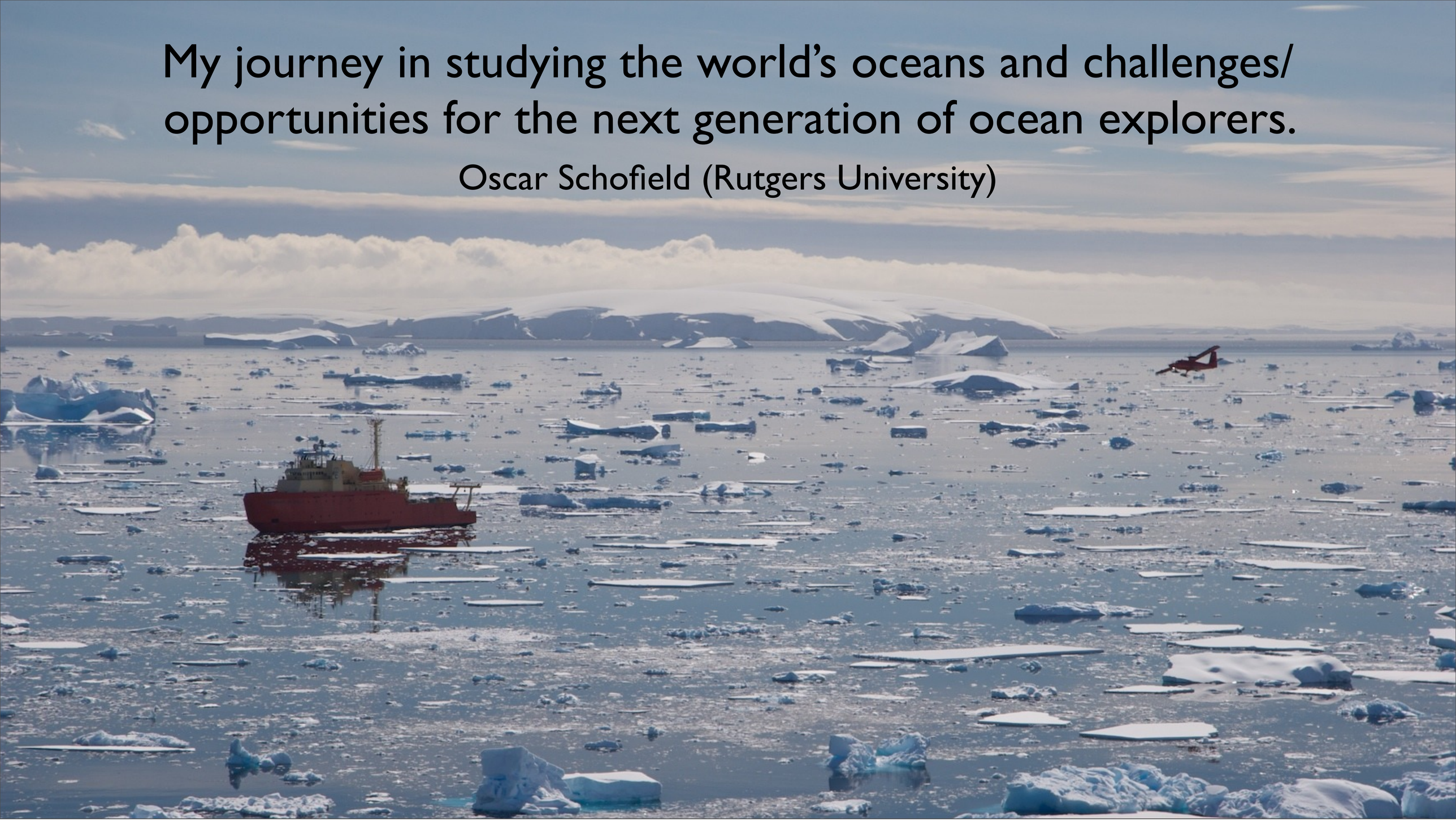
My journey in studying the world's oceans and challenges/ opportunities for the next generation of ocean explorers.

Oscar Schofield (Rutgers University)



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Unfortunately scientists sometimes do not articulate the urgent need effectively.

$$\frac{dD}{dt} = \left(D*(1-\frac{D}{Kd})\right) - \left(\frac{\Omega kr,D*x\_k*y\_k*Kr*D}{\Omega kr,D*D+((1-\Omega kr,D)*C)+R\_kr,D+R\_kr,C}\right) - \left(\frac{\Omega s,D*x\_s*y\_s*S*D}{\Omega s,D*D+(1-\Omega s,D)*C+R\_s,D+R\_s,C}\right)$$

$$\frac{dC}{dt} = \left(C*1-\frac{C}{Kc}\right) - \left(\frac{(1-\Omega kr,D)*x\_k*y\_k*Kr*C}{(1-\Omega kr,D)*C+\Omega kr,D*D+R\_kr,D+R\_kr,C)}\right) - \left(\frac{(1-\Omega s,D)*x\_s*y\_s*S*C}{(1-\Omega s,D)*C+\Omega s,D*D+R\_s,D+R\_s,C)}\right)$$

$$\frac{dK}{dt} = -x\_k*K*\left(1-\frac{(\Omega kr,D*y\_k*D)+(1-\Omega kr,D)*y\_k*C)}{(\Omega kr,D*D+(1-\Omega kr,D)*C+R\_k,D+R\_k,C}\right) - \left(\frac{\Omega p,K*x\_p*y\_p*K*P}{\Omega p,K*K+(1-\Omega p,K)*S+C\_p,Kr}\right)$$

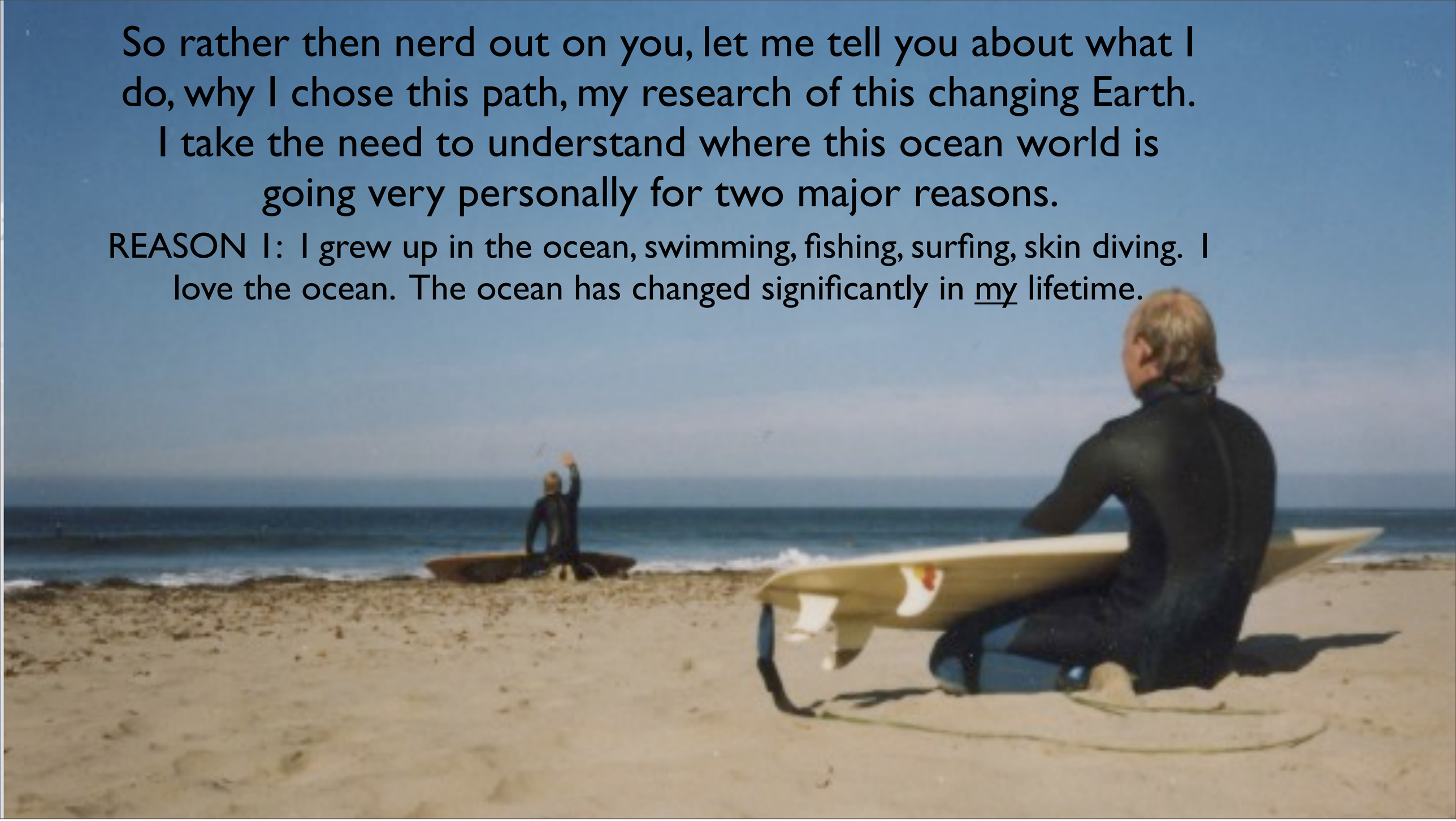
$$\frac{dS}{dt} = -x\_s*S*\left(1-\frac{(\Omega s,D*y\_s*D+(1-\Omega s,D)*y\_s*C)}{\Omega s,D*D+(1-\Omega s,D)*C+R\_s,D+R\_s,C}\right) - \left(\frac{(1-\Omega p,K)*x\_p*y\_p*S*P}{\Omega p,K*K+(1-\Omega p,K)*S+C\_p,S)}\right)$$

$$\frac{dP}{dt} = -x\_p*P*\left(1-\frac{(\Omega p,K*y\_p*K+(1-\Omega p,K)*y\_p*S)}{\Omega p,K*K+(1-\Omega p,K)*S+C\_p,K+C\_p,S}\right)$$

translation, "milk in my coffee please"

So rather then nerd out on you, let me tell you about what I do, why I chose this path, my research of this changing Earth. I take the need to understand where this ocean world is going very personally for two major reasons.

REASON 1: I grew up in the ocean, swimming, fishing, surfing, skin diving. I love the ocean. The ocean has changed significantly in my lifetime.



SO WHY DID I CHOOSE THE PATH I DID?

FAMILY?

Mom is an artist and baker

Dad was a wine maker

Yes, from them I was taught how fun & hard it was to observe the world

SO WHY DID I CHOOSE THE PATH I DID?

FAMILY?

Mom is an artist and baker

BUT I WAS DIFFERENT.....
I WAS A GEEK.....
I WAS A SCIENTIST.....

Dad was a wine maker

Yes, from them I was taught how fun & hard it was to observe the world

Science is a process with which to explore and understand the world

When I was an undergraduate I was lucky to do science with my hands. D*oing* science was exciting, creative, and an adventure!

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hand lowering a sensor
at age 18 on my first ocean cruise

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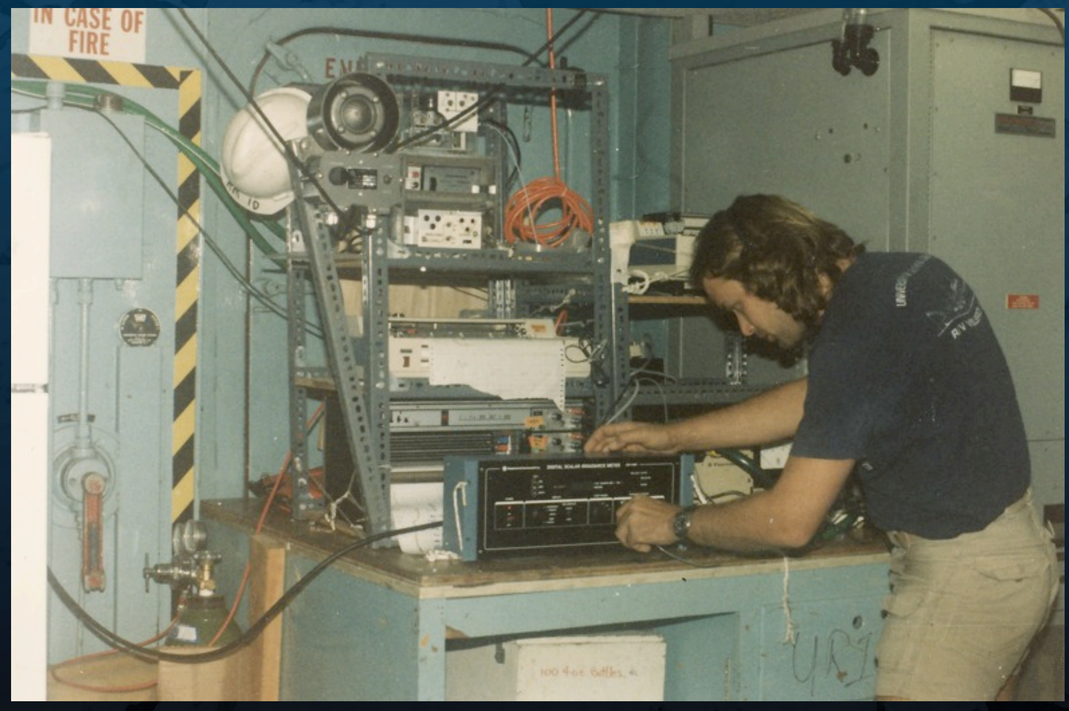
We built instruments and brought them sea



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Many instruments required human power to collect samples in the ocean

hand lowering a sensor
at age 18 on my first ocean cruise

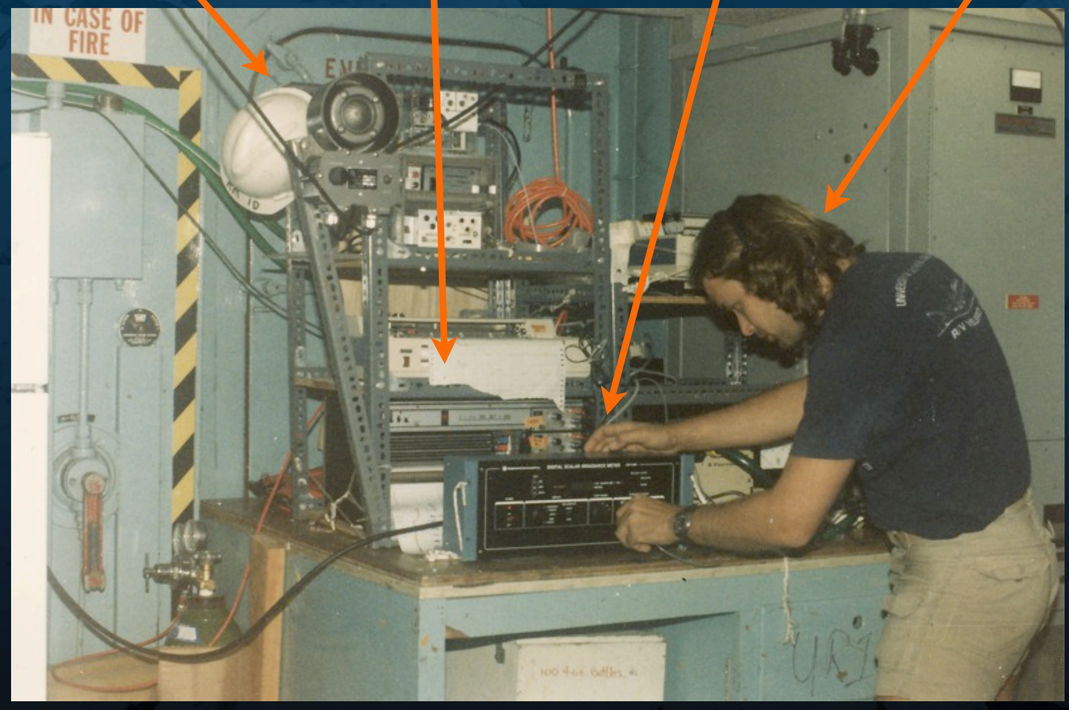
We built instruments and brought them sea

hard hat

no computers, data recorded to paper

instrument controlled by hand

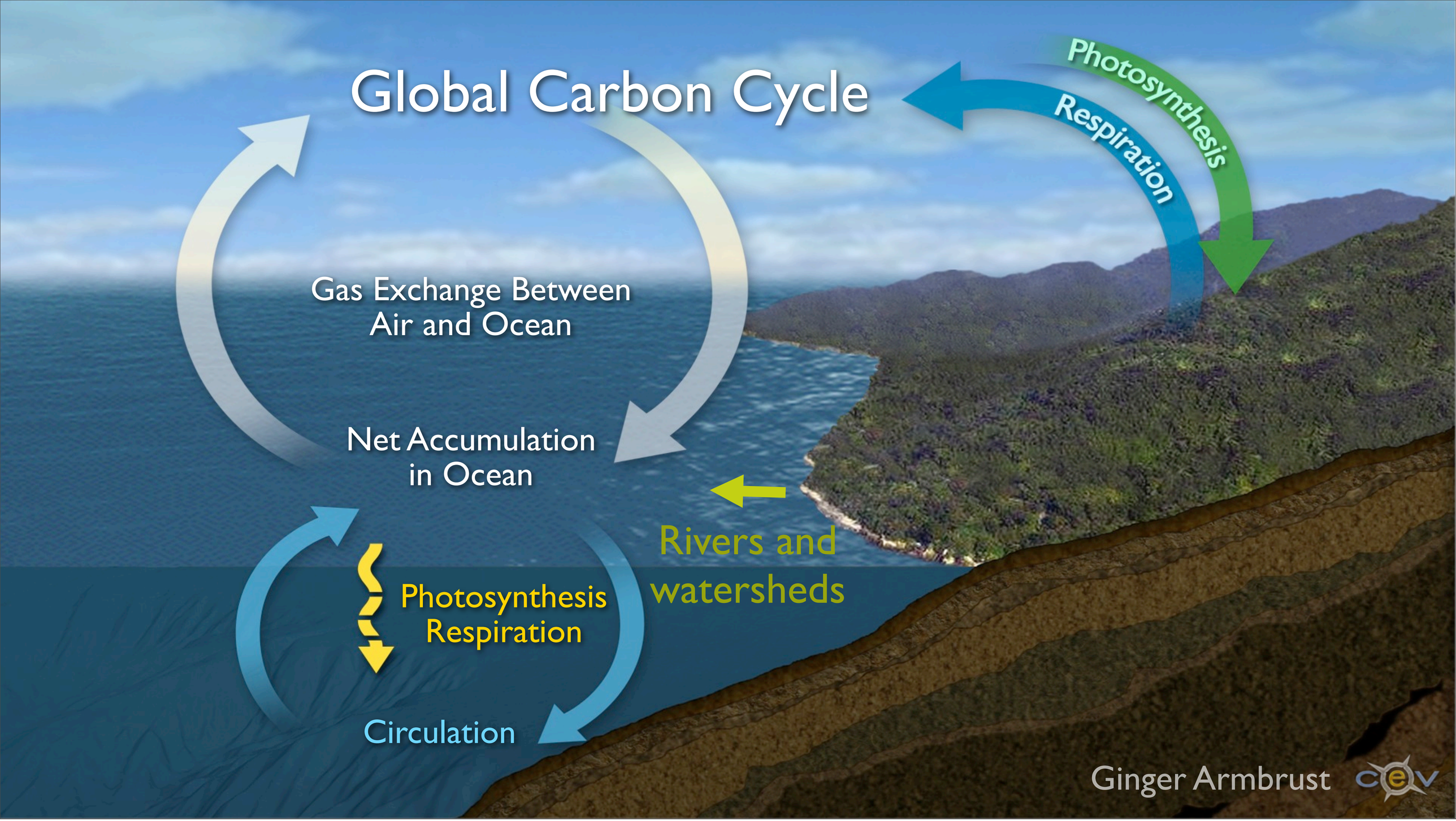
bad 80's hair



Tides
Intensified Atmospheric Inputs
Precipitation
Ice
Mesoscale Eddies
UV
Infrared
Evaporation
Thermal Radiation
Heat Transfer
Halogens
Surfactants
Dimethyl-sulfide Flux
Wind Stress
Dust
CO_2
Aerosols
Wave Breaking
Sea Spray
Bubble Production & Turbulence
Wave Current Interaction
CO_2
Eastern Boundary Currents
River Inputs
Nutrients (N,P,S)
Rip Tide
Surf Zone
Penetrating Radiation
Near Surface Shear and Microbreaking
Langmuir Circulations
Ekman Spiral
Ekman Transport
Surface Layer
Thermocline
Deep Ocean
Internal Wave Radiation
Sheer at Mixed Layer Base
Phytoplankton
Pelagic Predators
Zooplankton
Bacteria
Organic Carbon
Bacteria
Deep water formation
Ventilation (upwelling)
Marine Snow
Deep Consumer
CO_2
Particulate Plume
Wind Driven Coastal Upwelling
Particle Sinking
Particle Resuspension
Diffuse Boundary Layer
Shear Driven
Flow Filtration
Groundwater Input
Sediment Transport
Counter Current
Gas Hydrates
Methane

