Glider-based acoustics in the Antarctic

Antarctic Ecosystem Research Division

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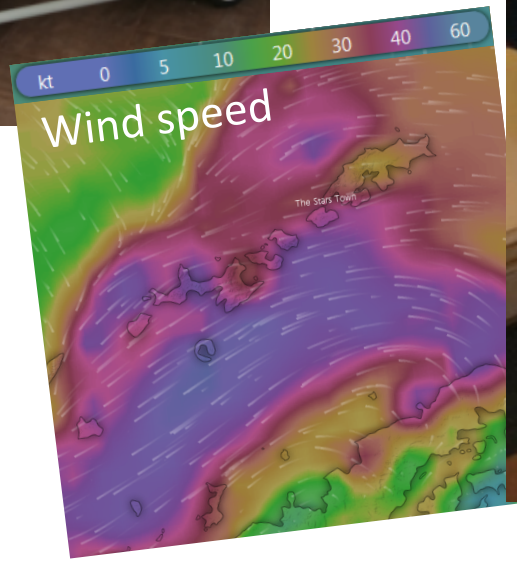
Oceanography, Options and Life Choices

- 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$$$ vs. Fund$$$

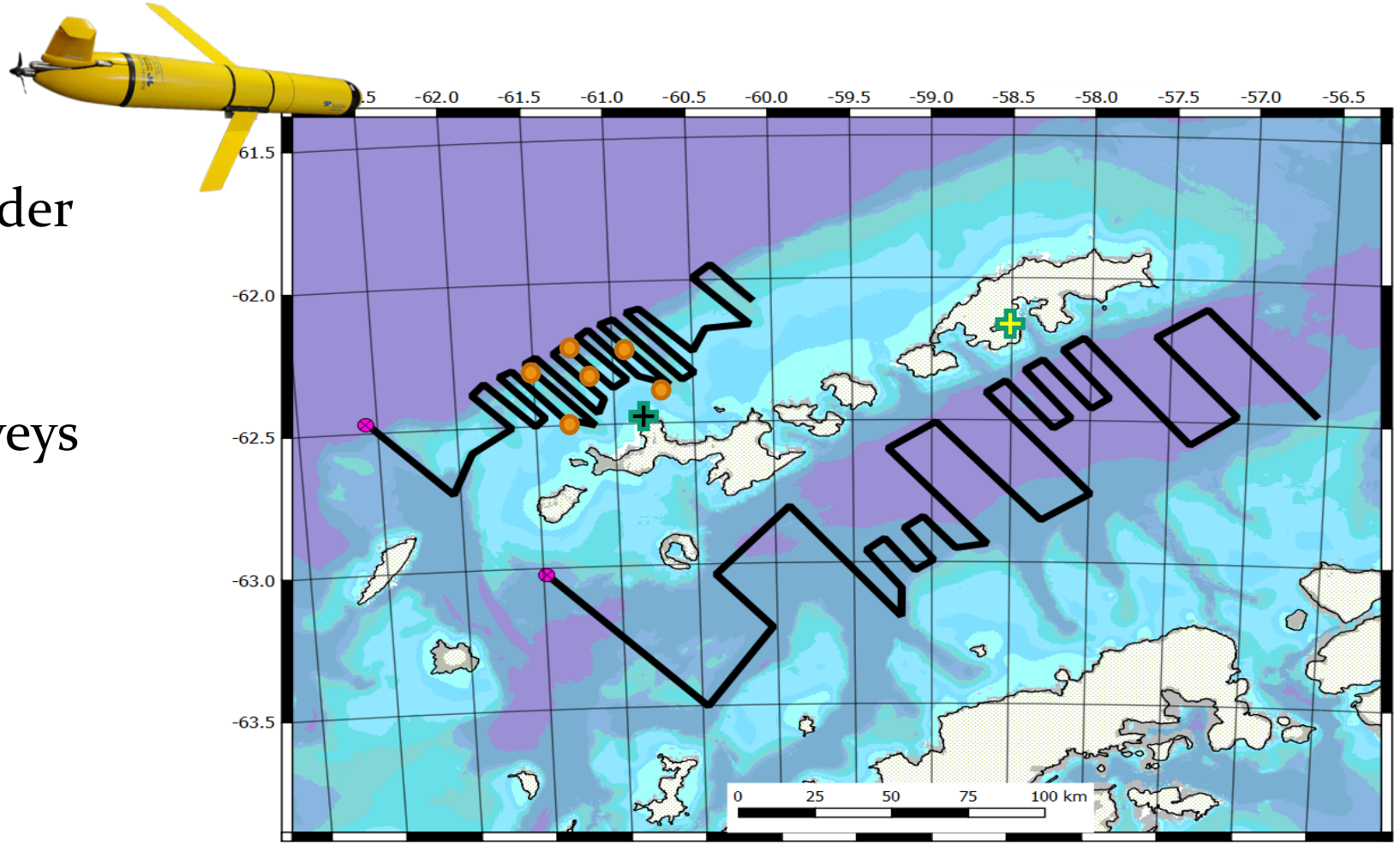
We chose gliders



"BEST CHOICE EVER!"

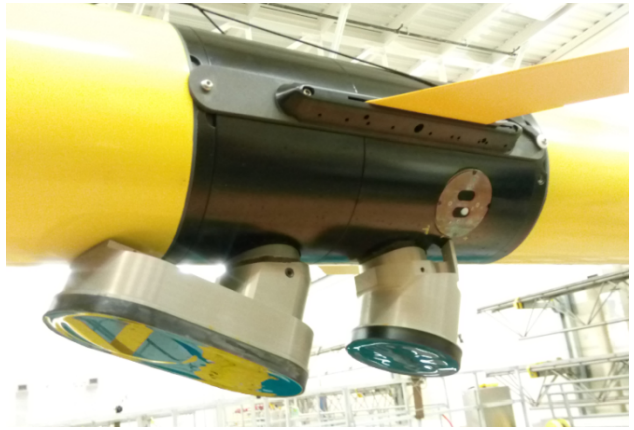
Autonomous Ocean Surveys

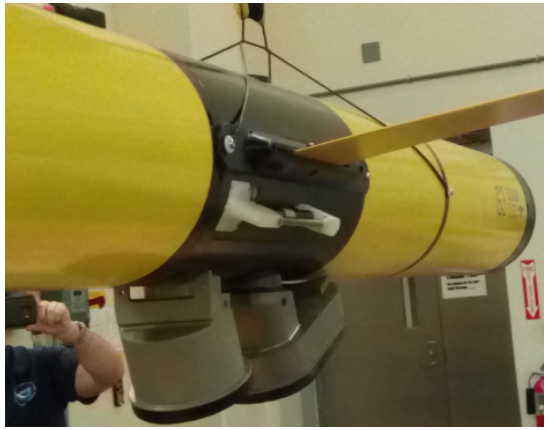
- Goal:
  - Measure krill biomass from glider acoustic surveys
  - These glider surveys replaced ship surveys.

