

# *Glider-based acoustics in the Antarctic*

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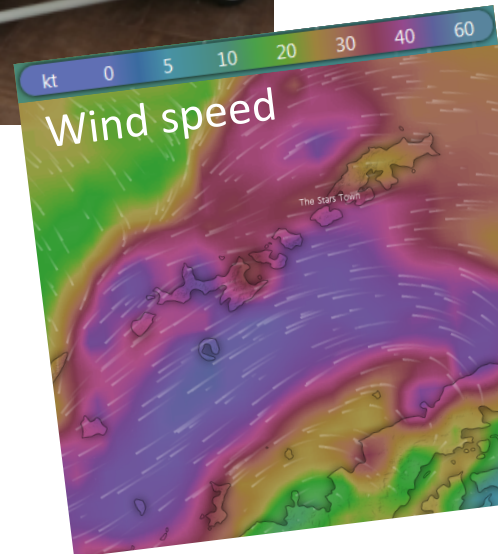
# Oceanography, Options and Life Choices



- NOAA Fisheries and AMLR
- Science based management
- Surveys of ecosystems and biological resources
- Platforms and strategies
  - Ships
  - Field camps
  - Aerial platforms
  - Autonomous surface vehicles
  - Autonomous underwater vehicles
  - Satellites & extraterrestrial platforms?
- Cost\$\$\$ vs. Fund\$\$\$

# We chose gliders

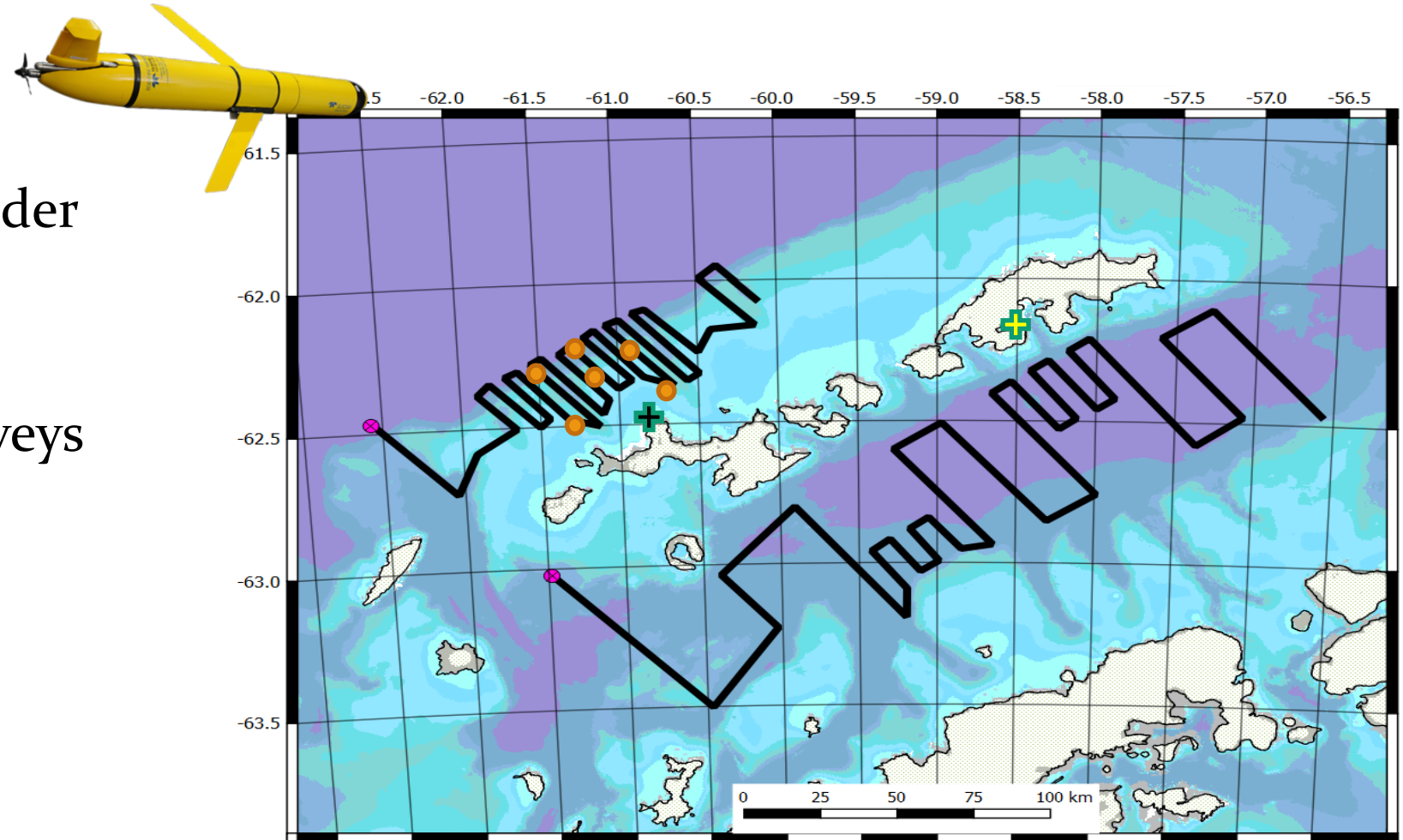
# "BEST CHOICE EVER!"





# Autonomous Ocean Surveys

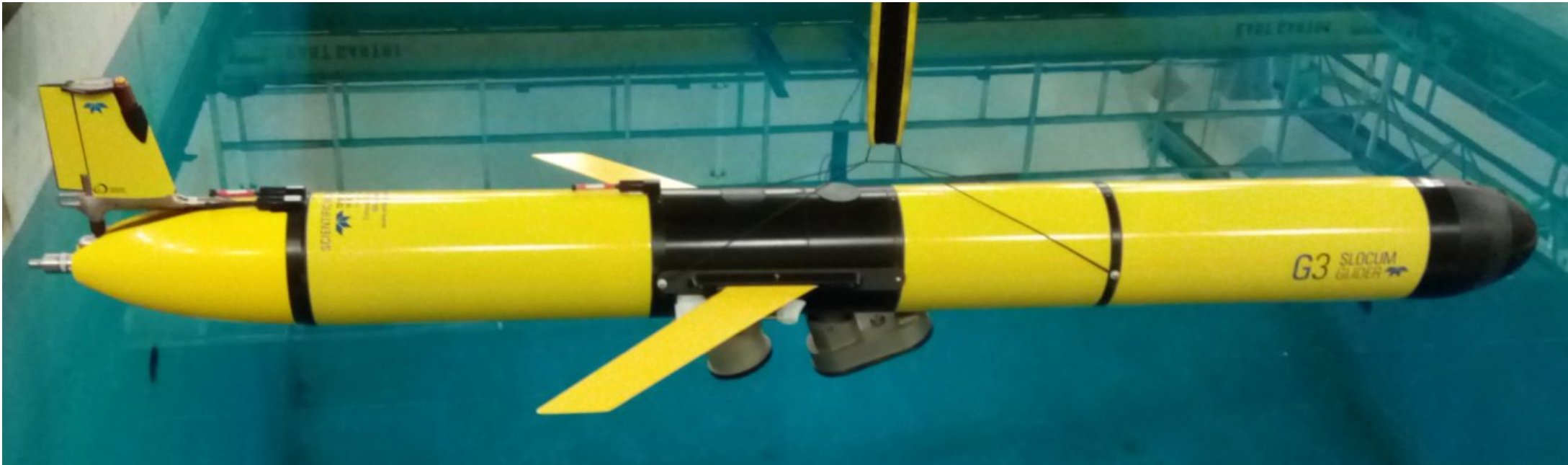
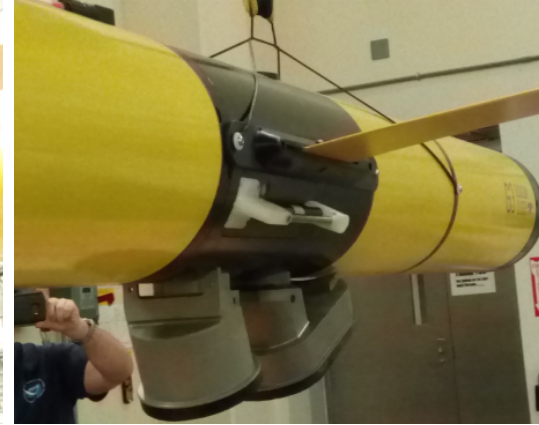
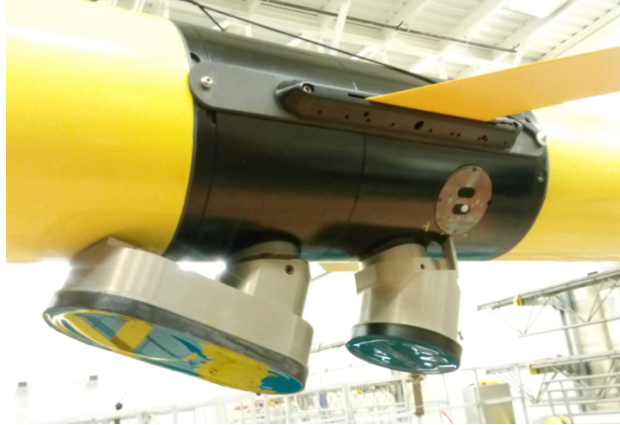
- Goal:
  - Measure krill biomass from glider acoustic surveys
  - These glider surveys replaced ship surveys.