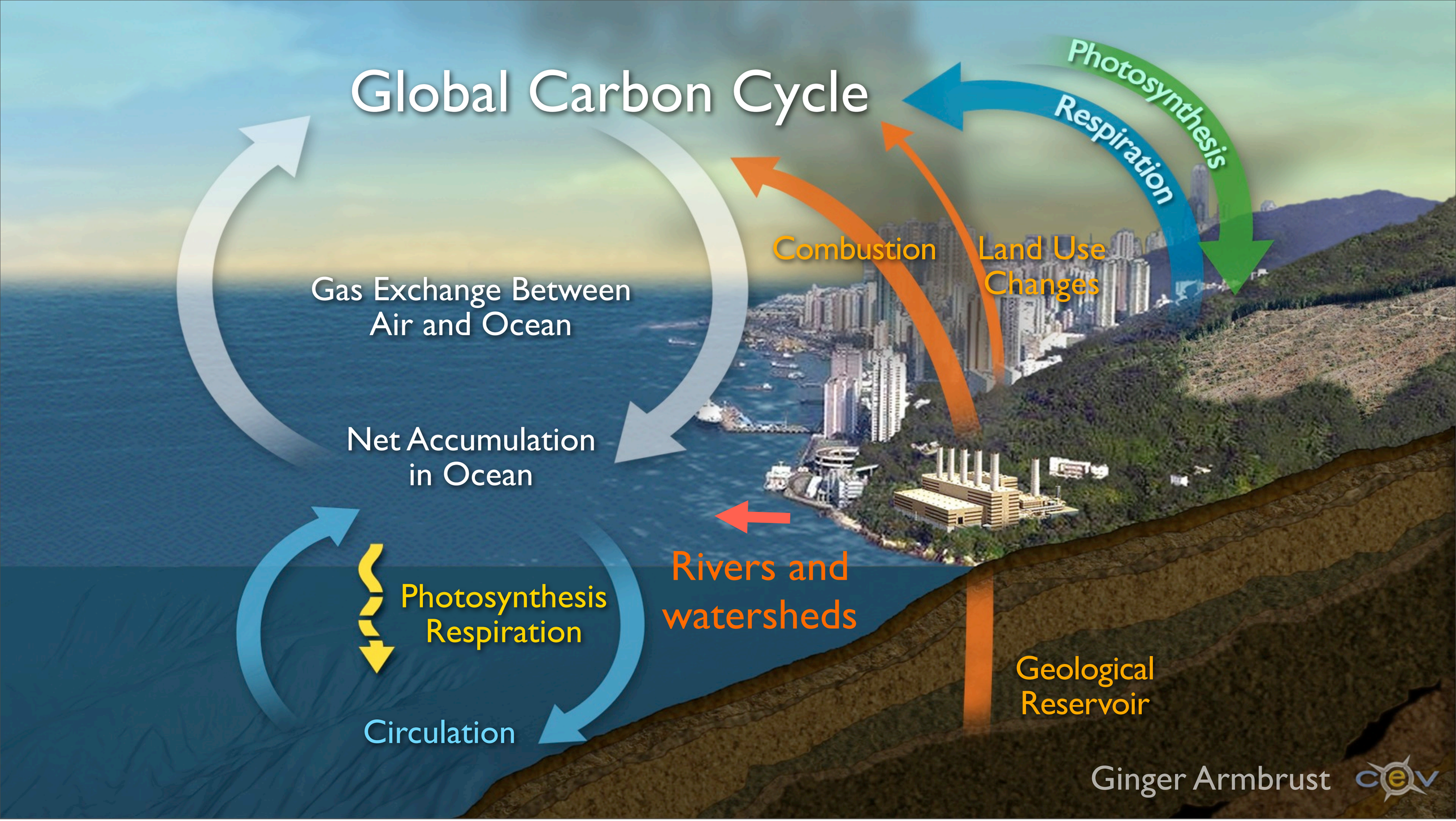
Spreading Mid-Ocean Ridges
Microbes & Deep Biosphere
Crustal Magma Chamber
Down flow zones
Brittle-Ductile Boundary
Heat Source
Magma Generation
Topographic Turbulence
Hydrothermal Recharge
Deep-Sea Ecology
Hydrothermal Discharge
Benthic/Pelagic Exchange
Sediments
Ocean Crustal Aquifer
Lithospheric Heat
Updip Limit
Accreted Sediments
Shallow Earthquakes
Locked Zone
Downdip Limit
Free Sliding
Deep Earthquakes
Ocean Crust
Lithosphere
Asthenosphere
Subduction Zone
Continental Crust
Melting
Crust
Mantle
Liquid Outer
Mantle Convection
cev
Monday, April 11, 2011

Global Carbon Cycle



Ginger Armbrust

Global Carbon Cycle



Ginger Armbrust

This oceans
are changing
in our lifetime

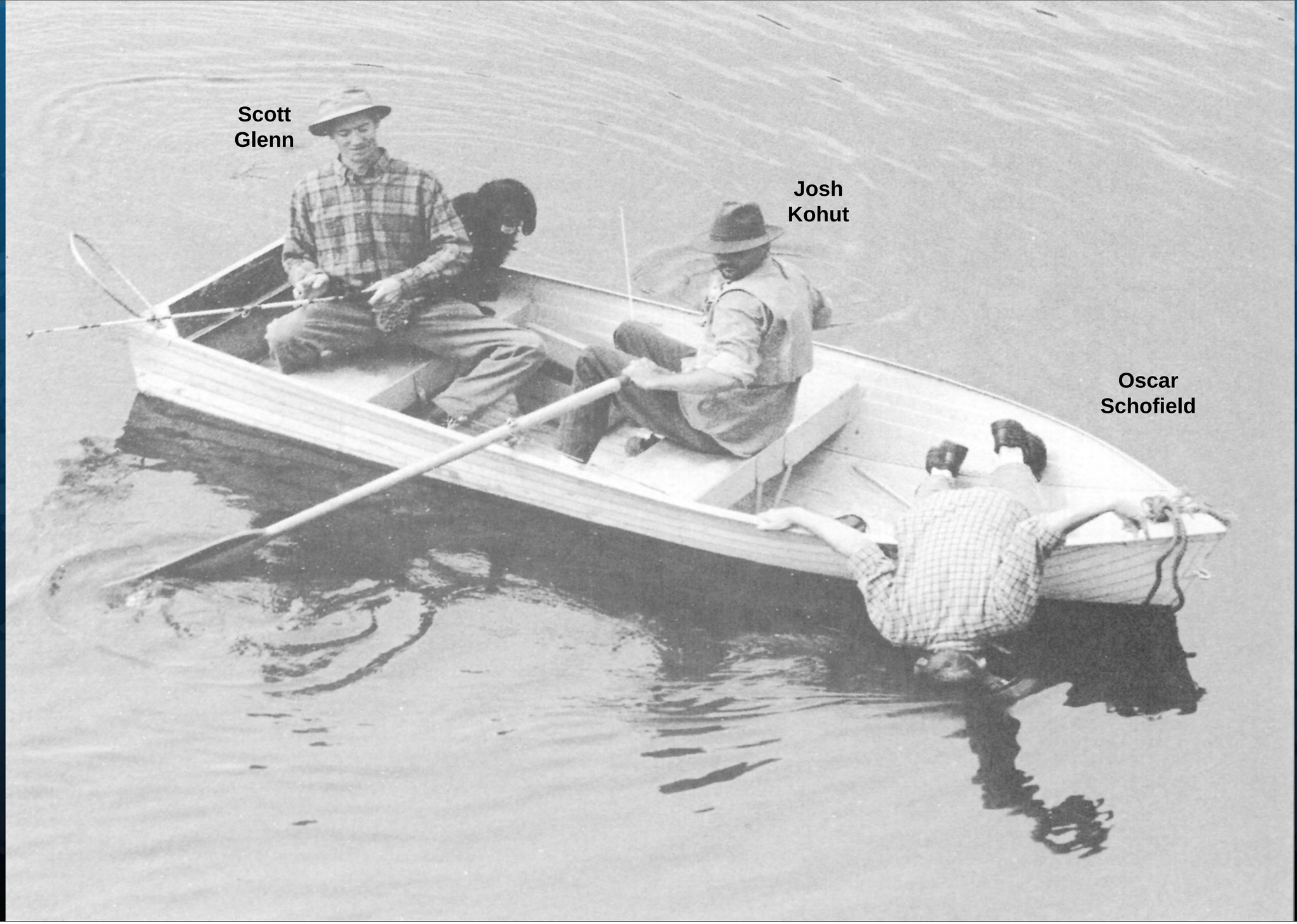
Annual Sea Ice Minimum - 1980

Image Source: NASA (svs.gsfc.nasa.gov)

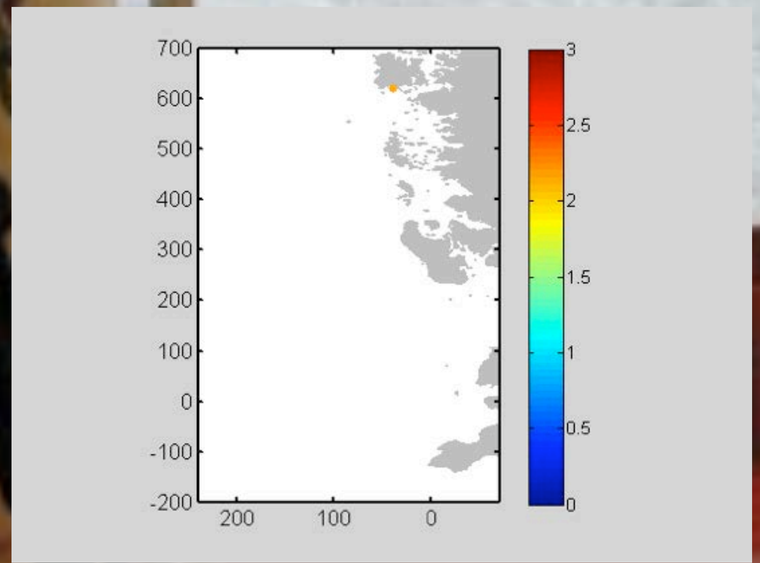
This oceans
are changing
in our lifetime

Annual Sea Ice Minimum - 2007

Image Source: NASA (svs.gsfc.nasa.gov)

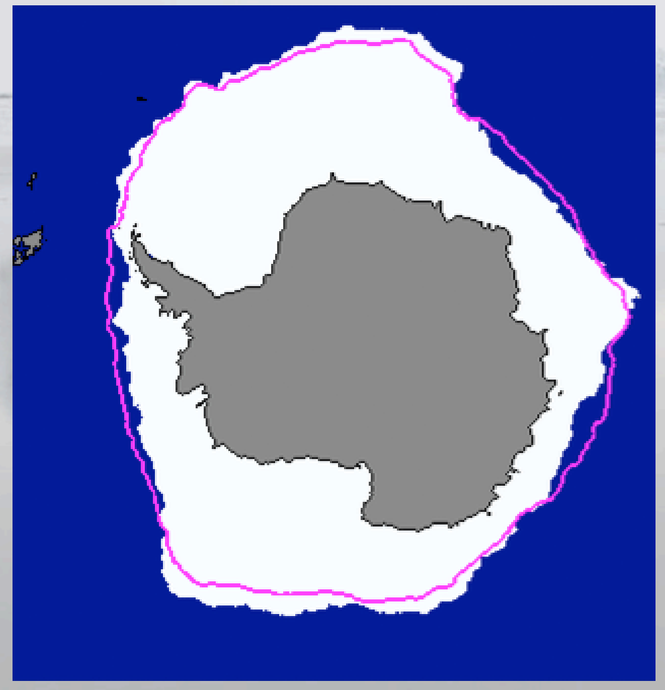

Scott
Glenn
Josh
Kohut
Oscar
Schofield

So lets go to the office

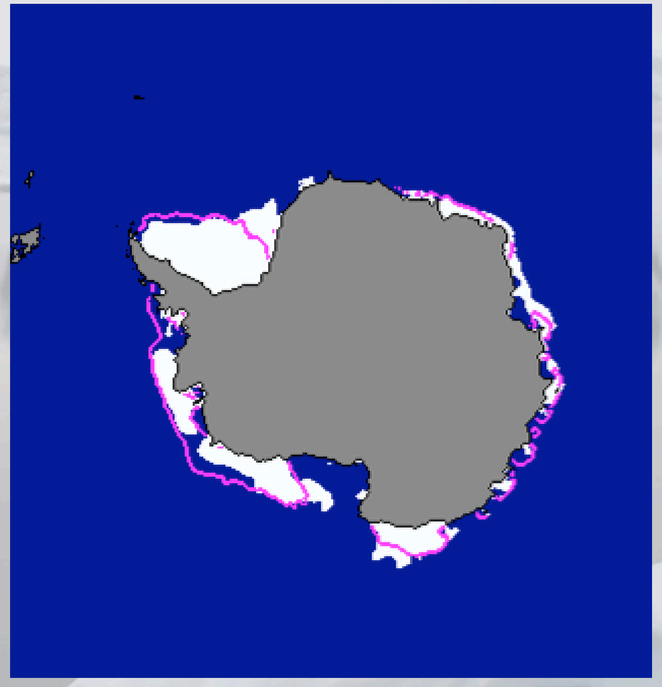



NSF
L

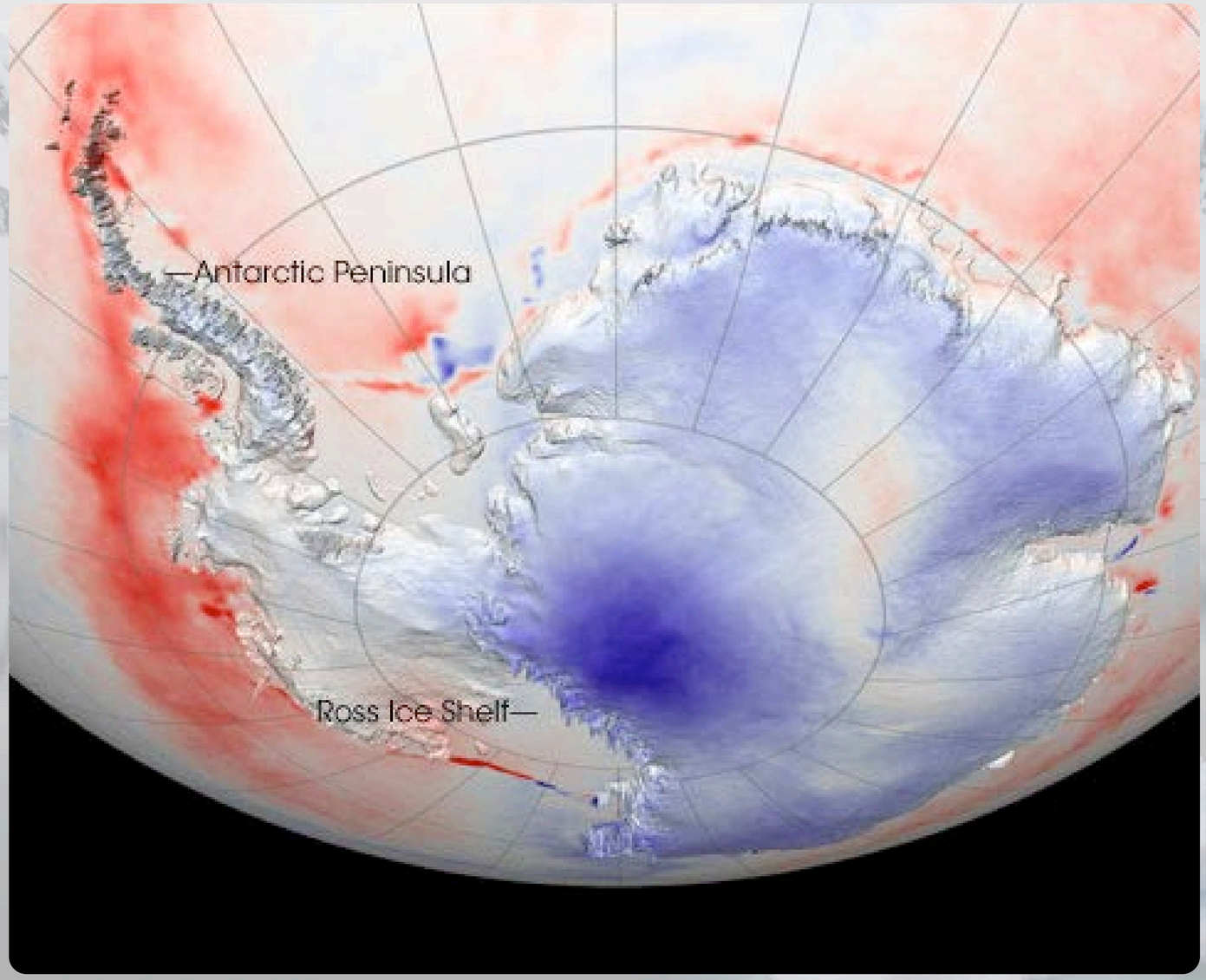
The central hypothesis when the LTER began was that sea ice timing and magnitude structure the productivity and composition of the Antarctic ecosystem. The ice dynamics are driven by large-scale interactions of the atmosphere and ocean.



