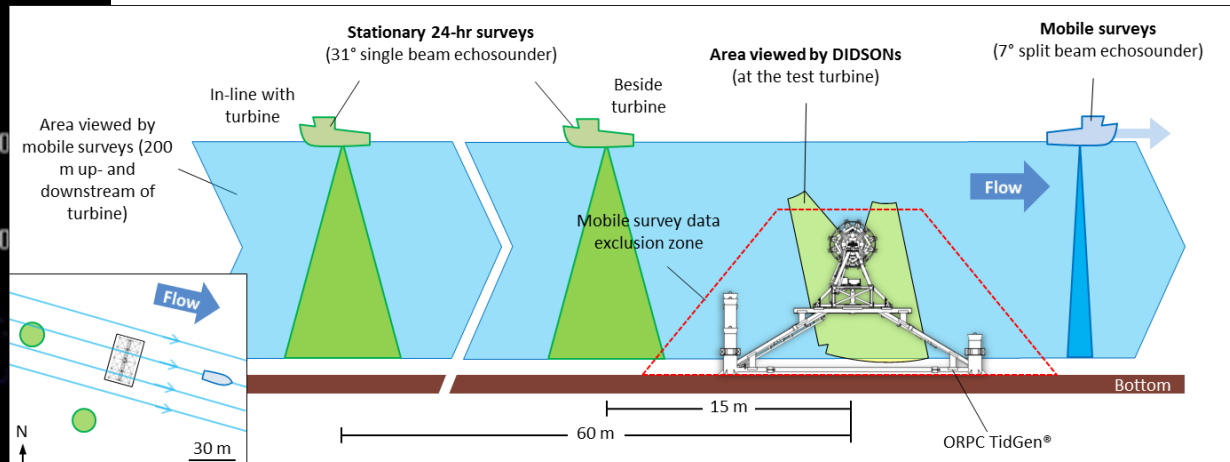
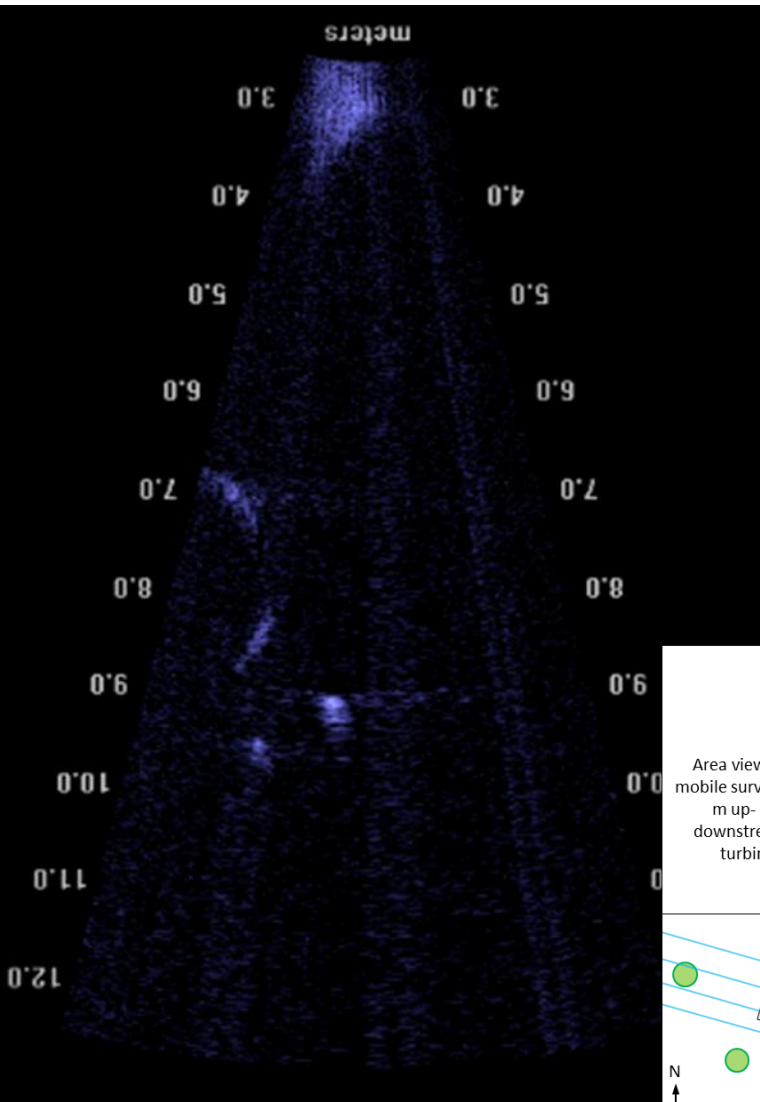


# Active acoustics in turbulent environments, particularly around energy devices

Experiences of the Zydlewski Lab,  
University of Maine  
Gayle Zydlewski, Haley Viehman,  
Garrett Staines, Haixue Shen

## Problems, Solutions, and Future Directions



# Turbulence and other Noise

## 1. Noise

- Electrical/system interference noise (e.g., DIDSON, ADCP, boat systems)
- Random interference (e.g., boat echosounders etc.)
- Interfering objects (buoy lines, non-animal)

## 2. Turbulence

- Air entrainment in the top 10 m
- Air entrainment to mid-water column
- Air entrainment surface to bottom

