# HOT DAYS ALONG THE WEST ANTARCTIC PENINSULA

# LTER Palmer has maintained a 22 year time series along the West Antarctic Peninsula

## Current team

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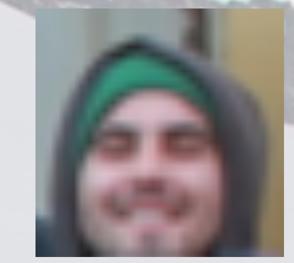
- Penguins & Fish



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- Ocean Modeling

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Doug Martinson (LDEO) - Ocean Physics
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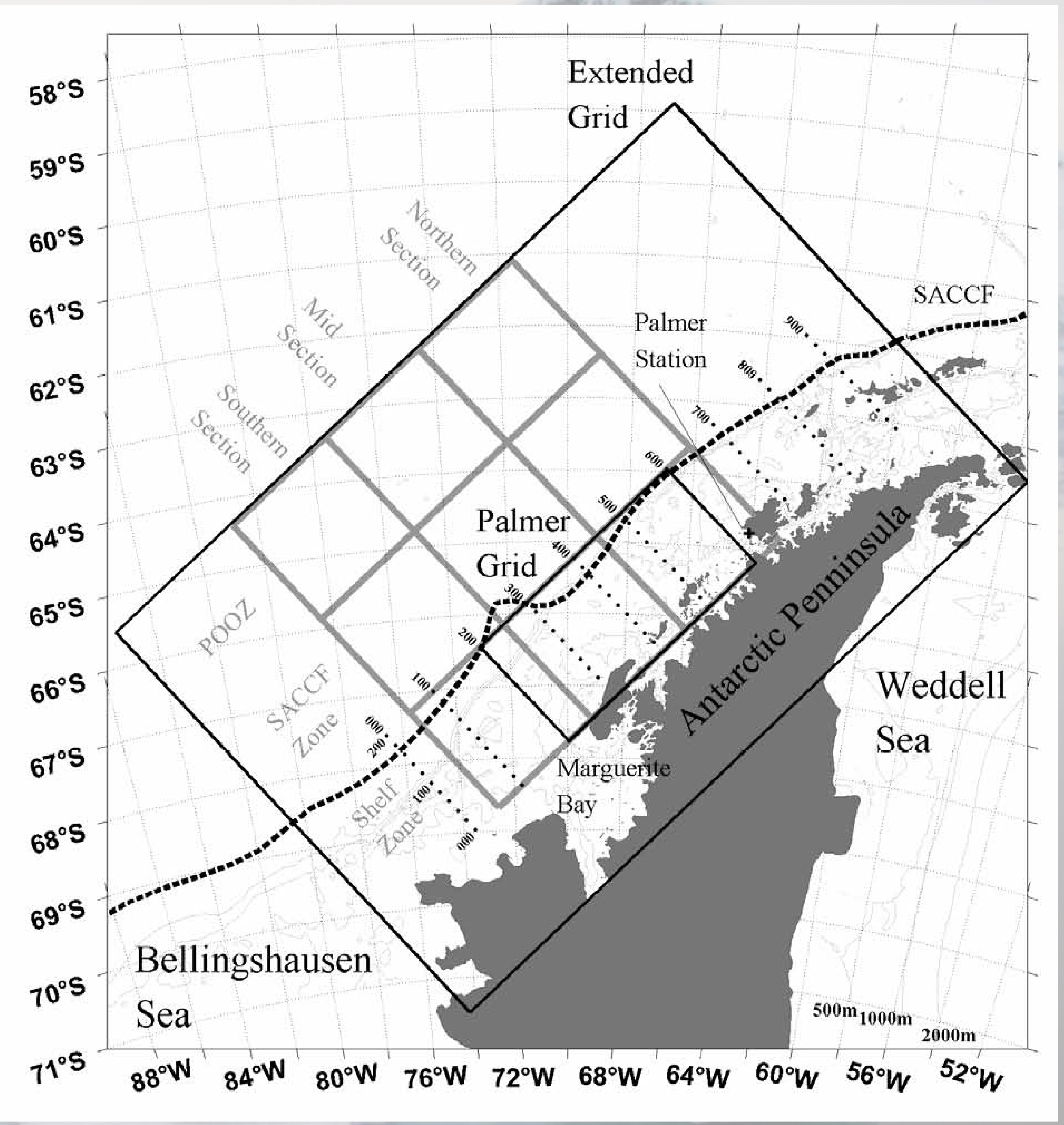
Marine Mammals

**Acknowledgements to past LTER PIs**: Ray Smith, Barbara Prezelin, Robin Ross, Langdon Quetin, Dave Karl, Maria Vernet, Eileen Hoffman, John Klinck, Dave Karl

## Our Current grid




**Acknowledgements to past LTER PIs**: Ray Smith, Barbara Prezelin, Robin Ross, Langdon Quetin, Dave Karl, Maria Vernet, Eileen Hoffman, John Klinck, Dave Karl

The man!

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# Increases in Antarctic penguin populations: reduced competition with whales or a loss of sea ice due to environmental warming?

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**Summary.** A central tenet of Antarctic ecology suggests that increases in Chinstrap Penguin (*Pygoscelis antarctica*) populations during the last four decades resulted from an increase in prey availability brought on by the decrease in baleen whale stocks. We question this tenet and present evidence to support the hypothesis that these increases are due to a gradual decrease in the frequency of cold years with extensive winter sea ice cover resulting from environmental warming. Supporting data were derived from one of the first, major multidisciplinary winter expedition to the Scotia and Weddell seas; recent satellite images of ocean ice cover; and the analysis of long-term surface temperature records and penguin demography. Our observations indicate there is a need to pay close attention to environmental data in the management of Southern Ocean resources given the complexity of relating biological changes to ecological perturbations.

## Introduction

Populations of many krill-eating, Southern Ocean predators have exhibited significant changes during the last four decades. Notable among these, have been increases in the abundance of Chinstrap Penguins (*Pygoscelis antarctica*), which breed mainly on the Antarctic Peninsula and islands of the Scotia Sea (Watson 1975). At many colonies, numbers have increased 6–10% per annum (Laws 1985), and at some localities fivefold increases have occurred in the last 20 years (Rootes 1988). Chinstraps have also expanded their range southward along the western side of the Antarctic Peninsula (Parmelee and Parmelee 1987; Poncet and Poncet 1987) into areas historically dominated by the closely related adelie Penguin (*P. adeliae*; Fig. 1). A central tenet of Antarctic ecology explains these population changes in terms of a presumed increase in food availability that resulted from the decrease in baleen whale stocks due to commercial whaling (Sladen 1964; Emison 1968; Conroy 1975; Croxall and Kirkwood 1979; Croxall and Prince 1979; Croxall et al. 1984). This tenet is based on the fact that the dominant component in the summer diets of both Chinstraps and whales is the Antarctic krill (*Euphausia superba*). Although this tenet has been widely accepted, the possible mechanism by which a decrease in whales could have led to an increase in Chinstraps has not been questioned (cf. Horwood 1980). Indeed, the long-standing view has simply been that whaling led to a "krill surplus" that was used by krill-eating predators when competitive release altered the existing patterns of consumption (Laws 1985).

Although this whale reduction hypothesis has clearly been useful in guiding research on trophic interactions in the Southern Oceans, it is now apparent that increases in Chinstrap populations have not been mirrored by their sympatric, most closely related congener, the Adelie Penguin. Adelies share a significant portion of their range on the Antarctic peninsula and islands of the Scotia Arc with Chinstraps (Watson 1975). Alike in size and general appearance, both exhibit broad ecological similarities, not the least of which is a predominance of krill in their summer diets (Volkman et al. 1980; Trivelpiece et al. 1987, 1990; Trivelpiece and Trivelpiece 1990). Yet, when compared to Chinstraps, population increases in Adelies have not been as substantial, and at many sites appear to represent nothing more than recovery after human disturbance and exploitation (Poncet and Poncet 1987). Adelies, in fact, have declined noticeably at several localities on the Antarctic Peninsula, a change considered "unexplainable" by Poncet and Poncet (1987). This raises an interesting challenge to the whale reduction hypothesis: If the decrease of baleen whale stocks actually led to a krill surplus, why have populations of the ecologically similar Adelies residing in the same geographical areas shown such different responses?

Here we propose that the answer to this question does not rest with the idea of a krill surplus. Instead, we suggest

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**Key point: If the decimation of baleen whale populations did in fact lead to a "krill surplus", why were krill-dependent , top predator populations exhibiting such dichotomous trends?**

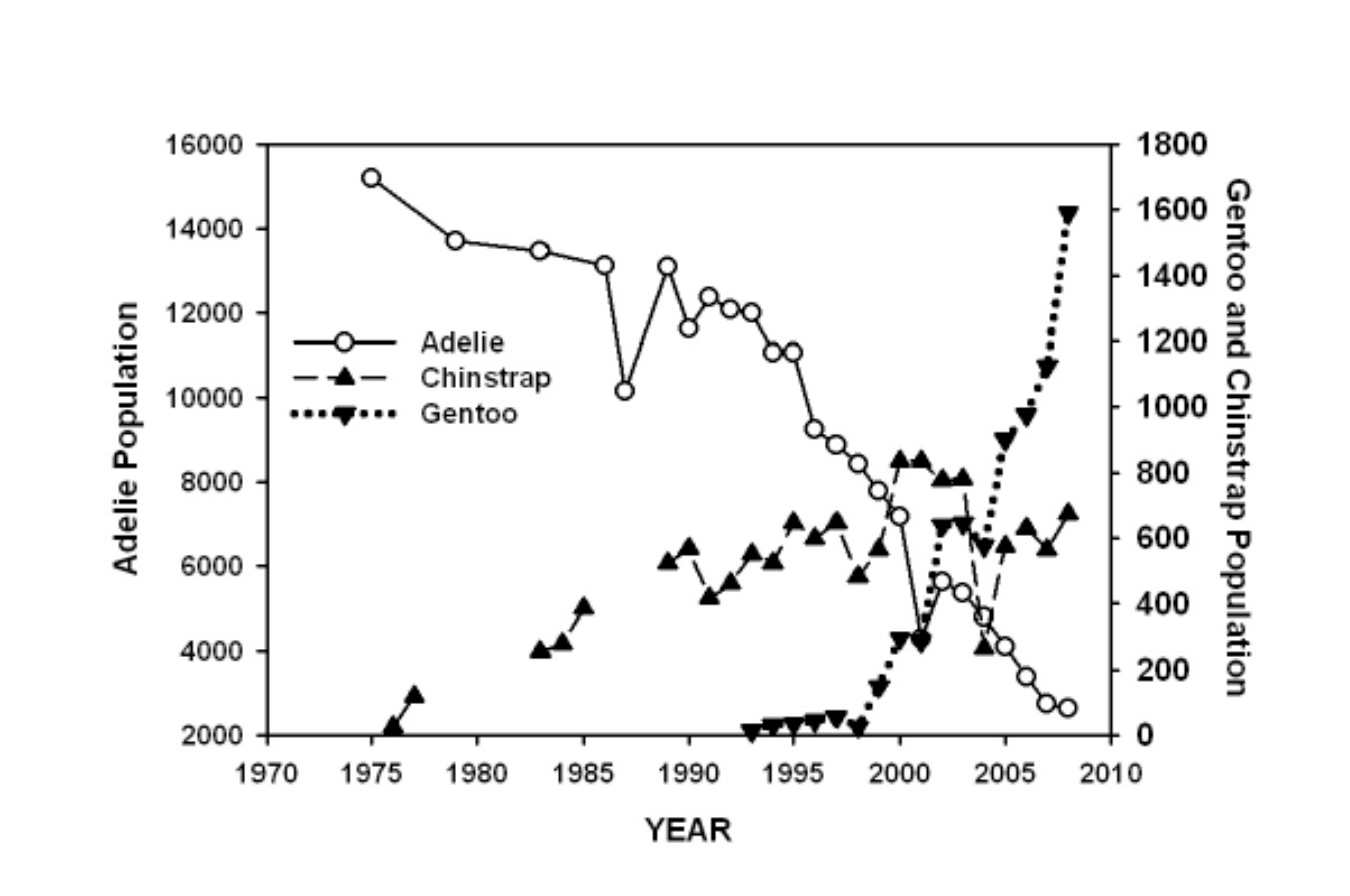
**"...the day bird people have something to tell us about climate warming is perhaps the day logic in climate science is abandoned..."**

**Anonymous Reviewer, Nature**

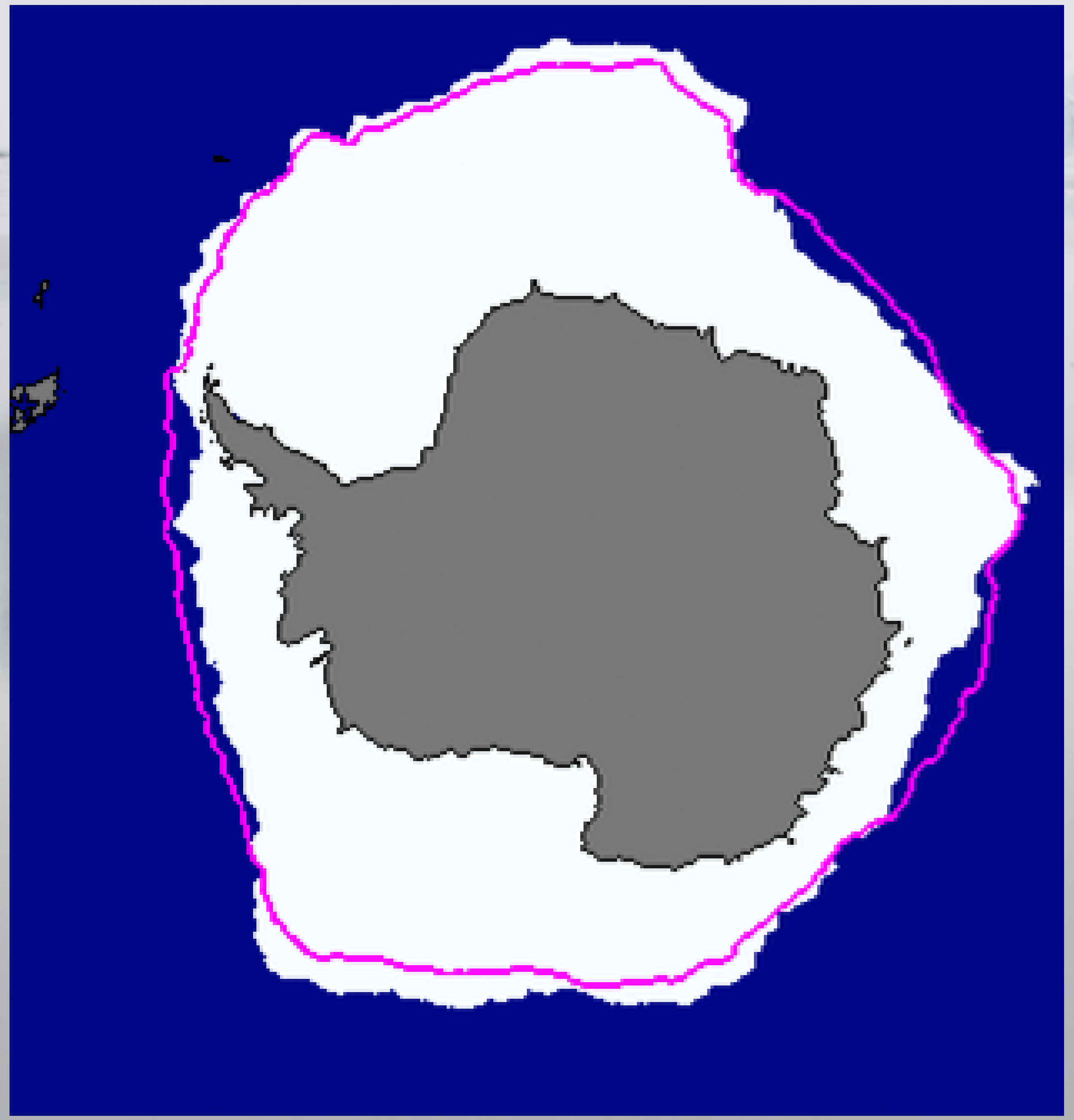
**"...a paper that creates this kind of controversy should be positive for science and the journal..."**

**G. Hempel, Editor, Pol. Biol.**

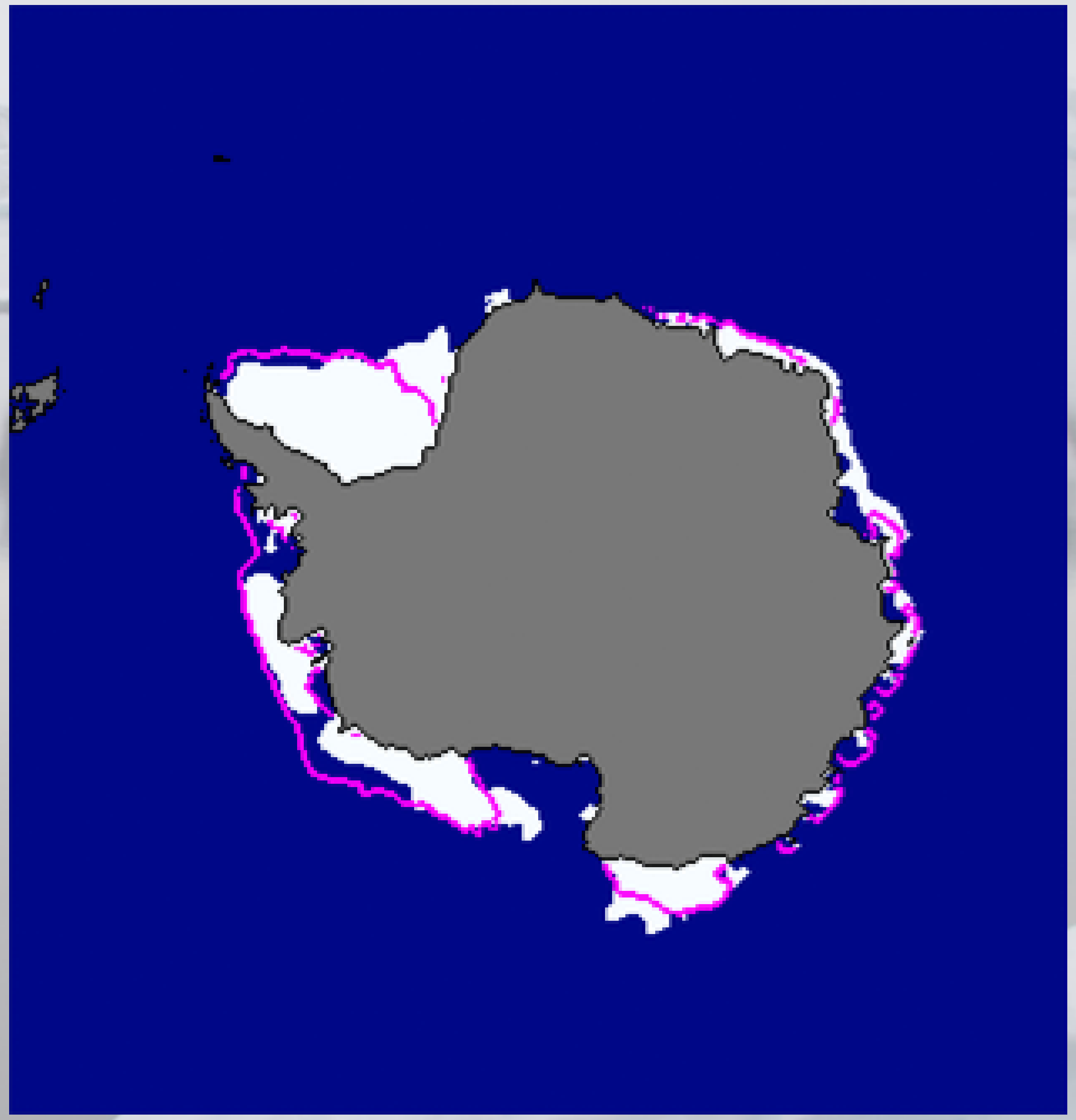
# The trends that reflecting a changing system



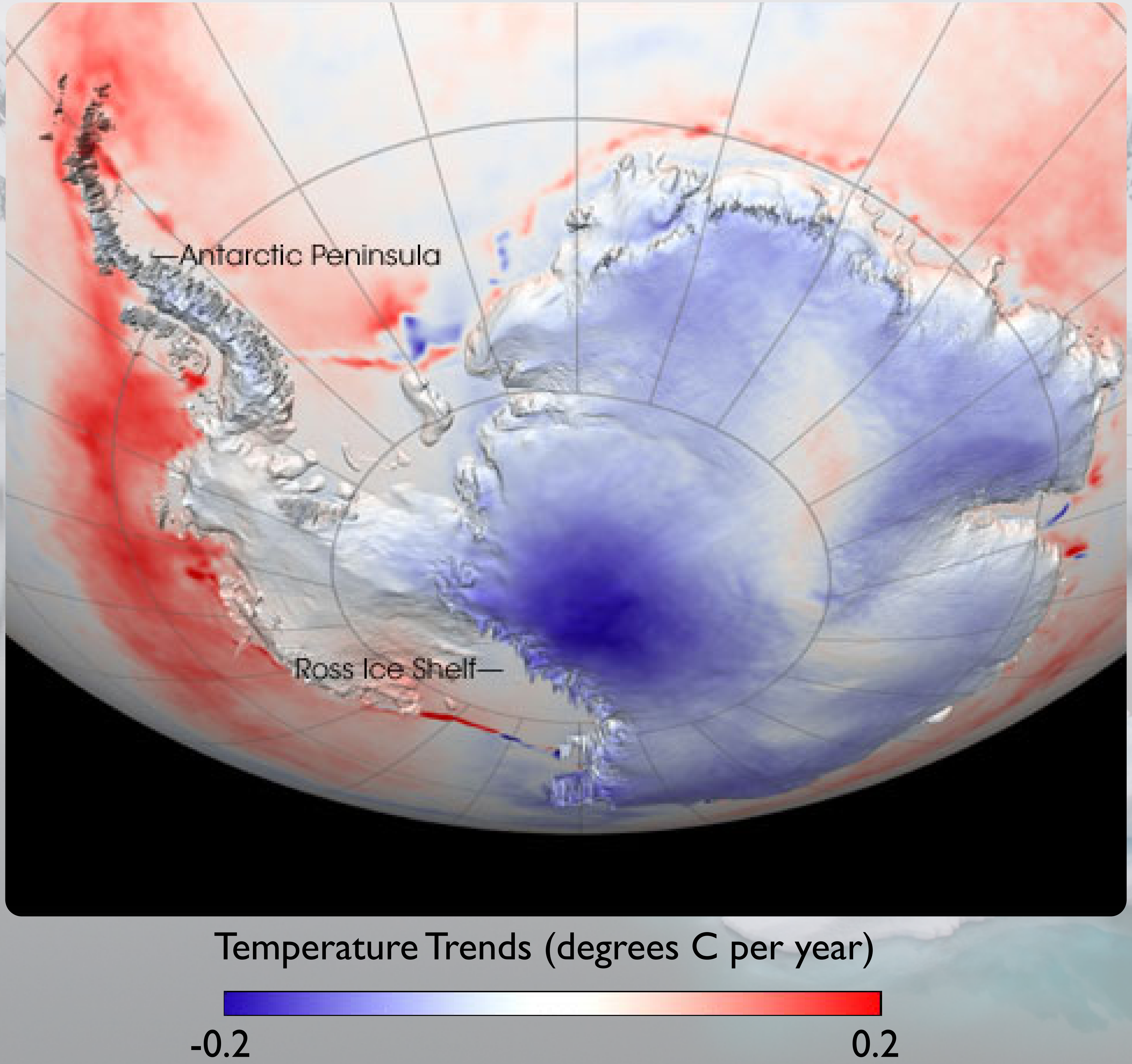

The central hypothesis when the LTER began was that sea ice timing and magnitude structure the productivity and composition of the Antarctic ecosystem. The ice dynamics are driven by large-scale interactions of the atmosphere and ocean.



Winter 2007

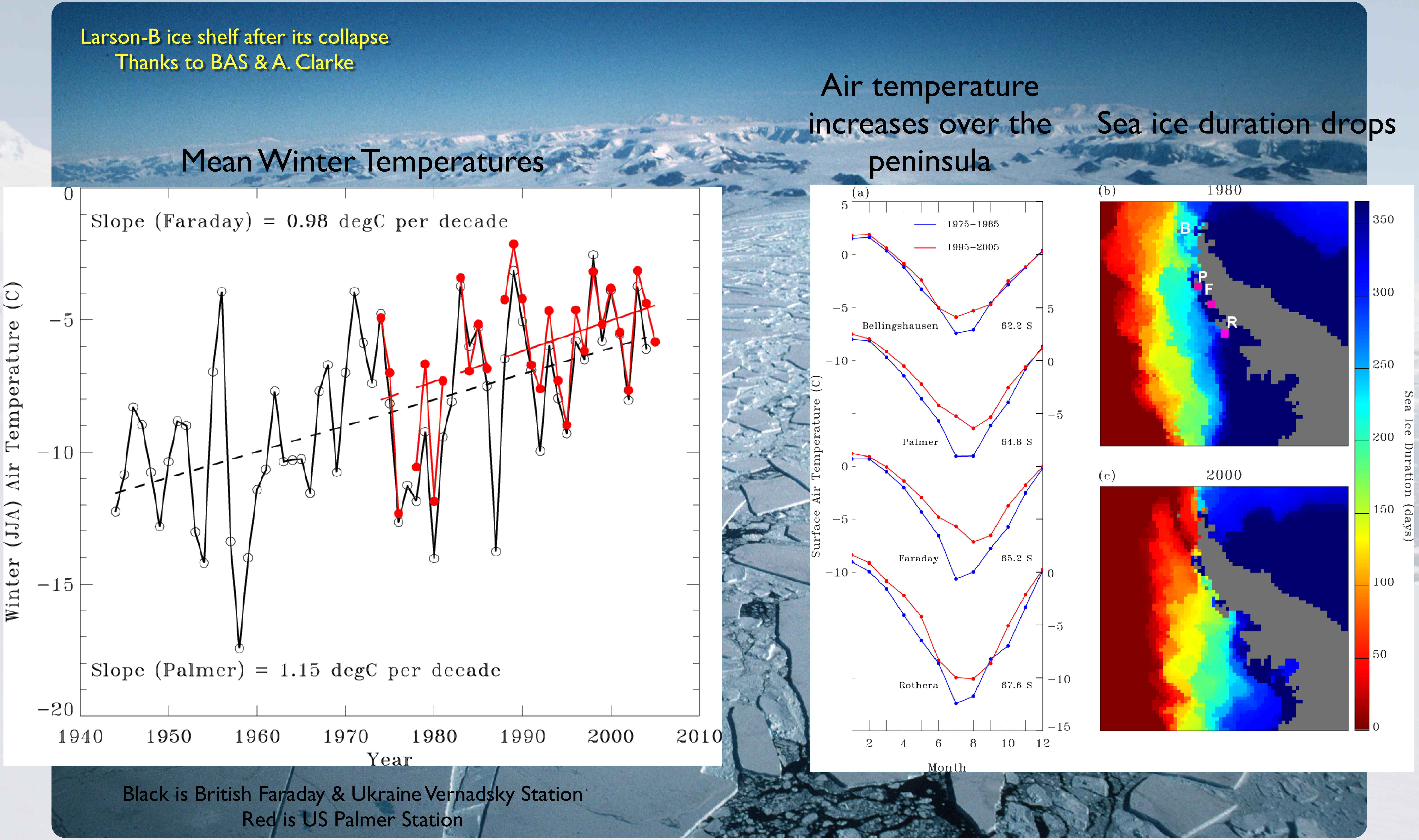


Summer 2007

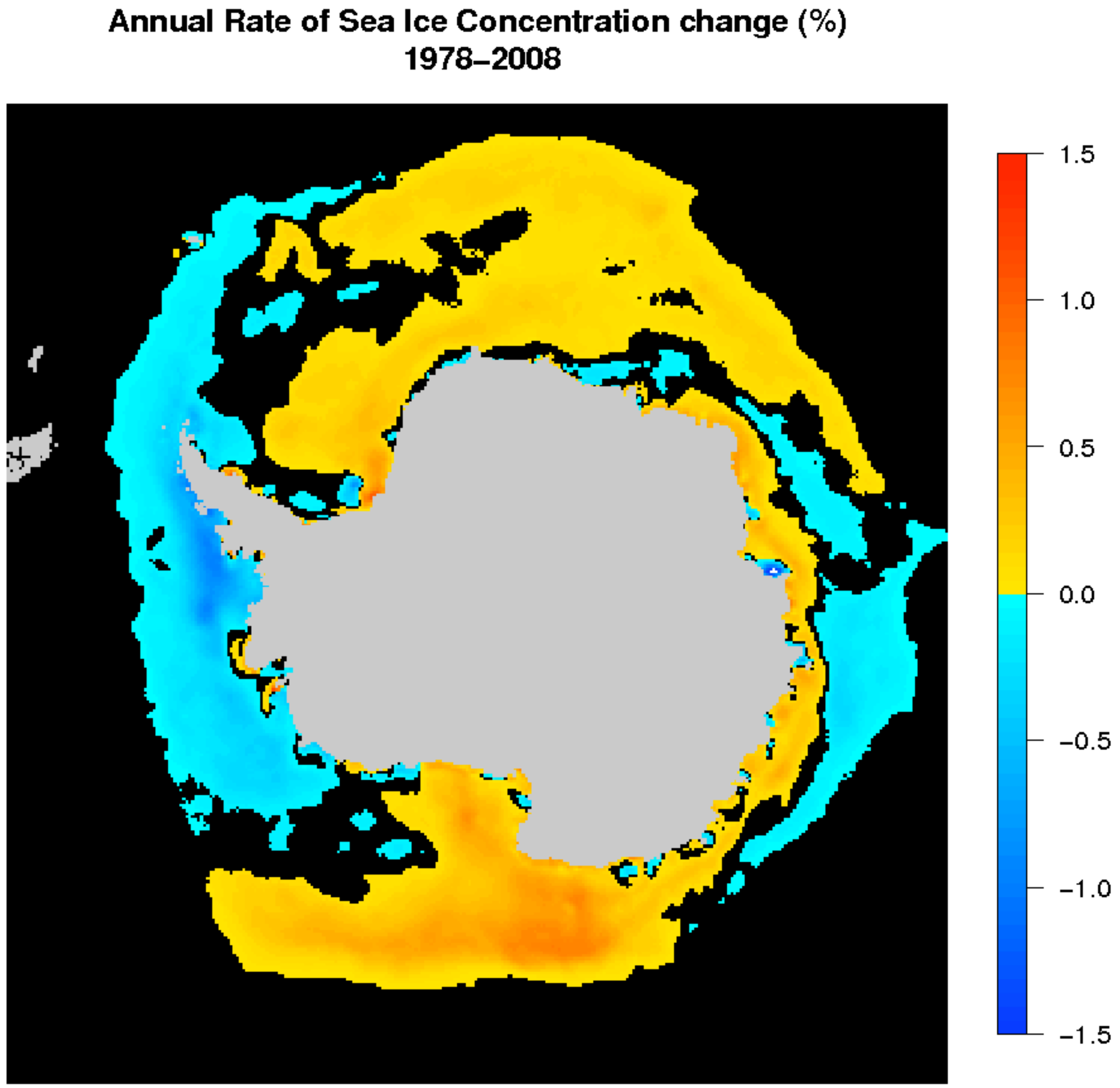


Antarctic Peninsula
Ross Ice Shelf
Temperature Trends (degrees C per year)
-0.2
0.2

# The WAP peninsula is experiencing the largest winter warming on Earth



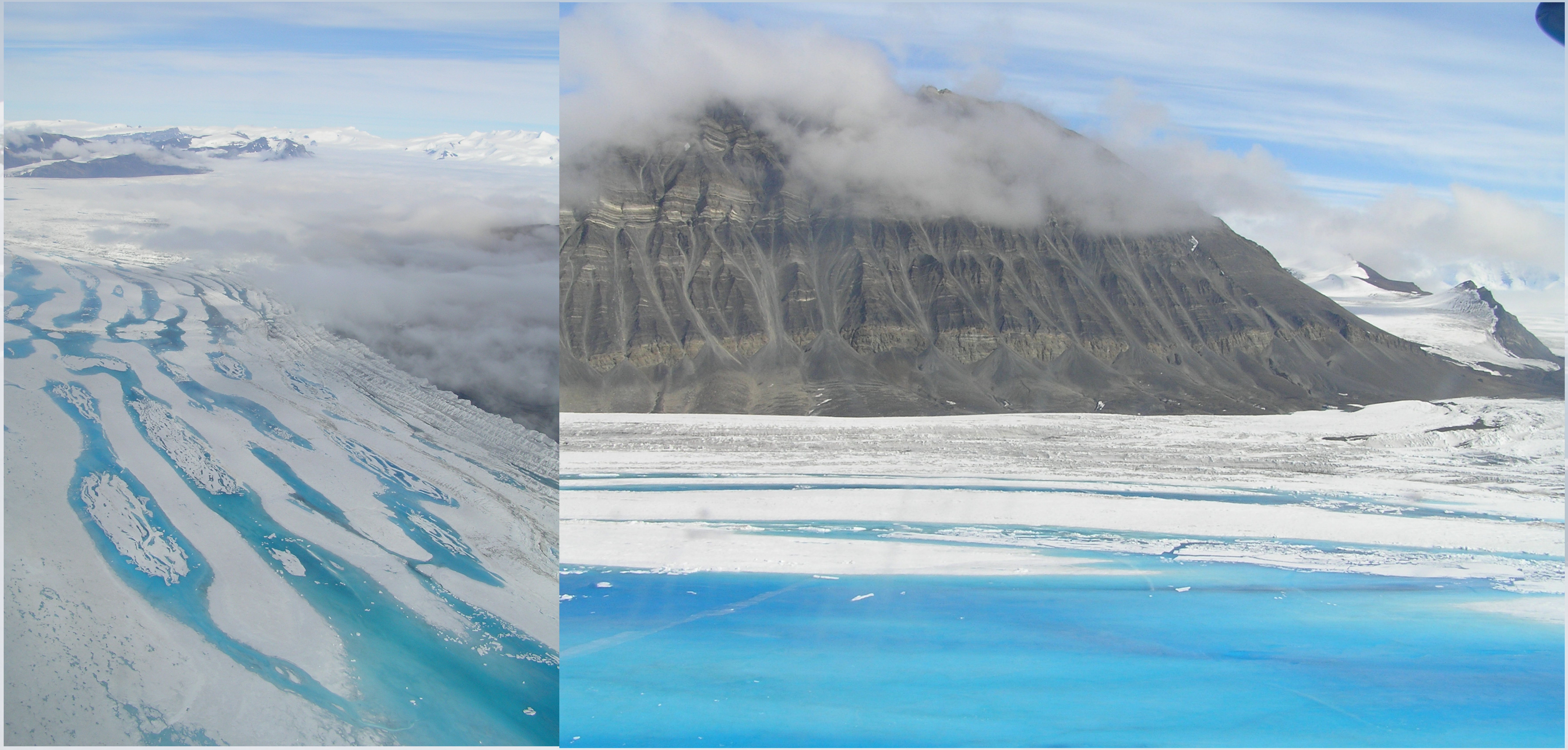
# 10 year analysis annual trends




ice decline

# Melt pools on surface of King George VI Sound

(from a BAS twin otter, January 2004)