Winter 2007



Summer 2007

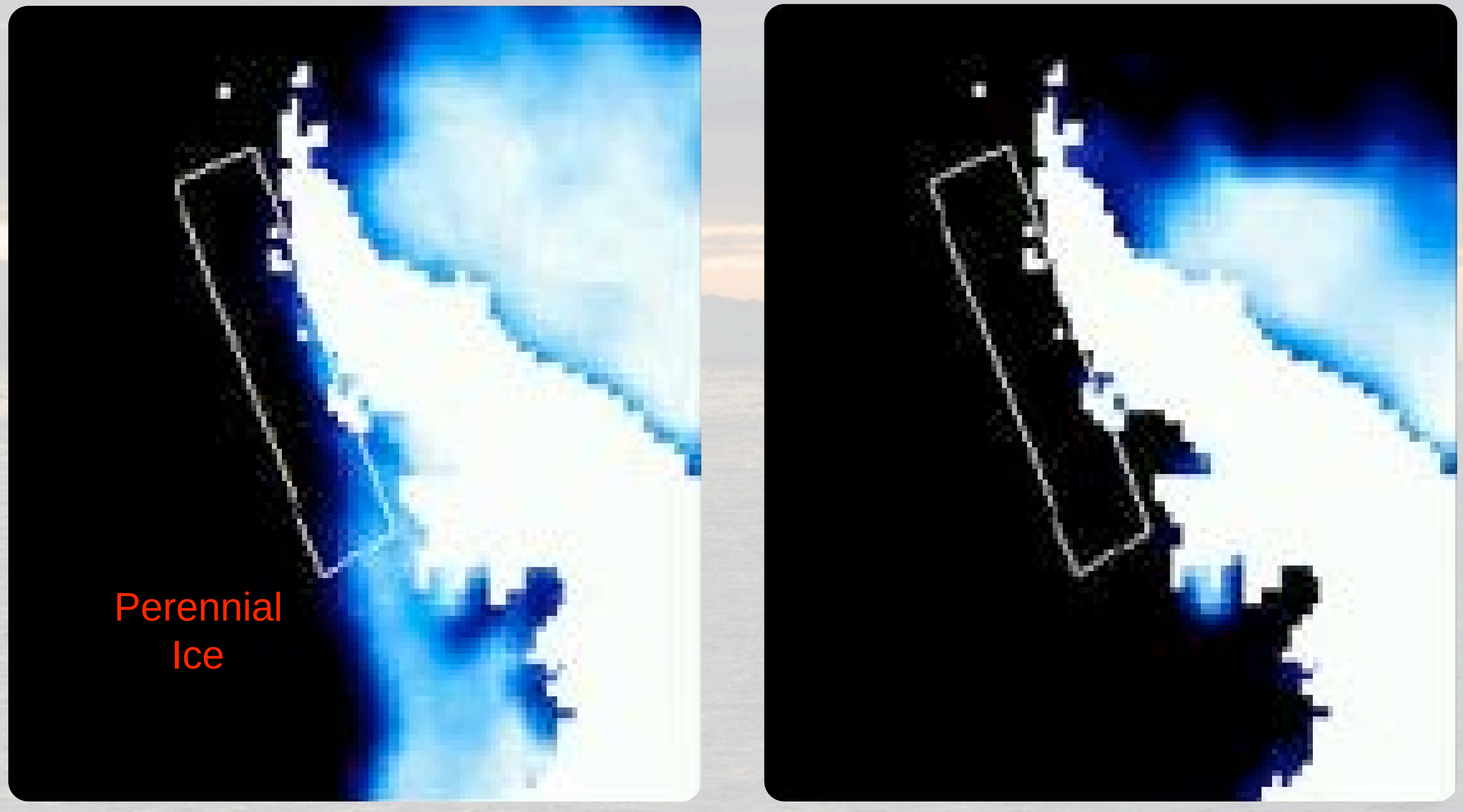


Temperature Trends (degrees C per year)

-0.2 0.2

Feb 1979

Feb 1999



0

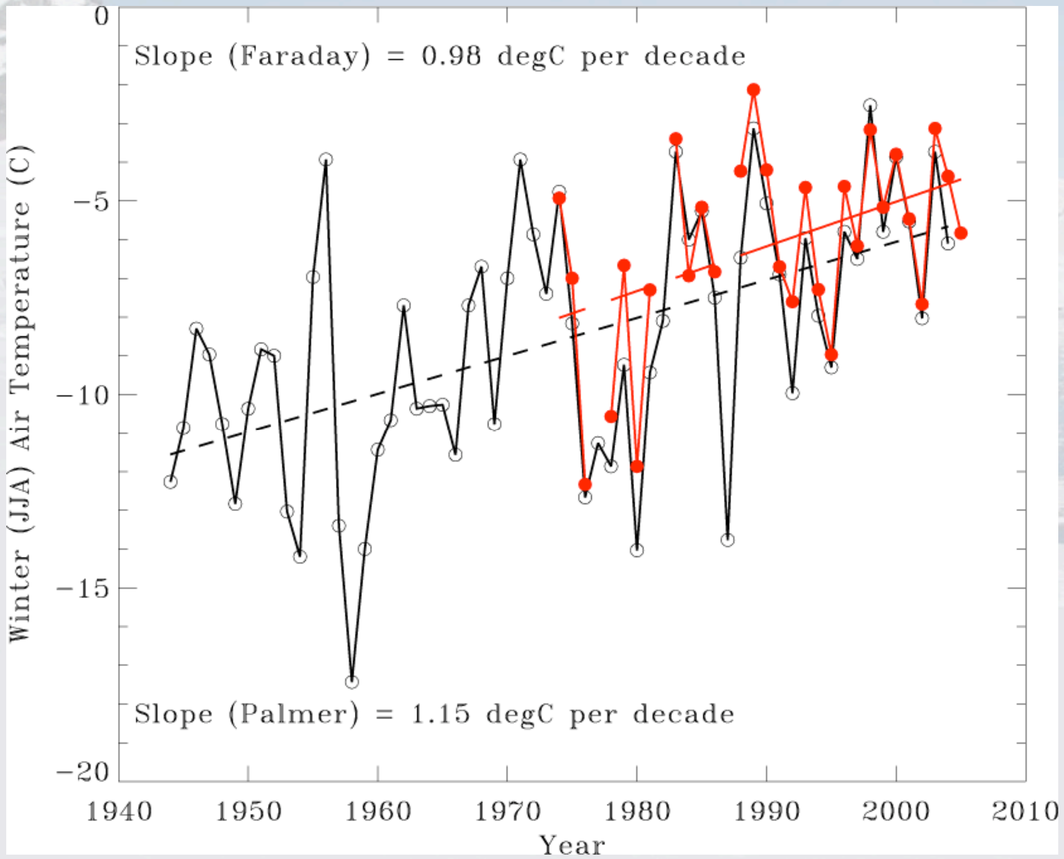
50

100

Sea Ice Concentration (%)

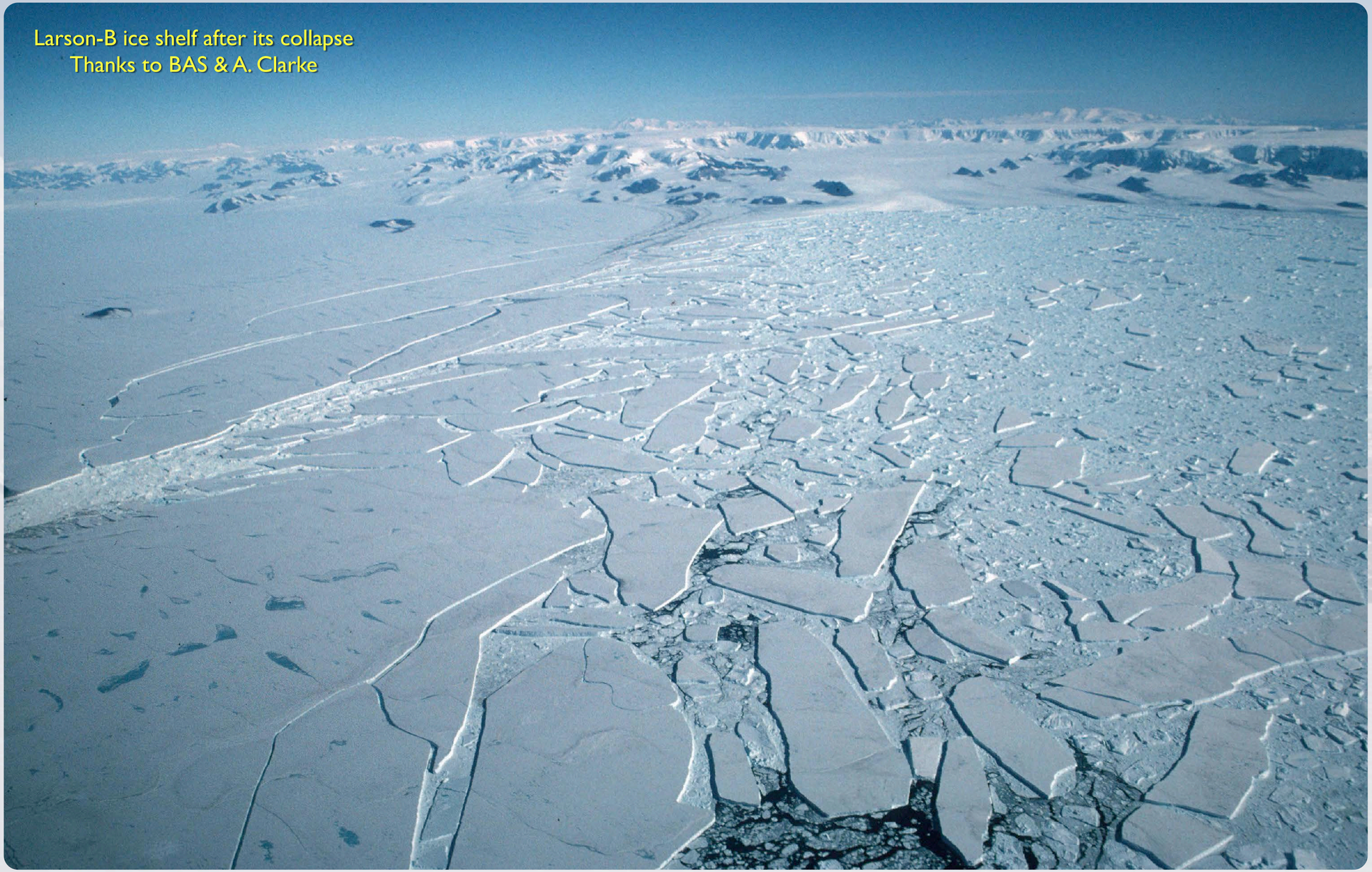
The WAP peninsula is experiencing the largest winter warming on Earth

Mean Winter Temperatures

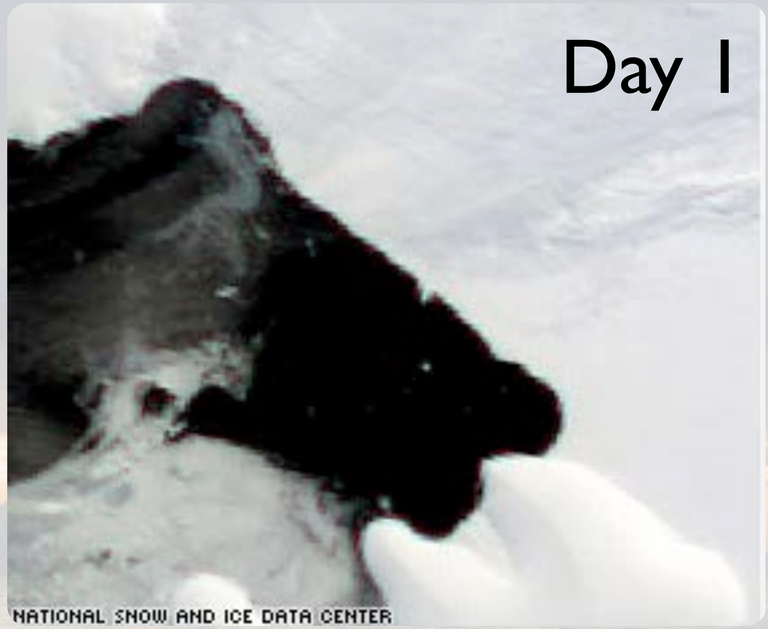


Black is British Faraday & Ukraine Vernadsky Station
Red is US Palmer Station

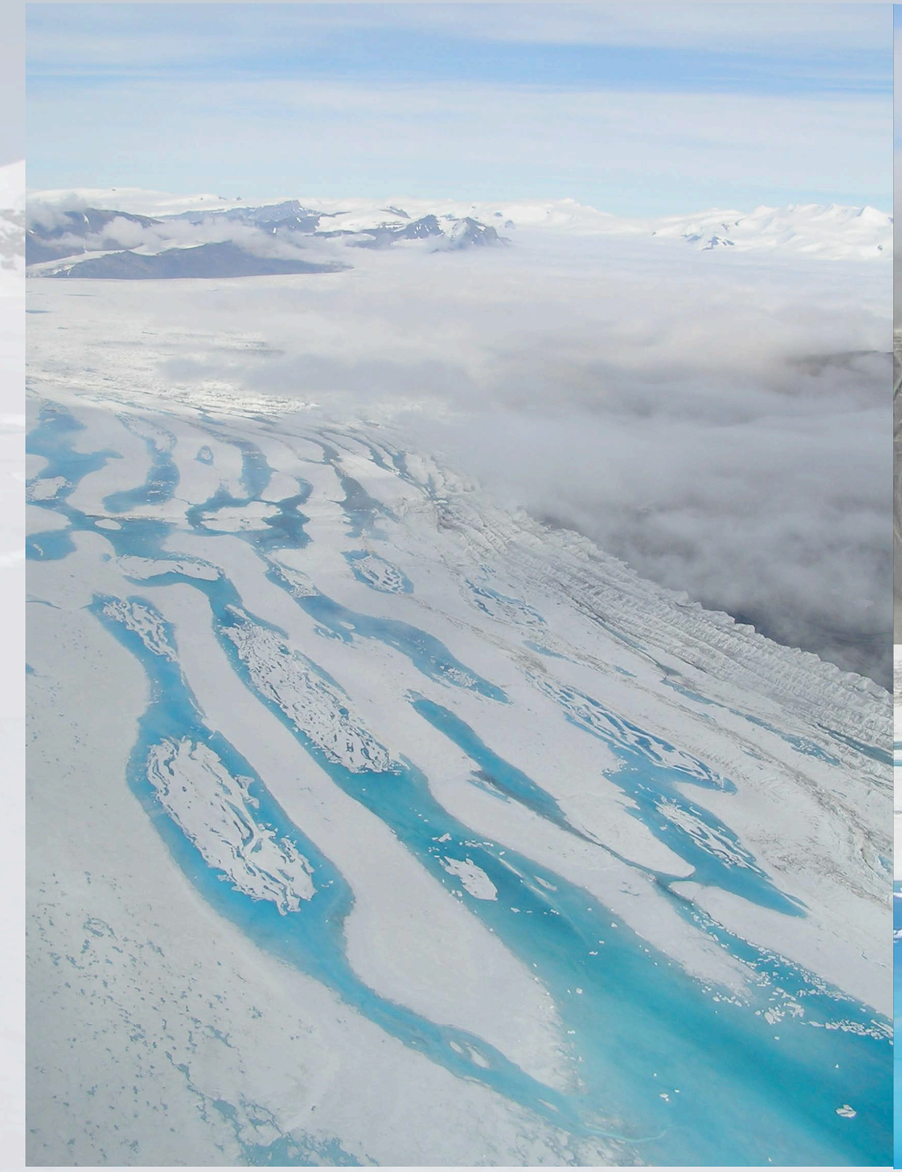
The WAP peninsula is experiencing the largest winter warming on Earth



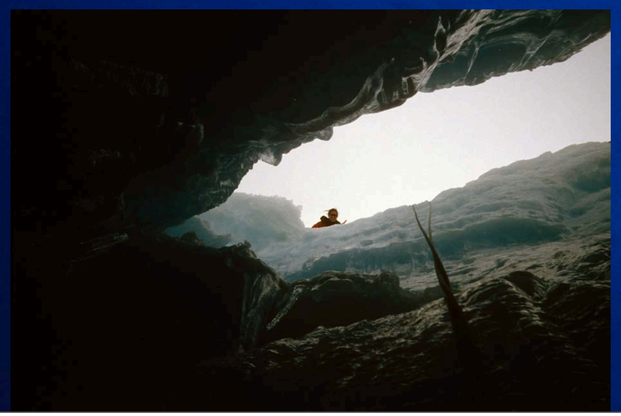
In 2008 the Wilkes Ice Sheet followed the Larson Ice Shelf and began to collapse

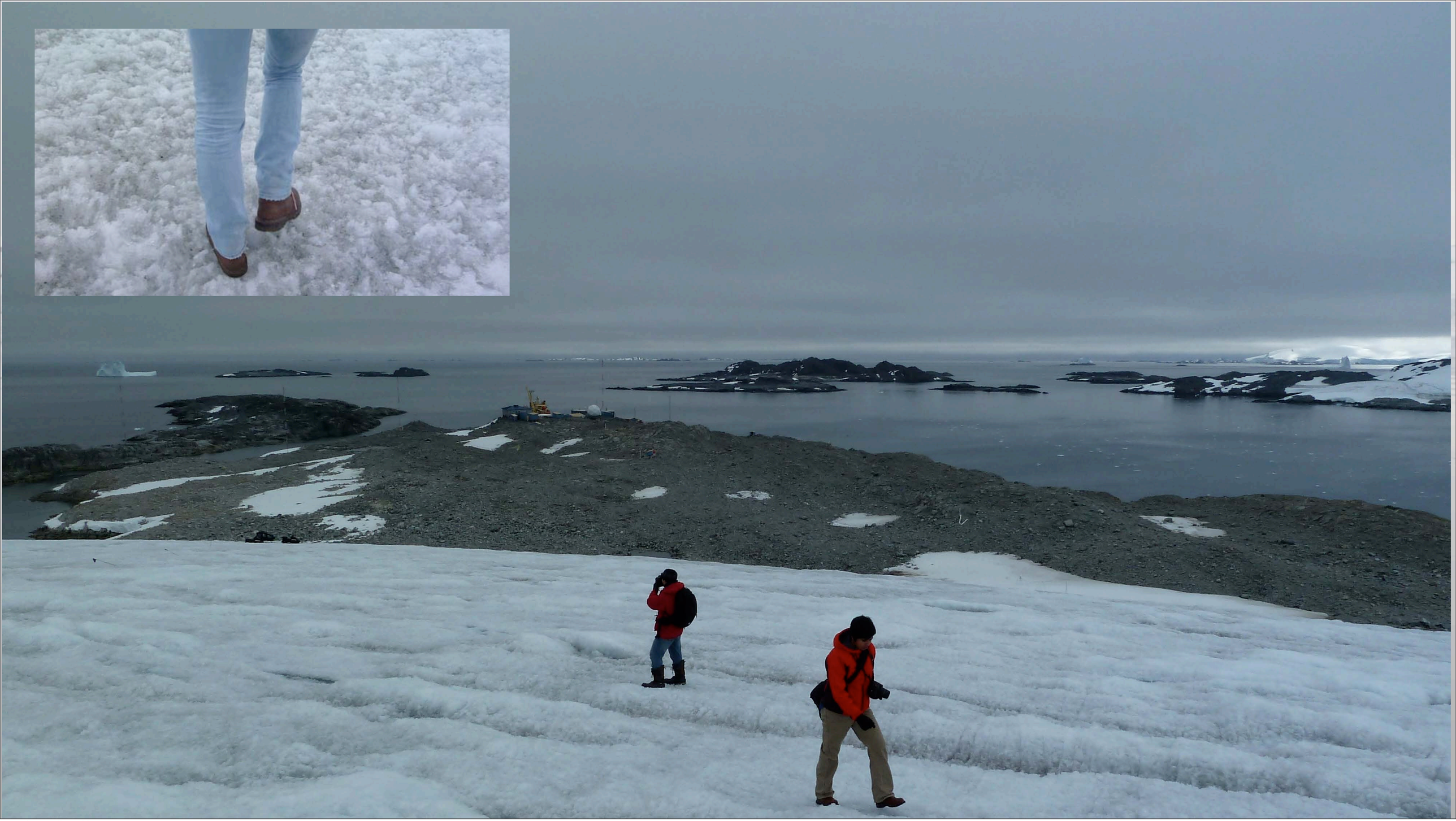


Melt pools on surface of King George VI Sound
(from a BAS twin otter, January 2004)