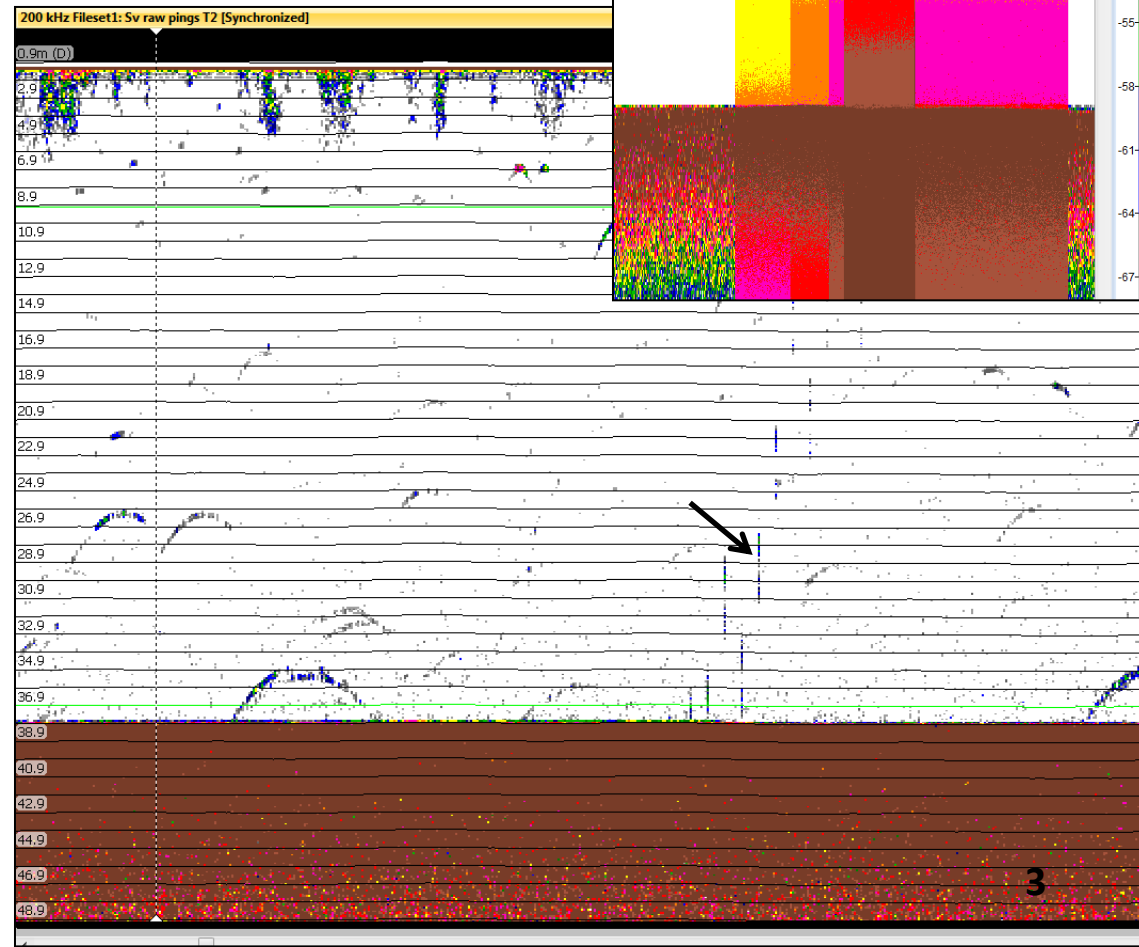
# 1. NOISE

## -System Interference

ES 60 single beam & DIDSON /  
ADCP

## Solutions

- Eliminate source
  - Do not use the DIDSON / ADCP
  - Duty cycle
- DIDSON
  - Use a pulse duration of 0.512 ms or higher.
- Treat as bad data regions (exclude those sets of pings)
- Intermittent noise removal method in Echoview
- Other?

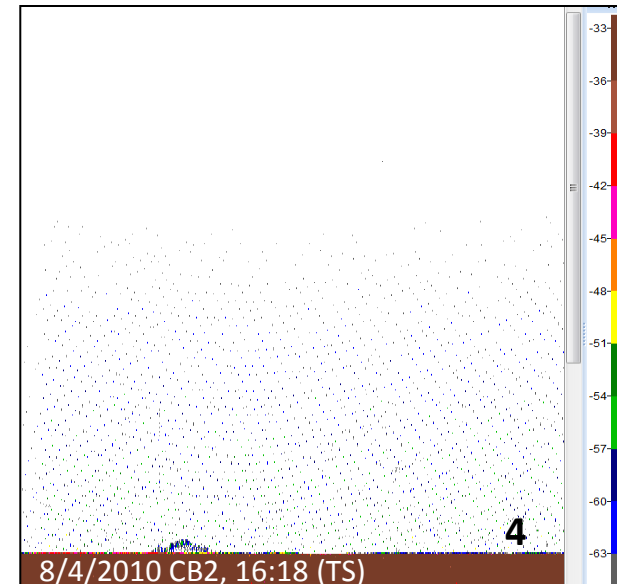
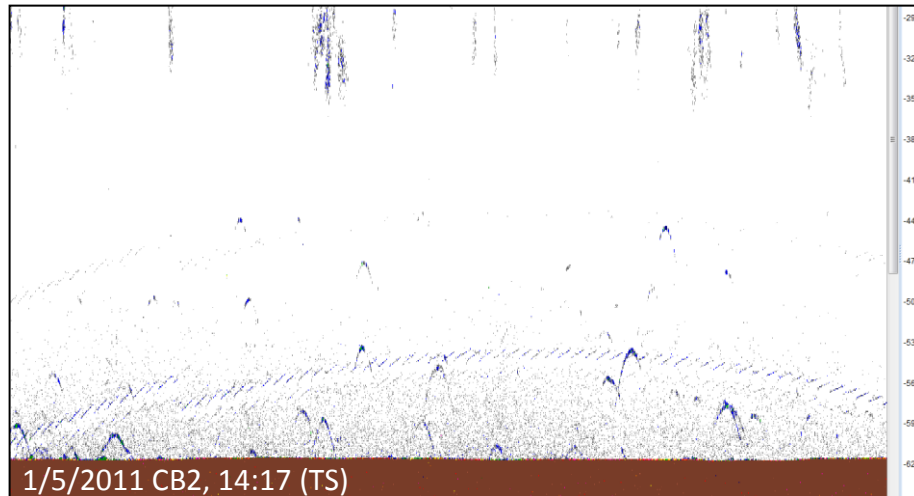
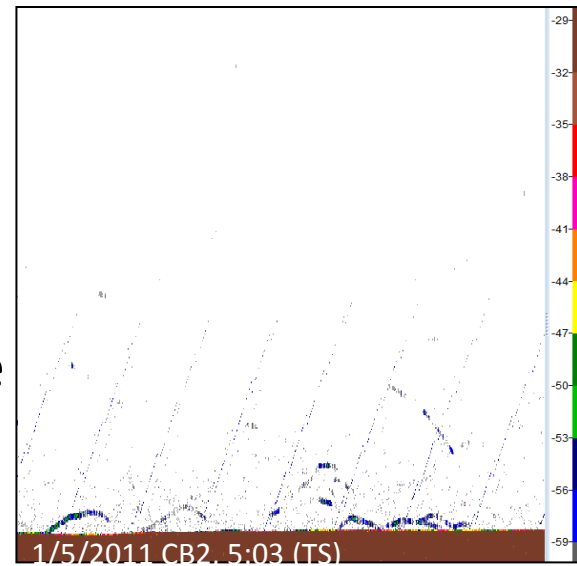
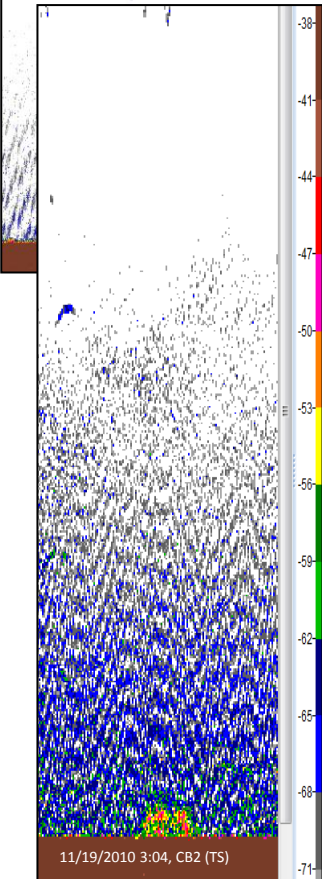
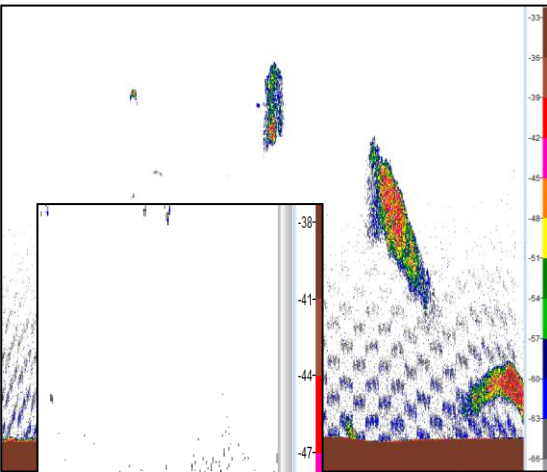