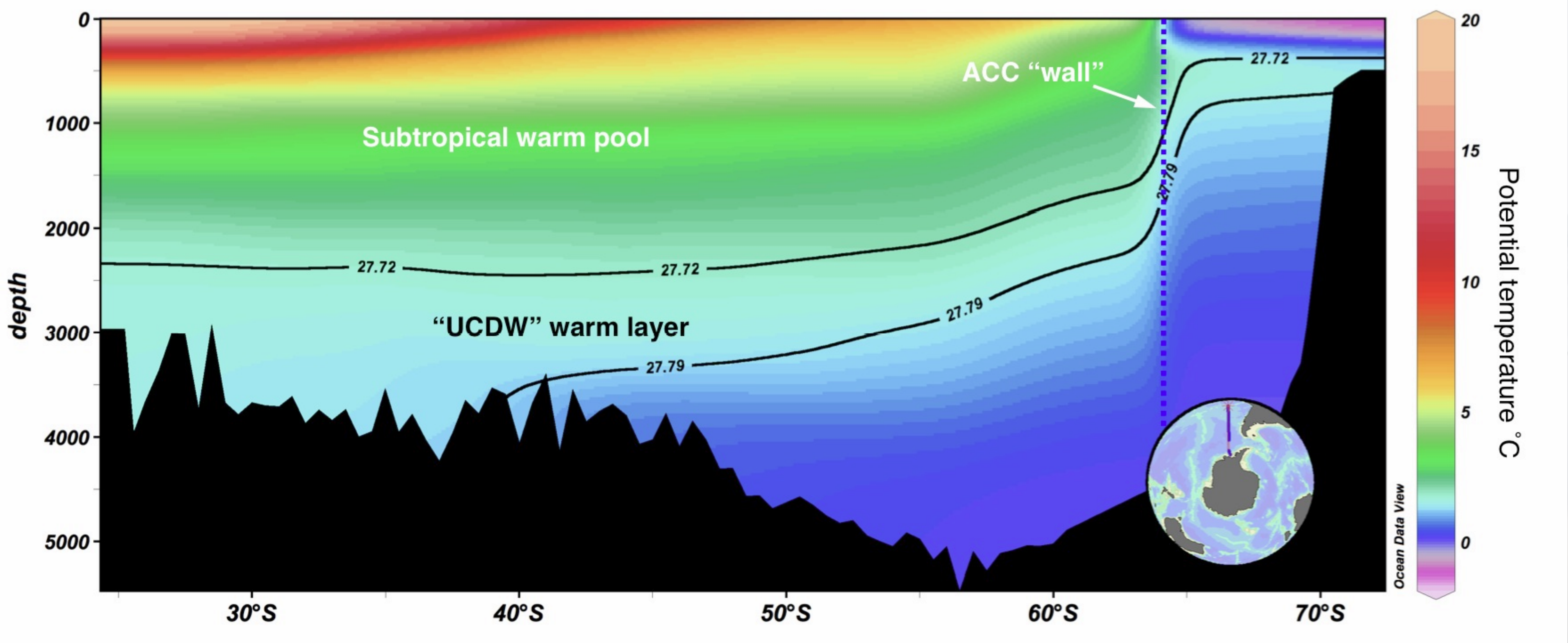
Palmer Station in the present

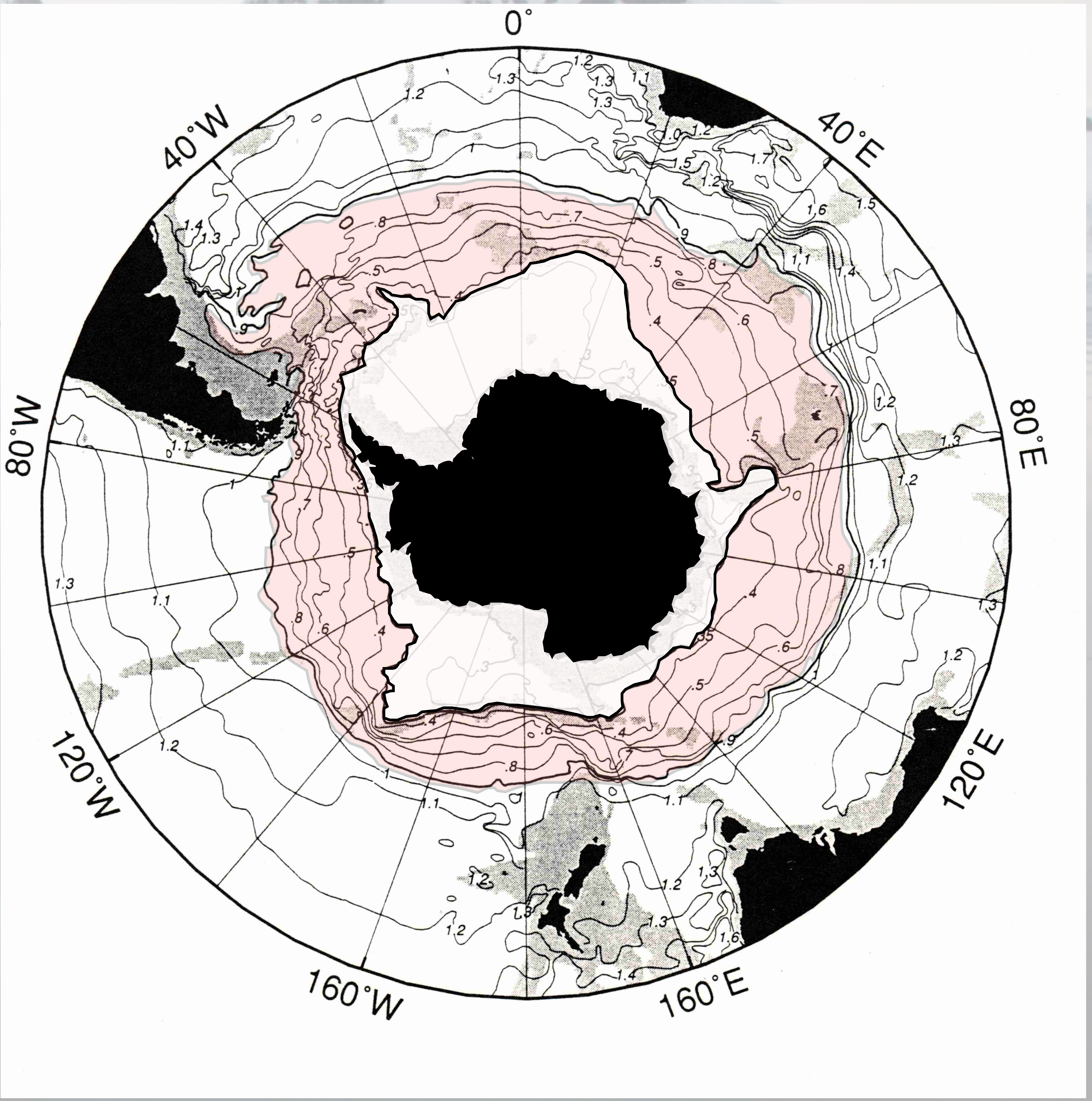
photo by Bill Fraser

# Plants at Palmer Station, the greening of Antarctica

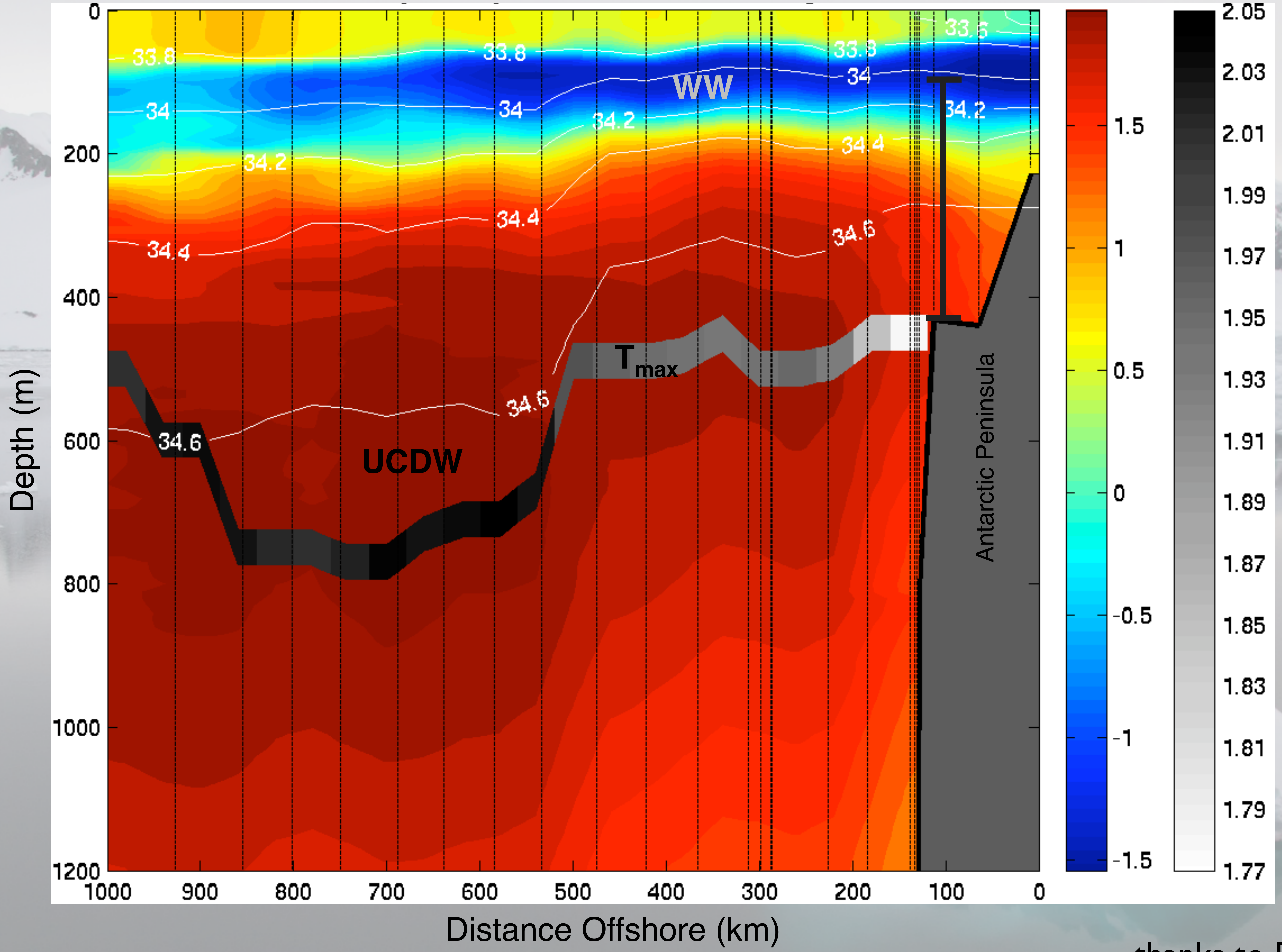

Let’s go the sea: What is driving the change?

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.

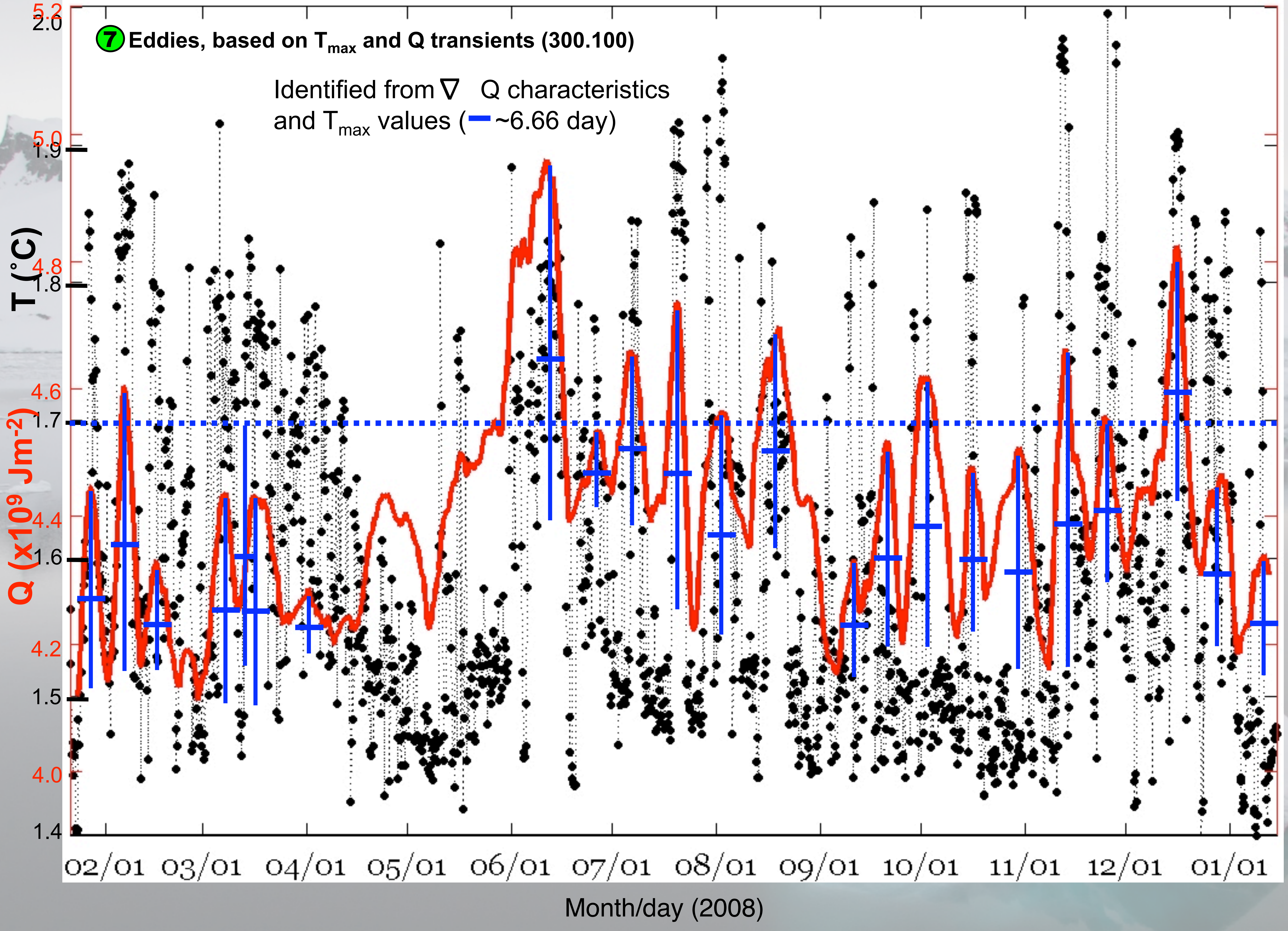



**Antarctic Peninsula to the Amundsen Sea: one of the few regions in Antarctica where the Antarctic Circumpolar Current (ACC) *directly* impinges on the shelf break. Upper Circumpolar Deep Water (UCDW) is Antarctica's warmest water.**