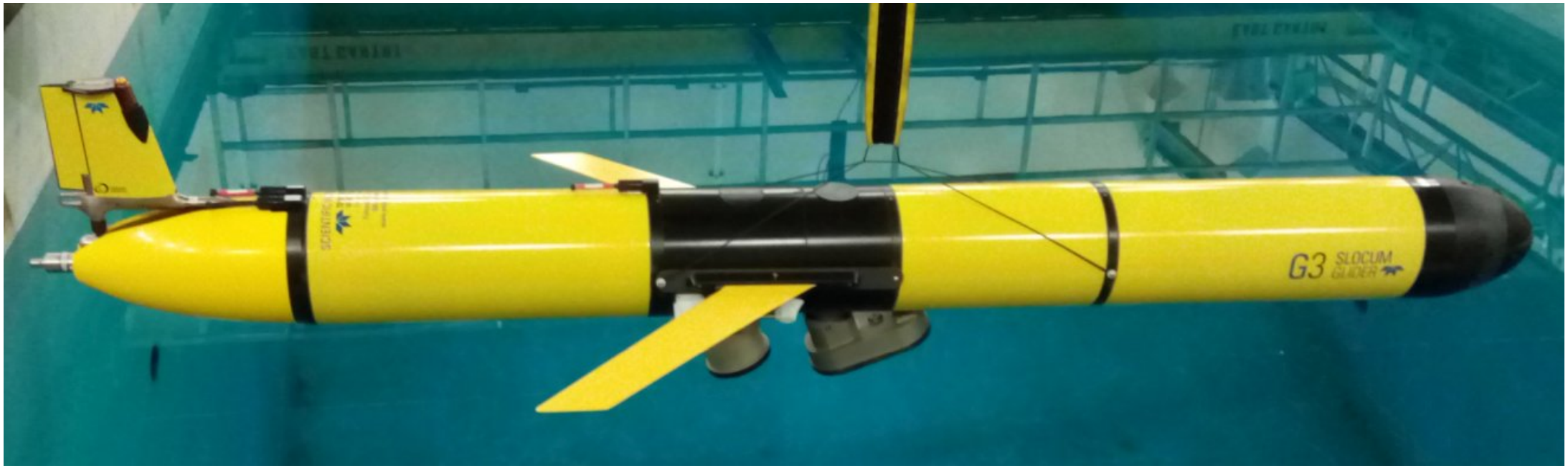


Glider outfit

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

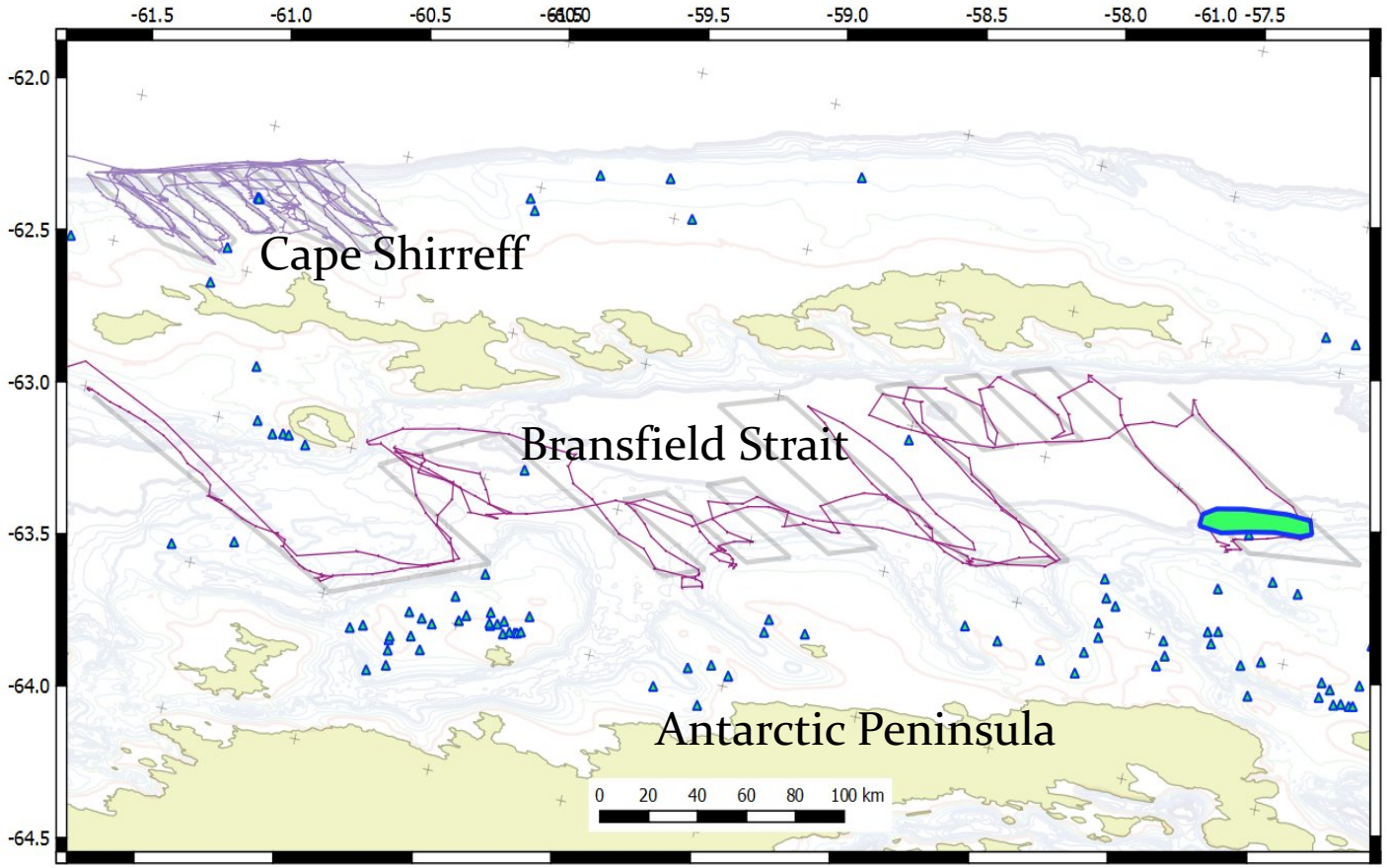






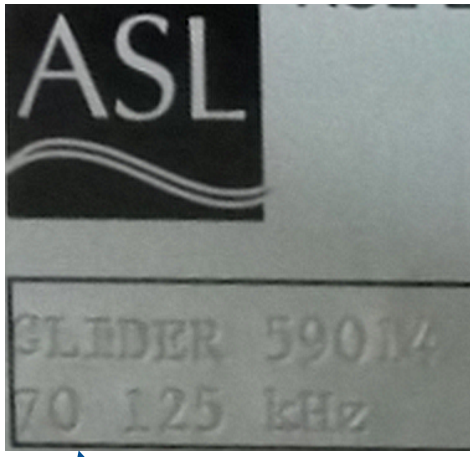
Glider survey

- 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
  - ~ 23° (expected 26°)