# System Interference

## Electrical Noise (*source unknown*)

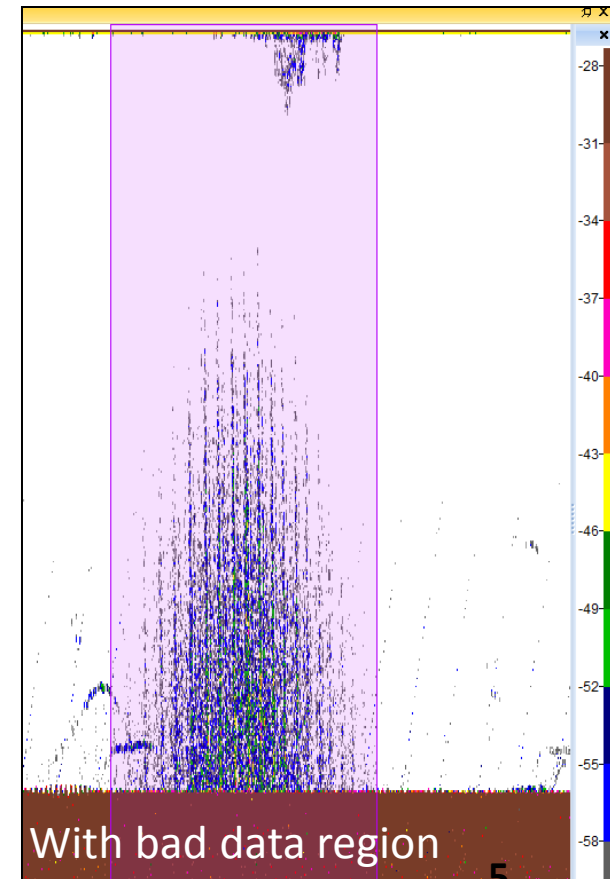
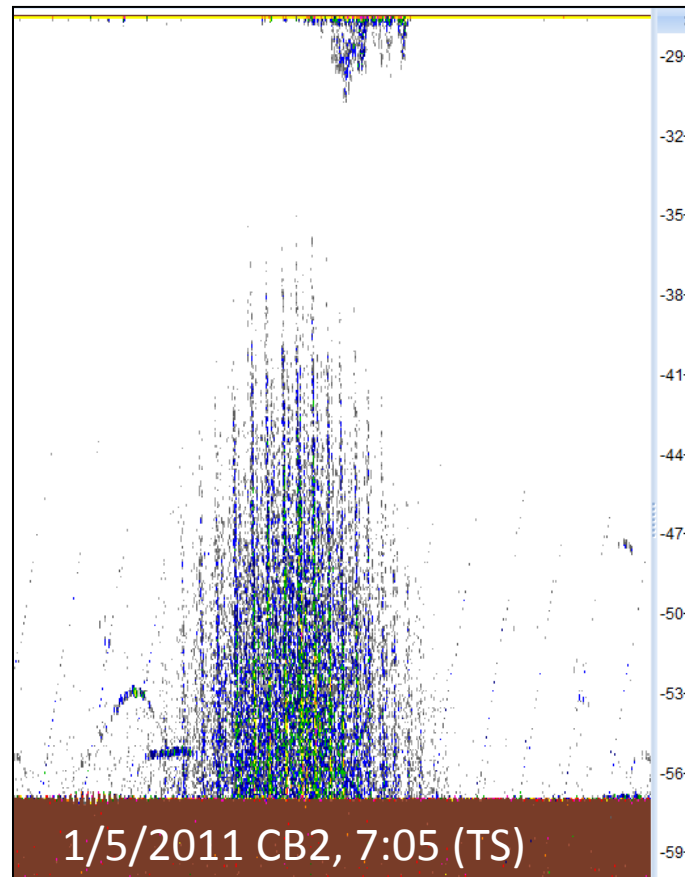
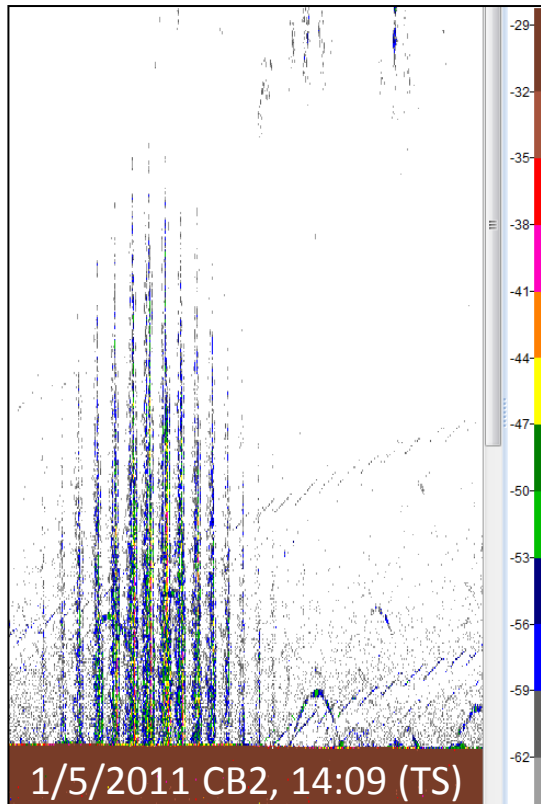
### Solutions

- Isolate issue and eliminate
- Use DC power only
- Grounding
- Apply threshold (e.g., TVG)
- Remove from dataset as bad data region
- Other?