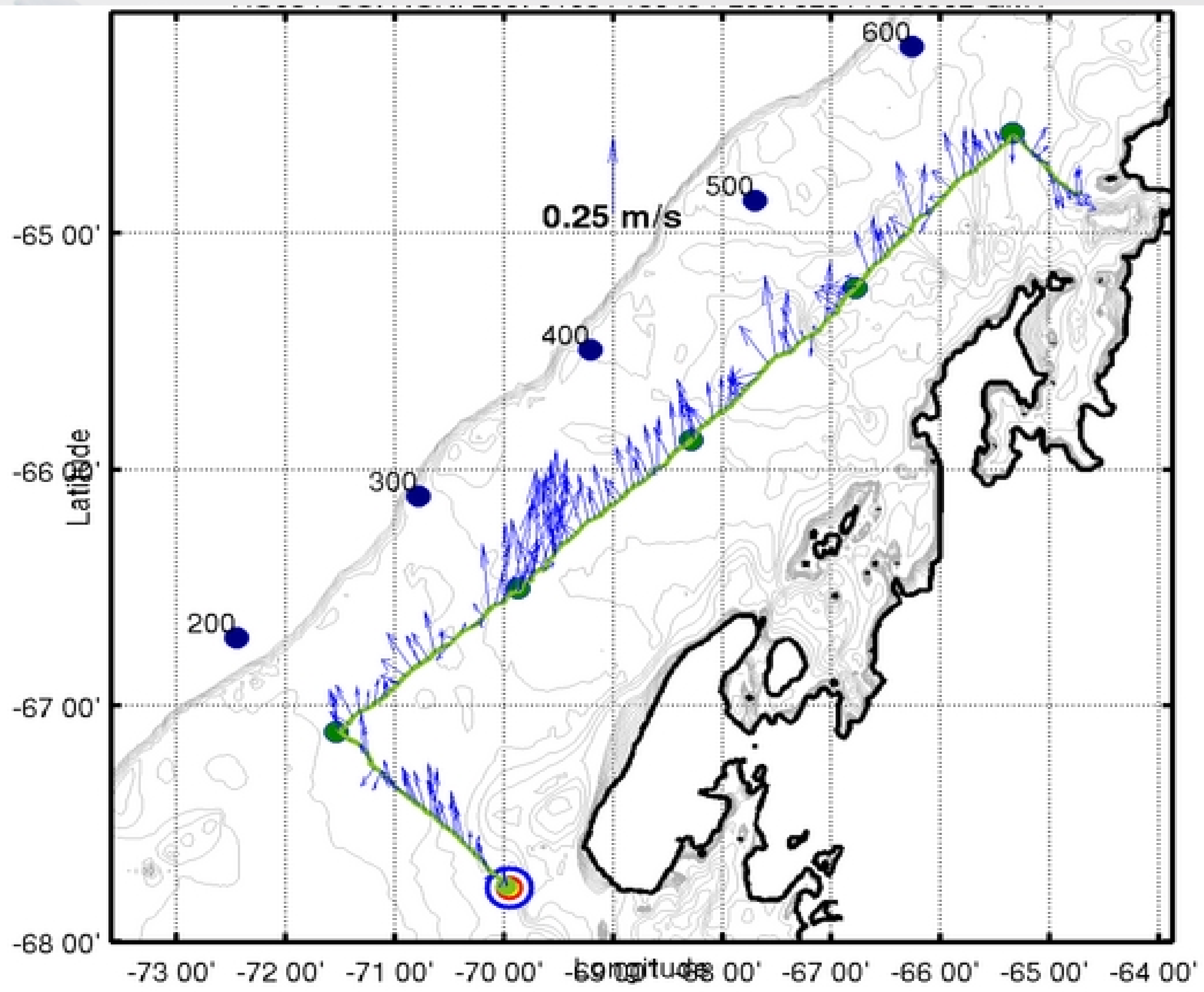


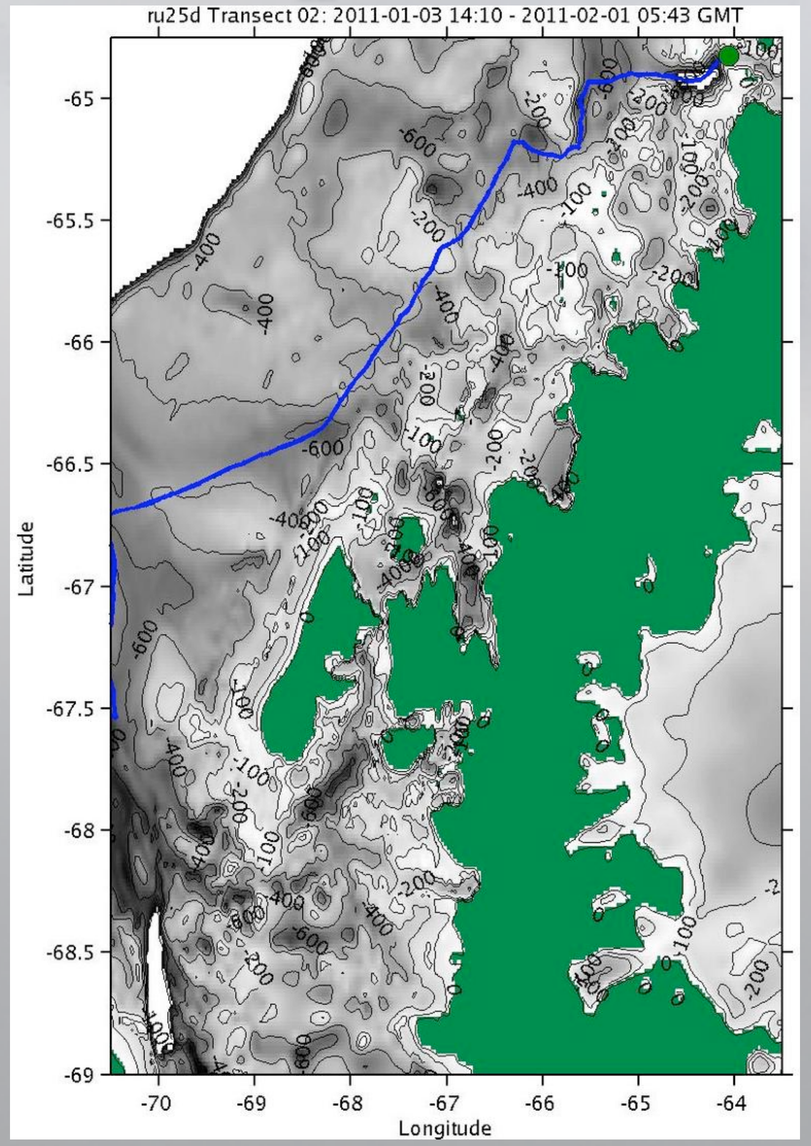

thanks to Doug Martinson

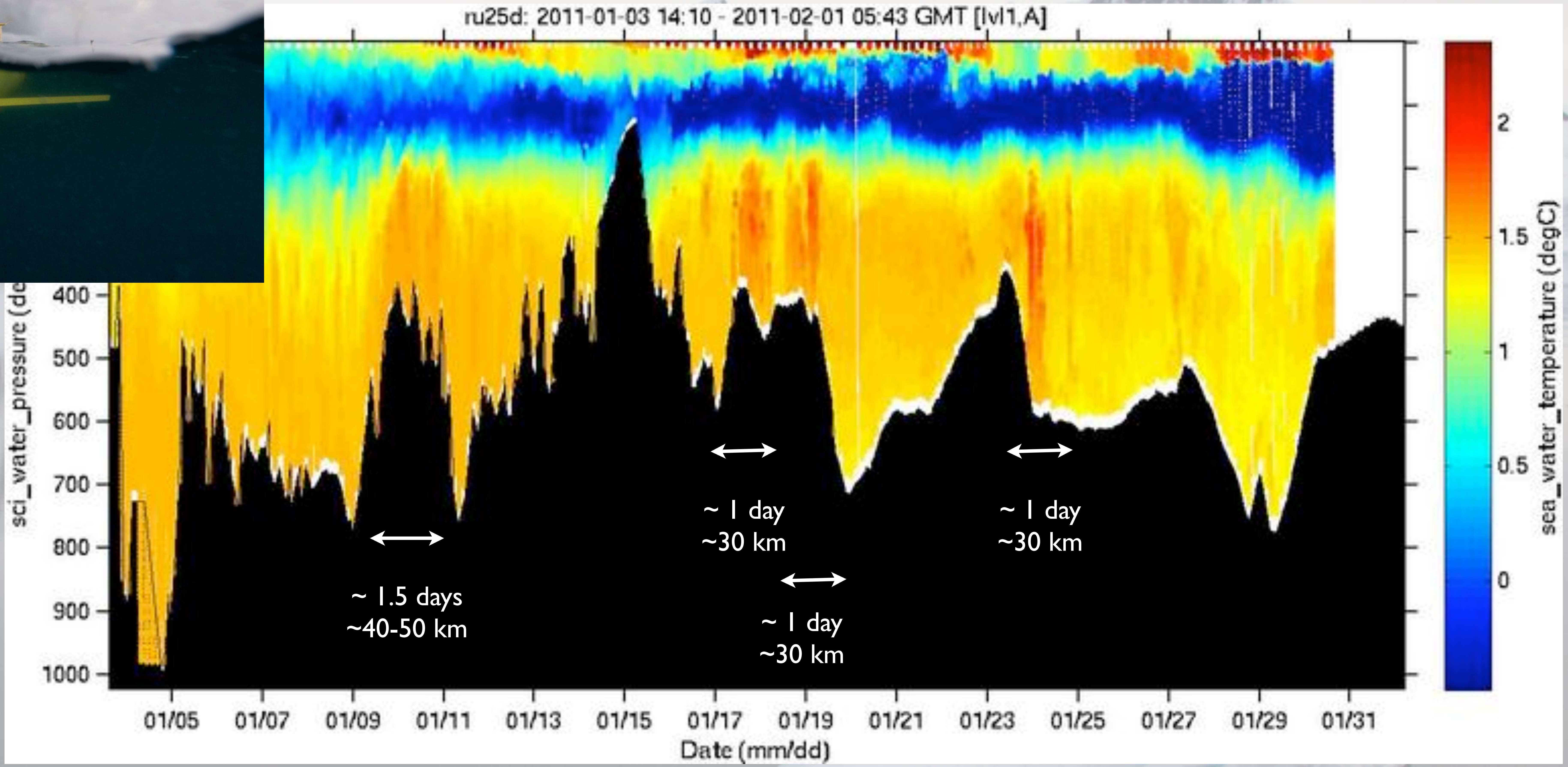



thanks to Doug Martinson

# Upwelling favorable winds result in Ekman mass transport offshore

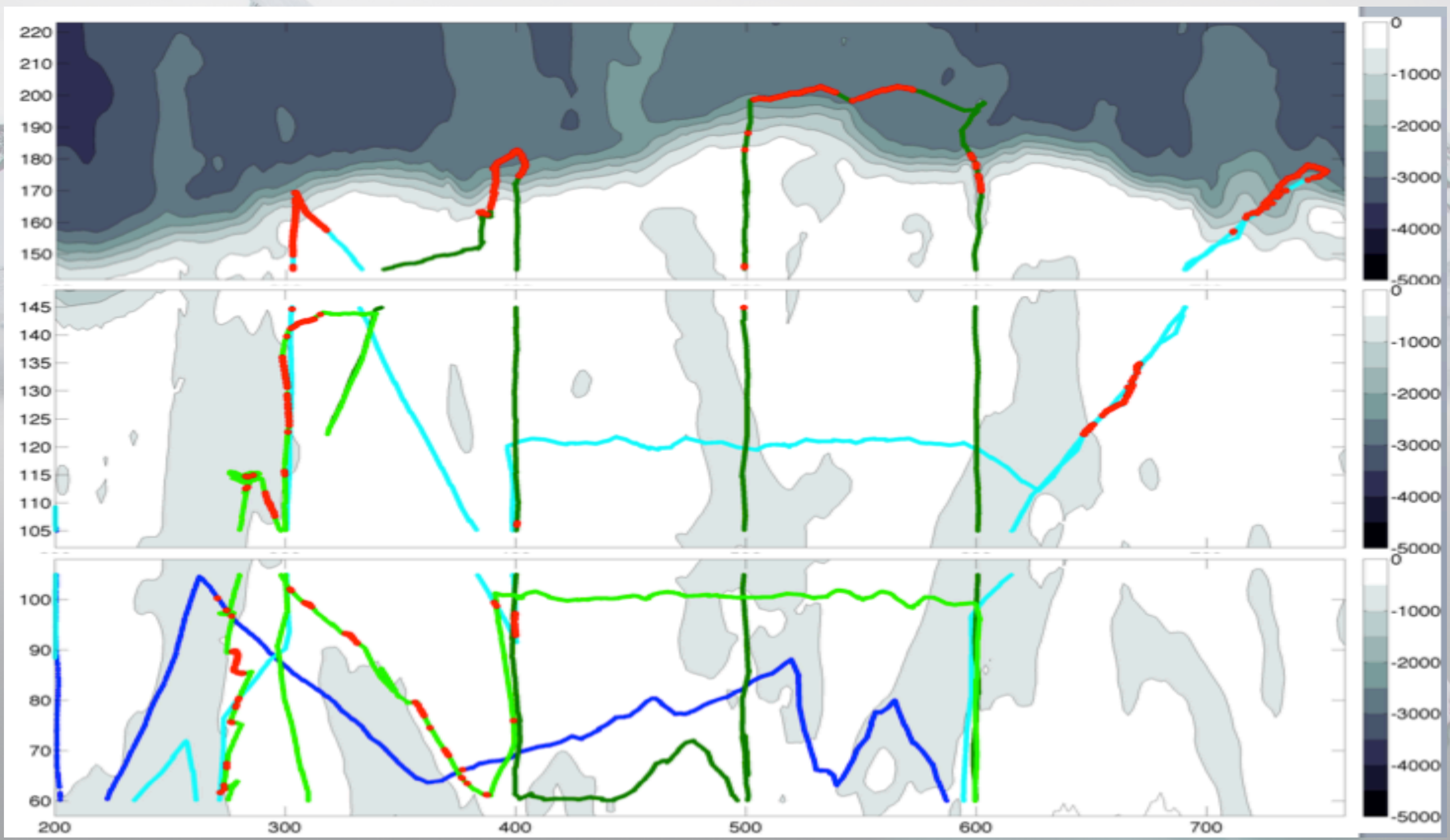


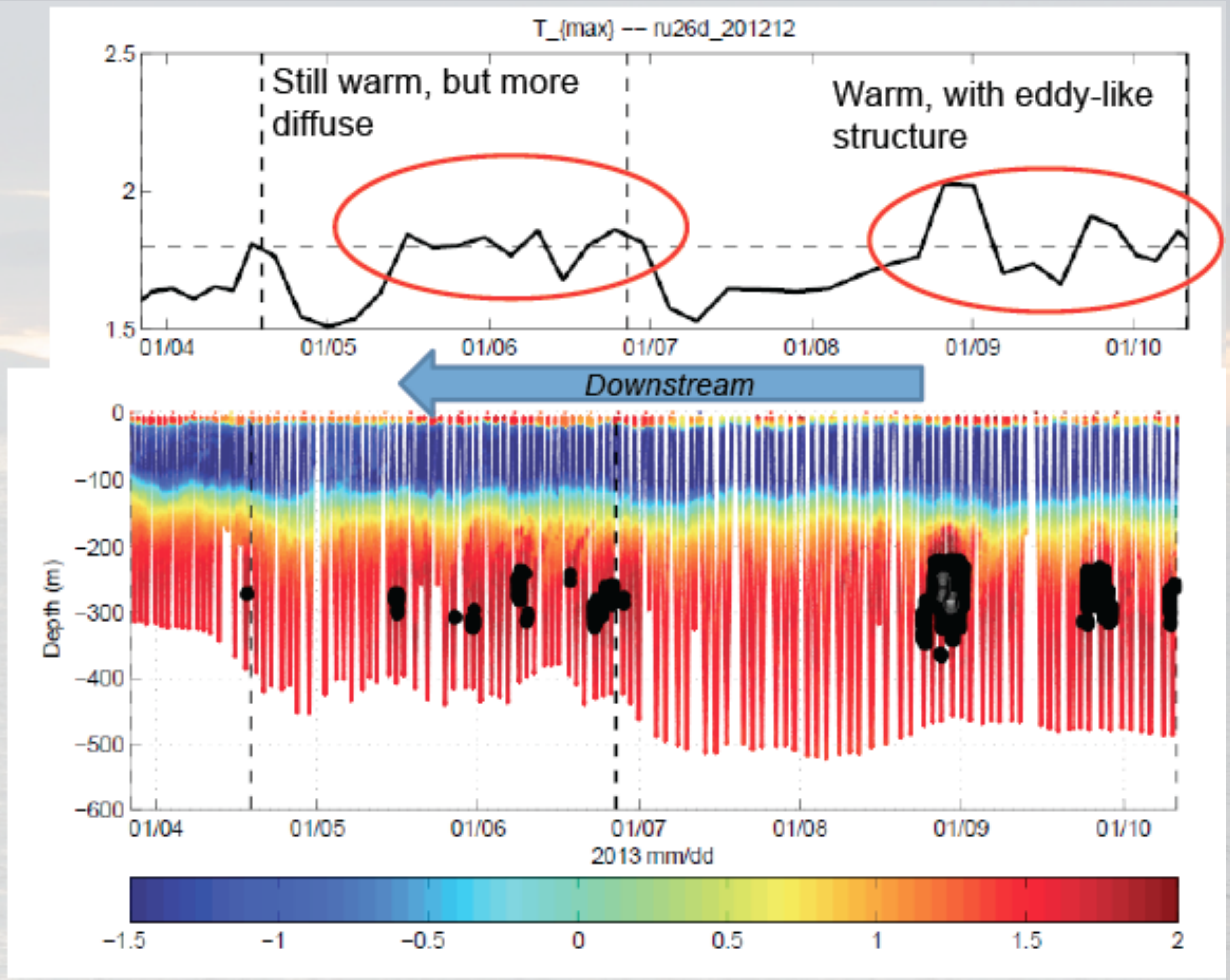




# 2011: Eddies moving across shelf

# Subsurface eddies spatially associated with northern side of the sea floor canyons across the Peninsula

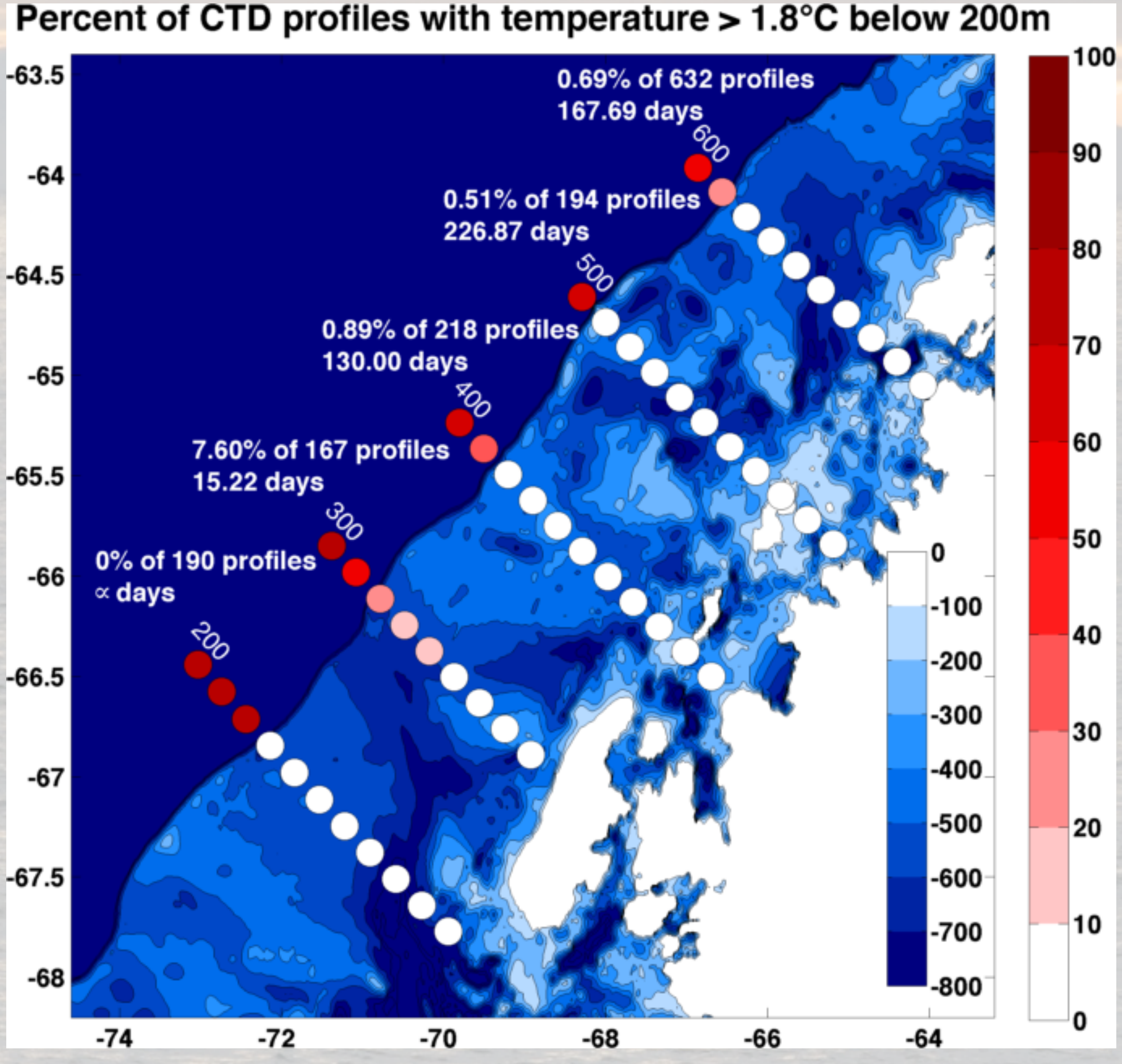



thanks to Nicole Cuorto

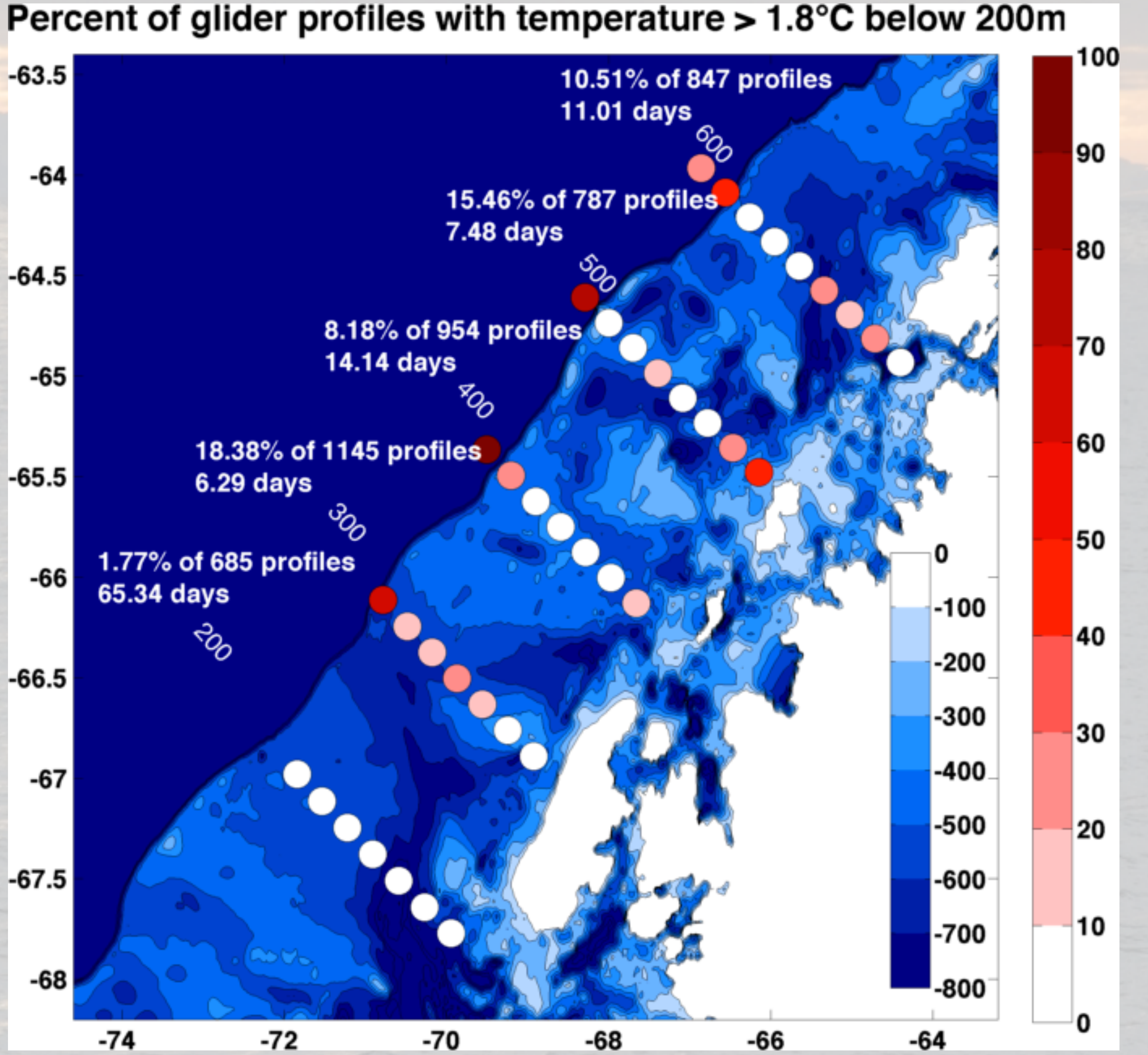

T_{max} -- ru26d_201212
Still warm, but more diffuse
Warm, with eddy-like structure
Downstream
Depth (m)
2013 mm/dd
01/04
01/05
01/06
01/07
01/08
01/09
01/10

## *Ships not effective at sampling the subsurface eddy transport of modified ACC water*

### 22 Years of cruises (924 days at sea)

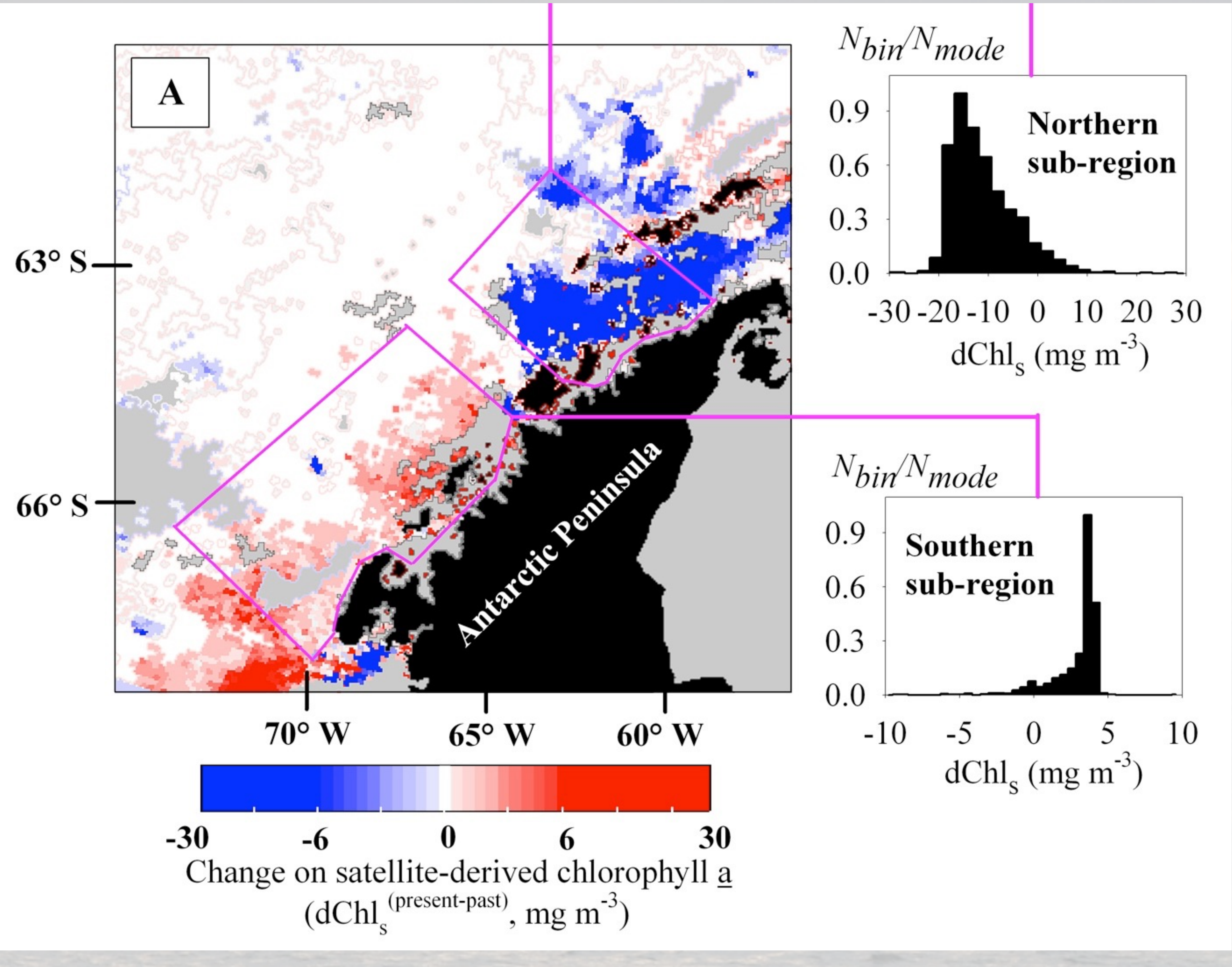



### 4 Glider missions (85 days at sea)

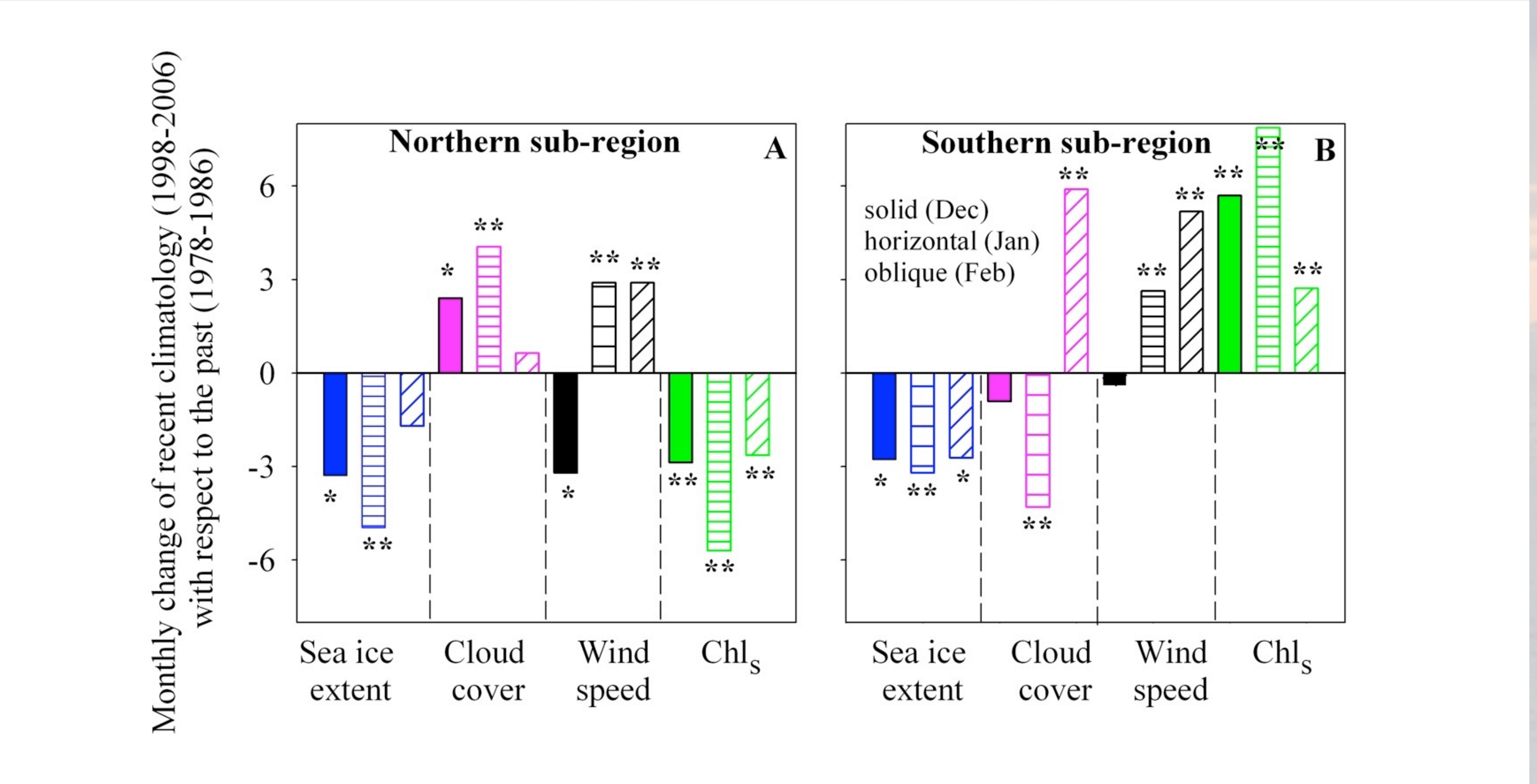



Is there a response in the marine food web?

# The decadal changes have resulted changes in the phytoplankton

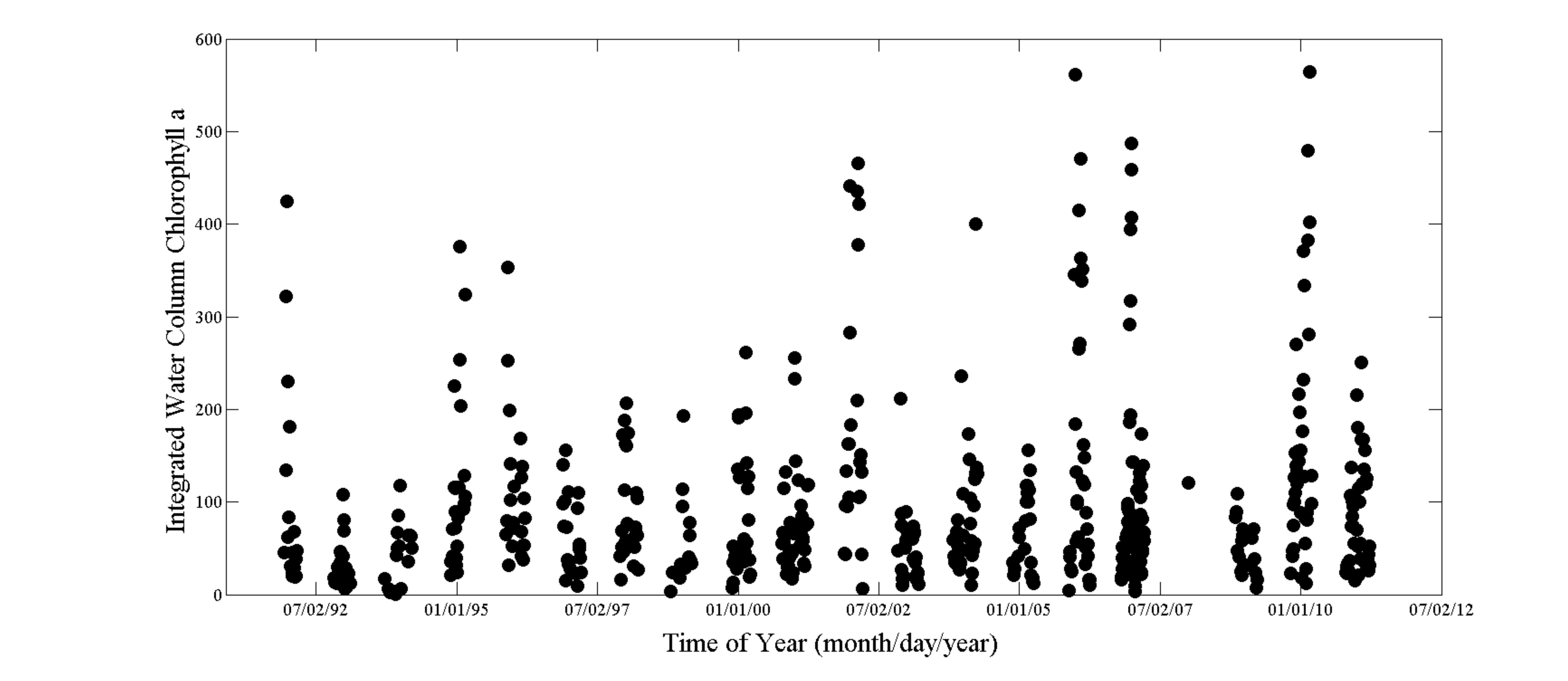



Montes Hugo et al. Science 2009

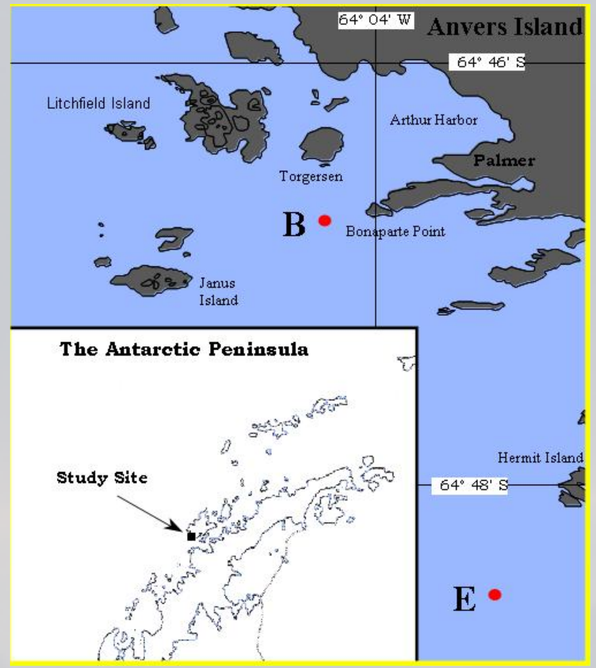


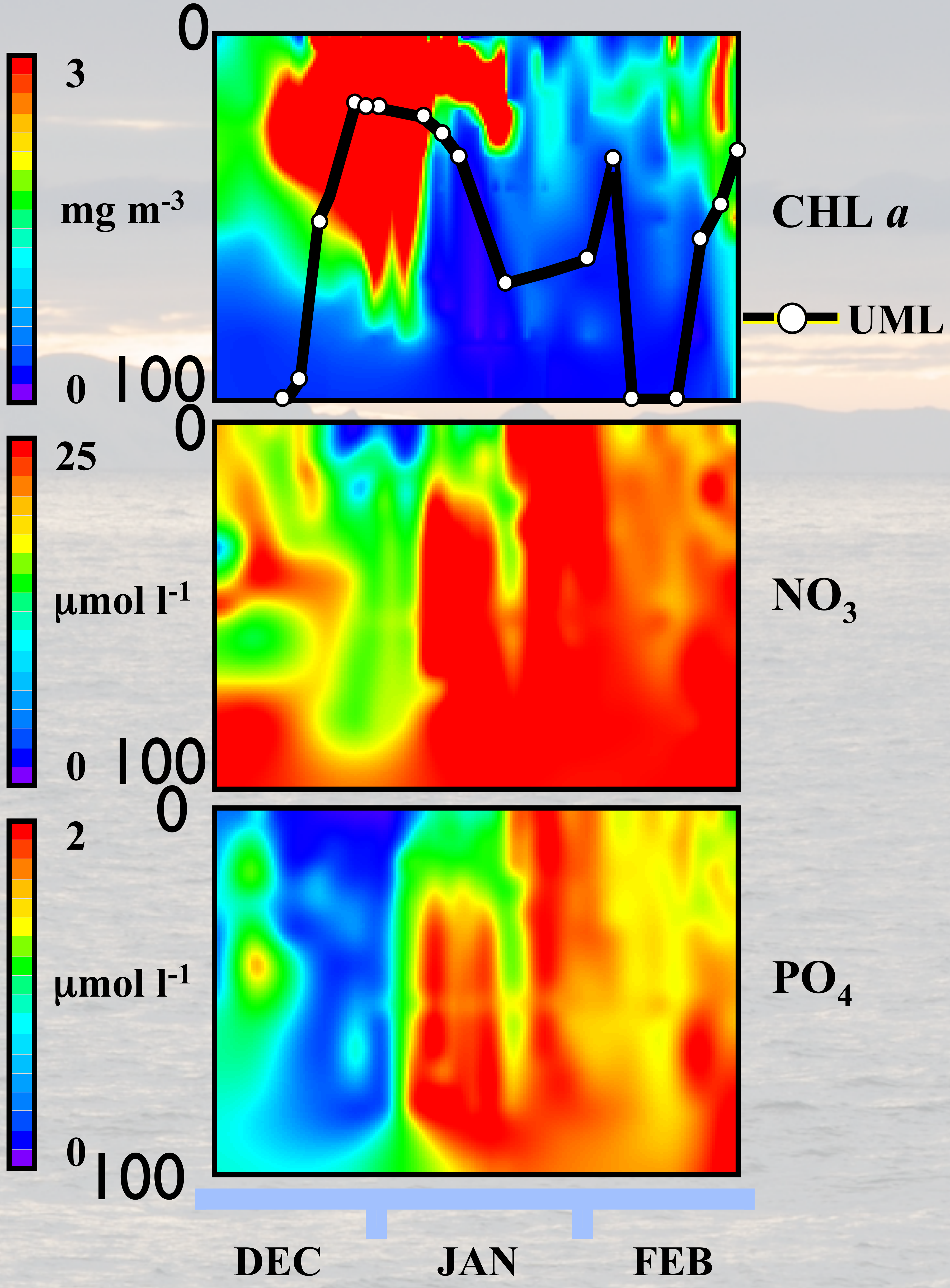

The changes driven by a decline in sea ice, wind and sun

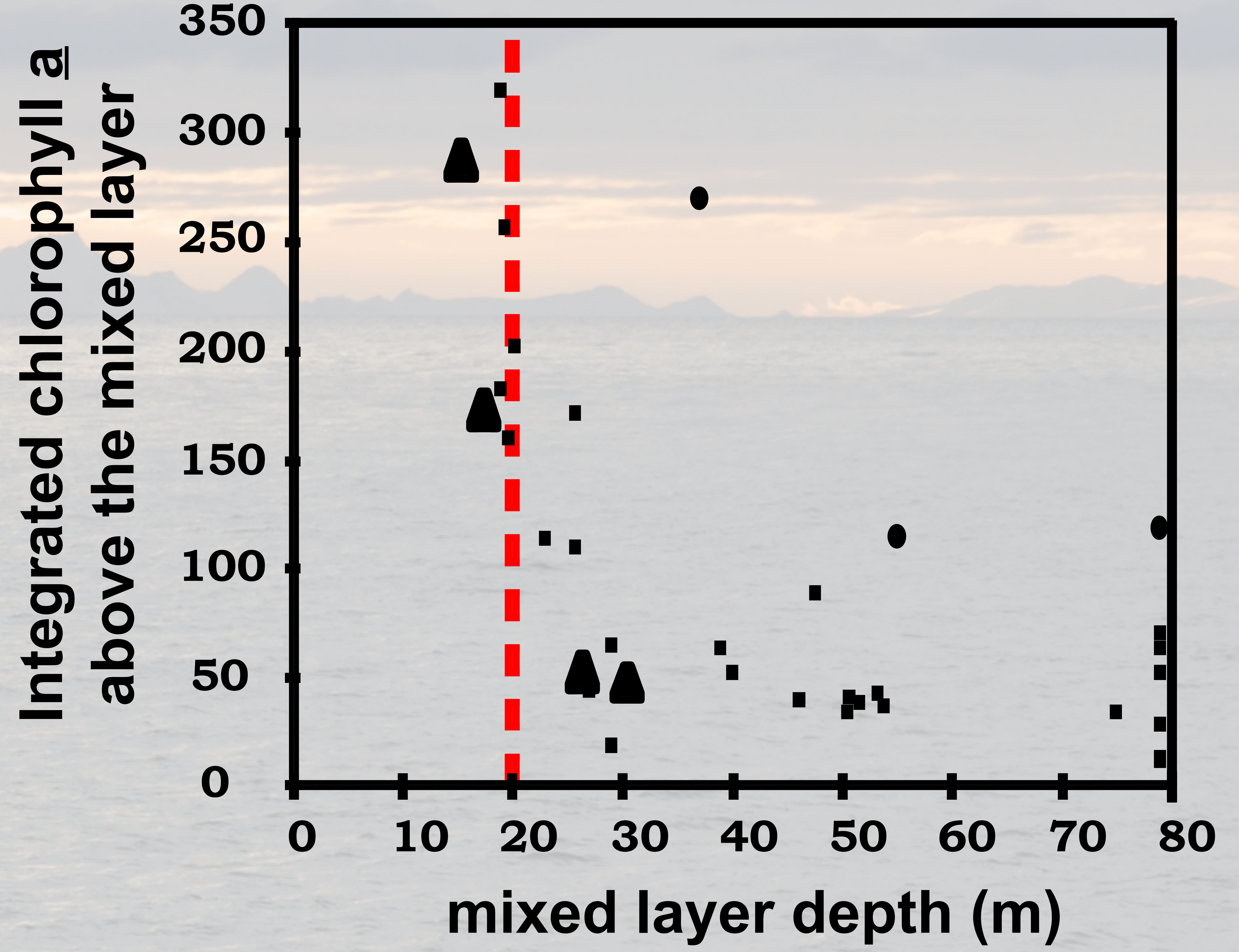
# Time series at Palmer Station



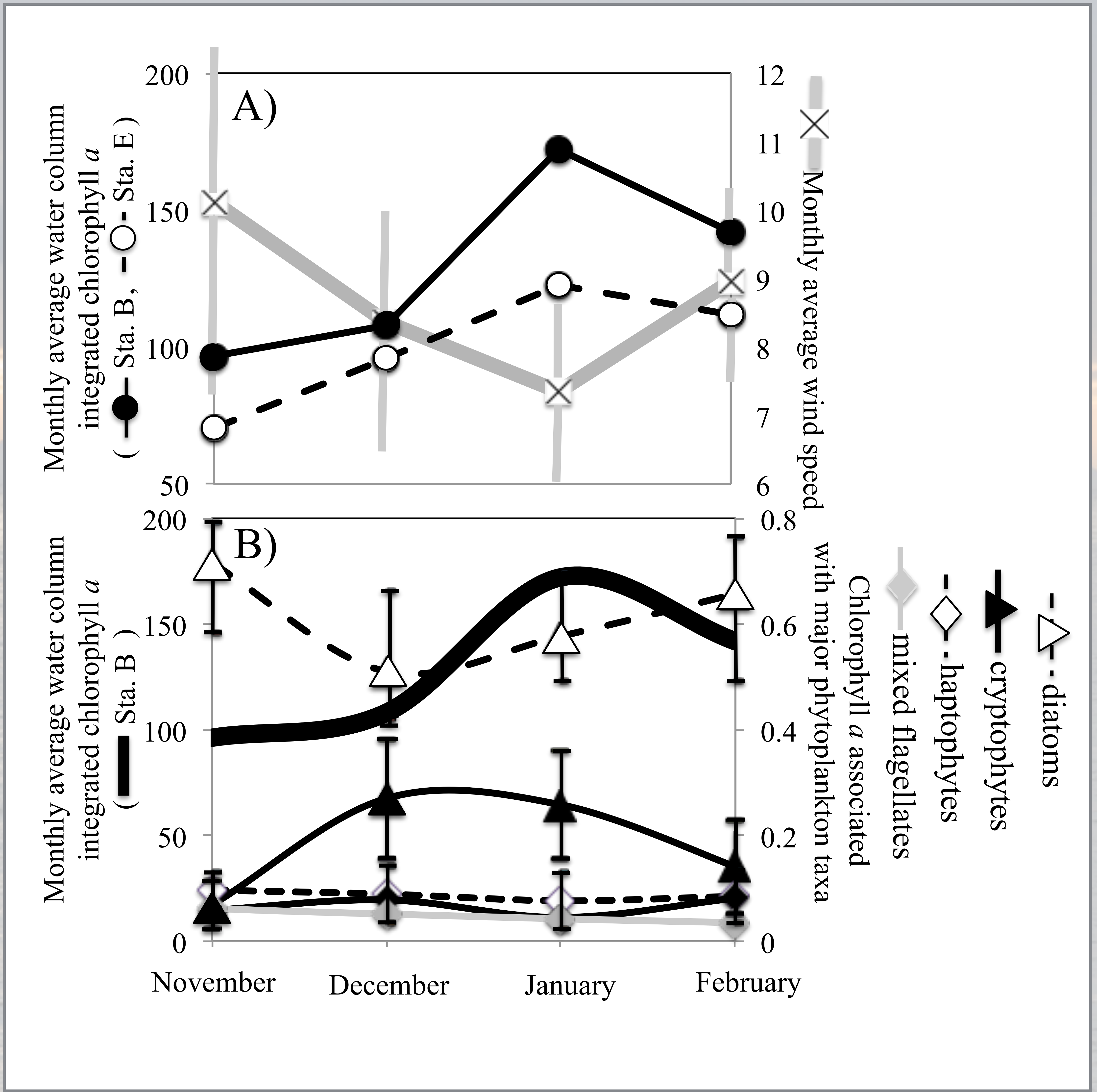
# What regulates phytoplankton blooms in this region?