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°

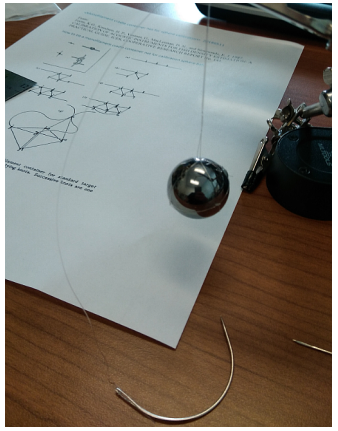
Lemon, et al. (OCEANS 2012)

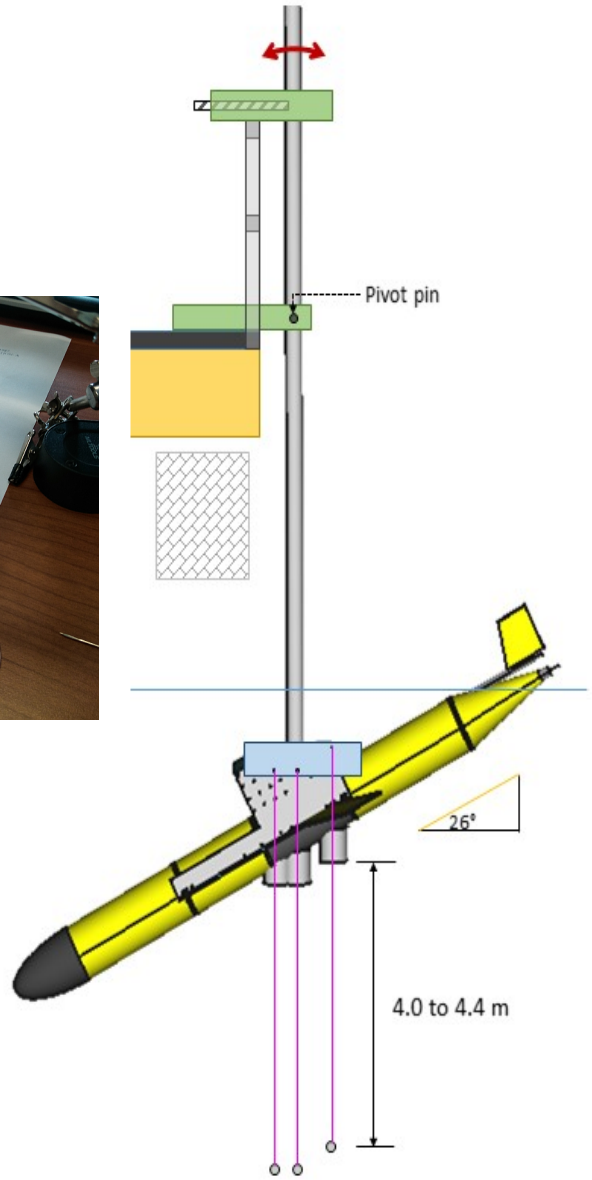
Frequency (kHz)	Nominal -3 dB Beam Angle (°)	Nominal Source Level (dB)
38	12	209
125	8	206
200	8	209
455	7	212
770	7	213