1990





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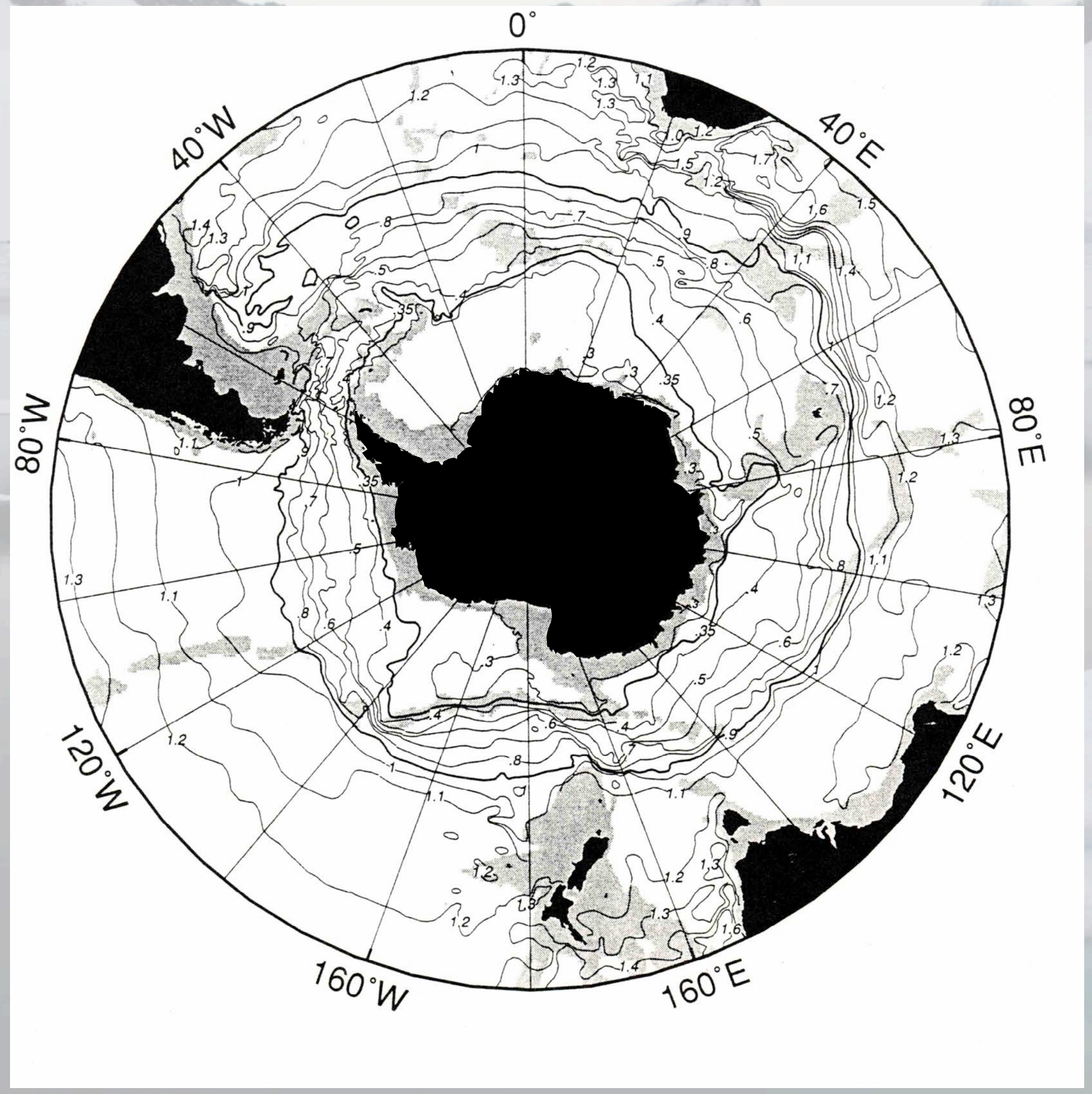
Palmer Station in the present

photo by Bill Fraser

Plants at Palmer Station, the greening of Antarctica

Heat input from Antarctic Circumpolar Current (ACC - world's largest ocean current = ~30,000 Niagara Falls). The heat is driven onto the shelf by intensification of upwelling-favorable winds.



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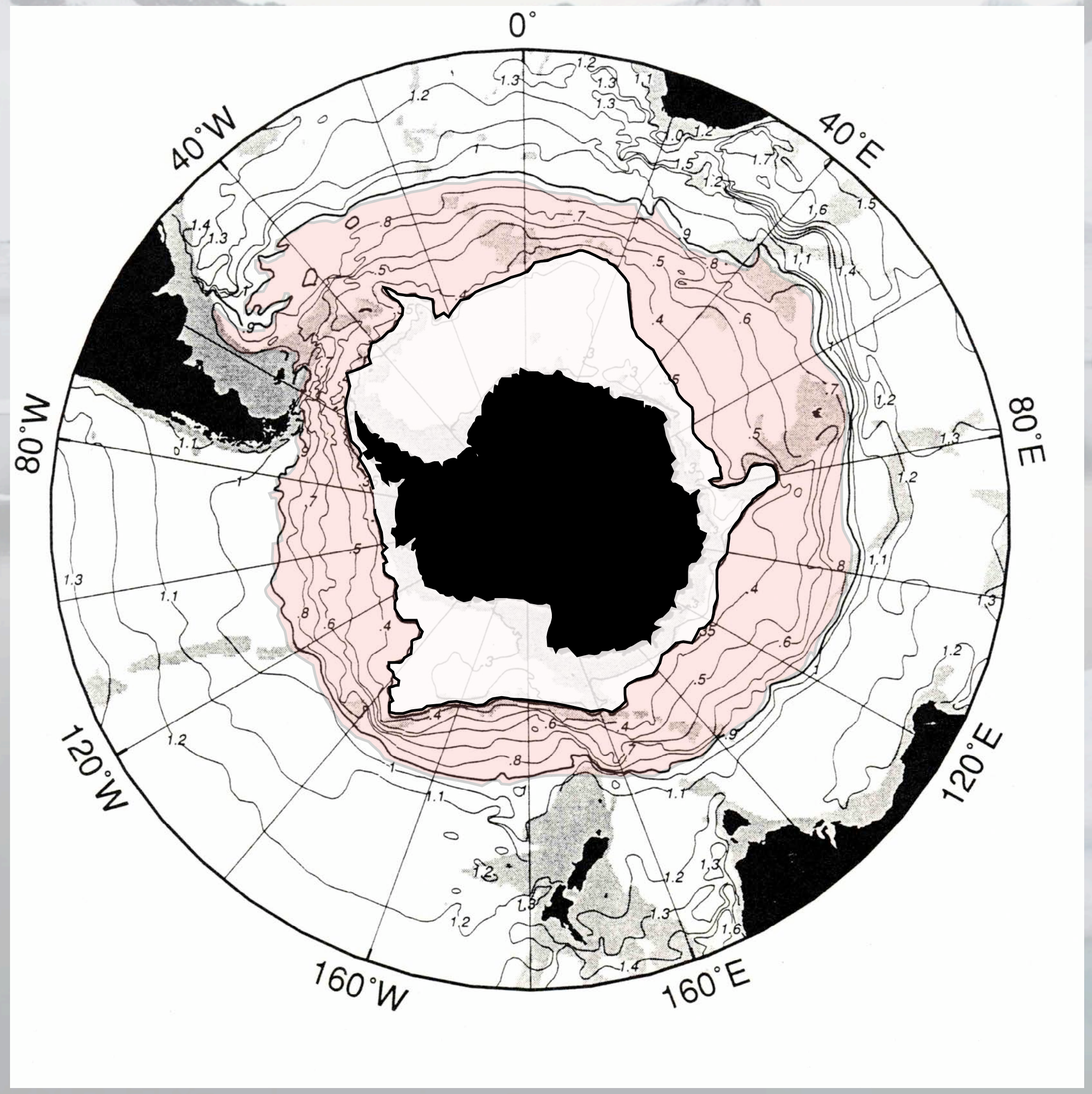

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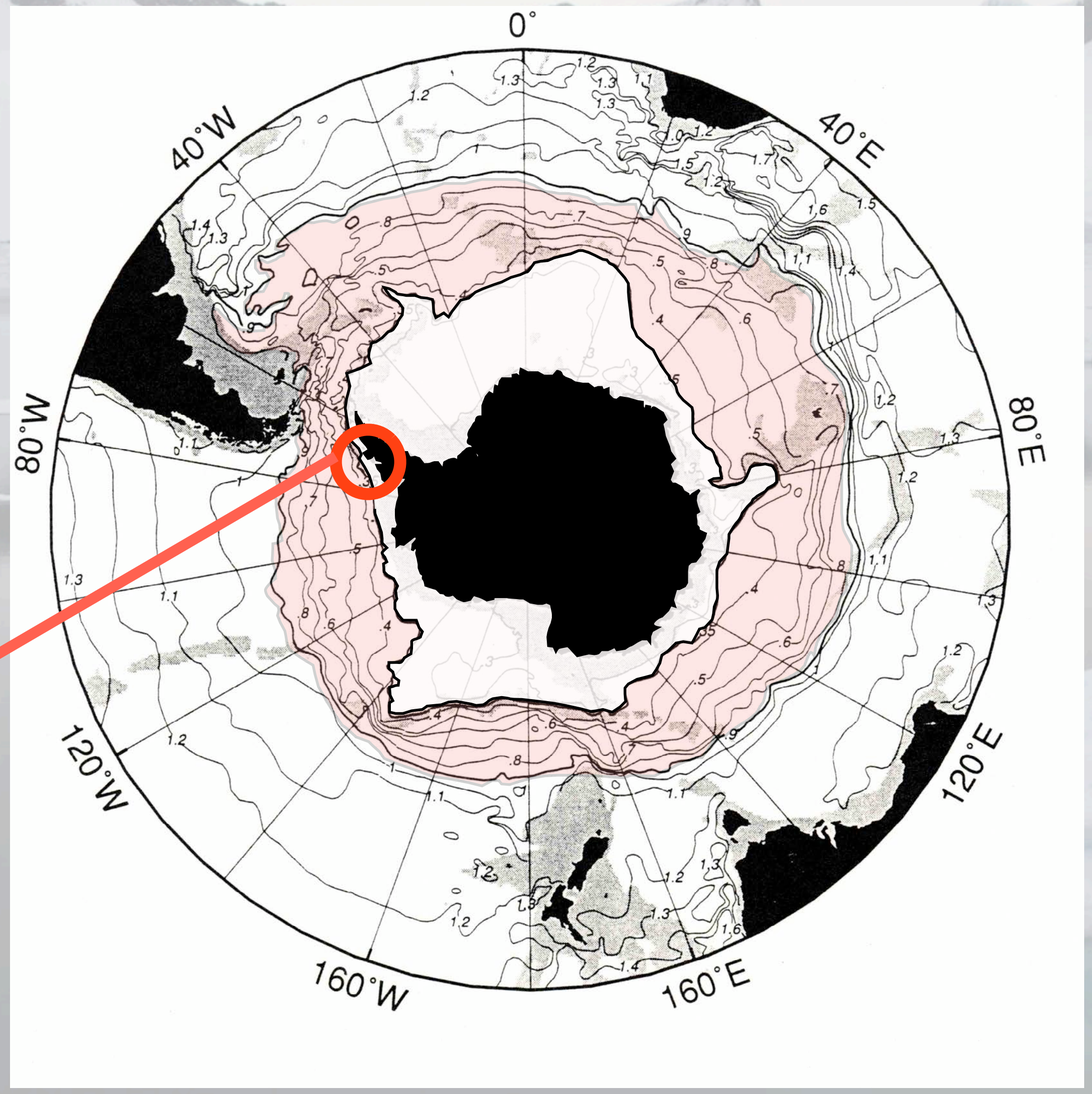
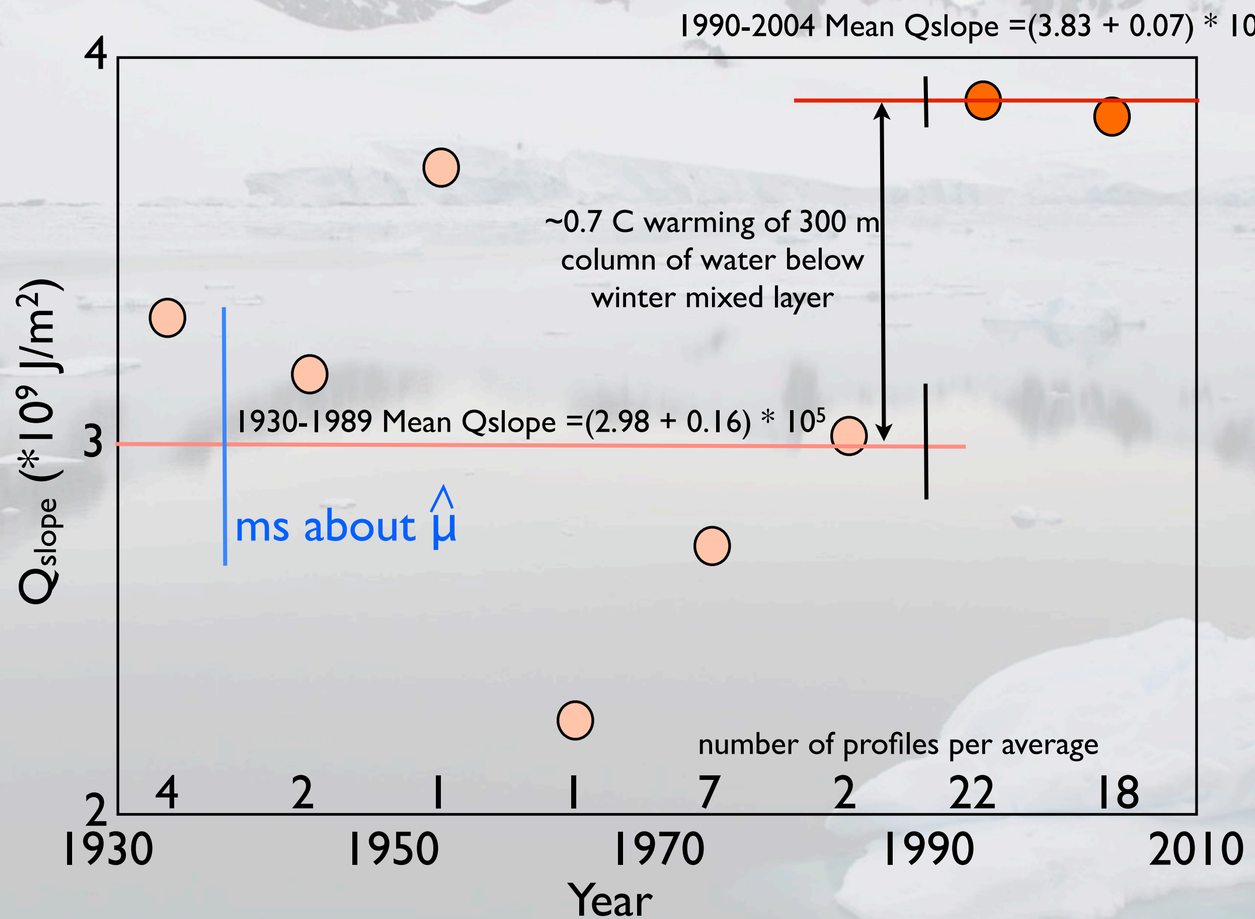


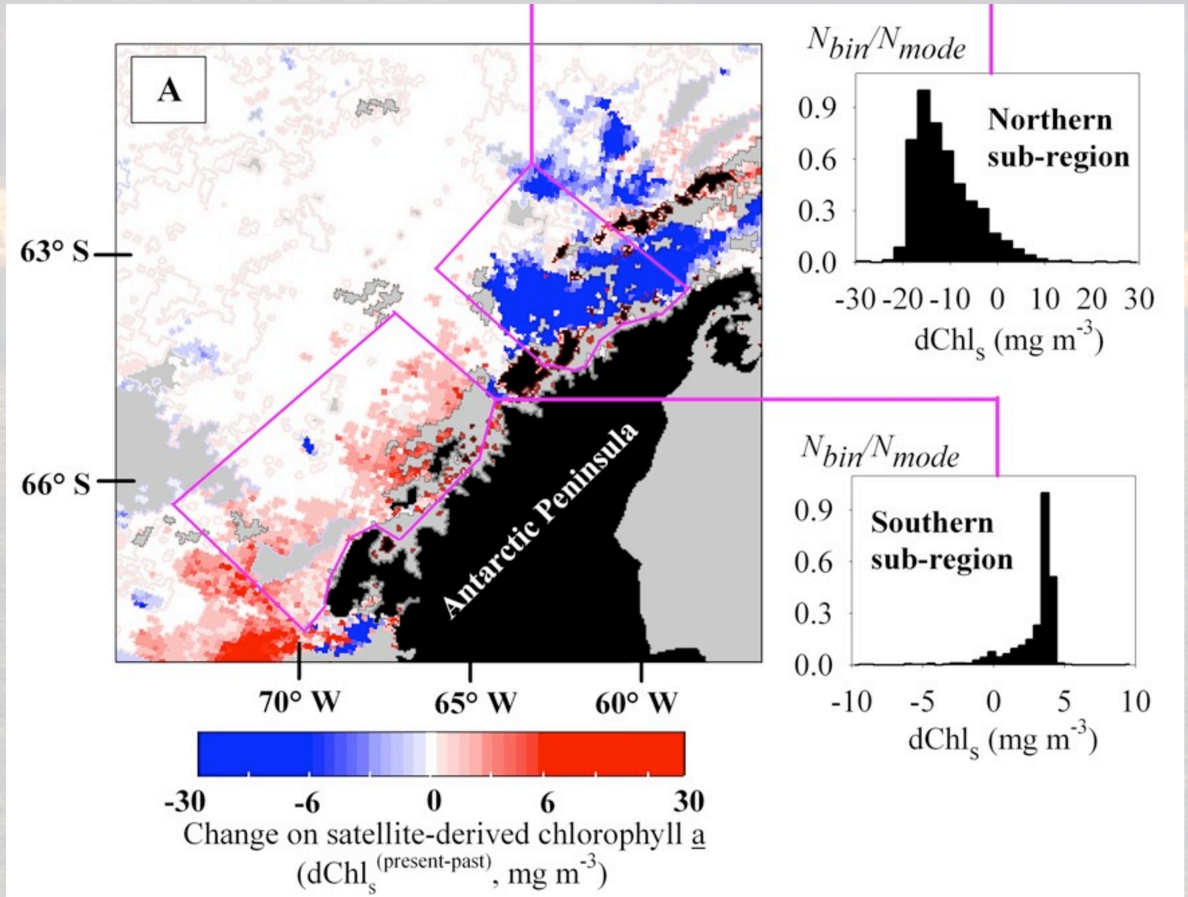
The WAP is the only location in the Antarctic where the ACC is adjacent to the shelf break. The ACC is Antarctica's warmest water

Heating on the WAP is driven by circulation and intrusion of the of the ACC onto the WAP continental shelf. Using decadal averages of the scant data, there was a jump after the year 2000.