# Glider outfit

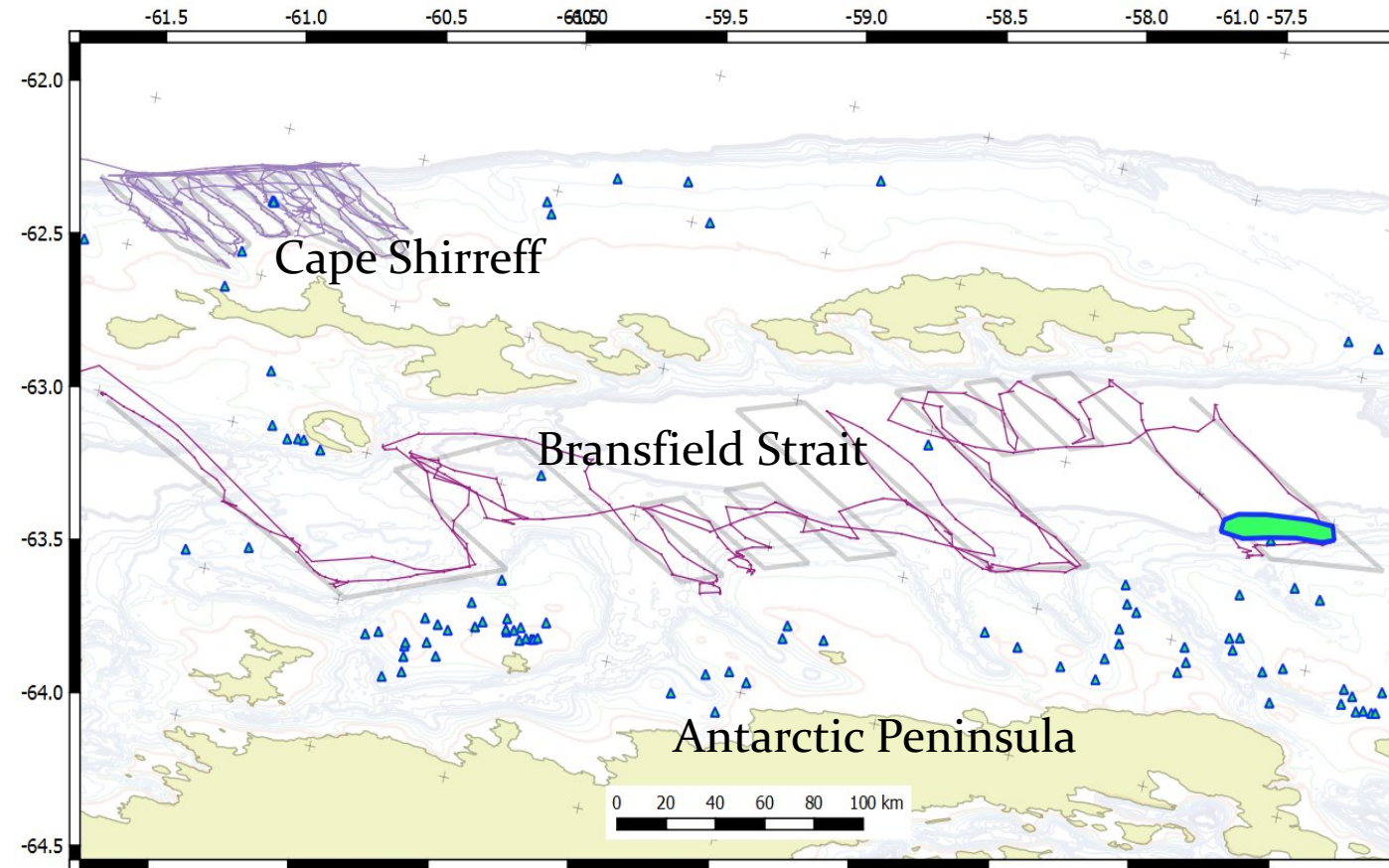
- Teledyne-Webb Slocum G3 Glider
- SONAR
- CTD
- EcoPuck
- Oxygen sensor



# Glider survey



- Glider surveys
  - Two areas near Antarctic Peninsula, Dec 2018 – Mar 2019
  - Slocum G3, 1000-m w/ deep drives
- Successful
- Planned transects vs actual glider tracklines
  - Better than expected, given:
    - Obstacles, environment, experience, deep gliders
  - Close enough to a transect
  - If not, will use geostats

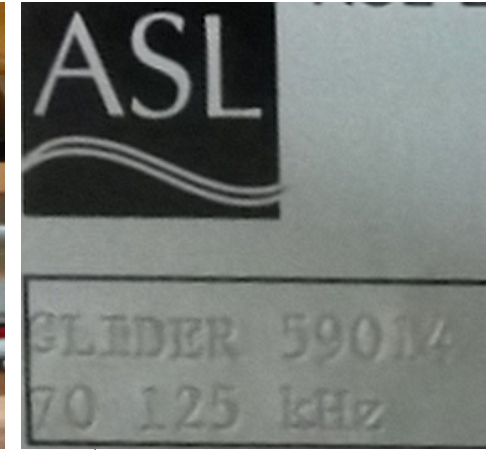




# Glider sonar



- Sonar
  - ASL AZFP (38, 67.5, 125 kHz)
- Theoretically, beams are vertically oriented during dives
- Sonar transducer angle vs glider dive angle
  - transducer angle different from expected
  - $\sim 23^\circ$  (expected  $26^\circ$ )



marked as 70





# Glider sonar



- Sonar
  - ASL AZFP (38, 67.5, 120 kHz)
- Beam opening angles (“beamwidths”)
  - Approximately 7°, 17, and 30°

