



# OPERATION FREE BYRD

U.S. AMLR PROGRAM

# *Gliders and the U.S. AMLR Program*

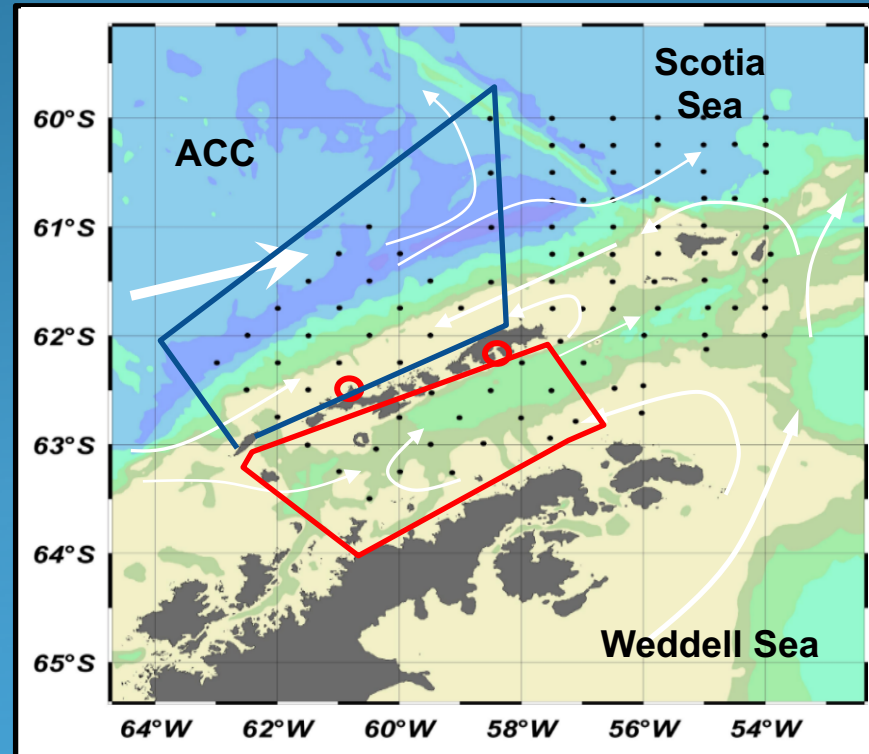
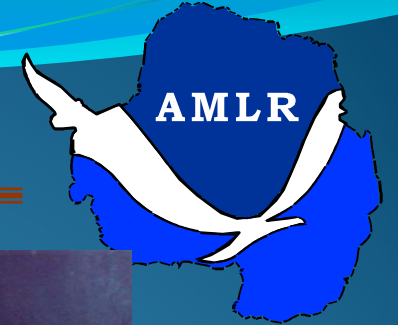
## *Developing an autonomous monitoring and assessment program in the Antarctic*

U. S. Antarctic Marine Living Resources Program (AMLR)

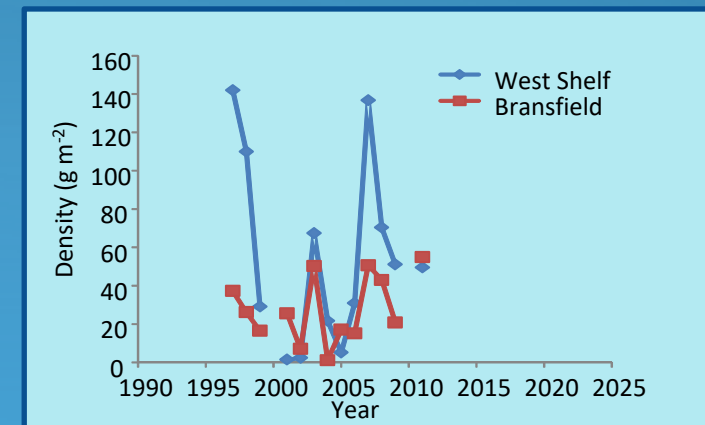
Antarctic Ecosystem Research Division

Southwest Fisheries Science Center, NOAA Fisheries

# Long-term ecosystem assessments based on shipborne studies



Krill Density



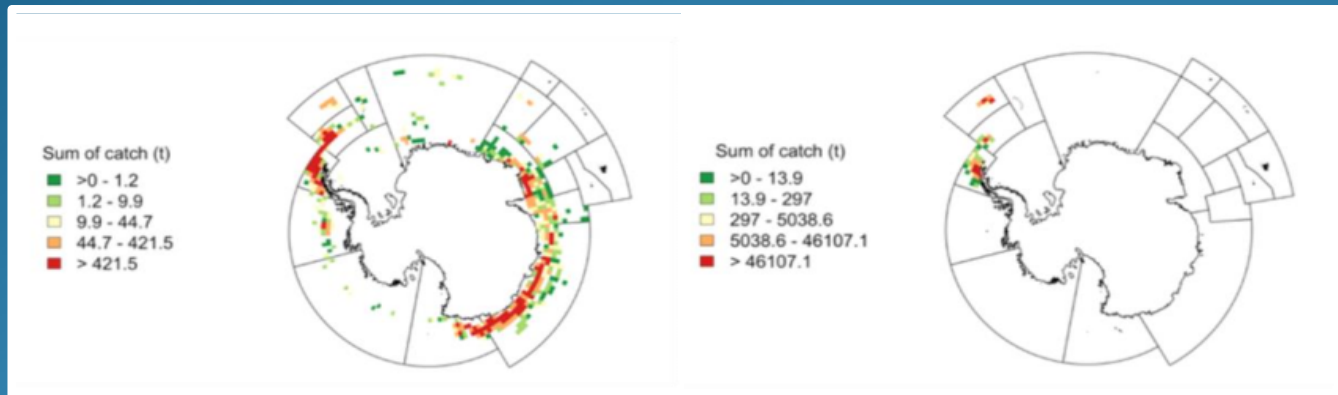


# Time and spatial scales of management have changed

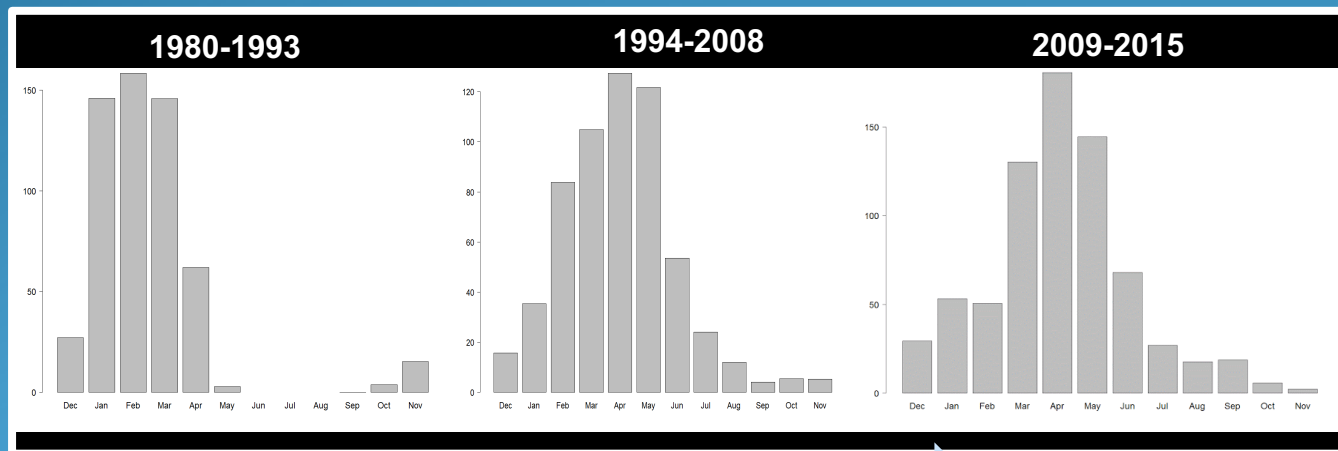


1970s

Present



Concentration of fishing effort and extraction



Shifts in the seasonality of the fishery  
(climate and commercial)

