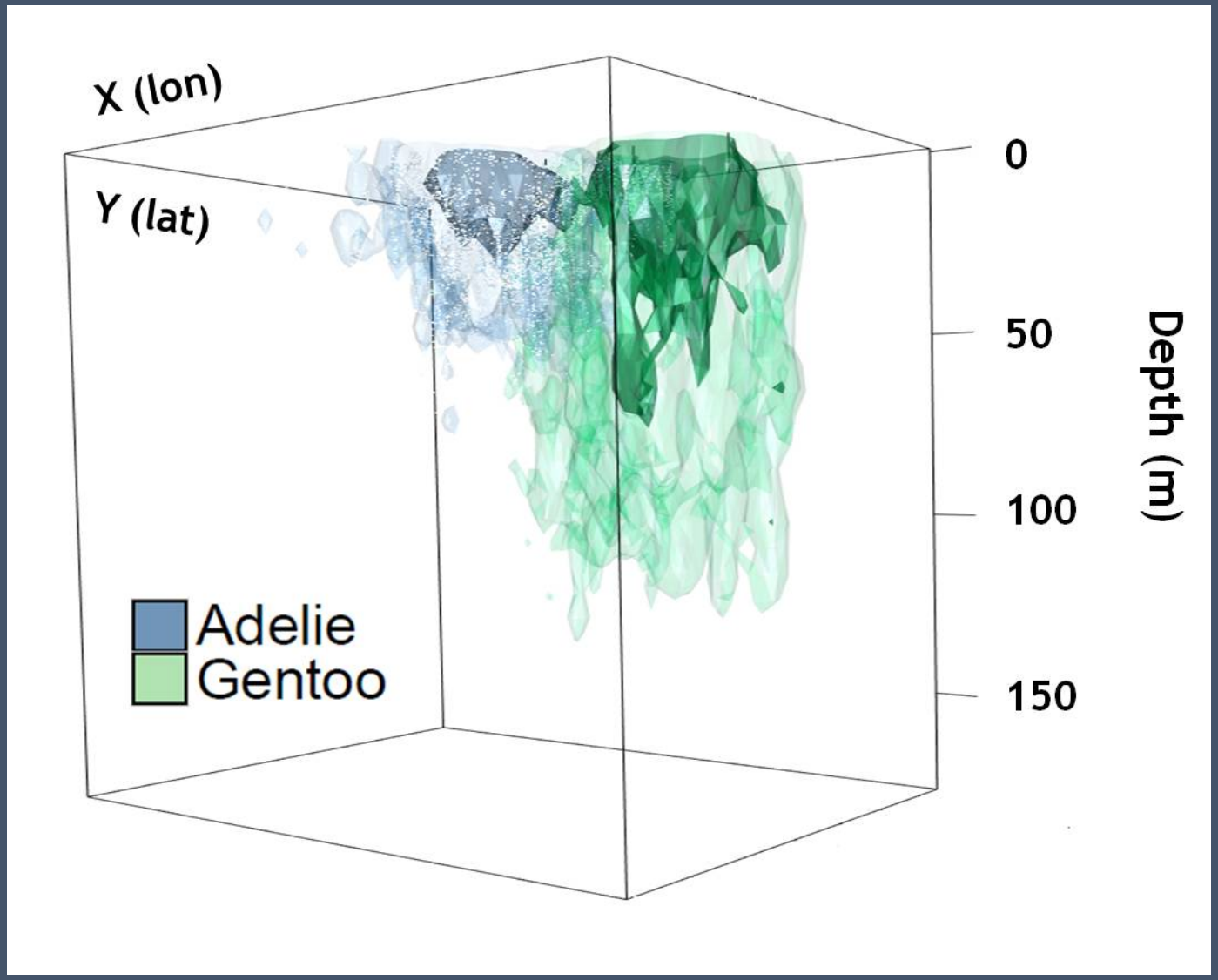
Ice-intolerant





FUNCTIONALLY EXTINCT




X (lon)
Y (lat)
0
50
100
150
Depth (m)
Adelie
Gentoo