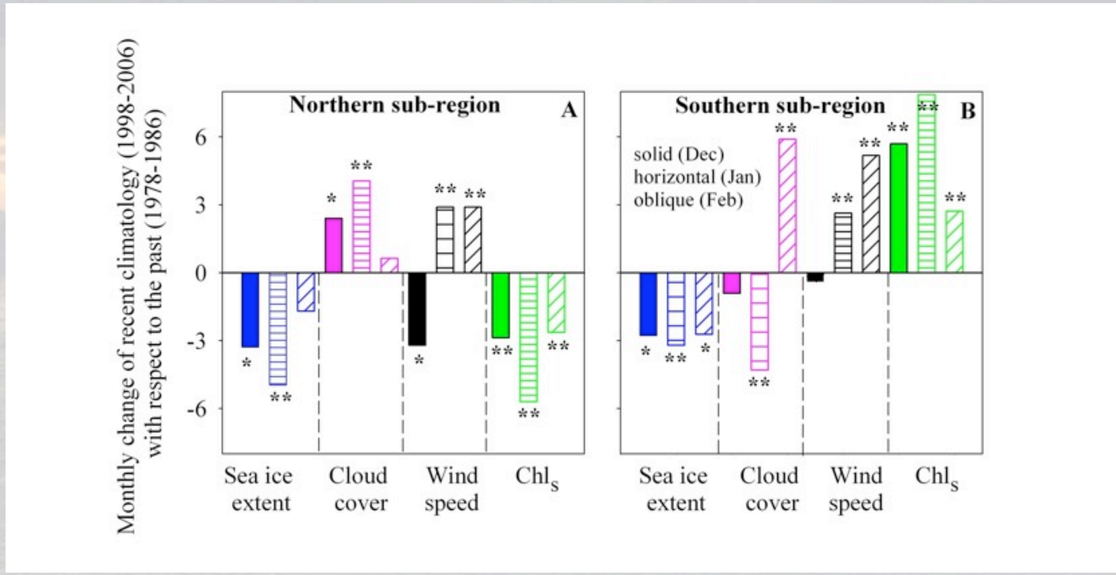


Thanks to Doug Martinson

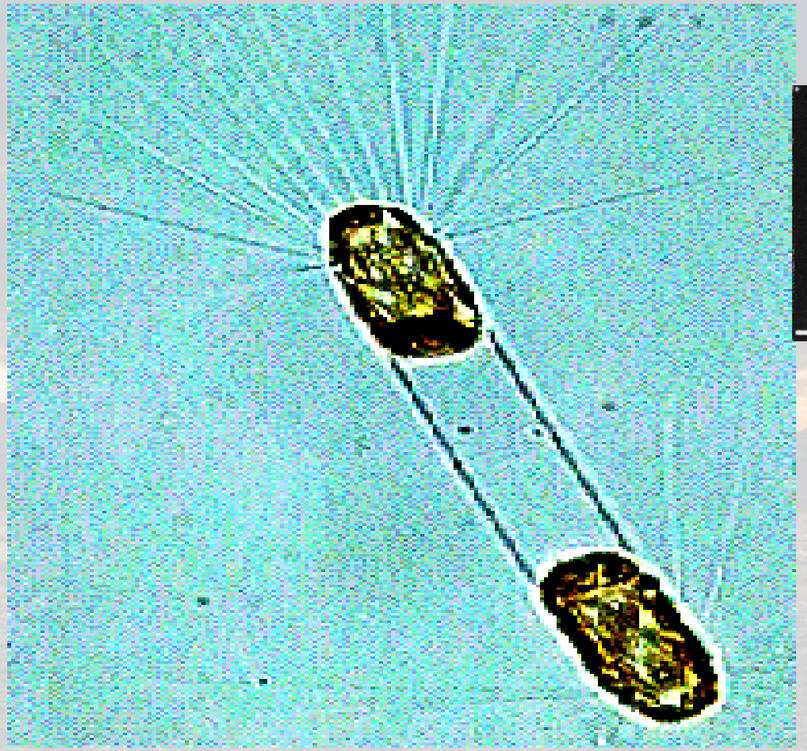
The decadal changes have resulted changes in the phytoplankton



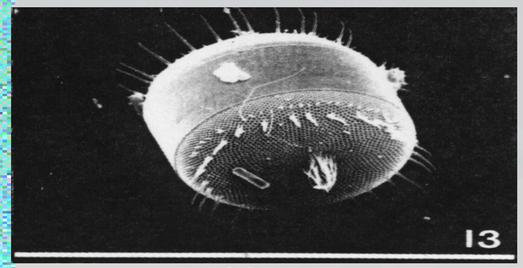
Montes Hugo et al. Science 2009



The changes driven by a decline in sea ice, wind and sun



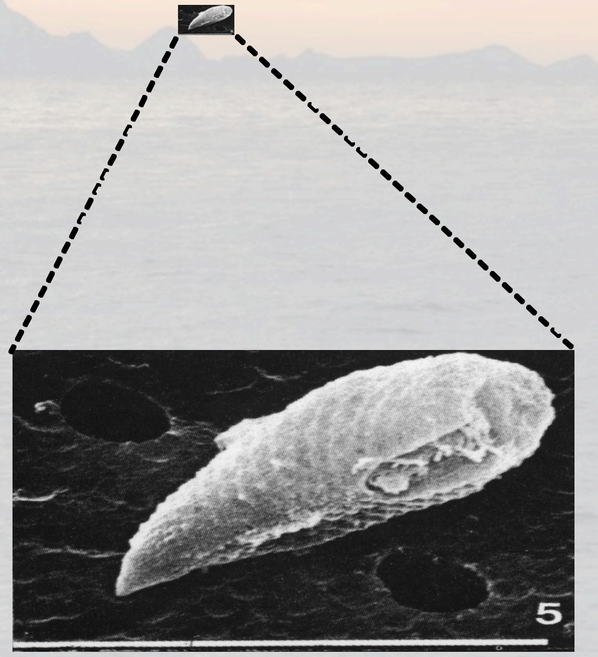
Corethron criophilum



100µm

Thalassiosira antarctica

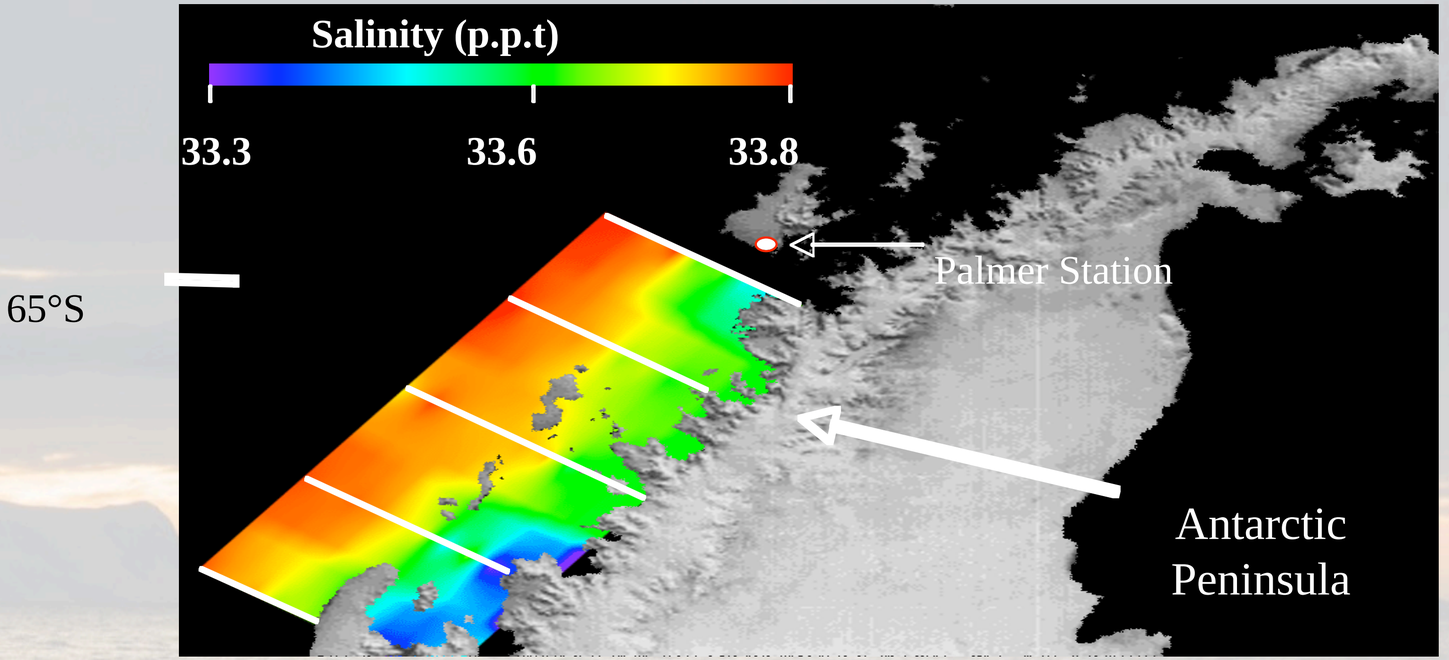
Palmer Cryptophytes --> 8 ± 2µm



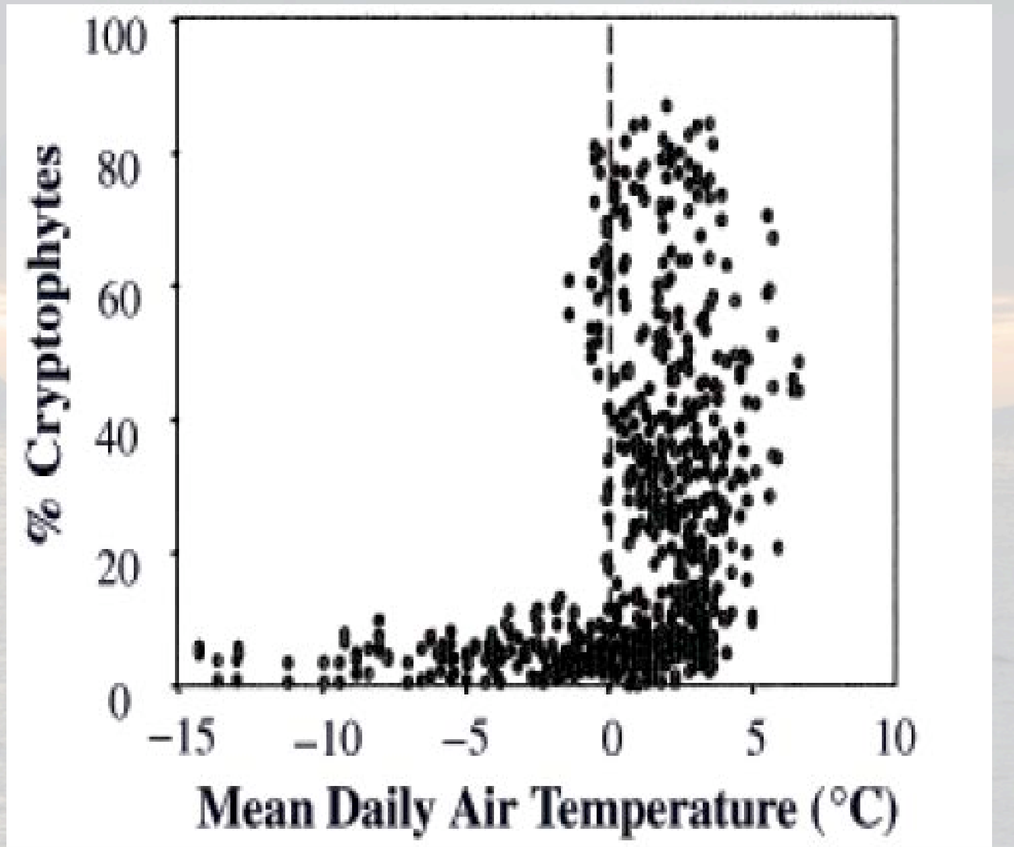
10µm

Cryptomonas cryophila

SEM Micrographs from*McMinn and Hodgson* 1993



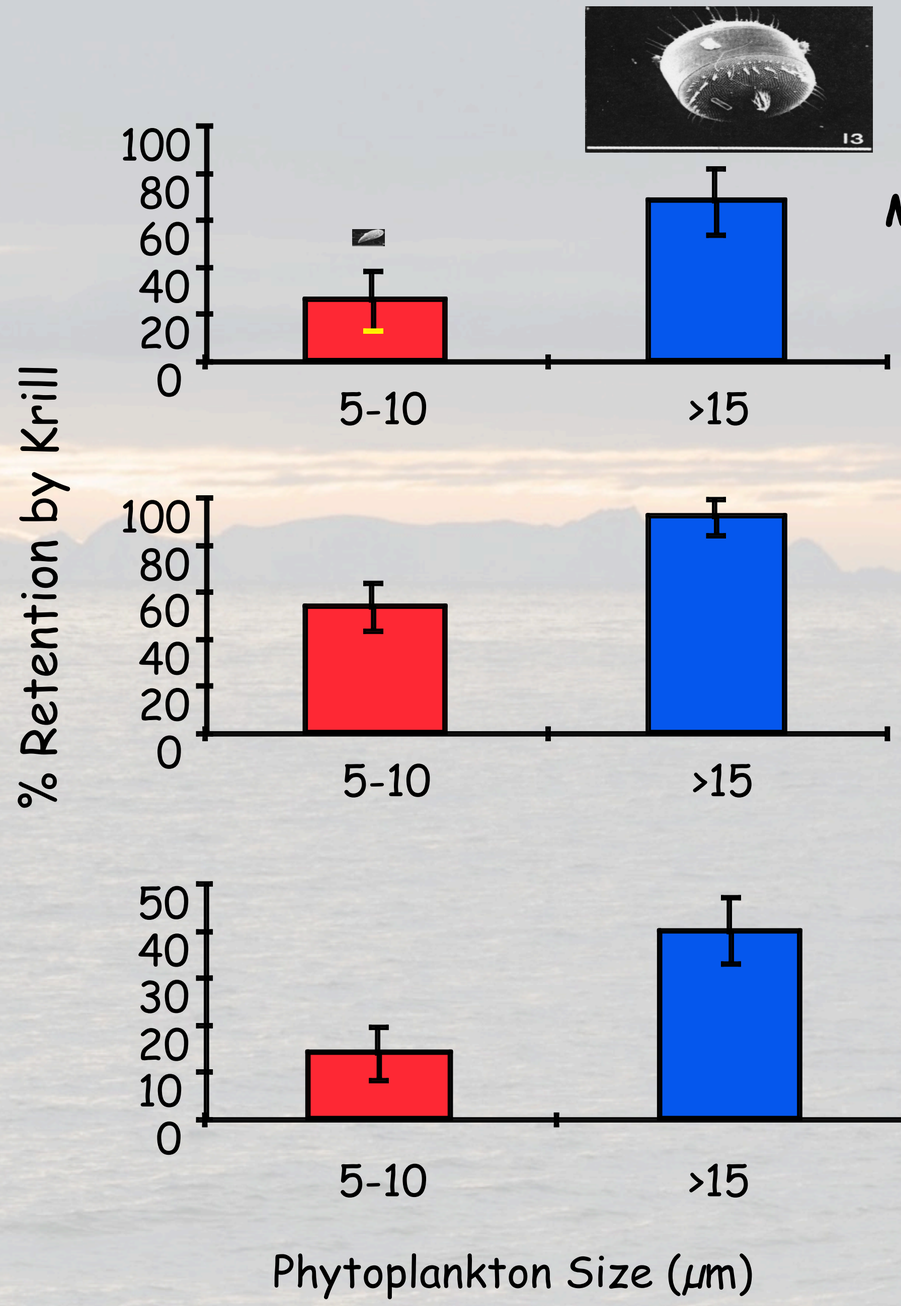
Moline et al.
GBC 2004



Moline et al.
GBC 2004

Zooplankton are dominated by krill or salps

Krill greatest biomass of any animal on earth

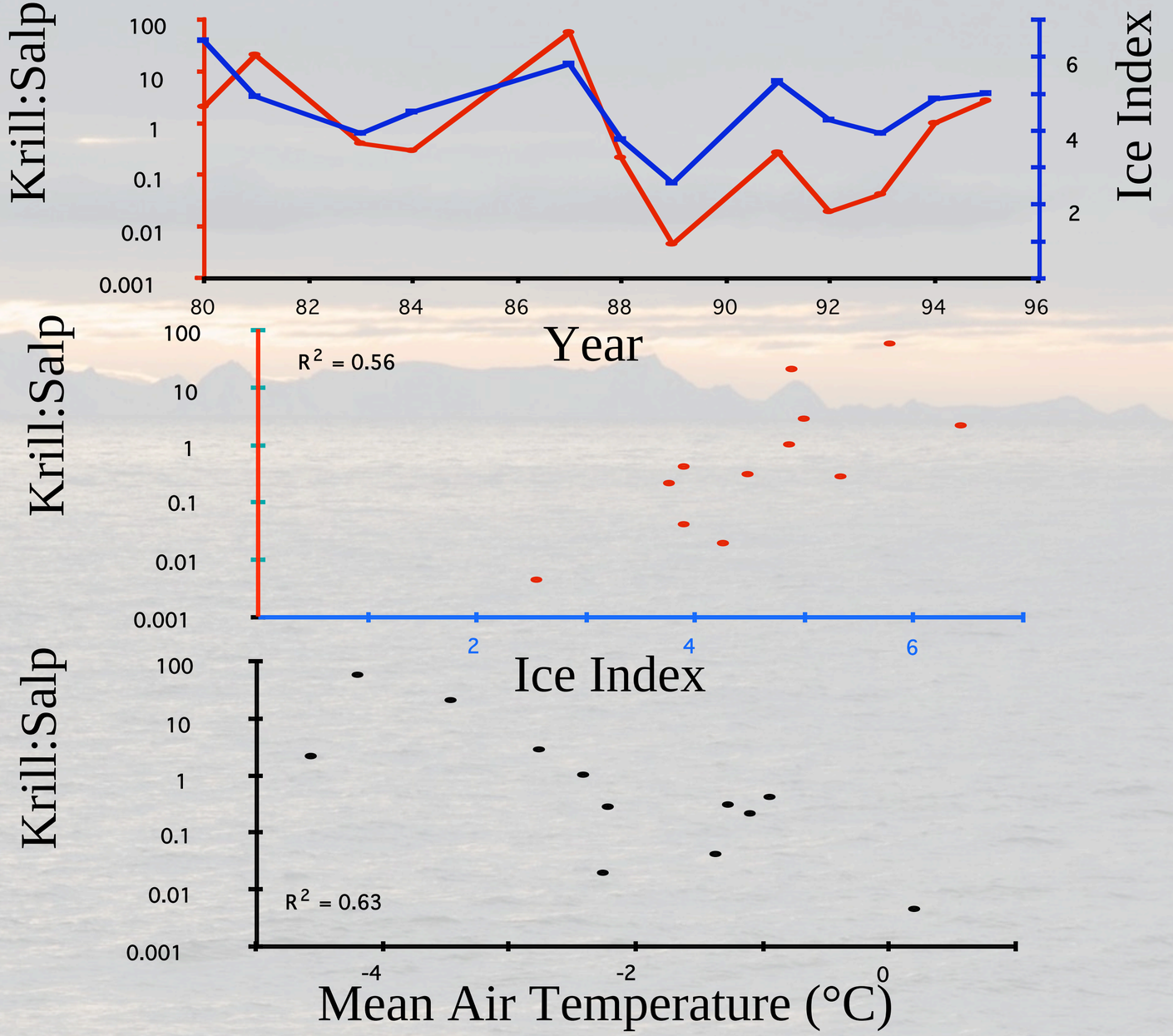


McClatchie and Boyd 1983

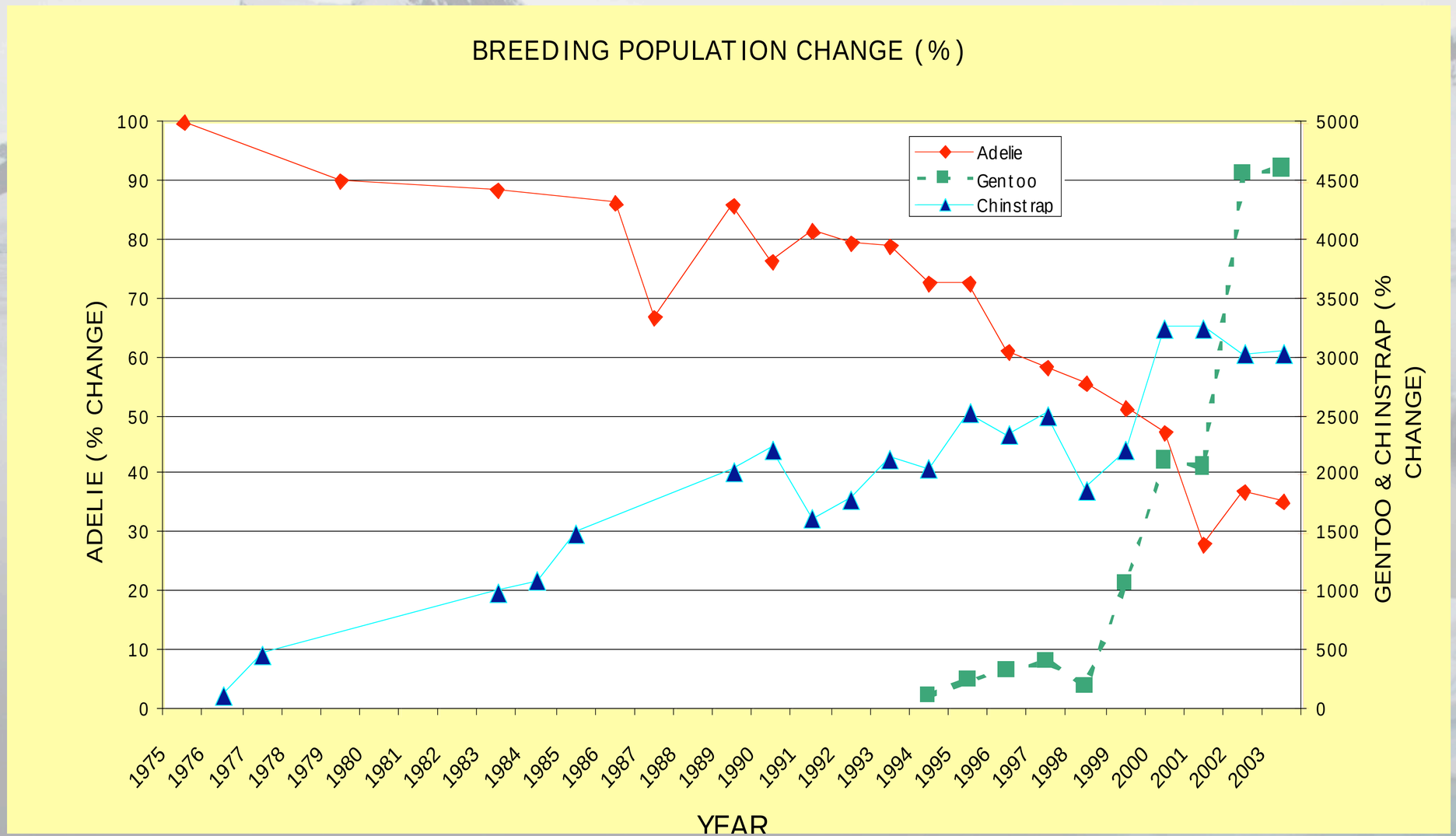
Boyd *et al.* 1984

Quetin and Ross 1985

From *Loeb et al.*, 1997



Is there an impact on higher trophic levels?