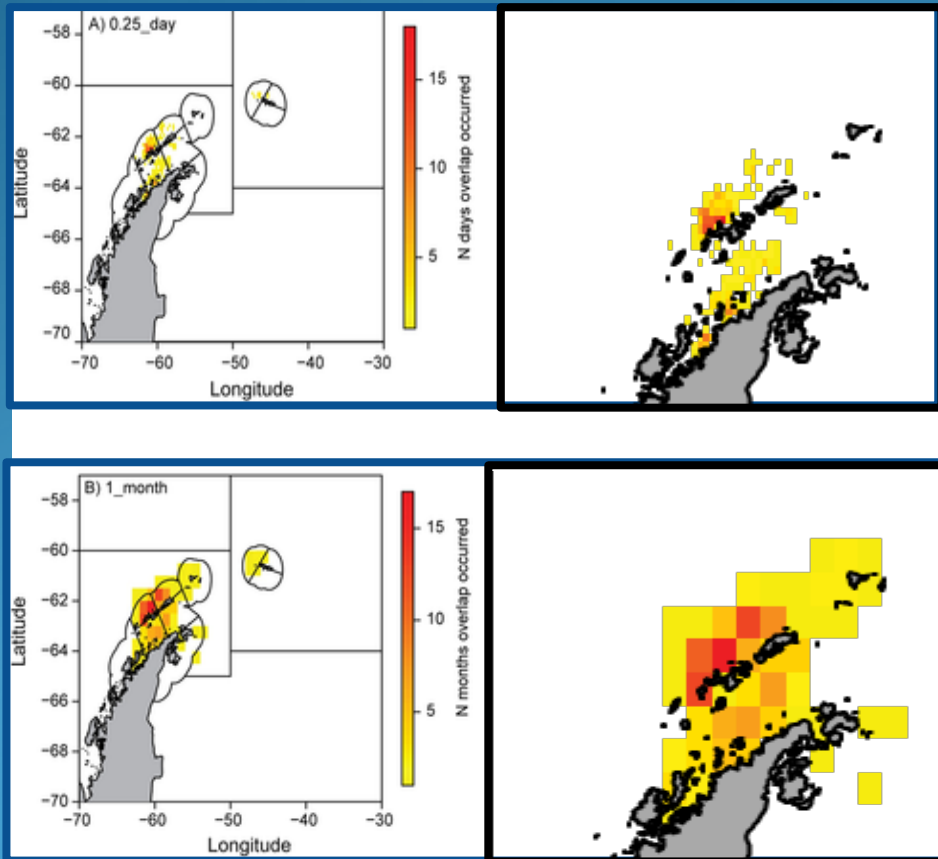
Fishery shifting



# Changing fisheries means changing interactions



Overlap between predators and the krill fishery



Management implications

Time and space scales of interactions are changing

Fishery allocations based on broad average biomass less relevant

Solution

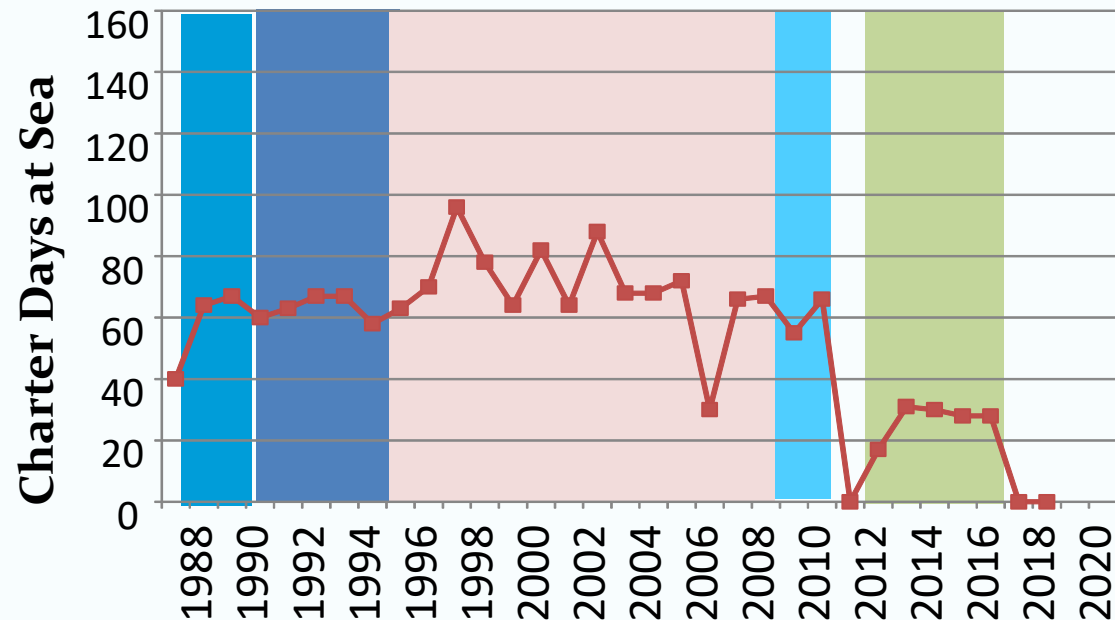
Monitor krill / predator / fishery issues at smaller scales

Develop management strategies for finer scales

# Costs of shiptime are prohibitive



U.S. AMLR Program



Flat / declining budgets  
Increasing costs  
Not flexible,  
Ultimately, not sustainable

Impacts at-sea and land-based programs

# How do we develop a new paradigm to replace annual cruise?

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## Needs

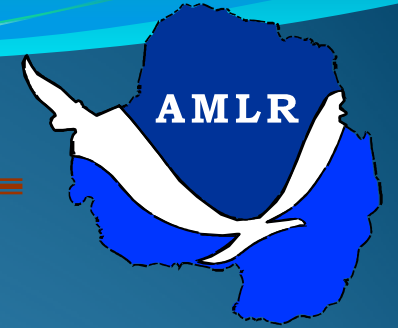
- A) Continue to estimate krill biomass for time-series
- B) Estimate krill flux and predator prey fishery interactions