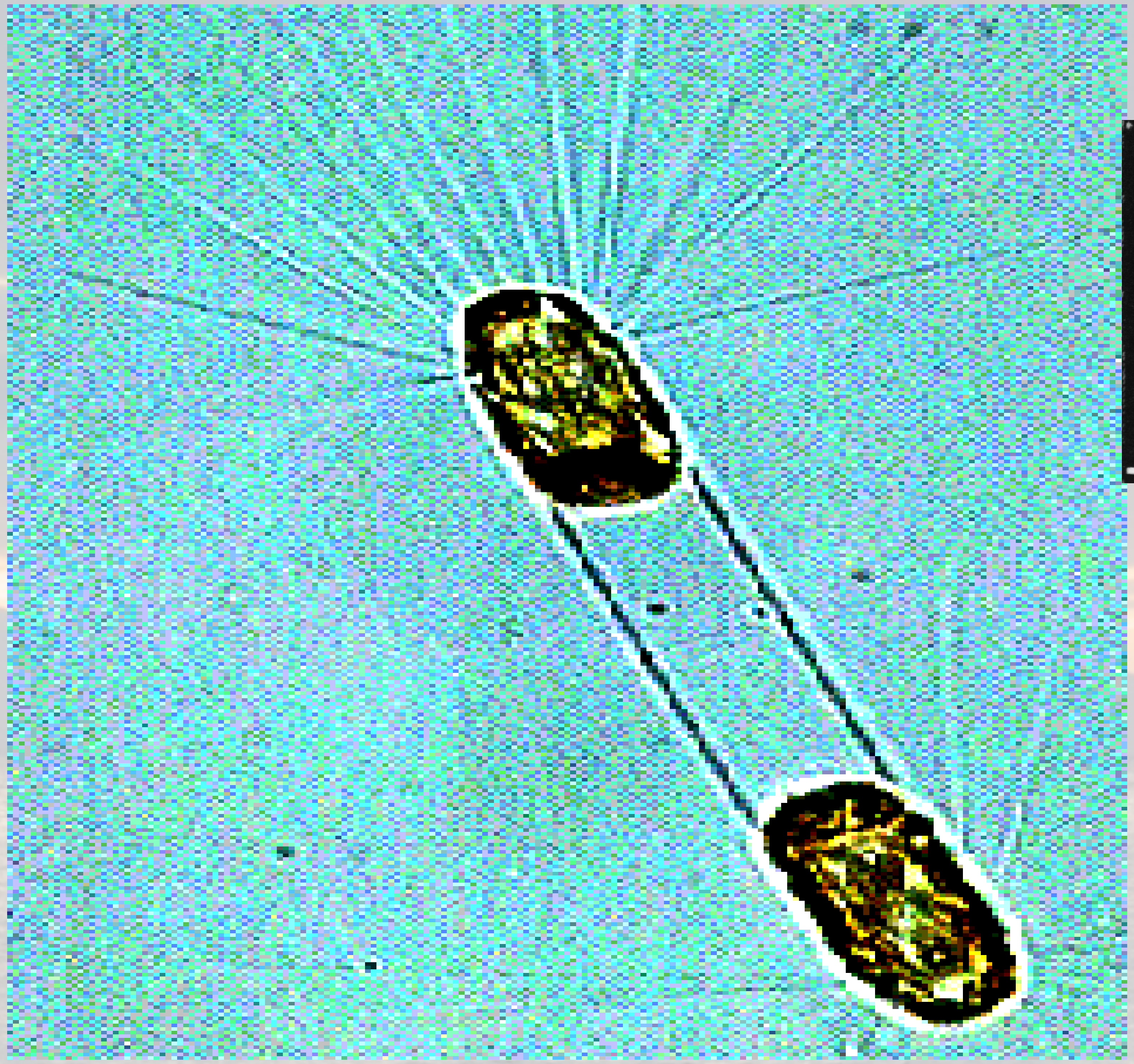



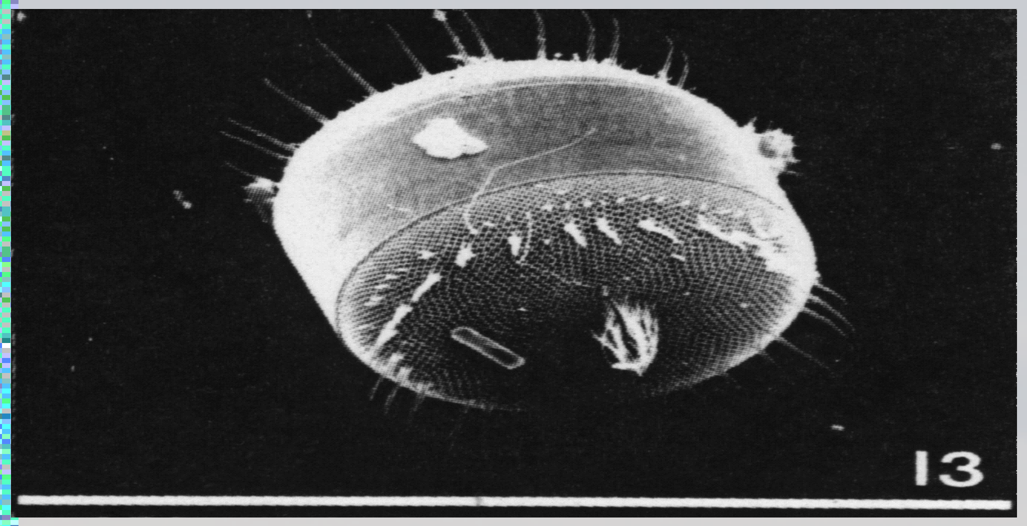
WAP Wind Speed DJF
Correlation = 0.55
Wind Speed
SAM DJF
Linear (Wind Speed)
Linear (SAM DJF)
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
1950
1960
1970
1980
1990
2000
2010
2020



A)
Monthly average water column integrated chlorophyll a ( Sta. B, Sta. E )
Monthly average wind speed
200
150
100
50
12
11
10
9
8
7
6
B)
Monthly average water column integrated chlorophyll a ( Sta. B )
Chlorophyll a associated with major phytoplankton taxa
0
0.2
0.4
0.6
0.8
diatoms
cryptophytes
haptophytes
mixed flagellates
November
December
January
February

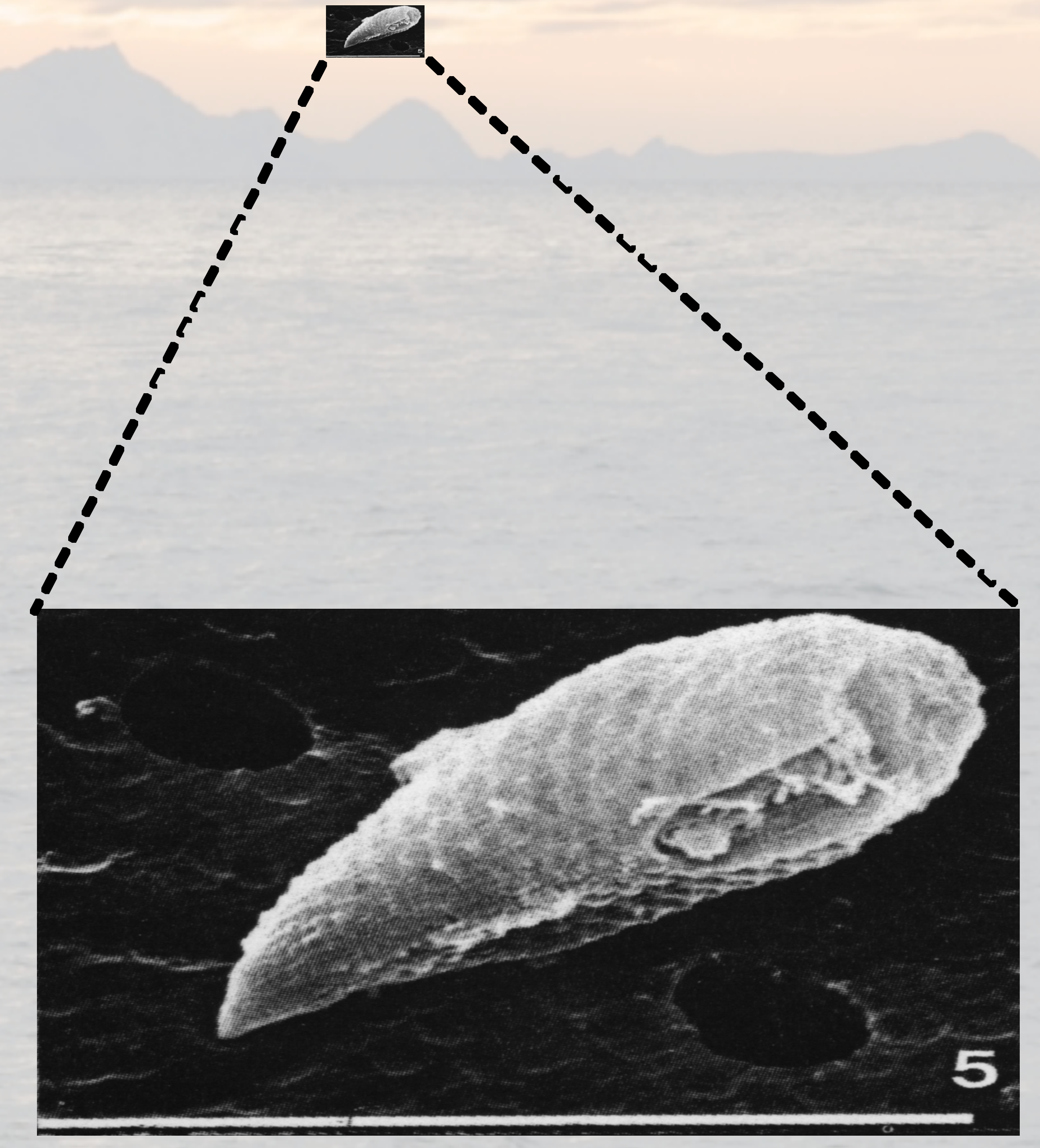


*Corethron criophilum*




100µm

*Thalassiosira antarctica*

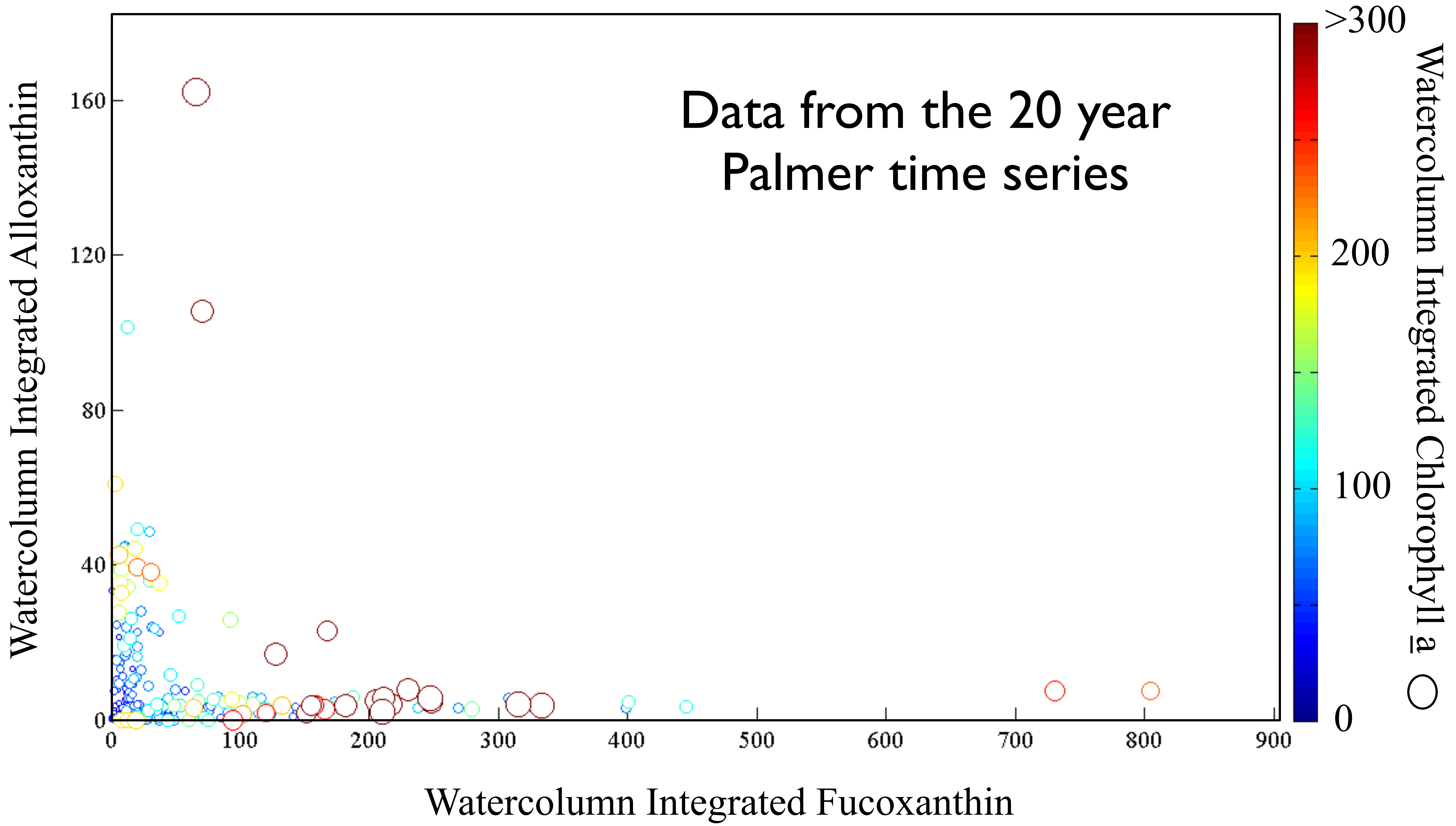



10µm

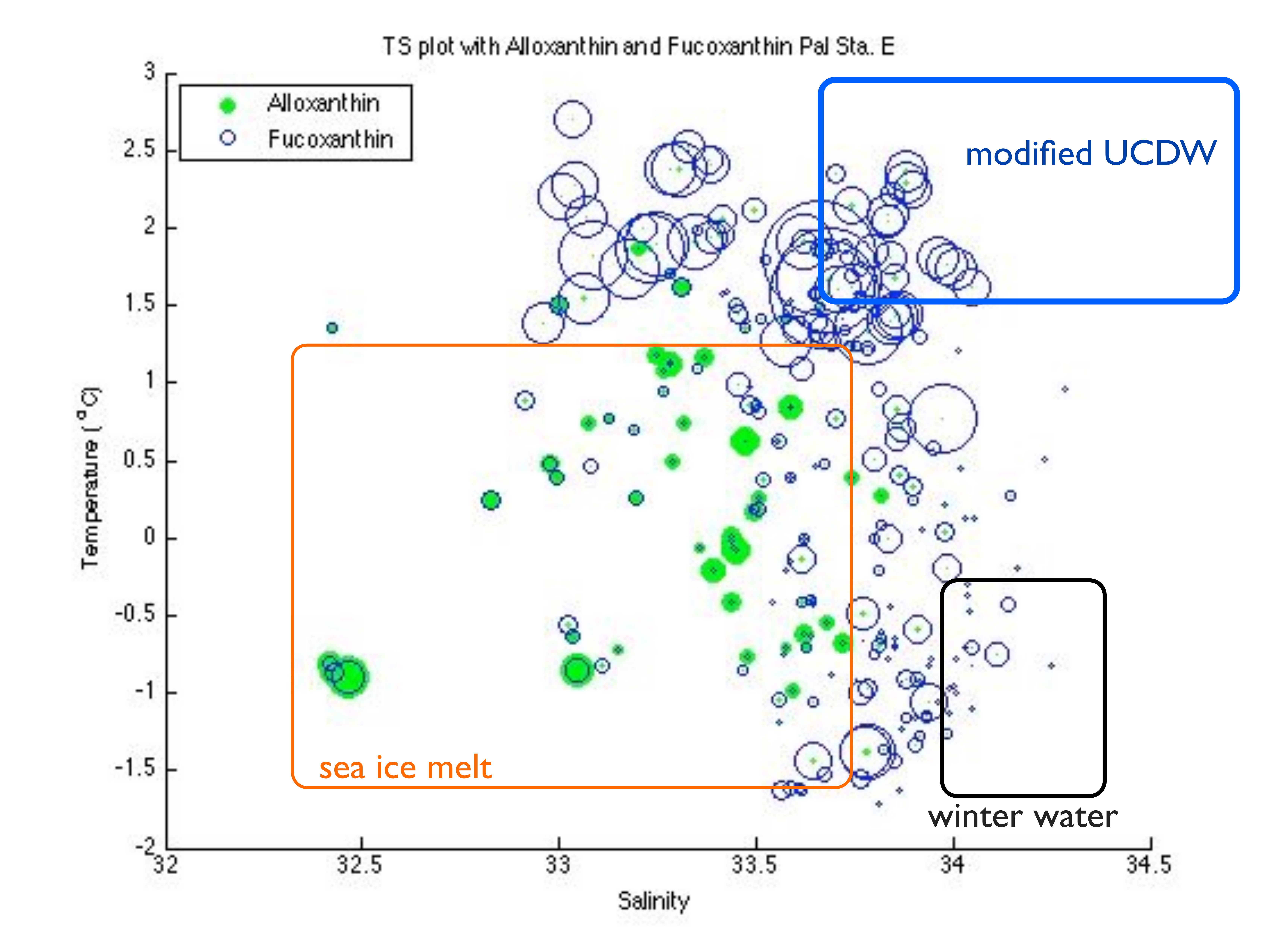
*Cryptomonas cryophila*

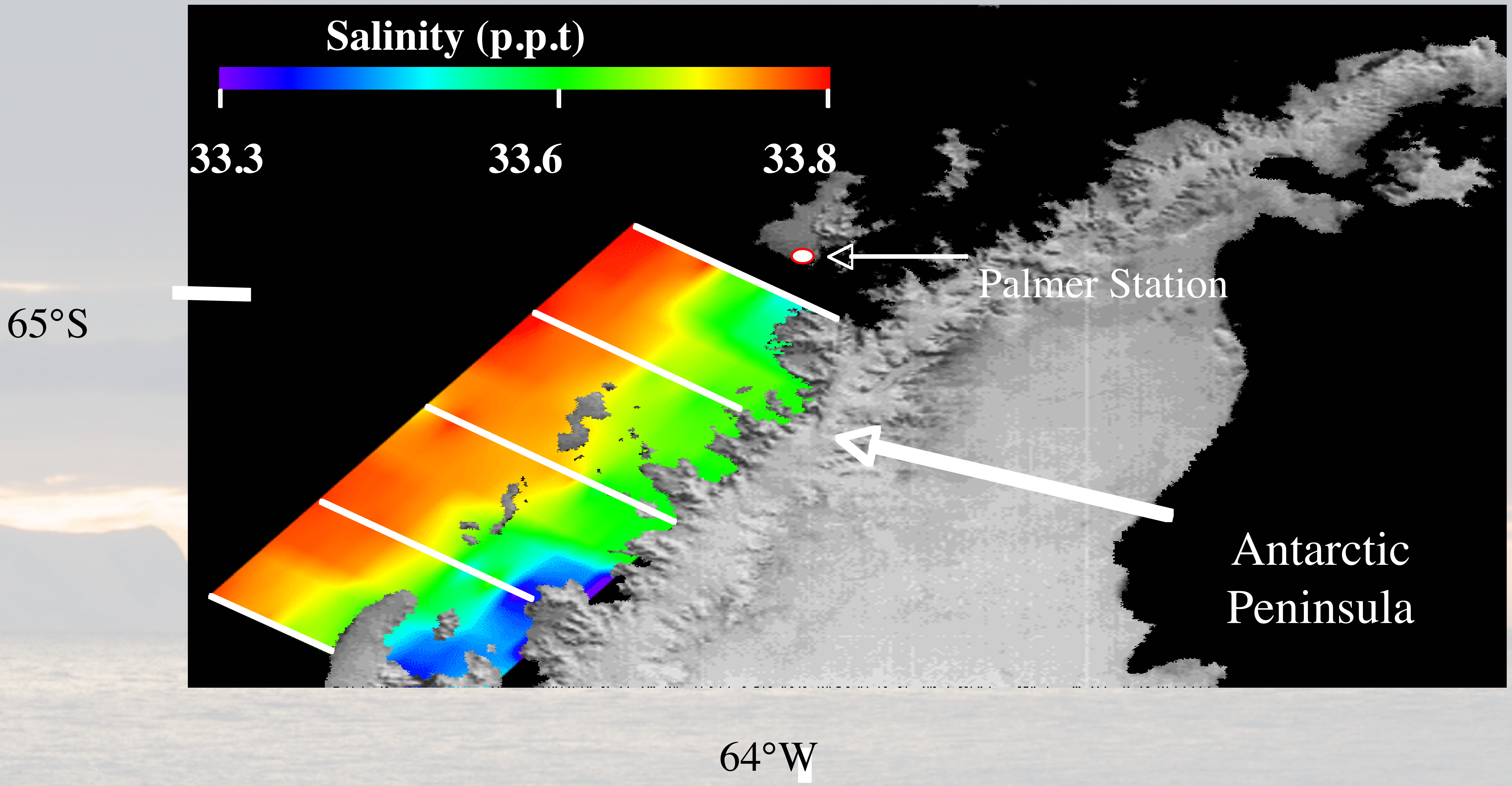
Palmer Cryptophytes -->  8 ± 2µm

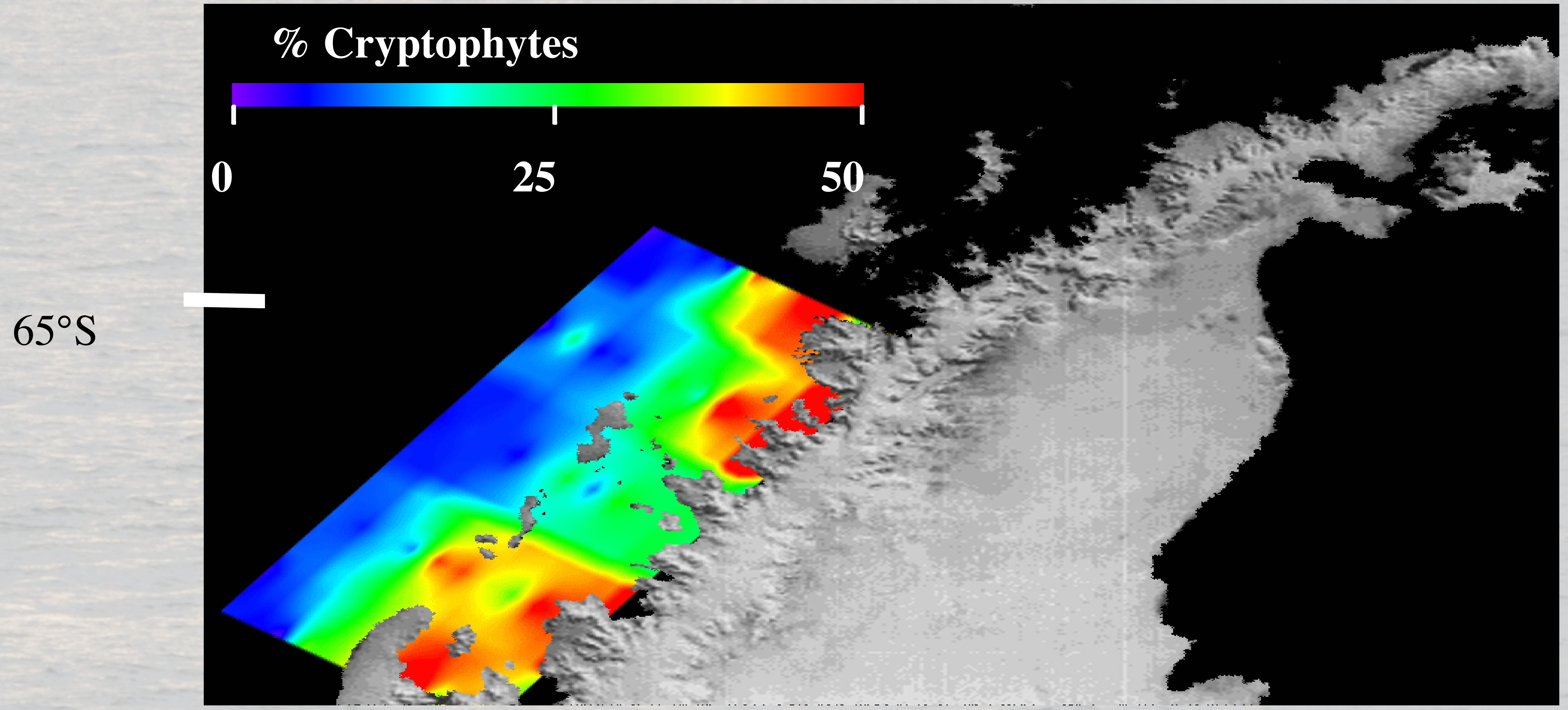
SEM Micrographs from*McMinn and Hodgson* 1993



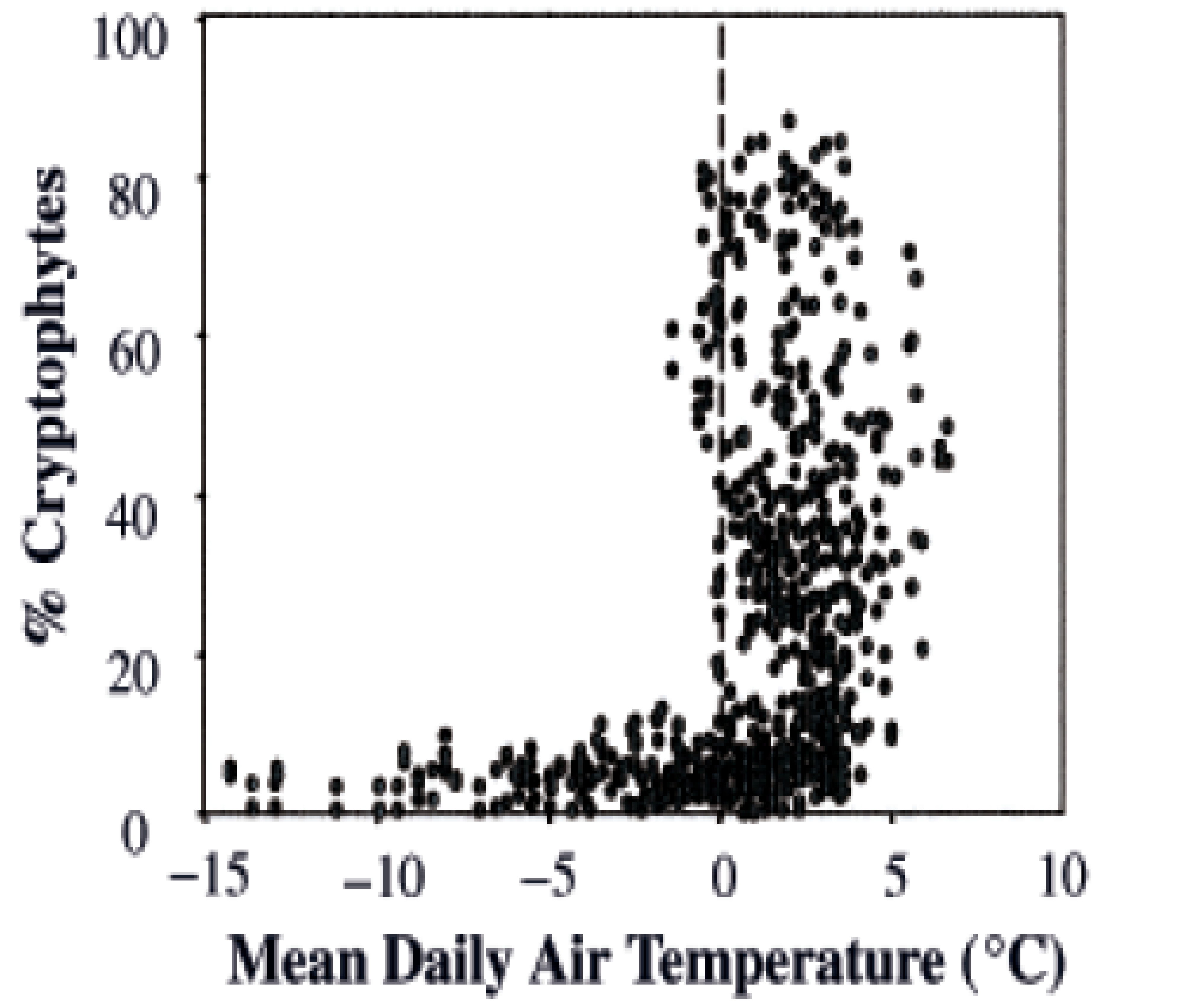
Data from the 20 year
Palmer time series
Watercolumn Integrated Alloxanthin
Watercolumn Integrated Fucoxanthin
Watercolumn Integrated Chlorophyll a
0
40
80
120
160
0
100
200
300
400
500
600
700
800
900
>300
200
100
0


TS plot with Alloxanthin and Fucoxanthin Pal Sta. E
Alloxanthin
Fucoxanthin
modified UCDW
sea ice melt
winter water
Temperature (°C)
Salinity
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
32
32.5
33
33.5
34
34.5



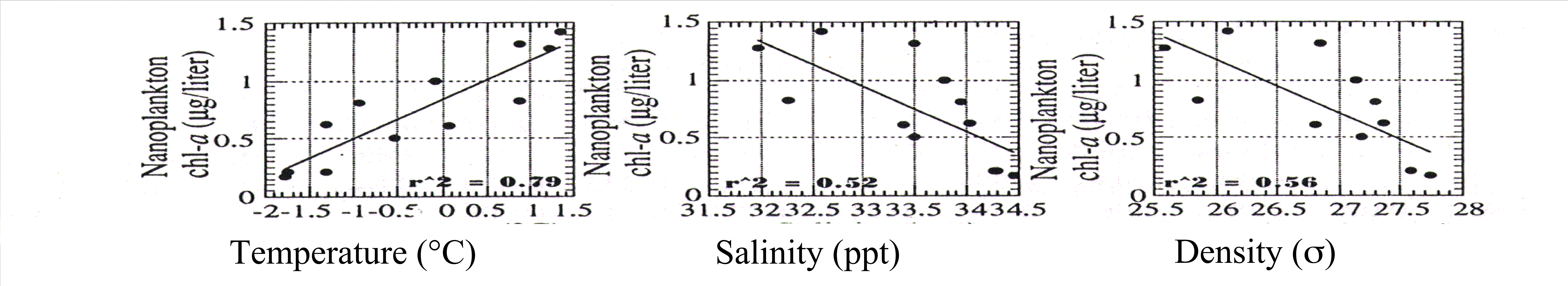




Moline et al.
GBC 2004



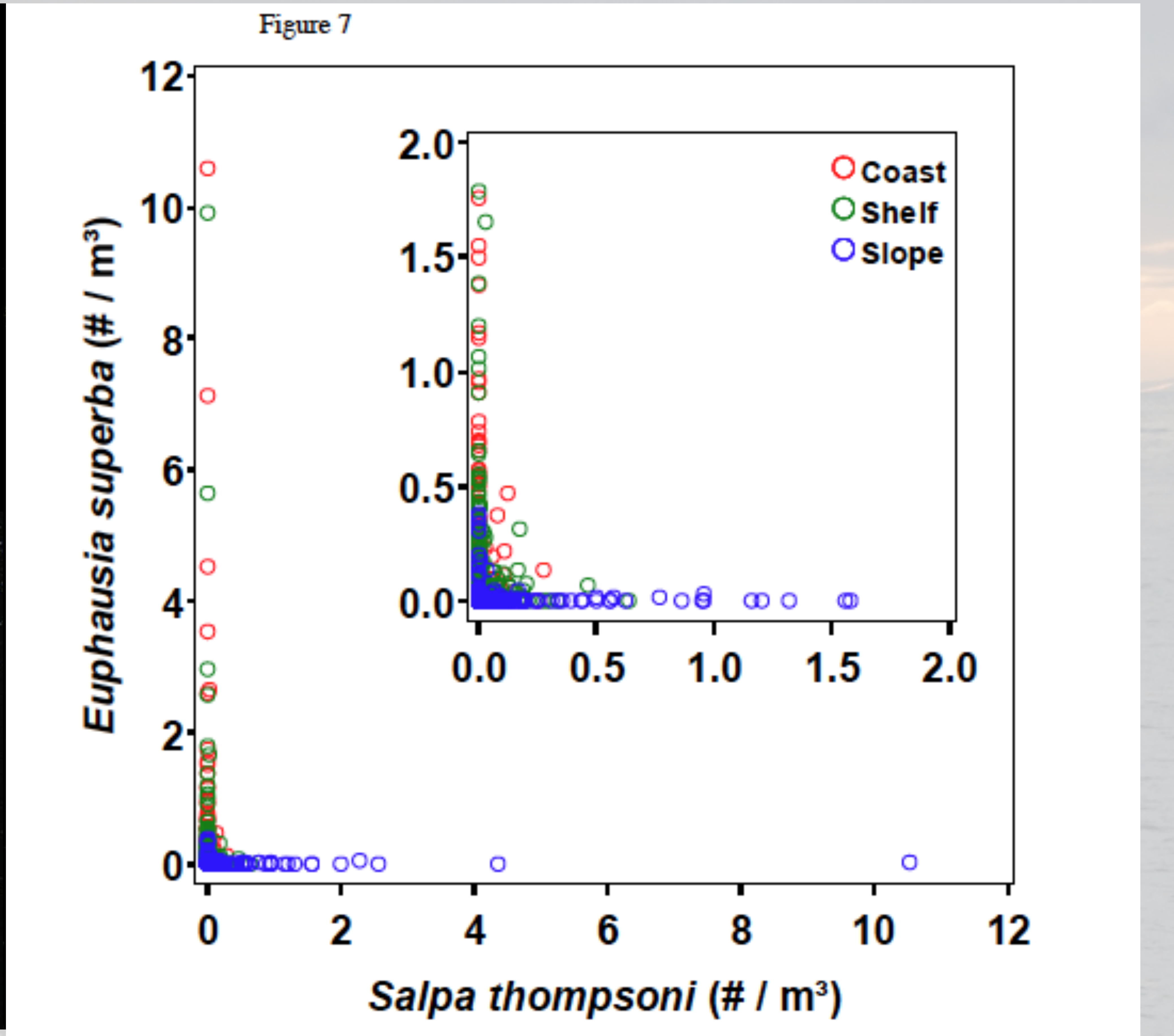

Moline et al.
GBC 2004

# A general feature in the warming WAP?

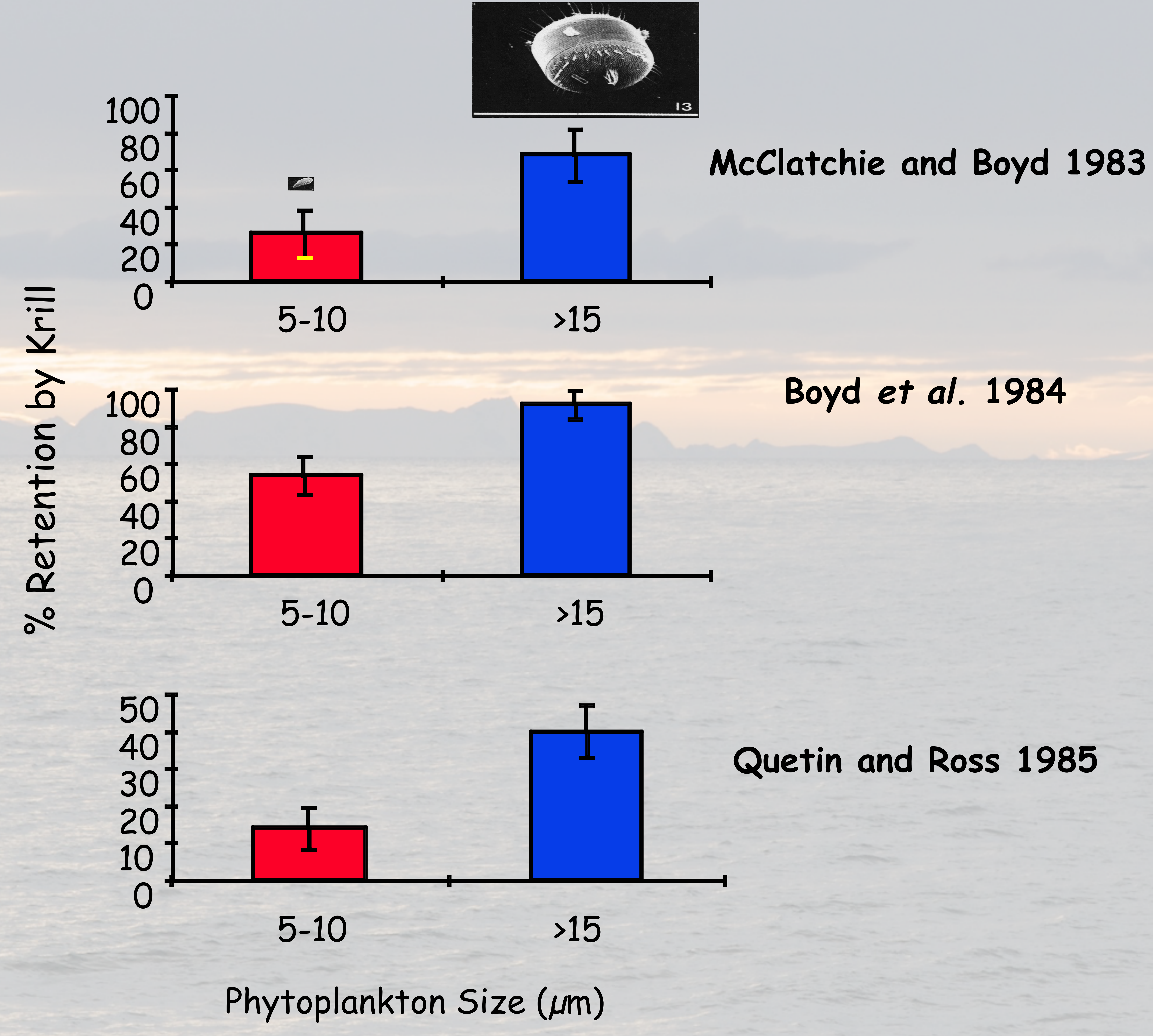



| Location | Reference |
| --- | --- |
| South Shetland Islands | *V illafañe et al.*, 1995; *Kang, S-H et al.*, 1997; *Kang, J-S et al.*, 1997 |
| Weddell-Scotia-Bellingshausen Confluence Areas | *Lancelot et al.*, 1991; *Nothig et al.*, 1991 *Tréguer et al.*, 1991; *Buma*, 1992; *Mura et al.*, 1995; *Kang and Lee*, 1995; *Aristegui et al.*, 1996 |
| Ellis Fjord | *McMinn and Hodgson*, 1993 |
| Bransfield Strait | *Kang and Lee,* 1995; *Kang et al.*, 1995 |
| **Historical Data** | |
| Anvers Island | *Krebs*, 1983 |
| Signy Island | *Whitaker*, 1982 |