## Glider AZFP beam opening angles

Frequency (kHz)	Beam angle (°)
38	30°
68	17°
125	7°

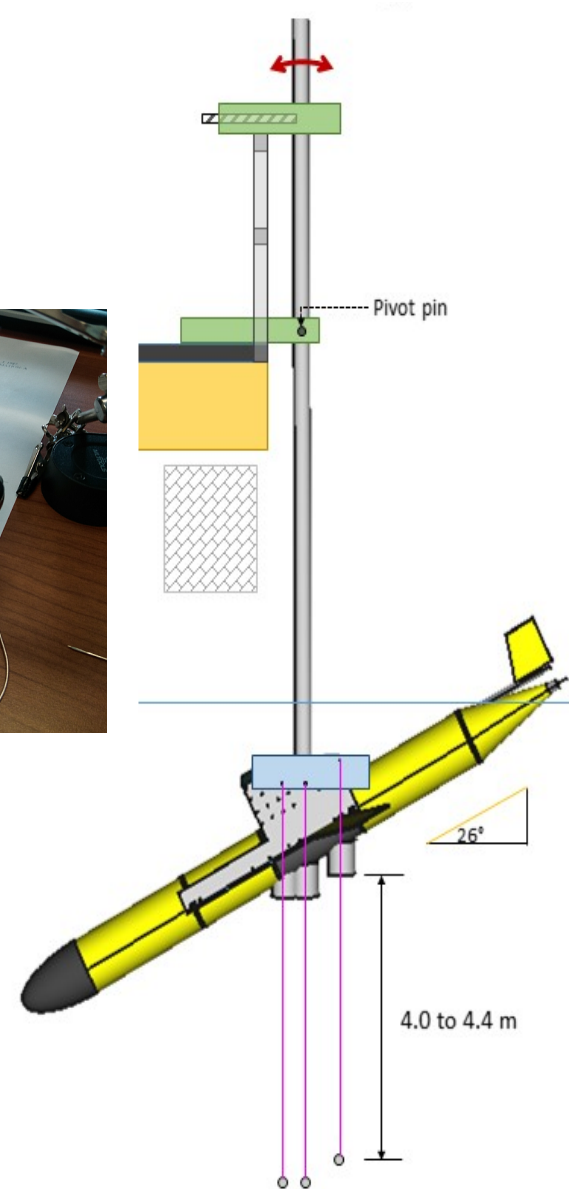
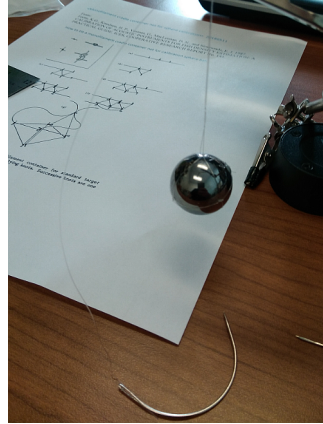
## Lemon, et al. (OCEANS 2012)

Frequency (kHz)	Nominal -3 dB Beam Angle (°)	Nominal Source Level (dB)
38	12	209
125	8	206
200	8	209
455	7	212
770	7	213

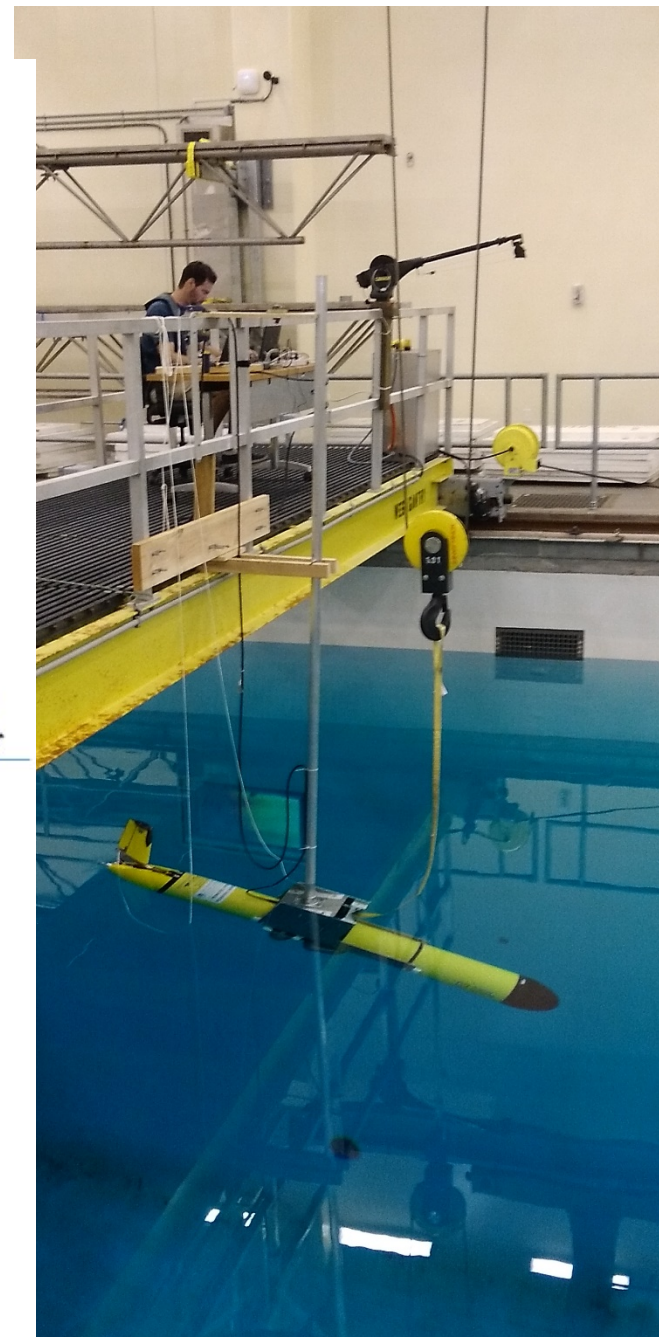
**Not for glider transducers**

# Glider sonar calibration

- SONAR Calibration
  - ASL factory calibration
    - +/- 1 dB
    - Hydrophone method (Lemon+ 2012)
  - NOAA/AMLR calibration
    - Glider-on-a-stick
    - NOAA SWFSC tank
    - Foote+1987, ICES CRR144.
    - Tungsten-carbide sphere
      - 0.5", 12.7 mm
    - Beam-center gain offset



AMLR01 AZFP (1000 $\mu$ s) F	Absorp (dB/m)	TS-theor (dB)	TS-meas (dB)	dTS (dB)
38	0.00691	-51.3	-51.4	-0.10
67	0.018686	-54.44	-49.6	4.84
125	0.00459	-50.64	-49.9	0.74



# Glider sonar operations



- AZFP operational schedule and parameter values
- Implemented by glider config file
  - AZFP.CFG
- Can set using AZFP-Link
  - (-) Potential for override by glider config file
    - Yes, we've experienced

Digitization rate	40000 samples/second
Ping interval	5 seconds
Ping per profile	1 ping
Pulse length	500 ms
Max Range	99.934 m
bin size	0.02 m