## Constraints

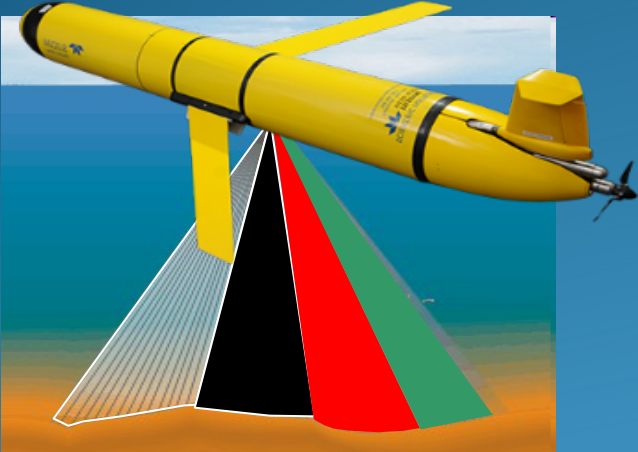
- 1) Must be flexible
- 2) Must be cheap (er than a ship charter)
- 3) Must be sustainable
- 4) Must be manageable by a small group (4-6)
- 5) Must provide data needed for management



# Idea



Acoustic equipped gliders



GPS TDR tags



Replace ship to be flexible

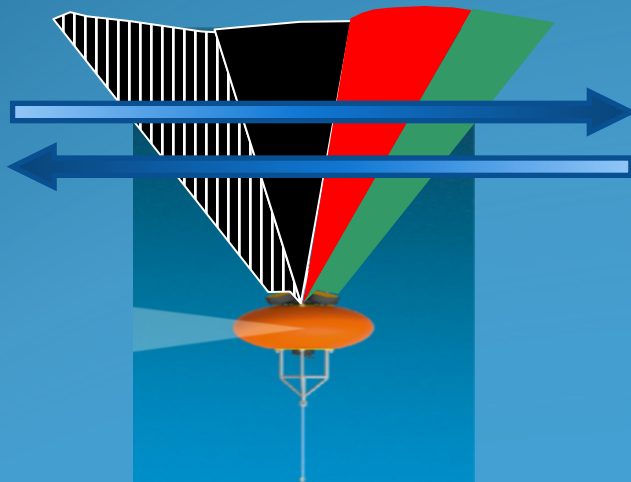
Measure interactions and variables at a variety of scales

Reinvest resources at camps

Use camera systems to extend and expand land-based studies

Aerial drones for counting populations

Shorter time at camps



Acoustic equipped ADCPs

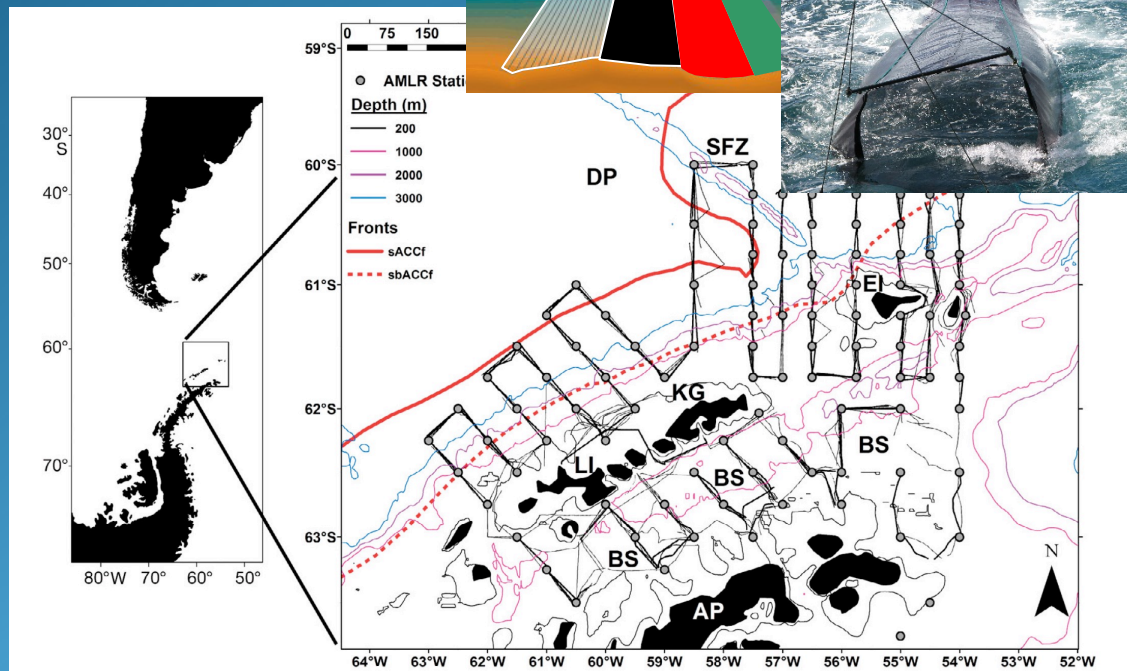
Autonomous camera systems



# Replace ship surveys with glider surveys

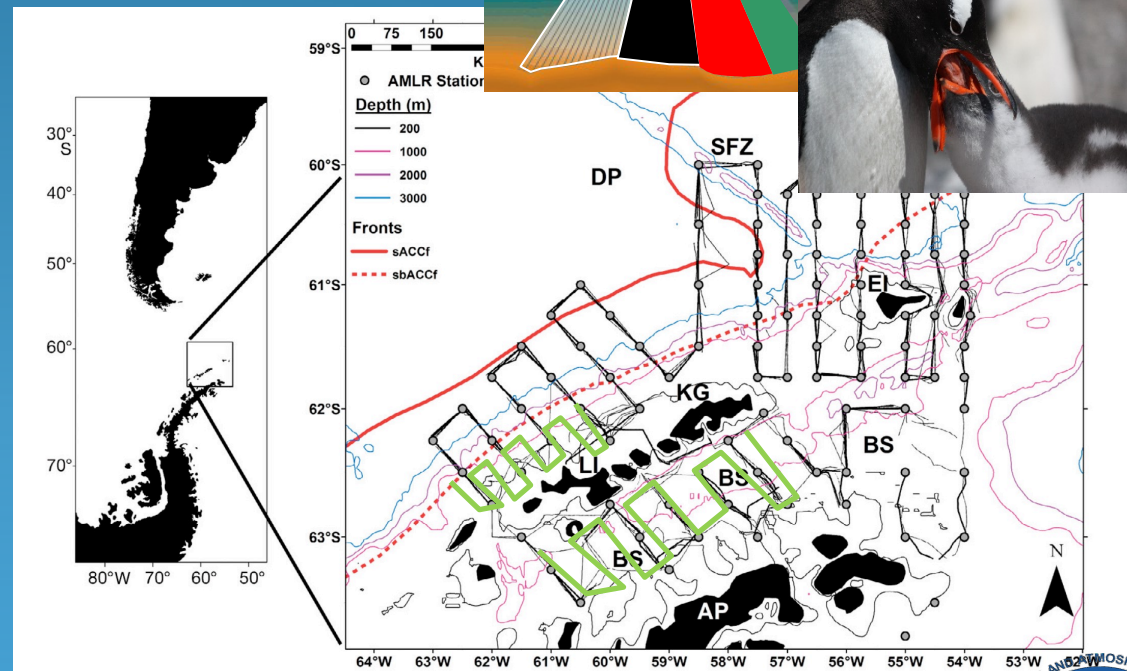
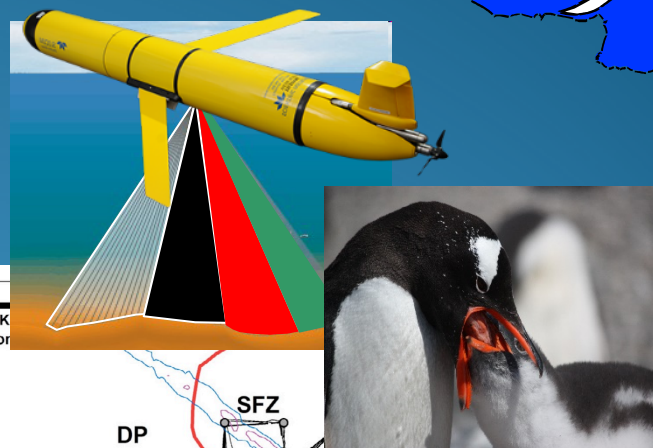