# Zooplankton are dominated by krill or salps

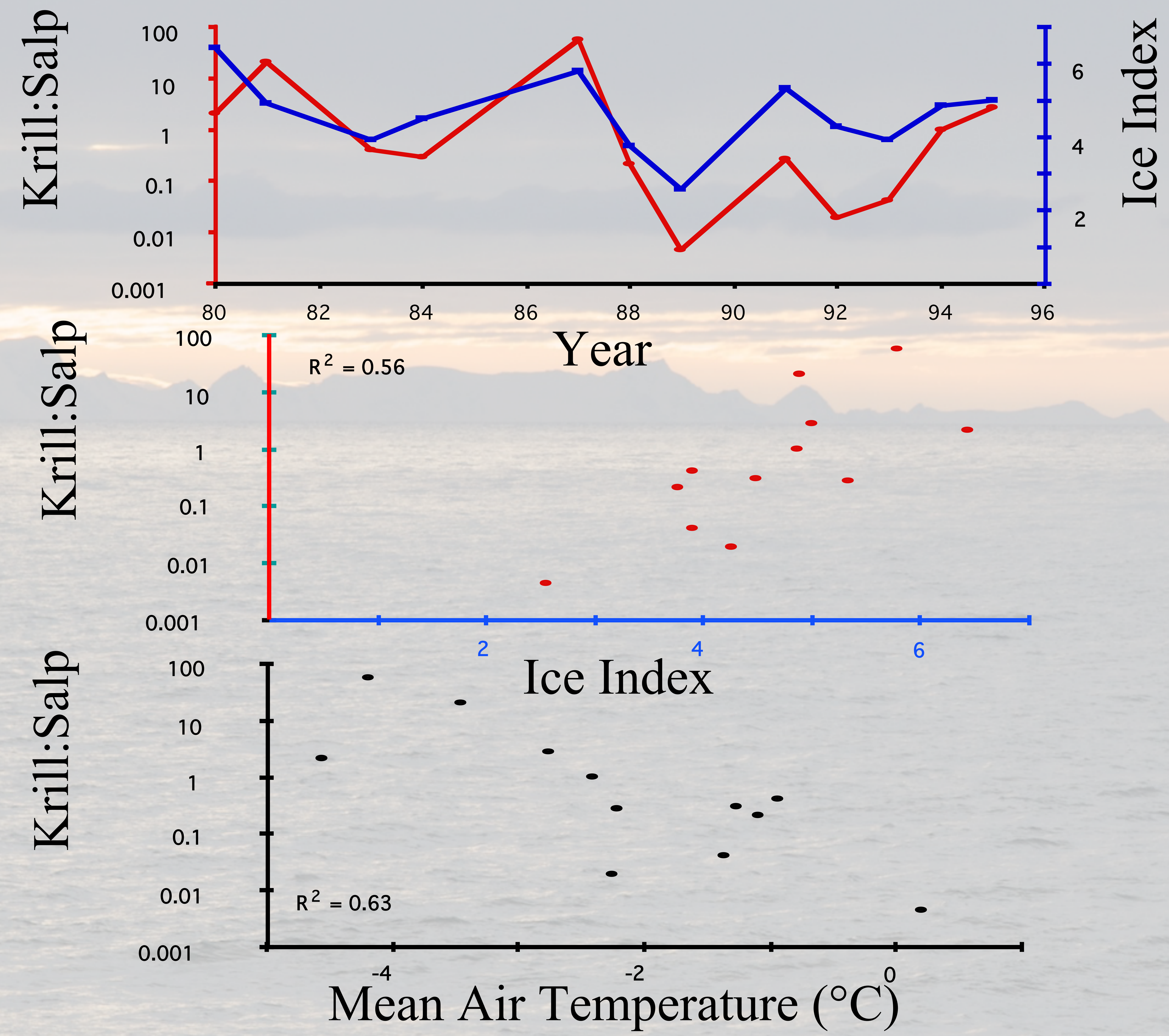



Thanks to Deborah Stienberg



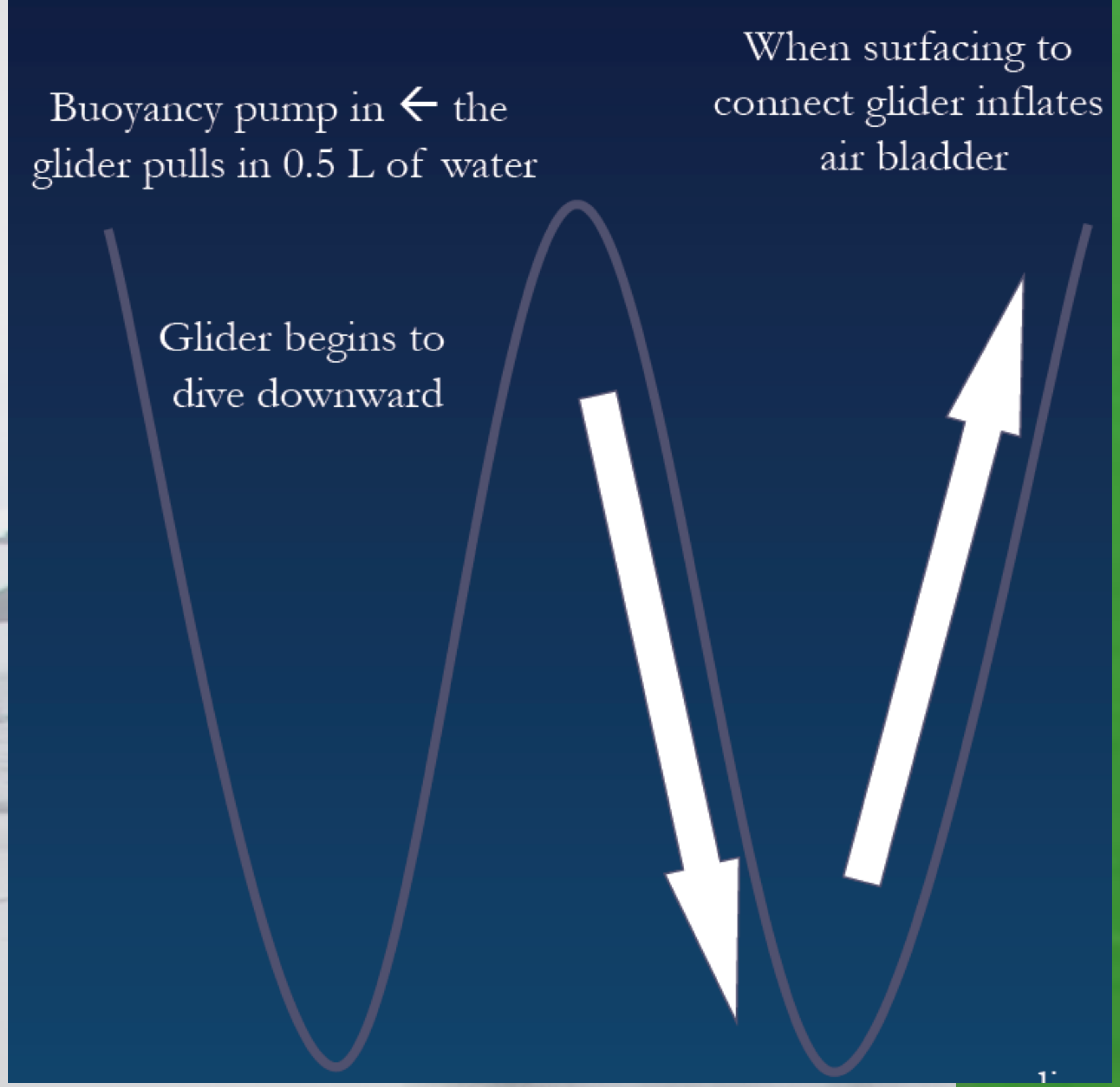
McClatchie and Boyd 1983
Boyd et al. 1984
Quetin and Ross 1985
% Retention by Krill
100
80
60
40
20
0
50
30
10
5-10
>15
13
Phytoplankton Size (µm)

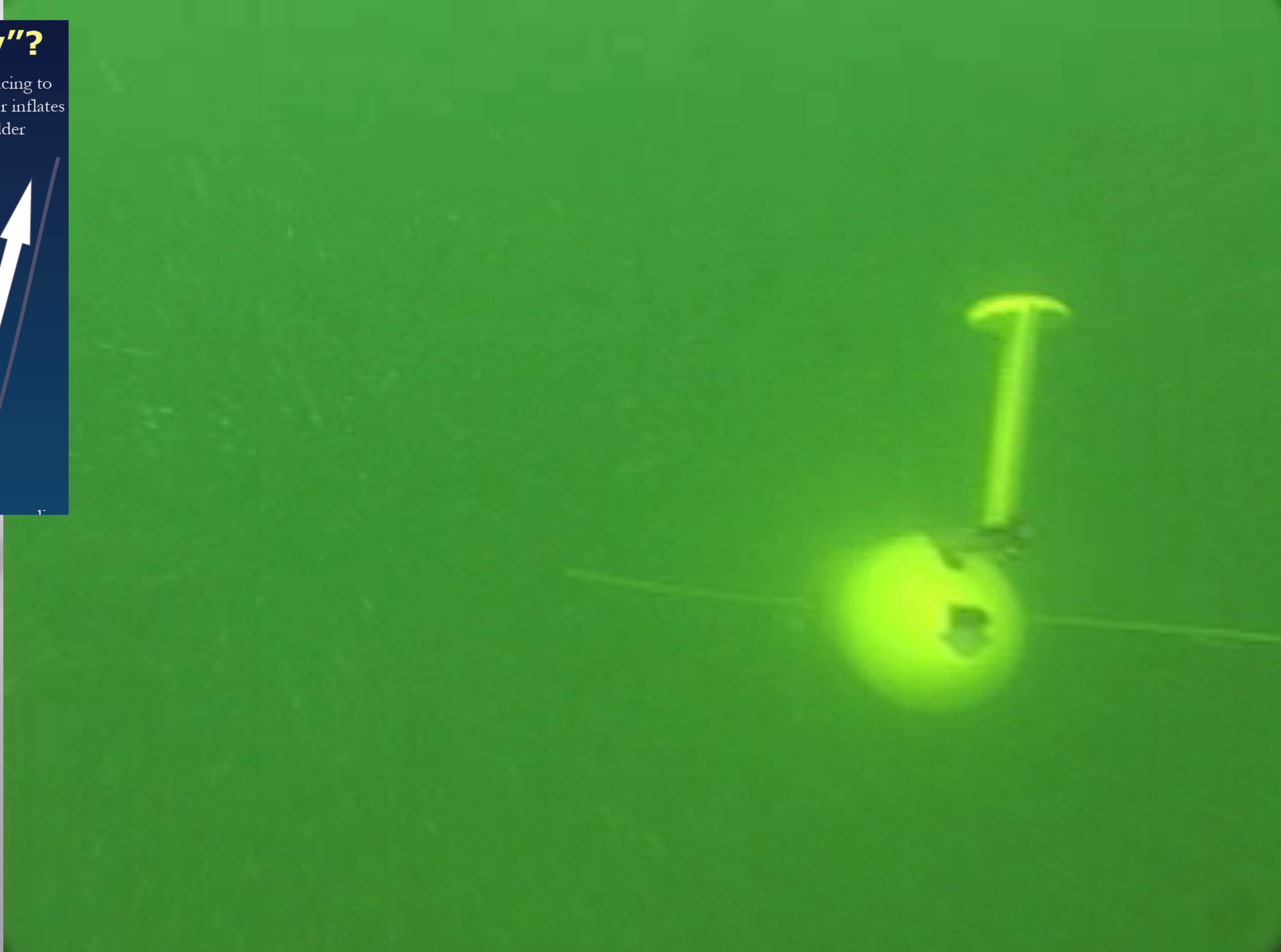
From *Loeb et al.*, 1997



# Is there an impact on higher trophic levels?

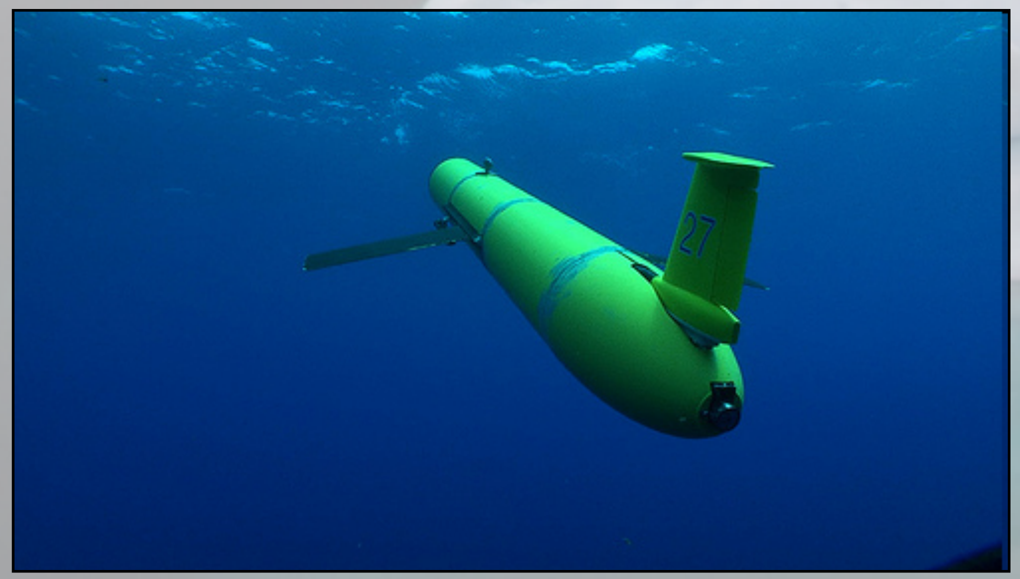
# How do Gliders "Fly"?

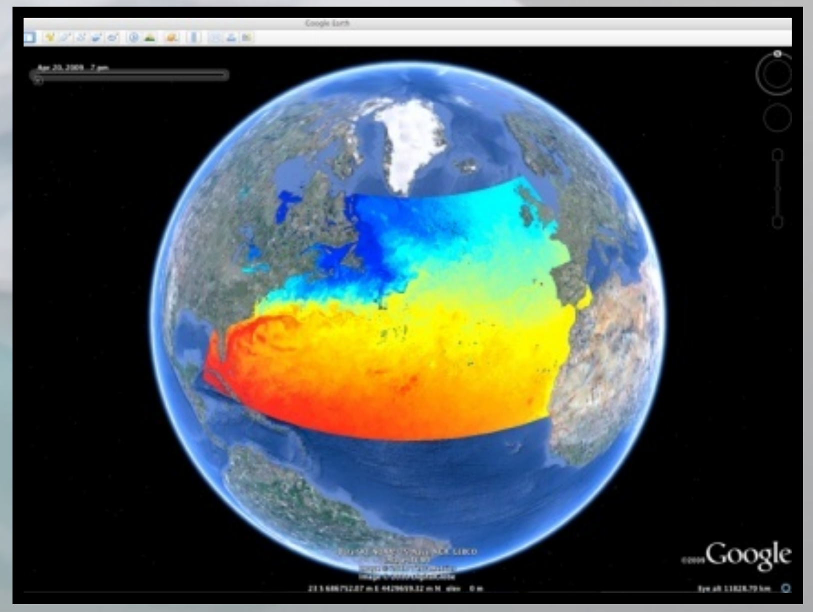


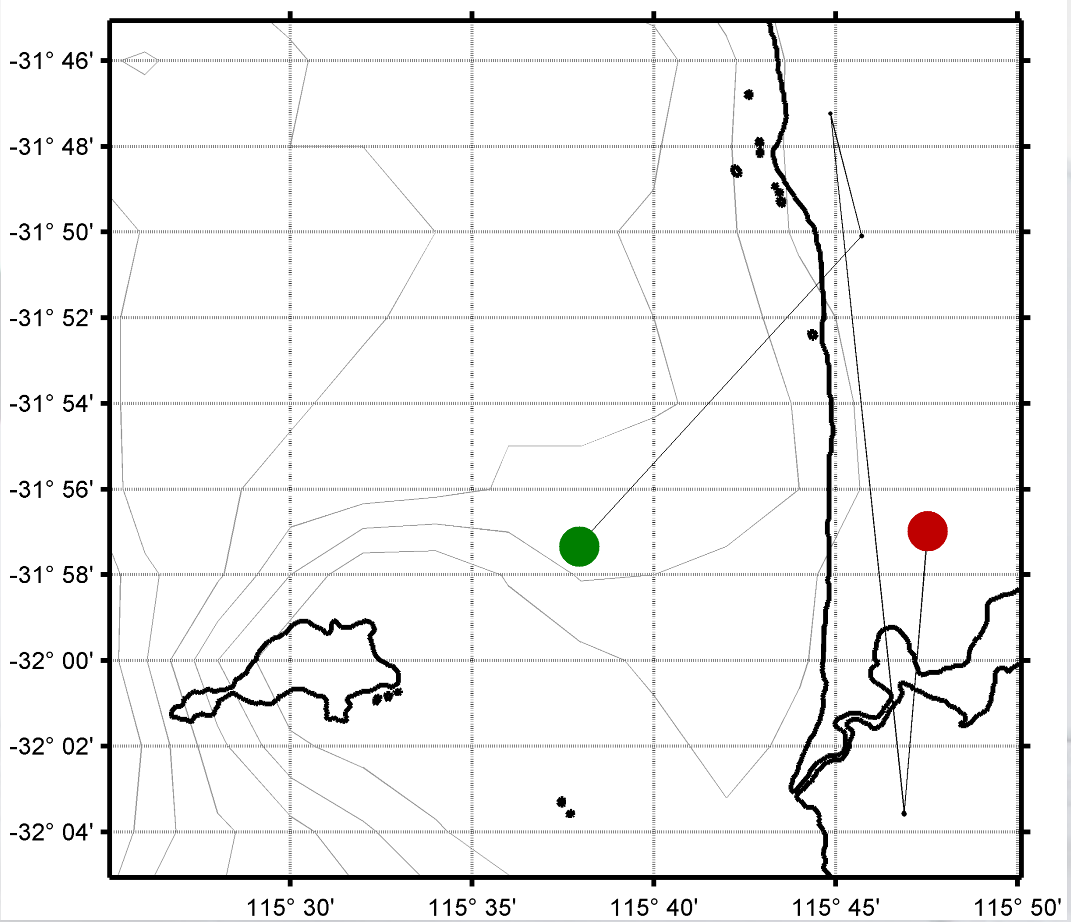
# RU COOL?