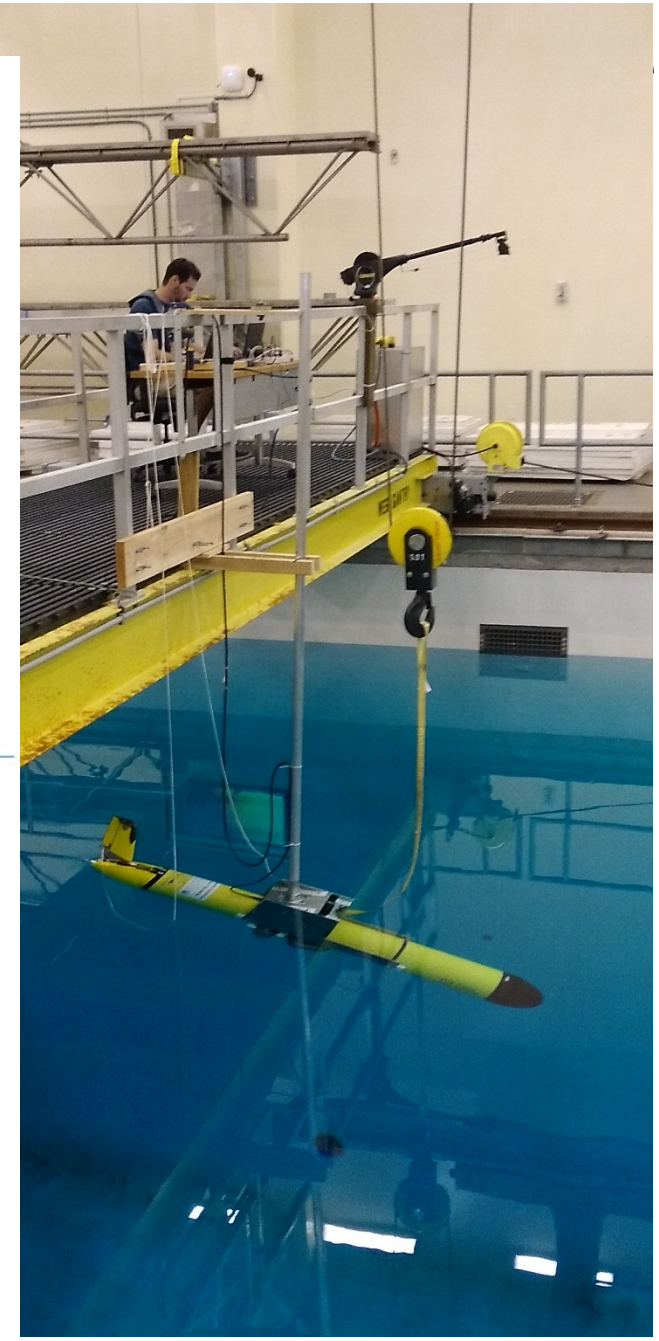
Not for glider transducers

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





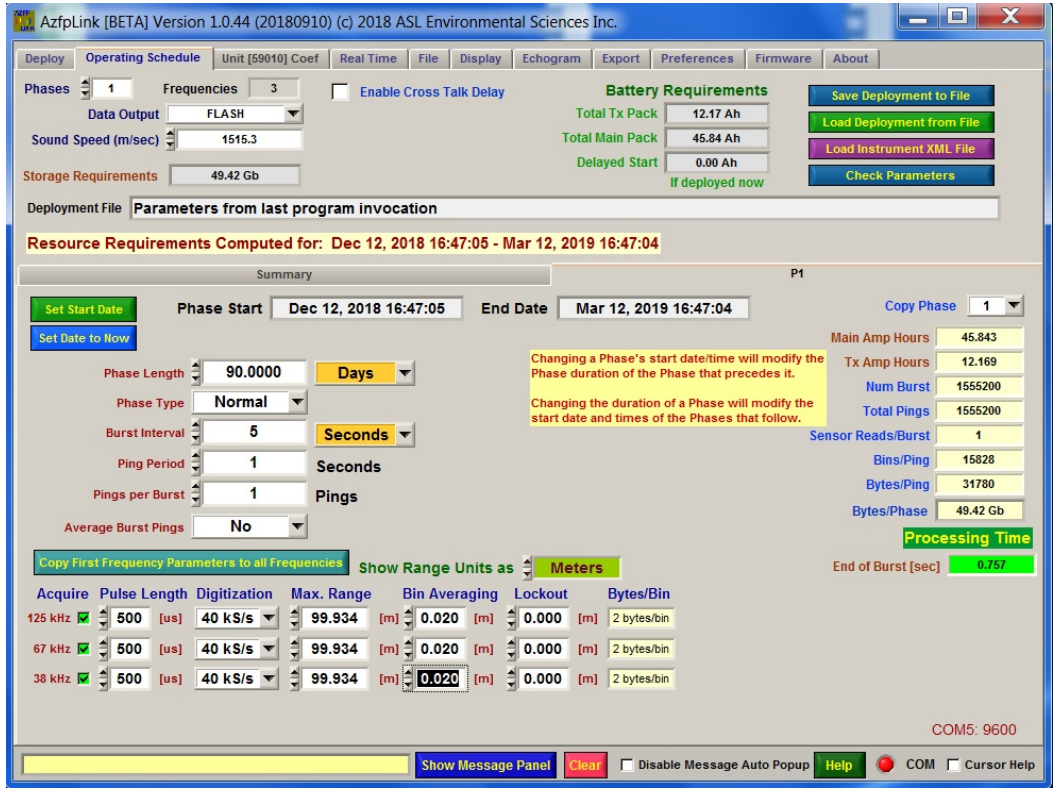


AMLR01 AZFP (1000 µs) F	Absorp (dB/m)	TS-theor (dB)	TS-meas (dB)	dTS (dB)
38	0.00691	-51.3	-51.4	-0.10
67	0.018686	-54.44	-49.6	4.84
125	0.00459	-50.64	-49.9	0.74

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're 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

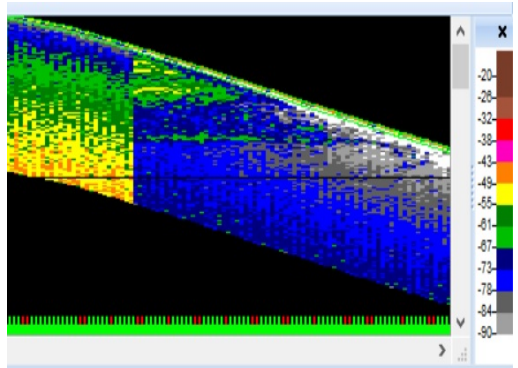


Glider sonar data

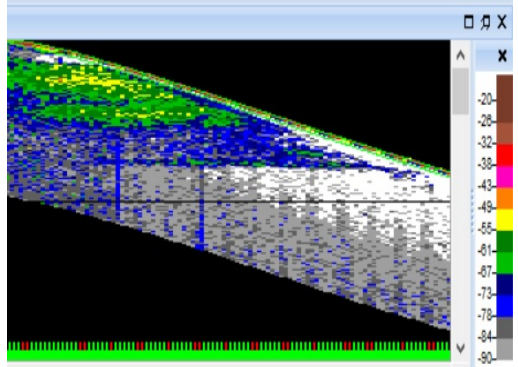
Original

100 m

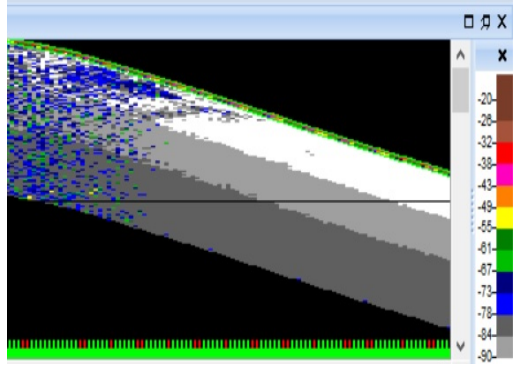
125 kHz



68 kHz



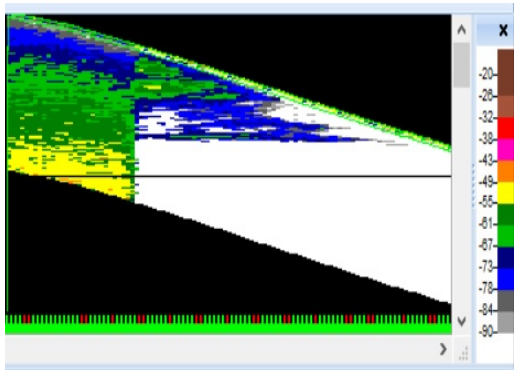
38 kHz

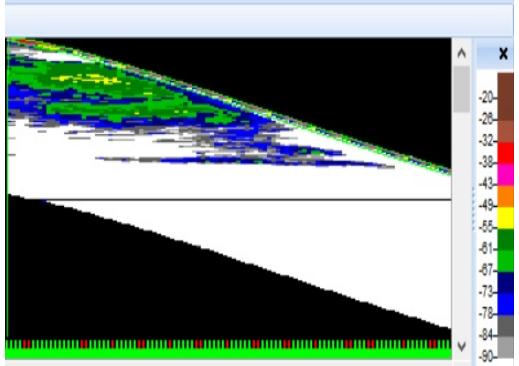


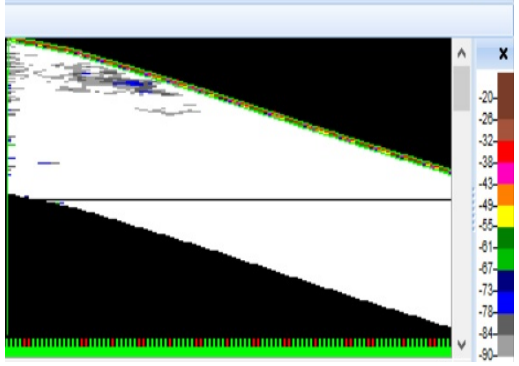
Processing

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

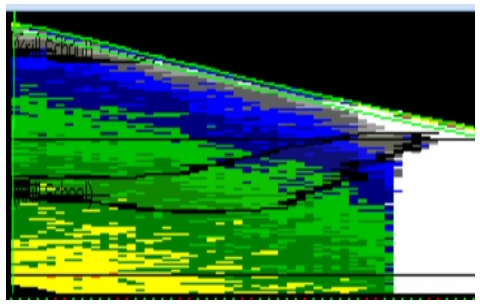
Processed

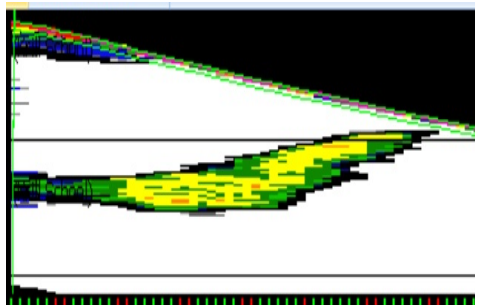


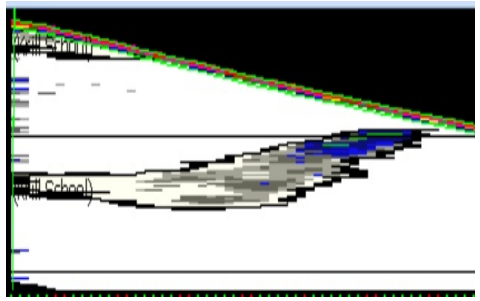




S_v (target aggregations)