The screenshot shows the AzfpLink [BETA] Version 1.0.44 (20180910) (c) 2018 ASL Environmental Sciences Inc. software interface. The 'Operating Schedule' tab is active, showing configuration for a deployment. Key parameters include: Phases: 1, Frequencies: 3, Data Output: FLASH, Sound Speed: 1515.3 m/sec, Storage Requirements: 49.42 Gb. Battery requirements are listed as Total Tx Pack: 12.17 Ah, Total Main Pack: 45.84 Ah, and Delayed Start: 0.00 Ah. The deployment file is 'Parameters from last program invocation'. The 'Resource Requirements Computed for: Dec 12, 2018 16:47:05 - Mar 12, 2019 16:47:04' section shows a summary of the deployment parameters. The 'Phase Start' is Dec 12, 2018 16:47:05, and the 'End Date' is Mar 12, 2019 16:47:04. The 'Phase Length' is 90.0000 Days, 'Phase Type' is Normal, 'Burst Interval' is 5 Seconds, 'Ping Period' is 1 Seconds, 'Pings per Burst' is 1 Pings, and 'Average Burst Pings' is No. The 'Processing Time' is 0.757 seconds. The 'Show Range Units as' is set to Meters. The 'Acquire' section shows three frequencies: 125 kHz, 67 kHz, and 38 kHz, each with a pulse length of 500 us, a digitization rate of 40 kS/s, a max range of 99.934 m, a bin averaging of 0.020 m, a lockout of 0.000 m, and a bytes/bin of 2 bytes/bin. The COM5 port is set to 9600. The interface includes various buttons for saving, loading, and checking parameters, as well as a message panel at the bottom.



# Glider sonar data

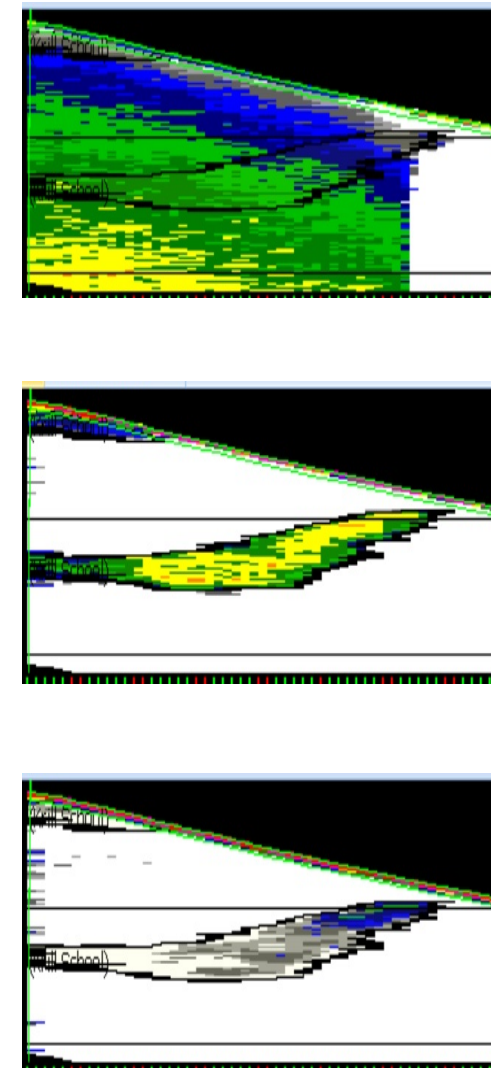
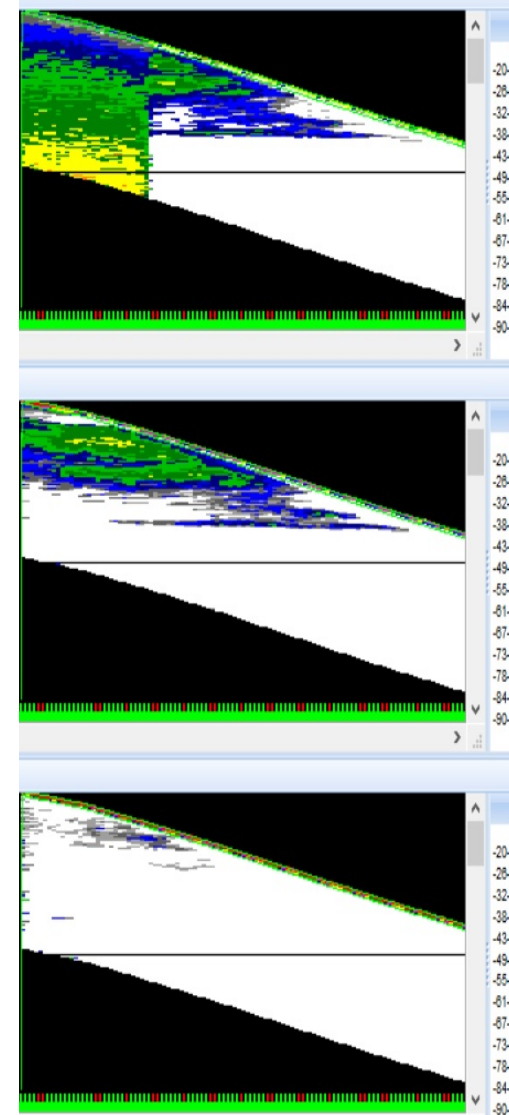
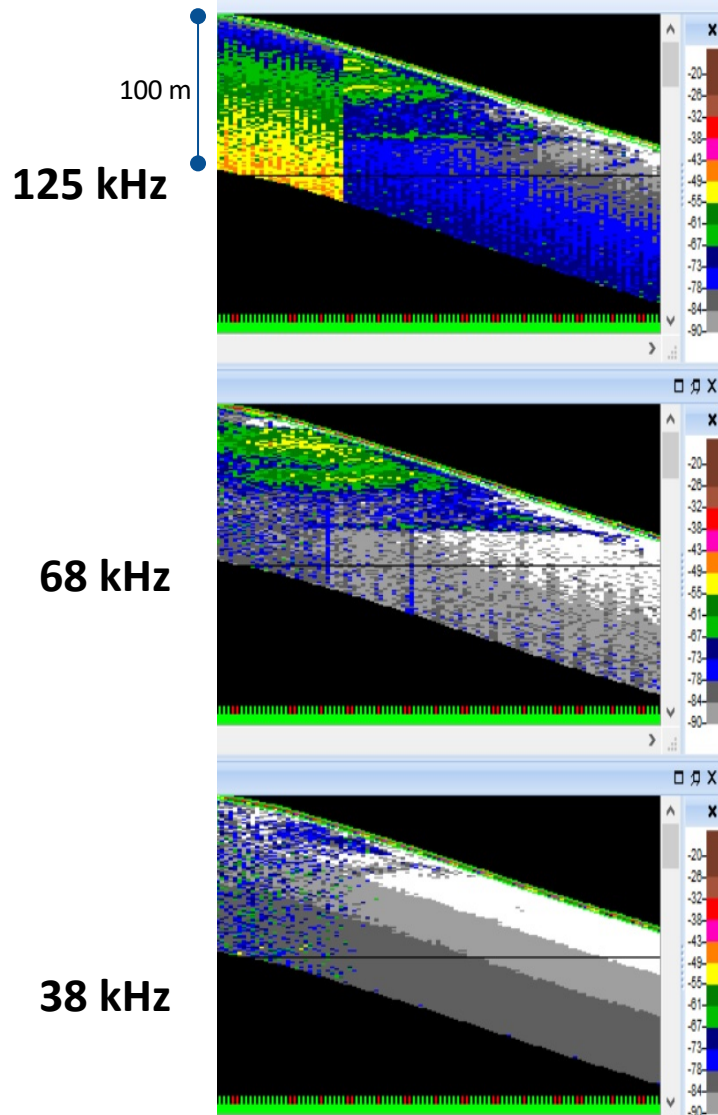
Original

Processing

Processed

$S_v$  (target aggregations)