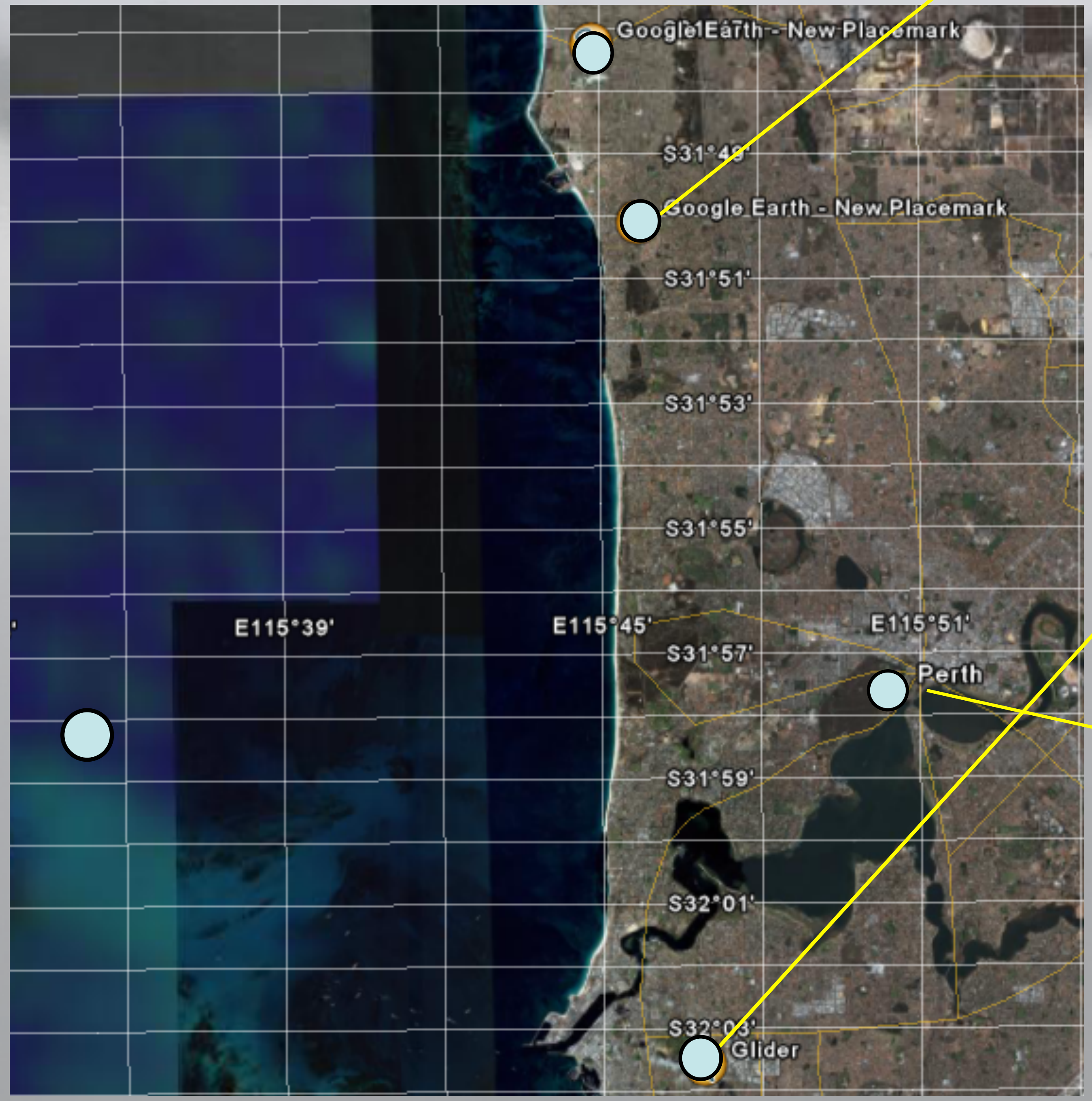

RUTGERS
Institute of Marine and Coastal Sciences
JERSEY ROOTS, GLOBAL REACH



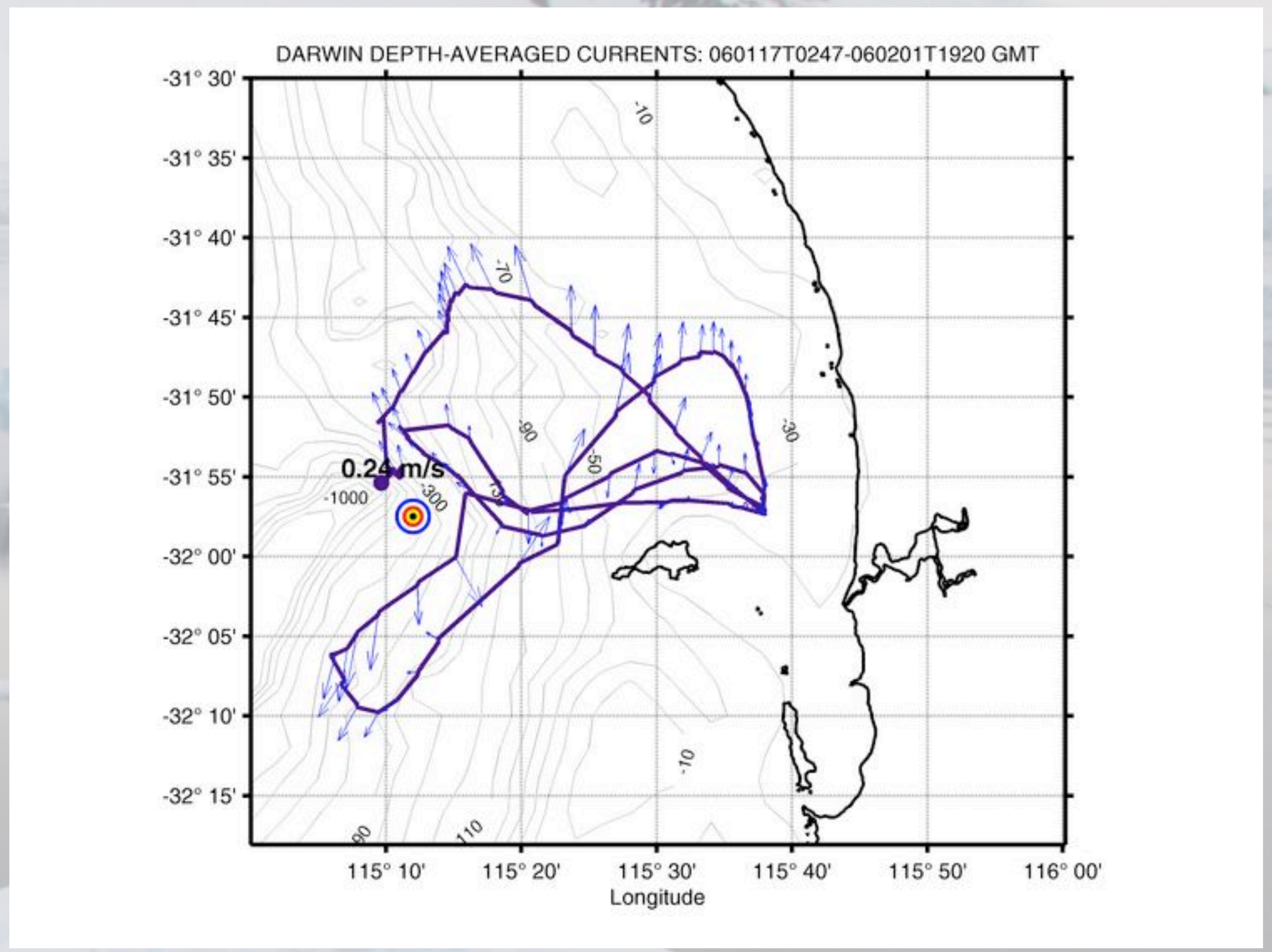

Google

# Darwin’s Odyssey



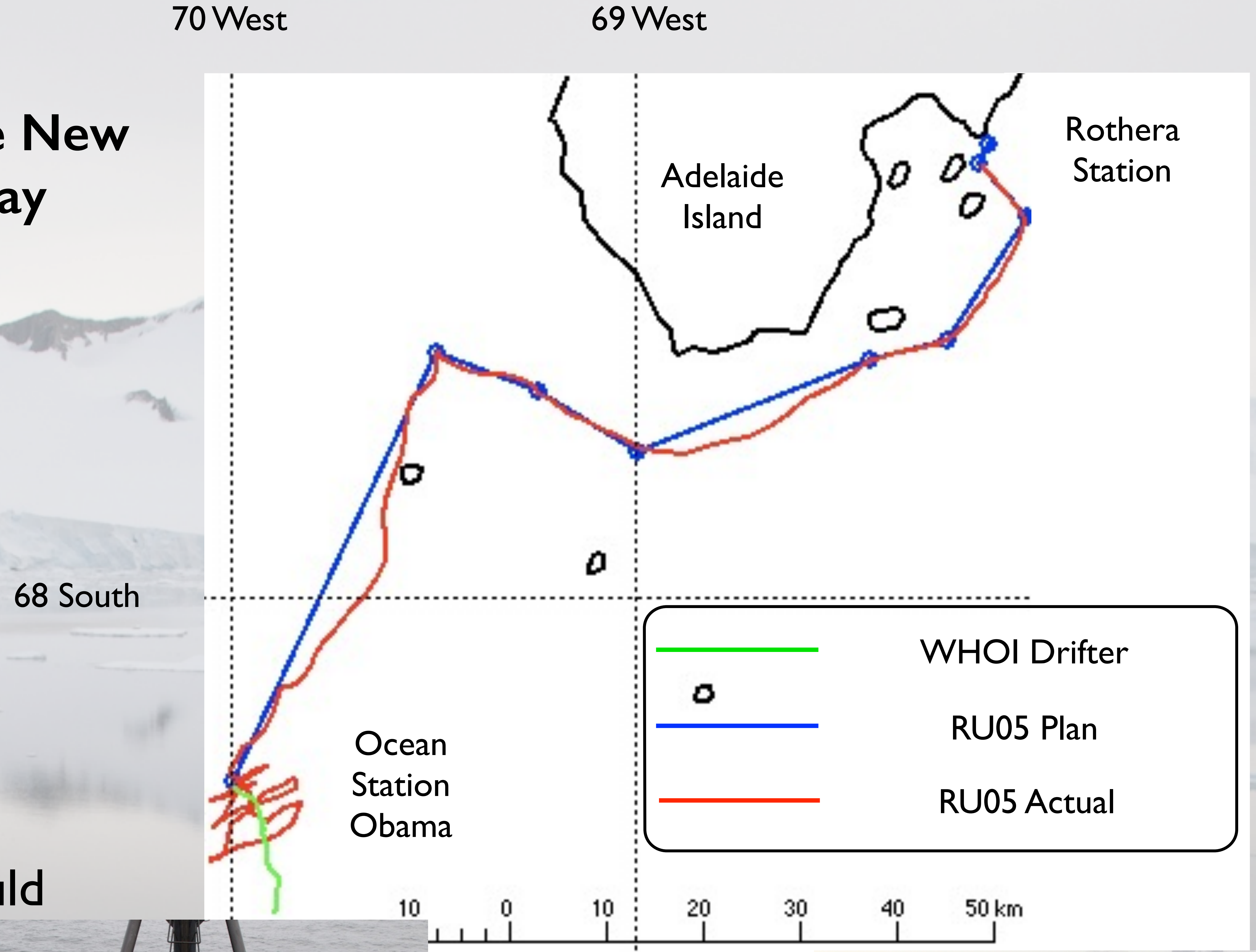




## Old Day Communication

HAM Operator Coms Palmer Station 1988

## Brave New Day

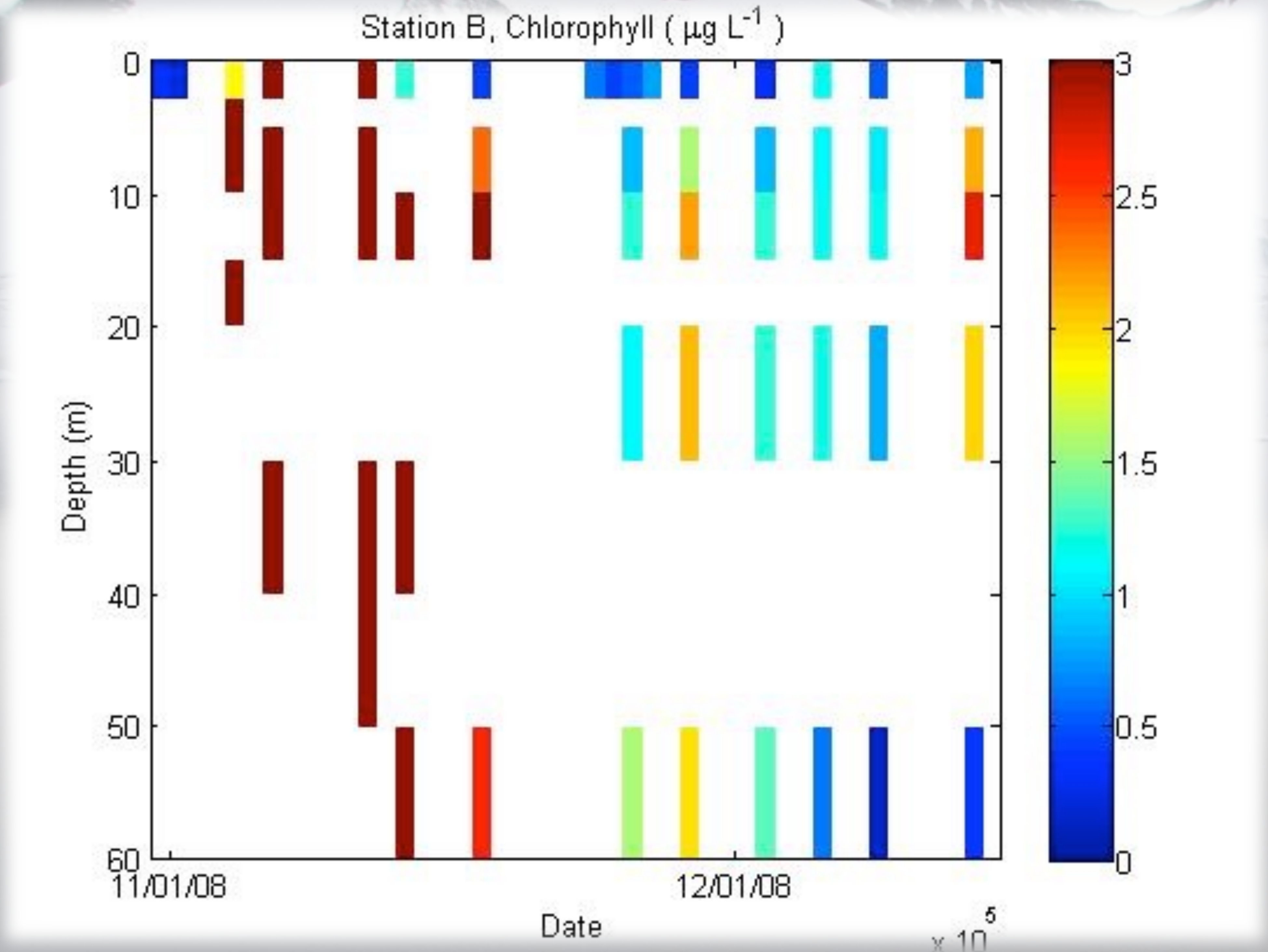



RV Gould

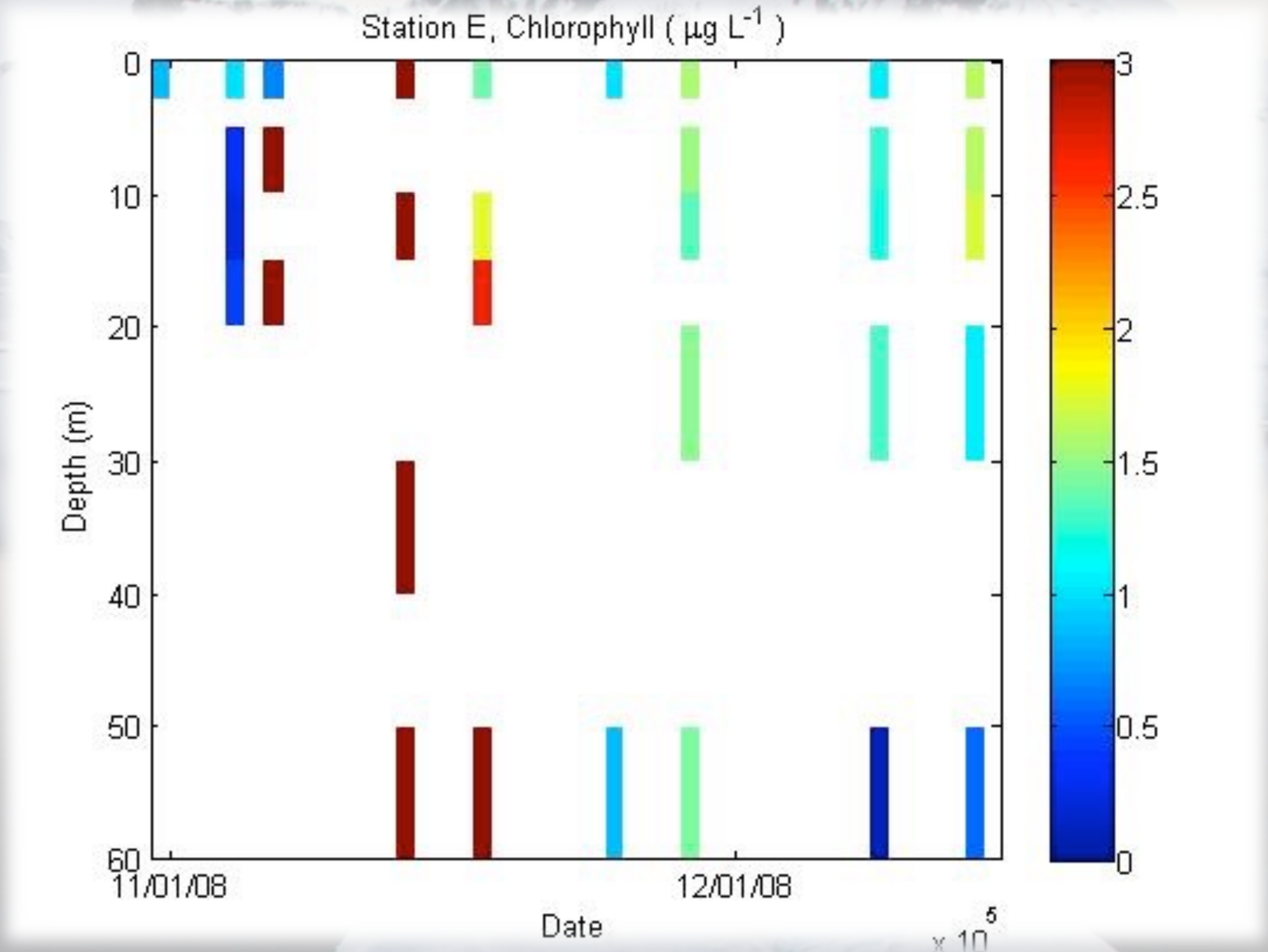

Rothera Base

Real time comms

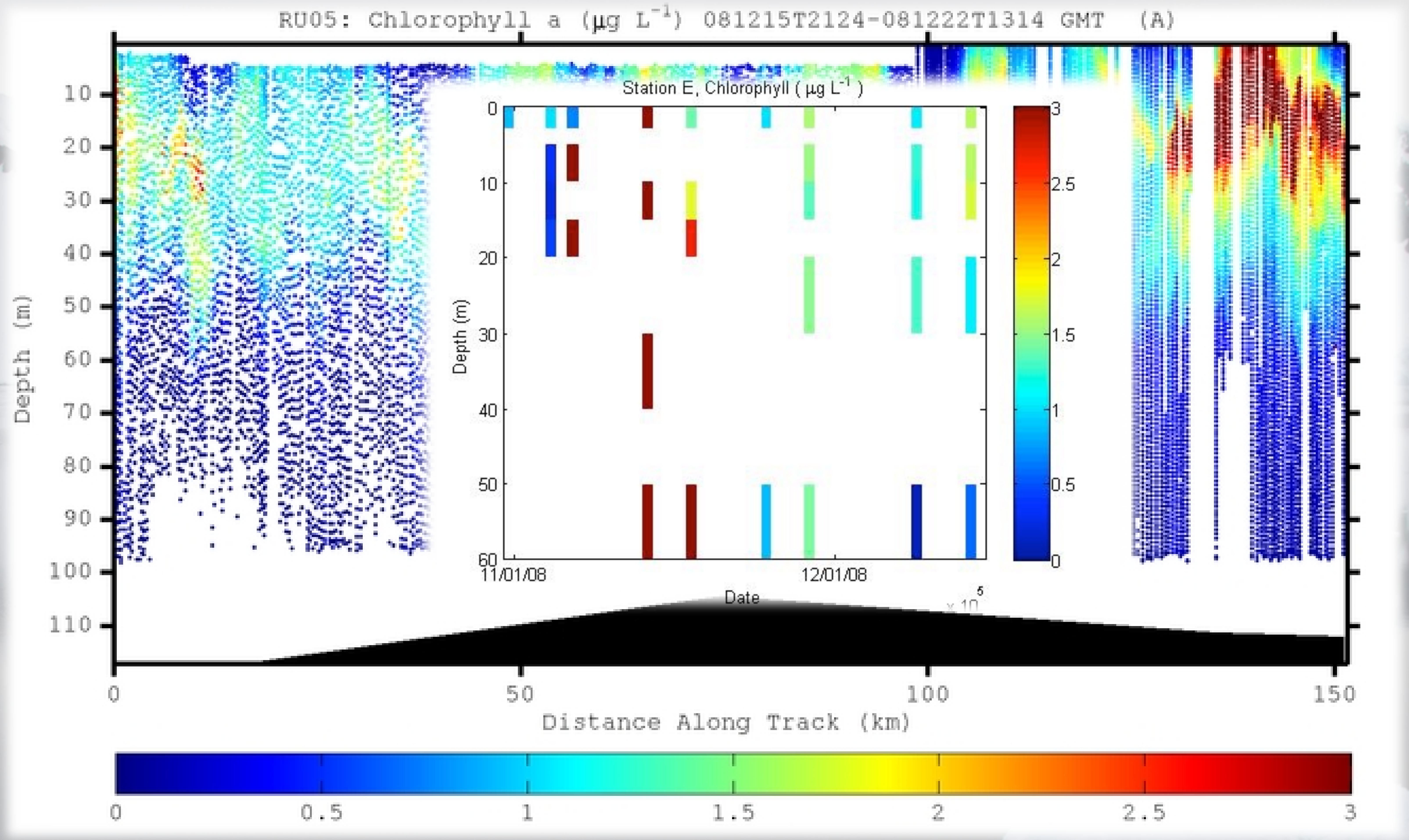
Rutgers COOLroom



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

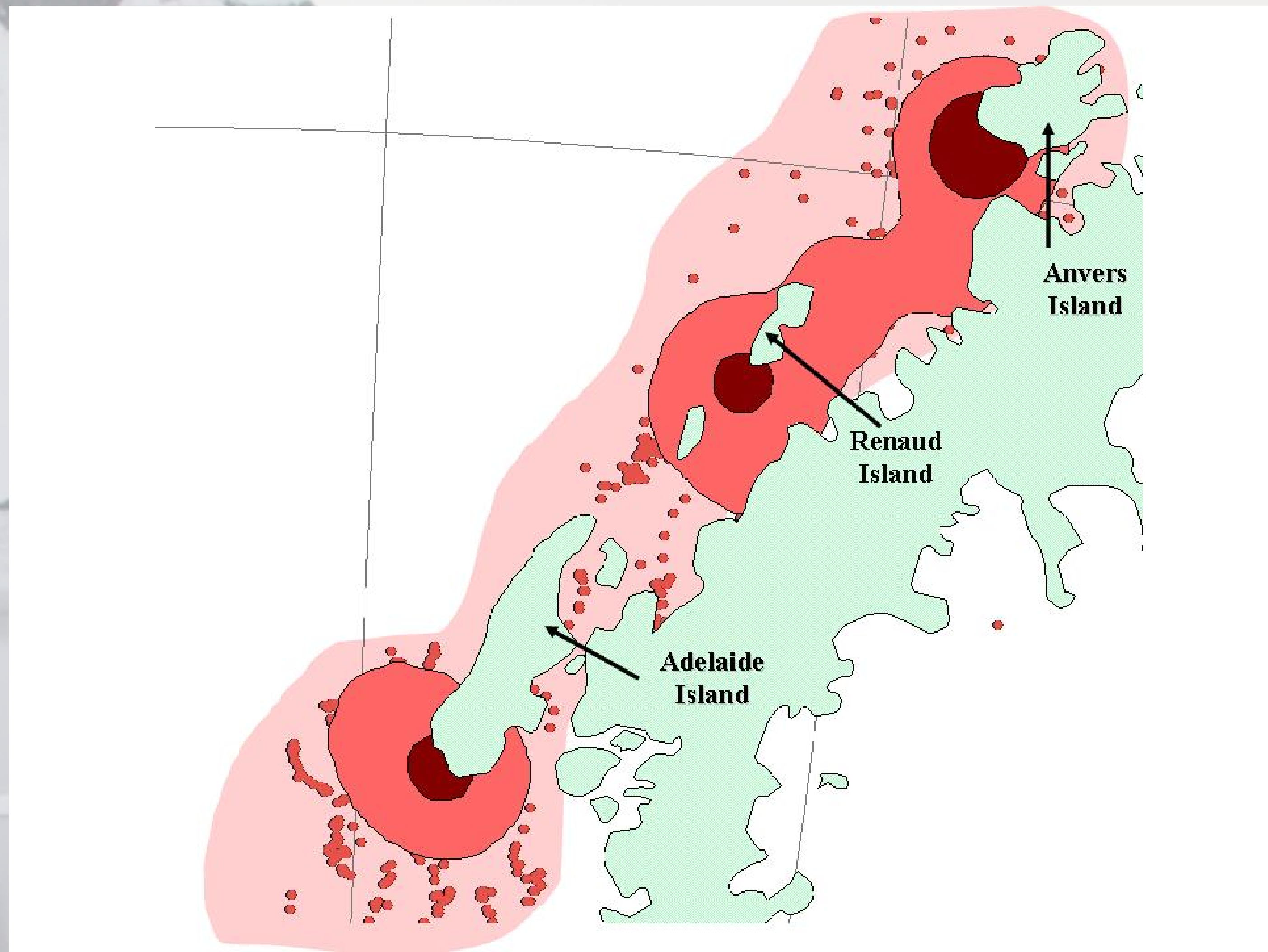
Station E, Chlorophyll ( μg L-1 )
Depth (m)
0
10
20
30
40
50
60
11/01/08
12/01/08
Date
x 10
5
3
2.5
2
1.5
1
0.5
0



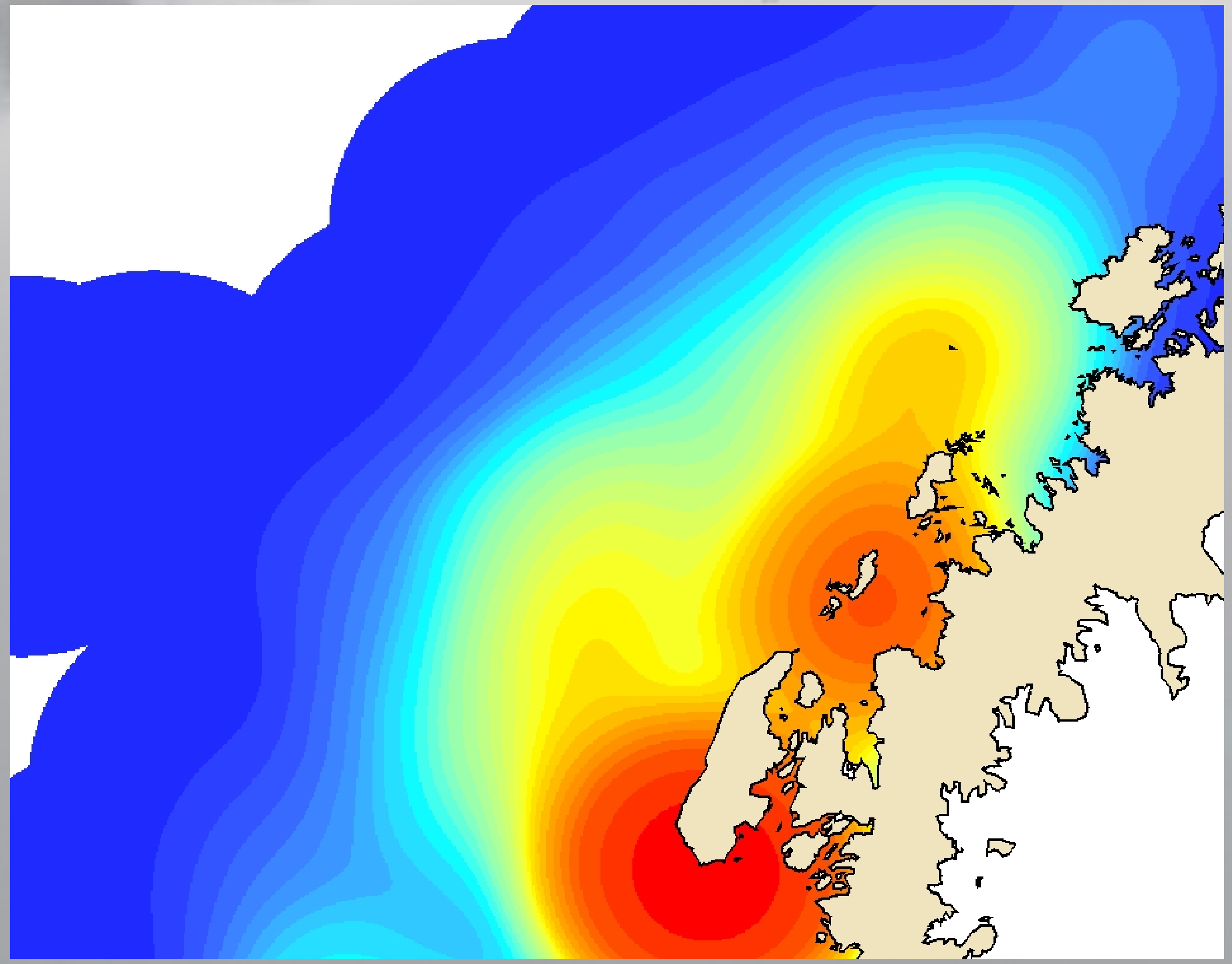
RU05: Chlorophyll a (μg L-1) 081215T2124-081222T1314 GMT (A)
Depth (m)
Distance Along Track (km)
Station E, Chlorophyll ( μg L-1 )
Depth (m)
Date
11/01/08
12/01/08

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.

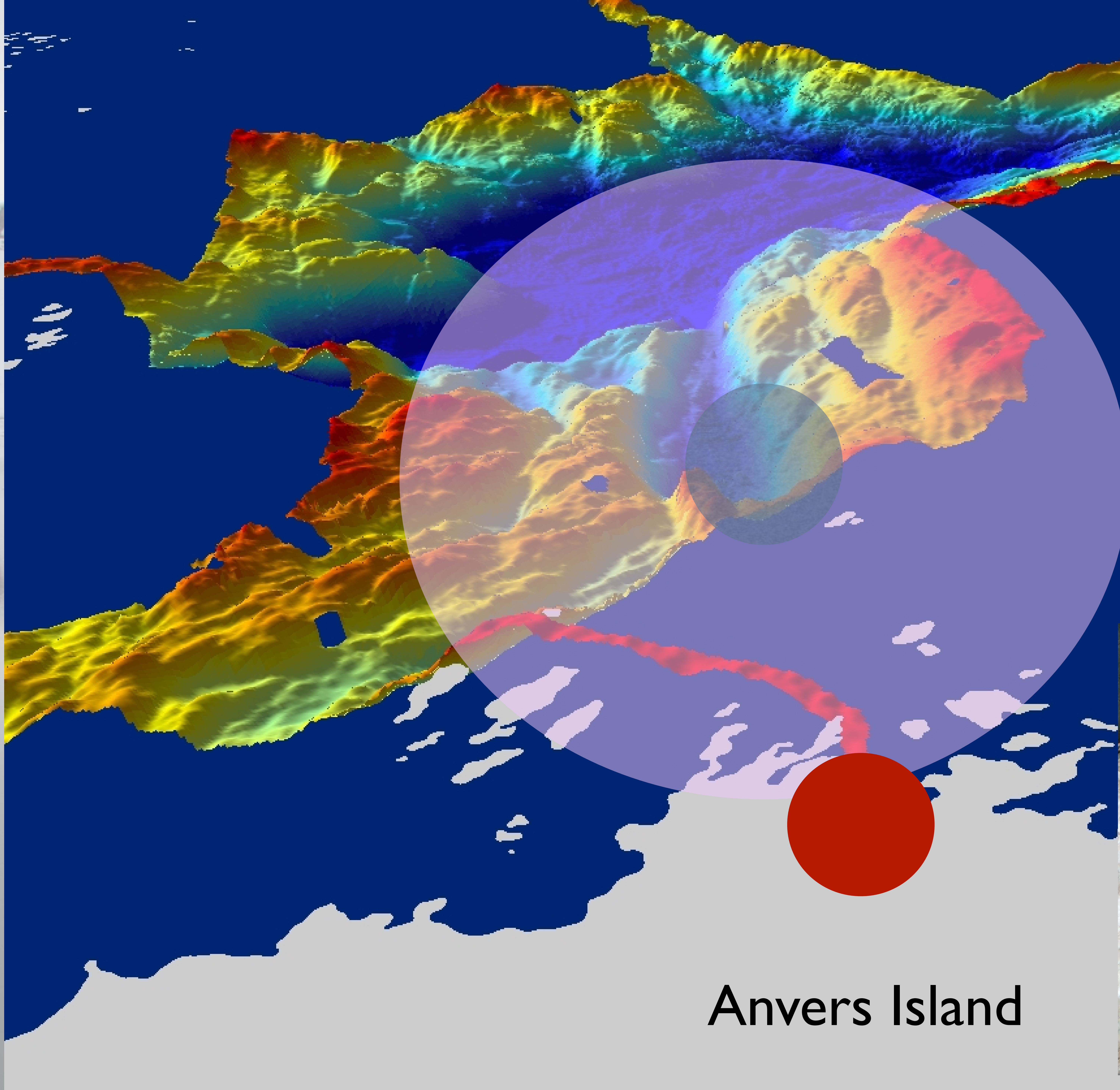
Summer foraging areas for Adelie penguins



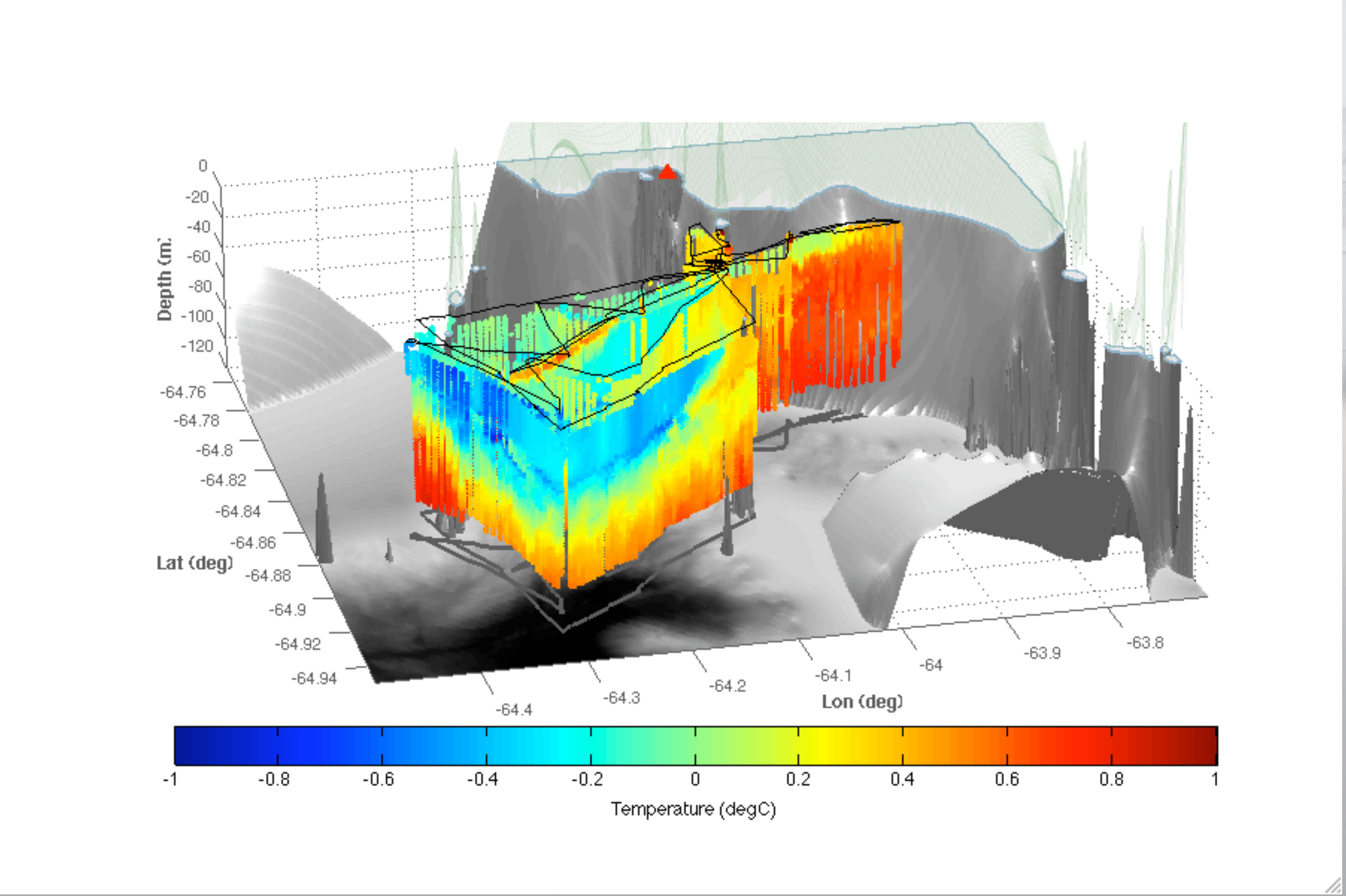

Winter foraging areas for Adelie penguins

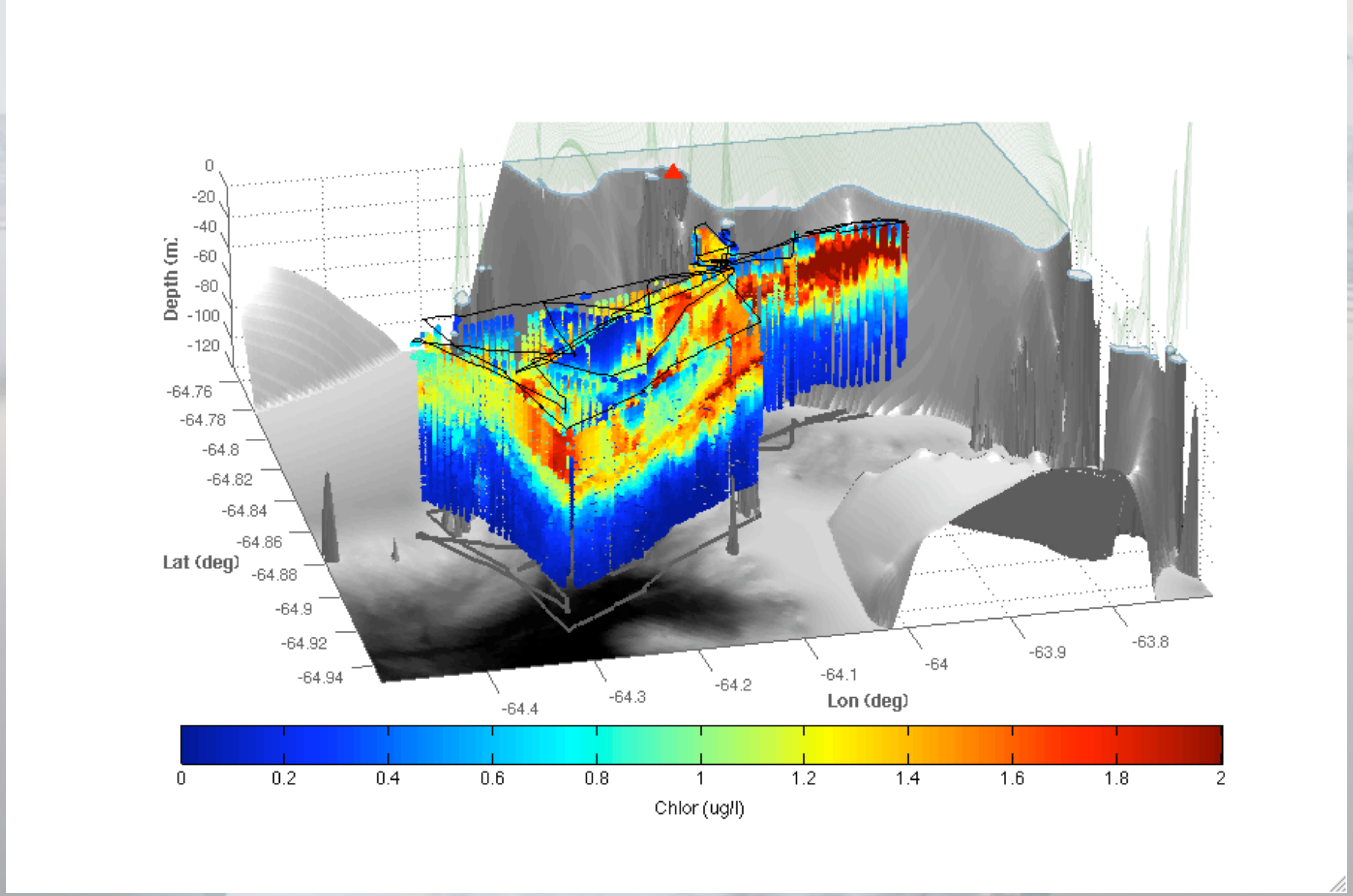


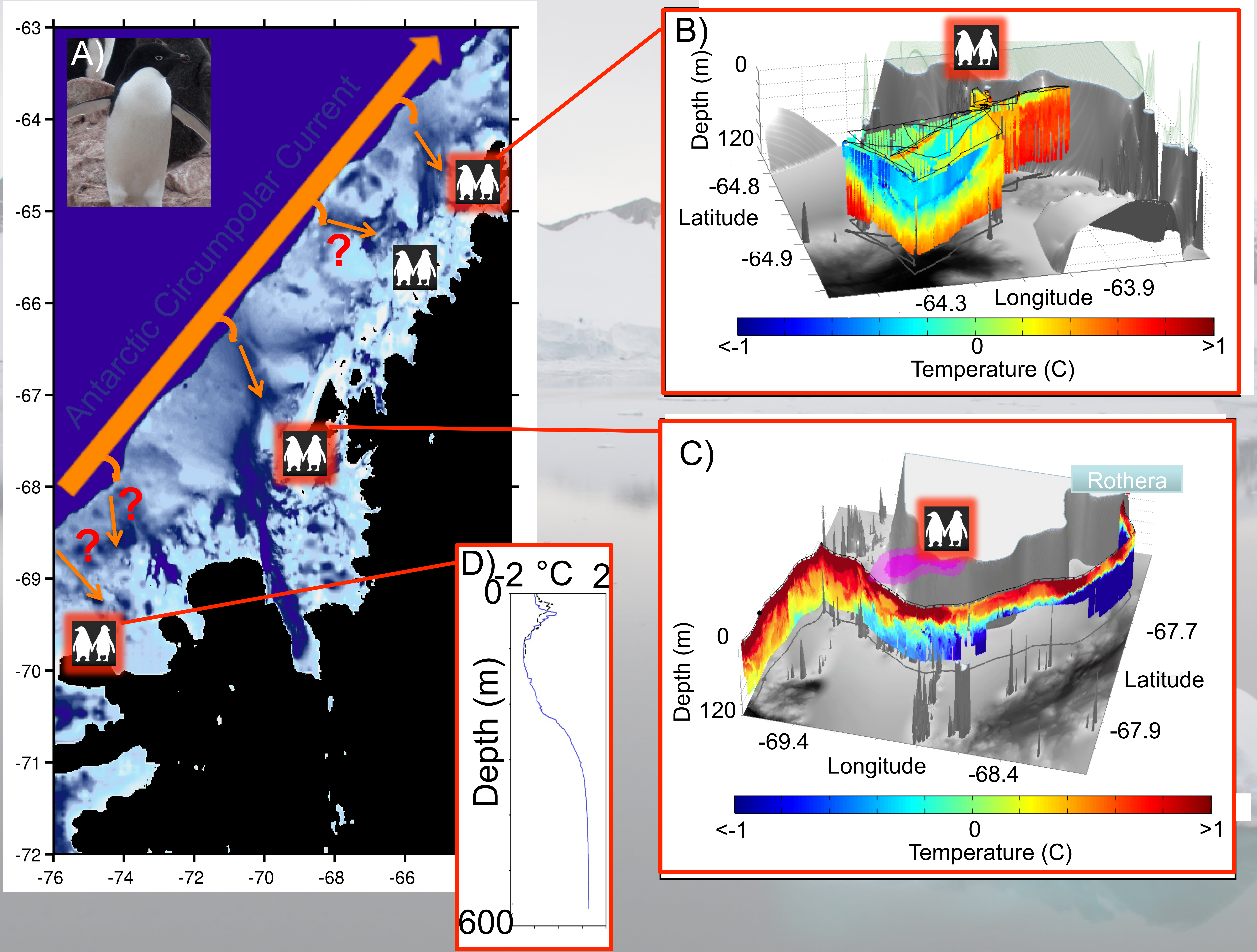
To be expanded by NASA grant awarded in Dec.