# Random: Other boat's depth-sounder

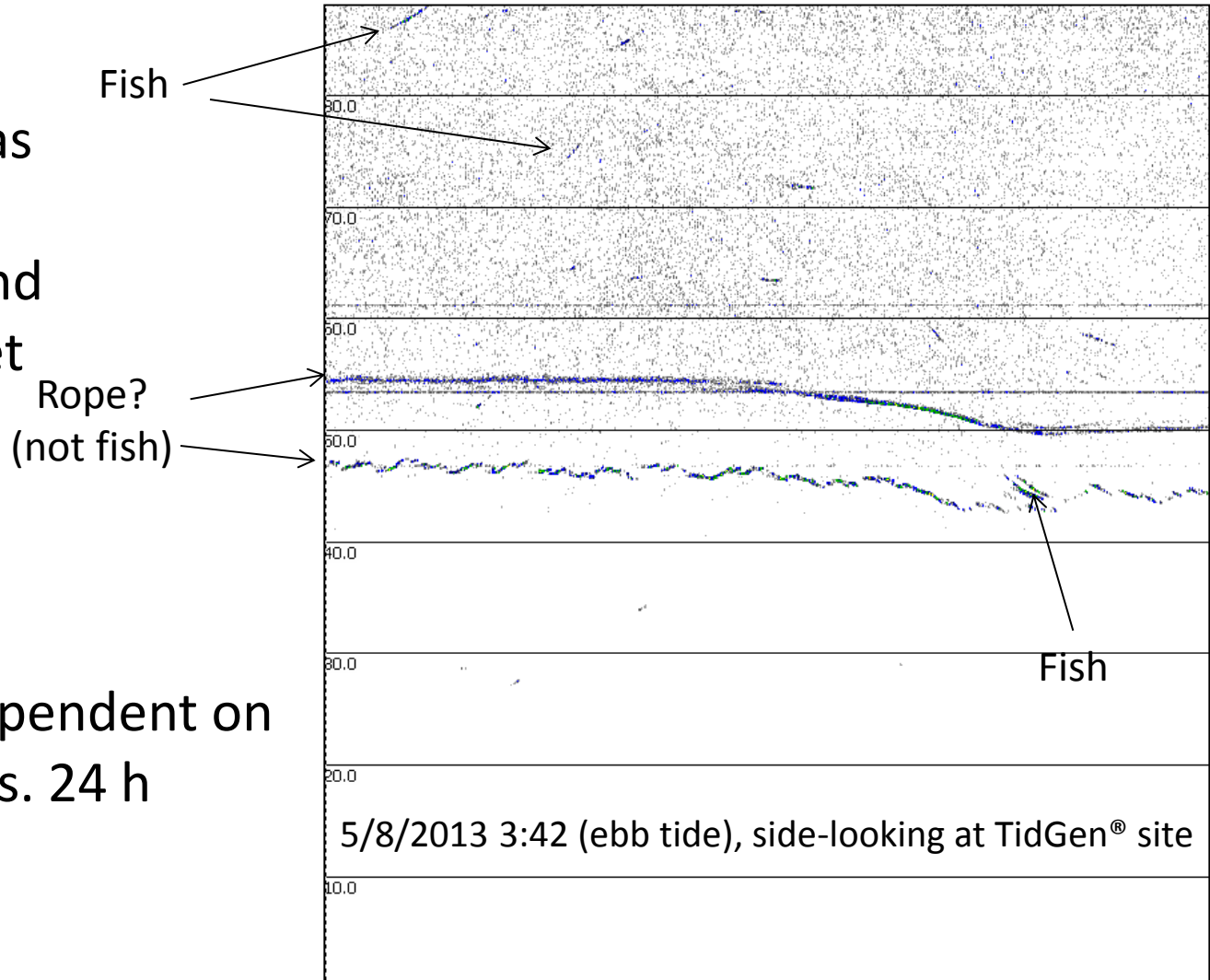
*Treat as above, but presence is random*