Traditionally



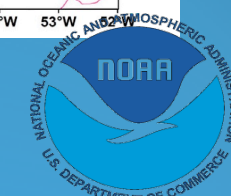
(e.g., Santora et al. 2010)

Autonomously



## And still meet the assessment requirements

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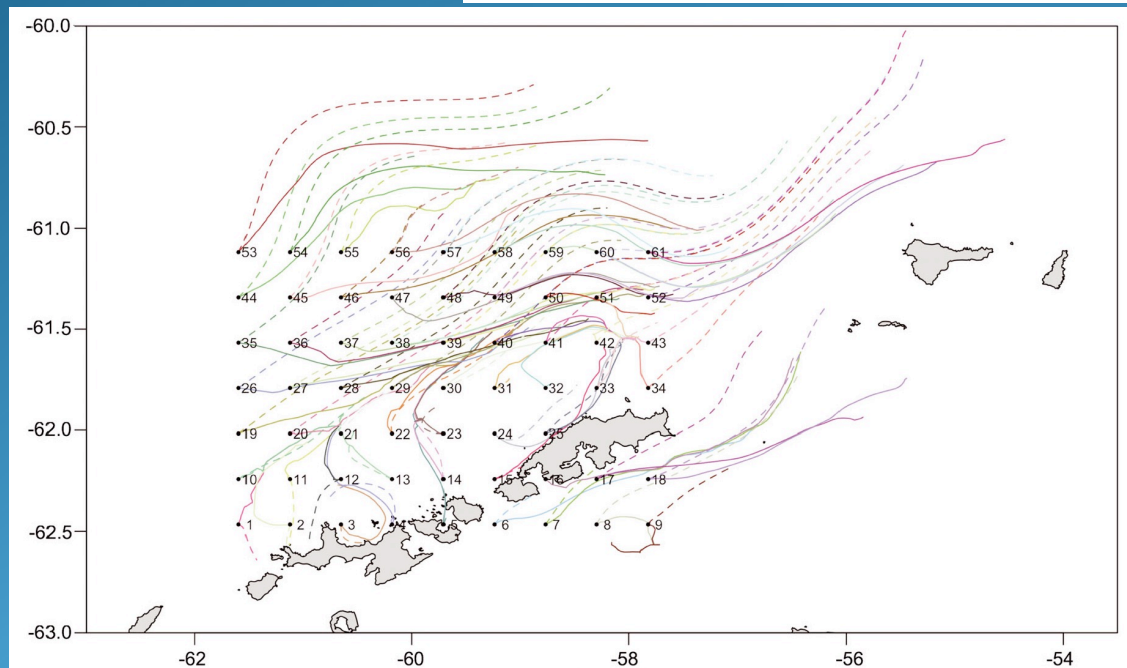


# Use acoustic moorings to estimate krill flux



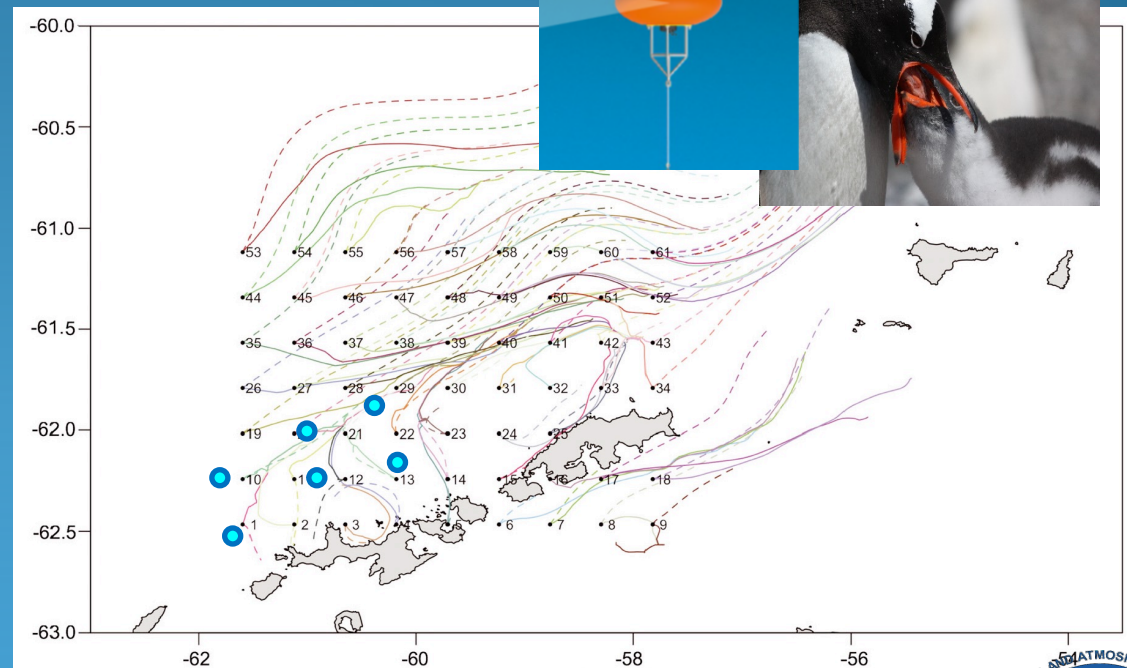
Traditionally

$$F(l, \vec{x}, t) = \max_{\vec{m}} [e^{-\beta(x)} \cdot F(l', \vec{x}', t+1)]$$



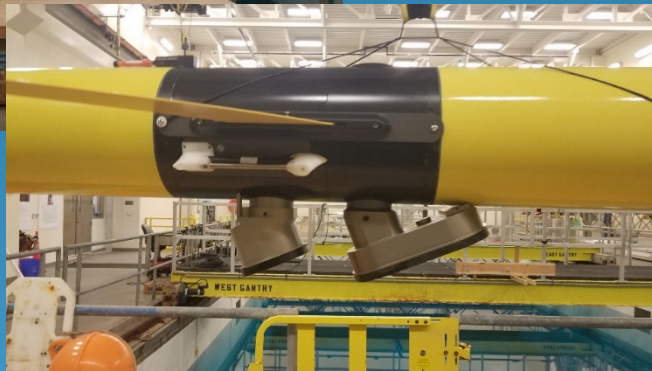
(e.g., Richerson et al. 2015)

Autonomously





# Going All In (2017-18)



## GLIDERS

Developed a standard glider configuration

Four Teledyne G3 1000m Gliders (2.7 m, 100kgs)

- a) Seabird CTD
- b) Aanderaa Oxygen Optode
- c) Ecopuck (fluorometer, backscatter, CDOM)
- d) Extended battery bays
- e) propeller