BREEDING POPULATION CHANGE (%)
ADELIE (% CHANGE)
GENTOO & CHINSTRAP (% CHANGE)
YEAR
Adelie
Gentoo
Chinstrap
100
90
80
70
60
50
40
30
20
10
0
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
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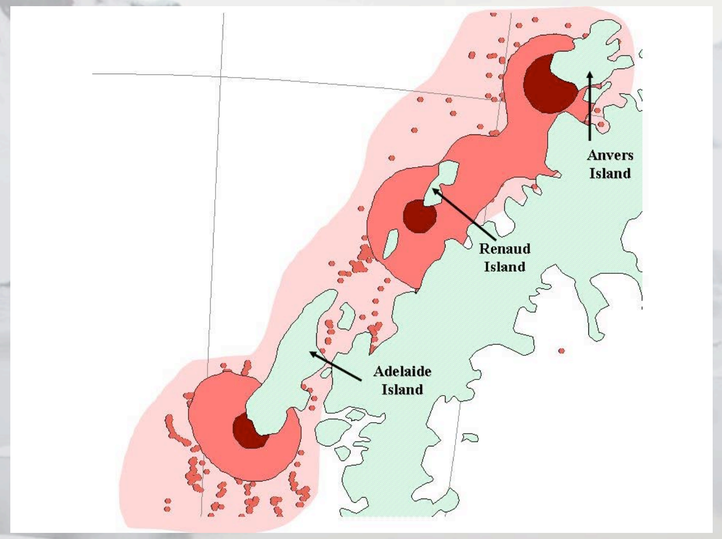
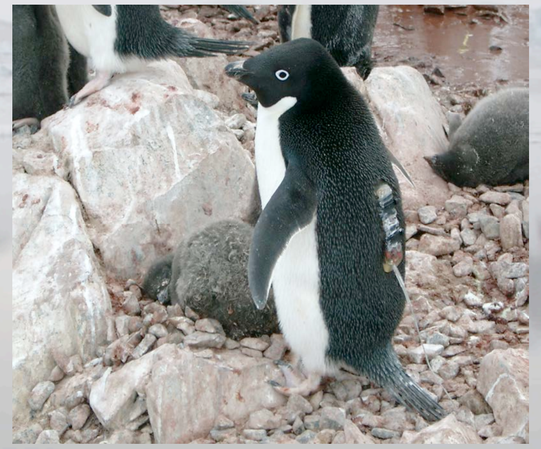
2003

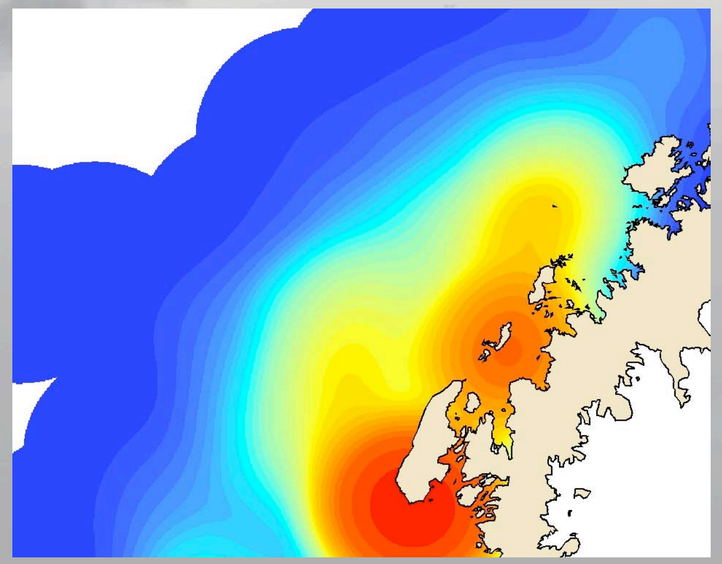
One focus idea of the LTER is testing, is that system is undergoing climate migration. We have structured sampling around the major Adelie penguin breeding areas along the peninsula.

Summer foraging areas for Adelie penguins



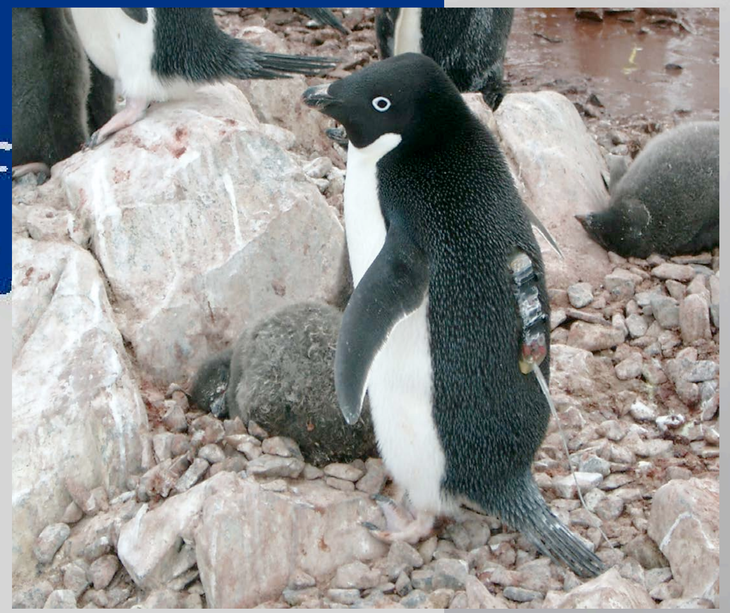


Winter foraging areas for Adelie penguins



To be expanded by NASA grant awarded in Dec.

Anvers Island



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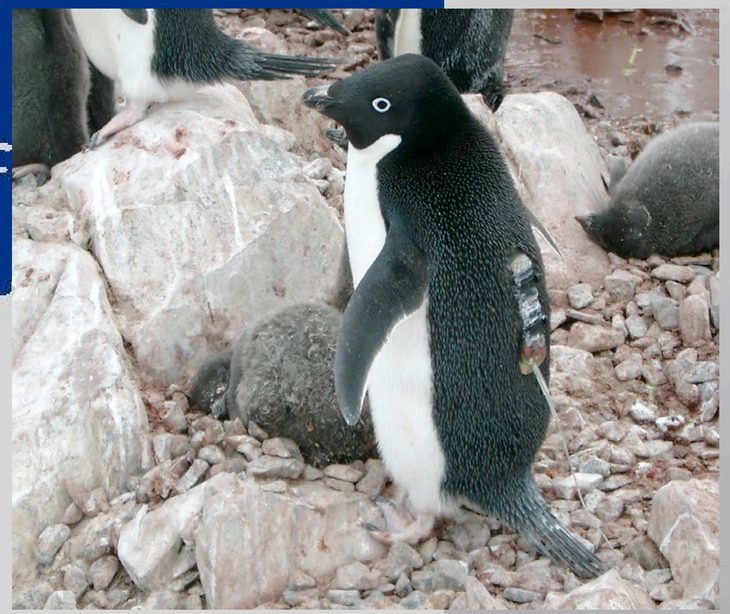
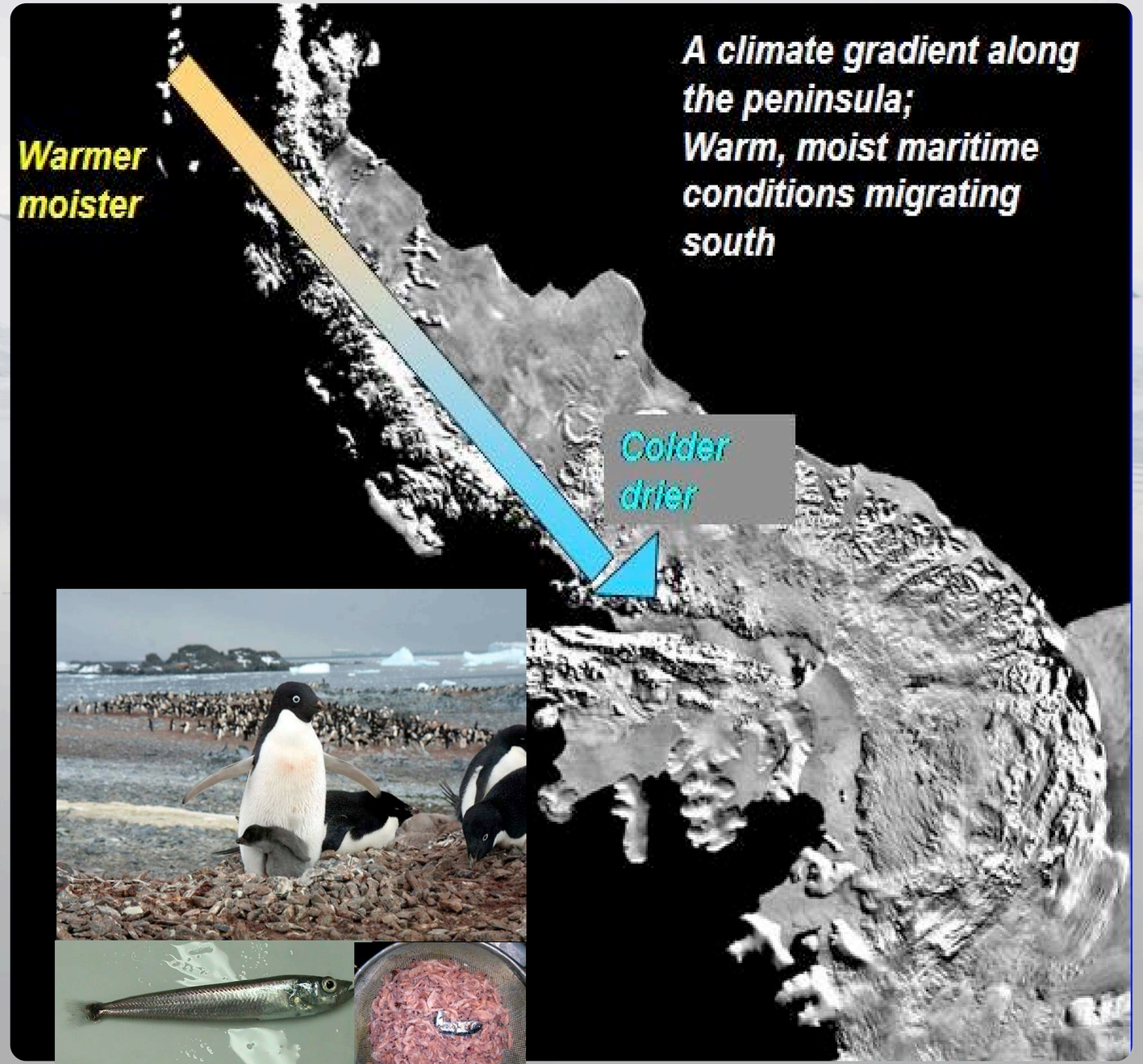
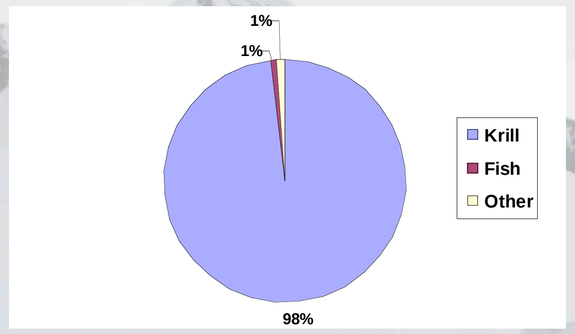