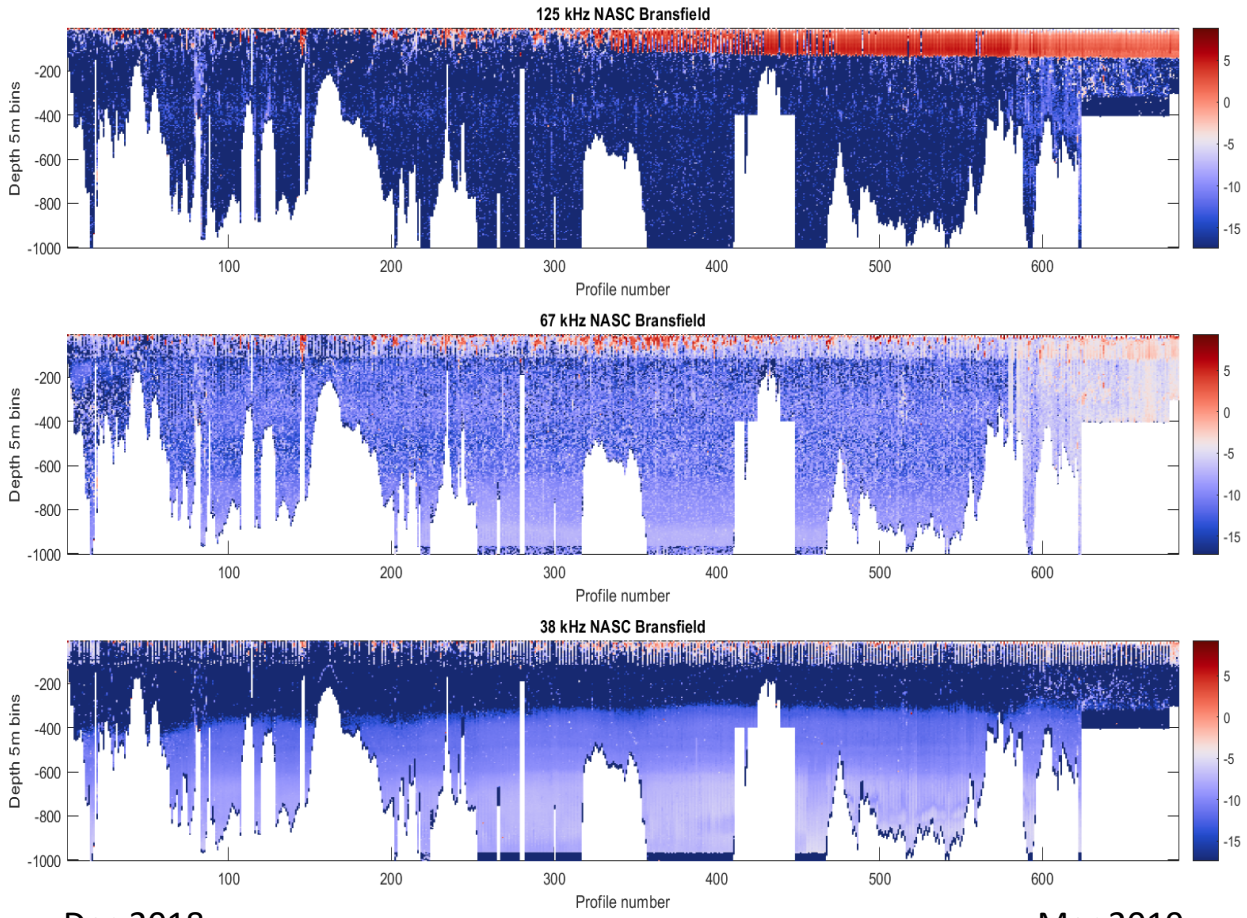


AMLR 2018-19 glider sonar survey data

System "noise"