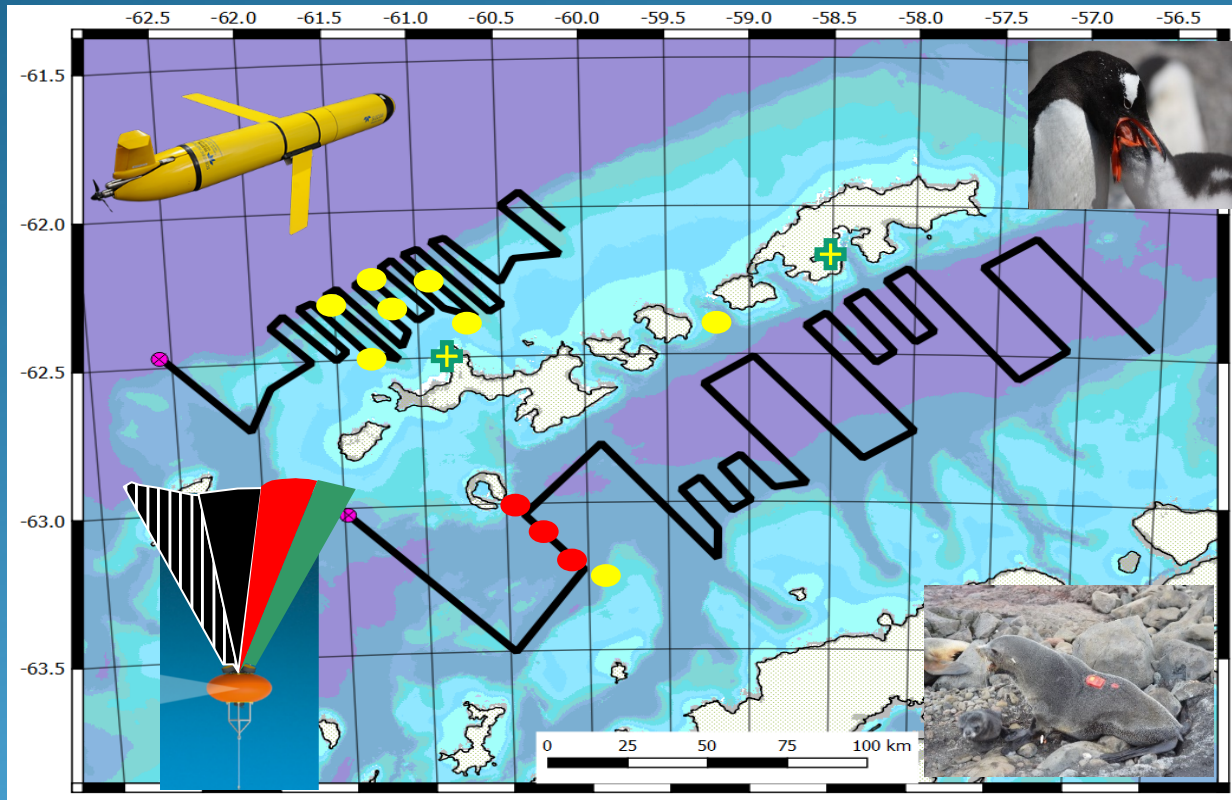
Active Acoustic Package - Three frequency ASL AZFP (38, 67, 125kHz); Single beam, Narrow band



## MOORINGS

Eight NORTEK Signature 100 integrated ADCPs and wideband echosounder (70 to 120 kHz) / CTDs

# Our goal for first deployment (2018)



Multiple gliders (only two were ready)

Moorings 8 US AMLR, 3 IMR

Tags and other instrumentation  
on seals and penguins



# Jumping In! Less than 12 months (2018)



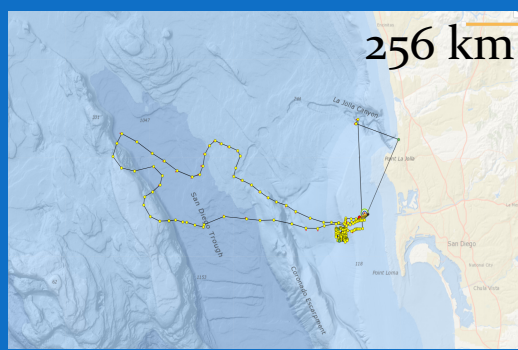
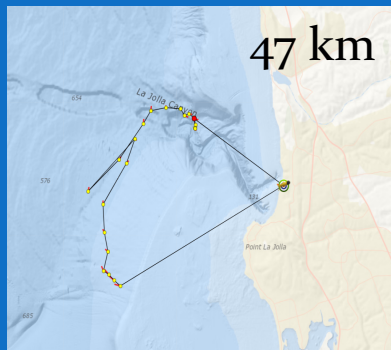
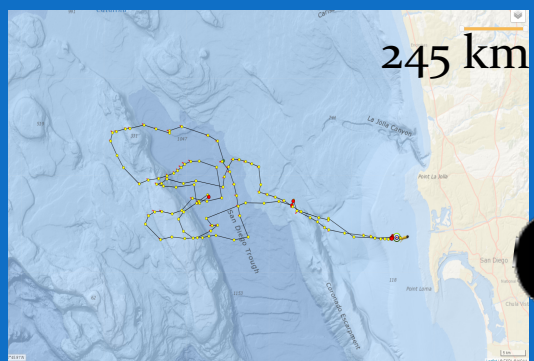
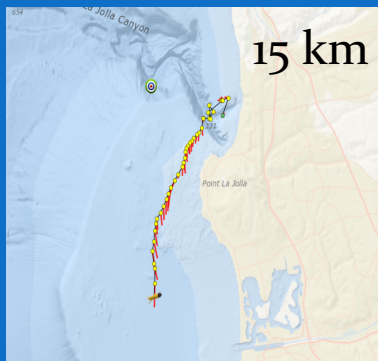
## Training

April (1 to 3 days)

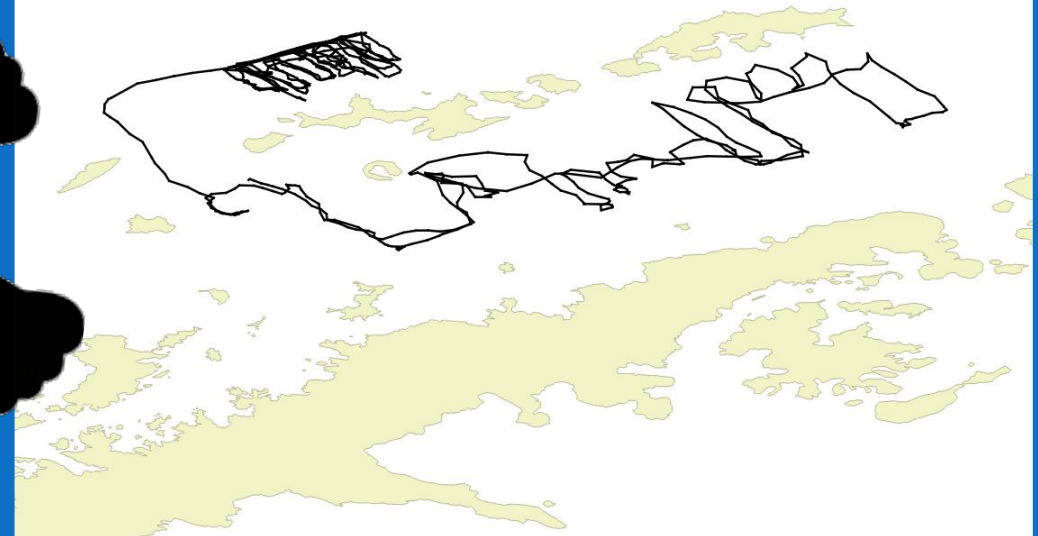
June-July (weeks)