- CalGain
- Nav
- Motion comp
- Bin
- - "Noise"
  - Bkg
  - Impulse
  - Transient
- Mask Bottom

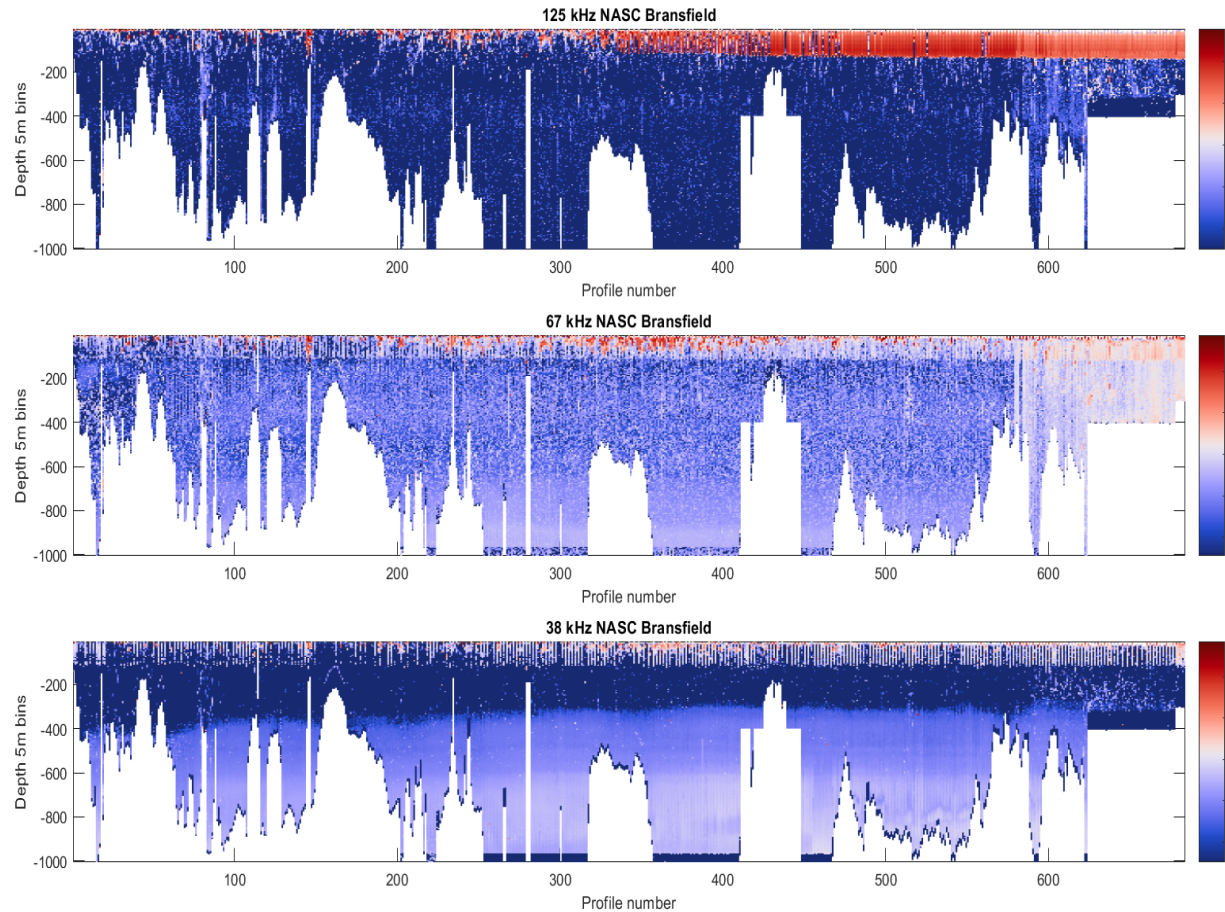


# AMLR 2018-19 glider sonar survey data



System “noise”