# Objects that look like fish but aren't

## Solutions

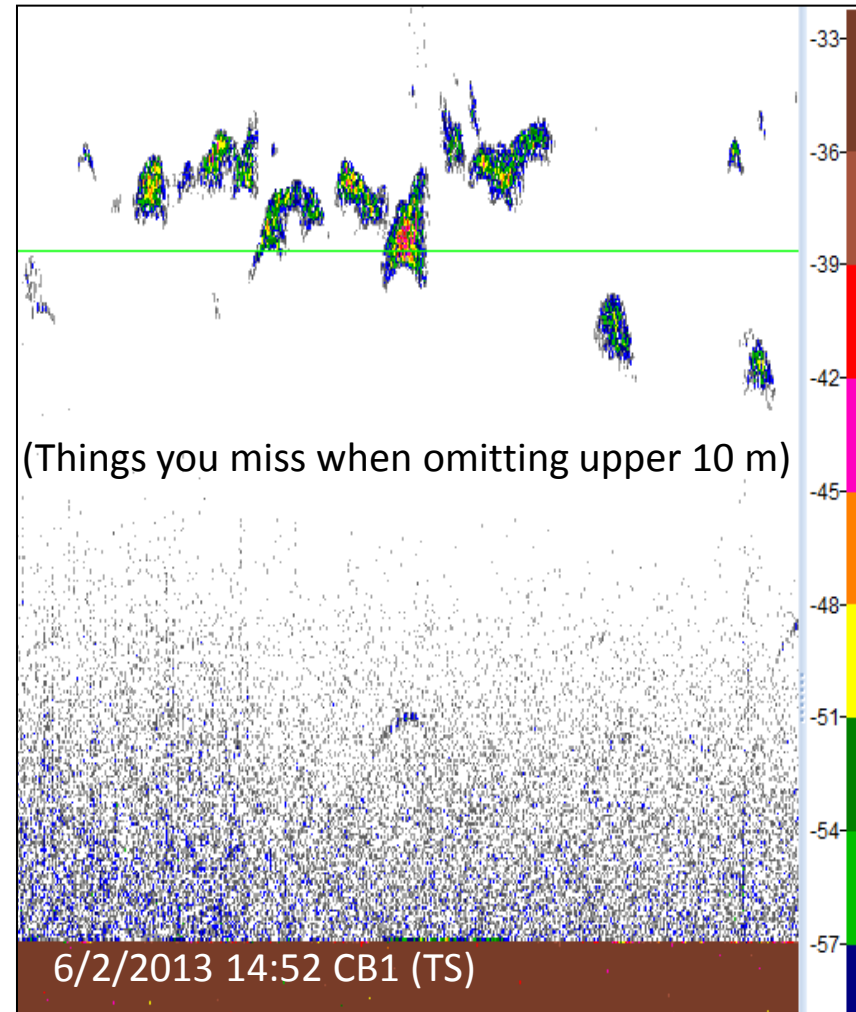
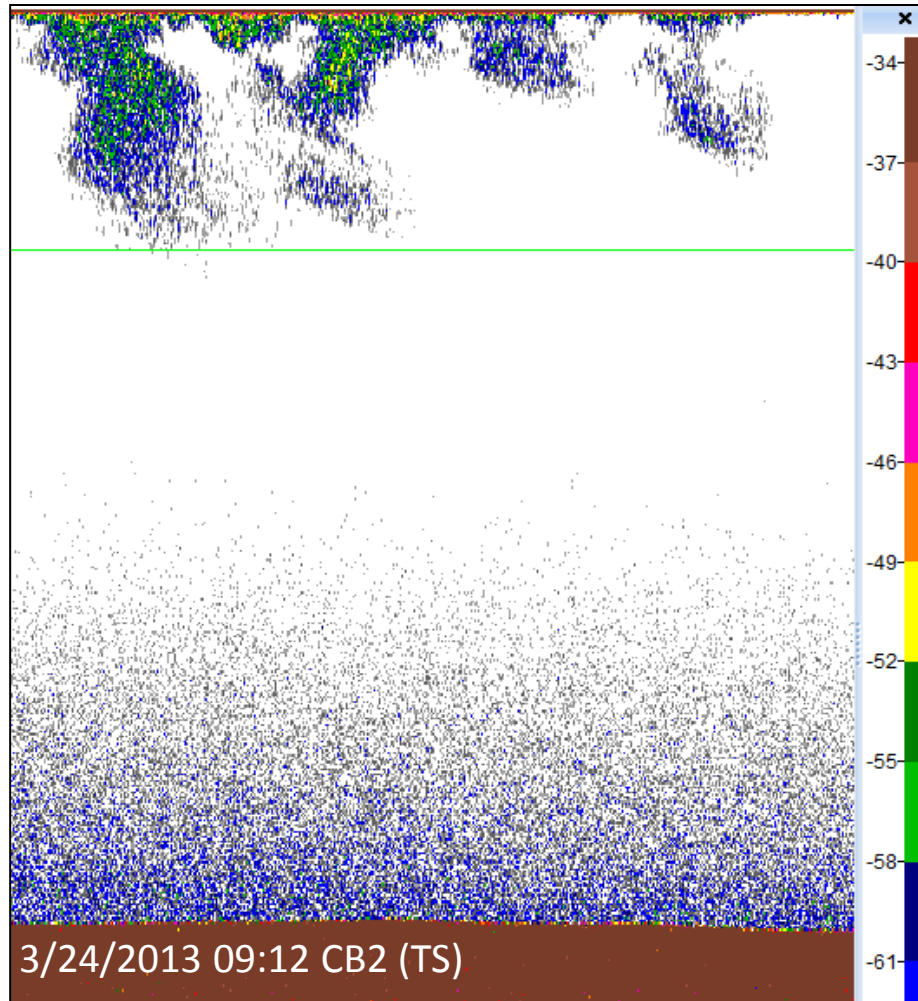
- Manually exclude as bad region
- Model the noise and apply to full dataset
- Other?



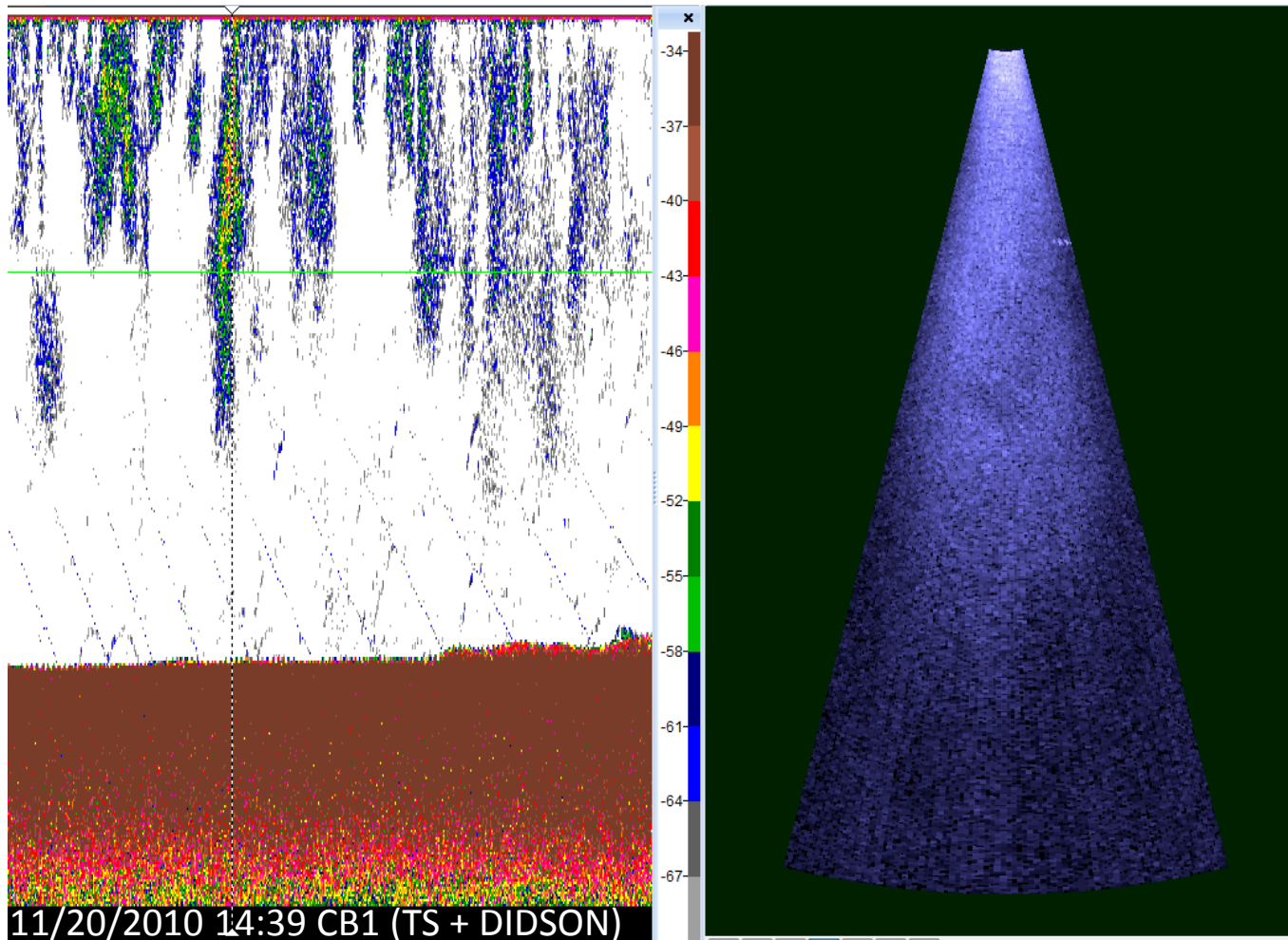
Solutions may be dependent on dataset: long-term vs. 24 h