## Deployment

December to March (months)



2,763 km (combined)





# Deployment details

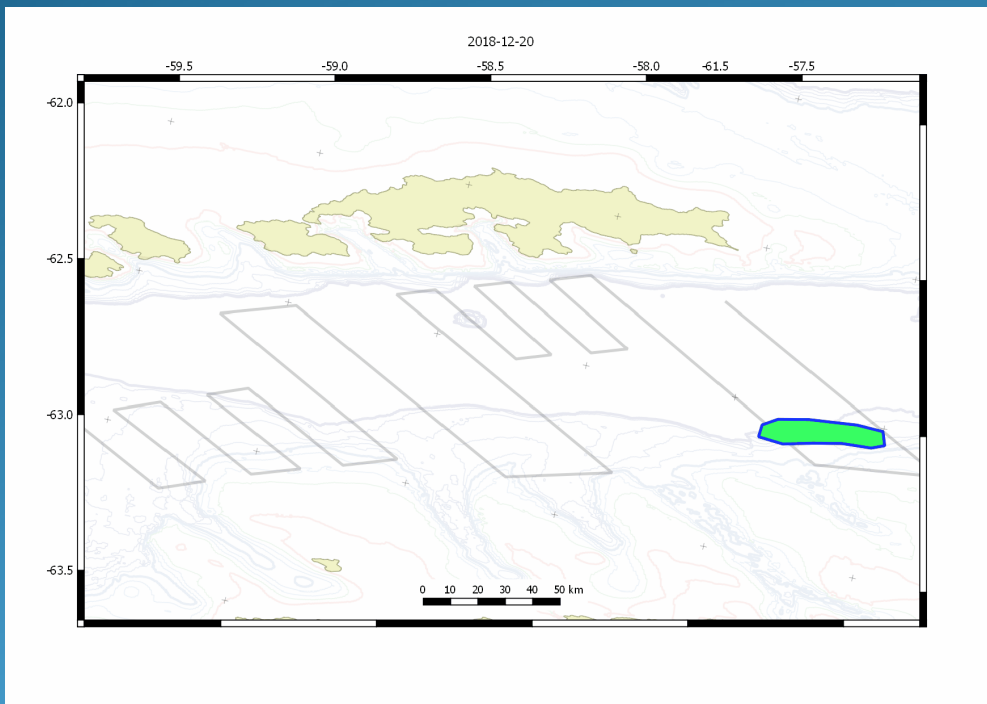


	Deploy Date	Recovery Date	Days	Distance (m)	Inflections	Profiles	Battery Consumption (Amp hrs)	Battery (%)	Number of Iridium Calls
AMLR01	12/16/18	3/8/19	82	1485	1426	684	409	57	470
AMLR02	12/11/18	3/8/19	87	1277	2815	1406	459	64	575

# Challenges to piloting



Icebergs ARE a major headache for pilots



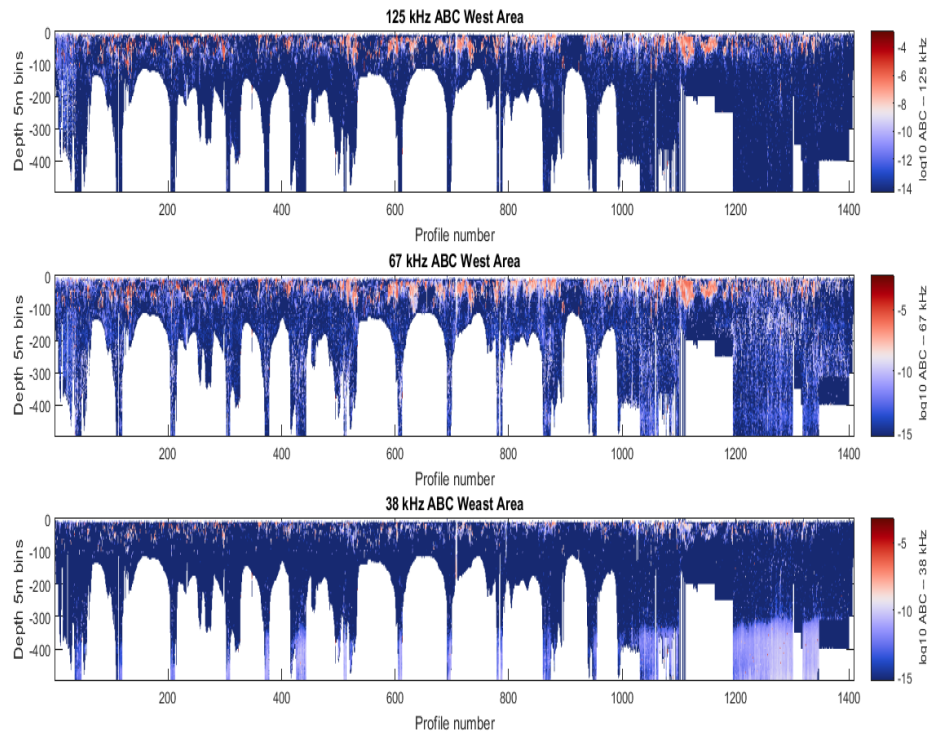
2,763 km (combined)