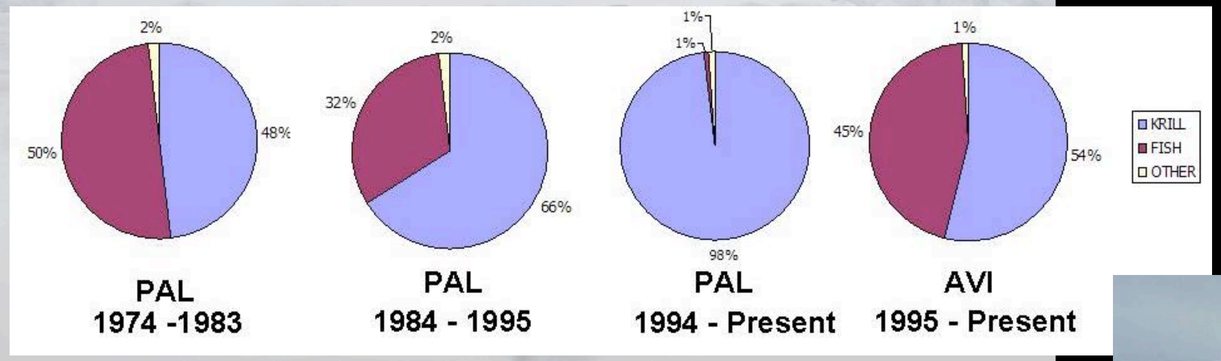
Changing diets for the Adelie penguins

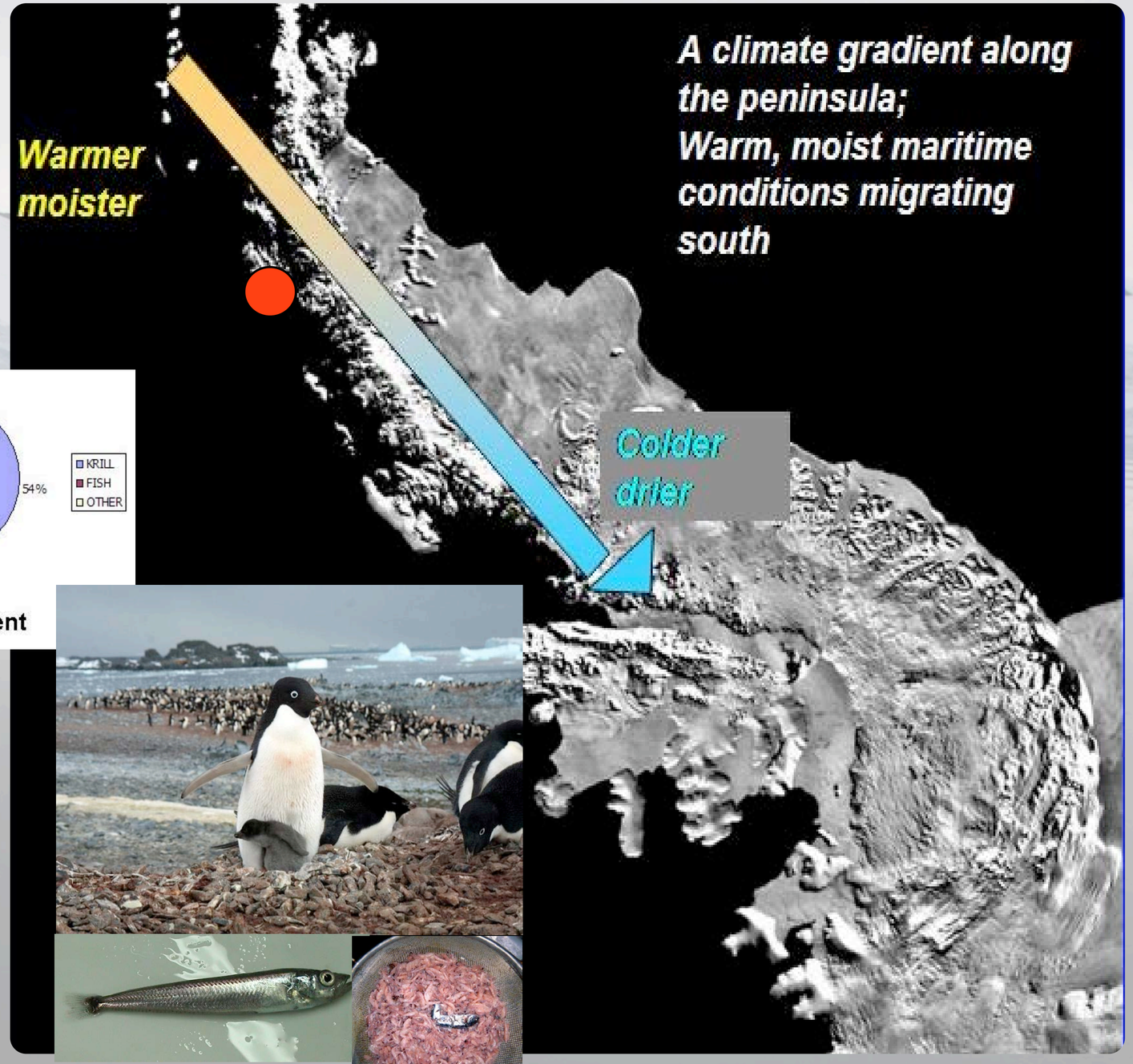


Changing diets for the Adelie penguins

1994-present

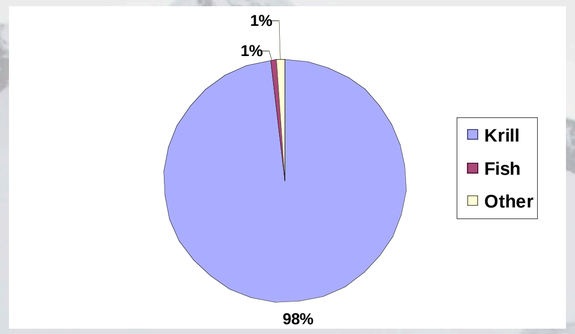


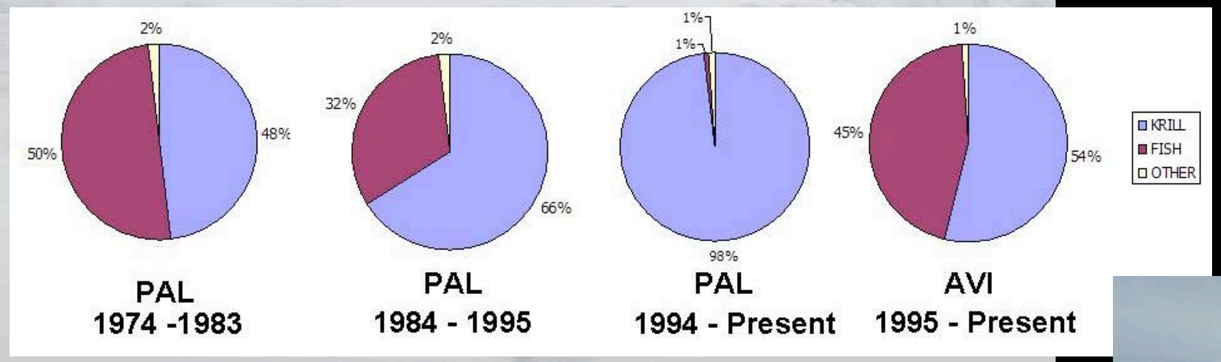




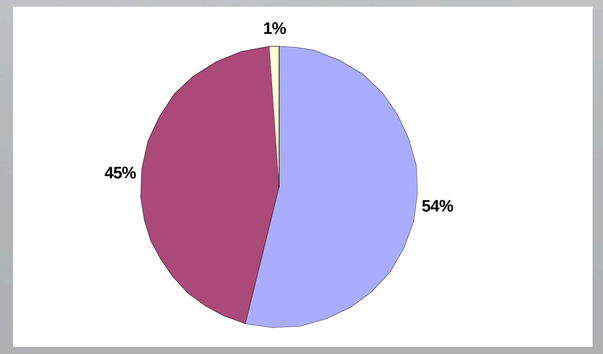
Changing diets for the Adelie penguins

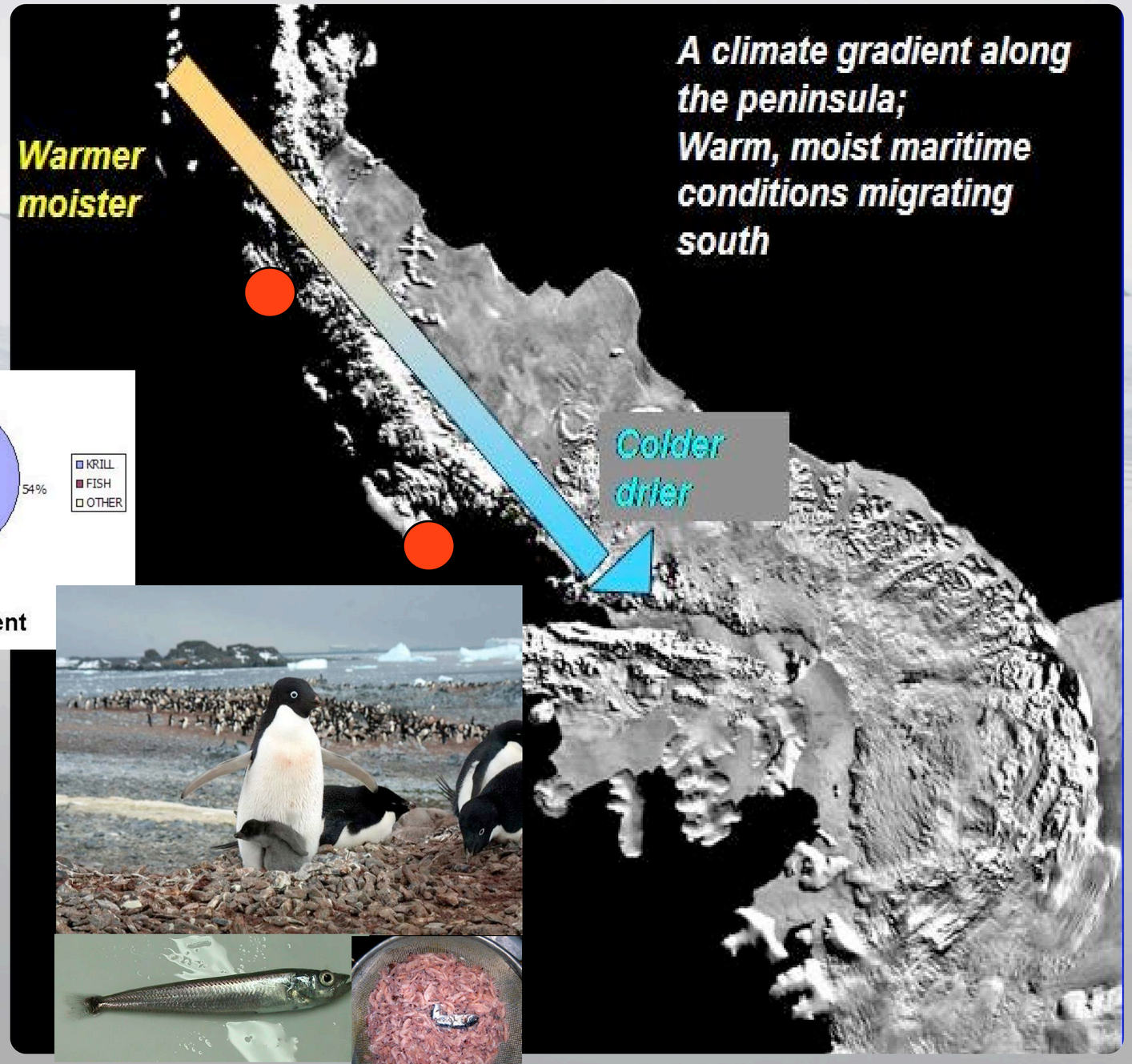
1994-present





1995-present

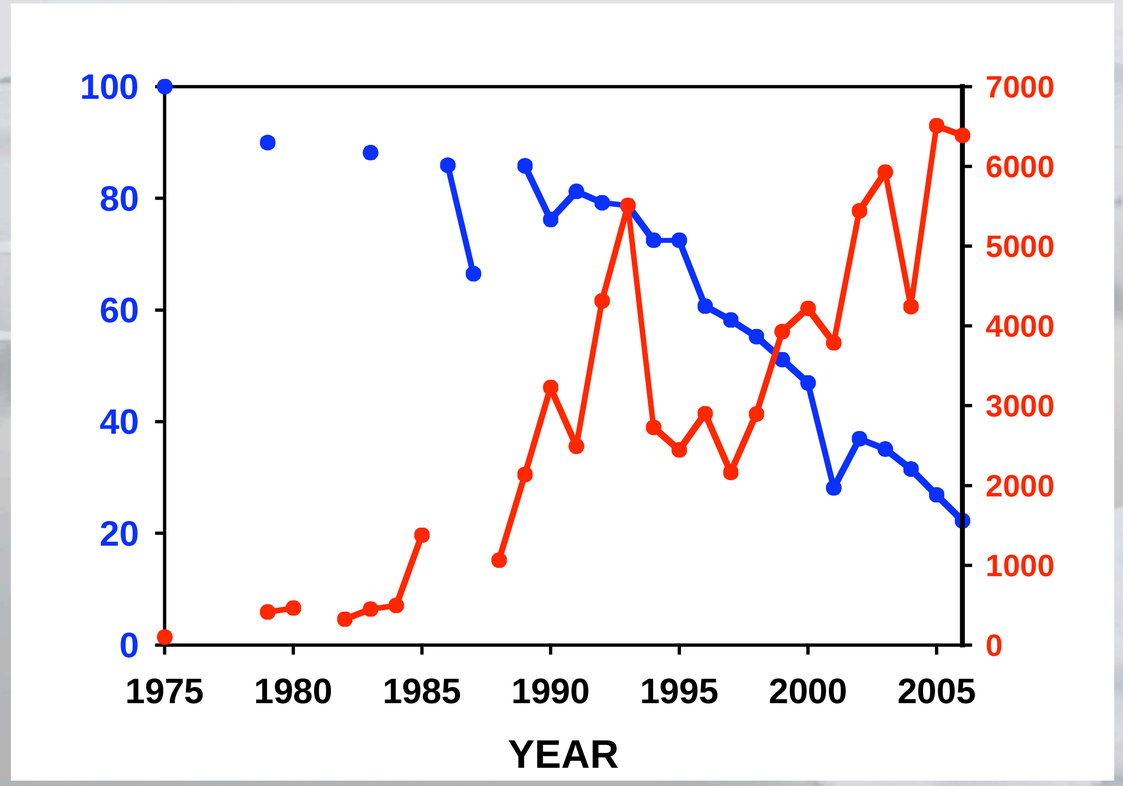


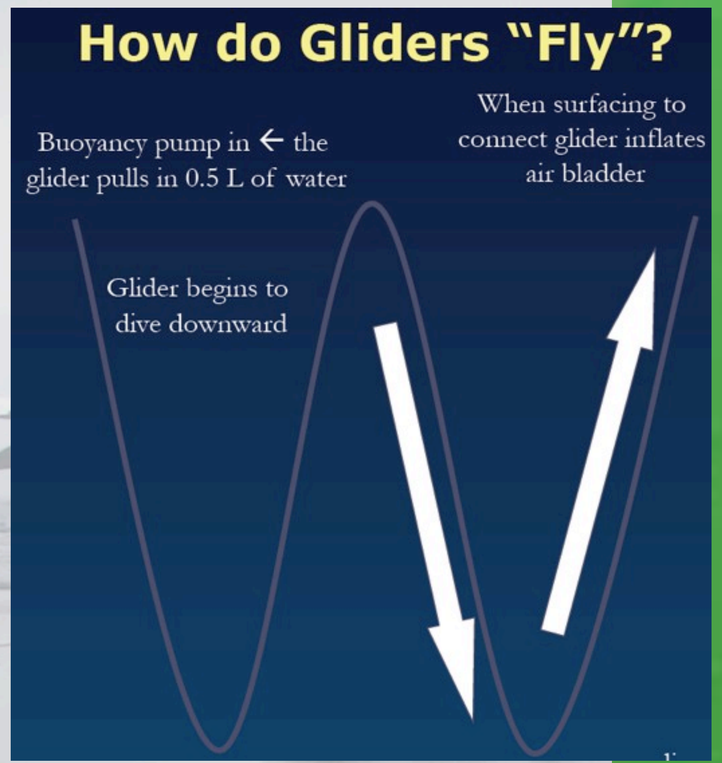


If that was not enough, warmer temps leads to more moisture and more snow. Breeding failure.....

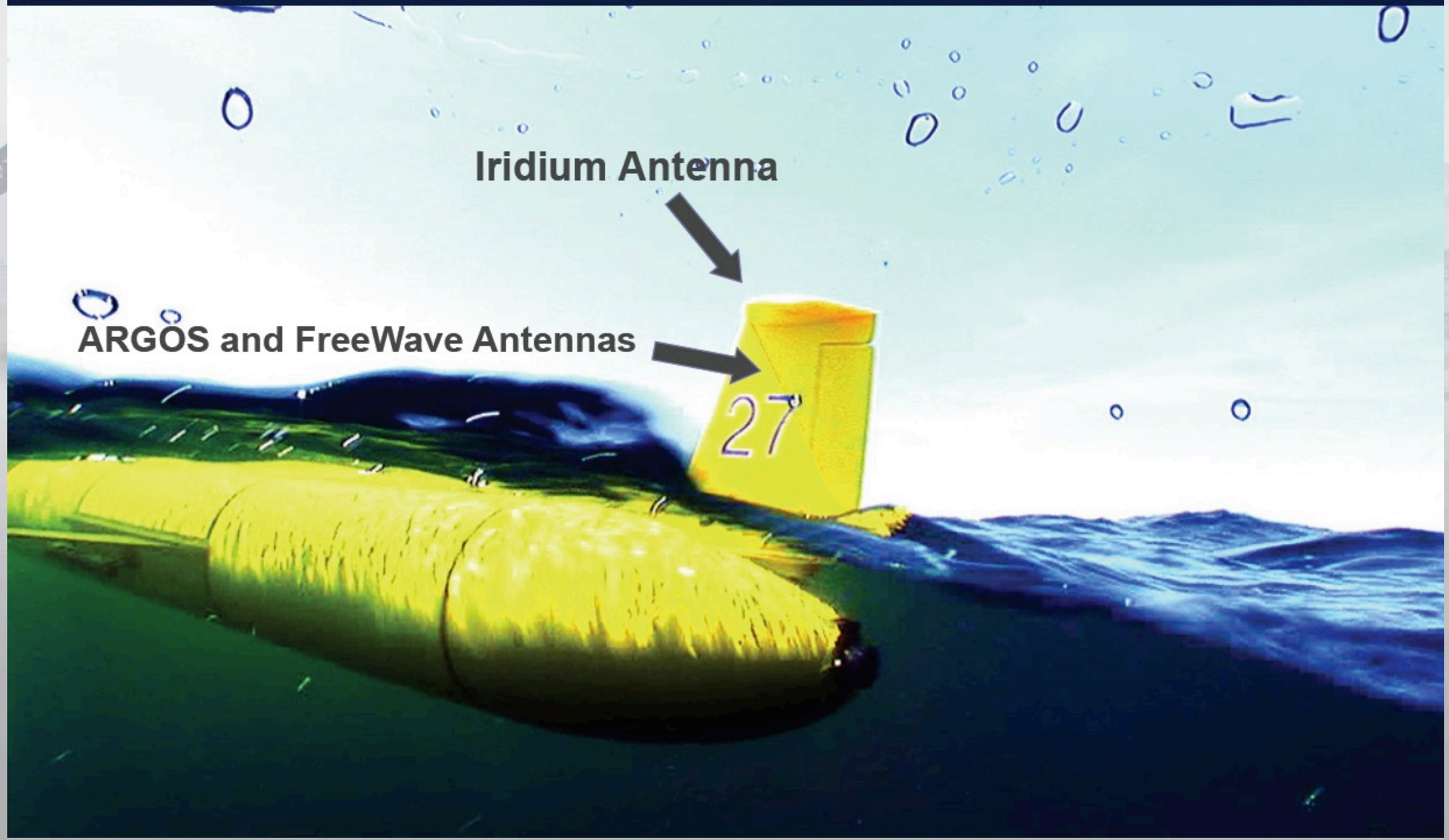
Adelie penguins
Weddell seals

Chinstrap penguins
Gentoo penguins
Fur seals
Elephant seals

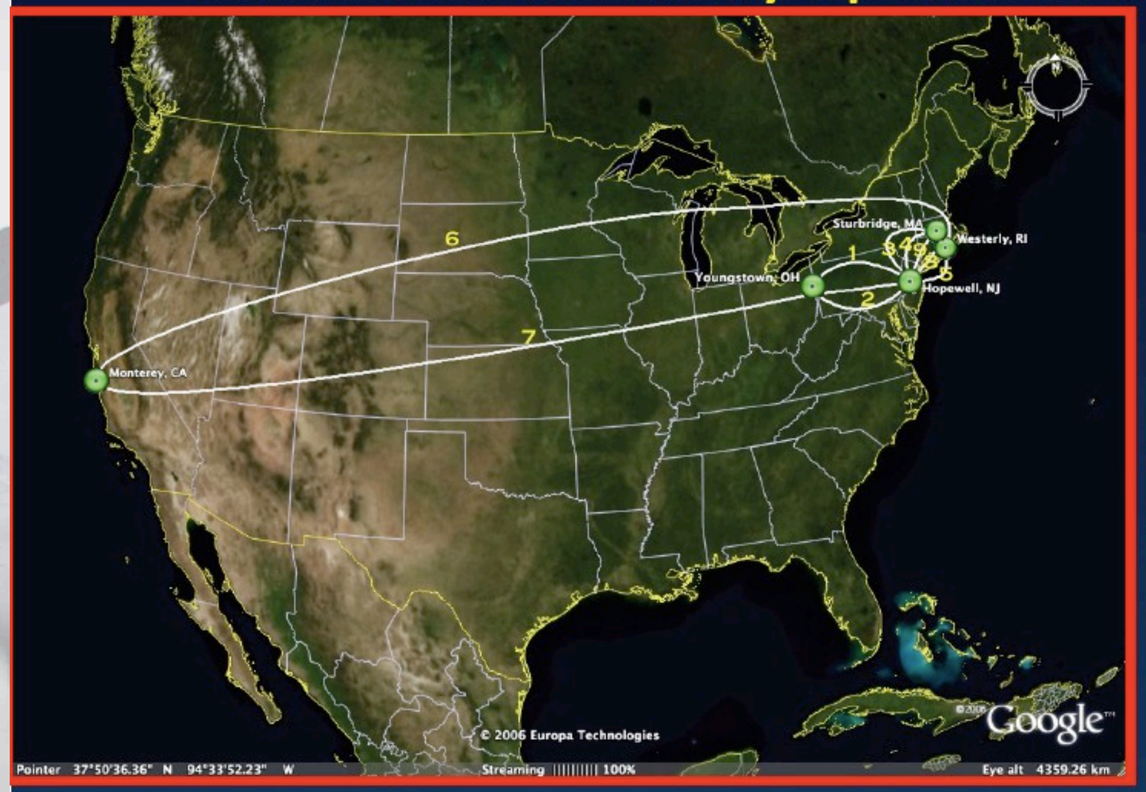



How do Gliders "Fly"?
Buoyancy pump in ← the glider pulls in 0.5 L of water
When surfacing to connect glider inflates air bladder
Glider begins to dive downward

How do Gliders Communicate?