Anvers Island

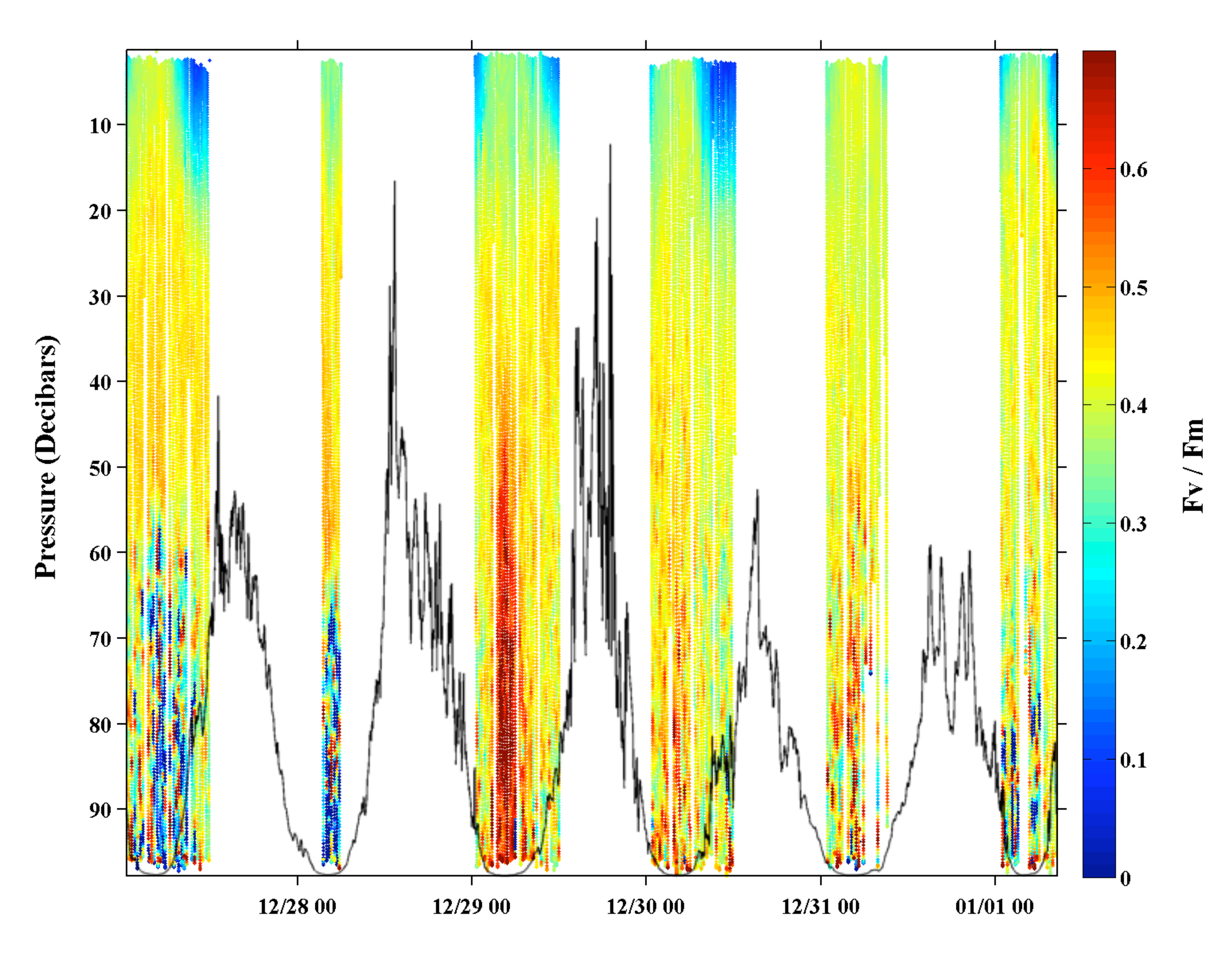
# Enhanced productivity is associated with the warm upwelled water

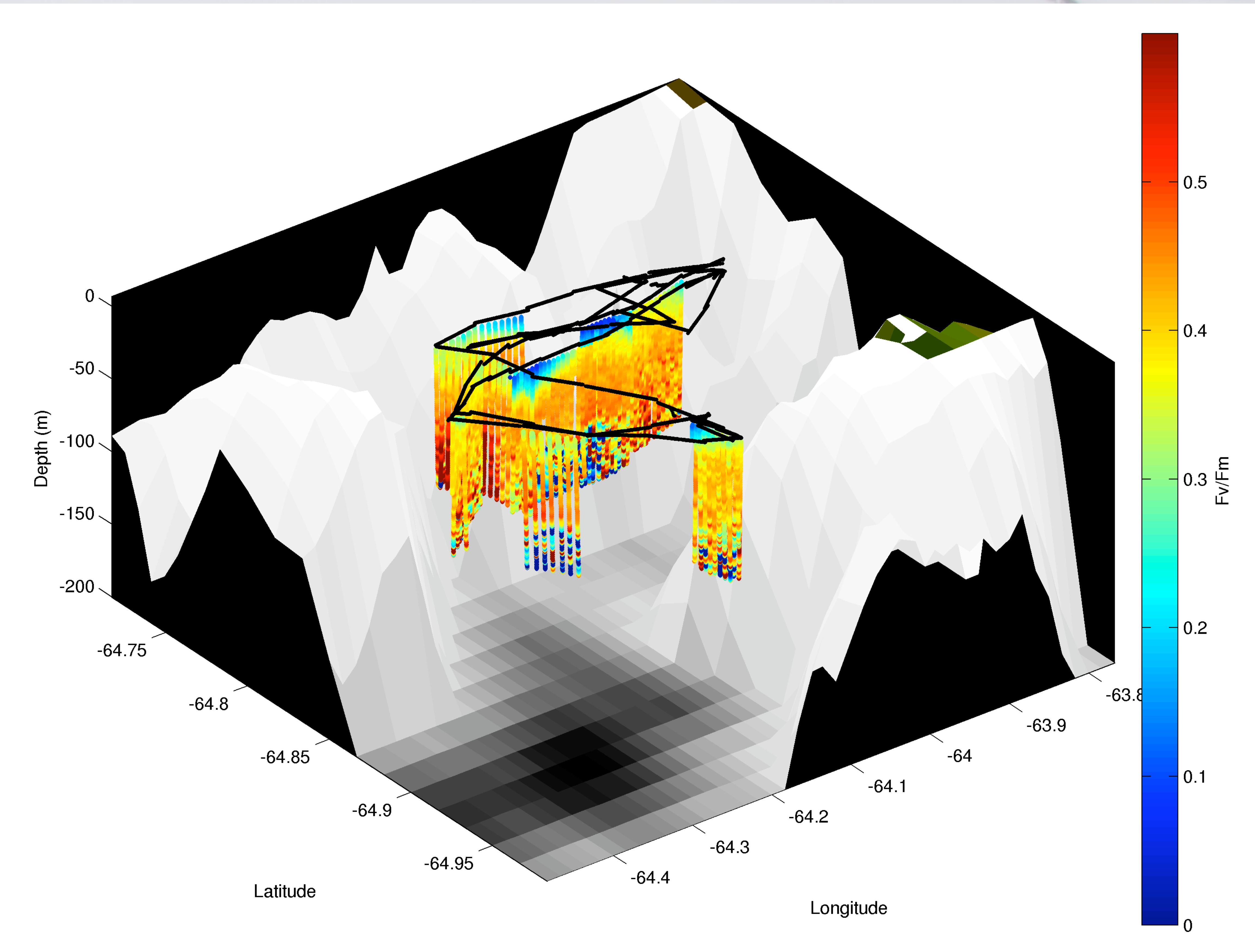



A)
Antarctic Circumpolar Current
?
?
?
-63
-64
-65
-66
-67
-68
-69
-70
-71
-72
-76
-74
-72
-70
-68
-66
B)
Depth (m)
0
120
-64.8
Latitude
-64.9
-64.3
Longitude
-63.9
<-1
0
>1
Temperature (C)
C)
Rothera
Depth (m)
0
120
-67.7
Latitude
-67.9
-69.4
Longitude
-68.4
<-1
0
>1
Temperature (C)
D)
-2
°C
2
0
Depth (m)
600

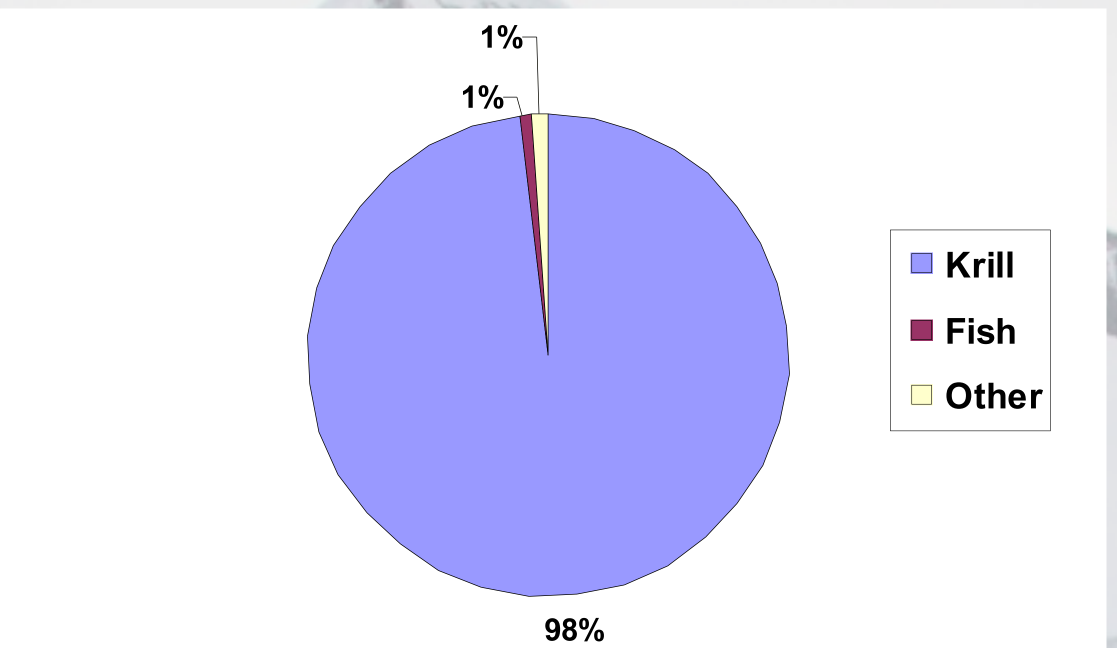
# Glider measurements of Fv/Fm indicate that the phytoplankton populations associated with upwelling are healthy

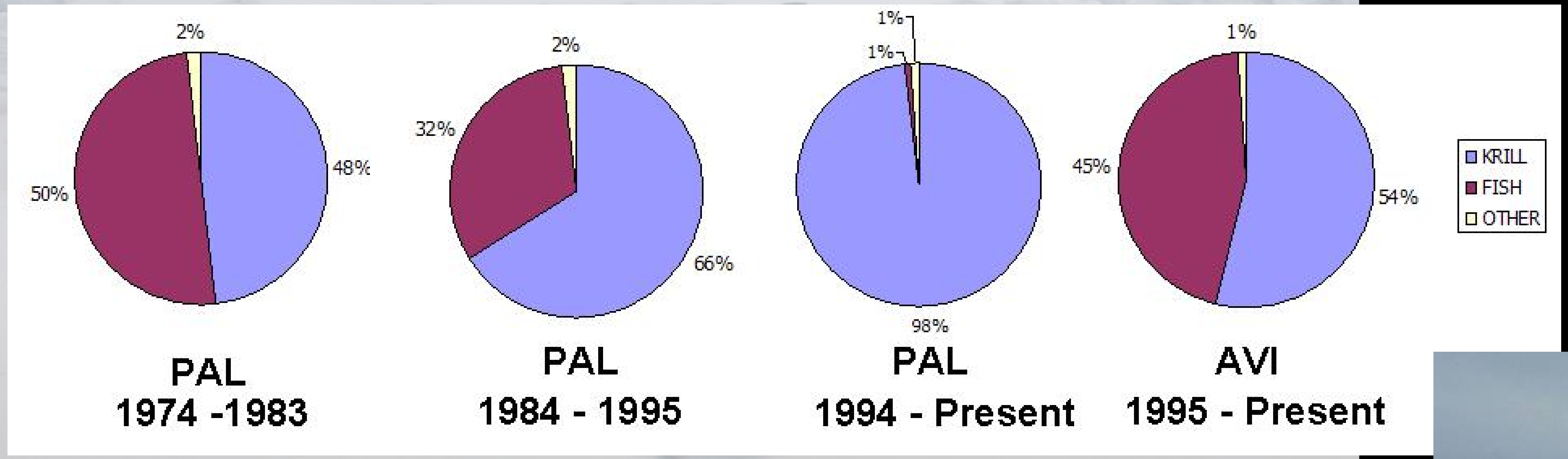


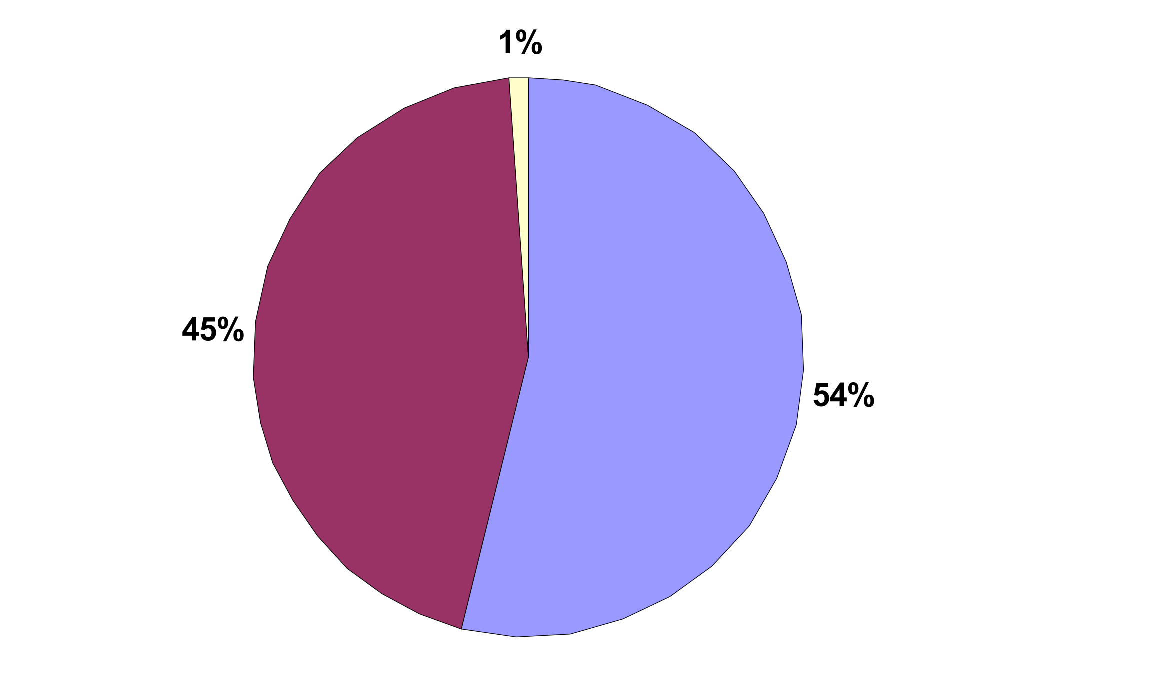
# Changing diets for the Adelie penguins

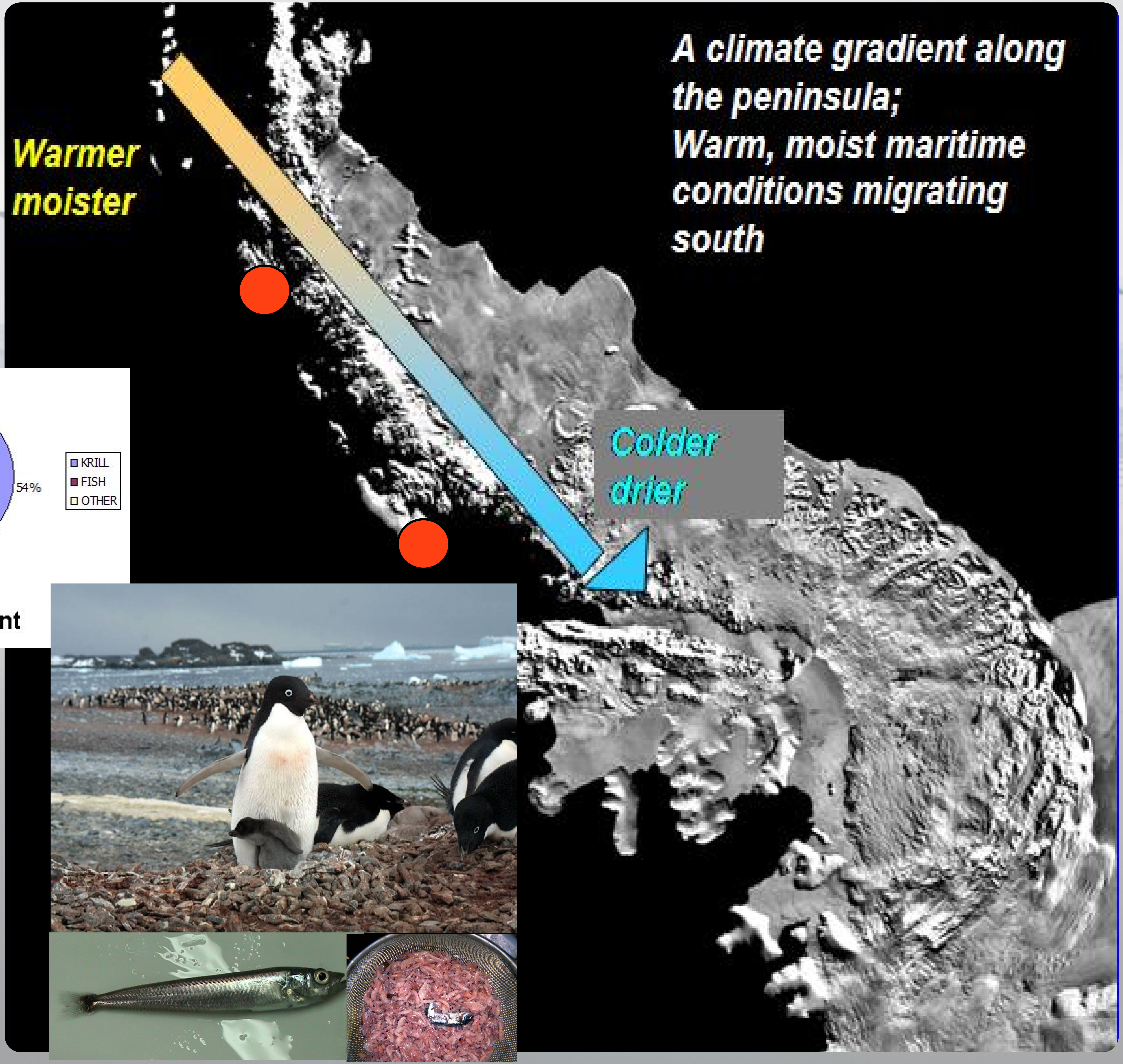
1994-present



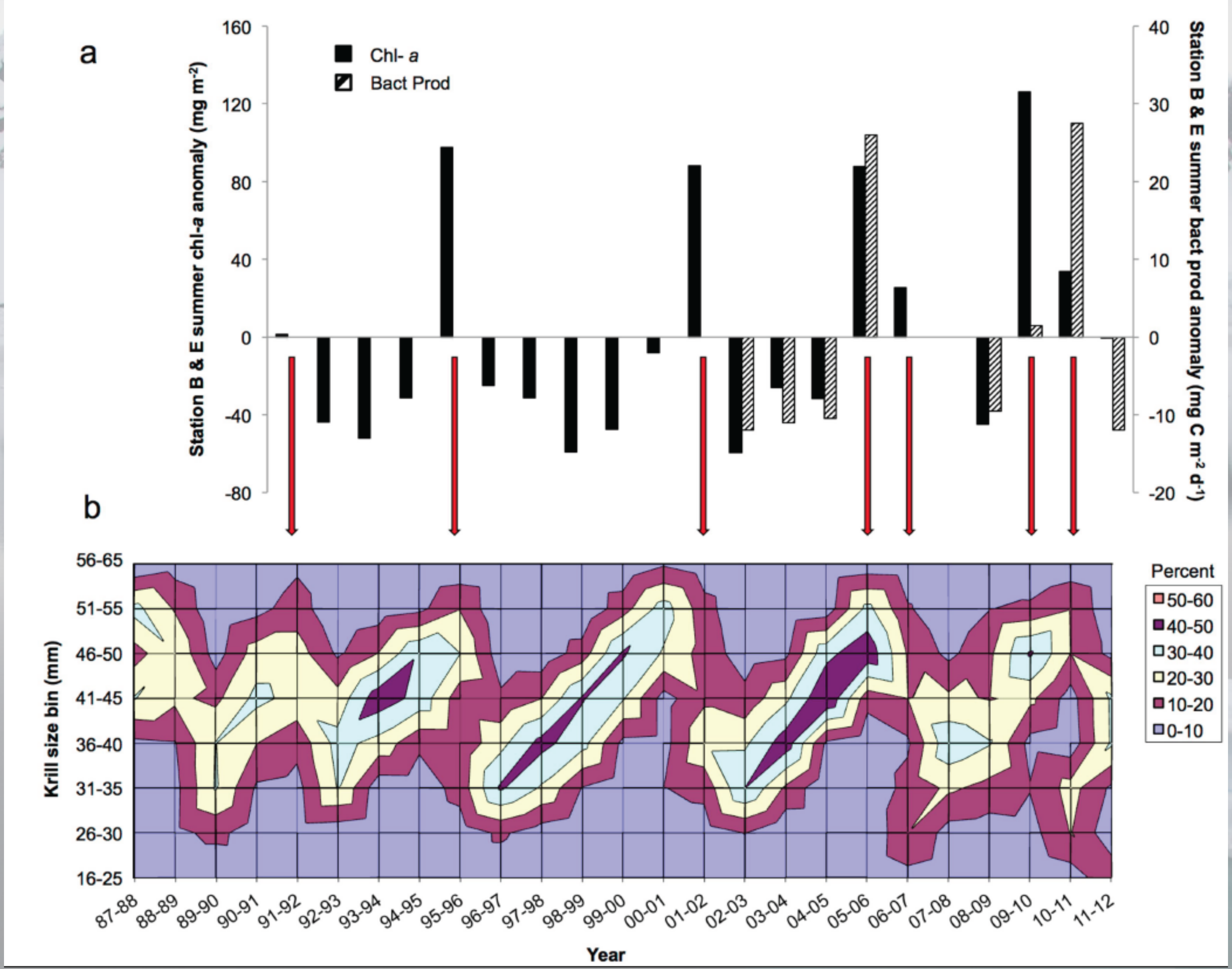




1995-present



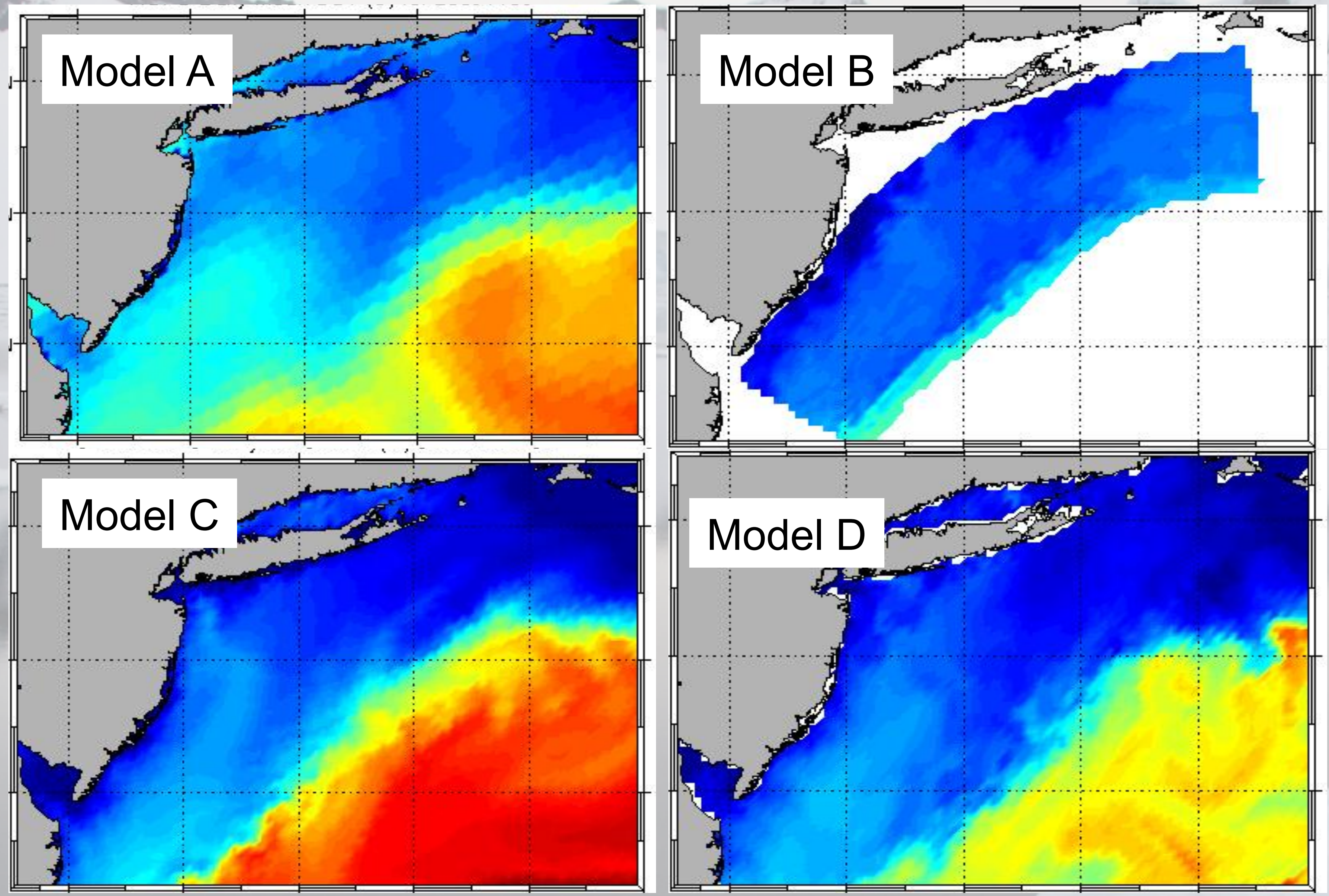



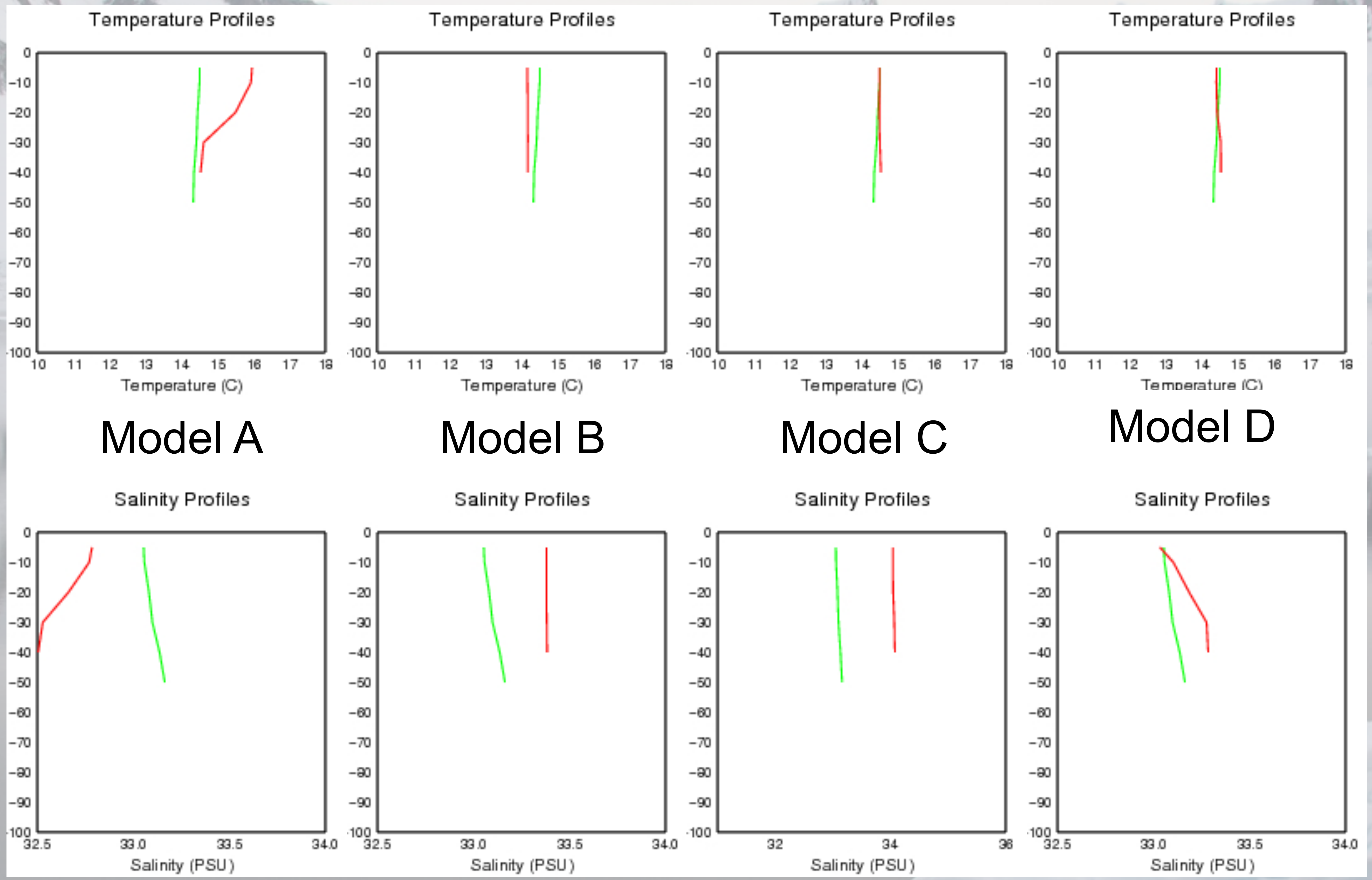
# Big Ice Winters Drive the Larger Phytoplankton Spring Blooms Which Primes the Food Web as a Whole



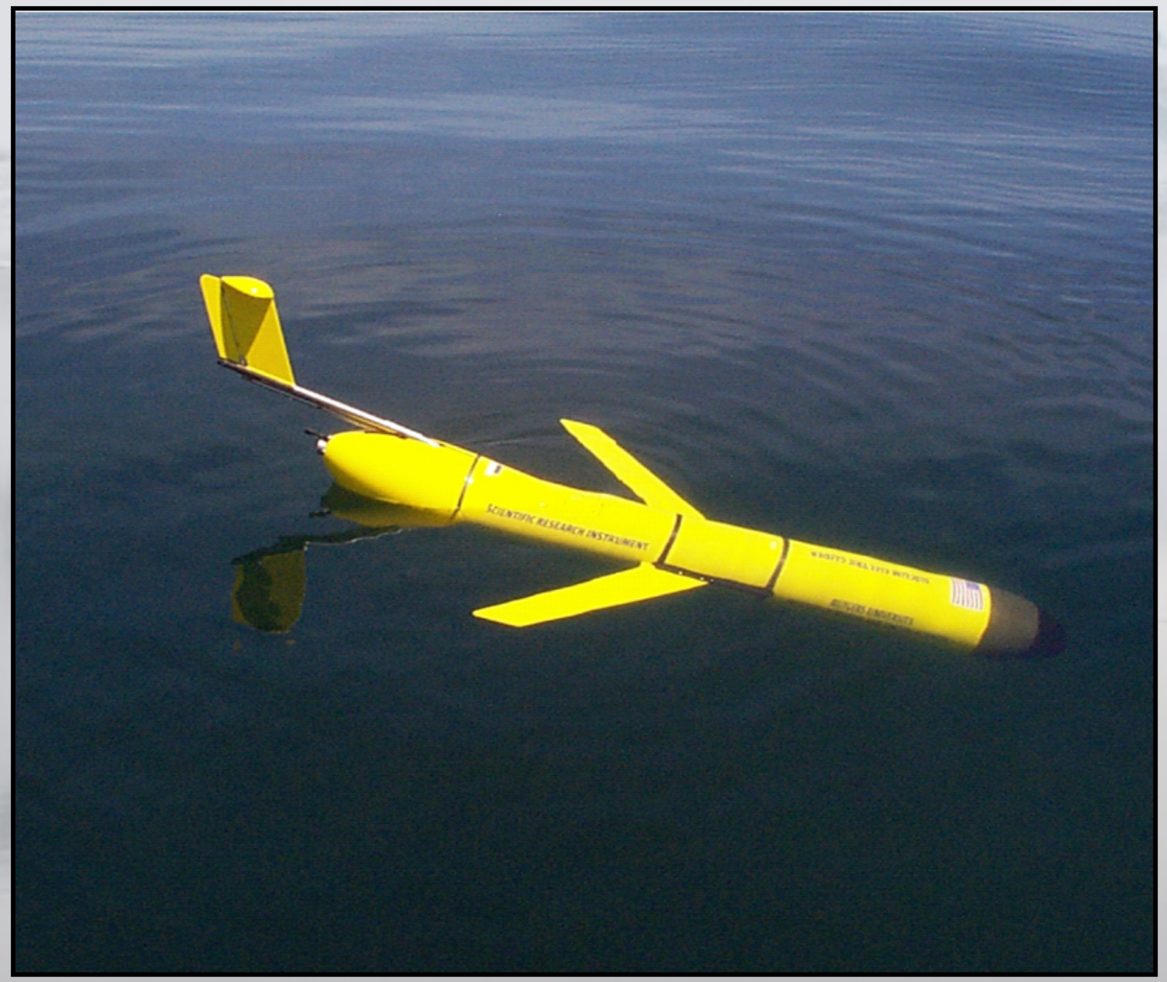

Design, Testing and Deploy
Observatory (simulated) data
Models
Sensor &
Platform
~3 km
~100 m
Virtual Ocean
Data Assimilation
RUTGERS
JERSEY ROOTS, GLOBAL REACH
I-COOL
International Coalition of Ocean Observing Laboratories
ARCHIVE FOR THE 'MIDDLE ATLANTIC BIGHT' CATEGORY
I-COOL Mission Blogs
Historic Blogs
Update on a cloudy Tuesday, but it is sunny in our heads....
NYHOPS Sfc Currents (m/s) for 2009–11–08 — Daily Mean
Observation
Salinity Profiles
Depth (m)
Salinity (PSU)
Data
Analysis
Science Questions & Drivers
Data Synthesis: Nowcast & Data Impact