# Turbulence

## Entrained air at surface



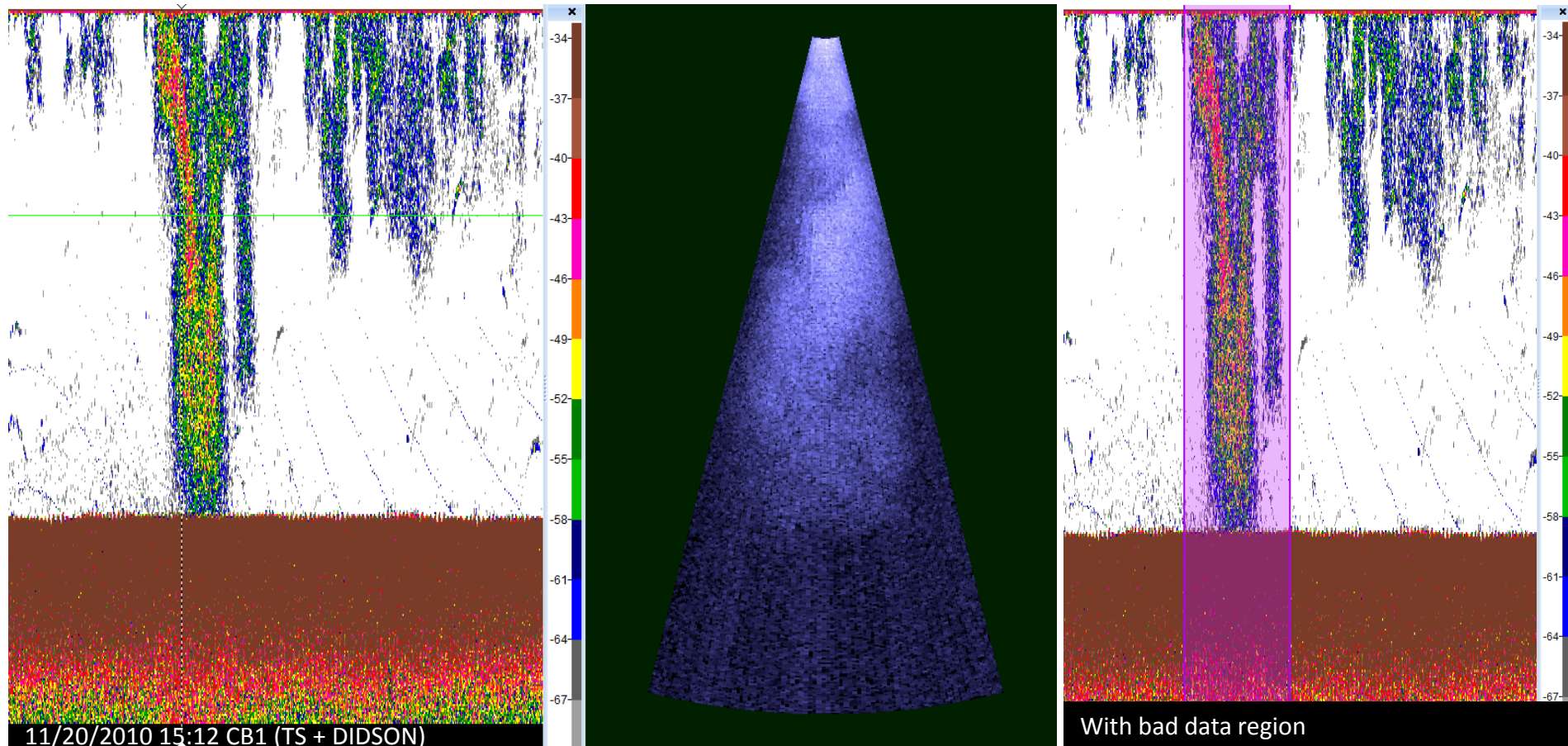
# Entrained air: most of water column





# Possible Processing/Analysis solutions:

- Do not collect data during highly turbulent periods
- Take out bad regions by hand
- Automated techniques (re-sampling or school detection)
  - still needs manual ground-truthing
- Other?



# Turbulence Exclusion

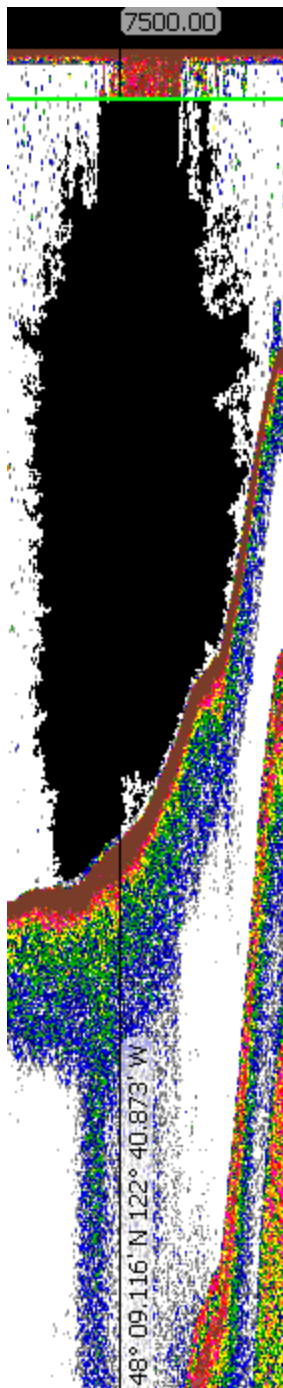
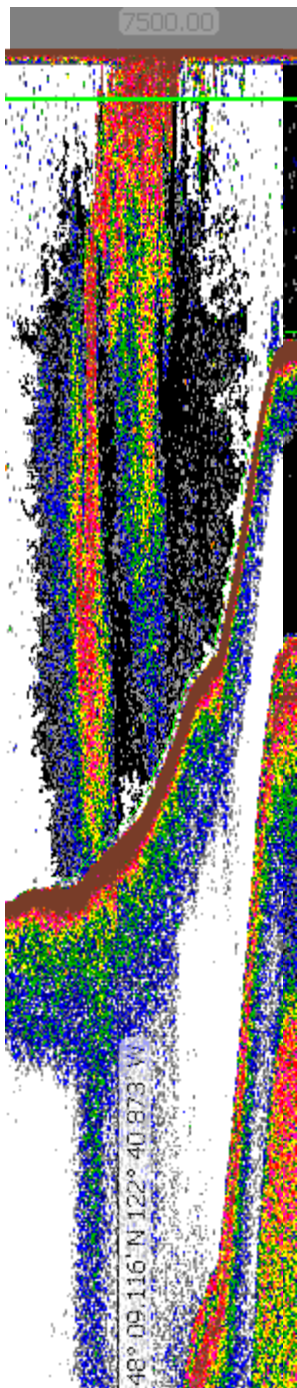
John Horne and Dale Jacques