# Integrated acoustic observations

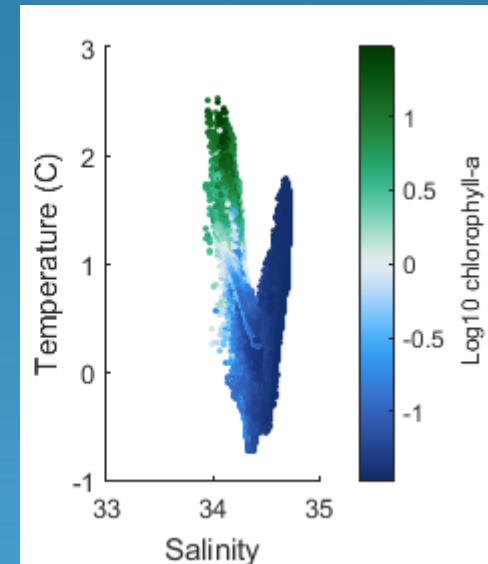


## Acoustic Profiles

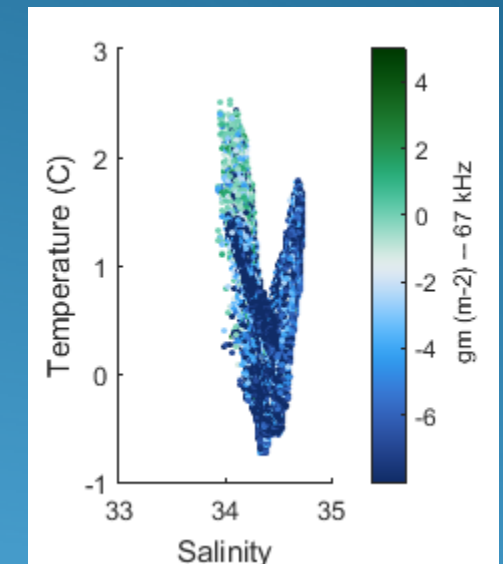


Calculate krill biomass

T- S- chl-a



T- S - gm<sup>-2</sup>



Fine scale environmental relationships



# So how did we do - Two major questions

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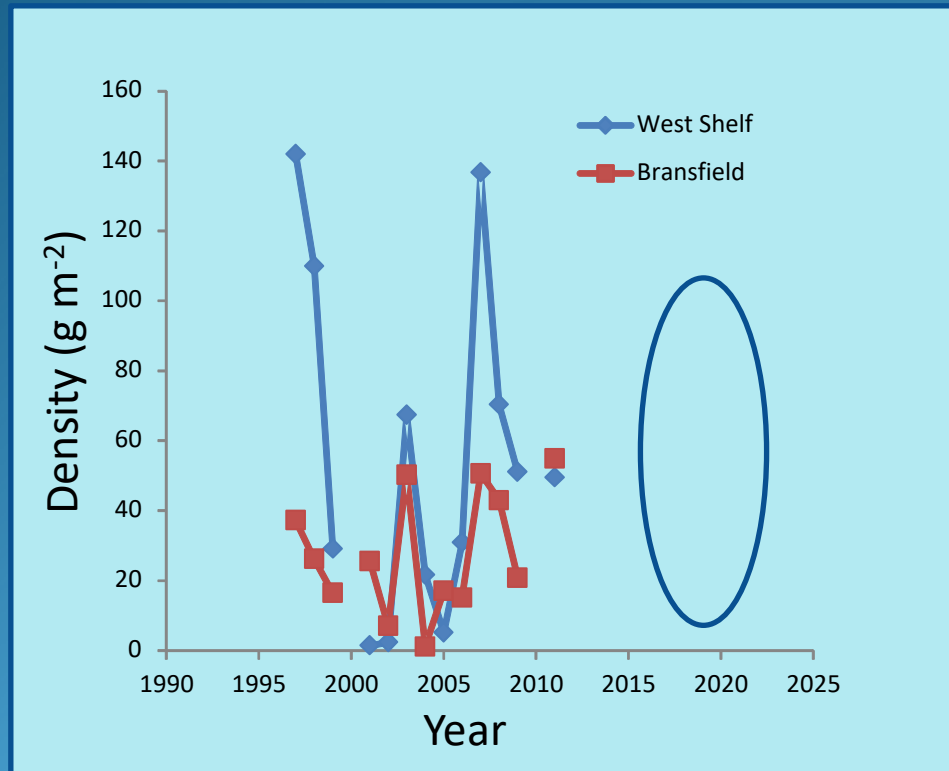


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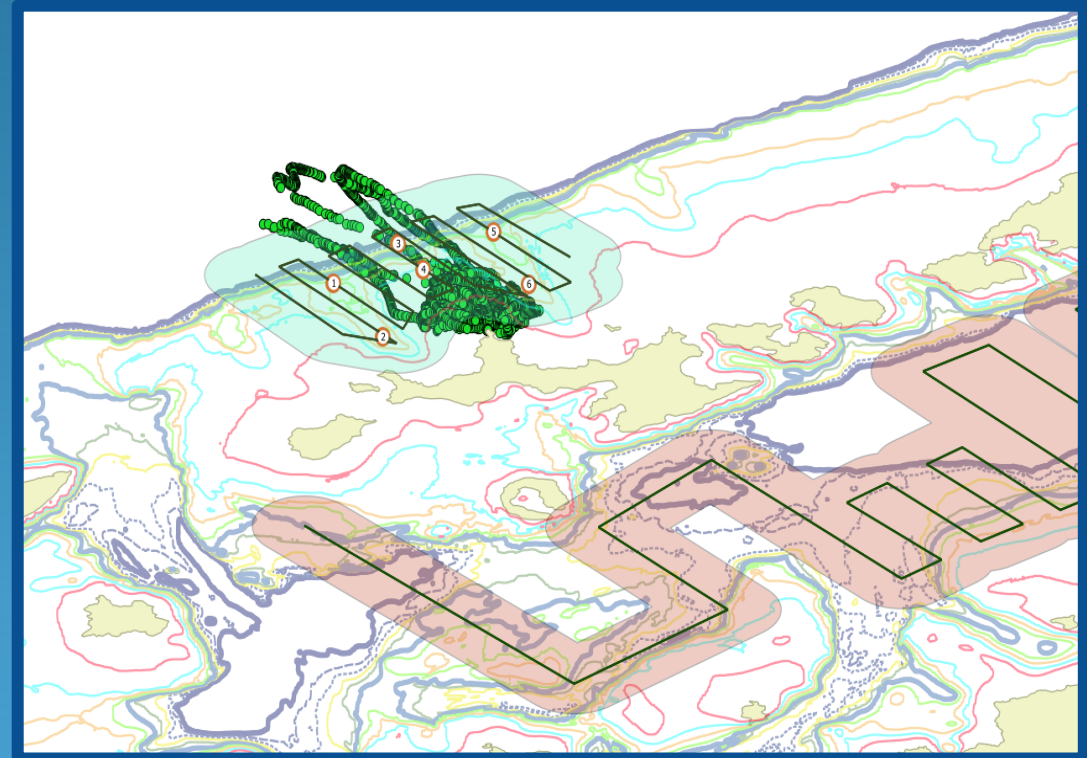
# Results