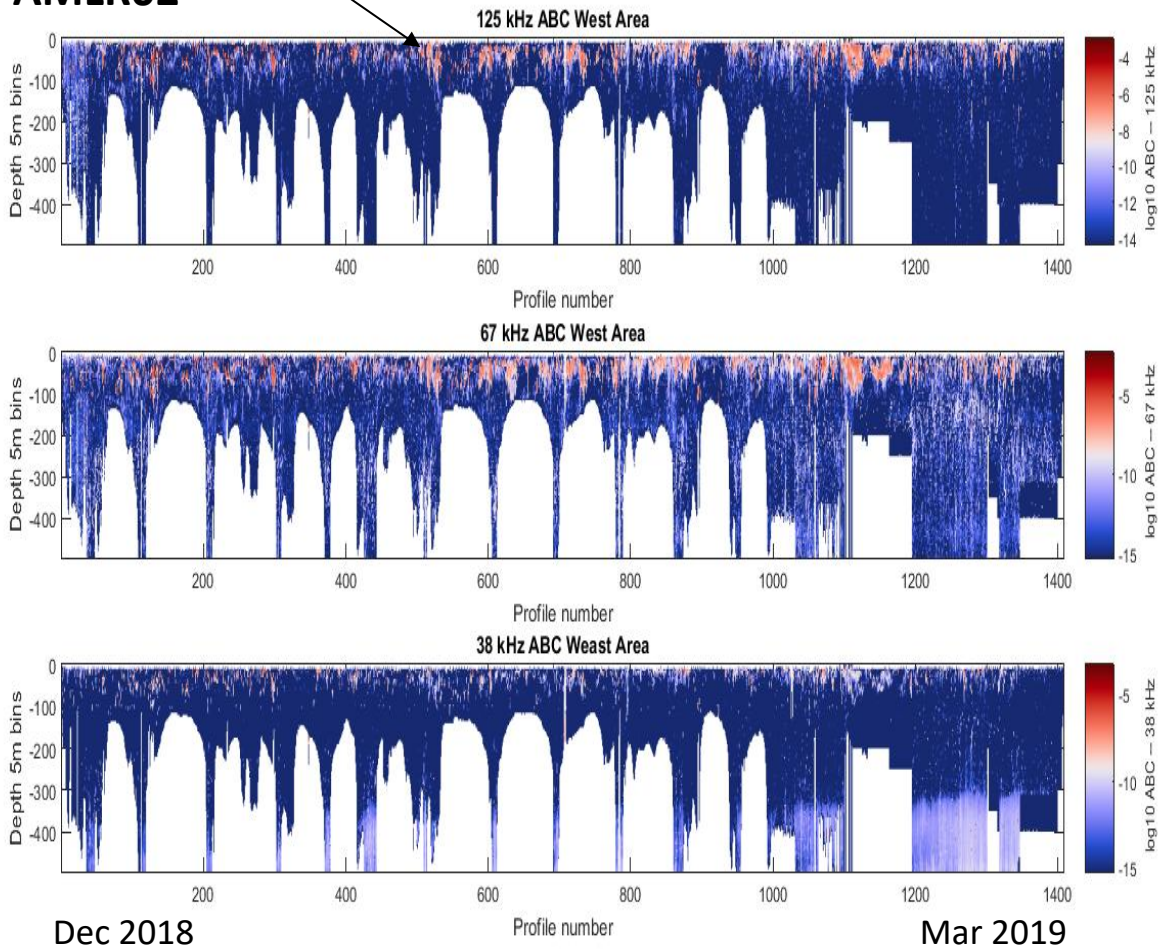
Krill

AMLR01



Dec 2018 — Mar 2019

AMLR02



Dec 2018 — Mar 2019

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

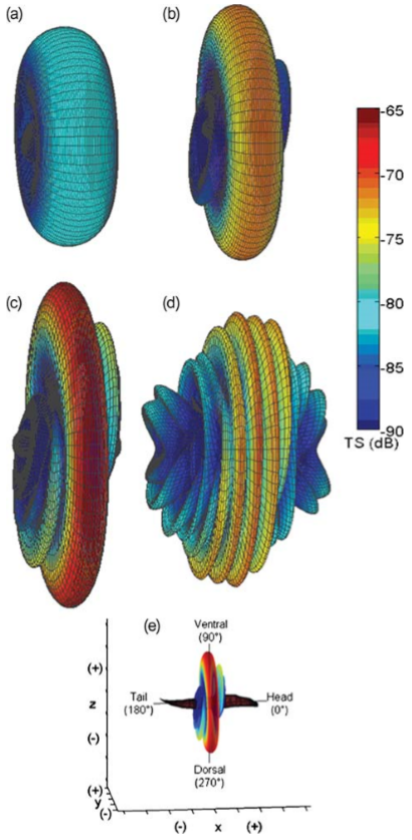
Converting glider acoustic data to biomass

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

$$s_a = \int_{z1}^{z2} s_v \, dz$$

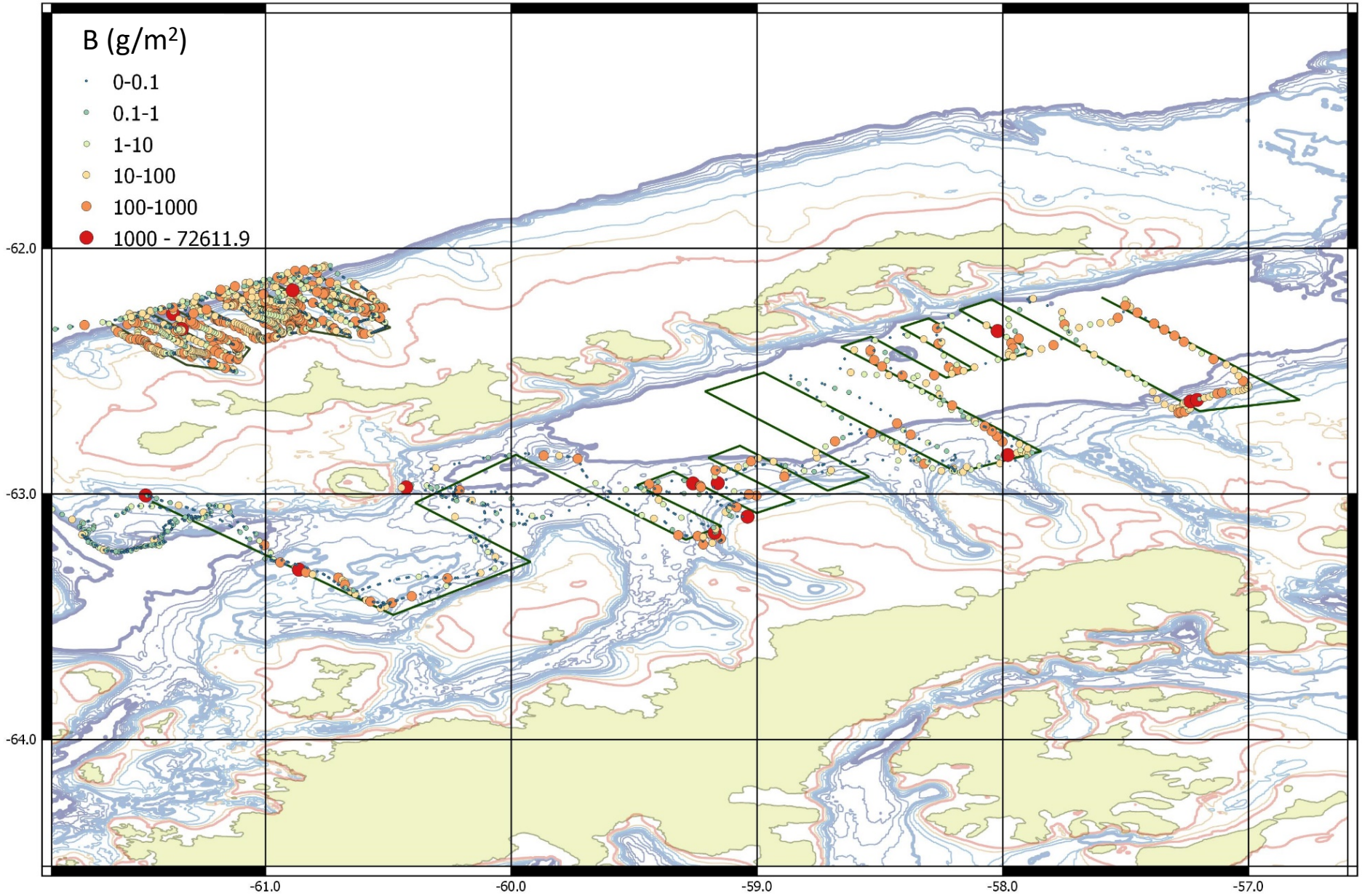
$$\hat{B} = \frac{s_a}{\bar{\sigma}_{bs\_theor}} \overline{w}$$ (MacLennan et al. 2002, Reiss et al. 2008)

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



(Cutter et al. 2009)

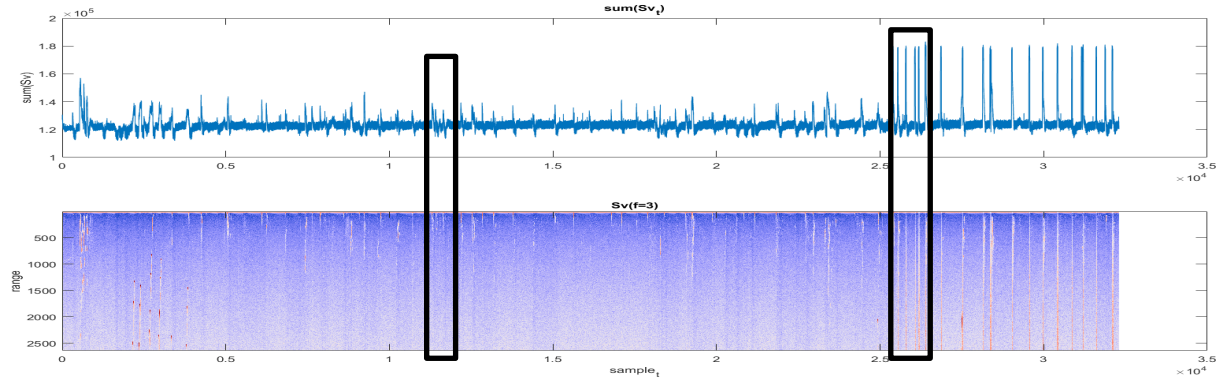
AMLR glider-based estimates of krill biomass