## Potential Processing Approaches:

1. Ignore (depth exclusion)
2. Threshold
3. Single targets  $>$  threshold or SNR
4. Frequency differencing (permutations)
5. 'School detection' parameters

## Applications:

1. Marine Renewable Energy: pelagic nekton characterization (strong turbulence)
2. Bio-Physical coupling: Hypoxia, fish, zooplankton distributions (mild turbulence)
3. Predator-prey interactions: seabirds and fish (strong through mild turbulence)

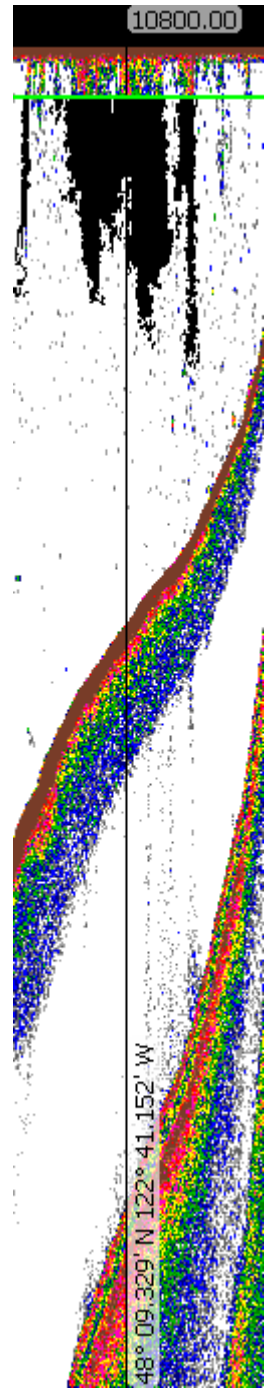
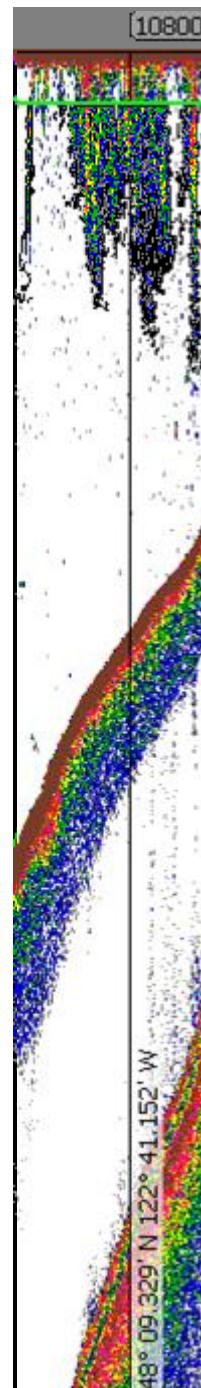