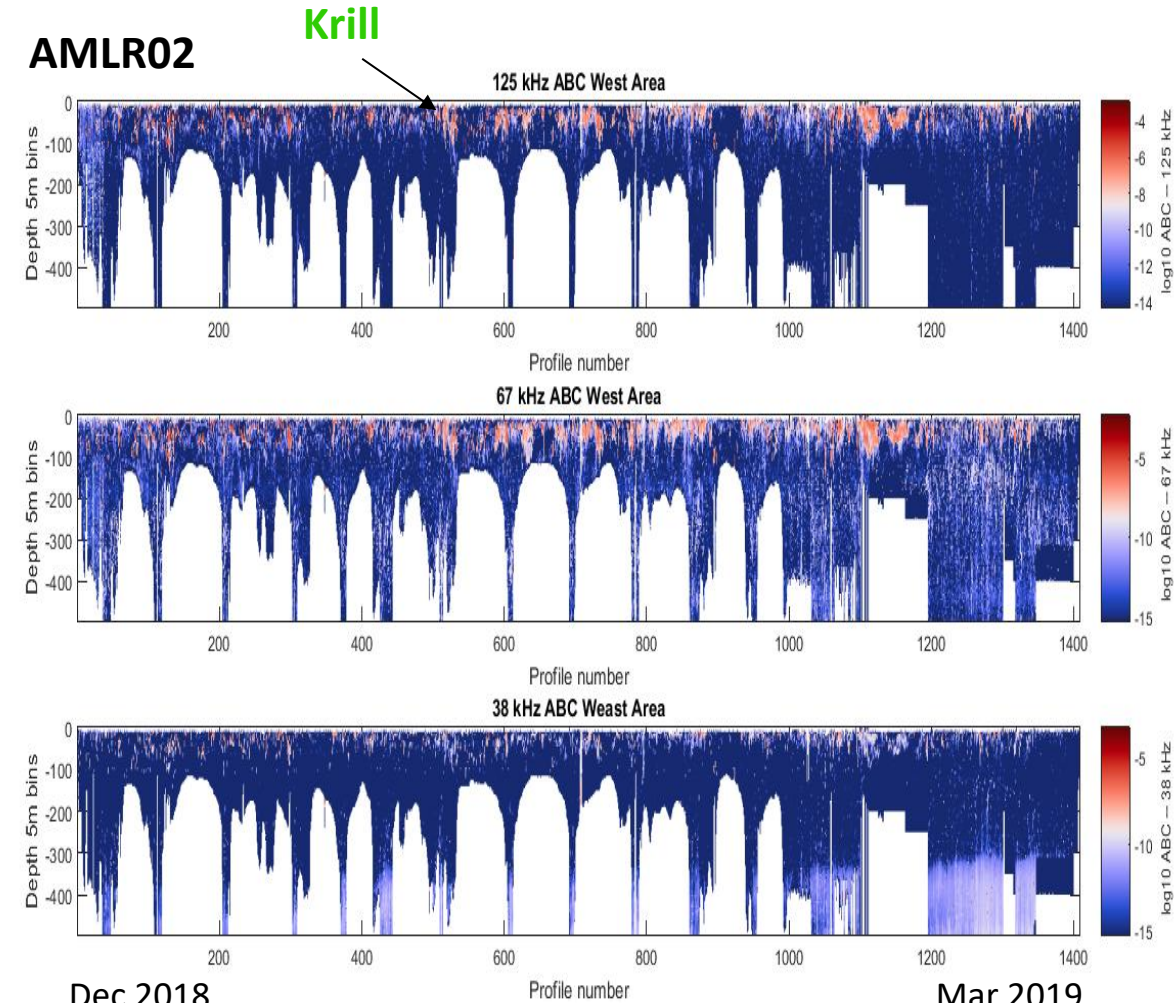
AMLR01



Dec 2018

Mar 2019

AMLR02



Dec 2018

Mar 2019

Integrated from 15 m to 200 m, scaled by krill LF & TS(L) → Biomass



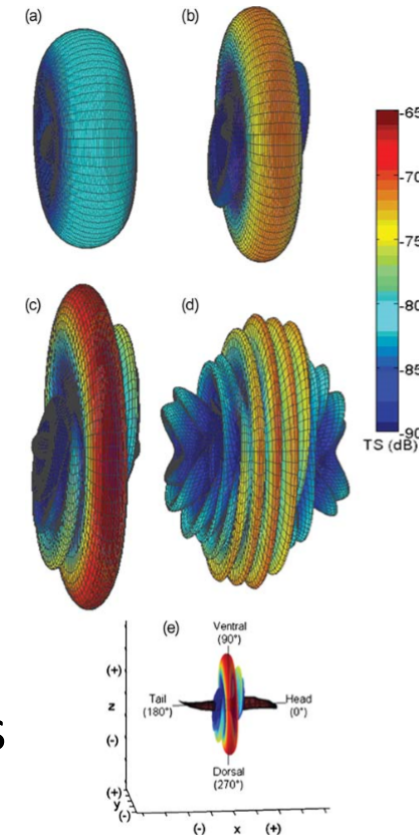
# Converting glider acoustic data to biomass

$$S_v = 10\log_{10}(s_v) \quad \text{measured}$$

$$s_a = \int_{z_1}^{z_2} s_v dz$$

$$\hat{B} = \frac{s_a}{\bar{\sigma}_{bs\_theor}} \bar{w} \quad \text{(MacLennan et al. 2002, Reiss et al. 2008)}$$

- $\hat{B}$  = estimated krill biomass density (g/m<sup>2</sup>)
- $TS_{theor,krill} = 10 * \log_{10}(\sigma_{bs\_theor})$ 
  - $TS = f(f, L, \vartheta, \dots)$ 
    - modeled (SDWBA, CCAMLR)
- $L$  = length frequency of krill
  - Krill lengths obtained from predator guts
- $w$  = length-weighted mass of krill

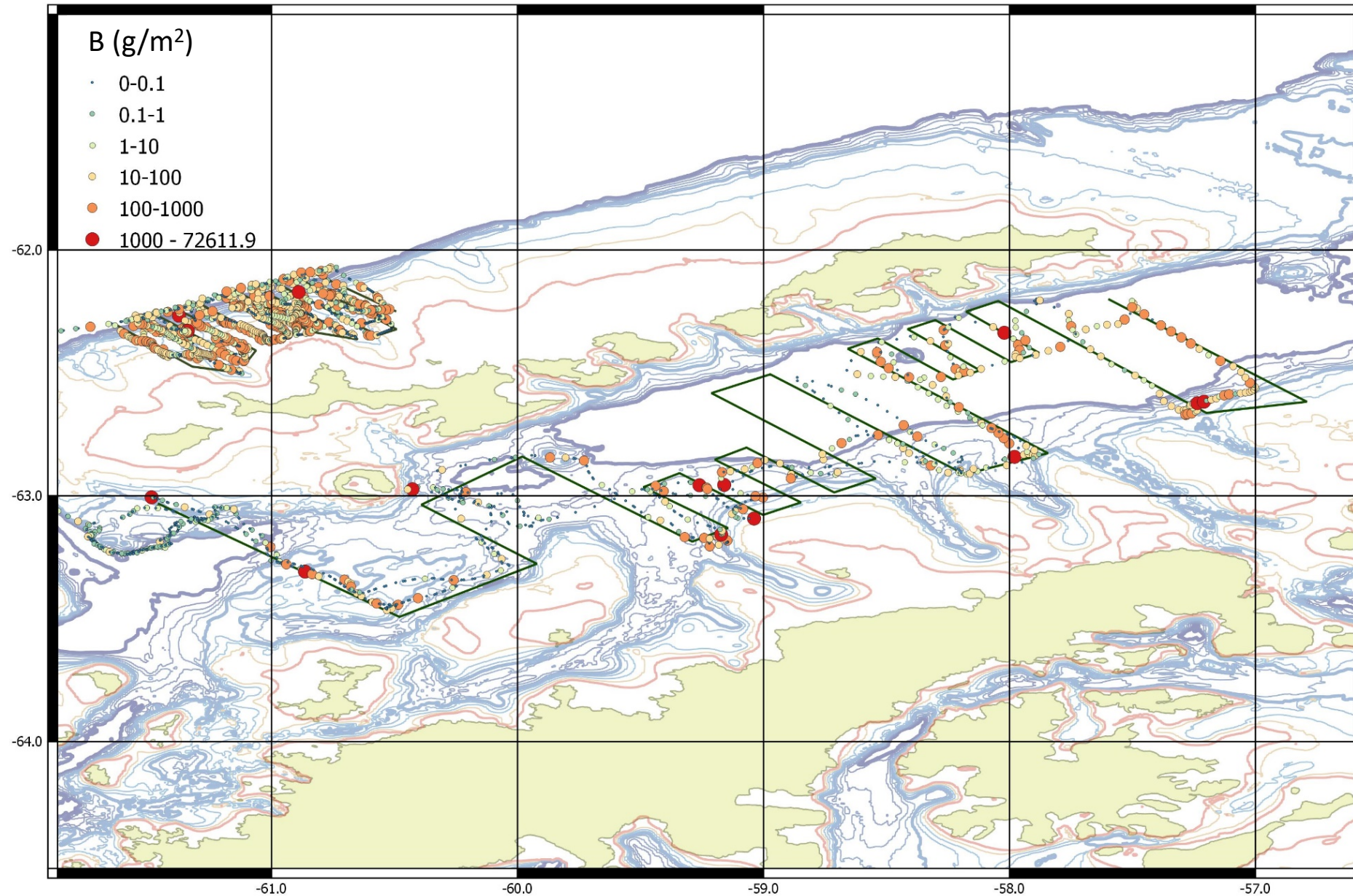


(Cutter et al. 2009)