Glider AMLR01 AZFP sonar data problems

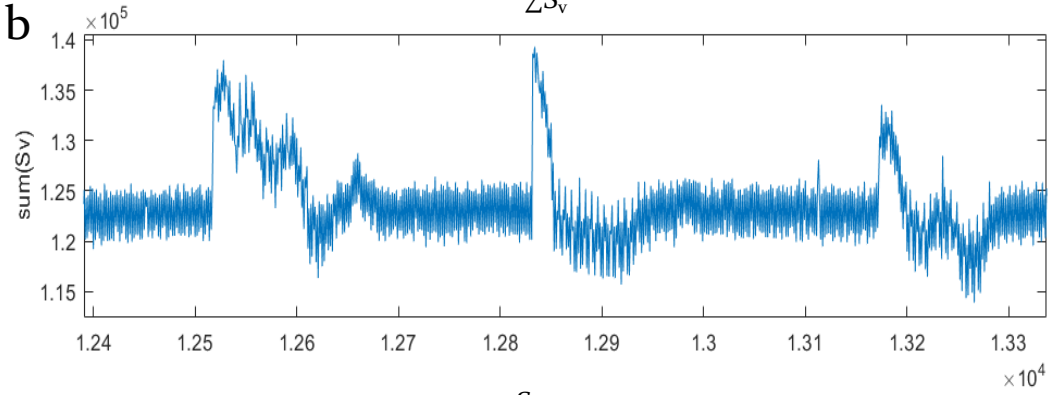
a

$S_{v,f=125kHz}$

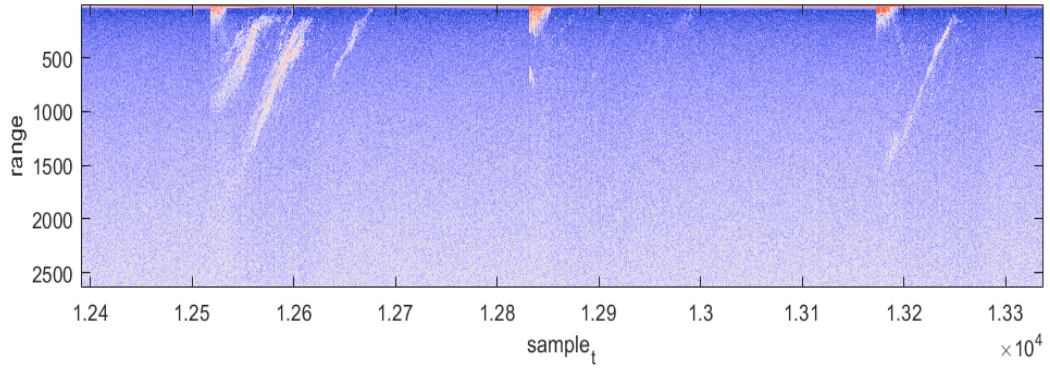


b

$\sum S_v$

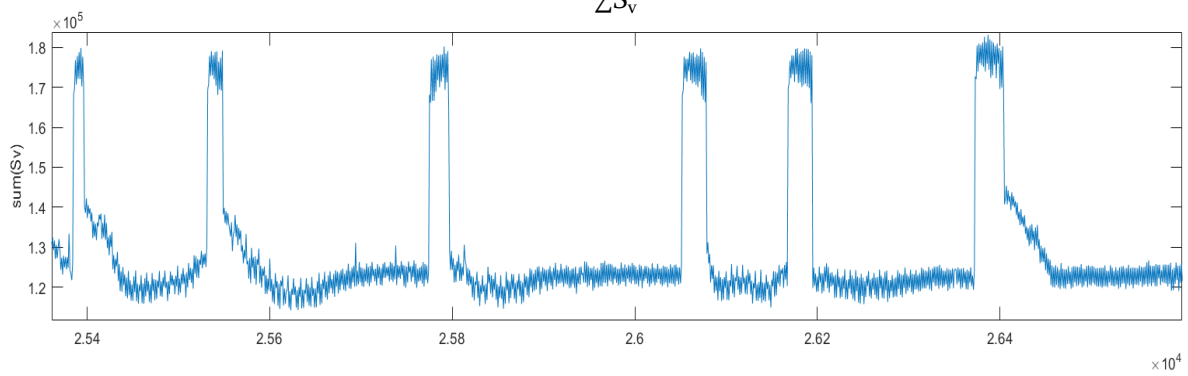


$S_{v,125\ kHz}$

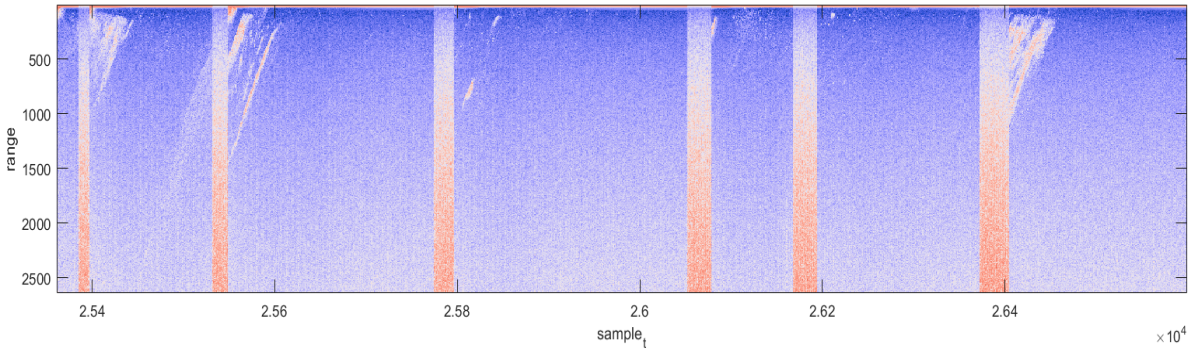


c

$\sum S_v$

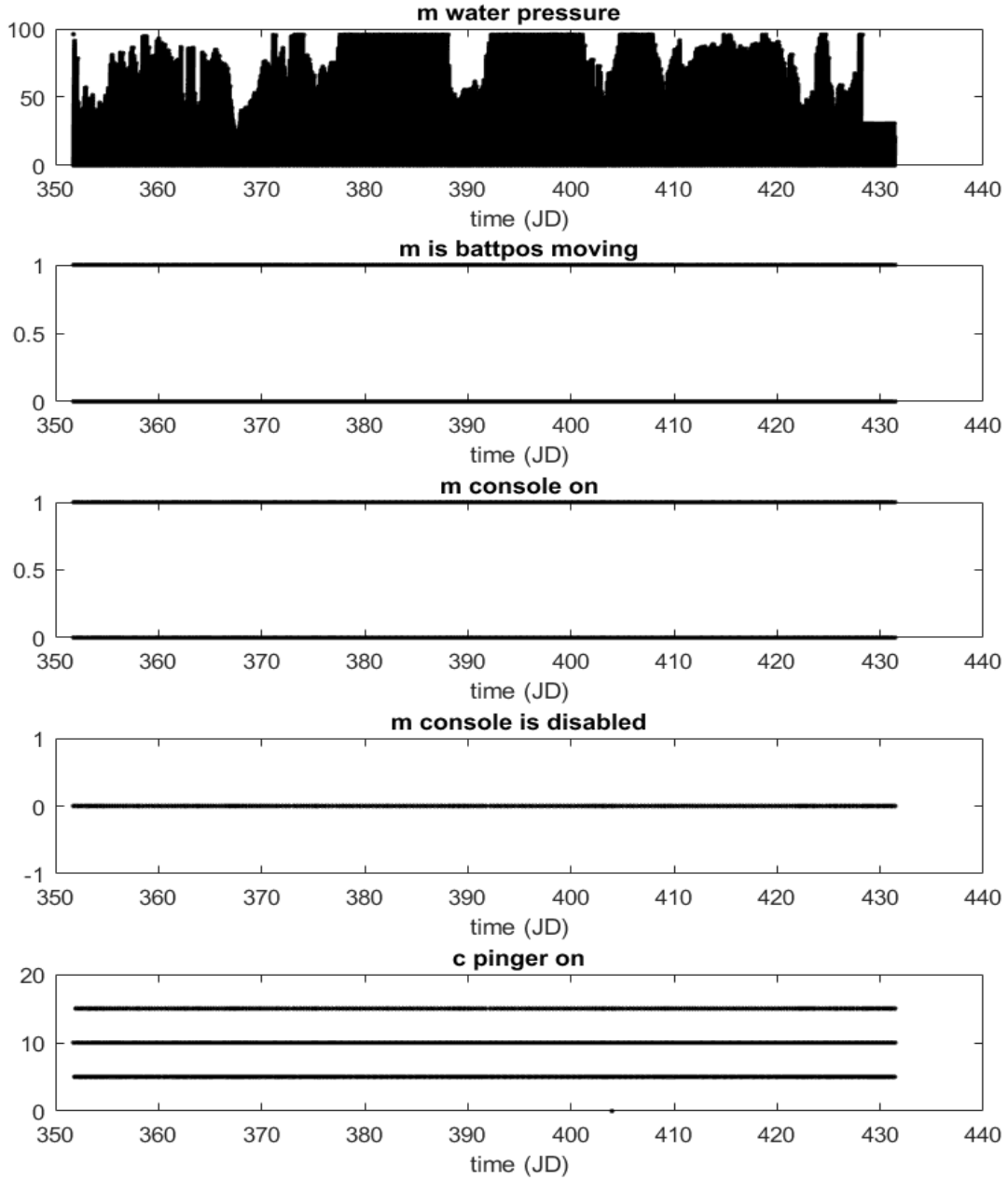