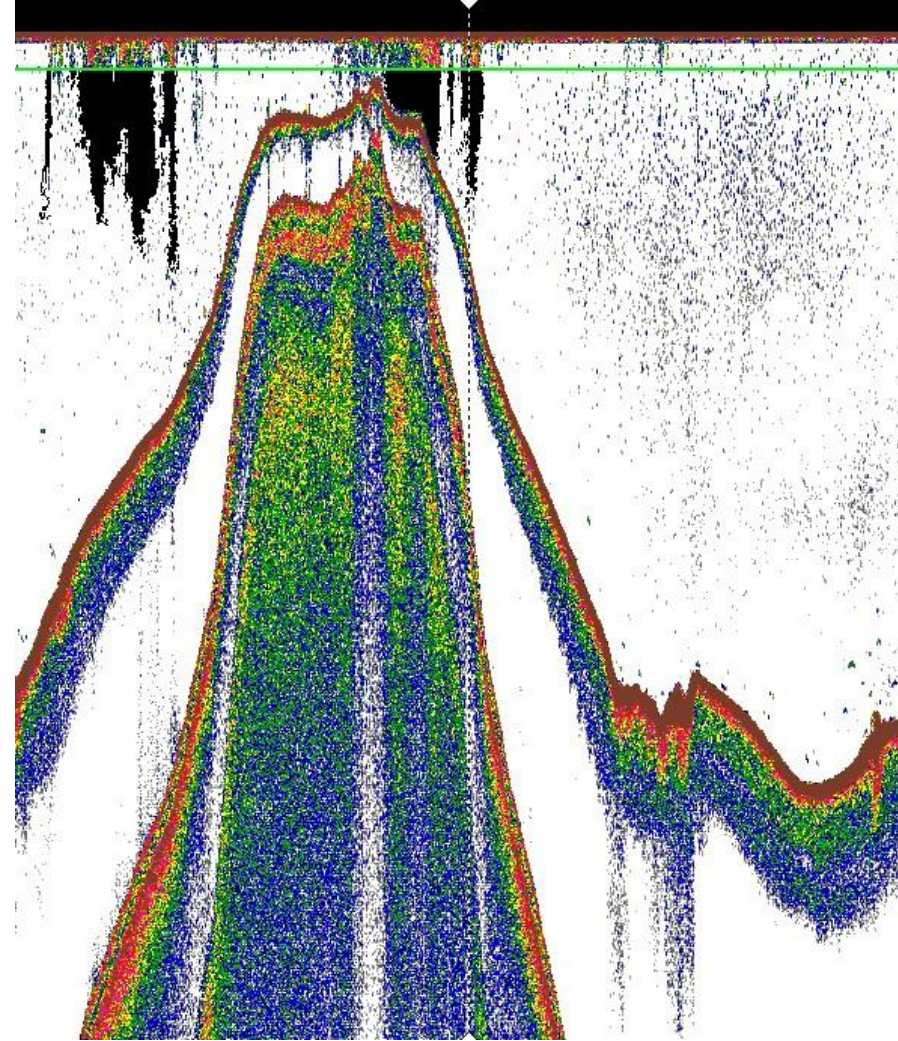
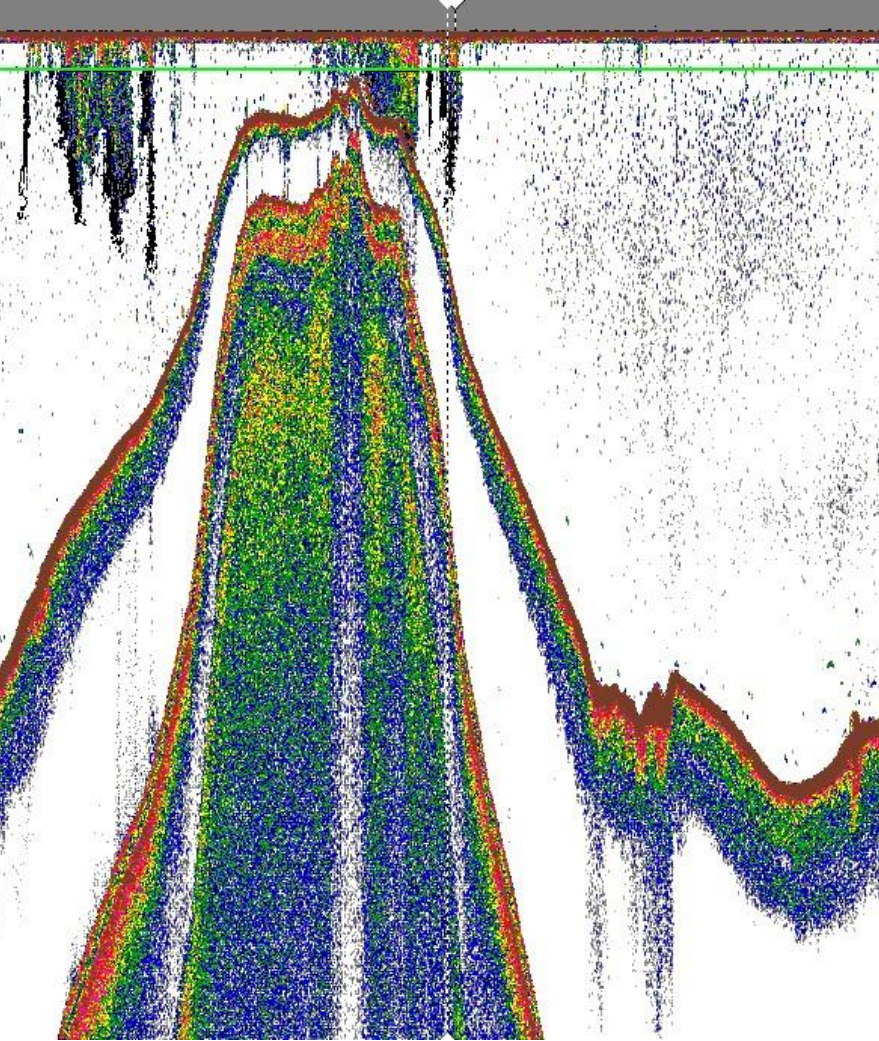
### Echogram Processing:

1. 120 kHz, passive noise removal, -75 dB threshold
2. Surface exclusion
3. 'School detection' (black outline) below surface exclusion
4. Bitmap Mask

Left: Strong, whole water column

Right: Medium, half water column



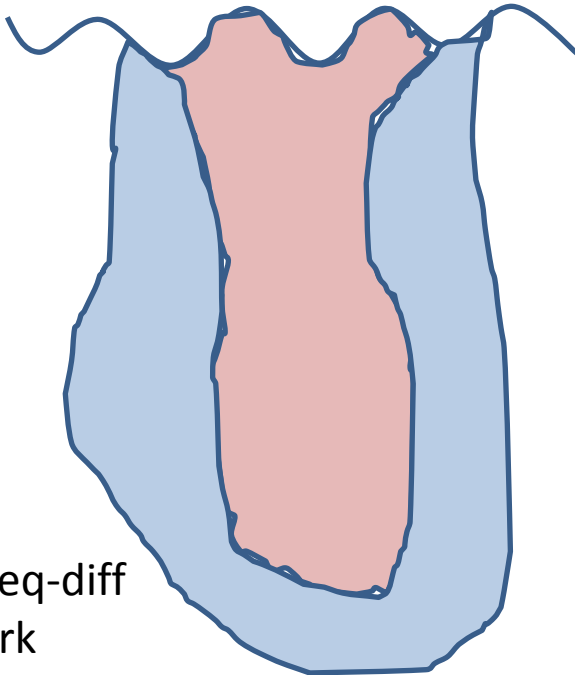


Mixed Conditions: whole water column, half water column, other scatterers

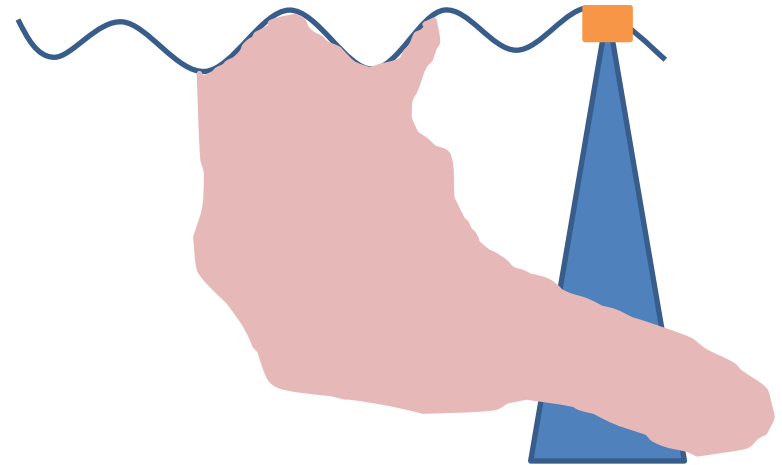
# Constraints

1. -75 dB threshold: if lower, then contiguous pixel selection messes up (chosen through trial and inspection)
2. Frequency-dependence of turbulence (i.e. bubble size)
3. Fish or zooplankton aggregations intersecting with surface or surface exclusion line
4. Deeper current turbulence \*not\* intersecting with surface (i.e. chord intersection)

Frequency-dependence



Chord intersection



Also why freq-diff  
doesn't work

# DISCUSSION...choose a topic

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# Notes