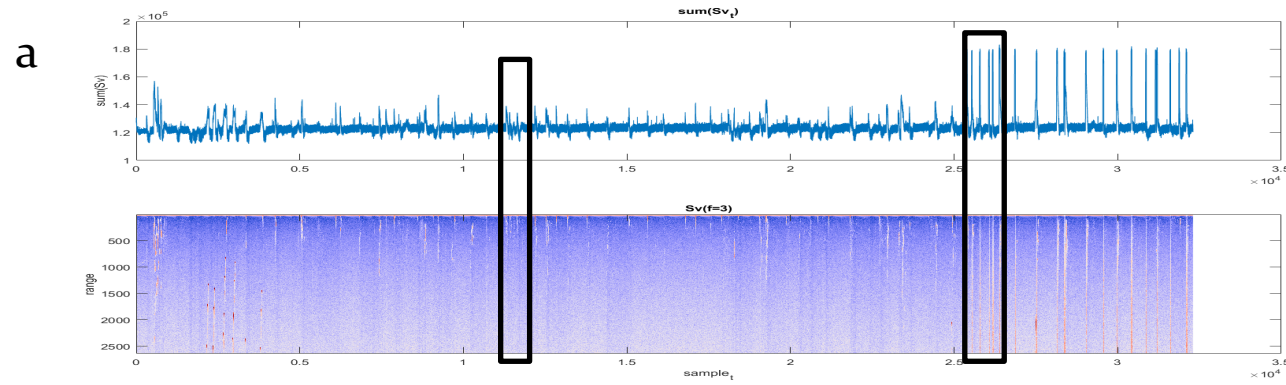




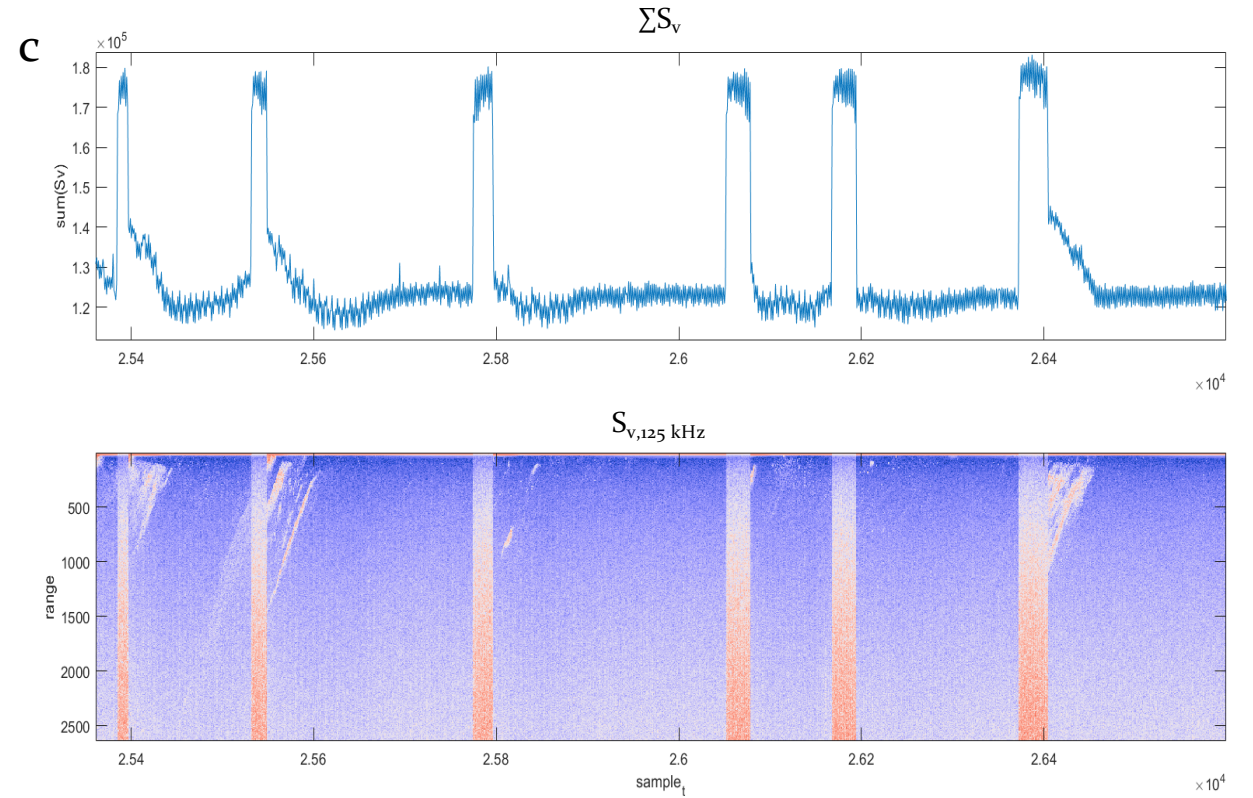
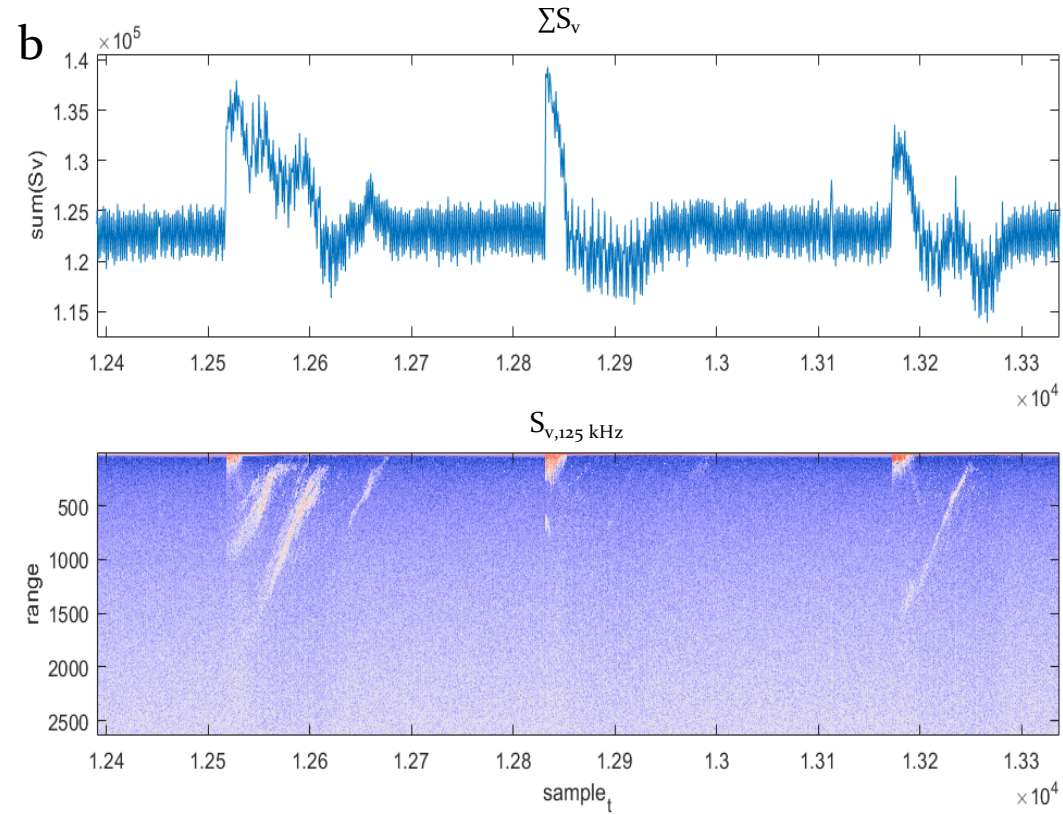
# AMLR glider-based estimates of krill biomass