$S_{v,125\ kHz}$



Diagnose sonar problems

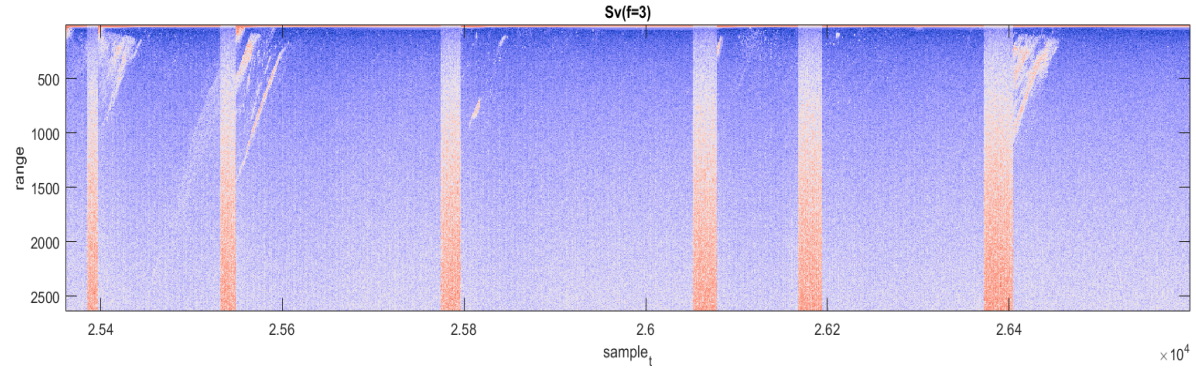
- Glider system data
  - AMLR01 dbd

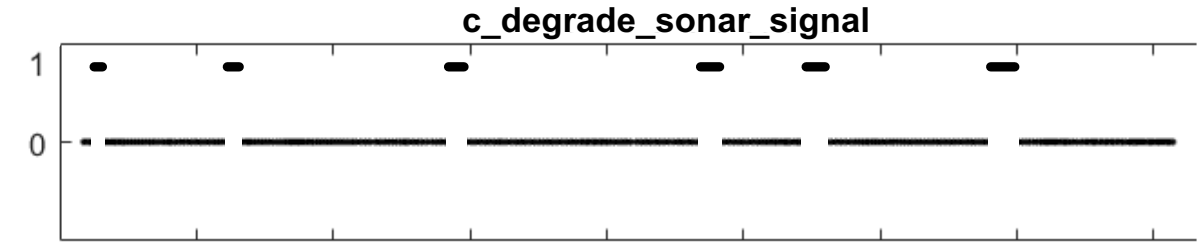


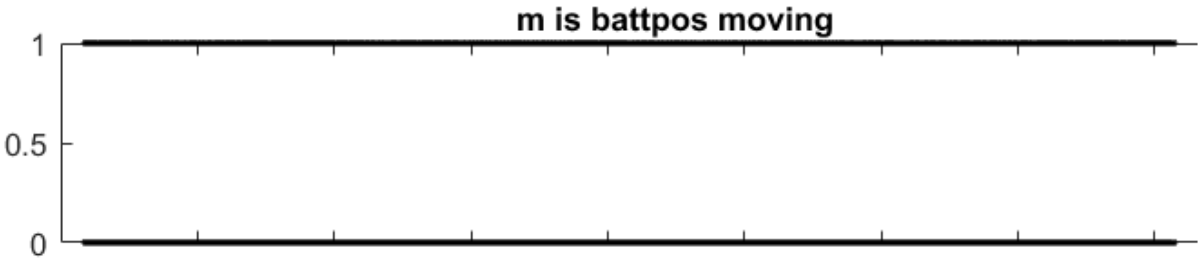
these & 100s more

Diagnostics

- Oh, that makes sense…







THANK YOU

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