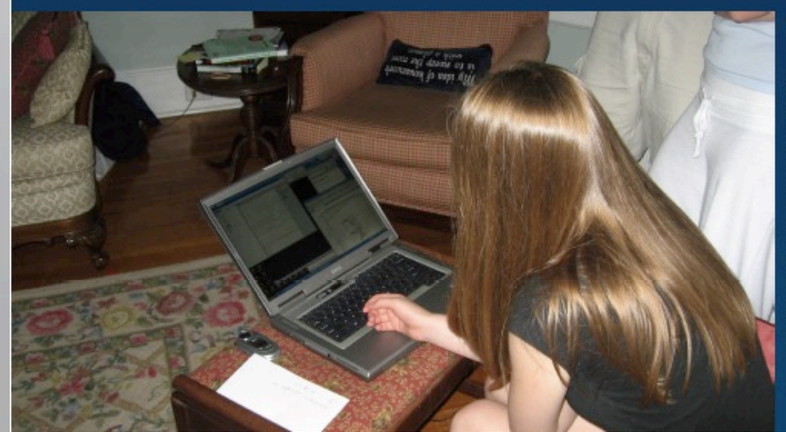


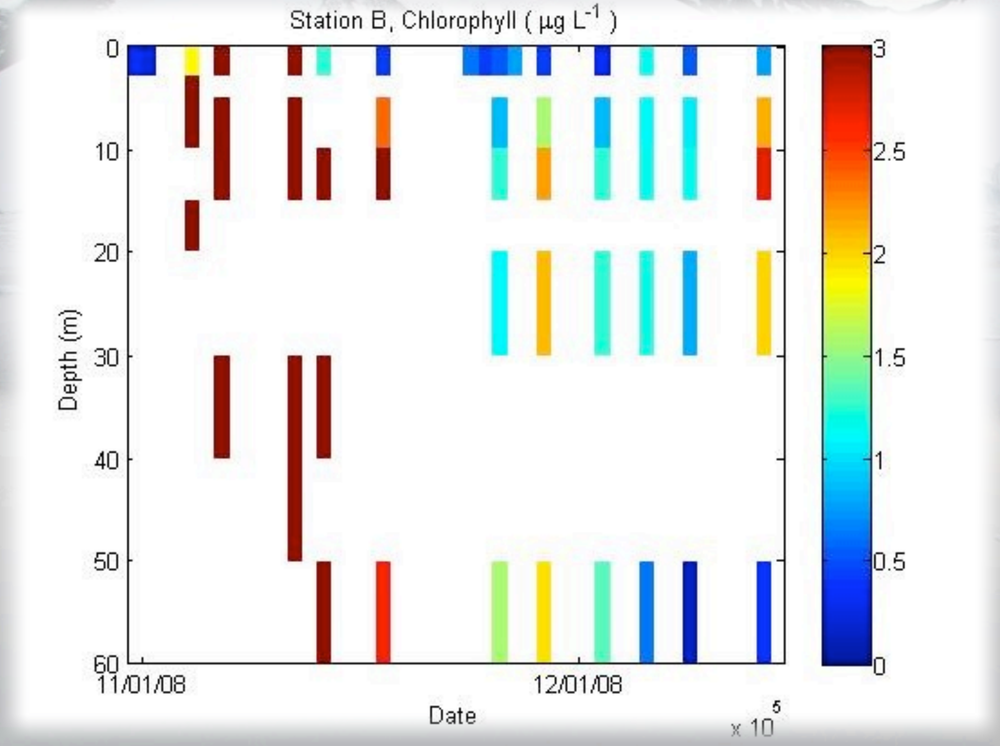
Sustained Observatory Operations from Multiple Locations

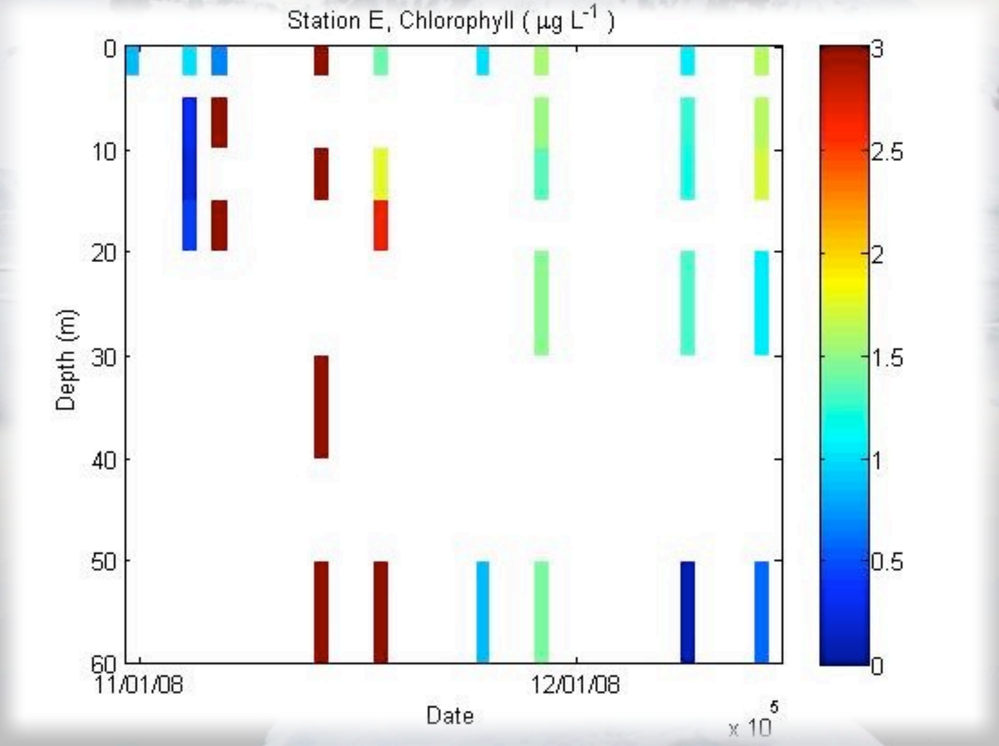


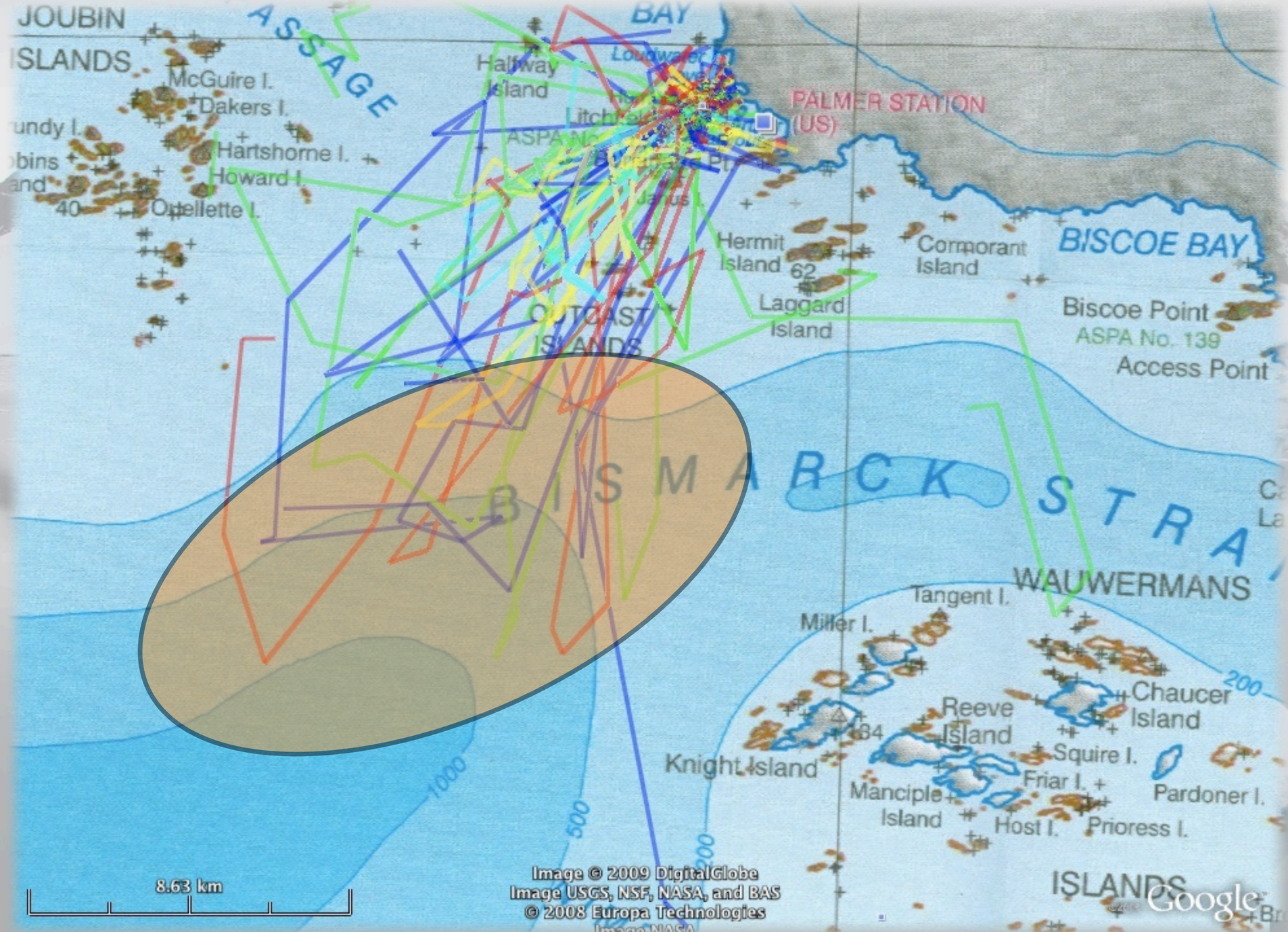
McDonald's WiFi

My Living Room – Glider Recovery in Hawaii

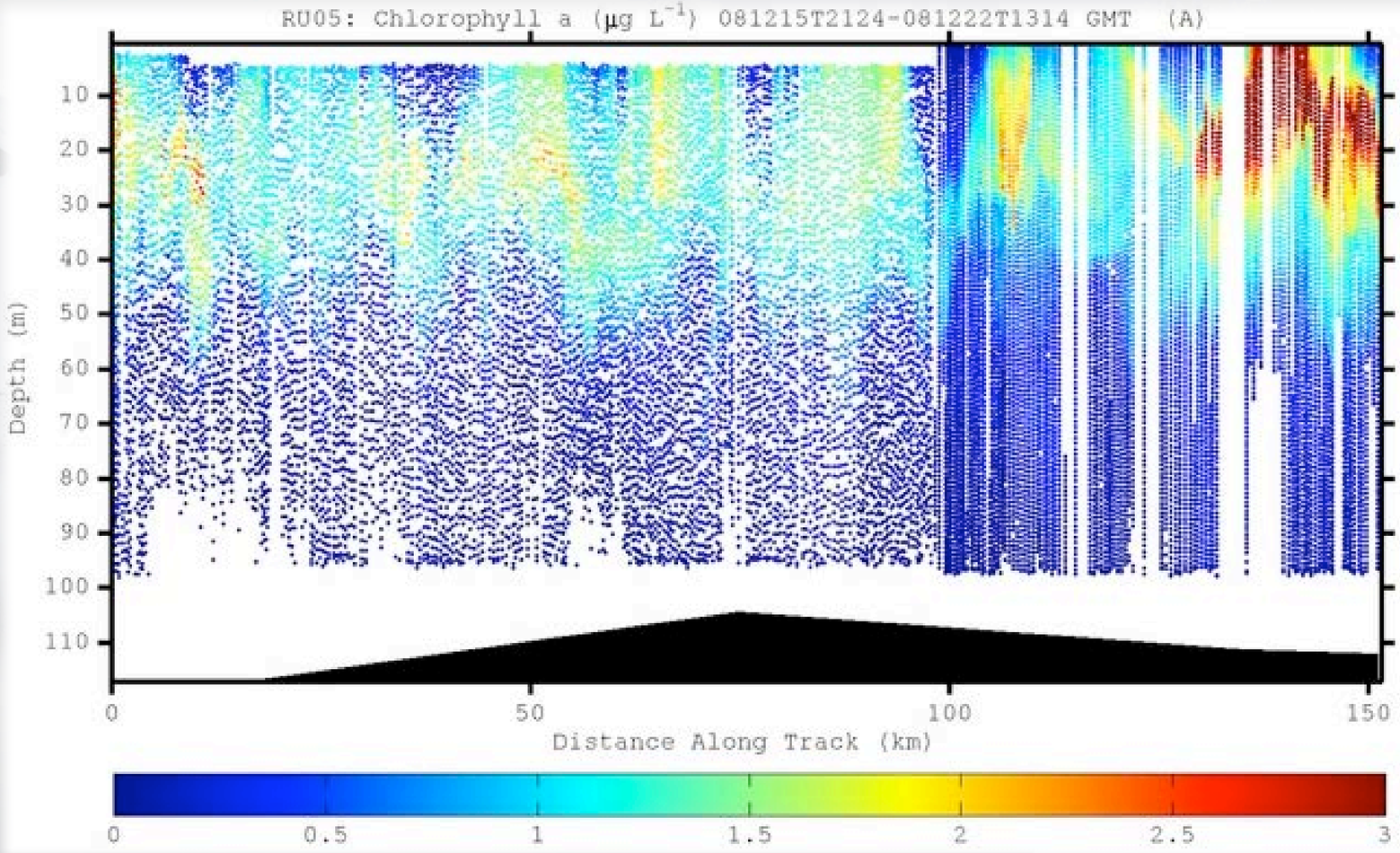


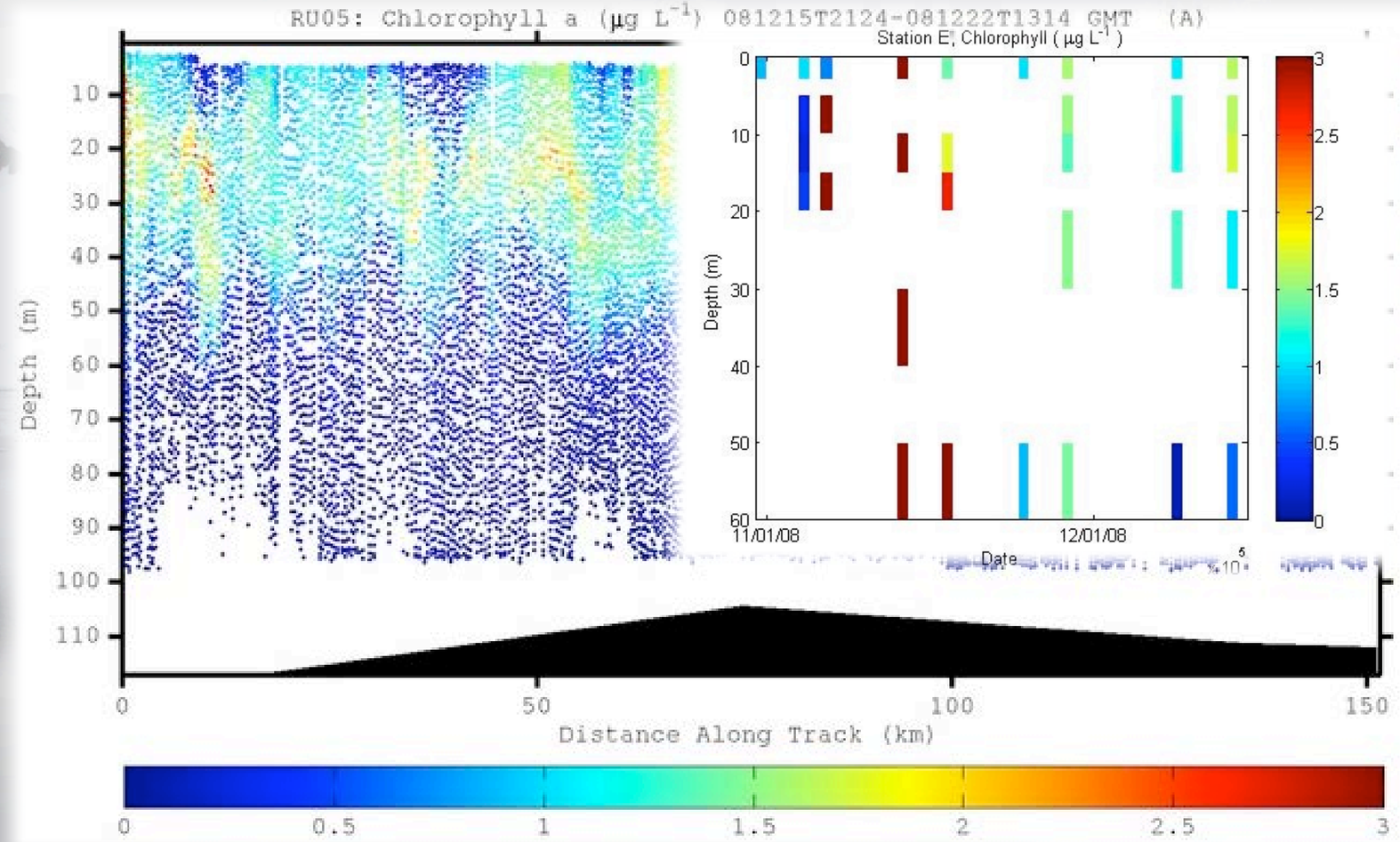

Station B, Chlorophyll (µg L-1)
Depth (m)
0
10
20
30
40
50
60
11/01/08
12/01/08
Date
x 10^5
3
2.5
2
1.5
1
0.5
0


Station E, Chlorophyll (µg L-1)
Depth (m)
0
10
20
30
40
50
60
11/01/08
12/01/08
Date
x 10^5
3
2.5
2
1.5
1
0.5
0


JOUBIN
ISLANDS
ASSAGE
BAY
McGuire I.
Dakers I.
Hartshorne I.
Howard I.
Ogellette I.
Halfway Island
PALMER STATION (US)
Hermit Island
62
Laggard Island
Cormorant Island
BISCOE BAY
Biscoe Point
ASPA No. 139
Access Point
OUTCAST ISLANDS
BISMARCK STRA
WAUWERMANS
Tangent I.
Miller I.
Chaucer Island
Reeve Island
84
Knight Island
Squire I.
Friar I.
Manciple Island
Host I.
Prioress I.
Pardoner I.
ISLANDS
200
1000
500
8.63 km
Image © 2009 DigitalGlobe
Image USGS, NSF, NASA, and BAS
© 2008 Europa Technologies
Image NASA
Google

Good bye my friend,
I hope you come back


RU05: Chlorophyll a (µg L^{-1}) 081215T2124-081222T1314 GMT (A)
Depth (m)
10
20
30
40
50
60
70
80
90
100
110
0
50
100
150
Distance Along Track (km)
0
0.5
1
1.5
2
2.5
3


RU05: Chlorophyll a (µg L^{-1}) 081215T2124-081222T1314 GMT (A)
Depth (m)
10
20
30
40
50
60
70
80
90
100
110
0
50
100
150
Distance Along Track (km)
0
0.5
1
1.5
2
2.5
3
Station E, Chlorophyll (µg L^{-1})
Depth (m)
11/01/08
12/01/08
Date
×10^{5}

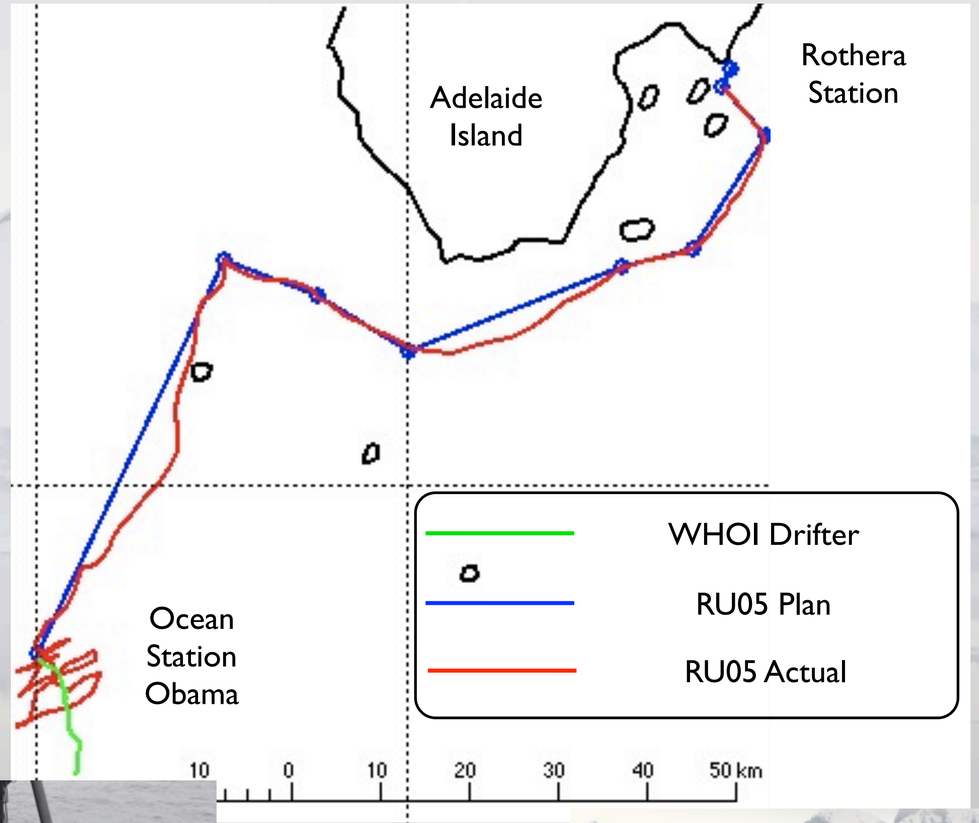
Old Day Communication

HAM Operator Coms Palmer Station 1988

Old Day Communication

HAM Operator Coms Palmer Station 1988

Brave New Day



RV Gould

Rothera Base

Real time comms

Rutgers COOLroom

So a protracted presence at sea?

Mission Complete: Scarlet Knight is the first underwater robot to cross an ocean basin

221	*Days*
7,409	*km*
11,000	*Dives*
11,000	*Climbs*

Energy equivalent of 8 minutes of power for lights on the Rockefeller Center Tree.

Tuckerton, New Jersey, USA

Baiona, Galicia, Spain