## Estimating krill density



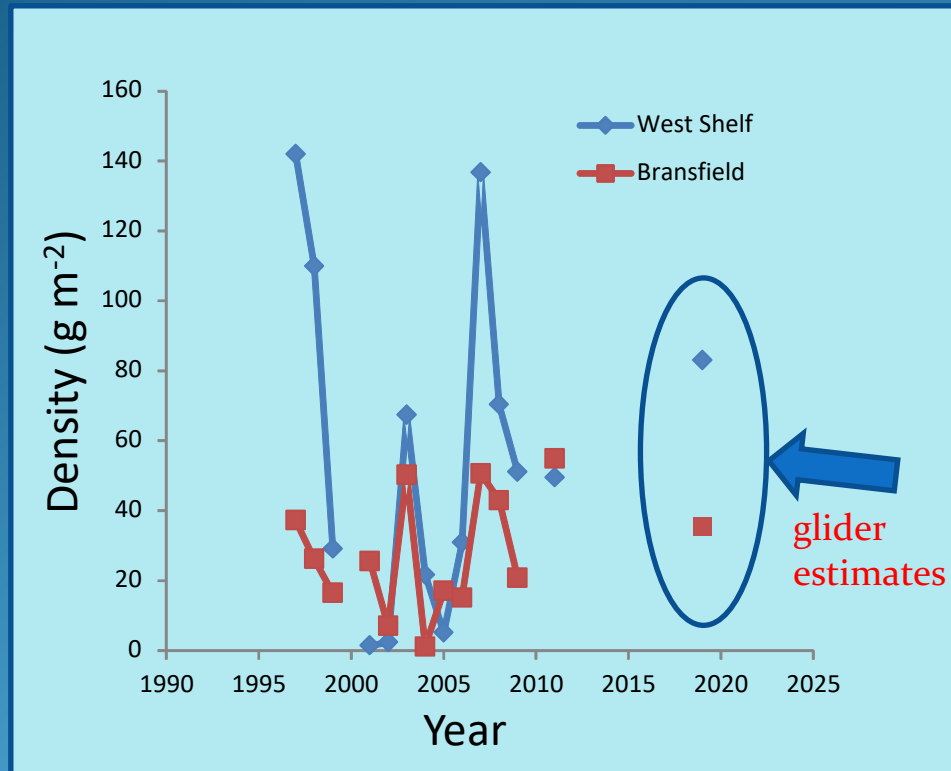
## Estimating flux



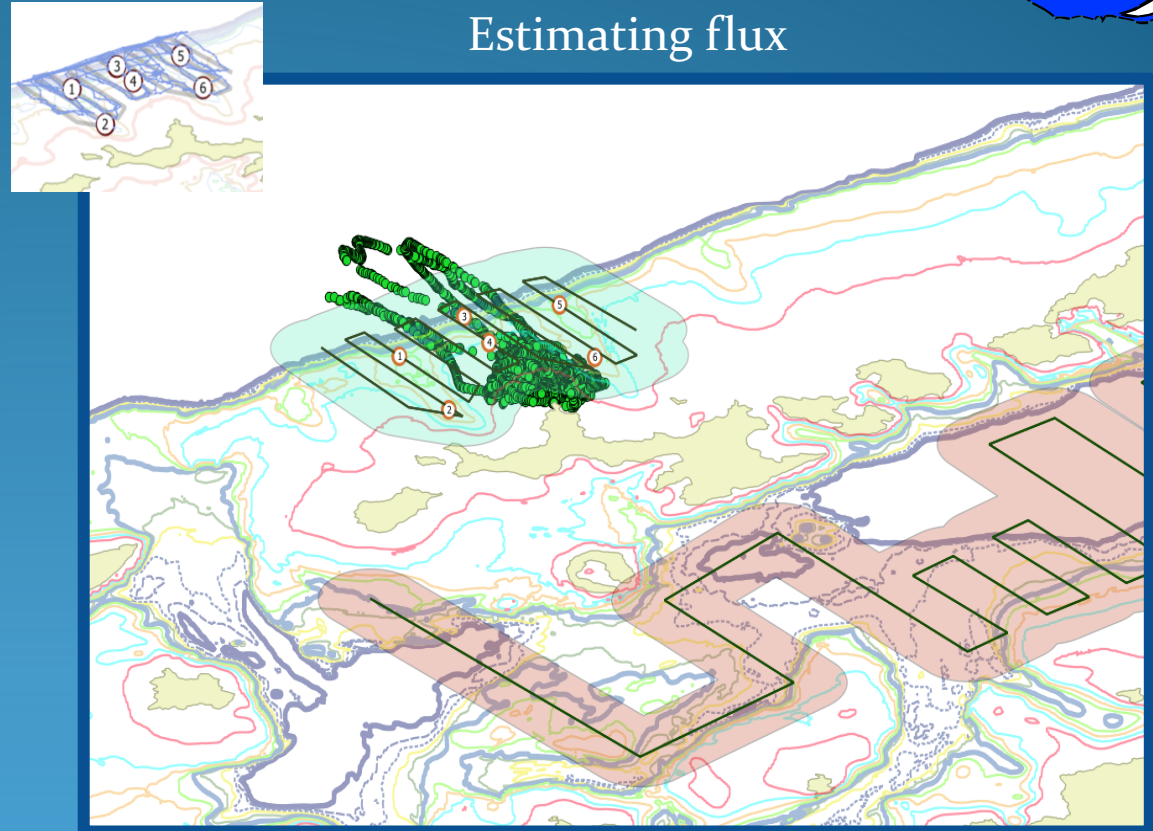
# Success!



## Estimating krill density



## Estimating flux



# FreeByrd – a longterm, flexible, multi-scale autonomous Ecosystem Research Program



Simultaneous observations at multiple scales

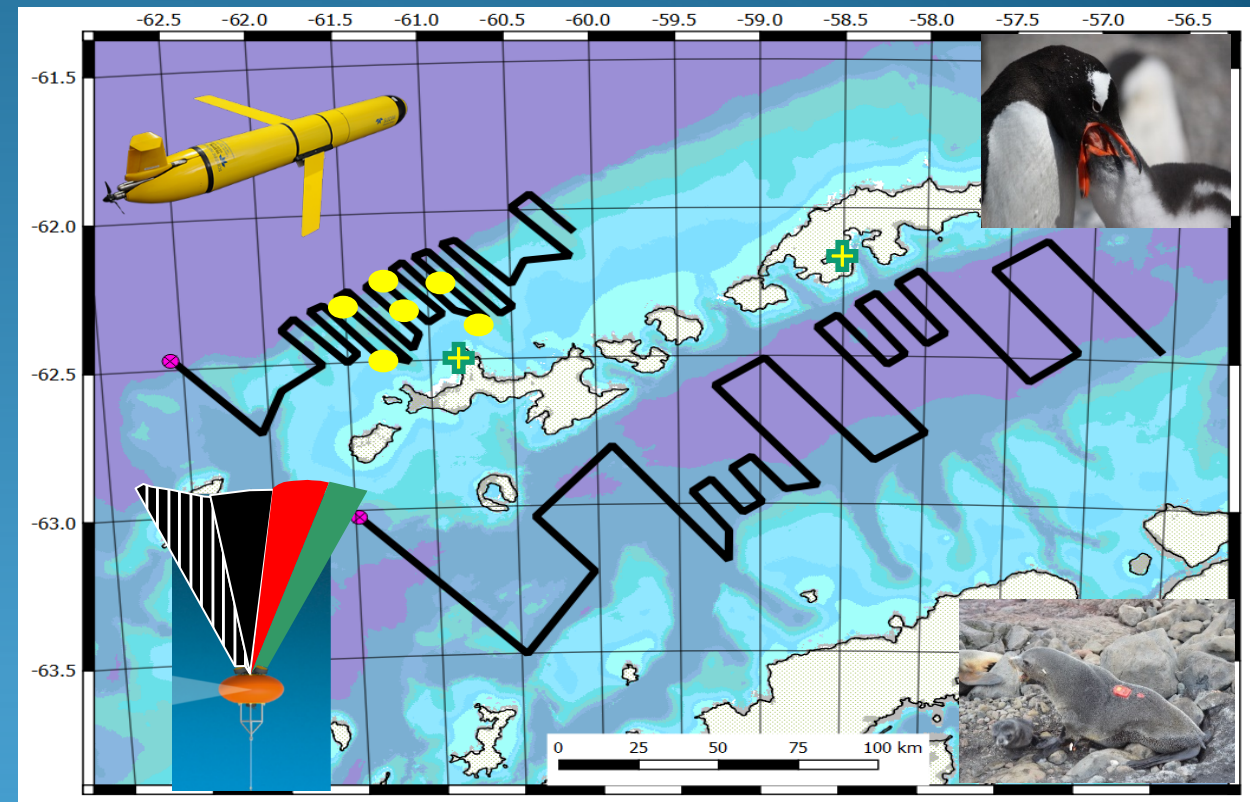
gliders + penguins → krill biomass

ADCP/Es → krill “flux”

GPS tags → predator foraging

Lower annual cost

savings → adapt to budget reality  
(free resources to do more)







# QUESTIONS