An ensemble of different numerical models run by different laboratories

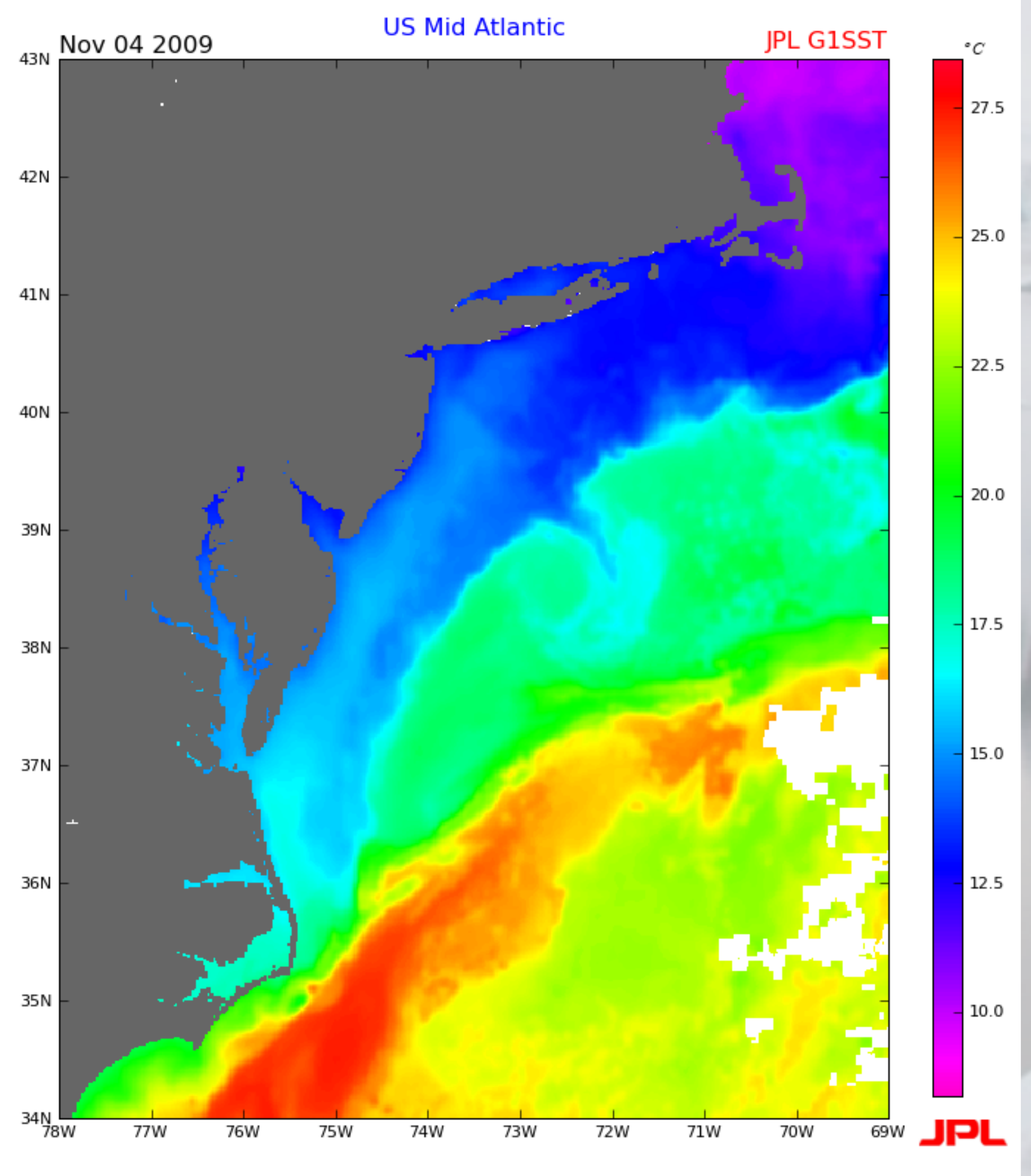



Temperature Profiles
Temperature (C)
Model A
Model B
Model C
Model D
Salinity Profiles
Salinity (PSU)

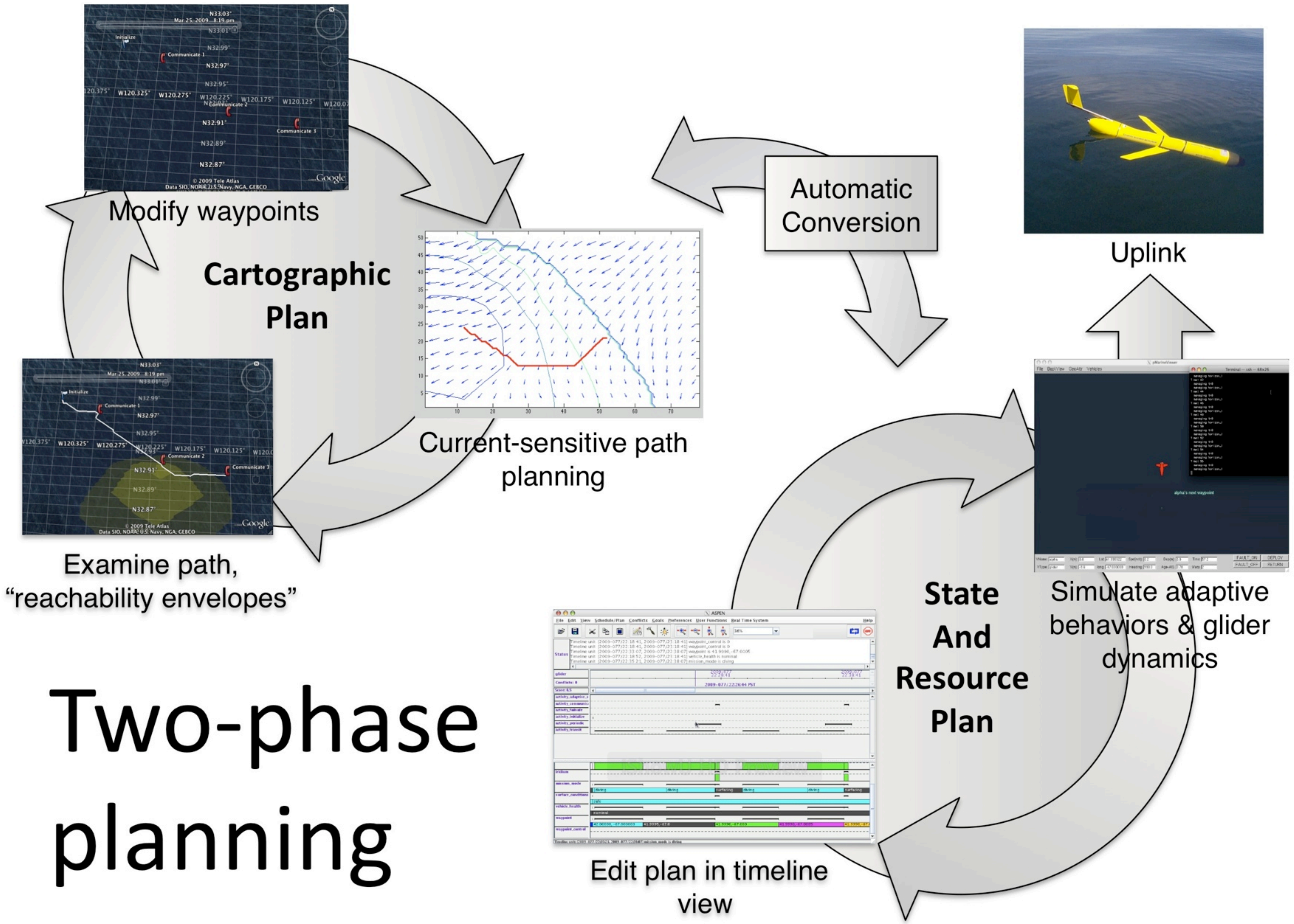
# COMBINING THE FIELD ASSETTS WITH OCEAN FORECASTS FOR PLANNING AND PROSECUTION EFFORTS



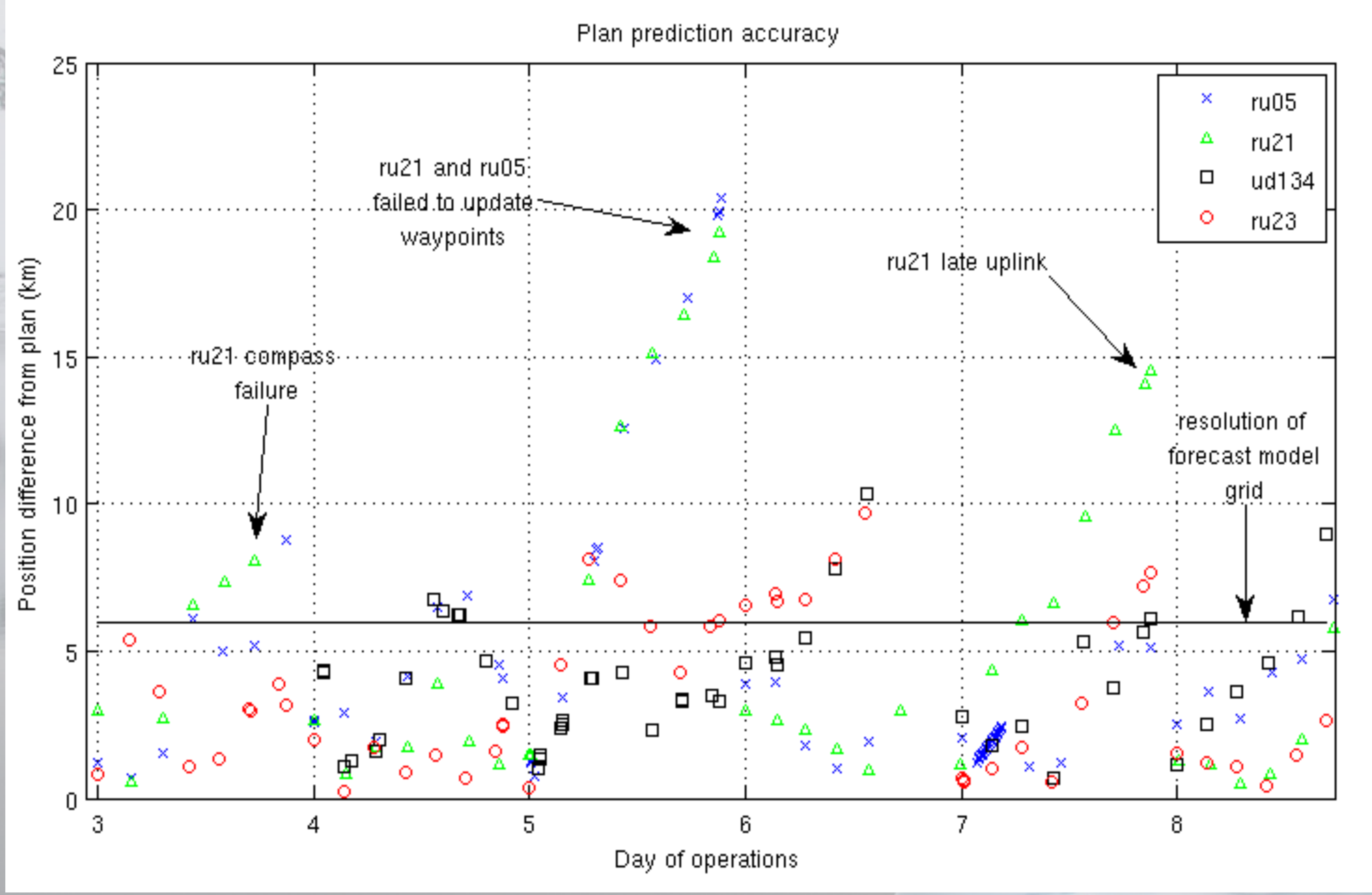
- Known constraints (slow 0.5 knot, Battery, shipping lanes)
- Uncertain constraints (time-varying 3D currents)
- Operate autonomously & re-plan daily

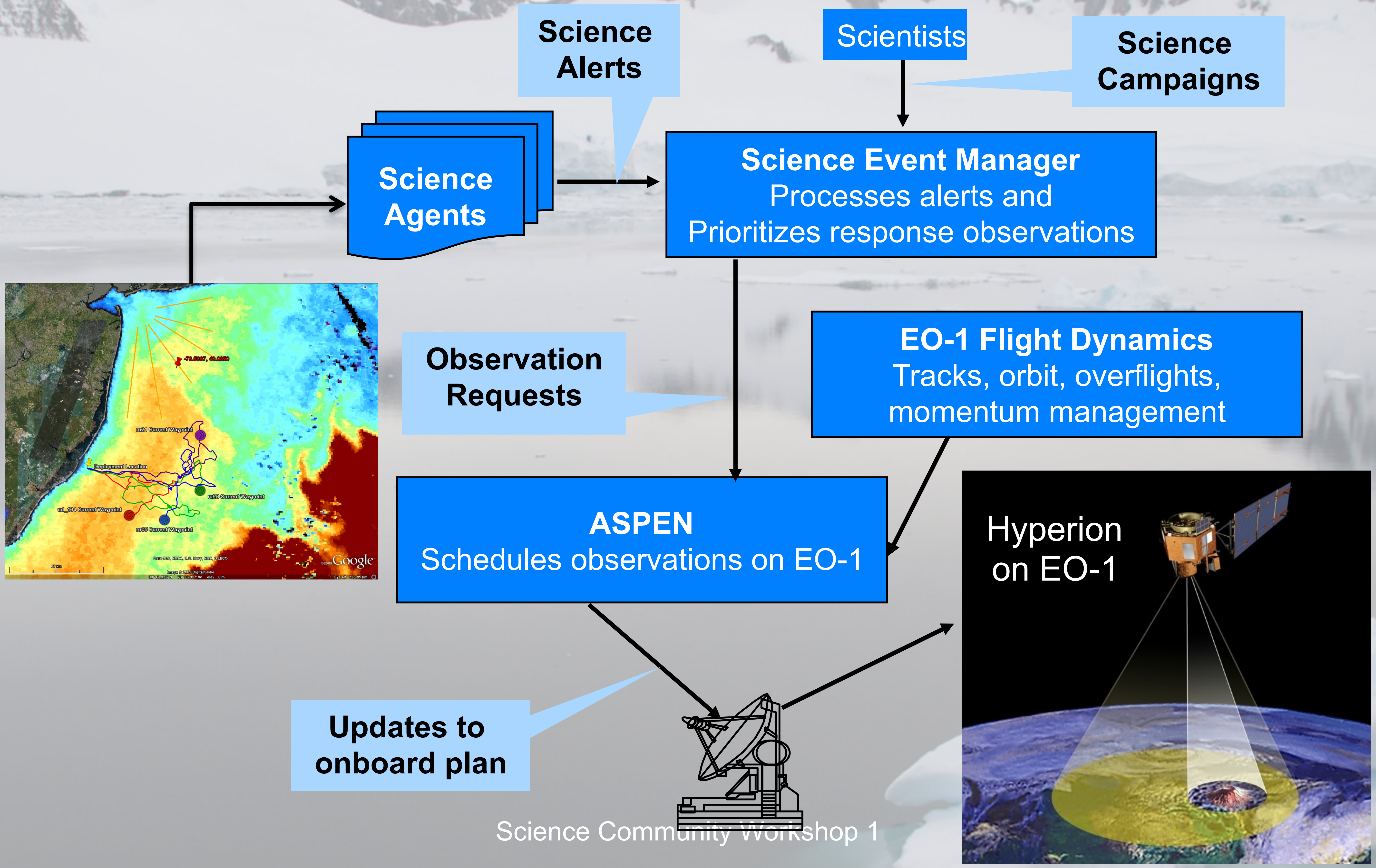


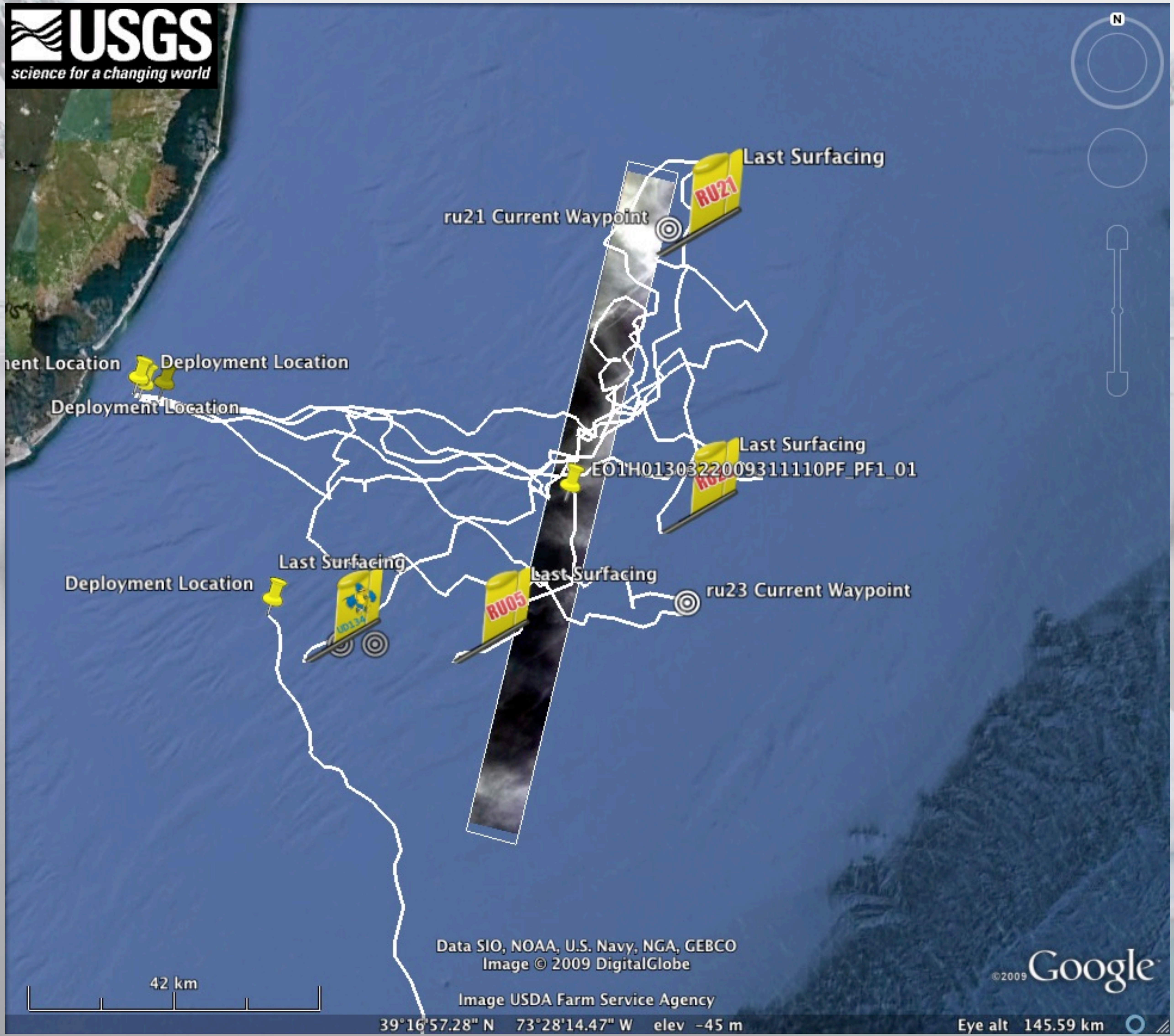

- From A to B in the shortest time
- Follow a time-varying feature (shelf-slope salinity intrusion)




# Two-phase planning


Plan prediction accuracy
Position difference from plan (km)
Day of operations
ru05
ru21
ud134
ru23
ru21 and ru05
failed to update
waypoints
ru21 late uplink
ru21 compass
failure
resolution of
forecast model
grid
0
5
10
15
20
25
3
4
5
6
7
8


Science Alerts
Scientists
Science Campaigns
Science Agents
Science Event Manager
Processes alerts and
Prioritizes response observations
Observation Requests
EO-1 Flight Dynamics
Tracks, orbit, overflights,
momentum management
ASPEN
Schedules observations on EO-1
Hyperion
on EO-1
Updates to
onboard plan



USGS
science for a changing world
Last Surfacing
RU21
ru21 Current Waypoint
Deployment Location
Deployment Location
Last Surfacing
EO1H0130322009311110PF_PF1_01
Last Surfacing
Deployment Location
Last Surfacing
RU05
ru23 Current Waypoint
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2009 DigitalGlobe
42 km
Image USDA Farm Service Agency
©2009 Google
39°16'57.28" N 73°28'14.47" W elev -45 m
Eye alt 145.59 km

# Unfortunately scientists are not always good communicators.

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

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

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

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

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

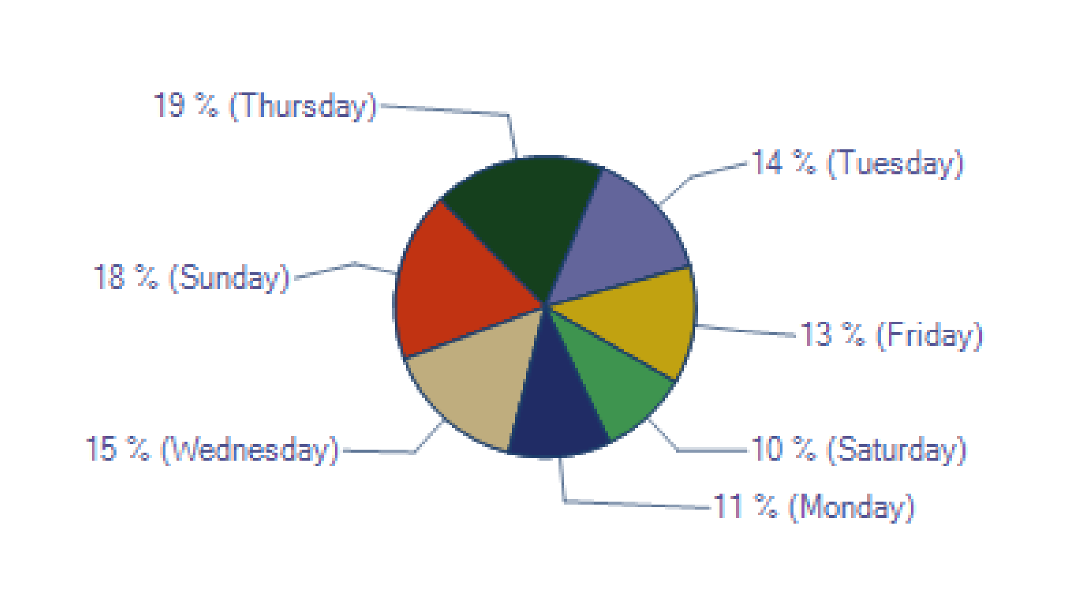
translation, "milk in my coffee please"

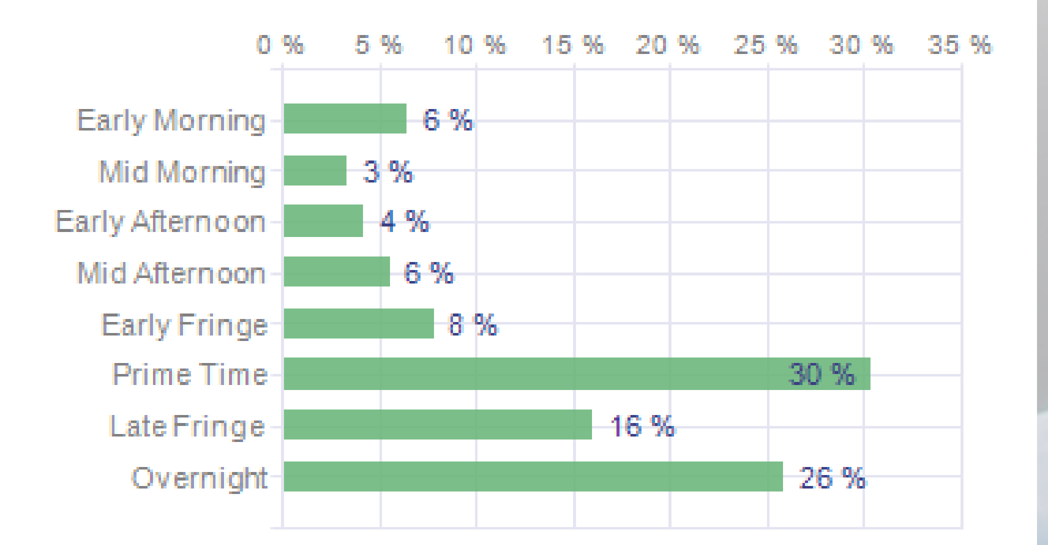
# Interaction between researchers and young filmmakers can translate research to a large public audience.


## Carriage Summary
### Atlantic Crossing: A Robot's Daring Mission
### 1/1/2010 - 2/19/2012

| | Telecasts | Stations | Markets | States | % Coverage |
|---|---|---|---|---|---|
| All Stations | 447 | 201 | 93 | 34 | 62.22 % |
| Main Channels | 201 | 115 | 66 | 28 | 46.83 % |
| Primary Stations | 79 | 50 | 49 | 24 | 28.57 % |
| Metered Stations | 215 | 83 | 37 | 25 | 49.37 % |
| Nielsen Channels | 199 | 112 | 66 | 30 | 48.33 % |

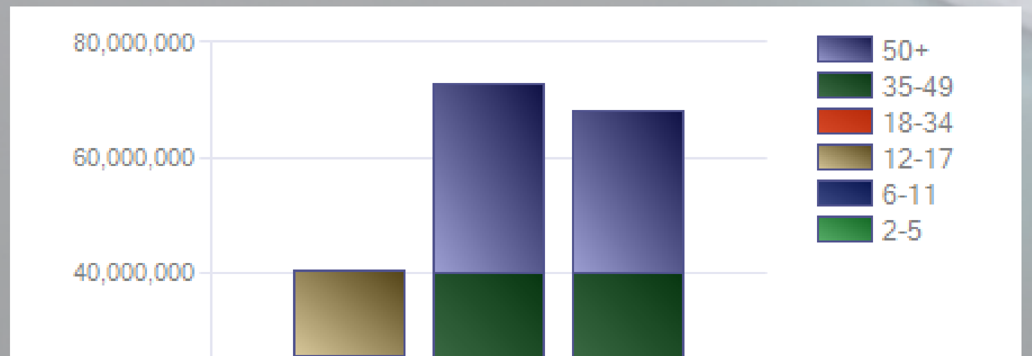
### Distribution of Airings by Day and Daypart

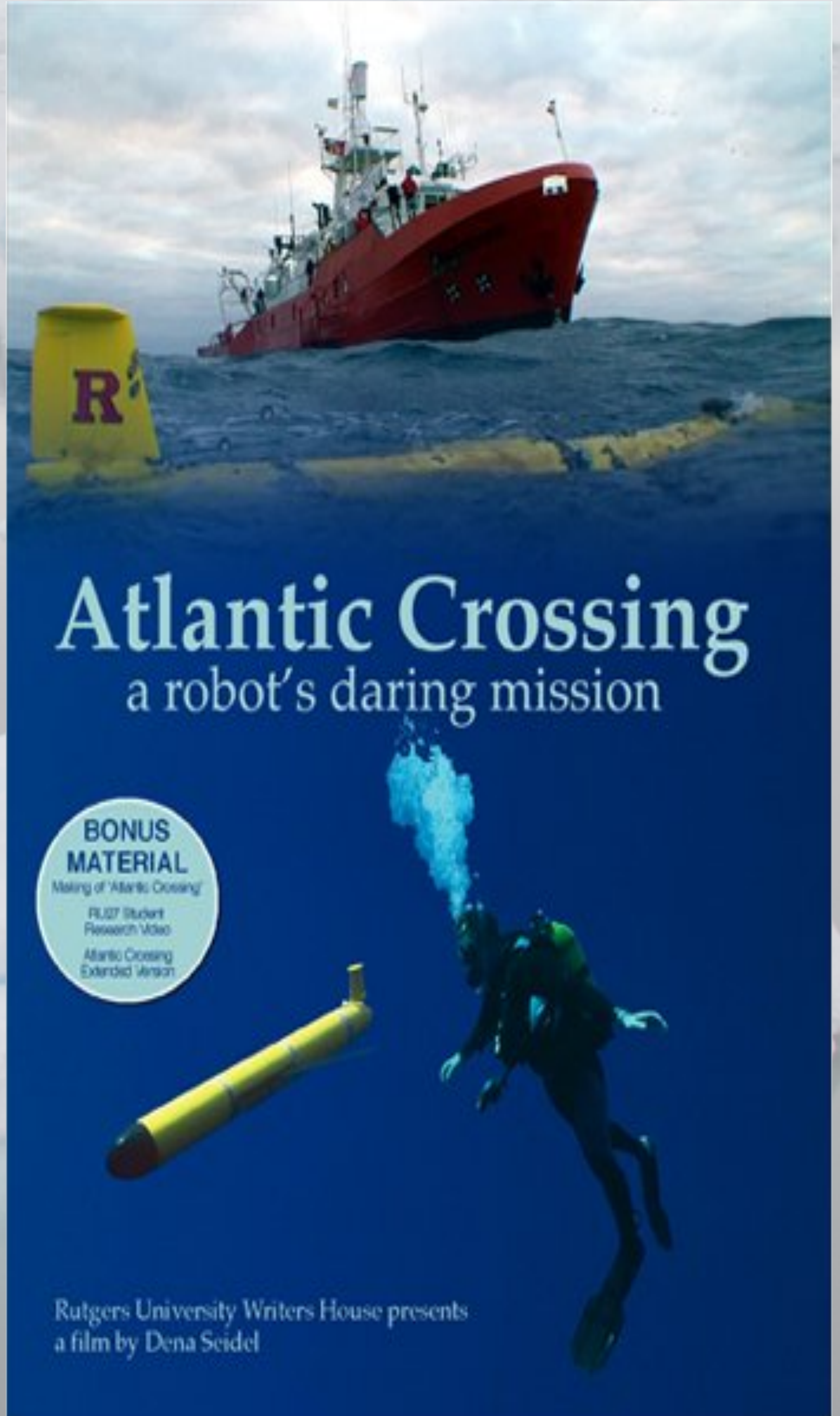


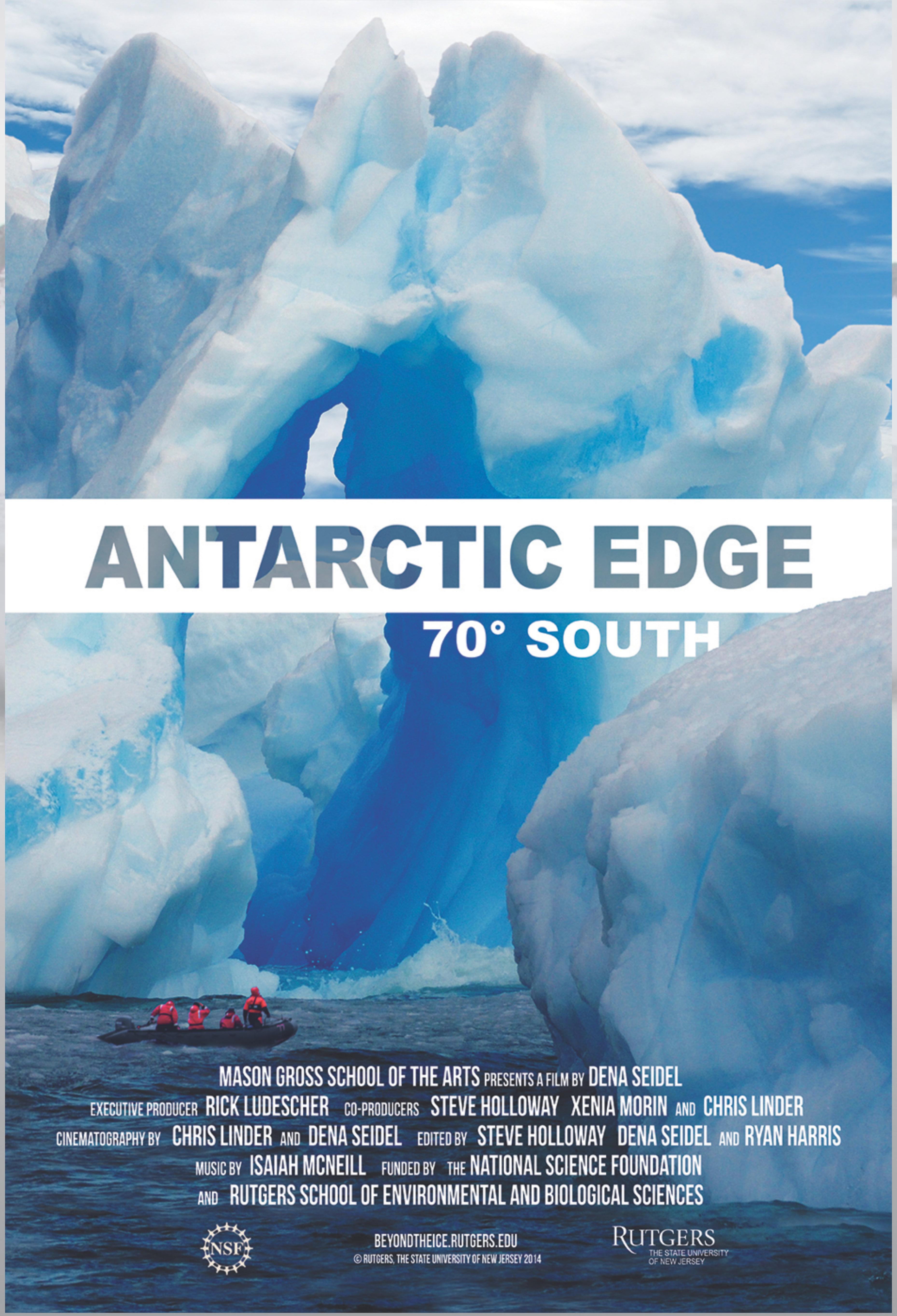




### Demographic Information of Potential Audience

| Demo Group | Men | Women | Total |
|---|---|---|---|
| People 2+ | | | 180,907,030 |
| DMA Households | | | 71,329,330 |
| Kids 2-5 | | | 10,218,649 |
| Kids 6-11 | | | 15,112,772 |
| Kids 12-17 | | | 14,878,666 |






THEATRICAL RELEASE
APRIL 17TH, NEW YORK CITY

# Conclusions:

Minor variations in the ocean state can have profound impacts on polar ecosystems

These profound changes are occurring in many polar oceans, changes appear to be accelerating

New technologies offer a mode to study and understand these changes, so it is time hopefully speed up our uphill trek to quantitative understanding, animals will help show us the way

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