# Glider AMLR01 AZFP sonar data problems



$S_{v,f=125\text{kHz}}$

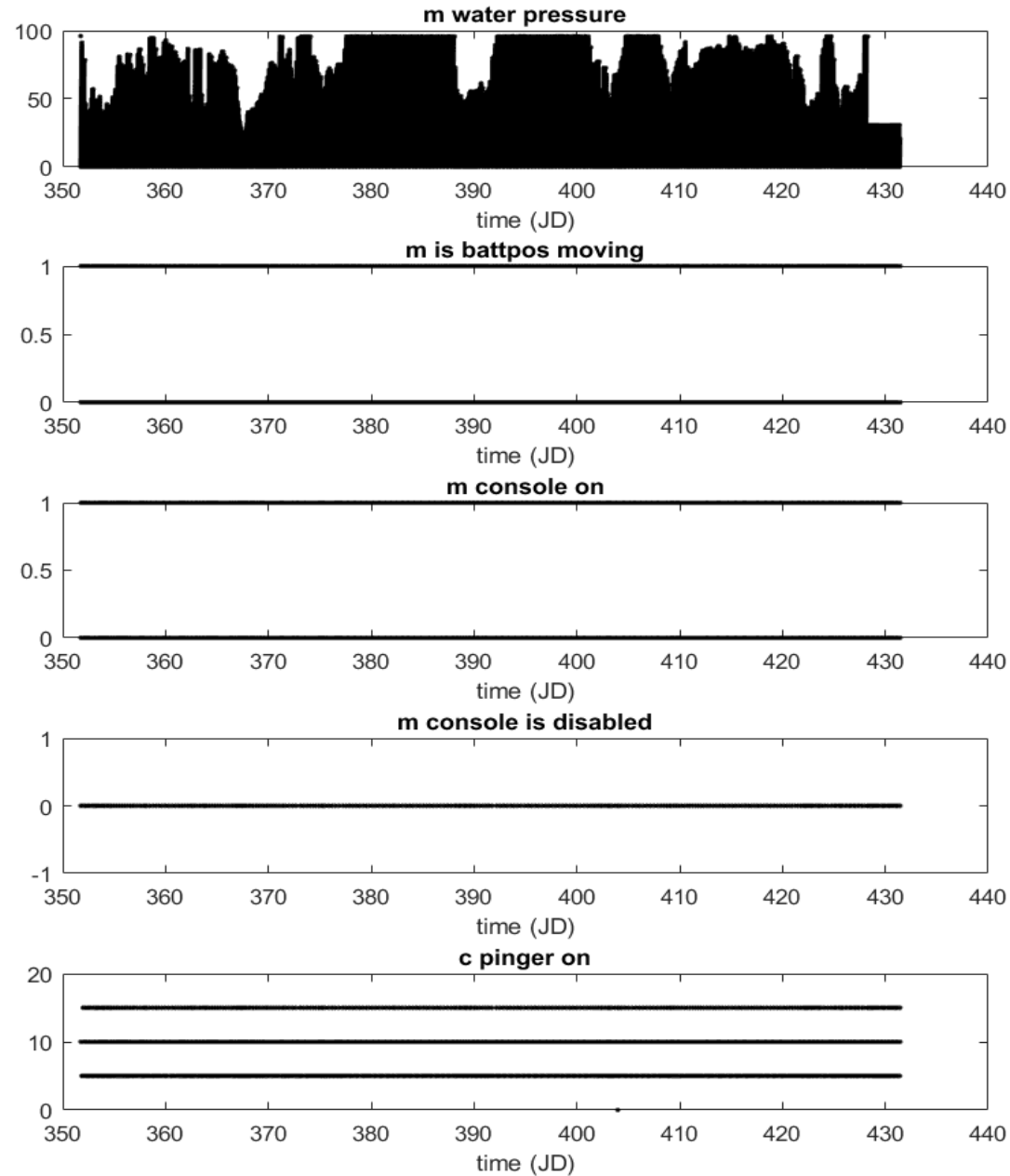




# Diagnose sonar problems



- Glider system data
  - AMLRo1 dbd



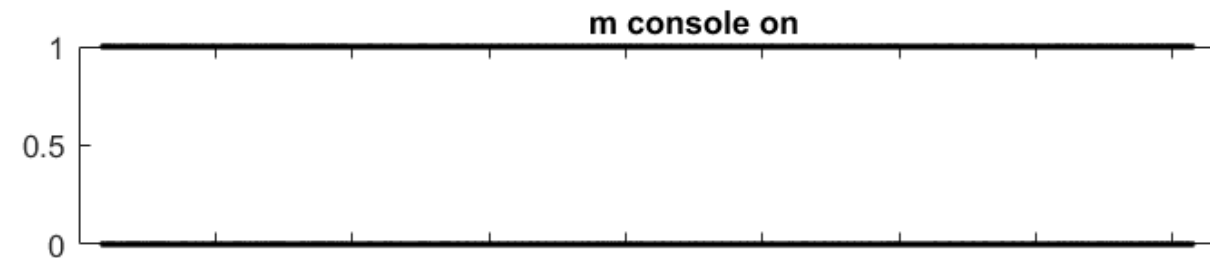
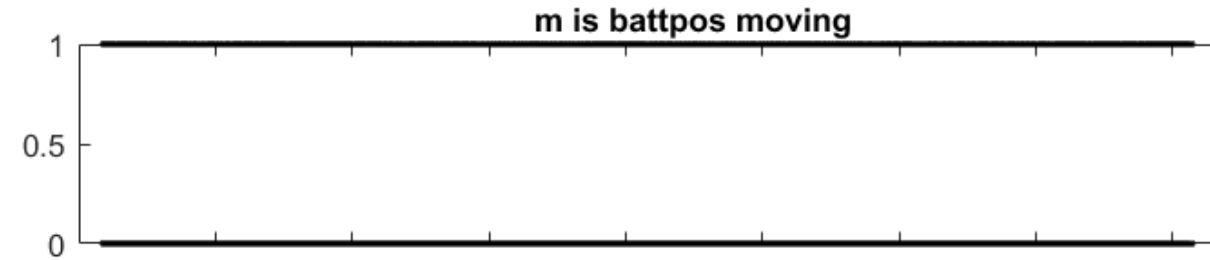
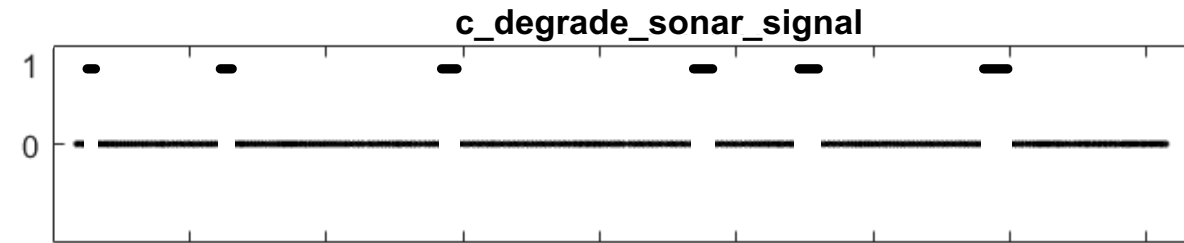
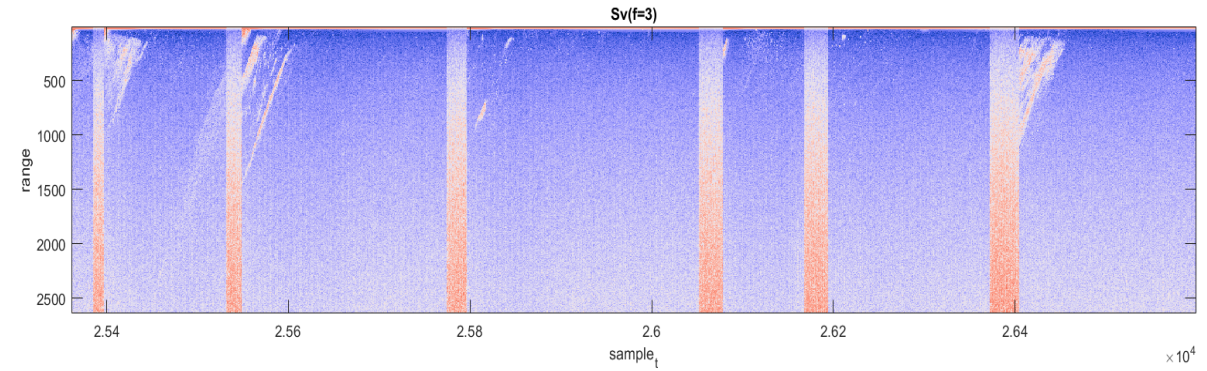
these & 100s more



# Diagnostics



- Oh, that makes sense...





# THANK YOU



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